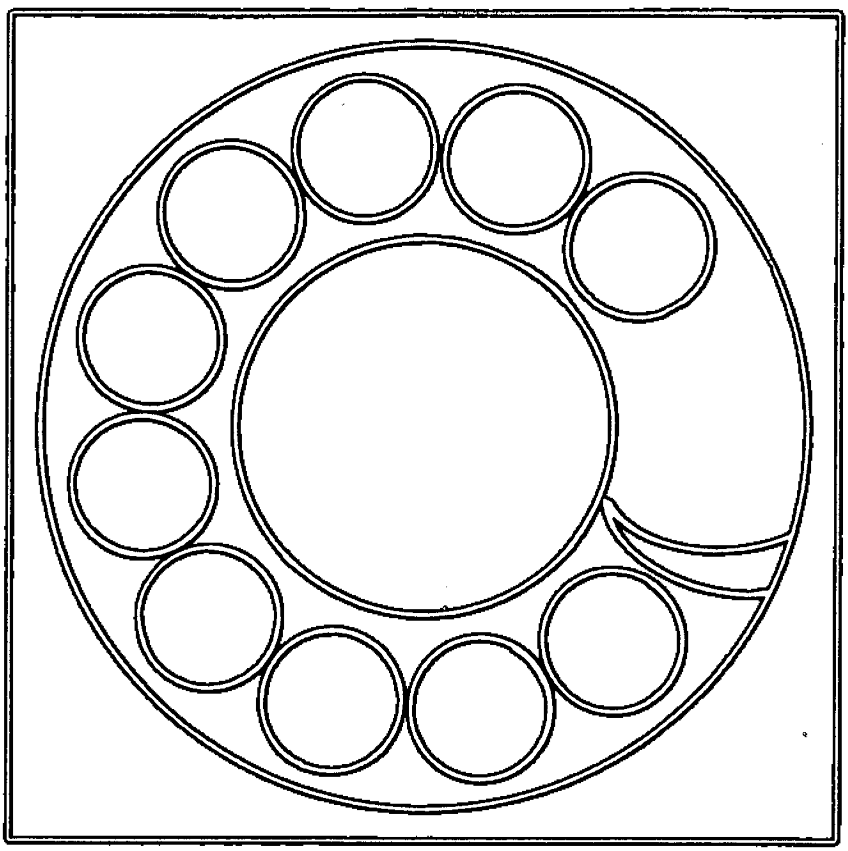
DEMAND-RESPONSIVE TRANSPORTATION SYSTEMS & SERVICES



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DEMAND-RESPONSIVE TRANSPORTATION SYSTEMS & SERVICES

Proceedings of the Fifth Annual International Conference on Demand-Responsive Transportation Systems conducted by the Transportation Research Board on November 11-13, 1974, Oakland, California, and co-sponsored by the American Public Transit Association, California Department of Transportation, Alameda-Contra Costa Transit, Massachusetts Institute of Technology, Urban Mass Transportation Administration, and Technology Sharing Program of the U.S. Department of Transportation

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The conference that is the subject of this report was approved by the Governing Board of the National Research Council acting in behalf of the National Academy of Sciences. Such approval reflects the Governing Board's judgment that the conference is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the committee selected to organize the conference and to supervise the preparation of this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project.

Responsibility for the selection of the participants in the conference and for any summaries or recommendations in this report rests with that committee. The views expressed in individual papers and attributed to the authors of those papers are those of the authors and do not necessarily reflect the view of the committee, the Transportation Research Board, the National Academy of Sciences, or the sponsors of the project.

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INTRODUCTION

Daniel Roos, Massachusetts Institute of Technology and chairman of the Committee on Urban Transport Service Innovations (Paratransit)

During the past 4 years, the demand-responsive transportation (DRT) concept has evolved from an experimental to a production stage. C. Kenneth Orski, associate administrator of the Urban Mass Transportation Administration, stated in his keynote address at the conference, "The utility of demand-responsive transportation requires no further proof. More than 50 DRT systems in some 22 states testify to the popularity of the concept." To reflect this acceptance, UMTA has recently made its first capital grants for DRT systems.

In light of these developments, this conference did not focus on concepts and systems that already had been tested. Rather, it was oriented toward a number of significant issues that are still unresolved and will impact the future of demand-responsive transportation. These issues include the following.

1. Integrated service. Most of the implemented demand-responsive systems are in small- and medium-scale cities that have few or no fixed-route bus systems. The role of demand-responsive service in larger metropolitan areas that have significant fixed-route service is still unresolved. In particular, the issue of how demand-responsive and fixed-route services are integrated is of utmost importance. A number of difficult areawide approaches are currently being implemented in Ann Arbor, Rochester, Orange County, Santa Clara County, Regina, and Toronto.
2. Service for the elderly and handicapped. The door-to-door service aspect of demand-responsive transportation provides unique opportunities to offer service for the elderly and handicapped. However, should that service be combined with more general demand-responsive service or should it be provided as a special service? What special design features must be included in vehicles to serve these groups?
3. Role of automation. All of the demand-responsive systems implemented to date have used manual dispatching techniques. The new areawide systems will use a number of different automated dispatching approaches. Considerable debate exists as to what the role of computers should be and whether dispatching should be computer aided or computer controlled.
4. Taxicabs and demand-responsive transportation. During the past year, a number of DRT systems operated by taxi companies have been implemented. The conference addressed not only the role of taxi companies in DRT operations but also the more general issues of taxicab operations. Charles Boynton, president of the International Taxicab Association, in the opening address at the conference, presented his views on the future of the industry and, for the first time in this series of conferences, one session was devoted exclusively to taxicabs.

DRT and conventional taxi operations are 2 examples of a class of transit-like service that has recently been referred to as "paratransit." Other paratransit concepts include car pooling, van pooling, subscription bus, and various types of rental car services. Because of the increasing importance of these options, a Transportation Research Board Committee on Urban Transport Service Innovations (Paratransit) was established this year. The committee was responsible for the organization of this conference. In many ways, the objectives of this new committee are similar to those of the conference:

1. Recognition that demand-responsive transportation involves many different groups, such as transit, taxi, labor, and government, who must understand each other and be able to work together;
2. Recognition that a number of significant unresolved issues are common to many different paratransit concepts, some of which are technical issues such as ride-sharing techniques and vehicle design and some of which are institutional issues such as regulation, insurance, and labor; and
3. Realization that any successful urban transportation system should consist of integrated paratransit and transit services rather than sets of independent uncoordinated services.

We have only begun to understand many of these important issues and to initiate a number of promising new service concepts. Much remains to be done in the coming years, and progress will be reported at forthcoming demand-responsive conferences and other similar forums.

The active role that UMTA has played recently in the area of paratransit is encouraging. This was the first year that UMTA was a cosponsor of the demand-responsive conference. UMTA staff provided us with assistance in organizing the conference, and many key UMTA professionals were participants in the conference. In addition, UMTA provided some financial support to assist in the distribution of these proceedings. We are extremely grateful for this invaluable assistance.

The Sixth International Conference on Demand-Responsive Transportation Systems will be held March 15-17, 1976, at the Sheraton-Park Hotel, Washington, D.C. Those interested in attending or presenting papers should write the Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

STATE OF THE ART OF DEMAND-RESPONSIVE TRANSPORTATION

Robert P. Aex, Rochester-Genesee Regional Transportation Authority

This paper examines demand-responsive transportation (DRT) services and the techniques used to provide those services. Two systems are examined for illustrative purposes. One system, in Batavia, New York, which has a population of about 18,000 within about 5½ miles^2 (14.3 km^2), is a small, manual system that has been operating since October 1971 with 4 to 5 vehicles. It will probably continue to remain a small manually operated system. The Rochester, New York, system is considerably larger and more automated. It operates with 15 vehicles in a 10-mile^2 (26-km^2) portion of the metropolitan area. The present service area has a population of about 40,000. The Rochester system is programmed to have 100 vehicles servicing the entire metropolitan area. Vehicles are manually dispatched, but a digital communication system is used. Plans are to automate dispatching by a computer that will be interfaced with the digital communication equipment. The Rochester system is to be integrated with the existing fixed-route system.

VEHICLES

The first vehicles used for DRT were 10-passenger vehicles such as Ford and Dodge vans. The early models did not provide enough head room for passengers to stand, and bubble tops or other devices were added to provide standing room. Larger vehicles were then used, such as those manufactured by Flxible and Grumman. They were 15- to 20-passenger units consisting of a special body mounted on a truck chassis. Those vehicles tended to be somewhat austere; they were equipped with standard forward seats on each side of a center aisle and rubber fabric floor covering. They usually had no air conditioning. Later, air conditioning and carpeting, which was sometimes carried up the sides to the bottom of the window sash, were added.

Recently 20- to 25-passenger vehicles, some powered by diesel fuel, have become available. The Twin Coach vehicle manufactured by Highway Products is an example of units of this type. The manufacturers of mobile-home and recreation vehicles also introduced a DRT vehicle, which was basically a modified mobile-home body mounted on a truck chassis. Although not suitable for heavy-duty service in larger systems, it provides reasonably satisfactory service for small systems.

Many manufacturers offer options of interior treatment and seating. The Rec-Vee vehicle by Funcraft Vehicles, Ltd., is an example of changes in the interior. The angled seating is a part of a molded fiber glass body. One of the latest offerings is the Electrobus, a battery-powered vehicle manufactured by Otis Elevator Company.

COMMUNICATION

Initially, the communications used for taking orders and dispatching vehicles consisted of the telephone and the voice radio, which are quite adequate for small systems that have 8 to 10 vehicles. Telephone operators can now keypunch information they receive onto cards, which are then used with digital communication equipment to relay the instructions to the drivers in their vehicles. The radio voice message system serves as the backup for the digital system and enables the driver to take the initiative in contacting the dispatcher when necessary.

RECORDS

In the early days, the handwritten dispatcher's log and the handwritten driver's log constituted the basic records. Today's digital communication equipment produces hard-copy records at the point of dispatching and at the point of receiving. These permanent records can be based in analysis and reporting.

SERVICES AND MARKETS

Originally, the basic service of a DRT system consisted of many-to-many or many-to-few service. Gradually, many-to-one service was added from home to work and then home to school. Now services are provided for those who live in senior citizen housing units, usually to and from a shopping center. In addition, subscription service is available for those enrolled in adult education classes; the transportation charge is included in the registration fee.

Small package delivery is a service that is slowly developing. Although this has proved to be unprofitable for private delivery companies, it is profitable for DRT systems and is compatible with passenger service; that is, each service can be performed without adversely affecting the other. Revenue from package delivery service can reduce operating deficits that accrue from passenger service.

DISPATCHING AND COMMUNICATIONS

Small systems, such as Batavia, continue to dispatch manually because it is practical and economical. However, a system that has more than 8 or 10 vehicles must have digital communications, computer dispatching, and an interface between the computer and the digital communications equipment. Plans for the Rochester system include computer dispatching and the interface of the computer with digital equipment. Our experience in Rochester has confirmed our belief that automation in communications should precede automation in dispatching.

INTEGRATED TRANSIT SERVICE

DRT systems were first installed in small communities. Installations in larger communities, such as Rochester, present a challenge and an opportunity to develop integrated transit. In most fixed-route transit systems, lines operate at a financial loss because of underuse of manpower and equipment during off-peak periods. Integrating fixed-route service and demand-responsive service provides an opportunity to

1. Provide service to those who have had little or no service,
2. Improve the quality of service during off-peak hours,
3. Improve the overall economic results of the total system, and
4. Serve new markets.

RIDERSHIP

In Rochester, ridership continued to increase before, during, and after the fuel shortage. Since the system started on August 6, 1973, its weekly ridership has increased from 714 to 3,900. Integrating DRT and the fixed-route systems indicates that as many as 30 percent of the former riders on a fixed-route line can be diverted to the demand-responsive system while a substantial number of new riders can be attracted who did not previously use the fixed-route system.

COST PER PASSENGER

Inflation during 1974 has increased costs of both DRT and fixed-route systems. Nevertheless, improved use of manpower and equipment has resulted in progressively decreased operating costs per passenger for the Rochester DRT system. The cost per passenger was $5.00 during the first month of operating in August 1973 and $2.54 during August 1974.

THE FUTURE

DRT systems in small communities have proved that they have a role in the total transportation system. I believe that small DRT systems will continue to be implemented in increasing number. Much remains to be learned of the role that larger systems in metropolitan areas can play. Automation will permit large systems to be integrated with fixed-route transit.

E. W. Ziegler, Urban Mass Transportation Administration

Most DRT systems have been small experimental projects to introduce the concept to a locality or to test techniques. These projects have provided an improved view of the role of DRT service in large transit systems. Operating and planned DRT systems indicate that those systems can substantially augment fixed-route service in suburban metropolitan areas. DRT systems provide better local transportation service and, as a feeder to express bus service, lead to increased transit ridership and lower operating costs. The use of DRT for feeder distribution service is likely its largest future role.

When DRT and line-haul services are mixed, each service is used at its best: DRT in areas where origins or destinations are scattered and fixed route in corriders where there are heavy volumes. The line-haul service can be provided by express buses or by rail rapid cars, depending on local factors such as passenger volume and funding availability. Interconnecting DRT service areas will provide accessibility via transit to all points in suburban areas.

Integrated DRT and fixed-route systems facilitate phased introduction and improvement of transit systems. DRT service can bring transit service into new areas quickly. As ridership and vehicle supply grow, buses can be moved to dedicated lanes to increase capacity and, later, dedicated lanes can be changed to dual mode where additional capacity is needed. Concurrently, planning and construction of rail lines and, as appropriate, personal rapid transit can take place for high-volume areas. This approach should be useful in widespread metropolitan areas such as Los Angeles.

Economically, a transit system with both DRT and fixed-route service should be stronger than one with either type of service alone. DRT feeder service facilitates access to fixed-route, line-haul service and allows more efficient operation by reducing the number of fixed-route vehicle stops. Integrating DRT service into a larger system provides management flexibility: Demand for DRT service peaks much less than demand for line-haul service, and line-haul drivers can be used in DRT vehicles during off-peak hours and thus reduce total costs significantly.

Passenger origins and destinations in suburban areas are not like those in corridors. In these areas, door-to-door service is attractive, particularly for senior citizens and the handicapped who depend on transit for mobility.

DRT service has been effective in raising local funds for transit operations. In Ann Arbor an increase in the property tax rate was approved by ballot, and in California local allocations of revenues from a gasoline tax are being used. DRT systems have been most successful in areas where fixed-route service has been least successful, i.e., the suburban areas in which about half the population lives. The improved efficiency of DRT service is most evident in Regina, Saskatchewan, and Batavia, New York, where its introduction increased transit ridership and decreased the operating subsidy of the systems. DRT and fixed-route systems cost about the same to operate on a vehicle per hour basis. The major operating costs of each are in drivers and vehicle-related factors such as maintenance, storage, and fuel. However, DRT requires fewer vehicles because passenger origins and destinations are known so that vehicles can be used more efficiently.

The operating costs of DRT service can be tailored to the services desired and the availability of funds in each area. Raising the fare or decreasing the size of the service area reduces the number of vehicles needed and the cost of system operation. Conversely, lowering the fare or serving a larger area increases the number of riders but also increases the operating subsidy.

In Orange County, California, the county transit district plans to offer each city a base-level DRT service. The base service will feature a medium to high fare, less than 24-hour service, and a specified service area. If a city wants better service or lower fares, the transit district will provide the improved service but the city must provide the incremental funding.

One of the results of the research and development program of DRT systems is a better understanding of the diversity of scheduling methods. These methods include the following:

1. Shuttle service in which vehicles move back and forth between a few points and are coordinated by radio communication;
2. Zonal service in which fixed schedules are maintained at a transfer point, often a line-haul interconnection, and each bus stays within a fixed zone until returning to the transfer point;
3. Subscription gather service in which passengers are picked up at the same time each weekday and brought to a line-haul transfer point;
4. Scatter service in which passengers at a high-volume inbound point, such as a rail rapid station in the evening, are taken to diverse destinations; and
5. Many-to-many service in which a passenger can be picked up at any point and delivered to any point without a transfer.

Any one of the scheduling methods can be the best under particular circumstances. The factors that affect the choice of scheduling methods include demand levels, demand patterns, and local priorities. For example, zonal scheduling provides efficient service when relatively heavy demand is focused on a major trip generator. Some factors, such as the demand pattern, are subject to management control. In Haddonfield, New Jersey, service was improved by instituting a shuttle service between 2 major trip generators, a rail rapid station and a large shopping center. This allowed the system to operate as a feeder distribution service focused on one point, the rail rapid station; the shuttle provided service to the shopping center.

The optimal scheduling method is likely to involve a combination of the various methods, and the combination will change with circumstances. On Sunday in Haddonfield demand is relatively light and has little focus, so many-to-many scheduling is used throughout the day. On weekday evenings a large number of trips originate at the Cherry Hill Mall shopping center and at the rail rapid station. During this period shuttle service brings passengers from Cherry Hill Mall to the rail station, scatter service takes those passengers and incoming rail passengers to their destinations, and many-to-many service carries passengers with origins other than the rail rapid station. Throughout the evening individual vehicles shift among shuttle, scatter, and many-to-many services as needed.

The research and development program is identifying improved techniques for determining the most appropriate mixture of scheduling methods under various operating circumstances. These techniques can be expected to result in further improvements in the operation of DRT services. Quantification of the techniques will enable decisions to be incorporated into the computer system. These decisions will improve the ability of the computer system to support the operations manager, either by providing data needed by the manager to select the scheduling methods or by selecting the scheduling methods for review by the manager.

In summary, DRT fills a gap in current transit systems by providing effective and efficient suburban service. These services should be an integral part of a metropolitan transit system and should be closely coordinated with fixed-route, line-haul service. Such a coordinated system can provide comprehensive transit service between various suburban areas as well as between suburban areas and the central business district. Operating economies can be realized by combining DRT and fixed-route services. DRT provides better suburban service. Fixed-route drivers can be used on DRT vehicles in off-peak hours to reduce total system costs. Origin-destination data collected as a by-product of DRT operations, particularly computer-based operations, can contribute to a better use of vehicles and drivers in both types of services. Also, those data are useful in transit planning. The origin-destination data can replace information now collected in surveys, a major expense in transit planning studies.

A diversity of DRT scheduling methods have been identified. Research and development is in progress to determine the best combination of scheduling methods under a variety of operating circumstances. Identification and quantification of formal techniques to select scheduling methods will further improve the operating of transit systems.

Charles Boynton, Salt Lake City Taxicab Association

The International Taxicab Association is an association of taxicab owners and operators in the United States, Canada, and Mexico. During 1974 I was president of that association and gave to its members the message that is in this paper.

During the past few years, the taxicab industry has come a long way. A few first-order problems involving our industry, government, and consumers at all levels remain and must be resolved before we can make further progress.

The major issue facing the taxi industry today is clarifying its overall role in the urban passenger transportation system. If that were done, intelligent goals could be identified and more coherent policies developed. The issue is not just a taxi industry issue. We would be naive to assume that we could make this decision by ourselves. Urban planners, local governments, and federal agencies make decisions every day that affect what we do. They do not deliberately try to influence our future; as they carry out their legal and administrative duties, we are affected. Certainly the EPA clean air standards will have a major effect on us.

Clarifying the taxi industry's role is important because it has financial consequences to us and the communities we serve. It is also important because service standards are included, and thus the quality of transportation is affected. The future urban transportation system may have no taxis, nothing but taxis, or a certain number of taxis; each plan will create a different kind of situation.

I should like to discuss the urban public passenger transportation system, make a proposal, and ask for the help of others involved in solving urban transportation problems. Our industry has a duty to provide input to the solution of these problems, and we are trying to do just that.

CITIES SERVED

A carrier's importance to the market can be ascertained by examining the participation of the carrier in the whole market. If a carrier serves any particular market well, then that carrier is a power, but well-served individual segments do not prove that the whole can be well served. For example, PSA does a spectacular job in providing air service between most of the major cities in California. But, based on that example, one cannot conclude that air service is excellent throughout the United States. One would be equally silly to examine just United, American, or Delta and conclude that air service is adequate. All the services must be examined.

The same principle applies in the examination of urban carrier services. One cannot look at certain cities and equate transportation adequacy in those cities with transportation adequacy in all cities. A multiplicity of services must be examined.

I know that taxis are a major element in the urban transportation system, even though others may not agree. Here are some facts. Taxicabs serve more than 3,400 communities; rail rapid transit serves only 7 cities (although they are all large ones), and bus transit serves 1,023 cities, of which 185 now have public transit services. Rail and bus services are vitally important, but taxicab services are more widespread. There are more than 170,000 taxicabs that carry more than 2.4 billion passengers a year. Taxicabs serve 27 percent of all passengers included in bus, rail, taxi, and commuter services. How is it then that we still have such a low profile? Except for the U. S. Department of Transportation and its Urban Mass Transportation Administration, why do most government agencies think of cabs as being unimportant, useless, and wasteful? Instead of being the first public transportation service called when a need arises, we are often the last. Part of the problem lies with the industry, but most of it lies with government agencies.

PEOPLE SERVED

When urban passenger trips by bus, rail, and taxi are combined, one can estimate the size of the urban public passenger transportation market. Nationally, taxicabs carry more than 27 percent of that market, but a recent study in Dade County, Florida, revealed that taxis carried 11 to 13 percent of public passenger trips. In Salt Lake City, 15 to 20 percent of such trips are made in taxis, depending on the weather and time of year.

Most recent studies I have seen show a positive correlation between all urban public passenger trips and taxi trips. If there are, say, 10 million trips, then taxis would serve 1 to 2 million of them. The point is, the people we serve are the same people that other public transportation modes serve. They are people who, for one reason or another, do not use automobiles. For a long time taxis have been considered to be the mode of the rich and the tourists. We do serve some of that market just as buses and rail rapid transit do. But, an examination of a typical taxi trip sheet will show that most of our customers rely on taxis as a public transportation service that they need. They have no other way to get around. The reason we are out there is to provide a public not a private transportation service.

APPARENT BEST USES

In providing urban transportation service a fair question then is, What is the best use of rail, buses, and taxis? Rail, although the least flexible, is probably the most efficient for carrying large numbers of people going from one point to another. Bus is more flexible and more efficient for carrying many people going from one area to another. Taxi is by far the most flexible and most efficient for demand-responsive service. Any good urban system requires at least 2 of the 3 suppliers, one of which must be taxi. It is difficult to imagine having only rail rapid transit and nothing else at its ends to accumulate and disperse the passengers. It is difficult to imagine having a transportation network that offers only bus service. It is not too difficult, however, to imagine having only taxi service. Those 3,400 communities attest to that right now!

In the past, emphasis has been placed on fixed-rail systems. But cities now do not want fixed-rail systems, and for good reasons. Tearing up a city core for 10 years while track is laid underground to obtain a system with a useful life of, say, 40 to 50 years is nonsense. Everyone suffers for a long time with little reason, and then the funding responsibility is passed on to the next generation.

Creating just a bus system may not be the answer in certain cities either. There are practical size limitations to buses, even though newer buses can carry nearly 100 people. But, if distances are great, then overall rate of charge must be a high-priority consideration and the system that has the best ratio of passengers to operators will be favored. This approach gives the best rate at the cost of service, but in some instances rate of charge must be the sole guide. Chartered airplanes became the prime supplier of service across the Atlantic because some air carriers, such as Pan American, did not pay enough attention to rate versus service.

Los Angeles has a tremendous freeway system, which allows citizens to live scattered out like leaves on the wind. Until quite recently, it had virtually no downtown. If I lived there, I would not vote to build a fixed-guideway system. However, the BART system in the San Francisco-Oakland area makes sense. (I do know, though, that we could not affort to build another BART at today's costs.) Where population is concentrated and the transportation patterns are easily predictable, fixed guideways work. For most areas, though, buses moving people along the lines and taxis accumulating and dispersing passengers on the ends makes more sense. Shared use of the taxi, call it dial-a-ride, dial-a-bus, or cab pooling, in concert with buses is the best short-range solution to urban transportation problems. It may also be the best long-range solution, provided that combination continues to offer flexibility at favorable overall cost.

SUBSIDIZING TRANSPORTATION

The country has agreed that it will support the cost of getting a public passenger transportation system in operation through a subsidy to the company that does it. The recent transportation assistance act, which makes available $11.8 billion to finance capital and operating deficits, suggests how strong the support is. Many argue we are not doing enough and that $9 to $19 billion more are needed. The case is clear. Because current transit services cannot pay their way and because they are essential, the public pay the deficit.

The subsidy question has placed emphasis on coordinating transportation systems. When huge sums are conscripted, bickering will inevitably occur among those who are going to participate. The recent merging of the bus and rail lobbying groups into one unit, the American Public Transit Association, is typical of the recognition that the whole realm of public passenger transportation service should be coordinated under one roof. The job of coordination of research, demonstration grants, subsidies, and capital grants has fallen into the capable arms of the Urban Mass Transportation Administration. That agency, which has worked diligently with our taxicab association, has caused a lot of good things to happen. The federal government has become more evenhanded in its treatment of participants involved in solving the transit problem. Local governments making requests for money are required to be more responsible. It has encouraged an atmosphere of innovative thinking in hard-goods suppliers, and better tools are being built daily. It has pushed other branches of government into breaking down barriers to providing necessary services. Most important, it has raised awareness of the scope of the problem and has caused positive attitudes to be engendered on the question of financial help to distressed but vital people carriers. The whole picture of urban public passenger transportation has changed and become more challenging. This helps to draw more attention to the field and speeds up the pace of system development. The growth of knowledge about urban people transportation problems has been geometric. Linear induction motors, articulated buses, diversified-use vehicles, automatic vehicle locator systems, and personal rapid transit with 20- to 30-second headways are all fairly recent accomplishments.

In sum, the country has recognized as a public duty the creating of flexible public passenger transportation systems and has taken on the coincidental responsibility of making performance live up to expectations. Capital grants and fare subsidies have made it possible.

FUEL CRISIS

The shortage of fuel is not a U.S. problem that can be eliminated by politicians verbally attacking oil distribution companies. This is a worldwide problem. World economic systems are crippled to the point of crumbling when the gas valve is shut off. A worldwide monetary crisis has been heightened by the fuel problem, and the money redistribution problem has already caused bank failures on the order that we have not seen for 40 years. Small developing countries have absolutely no way to pay for their fuel needs. And, the oil exporting countries have no way to use up all the money they are getting for their products. I could go on, but the point is this: The taxi industry knows as much about the fuel problem as anyone around. Its conservation programs played an important role in fuel conservation in the past and will play an even bigger role in the future. A major reason taxis were designated as essential users of gasoline was that taxis use it frugally.

The continuing fuel problem will cause a reconsideration of the value of the private passenger car. There simply must be some clear-headed thinking about the true overall cost of private passenger cars. When there is, it will be clear that we must use less private passenger cars and more public passenger systems.

SERVICE

In one area of providing public transportation, particularly, taxis have an unusual responsibility. If any segment of the urban ground transportation network can solve the transportation problems of the old, the young, and the physically and mentally handicapped, it is the taxi segment. In fact, this area of need can only be met by taxi service. Many taxi companies are already providing this service. Many cities already have programs that are imaginative and meet the need. But high fares as compared to an ability to pay for this service are becoming more of a problem. Some who are in the group I described cannot afford taxis and must somehow have their rides subsidized. The method could be transportation stamps as are being tried in West Virginia. The solution is not in creating another urban transportation system but in using the ones we have right now. But we should subsidize the rider and not the company providing the service.

TAXES

Taxi companies pay fuel taxes and transit authorities do not. We are expected to provide services, like bus and rail, but operate under different guidelines. The taxi industry is trying to make its contribution to the urban transportation mix, but it is thus handicapped. We are doing a good job in many respects, but we are not filling our role as completely or as fast as we should.

MONEY

Why don't we? Money! Although we have many examples of profitable taxi enterprises that are meeting the public need, the majority of the industry is in money trouble because of antiquated laws, rates of charge, lag costs, and inflation. Interest rates are so far out of sight for our industry that it scares me to talk about it. The possibility of credit allocation does not encourage me either. If a taxi company is not in the best financial condition, it will not be able to borrow money for equipment purchases. And all of this occurs while we subsidize public transit. The taxi industry, taken as a whole, is on the ropes, and if the industry fails who will provide service to those 3,400 communities that depend on taxi service?

We cannot solve the problem by rate alone. As we increase rates, we lose trips. A study of the Miami area showed that, as rates for taxis were raised relative to rates for buses, trips were lost on a 1 to 3 ratio. My studies of the taxi industry indicate a range of ratios of trips lost to rate of increase from 4 to 1 to a low of ½ to 1. At that rate of trip loss, within a few years, some of us will run only 10 trips a day and the average rate will be $500 per trip.

We need subsidies now. Let me state emphatically that not all portions of all taxi services require subsidy but state equally emphatically that some portions of some taxi services do! Here are some of our needs.

Equipment Replacement

Depreciation reserves are not meeting replacement costs. Tax credits are useful, and some sort of inflationary bias in depreciation accounts in the future would be helpful. In the short run, capital does not exist to replace equipment much less to expand services!

Research and Design of Vehicles

It is clear that the traditional size and shape of cars are not right for the requirements being placed on taxis. Taxis are put to many uses, and innovation must occur in the vehicle design. The demand for a different kind of vehicle is moving faster than the supply in this case, and we need to spend money to develop a new vehicle for the future.

Increased Productivity Through Better Equipment Utilization

If we could increase our utility marginally, we could increase our productivity tremendously! Better efficiency means better rates ultimately. A significant contribution could be made if we knew vehicle use, status, and location better and faster. Two-way radio is the primary tool of the industry in determining status and location, but 2-way radio is not enough! Radio and computer technology exists by which location can be pinpointed and status revealed by the push of a button. The problem is we cannot afford it! If we could dovetail the status-location part of our business with the dispatching part, within a year we could come up with automatic identification-dispatch systems that would increase productivity 20 to 30 percent. A side effect of such a sophisticated system would be improved fuel to trip ratios.

Better Taxi Regulating Ordinances

Most of the cities in this country control taxi services under old and tired ordinances. Some of the major cities even disallow shared riding! Cumbersome rate and service standards stop any experimentation on the part of the taxi industry. The industry and government need to examine the whole area of taxi regulation and spend some time doing it.

Subsidized Rides

We need money to carry passengers who need taxi service but cannot afford it on a continuing basis. There is no other realistic way to solve the problem of transportation for some people other than to subsidize taxi rides. Positive attitudes could be expected from most taxi operators toward reduced charges for this type of service, for its overall impact would be reflected in greater productivity of the taxi. There are contracts right now under which high utility is achieved and resultant rate reductions of 10 to 20 percent are passed on to the user. There is nothing secret or unusual about this apparent rate differential. Many of us in the taxi industry would like to see rates much lower than they are, but not all rates can be decreased.

Change of Legal Status

If we were to receive money help on a continuing basis from local or federal sources, we would need to change our legal status somewhat. Many of us have had unfortunate experiences so many times with government bureaus that we would just as soon not be any closer to any government unit than we absolutely have to be. I think, however, that any attitude that reveals a reluctance to hold hands with government must change if we are to survive as an industry.

At the same time, a consistent approach to the taxi industry by the National Labor Relations Board, the Department of Treasury, and the Department of Labor would do wonders for our mutual confidence levels. Past inequities must be eliminated to allow us to operate more publicly in the future. We can do more in the urban passenger transportation area if we are treated as proper citizens of communities. We are not a bunch of gorillas who must be caged, even though we recognize that in a few problem cities we have some companies that operate by the rule of the jungle.

If our legal status is changed, we must not be deprived of the values we have built. And, we must be able to build private values while providing public service. There is no conflict of interest when TWA is paid a fair rate per ton-mile for mail cartage on the same plane that carries passengers who, by paying a different fare, create equities in the company. It is not inconsistent that a trucking company carries steel for private agencies and mail for the government. The same principles should apply to taxis, except here we are talking about carrying people. To provide partial public service should not require that the provider be publicly owned. Adequate administrative agreements could ensure that public money be properly handled. Profit making and providing public service can work hand in hand. Better urban public passenger transportation through use of taxis can occur if that concept is recognized.

A PROPOSAL

I propose, then, that our industry and UMTA have frank and open discussions to find a way (a) to allow us to be eligible for capital grants for equipment such as I have described and (b) to assist through subsidization particular groups of riders who use our service. The discussions should center on a few areas initially.

The first is finance. Our industry cannot finance the service that will be required of it in the future. There are consequences both to the public and to the agency when a private agency is given partial public support. The question of the possibility of the public subsidy accruing to the economic benefit of taxi company owners must be answered before any money is allocated.

The second area is service standards. Obvious questions such as priority of service could be discussed, and future system design should be improved correspondingly. Unrealistically high service standards benefit no one. Standards should recognize that different cities require different services. Certain commonalities exist among cities, and the most usual one is the inadequacy of urban public transportation. Perhaps the

Amtrak approach could be applied at a company level, wherein some taxi services would be public while others would not be.

The third area is the entry-exit problem. Free entry into the taxi industry is still not in the best interest of the public. Discussions should consider the matter of allowing free entry if compensation is paid to old carriers for past service or of controlling exit of the market by requiring forfeiture of large bonded sums.

Fourth, consideration should be given to equitable and consistent rate-making policies, which do not currently exist in many communities.

I believe that open discussions of these topics will lead to actions that will provide some kind of subsidy to taxi companies.

This proposal was made at our recent convention, and the directors of our association approved its intent on October 30, 1974. Now the question is, Should the federal government favor public subsidy to the taxi industry and work toward that end? I think it should!

PLANNING FOR NEW AND INTEGRATED DEMAND-RESPONSIVE SYSTEMS

Katherine O'Leary, Office of Research and Development Policy, U.S. Department of Transportation

The function of the Office of Research and Development Policy in the U.S. Department of Transportation is to provide guidance for the research and development programs conducted throughout the Department of Transportation (DOT). In support of this function, a year and a half ago we began to look at the concept of demand-responsive transportation (DRT).

At that time, the Urban Mass Transportation Administration (UMTA) was sponsoring 2 categories of activity in the area of DRT. One involved providing capital grants to organizations serving special groups such as the handicapped and elderly. The DRT concept suited this market well, for it could offer door-to-door transport in vehicles equipped, in many cases, to accommodate wheelchairs and to lower entry stairs for easier access by the elderly.

The second activity sponsored by UMTA was the experiment in Haddonfield, New Jersey. The purpose of the experiment was to develop, test, and demonstrate techniques for computer operation of a fleet of vehicles operating in a demand-responsive mode. With little knowledge of those activities and a long list of questions, I attended the Fourth Conference on Demand-Responsive Transportation in Rochester, New York, in September 1973. At that time, we predicted increased activity in implementation of DRT services throughout the country, and this has indeed been the case. My presentation deals with the history of DRT services in North America from the earliest to those newly in place since the Rochester conference.

To use the history of systems as a mechanism for understanding the DRT concept can be confusing before it is enlightening. No 2 systems are exactly alike. Many systems have a feature that no other system has and, to complicate things even more, 2 systems that serve similar markets can have completely different technical designs.

With this in mind, I have selected only a limited number of statistics to help me tell the story and will present these first. I will then briefly address the 3 main system characteristics that I think provide a context for viewing and understanding present as well as future systems.

Many people generally acknowledge the Atlantic City, New Jersey, jitney of 1916 to be the earliest forerunner to the demand-responsive transportation concept. It operates on a fixed route and picks up and discharges passengers on demand. It is still operating. (However, it could be said that the jitney is more like a fixed-route bus and that the taxi, with its door-to-door, on-demand, flexible-route operation, is the closest forerunner to DRT concepts in terms of overall operating strategies.)

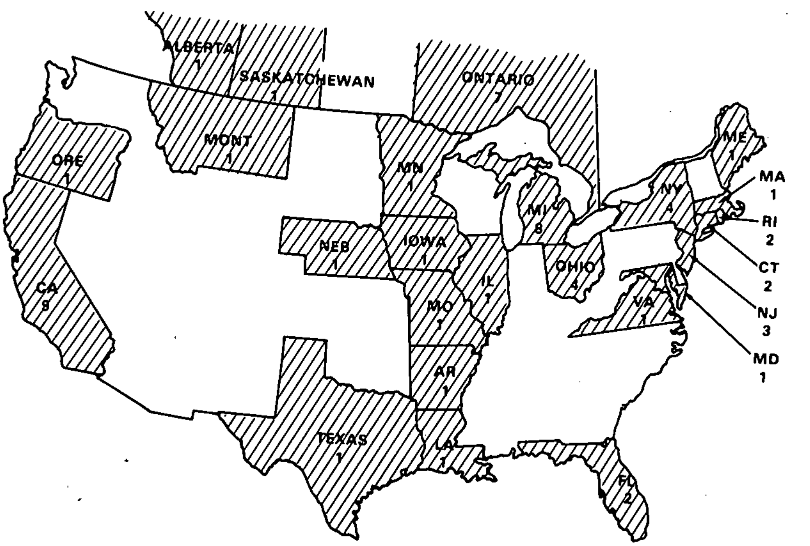
In Table 1, the Atlantic City jitney is the starting point of a listing of DRT service implementation. The most striking conclusion to be drawn from this chronology of DRT services is the accelerating activity in 1972, 1973, and 1974. Of the systems currently operating and those projected to operate by the end of 1974, 75 percent have been implemented during the past 3 years. This is significant for several reasons. For one, it is becoming difficult to keep track of the systems and thus to have a feel

Table 1. Chronology of demand-responsive transportation services in North America.

Year	City
1916	Atlantic City, New Jersey
1934	Davenport, Iowa
1946	Little Rock, Arkansas[a]
1958	Ft. Leonard Wood, Missouri
1961	Hicksville, New York[a]
1964	Peoria, Illinois[b]
1968	Reston, Virginia
	Flint, Michigan[b]
1969	Menlo Park, California
	Mansfield, Ohio
1970	Bay Ridges, Ontario
	Merced, California
	Ft. Walton Beach, Florida[b]
	Buffalo, New York[a]
1971	Columbia, Maryland
	Kent, Ohio
	Scott-Carver Counties, Minnesota
	Ann Arbor, Michigan[a]
	Regina, Saskatchewan
	Batavia, New York
	Columbus, Ohio[a]
	Cranston, Rhode Island
1972	Willingboro, New Jersey
	Detroit, Michigan[a]
	Haddonfield, New Jersey[a]
	Franklin County, Maine
	Toledo, Ohio[a]
	Lincoln, Nebraska
	Medford, Oregon
	Klamath Falls, Oregon[b]
	Rhode Island State
	Dallas, Texas
	Stratford, Ontario
	West Palm Beach, Florida
	Kingston, Ontario[a]
	Sudbury, Ontario
1973	Kent, Ohio
	La Habra, California
	Lower Naugatuck Valley, Connecticut
	Davis, California
	La Mirada, California
	Helena, Montana[a]
	Grand Rapids, Michigan[a]
	Bramalea, Ontario
	Ottawa, Ontario
	Rochester, New York
	Los Angeles, California
	New Orleans, Louisiana
	St. Petersburg, Florida
	Toronto, Ontario
	Bensenville, Illinois
	Cleveland, Ohio
	Calgary, Alberta
	El Cajon, California
	Hartford, Connecticut
1974	Hemet, California
	Holland, Michigan
	Luddington, Michigan
	Mt. Pleasant, Michigan
	Sault Ste. Marie, Michigan
	La Mesa, California
	Cambridge, Ontario
	Merced, California
	Traverse City, Michigan
	Dover, Delaware
	Fairfax City, Virginia
	Midland, Michigan
	Isabella County, Michigan
	Alpena, Michigan
	Houghton-Hancock, Michigan
	Richmond, California
	Washington, D.C.
	Benton Harbor-St. Joseph, Michigan
	Cleveland, Ohio
	Santa Clara County, California
1975	Rockville, Maryland

[a]Subsequently expanded. [b]Terminated.

Figure 1. Geographical distribution of 57 operating systems in North America as of May 1974.



for the number of communities and markets being served by the service. Second, system operating data are incomplete when all services are not represented, and this weakens considerably the available information that planners and operators of future services need to assist them in their decision making. Third, although the technical expertise required to ensure the successful implementation of DRT services can be found in a number of highly qualified professional firms, this number is still small compared to a growth rate of 2 to 3 DRT implementations per month. I should like to return to this point later in this paper, for DOT, as a result of these observations, sponsored an activity in early 1974 on how to plan and implement a demand-responsive service.

As of May 1974, we were able to identify some 57 demand-responsive services operating in the United States and Canada (Fig. 1). Of particular note are the numbers of systems in Michigan, California, and Ontario. The availability of state and provincial funds is undoubtedly an important factor in the somewhat intense activity of DRT services in those areas.

The DRT services in the United States represent a small number compared to the American Transit Association (now the American Public Transit Association) figure of 1,006 motor bus transit systems in 1973 (Fig. 2). Some arithmetic will yield a comparison of passengers carried daily by these service categories—somewhat incomplete data on DRT services (only 53 of 57 services reporting) do not distort the picture much in that DRT has a very small market share. A caveat here is that although the DRT market is small it is growing, while the motor bus industry has been static until recently.

Figure 3 shows a summary of the 57 operating services by the size of their fleets. For example, 8 services have fleets of 1 vehicle, 4 services have fleets of 2 vehicles, 5 services have fleets of 3 vehicles, and so on to the largest service with 80 vehicles in its fleet. The line on the chart corresponds to the scale on the right and represents what percentage of the total number of 57 services are described by the bars to that point. For example, 8 services having fleets of 1 vehicle represent about 15 percent of the total services. Adding the 4 services of 2-vehicle fleets makes 12 services represented out of 57 or 21 percent accounted for, and so on. Of the 57 services operating in North America as of May 1974, 70 percent have fleets of 7 or fewer vehicles. The 3 largest fleets operate shared-ride service and taxicabs. Most of the smallest services operating a single vehicle provide service for the elderly.

Fleets are like much else about DRT services—few things are typical. Diversity in type of vehicles used to provide DRT services exists not only from one service to another but within services themselves. For example, Regina, Saskatchewan, uses six 14-passenger, four 22-passenger, and seven 42-passenger vehicles to provide service in the DRT area. Detroit uses school buses to augment its regular fleet for charter operations.

The 57 operators provide service at adult cash fares ranging from 10 cents to $1.75 (Fig. 4). Seven services are provided at no direct charge to the passenger. These are predominantly for senior citizens and are funded variously by a combination of federal, state, and local governments and private agencies. Roughly 84 percent of all systems charge fares of 50 cents and less, 13 charge fares of 50 cents, and 8 charge fares of more than 50 cents. Of the 57 services, 2 are jitney services, 7 are taxi-based operations, and 48 are bus-based operations.

Figure 5 shows the variety in size of area served by 44 DRT fleets. Fifty percent of the service areas are less than 10 miles^2 (26 km^2). Of the operators serving the largest areas, 5 have 7 or fewer vehicles (these are special group services for senior citizens or handicapped persons), 1 has 28 vehicles for statewide senior citizen services, and 1 is a taxi operator who has 75 vehicles. Nine areas are the result of expansion from initial, smaller areas, such as Ann Arbor, which expanded to 22 miles^2 (57 km^2) from an initial area of 1½ miles^2 (3.9 km^2).

The following profile of the services emerges from these data.

1. A relatively small market has been demonstrated to date, but it is a rapidly growing one in that systems are proliferating at a rate of 2 to 3 per month and indications

Figure 2. Demand-responsive transportation services and total motor bus services.

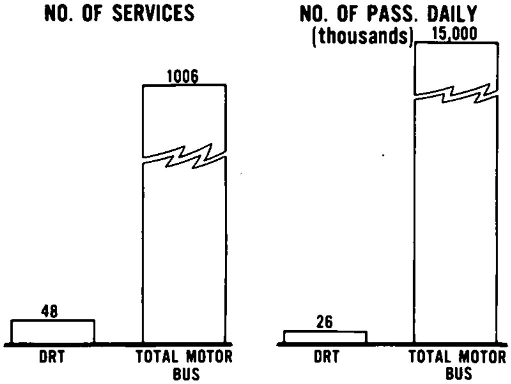


Figure 3. Fleet sizes of 57 operating systems as of May 1974.

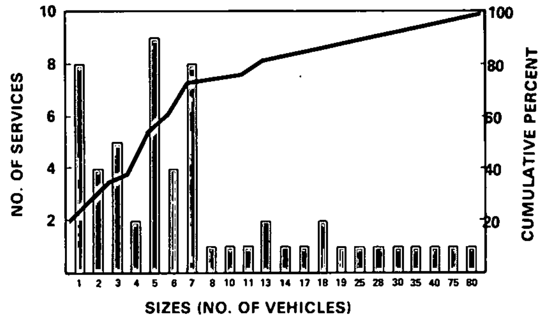


Figure 4. Fares of 57 operating systems as of May 1974.

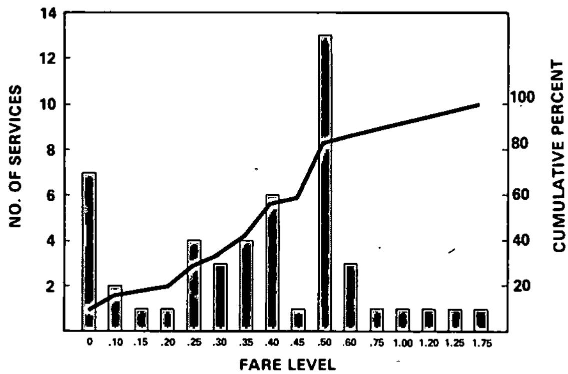


Figure 5. Service areas of 44 of 57 operating systems as of May 1974.

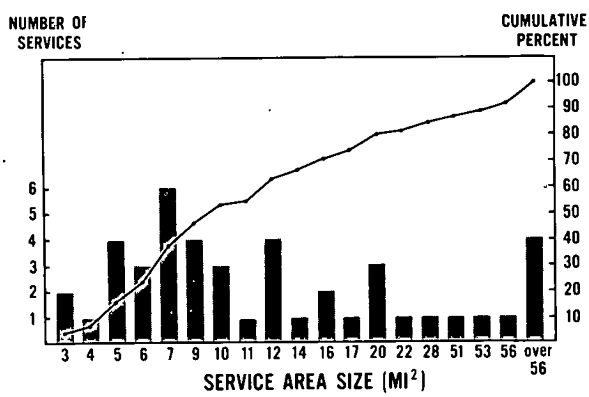
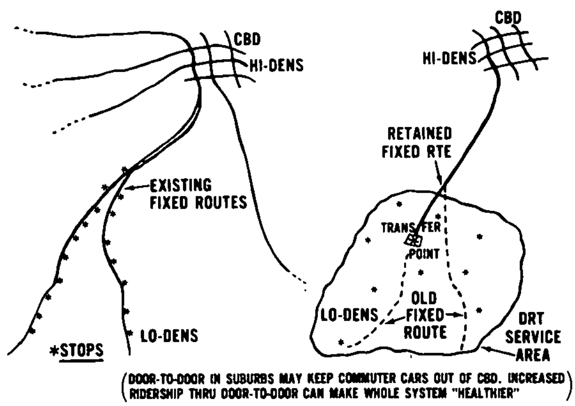


Figure 6. Feeder service to fixed-route transit.



are that this proliferation will continue;

2. Except for taxi operations, fleets usually have fewer than 10 vehicles;
3. Fares are typically 50 cents or lower; and
4. Size of area served is usually smaller than 13 miles^2 (34 km^2).

The demand-responsive services implemented to date differ from each other in basically 3 ways: technical design of the system in response to the market needs, markets served by the service, and funding sources for the service. Other papers in this Special Report discuss the design aspects of the currently operating demand-responsive services. My focus is on the markets served and the funding sources.

MARKETS SERVED

A major market served by a number of existing DRT services is the commuter market (Fig. 6). Where fixed-route transit existed in a region, DRT services have been substituted for unprofitable fixed routes in low-density areas and serve as feeders to the remaining fixed-route portion. Regina, Saskatchewan, actually was able to increase its ridership on the fixed bus routes to the center city through this process, referred to as route rationalization. When DRT serves as a feeder to rail rapid systems, the transfer point becomes one of the rail stations, as in the case of Bay Ridges, Ontario. One of the markets for which the Richmond, California, system is designed is the commuter market using the BART system. It acts as a feeder to the BART Richmond Station.

Commuting patterns, however, have been changing in character during the past decade. Although the CBD continues to be a dominant destination for a large number of work trips, industrial parks are developing as parts of new activity centers located in the lower density suburbs. In these areas, fixed routes can be uneconomic because of the low densities and thus low load factors. These commuter markets can also be served by DRT. The activity center (an industrial park or a large factory or a government center) operationally serves the same drop-off and pickup function as the transfer point of the previous applications. Increased vehicle productivity and thus improved economics can result by developing the commuter market as a subscription service because of the time and location certainties this gives the operator. In large metropolitan areas, the commuter market is best served by DRT in low-density suburbs. In middle-sized and small cities, commuter markets may be served by DRT in partial or entire areas of the cities themselves. This is in large part determined by trip origin and destination patterns, other site-specific variables, and density of demand.

A second market served by DRT services is that made up of groups having special mobility needs. Typically, these are handicapped persons and the elderly and, in some cases, the economically disadvantaged. Of the 57 services, some 24 provide service exclusively to these groups. These markets are also those for whom the UMTA demonstration grants for handicapped and elderly services are targeted.

A third market, distinguishable from the commuter and the special needs groups, is hard to describe in a single word. It is that group of people within a given area who need to get around in the area. The service that meets these market needs is areawide and provides the population in a given area with door-to-door transportation wherever their origins and destinations. Typically, patrons of this local transportation service are shoppers, bank patrons, school children, dental and medical outpatients, airport users, restaurant patrons—all of whom depend on the activities within the DRT service area itself. Such areawide DRT service is provided in Batavia by the B-Line Dial-a-Bus, which operates citywide service from 6 a.m. to 6 p.m. Monday through Friday. In addition to carrying people, other areawide service markets can be captured and can provide additional revenue. Batavia's system carries not only people but packages. DRT service in Batavia also transfers bank printouts (not money) from one bank to another.

The principal advantage in operating a fleet of vehicles in a flexible manner is that it can serve all, some, or one of the above markets depending on the needs of the area. The most important consideration in implementing successful DRT services is tailoring the service offered to the market to be served. The success of a system is defined in different ways by different people. An operator in business to make money would judge a system that does not as unsuccessful. If, however, the operator's objective is to provide mobility to a market segment, making money would not be a basis for judging the system's success.

FUNDING

A recent survey of operating systems revealed that of 22 reporting services all but 3 required subsidy to cover costs. Whether subsidy is required depends on the level of service offered and the markets served. The requirement for fare-box viability restricts the market served and the level of service to be offered to that market. If DRT service is striving for broad markets (for example, to get a substantial share of the commuter market away from private automobiles) and for high levels of service (for example, round-the-clock operators on an areawide basis), some form of subsidy most likely will be required. The key factor here is the breadth and type of market the service is designed to serve.

Of 49 operating services for which data on funding are available, more than half were funded from a single source (Table 2). These are mostly the U.S. privately funded systems such as taxi-based operations, jitneys, and commuter bus systems. (The U.S. Department of Housing and Urban Development has funded systems 100 percent.) Some examples drawn from the operating systems illustrate the range of options available for funding DRT services.

1. Recent expansion of the Ann Arbor transit operations including the expansion of DRT service was funded entirely from an increase in local taxes voted by the citizens.
2. The service in Batavia, New York, is funded 100 percent locally from fares, receipts from package delivery, sale of marketing space. There the system is breaking even without any form of subsidy.
3. Canada's systems are eligible for federal subsidies to cover planning studies and portions of operating and capital costs. The Regina, Saskatchewan, system has drawn on funds from federal, provincial, and local sources.
4. The St. Petersburg DRT service for elderly and handicapped persons uses local sources for one-third of its funds and an UTMA grant for the remaining two-thirds.

The sources are varied and depend on local circumstances to a large extent. Where private sources do not cover all costs, funding is usually from multiple sources.

Table 2. Funding of 49 operating systems.

Fund Sources	Systems Funded by a Single Source	Systems Funded From a Combination of Sources
Public funds in United States		
Federal	4	19
State	4	
Local	6	
Private funds in United States	10	
Public funds in Canada		
Federal	–	3
Provincial	1	
Local	2	
Total	27	22

INFORMATION ON DRT

At DOT we felt that the existing technical expertise would get stretched thin if it tried to keep up with the rapid pace of DRT implementation activity. We wanted to ensure that failures resulting from bad or, even worse, no information would be kept to a minimum. To avert a large number of failures and to avoid condemning a promising concept to an early demise as a result of bad publicity, we set about to test whether we could devise a method to get some basic information out to the large number of planners and operators making decisions daily on whether to try DRT services in their areas.

The method we devised was to synthesize the substantial array of available literature on DRT services into a state-of-the-art document and to validate the document prior to its dissemination at a workshop where experts (operators of DRT services) and local transit operators and planners would comment (page by page) on the accuracy and relevancy of the material to their needs. The workshop was jointly sponsored by DOT's UMTA and Technology Sharing Program, which is a part of the Office of Research and Development Policy. The report and its revisions were prepared by the Technology Sharing Office at the Transportation Systems Center in Cambridge, Massachusetts. The response both to the workshop validation method and to the document was positive. I mention the document for 2 reasons: (a) The document provided a source for many of the statistics that I used to profile the operating DRT services, and (b), and more important, many will undoubtedly find the document a useful tool in developing a feel for the DRT concept and its status as an operating service. We are currently preparing a supplement to this overview document dealing with vehicles and their operation in DRT services. Copies are free and available on request.

SUMMARY

Many DRT systems are operating, and many systems are being implemented every year. Those who plan and implement systems should understand the markets DRT can serve, tailor system design to those markets, and understand the funding consequences of the level-of-service and market decisions. At the Department of Transportation, we must ensure that the best and latest information is available for people to use in making decisions and that they know where to get that information.

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Every successful DRT program starts with an effective planning effort. DRT systems that have had serious difficulties started with planning deficiencies such as inaccurate demand forecasting or absence of a long-range economic plan. This paper discusses some of the key elements of DRT planning and identifies some common pitfalls.

APPROACH TO PLANNING

For planning to have the necessary depth and quality, management must make a commitment to it. This means that the people who do the planning must realize that planning is vitally important and that the plans they produce will receive proper attention, including a detailed review and personal critique by management. A degree of formality, at least to the point of full documentation of the plans, is essential for both communication to management and later assignment of implementation responsibilities. For a new DRT system, the planning is from the ground up and covers initial concept through routine operations. There are 3 fundamental items for achieving this.

1. Work statements are descriptions of every task that must be performed to accomplish the program objectives. The scope of each task is defined so that each is a complete "package" of work to be performed by a person or group within a specific time period and budget. Thus, the completion of a task is indicative that a certain "value" has been earned. In many instances, the completion of a task is marked by production of a deliverable item. Some tasks are the carrying out of further planning functions such as supply and demand estimates or organization plans; those planning tasks are discussed later in this paper.
2. Schedules and the tasks of the work statement laid out chronologically into a logical sequence of events. The schedule may be presented in the form of a bar chart or as a task interrelationship network (similar to a PERT chart). The network permits a careful evaluation of the logical progression of events, i.e., that each item needed for subsequent tasks is generated in earlier tasks.
3. Budgets contain the costs (or applications of funds) to accomplish the tasks and a schedule for the expenditures. The costs are estimated from existing DRT data, site data, vendor information, and experience. The status of each task is indicated by the relation of funds or person-hours expended to date versus those budgeted.

The work statements, schedules, and budgets are the basic planning items of any program. Figure 7 shows how the plans can be exhibited throughout the duration of the program. Periodic management meetings, reviews, tracking, and control of the program can be aided in this way.

In addition to the 3 basic planning items, other key elements must be incorporated for effective implementation and control.

1. The plans should be arranged to fall into natural phases. Each phase is, in effect, a complete program with a distinct start and end. Management can review progress and status near the end of each phase and decide whether it is satisfactory and, if not, what to do about it. The phases are arranged so that the financial exposure of earlier phases is far less than the exposure of subsequent phases. Thus, if major changes or cancellation is desired, the losses incurred are minimized.
2. Resources that must be considered include personnel, sources of funding, facilities and equipment, management, and intangibles such as political support. Various options and alternatives are possible and should be considered. For example, sources of funding can be federal, state, or local sources, fare-box revenues, or advertising income.
3. Contingency plans should be prepared for each element of the plan. For example, it is theoretically feasible to implement a DRT system in about 4 to 5 months after contractual authorization is received. Experience has shown, however, that a slippage of from 4 to 8 weeks usually occurs for several reasons including unavoidable late delivery of equipment such as vehicles and radios or delays in funding. Some of the principal pitfalls are discussed in more detail later in this paper.
4. The program should be controlled on the basis of work accomplished (i.e., earned values), costs incurred, and schedule. All 3 are vital, but they must be viewed together to obtain an accurate picture of the status of the program and to identify any potential problems that may be developing. The cost versus schedule and milestone chart shown in Figure 7 is a convenient visual tool to accomplish this. Accountability by specific persons, groups, or organizations for each task must be clearly defined in writing for effective control.

DEMAND ESTIMATES

Estimates of what the ridership will be are often the least precise elements of DRT planning because of the large number of factors that affect demand and the general lack of sufficiently accurate forecasting tools. For example, some key variables that affect ridership are fare, reliability, service level, and marketing. Important parameters describing the site are population density, service area, age, income, automobile

Figure 7. Management control system.

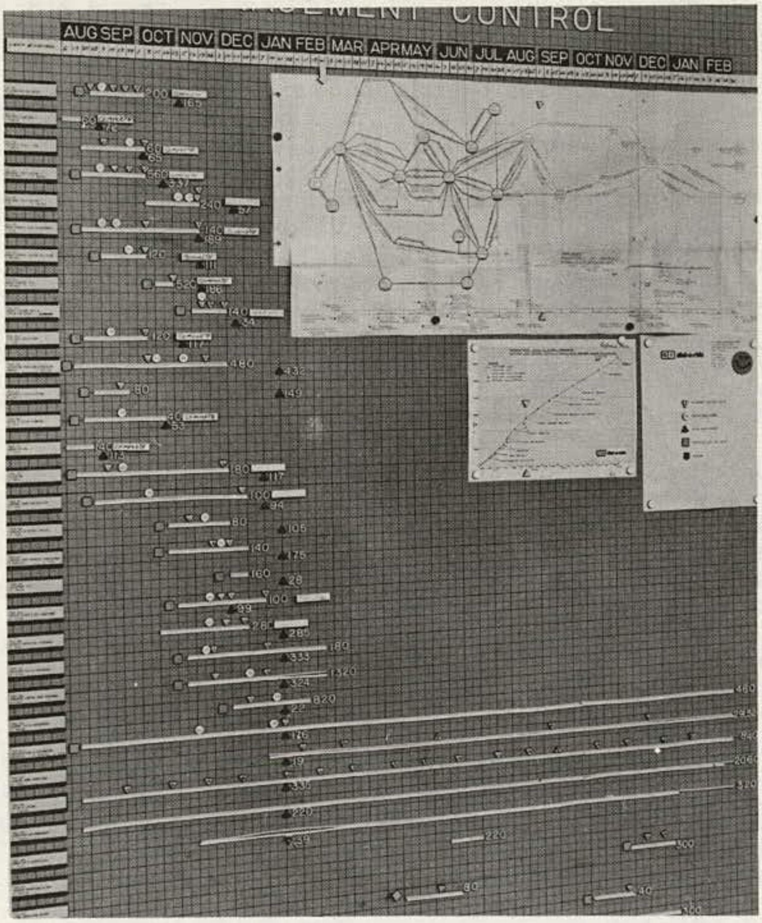

Figure 8. Demand forecast by sector model.

```
FARE = $0.50       SERVICE LEVEL = 4.5


DIAL-A-RIDE DAILY PATRONAGE:
  WORK INTERNAL   =    182.
  WORK EXTERNAL   =    319.
  OTHER INTERNAL  =   1057.
  OTHER EXTERNAL  =    201.
     TOTAL WORK   =    502.
     TOTAL OTHER  =   1258.
     TOTAL INT.   =   1239.
     TOTAL EXT.   =    520.
        TOTAL     =   1759.
```

ownership, and external transit interfaces. Many other variables could be considered, but there is a practical limit to the complexity. Models have not yet been developed that consider all of these factors. Several worthwhile attempts, however, have been made to incorporate enough of the important factors to yield useful results (4).

A sector model has also been developed recently that accepts as input basic statistics usually available at any potential site such as service area, employment, students, and census data. If data on some details are not available, default values for the missing data are used. Modal-split factors as functions of fare and service are incorporated into the model. Outputs are in the form of internal and external work and non-work DRT trips. One version of the sector model has been programmed to permit alternative operating conditions to be quickly explored; an example of the output is shown in Figure 8.

A word of caution is appropriate at this point. Simple extrapolation of ridership results from one DRT to another without a full consideration of subtle but important facets can lead to inappropriate system design and unsatisfactory operations. This has actually happened in regions where one or more DRT systems have been successful but other nearby implementations in the same city by the same people have run into ridership difficulties because of different ethnic and transit interface conditions.

SUPPLY ESTIMATES

DRT supply models are easier to develop and calibrate than demand models, and the results are more accurate. Some basic tools were developed at Massachusetts Institute of Technology (5) and have been calibrated from operating data at a number of sites. Input to supply models usually consists of the output ridership estimates from the demand model and service parameters such as hours of operation, types of DRT service, and level of service. An example of the prediction from a supply model in the form of a computer printout is shown in Figure 9.

Figure 9. Supply estimates.

DIAL-A-RIDE HOURLY PATRONAGE
BY TRIP TYPE AND PERIOD OF DAY
(ONE-WAY TRIPS/DAY)

	PERIOD OF DAY				
TRIP TYPE	7 AM- 9 AM	9 AM- 10 AM	10 AM- 4 PM	4 PM- 6 PM	6 PM- 7 PM
INTERNAL	36.	56.	151.	74.	56.
EXTERNAL	64.	39.	29.	71.	39.
TOTAL	100.	95.	180.	145.	95.

DIAL-A-RIDE VEHICLES IN SERVICE
BY PERIOD OF DAY

	PERIOD OF DAY				
	7 AM- 9 AM	9 AM- 10 AM	10 AM- 4 PM	4 PM- 6 PM	6 PM- 7 PM
VEHICLES	8	10	13	9	10

ANNUAL DIAL-A-RIDE PATRONAGE = 512349.
PEAK HOURLY PATRONAGE = 180.
PEAK VEHICLES IN SERVICE = 13
SPARE VEHICLES = 3
TOTAL FLEET SIZE = 16
ANNUAL VEHICLE-HOURS = 38438.
MEAN VEHICLE PRODUCTIVITY = 13.33

ECONOMIC PLANNING

The economics of DRT operations are determined primarily by the strategic objectives of the service and by personnel costs. The heart of the issue is the degree to which a DRT system is to meet the transit needs of those who cannot pay the actual costs of service but who urgently need some form of door-to-door transit versus the degree to which the operation should meet costs out of fare-box revenues. Those responsible for the program should tackle this issue at the earliest stage of planning, and clear-cut decisions should be well documented. Otherwise, the program will be plagued by lack of direction.

Cost of operating DRT is strongly dependent on the cost of labor, both direct and indirect, since DRT is labor intensive, accounting typically for more than 80 percent of total costs. Labor rates vary widely among locations, and both present rates and potential increases should be carefully evaluated during planning.

Total cost of DRT ranges from under $10 to more than $20 per vehicle-hour. Cost per trip varies from under $1 to more than $4. The lower costs usually occur in areas where the demand is high (e.g., where there is a significant commuter market) and where the labor rates are relatively low. The reverse usually applies for higher costs. No guidelines are available that will define simply what the costs will be for a new service. However, consideration of economic alternatives in the early stages of planning will permit choices to be made that could lead to costs at the low end of the ranges. If the alternatives are not explored, then higher costs could inadvertently become locked into the program.

Fares in most DRT systems are in the 25- to 50-cent range, a level at which recovery of costs from fare-box revenues cannot be achieved. (TSC and MITRE under UMTA contracts have investigated the economics of many of the existing DRT systems and have published the statistics in a number of reports.) A fare of $1 or more per trip is needed to achieve a breakeven point; this is evident from the profitable operation of shared-ride taxi services. However, this fare level is beyond the range established by the social objectives of most publicly financed DRT systems.

Planning the economic alternatives of operation involves the following: establishing the ranges of the variables acceptable from the viewpoint of the social objectives, using a demand model to determine ridership and revenues, using a supply model along with unit cost data to assess cost, and defining sources of subsidy. The process is iterative; i.e., with given variables of fare, level of service, type of service, labor rates, vehicle costs, and so on, the economics of operation are determined, and, if they are not acceptable, the process is repeated with new variables.

Start-up costs include procurement of vehicles, radios, control equipment, and other equipment and services to provide planning, design, and implementation. Capital grants for equipment can be obtained in many instances by a public organization on an 80 percent federal and 20 percent local basis from UMTA. Furthermore, highway funds can be diverted to provide the local share of the capital costs. The application for these funds usually requires a certain level of prior planning as defined in the UMTA guidelines. If a public organization contracts with a private operator, then it is expedient for the public organization to take advantage of the capital grants program and own the vehicles, leasing them at a nominal rate to the private operator.

Grants for operating subsidies are harder to obtain and are often not available unless the program qualifies in some special category. Furthermore, the grants are only to help to get the program started or to conduct research; long-term subsidies are not available. Some of the federal agencies that have made special DRT grants are the Department of Housing and Urban Development, UMTA, Department of Health, Education and Welfare, and Office of Economic Opportunity.

Operating subsidies are more often covered by local general funds, state sales and gasoline taxes, and property taxes. Operating subsidies for transit have been considered in the U.S. Congress, and citizens in many cities and counties voted in November 1974 on whether to raise local taxes for DRT.

TECHNOLOGY LEVEL

The level of technology needed for service requirements should be given careful consideration. Unnecessarily elaborate systems cause higher costs, are more complex to maintain, and may have a higher failure rate. In fact, some of the most successful DRT systems are the simplest.

Computer technology has been applied in a number of DRT and taxi operations (Haddonfield, Los Angeles, and Davenport), and other implementations are planned. A lesson that has been learned is that using a computer for DRT makes for a lot of complexity and that a good, simple manual operation is essential for backup while the computer system is being checked out. Another lesson is that manual control is adequate for DRT systems having about 20 vehicles.

Thus, it is doubtful that a new DRT system should use a computer. Rather, the initial operation should be controlled by a manual system that will be compatible with computer control. The initial manual operation gives personnel a chance to become familiar with DRT and makes them better qualified to direct and control the computer system when it is installed.

OPERATOR SELECTION

Selection of the organization that will operate the service (i.e., provide drivers, controllers, maintenance, supervision) is easy in some cases because there is only one choice. That is, an organization, either public or private, has a prerogative, obligation, or other special qualification to provide the transit service. In other cases where there are several alternatives, the selection of an operator may not be an easy process although it will often prove to be the most significant decision made in planning the program. A prudent approach to selection is, therefore, highly recommended. The only effective way to make a thorough evaluation of the alternatives and a wise selection of operator is by competitive bidding. A request for proposals should be issued to organizations who have expressed interest in or appear to be capable of doing the job. Any transportation company offering a passenger service in or near the intended service area should be included on the bid list; otherwise, the excluded company may protest the start of DRT service. Of particular importance in evaluating the proposals are the proposed operating costs, the qualifications of the personnel, and the operator's history of performance on similar programs.

A wide range of organizations have operated DRT systems, including transit districts, taxi companies, city employees, and management and operations companies. In fact, in Great Britian a new company called Dial-A-Ride, Ltd., was formed specifically to operate DRT systems. Where several DRT systems or modules are needed to cover the total service area, a particularly interesting concept is for the sponsor to contract the operations to several competing organizations (6). Periodically—once every year or two—the operation of each module is reviewed and, if found to be unsatisfactory, the operation can be put up for bid. This keeps all the operators trying to improve and helps to control costs by competition. Major equipment such as buses, radios, garages, and control centers should be owned by the sponsor; otherwise, the capital investments would have to be made by the operators, which would prohibit contracts lasting less than several years and would severely limit competition.

PERSONNEL

When a new DRT system is being implemented, qualified personnel will generally not be available and will have to be recruited and trained.

Drivers can become familiar with DRT procedures, public relations, geographic area, equipment usage, safety, and radio codes and discipline in about 2 weeks. After that, on-the-road experience is needed to learn the streets, house numbers (many houses are often unnumbered), and quick routes through congested traffic.

Drivers usually take 2 to 4 months to thoroughly learn the streets in a small DRT system and longer in large systems.

Controllers must have the ability to cope with the complex problems of DRT control. They must also be able to tolerate the tensions caused by the pressures of the job. Controllers can acquire basic manual skills in DRT procedures, area familiarization, radio codes and discipline, and scheduling and routing techniques in about 2 weeks. If a computer is used, an additional 2 weeks of training is needed. After this initial training, a controller can become fully proficient in about 6 months.

When an organization with existing work rules designed for some other job function implements DRT service, personnel policies, including work rules, should be reevaluated and changed to reflect the needs of DRT. Sometimes this is not possible because DRT personnel represents such a small percentage of the total work force that a separate set of DRT work rules is not feasible. Using existing rules can create both operating problems and added costs. For example, personnel in many organizations bid for the available jobs at certain times—often 4 times a year. The procedure includes listing all the jobs and having each person bid for his or her choice in order of seniority. If DRT jobs are bid with other jobs this way, inevitably new, untrained personnel will periodically replace trained personnel. It takes weeks of training plus months of experience before new personnel achieve full productivity. Therefore, if the turnover is large, as it has been in a number of existing DRT operations, extra staff must be considered in the staffing plans.

CONTINGENCY PLANNING AND PITFALLS

The art of planning lies in development of contingency plans. These are the fallback positions when things go wrong, as they always do to some extent. The following are some DRT pitfalls that should be included in the contingency planning.

Legal

If DRT is implemented in competition with other forms of transportation, legal issues may develop. Since DRT systems are different from other systems such as taxi, jitney, charter bus, or fixed-route bus, legislation enabling their operation is often required. This enabling legislation may be opposed by any transit organization that feels threatened. Allowances must be made for the time delays that may result, and purchase of major equipment should be scheduled to occur only after legal issues have been cleared.

Equipment

Modifications must often be made to standard equipment. Appropriate funds and time should be allocated to accomplish this. Furthermore, uncontrollable delays may be experienced in the manufacture of the equipment, and sufficient schedule slack should be planned for realistic delays. Public announcement of the start-of-service date should be made only after all essential equipment has been received.

Startup Overload

When a new system is started, most of the personnel know what to do, but perform slowly and inefficiently. Thus, at first they can handle only a limited ridership; later, their skills will develop so that they can handle several times the initial demand without difficulty. Advertising and formal inauguration should, if possible, be postponed until a few weeks after startup, and extra personnel should be on hand to help answer inquiries.

Radio License

If there is not a suitable existing license, then a new radio license must be obtained from the Federal Communications Commission. This is time-consuming and can easily get into procedural difficulties if it is not handled by experts.

Critical Paths

The 2 most common critical paths in DRT schedules are the vehicles (specification, bidding, procurement, checkout) and the radios (FCC license, radio manufacture, installation). Both of these paths need to be carefully monitored.

Service Mix

DRT includes a wide range of services (many-to-many, many-to-one, subscription, parcel delivery, shuttle, many-to-few, route deviation, and any mix of these). The mix of services should be chosen after careful consideration of the service objectives and economics. Often, choosing the right mix from the very large number of possible combinations is not immediately obvious, but the wrong mix will be costly and embarrassing to change after service has started.

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This paper discusses some aspects of implementing various DRT services, emphasizes funding at the state and federal levels, and reviews what several state transportation departments are doing with respect to DRT.

FUNDING

Identification of federal and state funds for DRT services is almost impossible for 2 reasons: Funding from state sources varies from state to state, and new federal legislation has not at this writing been signed and it is premature to estimate what programs the final legislation may affect.

In California, local funds are available through the state Transportation Development Act of 1971. In Michigan, funds from a special addition to the gasoline tax and some general funds are available for DRT services. Equally as important as having available funds is identifying the need for funds. At present, the tendency is to find a program to go with available funds, whether the program has high priority or not. What we really need to do is to establish the need for service and then work with state administrations to obtain funds to meet that need.

In California, we are at work now on establishing those needs. The legislation that established the California Department of Transportation also called for development of a state transportation plan. The first part of this plan will identify our needs for public transportation. The plan is being developed with input from the local governments. Some of the areas, especially the smaller urban or rural areas, may be overly cautious in their needs for public transit, but the process for producing the plan is continual, and we already see an increased awareness of transit needs.

Federal funds through UTMA are mostly concentrated in the capital grants program. Since regular DRT service has gone beyond the demonstration phase, funds through that channel, I think, will be hard to justify. Funds for operating and capital expenses are available through other federal programs such as Title 3 of the Older Americans Act.

These various programs are quite detailed and complex. For instance, capital assistance funds from UMTA for nonprofit, private organizations are available on an 80-20 basis to provide service designed predominantly for the elderly and handicapped. This program (known as 16b2, after the Federal-Aid Highway Act of 1973 amendment to the Urban Mass Transportation Act of 1964) is an excellent example of the tendency to establish a program to fit the fund.

GROUPED SERVICES

I want to emphasize the importance of combining services. At present, we have programs to provide mobility to the elderly and to the handicapped, to provide hot meals, and to provide transportation services as part of a variety of subsidized social programs. Often these services operate in competition. One of the great advantages of DRT service is that it is flexible enough to meet the needs of almost all of these programs. Only when there are heavy volumes and common trip ends do fixed-route systems enter the competition. Grouping services can potentially reduce overall transportation expenses in many areas.

MARKETING

DRT can serve a variety of riders, but the market segments must be identified and then the service marketed to that segment. In doing so, community support can be increased. You can easily show the garage owner that DRT not only provides good transportation to those who leave their cars for repairs, but costs the garage owner less than having a garage employee transport them. This leads to the second point. Decision makers will back a system—even if it is costly—as long as it has community support. University student groups, PTAs, chambers of commerce, and social, service, and conservation groups are examples of potential supporters. Our goal should be to implement a service for which there is a waiting market for the product, not to create a service and then look for a market.

Successfully selling an operating system, especially a DRT, also depends largely on employees, especially the drivers. They are the best market developers. A happy, helpful, courteous driver can attract ridership, and the opposite can certainly lead to disaster.

INSTITUTIONAL CONSTRAINTS

Institutional constraints should be identified, understood, and dealt with before service is implemented, if at all possible. Artificial barriers such as city limits and county lines do not always coincide with logical service areas, but they can limit service. Users are not aware that and do not always understand why institutional constraints prevent the provision of reasonable service.

COST OF SERVICE

Often we fail to identify the real cost of transportation. The perceived cost of automobile transportation is low; the true cost is unknown. The cost to the responsible agency of public transit is easy to identify, but the hidden cost (usually a negative value, i.e., a cost of not having the service) is not easy to identify. Nationwide, at any one time, about half of the population cannot be served by the automobile. Among this 50 percent are people who cannot get employment, cannot get to the doctor, and so on. The point is that the lack of transit service may be the reason that some are on relief. What then is the cost of not having a transit system? Public transit seems to cost a lot of money, but in almost all cases the alternative may cost society a great deal more. We have reacted to the perceived cost and ignored the other costs. We are now beginning to credit transit for reduced pollution and congestion and increased energy efficiency, but we still are not looking at the total costs.

STATE TRANSPORTATION DEPARTMENT ACTIVITIES

Of the 26 existing state transportation departments, about half have major units that have public transit responsibilities. Few have active DRT programs. Many provide technical assistance to agencies within the state. In most cases, this includes feasibility studies of possible implementation sites.

Most state transportation departments are still defining their role in public transit. This role is made more difficult by the relations that already exist between local and federal governments. In the past, state governments generally have been hesitant to aid local governments in developing solutions to public transit problems. That void was filled by federal involvement and programs. Now, for the states to establish a role, the previous relation must be changed.

Public pressure to develop new policies in relation to clean air, urban sprawl, noise, mobility for those without it, and resource conservation is forcing changes in public transportation. To be responsive to these types of issues and carry out other responsibilities, states must develop equitable allocation of state and federal pass-through funds, coordinate public services, and provide technical assistance. In other words, the states must become more involved and more active.

In preparing this paper, I contacted staff members of 17 states that are most apt to be involved in DRT activities. I received information from 11; only a few are directly involved in DRT. Of those, the following 4 examples illustrate the range of activities that state-level organizations can be expected to be involved in.

Oregon

In 1973, Oregon established a cooperative program (known as the Special Transportation Program) to improve mobility for disadvantaged in 6 areas of the state. Funds from federal programs were combined with local and state funds. Three demonstration projects resulting from this program involve DRT service.

1. In Albany, a combined fixed route-route deviation service (by telephone request) has been established. The goals of this project are to use private enterprise such as taxi service to provide demand-responsive service, establish problems and solutions involved in intergovernmental multiple funding, and group social services to minimize costs.
2. In Columbia County, a system that serves senior citizens is operating (it was in existence before the state program but is continuing with state assistance). This service operates buses primarily in rural areas (only one city in the county has a population of more than 5,000). Highly personalized service is provided for the senior citizens, who represent almost 12 percent of the county's population. Use of the service is via reservations through senior citizen centers. Donations are collected and fund-raising

activities are used to augment the local share of costs (community support!). Funds from the state and Title 3 of the Older Americans Act provided for the costs of the program.

3. In the Portland area, about 12.7 percent of the population is in the elderly category. A project here attempts to coordinate several separate systems that already provide service for the elderly and handicapped. The object is to demonstrate the effectiveness of maximizing the use of these services. In 6 months of operation, the project has more than doubled its projected ridership. It now serves about 4,000 riders monthly, and agency participation has greatly increased.

Data on these 3 systems are given in Table 3. In addition, the state is quite active in marketing these services to maximize ridership and fare revenue.

Florida

Florida's Division of Mass Transit Operations is involved in a number of projects to improve systems in that state. It has a cost-sharing program in which 10 to 100 percent of costs are funded depending on the project (generally, it is one-half of the nonfederal costs for local programs). At present, no DRT system exists in the state. A transportation of the elderly (TOTE) demonstration program is in operation in St. Petersburg. It is identified as a modified door-to-door, non-fixed-route, subscription, demand-responsive system. It began operation in September 1973, uses 13 special vehicles, and basically provides mobility for the elderly and handicapped. A full DRT system is being planned for St. Petersburg in an area not easily served by a fixed-route system.

Wisconsin

The current budget for the Wisconsin Department of Transportation includes funding for 2 state transit-aid programs. The first of these provides $5 million for operating assistance and $2 million for planning and demonstration projects. Under the second program the first demonstration project is to be a DRT system in Merrill. The city will provide 10 percent of the funds and will be eligible for operating assistance at the end of the 1-year demonstration.

One of the objects is to study the feasibility of consolidating the transportation services currently provided in that city. Estimated cost for 1 year is $170,000. In the October 1974 issue of Wisconsin Urban Transit Trends, the project is discussed as follows: In addition to providing benefits to Merrill, this project will give department staff first-hand experience in the design and operation of a demand-responsive transit system. This will enable DOT staff to respond to requests by other systems throughout the state for assistance in analyzing the feasibility of similar systems. Although there are demand-responsive transportation services being provided to the elderly and handicapped in other parts of the state, the Merrill project will represent the first demand-responsive system open to the general public in Wisconsin.

Table 3. Demand-responsive transportation projects in Oregon.

Item	Project 1	Project 2	Project 3
Funding, dollars			
State	18,279	34,638	45,000
Local	31,862	14,831	22,609
Federal	22,976	11,356	36,578
Total	73,117	60,825	104,186
Miles operated/month	2,600	55,523	–
Riders/month	1,687	–	–
Operating costs/mile, dollars		0.196	
Cost/passenger, dollars		2.50	

Michigan

In 1972, Michigan established an assistance program to provide support, improvement, expansion, and establishment of public transportation systems in that state.

Included are 3 types of projects: operating assistance, demonstration, and capital. Under this program, 100 percent funding can be provided by the state from gasoline tax sources.

The revenue source provides about $20 million per year in a state General Transportation Fund. Fifty percent of this amount goes directly to metropolitan areas with public transportation services. Most of the rest of the funds are for state-established demonstration projects. Of the programs thus funded, the one of particular interest is the Dial-A-Ride Transportation (DART) Program. This program is designed to provide basic transportation services in nonmetropolitan areas of the state. Door-to-door, shuttle-bus service between major traffic generators, charter service, and package delivery or combinations of these are allowed.

The first Michigan DRT service was established in September 1971 in Ann Arbor, before the DART Program began. Since the DART Program, DRT service has expanded considerably. For instance, in the first year, service was implemented in 8 cities with populations ranging from 9,000 to 35,000. At the end of 1974, 9 cities had DRT, and 9 others expected to have it by the middle of 1975.

During the first year of operation, the state pays all the capital and operating costs except for a local $1,000 commitment. After the first year, the state continues to provide about 30 percent of the operating cost of the systems. The estimated costs for the first year for the typical installation is $175,000, which provides for four 12-passenger vehicles with radios operating 60 hours per week each. The typical fare is 50 cents; senior citizen fare is 25 cents. Each of the DART cities will soon be equipped with a vehicle designed for providing service to wheelchair users.

Another Michigan program is the Small Vehicle Acquisition and Operating Assistance Program. This program is intended specifically to provide for obtaining equipment and operating assistance for both new and expanded existing systems for cities and rural areas where small vehicles are appropriate. Under it, programs to continue the original DART projects to complete the 12-month demonstration program are eligible for funding.

An experimental bus project in connection with DART is under development. A variety of small buses will be placed in service and tested.

California

In California, the transportation department has no direct involvement in DRT services. It does act as a clearinghouse for information and provides technical information on such services. The California Transportation Development Act of 1971 provides funds to local agencies to provide for public transportation or, if there are no unmet transit needs that can reasonably be provided, to be used for road and street projects. In a few instances, these funds are being used or planned for use to provide DRT service. But this is a local program, and the state is only involved in administration of the funds.

We are currently involved in identification of transit needs—both in the planning effort associated with the state transportation plan and in separate studies. With information from these sources, we will work to develop other fund sources.

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Loren A. Ball, AC Transit, Oakland, California

We began DRT service on September 16, 1974, after more than a year of planning and carried 603 riders the first day. At the end of 7 days, we had a total of 4,277 passengers. Our passenger response to DRT has been about 3 times that of other DRT operations of comparative size. We are encouraged by this.

The enthusiastic response to our initial service is the good news about our service. The bad news is the trouble people had getting through on the telephone to get a bus to provide them with door-to-door service. Part of the telephone tie-up is based on our call-back procedure. To eliminate no-show customers, control room operators are instructed to call back and get verification. We leave it to the discretion of the individual operator as to whether a call-back is needed. After the first few days of being swamped with phone calls, we installed 2 additional trunk lines for outgoing calls in order to free the regular DRT numbers.

Even with the call-back procedure, however, we experienced a sizable number of no-show customers; the first week we had some 1,200. That number has been daily declining, and we feel that the initial pranksters have gotten their tomfoolery out of their systems or, I should say, out of our system.

Statistics on numbers of people carried and numbers of telephone calls do not tell the story. The most rewarding experience for us has been the response of the people: senior citizens who call and thank us for providing them with a way to get to the doctor's office or a friend's house, housewives who can now get to and from the grocery store, unemployed people who can get to a job interview.

The area that we are serving is a 5-mile^2 (13-km^2) district in the heart of Richmond. Some streets are narrow and have speed-control dip gutters, which make operation of a conventional bus impossible. Turns at some intersections are impossible for a 35-ft (10-m) coach.

Faced with this problem, we decided the right DRT vehicle would be a minibus, but we were not satisfied with the small buses on the market. So we took 13 of our conventional buses, cut out a 6-ft (1.8-m) section, and rejoined the ends to make coaches with a short turning radius. This included, by the way, removing the rear door. The new coaches seat 18 passengers, rather than the 45 they used to carry. We remodeled the inside with carpets, comfortable lounging chairs, tasteful paneling, and fresh paint. One of the first riders on the new coaches said, after looking at all the improvements, "This looks like the VIP room at American Airlines. Where's the bar?" We also installed a distinctive musical tape, which sounds a melody to announce the arrival of the DRT bus at a passenger's doorstep. We put a spotlight on each coach to light the way to people's doors at night and provide them with security.

The drivers bid for the DRT positions during the regular sign-up. Control room operators are screened through testing and chosen through seniority. We launched an intensive 2-week training session with drivers and control room operators in simulated DRT situations. By having control room operators ride with drivers, we derive the additional benefit of personal contact between people who will be working together.

DRT fares are 25 cents per person. At that low rate no transfers are issued or accepted on DRT buses, including the BART to AC Transit transfer.

Our marketing of DRT services received assistance from Model Cities Program employees, who made a door-to-door distribution of materials explaining what DRT is and how people can use the service. The Model Cities people also helped by contributing funds toward production and publication expenses of informational materials and by purchasing $3,000 worth of bus tokens for free rides. The city of Richmond assisted by including an informational brochure in a direct mailing, and the local community hospital included the brochure in its employees' paychecks. Other agencies also distributed informational pamphlets.

We have not integrated DRT with conventional bus routings. Our DRT system is superimposed over the fixed-route system in Richmond, but the two operate independently.

The cost of operating DRT systems remains the most difficult problem to solve. Even though there is a social need to be fulfilled, we have to ask whether the public is willing to pay the price through taxes, higher fares, or federal or state subsidies.

IMPLEMENTATION AND OPERATION OF NEW DEMAND-RESPONSIVE SERVICES

David R. Shilling, Orange County Transit District, California

This paper presents an overview of the problems, pitfalls, and potentials of initiating and operating a new demand-responsive transportation (DRT) system. It is meant to be not a comprehensive how-to-do-it manual but an attempt to highlight major steps in the process of starting a DRT system and to provide the potential sponsor with useful information on the formulation and management of a DRT operation. It gives the uninitiated an opportunity to learn from the experiences of others.

SYSTEM OVERVIEW

A DRT system is made up of a fleet of small radio-dispatched vehicles. The vehicles, operating on city streets with flexible schedules, respond to requests for transportation as they are received by a central dispatcher. The dispatcher-scheduler combines customer information regarding location, number of riders, and desired pickup time with information regarding vehicle position, tentative routes, and trip characteristics of other passengers. Using preplanned scheduling-dispatching procedures and a radio communication link to a fleet of small buses, the dispatcher assigns a vehicle to pick up and to deliver each customer from point of origin to destination. A 2-piece trip ticket showing origin, destination, number of passengers, and promised bus arrival time is completed. The ticket is stamped by time clock when the request for service is received, when the vehicle is dispatched, and when pickup and delivery are made. The customer is advised of the expected pickup time and, perhaps, the fare.

A large metal-backed map and magnetic pieces are used in the control center. The magnetic pieces hold trip tickets containing the customer trip data—one kind of piece denotes an origin and another kind, a destination. When a trip is assigned, colored markers corresponding to the vehicle are placed on both pieces. These markers also serve as pointers to the vehicle's next stop and effectively trace a tentative route for each vehicle. When the bus arrives at a stop, the driver notifies the control center operator, who updates the position of the bus on the map and in turn notifies the driver of the next stop. The map, therefore, represents quite accurately the true state of the system, i.e., vehicle position, customers on board, and customers waiting. Given this full view of the system, the control staff can alter tentative routes as necessary to accommodate new trip requests (1).

As calls are received and relayed to the driver via 2-way radio, the vehicle moves through the city and passengers board and get off along the way. Passengers whose origins and destinations are in close proximity are batched to increase vehicle productivity (passengers delivered per vehicle hour). In an efficiently planned and operated system, service is orderly and predictible, fares are reasonable and commensurate with the level of service provided, and wait and travel time is minimized.

PLANNING THE SYSTEM

Planning any form of public transportation service requires that some thought be given to what the operation is to achieve. A common experience in transit is to develop a system in response to public outcries for service, only to be astonished at how little the system is used. Marketing considerations aside, the key here is perceptions of service versus the realities of operation. An interest group or city may support the formation of a transit system only to find that the operation falls short of their expectations in terms of frequency of service or route alignments. DRT can respond to these problems because of its characteristic flexibility in routing and scheduling, but it too can be poorly planned and implemented and inadequately operated (2).

Awareness of the characteristics of the service area, both geographically and demographically, is critical. For example, when will be the peak periods of demand? Who will ride? Where will they be going? What will be the effect of weather on demand? What seasonal variations in ridership can be anticipated?

The characteristics of the potential service area to be evaluated before system operations start should include an overall evaluation of land use and demographic considerations. The location of major employment centers, commercial or industrial complexes, and open space and recreation centers should also be considered. An analysis of the population within the service area should be undertaken, particularly the location of senior citizens and the young and concentrations of minority populations, for these groups have a high propensity to use DRT. Other considerations include the location of schools and other activity centers, employee origin and destination data (if available) and nodes of major employment, and other transportation services existing in the service area.

FUNDING

The cost of operating a DRT system is not cheap, and in most situations deficits are inevitable. To break even in virtually any transit system where demand is relatively low and costs relatively high is not a realistic goal. To place the break-even goal above providing good, low-fare service can only result in increasing fares to cover costs, which will drive patrons away from the service and result in even higher losses. This has been the experience of transit operators for years. Perhaps now, with the availability of other funding sources, this trend can be reversed (3).

Funding transportation services has been a major stumbling block to system development in underfinanced areas. But many sources of money are available, and special service contracts with public agencies having access to revenue sharing funds or other sources can provide services to special-need groups such as the handicapped, the elderly, and the poor while underwriting some of the cost of the operation. Private contracts can also be negotiated with business firms and shopping centers to defray part of the cost of service in return for providing transportation to employees and shoppers.

If the system is to be successful, an ongoing local commitment to funding is necessary. An area that can only scrape together enough money to operate a bus system for a limited period of time is asking for trouble. Once service is instituted, those who begin to rely on the operation will not tolerate its untimely extinction. Historically, bus systems that have given potential riders this treatment never regain their patronage regardless of ultimate improvements in the operation. Thus, it is necessary to operate a competent system from the beginning and to make a commitment to an ongoing program of ever-increasing service.

MARKETING

Marketing the DRT system is paramount to its success. It will be a new concept to most people. Consequently, significant time and money should be expended to tell the people about the new service and how to use it.

A small city, in response to a perceived demand for bus service, may quietly initiate a limited system with modest funding and be rewarded with limited patronage and correspondingly modest revenues. An operating system not only needs promotion but needs preservice surveys to determine the market it will serve. Other marketing techniques that can be employed to determine public opinion and desires about public transportation include attitudinal surveys to determine what people want (and do not want) their public transit system to be like. This activity also develops a public awareness of the system even before service begins. A stratified random sample of 300 households was made prior to the initiation of service in La Habra, and follow-up and on-board surveys are planned (4). The data gained from such surveys can provide the operator valuable information for use in attracting more people to the service and can aid in system design prior to actual operations.

Local communities that begin the development of a bus system without undertaking preservice surveys to accurately assess the utility and potential use of the service are risking a large sum of money and political embarrassment if that system fails. Surveys must be undertaken, and questions must be worded carefully so that those interviewed know exactly what they are responding to. For example, a survey in La Habra indicated that 55 percent of the population said they would ride the DRT bus at least once a week. But because the survey was vaguely worded, the La Habrans thought they could go anywhere in Orange County on the DRT bus. This wildly inflated their positive response; in fact, only 5 percent of the population rides DRT once a week (5).

While preservice marketing surveys may provide insight into system design needs, an ongoing promotional and advertising program must be established and maintained as service is initiated and ridership builds. An aggressive direct-mail campaign, door-to-door contact with the business community, advertisements in local newspapers, "demonstration days" at local shopping centers, and cooperative promotional events between the operator and local merchants can highlight the advertising effort. It is best, however, to limit promotional activities during the first few months of operation to avoid an inundation of requests for service. Ridership should be built gradually as driver and dispatcher experience increases. This will minimize the number of patrons who get relatively poor service during the critical initial months of operation.

More personalized advertising can also be undertaken. In La Habra, for example, bilingual employees were sent into the Mexican-American community to inform Spanish-speaking residents about the service. A bilingual brochure was also developed and distributed, and drivers and dispatchers took a conversational Spanish course to better assist Spanish-speaking patrons and to stimulate minority use of the system (6).

Perhaps the most effective promotional tool is the service itself. The buses on the street provide visibility; and if drivers and dispatchers are friendly and helpful, word-of-mouth promotion from customer to customer can largely result in the public's positive response to the DRT system.

PERSONNEL AND TRAINING

Employees can either make or break the DRT operation. No amount of planning, promotion, or fancy vehicles can overcome the negative reaction of the patron to a surly driver or rude telephone operator.

Responsibility for the recruitment, training, and maintenance of staff lies with the DRT manager. The manager must have the ability to select the right people and to provide them with the right skills. He or she must be able to instill in them the personal desire to provide excellent service to the public. Without these capabilities, the system will suffer. Selection of DRT supervisory personnel should be carefully done.

Personnel requirements will, of course, vary from one site to another. Specific vehicle requirements, hours of service, and labor pool available in the area selected are all factors to consider. However, a few rules of thumb can be extrapolated: For each bus, $1\frac{1}{2}$ drivers are usually required. If a 12-hour service day is planned, ideally twice as many part-time drivers are needed as full-time drivers because of the need for split-shift scheduling and accomodating peak-period vehicle needs.

Controller-dispatcher requirements will vary with fleet and service-area size and demand, but 1 controller for every 4 buses (2 for 5 buses) is about right for most manual systems. During off-peak periods in a small system (i.e., 6 buses), 1 dispatcher can also perform the functions of telephone receptionist, vehicle scheduler, and dispatcher. However, during periods of high demand, or in larger systems, these 3 functions will have to be divided among several people. Optimal operations achieve the desired level of service with the minimal number of employees.

Personnel training involves preemployment screening of applicants and on-site training under simulated DRT operating conditions. Ideally, drivers and dispatchers are cross-trained to afford opportunities to shift employees from one function to another as required. Aptitude tests in basic knowledge and logic are necessary, for DRT operations require that employees have initiative and ability to solve problems. Spatial perception testing is also important in the determination of a dispatcher's ability to be efficient at assigning passengers to vehicles and routing vehicles through the service area. Although not a prerequisite for employment, potential drivers should be trained and tested for any special class of driver's license required by state law to operate a vehicle for pay or to operate a vehicle that exceeds certain seating and weight maximums.

After employees have been hired, a 2- to 4-week training course should begin before service starts. This training program should include vehicle operations and accident procedures, telephone handling, scheduling and dispatching, service area familiarization, safety programs, and general administrative and personnel regulations. Having drivers and dispatchers practice the pickup and delivery of passengers at hypothetical origins and destinations provides excellent training and improves the employees' problem-solving capabilities.

Employees hired after the start of service are given on-the-job training under the direction of the system supervisor or a senior driver or dispatcher. Ongoing training must also be undertaken to maintain a high level of proficiency, to ensure adherence to safety procedures, and to keep the staff up to date on the latest changes in procedures or the service area or advances in system operation techniques.

An operation employing a part-time staff of housewives and college students is more easily managed and less costly than one involving a union. In such situations, modifications to recruitment and training programs may be required. However, DRT operations staff must be screened and trained adequately and continually monitored to ensure safety, courtesy, and efficiency. DRT is far more personalized than traditional fixed-route operations, and the close association of the DRT employee to the public can spell the ultimate success or failure of the service.

Another opportunity worth investigating is contracting with local cab companies or with local charter bus operators to operate the system. More than likely such a firm will have an immediately accessible labor pool and maintenance facilities and perhaps even vehicles to do the job. However, because of potential problems with the control of a contract operator, this should be viewed as an intermediate solution. In the long run, operation by or directly under the control of the sponsoring agency may be desirable. Determination of the ultimate operation formula will necessarily be based on a number of political, economic, and administrative variables.

EQUIPMENT SELECTION AND MAINTENANCE

Basic equipment for the average DRT operation includes vehicles, fare boxes, radios with console units and a base station, antennae, tow trucks, maintenance trucks, supervisor's automobile, control room office equipment, shop equipment for maintenance, bus signs, and spare parts. In areas where there are existing transit properties, much of this equipment need not be duplicated. The most critical equipment—vehicles, radios, and maintenance—is discussed below.

Satisfied personnel is the key to an efficient operation, but a vehicle fleet, adequate in both size and reliability, is also a necessity. Most operators who have experience with small buses agree that a really good DRT vehicle does not exist. The claims of small bus manufacturers to the contrary, virtually every bus in the under-30-ft (9-m) category suffers from some mechanical deficiency. Most small buses have a medium-duty truck chassis; brakes, transmissions, and other subcomponents are inadequate to meet the demands of day-to-day transit service. DRT system planning should include a review of all available equipment, and vehicle capacity and cost should be matched with estimated demand and available funding. For example, a 25-passenger German diesel bus at $26,000 may not fit the requirements of a low-demand service area where a van or taxi could handle the load or where the availability of diesel fuel (or a place to store it) is in doubt or where an estimated 3 buses are needed but only $50,000 is available to purchase them or where parts and service are so distant that vehicle downtime could spell disaster for the level of service. Vehicle selection must be based on the requirements of the service and the ability of the operator to purchase and to maintain the equipment.

Radio communications, the nerve center of demand-responsive transportation, is important. In most small-bus operations, 2-way voice communication with base station and console in the VHF or UHF bands will be adequate. But in high-demand areas, digital communication may be necessary to minimize airtime. In rural areas the availability of frequencies may be greater than in high density urban centers. The Federal Communications Commission controls the allocation of frequencies. A check with that agency early in system planning is necessary. In some cases, local jurisdictions may be willing to share a public works frequency. In others, existing transit properties may already have a spare frequency in reserve that could be used.

Radio equipment can be maintained under a maintenance contract with the distributor or a local radio shop or by the public communications department of the city or county. In any event, radio equipment and frequencies adequate to meet demand should be planned for early, and a reliable maintenance program established.

Equipment maintenance is a real concern. Vehicle reliability is necessary to maintaining an ongoing high level of service, particularly where demand requires that most equipment be in operating condition. If operated by an existing transit entity or taxi firm, vehicle maintenance can be undertaken in the existing shop. But if the DRT is self-sufficient, a maintenance staff should be hired or a maintenance contract written for regular maintenance and emergency needs. Often, a local truck dealer or large garage can accommodate this requirement. The maintenance program should also include bus washing and sweeping—a good parttime job for a high school student. Towing and tire repairs can be provided by a local garage or service station.

ACCOUNTING, RECORD KEEPING, AND MONEY HANDLING

Responsibility for records and money rests with the DRT manager. Records pertaining to passengers carried, revenues, driver hours, mileage, and fuel and oil consumption must be maintained not only for budgetary reasons but as a means of assessing the overall efficiency of the operation in terms of cost per hour, per passenger, or per mile. When costs exceed realistic maximums, a review of operational efficiency should be made. On the other hand, when excellent system performance is achieved at costs lower than expected, rewards to the manager and staff are in order.

Weekly passenger and fuel summaries should indicate the number of passengers, hours driven, mileage, and fuel and oil consumed. A comparison of weekly costs and revenues can be made to determine accuracy or to identify a possible pilferage problem.

Monthly reports summarizing ridership, revenues, and mileage and analyses of trip tickets from selected days should be made to determine level of service in terms of wait and ride time, early or late pickup time deviation, and vehicle productivity (expressed in the number of passengers carried per vehicle hour). Other items in the monthly report include maintenance records and vehicle downtime by vehicle.

Fare revenue deposits are reconciled with ridership records as an accuracy check. The removal of fares from locked fare boxes is done by a trusted employee who counts the money, compares receipts to ridership by vehicle, and deposits the money (in a DRT account, for example). A statement is submitted, perhaps weekly, to the controlling agency's accountant or comptroller. Detailed costs analyses are also developed in which are itemized salaries, maintenance costs, supplies, fuel, marketing and advertising cost, insurance, vehicle depreciation, uniform rental costs, and management fee (if any). Cost per mile, per passenger, or per hour can then be determined.

COMPUTER CONTROL

Much has been said about advances in computer technology and its use in DRT operations. In a small system (one that has fewer than 15 to 20 buses and 100 service requests per hour), the receipt of calls for service and the scheduling and dispatching functions can be handled manually. But in a system having more than 15 to 20 buses and 100 requests per hour, a computer may be necessary.

Because of the economies of operating a larger fleet from a single communication center, automated scheduling and dispatching techniques are attractive to the large system operator. Moreover, a well-refined computer program can also make decisions with fewer errors—thus, maximizing the efficient use of employee-hours and vehicles and providing a corresponding higher level of service to the user.

The algorithms for such a system are being developed and tested at the Haddonfield, New Jersey, Dial-A-Ride Demonstration Project, and other private organizations have also developed computer-aided scheduling packages to assist in efficient operations in high-demand situations. Computerization can also assist in more efficient means of compiling and analyzing other system characteristics, such as

1. Real-time optimization of level-of-service variables (wait and ride time, pickup time deviation, and vehicle productivity),
2. A storage-retrieval information format for fuel consumption, maintenance, and other vehicle parameters,
3. A vehicle-monitoring system in which the performance of vehicles can be monitored on an ongoing basis, and
4. A vehicle locator system tied to the dispatching processor for spontaneous interrogation of vehicle location and a consequent higher level of machine-made trip assignment.

In a single DRT module having few vehicles or relatively low demand, these on-line monitoring characteristics are a luxury. However, in larger, more active systems or a system having several DRT modules, computerized information files, cost-effective automated scheduling and dispatching, and a real-time management information mechanism present real opportunities for greater efficiency in the transportation system.

CONCLUSION

Demand-responsive transportation offers the operator and the patron a unique opportunity to provide and to enjoy the benefits of door-to-door transportation at reasonable cost. Whether the operator is a transit agency, taxi company, charter bus company, independent management consultant, or local public social service agency, good service can be provided if several rules are followed.

1. Thoroughly understand DRT as one kind of transportation service and be sure it fits the needs of the area for which it is being considered. One of the basic rules of traffic engineering, for example, is to draw up the pavement striping plans before the first cubic yard of dirt is moved. In other words, plan the system around the function it is to serve. In some areas, shuttle, loop, or fixed-route may better serve the community than DRT. Consequently, needs must be identified first and then the system planned

to accommodate those needs.

2. After the requirements of a system have been identified, determine a financial plan. Modifications of desires to fit available funding may be necessary in terms of not only capital acquisition needs but also operating costs. In all but a few unique instances, systems touted to pay for themselves from the fare box have been a fiscal disappointment. Be prepared to subsidize the operation.

3. Understand that time and money invested in a marketing and advertising program will be returned, with dividends, in terms of patronage, revenues, and public support.

4. Develop a sound personnel recruitment, training, and management program. This will ensure an efficient operation, satisfied employees, and a good image with the community.

5. Select equipment and plan maintenance carefully. Unless vehicles, radios, and other equipment are adequate and reliable, the operation will suffer.

6. Develop sound accounting and reporting procedures to prevent losses and to monitor system efficiency.

7. Do not go to computer control unless it is needed. If a manual system provides fast and efficient delivery of customers from point A to point B, then the goal is achieved. But if a computer is needed, evolve the manual system to computer control over time.

8. Do not expand too fast. The initial success of a small system may lead to service being overextended. As a result, costs can increase beyond budget limitations and level of service will fall. The system will be less attractive and therefore less used. Be realistic, identify needs and inventory various opportunities to provide service, take time to identify the system that best serves the needs, develop surveys and preservice information to determine potential levels of use by various market groups, evaluate funding capabilities, seek financial sources, and perhaps contract operators to operate the system.

9. Seek professional help if you are uncertain about your abilities to achieve these things. There is nothing more embarrassing than to move forward with a visible public program only to see it fall because of inadequate planning or inept management. A realistic program, well thought out, funded, and instituted will in the long run better serve your needs and reflect well on your planning wisdom.

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Roy G. Helsing, LEX Systems, Inc.

The first step in implementating a DRT system is to establish goals and objectives.

Why is that important? If your goal is simply to run buses, then the system planner and designer will produce a much different system than if the goal is to improve the environment or to reduce the number of cars per household or to transport senior citizens at low fares. Goals should be specific, and objectives should be set to measure goal achievement. As consultants, we insist that transit districts or communities have goals; otherwise, we cannot design systems for them. Goals affect the number of vehicles, the way people are trained, and every aspect of the operation.

Program management is also extremely important. A single person should be accountable and responsible for the planning and design of the DRT system. That person will of course be supported by a number of people. The job of program management should not be given to an assistant clerk because he or she is the only one who has the time to do it. The program manager should be at a high level in the organization and be able to make decisions (because there will be a lot of decisions to make) and to report directly to the transit agency or the community or the city council or the mayor. The program manager must understand the goals and objectives and ensure that they are met in the planning and designing of the DRT system.

Planning can be thought of as part of system design, but system design also includes determining hours of service, fare collection methods (credit card, cash, or tickets sold on the outside), type of control system, location of the control center (in La Habra and La Mirada, the control center is in the city administrative building, where it is highly visible), and areas of high ridership potential. Signs, benches, shelters, and curb painting must be considered during system design.

Point-to-point travel times must be determined. Typically a demand-responsive vehicle will move at about 12 mph (19 km/h) while making pickups and deliveries, depending on the type of area. La Habra has a grid street pattern and many through streets, both north and south and east and west, and is ringed vertically by 4-lane, 40-mph (64-km/h) arterials. Buses can move quickly in this city. La Mirada, on the other hand, was designed as a city of cul-de-sacs to keep traffic out of the neighborhoods. Vehicles have more difficulty moving in that city.

Hills, a freeway splitting the city, and railroad tracks bear on the design of the system and the number of vehicles. If there are 2 cities of equal size but one of them has hills, dead-end streets, and a railroad track through its center and another has a perfect grid street pattern, more vehicles will be required in the hilly, less accessible city for the same level of service.

The most difficult time for sustaining public support is during the lapse between the time the decision is made to institute a DRT system and the time the buses start running. That lapse can be 3 to 6 or even 9 months, particularly if buses must be purchased. Newspaper coverage is important during this period to keep the public informed and interested.

Local business managers, taxicab operators, and private transit system operators should be included in discussions of the DRT system from the outset. The taxi operator has expertise in this kind of service, and business managers may help support the system with money or buying tickets.

The capital costs of most DRT systems are covered by matching grants. A serious question then becomes, Where is the money to operate the system to come from? Only about a third to a half will come from the fare box. There are a number of sources of funds for system operation, but they should be explored before service is started.

During the implementation phase, marketing and sales promotion are important. The project manager should talk to all of the service clubs, schools, and other groups about the system, how it works, and how it will affect the community.

Also during the implementation phase control procedures will be carried out and control personnel selected and trained. Spatial perception tests are useful in the selection of these employees, for they must make judgments based on different points in space. They have to visualize where the bus is, where it is going, and what stops it will make en route. Simple clerical tests that are nondiscriminatory in both language and intent are also useful in hiring control personnel.

Depending on the size of the system and the complexity of the area, demand-responsive transit can become an excellent planning tool for other modes of transit because data from the demand-responsive transit will reveal when and where people move. In large and dense areas, demand-responsive transit can help in determining where corridors should be for fixed-rail routes.

Marcel Zobrak, DAVE Systems, Inc.

I want to discuss how to obtain federal money for use in implementing a demand-responsive transportation system. The principal program is the Capital Grants Program of the Urban Mass Transportation Administration. Under that program eligible communities can obtain 80 percent of the funds for all capital equipment and facilities necessary for demand-responsive transit systems. That includes buses, maintenance facilities, the land for the maintenance facilities, control room equipment, radios, shelters, and signs. The other 20 percent must come from from local sources.

Funds are also available from the Federal Highway Administration. The Federal-Aid Highway Act of 1970 made some changes with regard to the Highway Trust Fund. Money is set aside in that fund for the Interstate Highway System. If the community decides it no longer wants the Interstate Highway, it can seek to get those funds for transit use. The procedures for doing that are not yet clear, but the intent of the law is that the funds can be used to procure capital equipment.

The Mass Transit Assistance Act of 1974 sets aside approximately $12 billion for public transit. Of that amount, some $8 billion is for capital equipment and $4 billion is for operating subsidies. Communities may borrow capital funds for use as operating funds if they choose.

The guidelines for applying to the Federal Highway Administration have not been promulgated as of this writing, but they will likely be similar to those of the Urban Mass Transportation Administration. In general they involve the submission of a preapplication that briefly describes the program and the amount of money needed. UMTA judges the preapplication and checks to see that the planning requirements have been met not only at the city level but also at the county or the regional level.

If the judgment is favorable, the application is submitted that describes in some detail the equipment and facilities, the expected cost, and the benefits to the community, the users, and the operators. In addition, the application must describe in some detail the system, the kind of operation, and its relation to other modes of transportation in the community.

UMTA must also be given a 5-year financial plan that includes a 5-year capital improvement program indicating how the system will be supported, how it will be expanded, and how equipment will be replaced.

An environmental impact statement must also accompany the grant application.

Before the application is submitted, a public hearing must be held, which requires that notice be posted 30 days before the hearing is held. The proceedings of the hearing and the notice of the hearing must be incorporated in the application.

Section 13-C of the Urban Mass Transportation Act provides that UMTA cannot grant money to any community in which those funds would adversely affect labor. A copy of the preapplication, therefore, goes to the U.S. Department of Labor, which makes an assessment of whether labor will be adversely affected. I suspect that what is most often done is that the local transit union is asked, "Do you think that this is going to adversely affect you?" If the answer is "yes," the application is likely to be in trouble. Communities would do well to clear their DRT plans with the local transit union and with the Department of Labor.

These requirements are all outlined in an UMTA manual, External Operating Manual, which is available from the Office of Public Affairs.

George Gray, Division of Mass Transportation, California Department of Transportation

There are 28 state transportation agencies that aid local communities or transit districts with planning guidance and funding. About half have definite groups that are involved in public transportation and about a fourth are involved in DRT services. In providing these services Michigan, Oregon, Wisconsin, and Florida are the most active; Michigan is far ahead of other states. Several states have some involvement, but usually on a single project. New Jersey, for example, has funded the Haddonfield project to the extent of some $420,000.

California is not directly involved in DRT. The Transportation Development Act of 1971, better known as the 325 Program or the sales tax on gasoline, makes funds available for local use, and some of it goes to DRT services, but as local option money. Local communities may do what they wish with it.

State assistance programs are bound to proliferate as new programs of resource allocations, pollution problems, and other impacts of transportation facilities become more apparent. Almost all the states with public transportation units provide technical assistance of some kind to the agencies within the state. The California Division of Mass Transportation provides this type of technical service, but our studies are general in nature. We identify the potential for new services only after a detailed study is called for once the local decision-making body has established evidence of real interest in a public transportation program.

The DRT activities in the Orange County Transit District and the Alameda-Contra Costa Transit District have no state involvement. DRT in La Mirada and El Cajon are city sponsored. The Santa Clara County DRT, which I think is going to be one of the bell ringers, is a county project with 325 Program funding.

As most other states do, California provides technical assistance to establish a variety of services where DRT may already exist, e.g., marketing, information systems, equipment specifications, and special services.

Claude J. Klug, Administrator, City of La Mirada, California

I am not a transit person and do not regard La Mirada DRT as being totally committed to transit; in fact, I consider its second objective to be transit.

We marketed DRT not as just transit but as a new innovative service in a dynamic city; it was part of the normal public relations program of the city.

When we started operation, we were overwhelmed with customers and had to back off. In fact, I still have 10,000 free tickets in my desk that we never gave out. We were one of the first cities in our area to start DRT (La Habra had started about 2 months earlier), and we really did not know what we were getting into. Basically people were concerned that it was a boondoggle because we had committed a subsidy of $100,000 a year for 5 years; the first year was for setting up and the remaining 4 years were for operation.

After we began operation, we found that we had oversold the system not only in the volume of people we could serve but also in what the people expected. They expected that they were going to get a vehicle at 8:02—not 8:00 and not 8:05. So we found that most people turned to the taxicab service, but you do not get a cab at 8:02 either.

Our vehicles are brightly covered, and our control room is all glassed in and in a prominent place in the City Hall. Almost anyone who comes in City Hall can watch the DRT in operation.

We found a bit of irony with regard to our public relations techniques. We put packets together for TV stations and made personal visits to all the right people, but got absolutely no coverage at all. About 6 months after we were in operation, the New York Times did an article on us. It was picked up all over the world, and since then we have had tremendous coverage.

During our first year, we carried 110,000 people. We anticipated in our study that we would carry about 50,000. We have reevaluated our system because it included some things that we have not really liked, such as service for school children, which cuts into other kinds of service. Since we are a city operation, we can change the philosophy behind the system quite readily, and we do.

We use the DRT system as a patrol system. A typical monthly report will give an idea of what a DRT operator reported: "Dead animal; small garage fire; bus 16 involved in a hijack; broken glass on a street; two signals malfunctioning; illegal dumping; dead animal; small brush fire; county truck involved with a private vehicle in an accident; two dead animals; two large shepherd dogs loose in an intersection"—this kind of reporting is a worthwhile service to the community. As a matter of fact, when we started DRT, I indicated to the city council that I could justify the $100,000 subsidy on the basis of services other than transit. We make other public facilities available. We emphasize charter service. During those times of the day when demand is low, we give free rides to the swimming pools in the summer or we have contracts with shopping centers.

We have a radio communications system that we could not have if we did not have DRT. We have a sophisticated FM paging system, and we only have that because we have DRT.

Community image is important to us because we are not a property-taxed city and we are always looking for business and industry. DRT has done a great deal in enhancing our image. Because of the publicity we got by being one of the earliest cities to have DRT, people from all over the world have visited the city. Being in Los Angeles County where there are 78 cities, La Mirada is almost unheard of. Many times a good image may help an industrialist make the location decision.

In La Mirada, we had a major train accident in which a gasoline tanker exploded and several propane cars were piled underneath. Thirty minutes after the police and firemen were there our DRT system was in operation. The vehicles were available and in use. What I am saying is that there are many other aspects to DRT than just transit. In our case, they have paid off.

John H. Davidson, Yellow Cab Company, Los Angeles

My comments are based on personal experience and the experiences of personnel in day-to-day supervision of demand-responsive services.

We have 2 forms of communication: the telephone that the patron uses and the radio that we use to and from the vehicles and the communications center and possibly between the vehicles if we use a Simplex radio frequency.

We start by getting the order. The DRT customer is quite similar to the taxicab customer. A high percentage of the people have never used this type of transportation before and many have language difficulties.

Sufficient time must be allowed to receive the orders, including recording the address, the name of the party, the number in the party, and the destination and giving the patron an estimated bus arrival time. An analysis of more than 120,000 orders indicates that a DRT order taker can handle from 2 to $2\frac{1}{2}$ orders a minute. By comparison, a taxicab order taker can handle about 4 orders a minute.

Telephone equipment should be simple at the start. We started out with a simple instrument with a single incoming line without transfers or hold buttons and moved to the sophisticated Automatic Call Distribution system with a large number of incoming lines, hold buttons, and transfers. A beginning installation of 2 incoming lines, 2 instruments with both lines, and hold buttons duplicated on each instrument will handle 200 calls per hour.

Some peripheral equipment is useful and is available from the telephone system or from equipment manufacturers. We found call counters on the lines to indicate incoming flow to be valuable and also circuit overload counters and all-truck-busy counters. A device that we have found useful in DRT operation and in taxicab operations is a linear recording device that shows when the call was answered and how long the conversation lasted.

Another item of peripheral equipment that is quite useful is a tape system to record all incoming calls and all radio conversations. The cost is not excessive. It stops many budding problems between dispatcher and driver and gives the DRT system operator a tool for analyzing and responding to complaints. The gruff order taker may make a drastic change in attitude if conversations are recorded.

Radio equipment should also be simple. A dispatcher or order taker must have the ability to route the calls and keep nonproductive mileage as low as possible. We find that an experienced dispatcher can handle about 1.8 to 2.2 orders per minute. A portion of the time is spent in the analysis of the orders to determine the most economical routing, and a portion of the time is spent in radio conversations. Excluding the calls by driver when the patron is picked up and again when the patron is delivered, radio conversations with the driver average 5½ to 6 per trip. In taxicab activity, the number of contacts will average from 4½ to 5 per order.

If DRT is operated by a municipality or transit district, cooperation from the FCC is better if the radio frequency used is from the public safety or transit bus frequency blocks. If a private operator is to operate the system, even though under contract, the use of assigned taxicab frequencies will expedite the initiation of the service.

Communications also include communications with the public and with the operating personnel. In regard to communications with the public, although a taxicab operator can start one of these operations in about a week from a technical standpoint, the public needs more time to realize what additional transportation will be offered. One system was inaugurated with 1 month's publicity and had 6,200 patrons in the first month. Another system in an adjacent community had 1 week's promotion and had only 3,000 patrons in the first month. The second operation required more than 8 months to approach, on a patron per vehicle hour basis, the first operation.

A continual line of chatter with employees must be maintained. This includes maintenance and office personnel, who are a vital part of this service. Let them know that the service is important to the community.

Discussion

EDWARD FRANZEN: What is the relation of the passengers per vehicle trip and the type of vehicle used, such as a big bus or a taxi?

CLAUDE KLUG: We started out with 3 minibuses and then 3 vans. We like the smaller vehicles because there are so many cul-de-sac streets and people on the streets are not so bothered by the little vans. If DRT is working well, a bus should only have 2 or 3 people aboard it at one time, but people get disturbed when they see so few people on board. We did not use the cabs because we wanted to change the image of public transit. We have armchair seating so people can talk in a pleasant atmosphere.

DAVID SHILLING: The smaller vehicles are better received. We have 19-passenger buses in our system. Rarely are more than 5 people on a bus at any one time. The operating costs of the buses and the vans are approximately the same because the key factor is the labor involved. As a transit authority, we have to plan our vehicle requirements for the next 6 to 12 years to plan for the peak periods, and that is why we operate the larger vehicles.

MARCEL ZOBRAK: A taxicab is cheaper to run than a van, so a trade-off must be made. Many people who do not know each other do not like to sit close together as they must in a cab. On the other hand, the space needed for a van or small bus increases operating costs.

ROY HELSING: If goals and objectives are properly set, the vehicle size should be determined by those objectives. In Santa Clara County, one bus size does fixed-route and demand-responsive service.

ROBERT SCOTT: How long do you wait for a passenger and still fulfill the spirit of the service that you are trying to provide?

JOHN DAVIDSON: In El Cajon, we wait 1 minute.

CLAUDE KLUG: This is not usually a problem because of telephone communications. If the passenger is not there when the vehicle arrives, the dispatcher calls. If there is no answer, the vehicle goes.

DAVID SHILLING: In Orange County we wait 30 seconds. If the load allows, we will telephone them. If they say they will not be ready for another 5 minutes, we do not wait. A 1-minute delay at each stop for 15 or 20 passengers per hour during peaks can be serious. People are also induced to be prompt because of other people who are waiting. If you get a dirty look from the people on a waiting bus, the next time you will remember to be on time.

MARCEL ZOBRAK: I think it is important to establish a definite policy that the bus will wait only 30 seconds or 1 minute. And, more important, to enforce it. If you wait 2 or 3 minutes, then you are encouraging patrons not to be prompt.

ROY HELSING: A number of behavioral factors are involved in this door-to-door service. If you are going to wait only 30 seconds, do not get there 10 minutes early; get there 3 or 4 minutes early or no more than 2 minutes late.

ABRAHAM KHAN: Many senior citizens do not use taxicabs many times because of the rates. If you design a demand-responsive system exclusively or primarily for senior citizens, what type of initial marketing and promotion is required to overcome their reluctance to use taxicabs if a taxicab company operates the DRT system? Do you find that the operation is somewhat more expensive when done by a cab company than by the bus company or a private contractor who has no affiliation with the taxicab company?

JOHN DAVIDSON: Both cities I mentioned sell tickets for 50 cents. The driver picks up the tickets and handles no cash. So we make no special attempt to go after the senior citizens per se. When they find out that they can take a $2.75 cab ride for 50 cents, we have no difficulty with getting their patronage. The city in both instances handled all of the advertising and asked some of our people and some of their people to talk to the senior citizens clubs. They invited some of the senior citizen leaders to come into the dispatching office in San Diego.

CLAUDE KLUG: We use slack times during the day to give senior citizens free rides. We also had a senior citizens month during which they were given free rides. We charged a quarter at the start and we now offer a senior citizen pass for $4.00 a month.

WILLIAM MEGEE: What is the total customer-hour operating cost, including provision for vehicle replacement or depreciation? What are the hours of service?

JOHN DAVIDSON: In La Habra, our gross vehicle operating cost per hour is about $12.50, and that includes a depreciation factor for replacement of the buses after about 5 years. Our net cost per bus is about $8.95. If we owned rather than leased the vehicles, the cost would be slightly lower.

CLAUDE KLUG: Our operating costs are 65.5 cents per mile, not counting depreciation. We contract our operation but own the equipment. Our cost per passenger is $1.17.

JOHN DAVIDSON: In El Cajon, the city is charged 80 cents a mile for all the trips on DRT or the El Cajon express. In La Mesa we lease the vehicle (a 5-passenger sedan) with the driver to the city for $9.35 an hour. The city bought the vehicles because it had access to the Program 325 money, formed a transit district, and leased the vehicles to us for $1 an hour. So we really get $8.95 an hour from the city, but we pay insurance, dispatchers, and so on out of that operation.

JOE COOPER: In determining an area in which to operate DRT, have you used community meetings for input?

DAVID SHILLING: When we developed our DRT expansion plan, we established criteria based on needs of the elderly and unemployed and also on some factors such as activity centers. We knew approximately that we wanted to run manual systems and we had a feeling for a limitation on our capacity to do that. We presented our plan to our board of directors, and we had 2 or 3 public meetings. Because the cities are subsidizing DRT, service areas for manual control correspond to city boundaries. Large cities may be divided into 2 or 3 manual-control areas that could be aggregated for computerized control later.

CLAUDE KLUG: We do not get any Program 325 money. The transit district did its studies, had public hearings, and informed us that La Mirada had no need for transit. Our answer is that, for an area that did not need any transit, we carried 110,000 people the first year of operation.

EDWARD FRANZEN: Have standard-sized station wagons, which have room for baby strollers and can comfortably seat 5 people, been used for DRT?

CLAUDE KLUG: When we started out we thought we needed 6 vehicles, and we bought 4 and used my station wagon as the backup vehicle. In the first month of operation, 2 of the vehicles were down all the time, so my 9-passenger station wagon was in use. But the question is, How much comfort and convenience do you want? Jamming 9 people in a station wagon lowers the level of service. It worked, but I certainly would not recommend it.

EARL COVEY: Why have you stressed service so strongly and have not stressed the cost of DRT?

CLAUDE KLUG: I said that we spent $100,000 a year of general fund money on DRT. But again, this service like all other services is expensive. Police and fire departments, sewers, and roads are all subsidized, and transit is just another public service. It is ridiculous to build swimming pools in parks and not have ways for people to get to them. So I consider transit to be another municipal service, but it is not free and it is expensive.

JOHN DAVIDSON: When we started DRT in El Cajon, we were giving fast service—so fast in fact that we were hauling only 1 person per trip. We were running cab service there too, and DRT was faster than the cabs. So we had to deliberately slow down. The cost per passenger to the city is about 65 cents a person. I agree that transportation is beginning to be thought of as another service like sewers, water, and fire and police protection.

CLAUDE KLUG: One thing that I as an administrator like about DRT is that you can turn it off and on. You cannot do that with a fixed-route system. We can cut down ridership any time by just slowing the level of service. The longer the response time is, the more ridership begins to fall off.

GEORGE GRAY: Many of the social programs have transportation costs built in them, but they are not identified—they are charged against the social program. A large part of the costs of the hot-meals program, for instance, is for transportation. If all of these costs in all of the programs can be identified as the transportation element and another associate program established, we may end up saving money.

IMPLEMENTATION AND OPERATION OF INTEGRATED TRANSIT SERVICES

Gordon J. Fielding and Susan B. Grant, Orange County Transit District, California

In July 1974, the Board of Directors of the Orange County Transit District approved an 8-month study to plan the expansion and implementation of demand-responsive transportation (DRT) in Orange County. The plan selected and assigned priorities to those areas of the county with the greatest need for DRT service. The study outlined a short-range and medium-range expansion plan. The short range deals with implementation during the next 2 years, and the medium range deals with needs through 1980.

Significant aspects of the short-range effort include the processes for selection of the next areas to receive DRT service and the development of preliminary system designs for the selected areas. Area selection was directed by the following guidelines: serve those most in need, distribute OCTD services equitably, and use resources effectively.

Initially, 27 feasible DRT service areas were defined (Table 1). Area definition criteria, given below, restrict the number of possible ways of drawing boundaries and constrain the area and population size encompassed by the boundary.

1. Community service area boundaries should coincide with one of the following, listed in order of preference: city boundary, LARTS traffic zone, census tract, river, freeway, rail line, and major arterial.
2. Community service area should contain more than 8,000 but fewer than 32,000 households.
3. Community service areas should be greater than 6 but fewer than 22 miles^2 (57 km^2) in size.
4. Community service areas should have at least 2 OCTD fixed routes serving the area and at least 20 one-way miles of service beyond their boundaries.

The second stage of the area selection process involved screening the 27 manually controlled areas to determine those most in need of additional service. A measure of the amount of existing and proposed fixed-route services in each area was selected and a cutoff value was established. Areas with less service than the cutoff value were considered for subsequent ranking, and areas with more service were not considered further.

Service was measured in terms of route-miles (km) per 10,000 persons. The value represents the amount of service that might reasonably be expected from a transit system in its early stages of development with the given land use patterns in the county. Simultaneously it permits enough areas to pass the criterion so that subsequent application of criteria corresponding to other guidelines is meaningful. Table 1 gives the service measure values of the feasible areas and identifies those areas selected as candidates for manually controlled DRT service.

The third stage of the selection process involved ranking the 8 candidate areas according to criteria indicative of the need for and effectiveness of public transportation

Table 1. Feasible demand-responsive transportation service areas.

Area	Population	Households	Area Size (miles^2)	Route-Miles per 10,000 Persons	Selected Candidate Area
Anaheim, Central	70,056	22,320	9.7	3.97	
Anaheim, East	51,562	16,974	10.3	5.62	
Anaheim, West	52,560	16,755	7.3	2.51	
Buena Park	56,766	16,081	10.0	2.15	X
Costa Mesa	78,454	25,723	16.0	4.79	
Cypress-La Palma	57,078	14,794	7.0	1.79	X
Fountain Valley	50,214	12,792	9.6	2.63	
Fullerton	85,578	26,764	21.7	2.89	
Garden Grove, East	80,399	23,268	9.4	3.22	
Garden Grove, West-Stanton	74,572	21,689	7.3	2.60	
Huntington Beach, East	70,029	20,514	13.6	2.30	X
Huntington Beach, West	77,725	22,338	10.1	1.70	X
Irvine	23,400	8,141	6.3	13.25	
Laguna Niguel-Laguna Beach-South Laguna-Moulton Ranch	33,220	10,395	12.8	5.30	
La Habra-Brea	65,975	19,182	11.2	2.09	X
Los Alamitos-Seal Beach-Rossmoor	36,715	13,769	10.6	6.54	
Mission Viejo-El Toro-Aegean Hills-Leisure World	66,176	11,798	15.8	2.78	
Newport Beach	53,276	21,985	14.6	7.30	
Orange, North-Peralta Hills-Villa Park	36,893	10,835	13.0	3.79	
Orange, South	57,516	17,087	9.6	2.10	X
Placentia-Yorba Linda-Other	54,985	13,739	21.2	4.64	
San Juan Capistrano-Dana Point-Capistrano Valley-San Clemente	45,950	12,516	13.7	4.87	
Santa Ana, North	68,649	20,883	10.2	4.66	
Santa Ana, Southeast	52,599	16,004	8.1	5.65	
Santa Ana, Southwest	51,974	15,875	8.1	2.73	
Tustin Foothills-Tustin	48,061	14,543	10.6	2.35	X
Westminster	69,583	17,566	10.7	2.01	X
Total	1,555,184	464,330	309.5		

Note: 1 mile^2 = 2.6 km^2.

Table 2. Ranking of selected candidate DRT service areas by 5 criteria.

	Young and Elderly			Households Without Automobile			Households With One Automobile			Route-Miles per 10,000 Persons			Daily Expected Patronage per 10,000 Persons			All Criteria		
																Percentile Score		
Area	Percent	Percentile Score	Rank	Percent	Percentile Score	Rank	Percent	Percentile Score	Rank	Number	Percentile Score	Rank	Number	Percentile Score	Rank	Total	Final	Rank
Orange, South	40.2	63.2	3	6.1	100.0	1	37.0	96.8	2	2.10	38.5	5	21.2	100.0	1	389.5	100.0	1
Huntington Beach, West	45.4	100.0	1	3.0	36.7	4	34.6	71.6	4	1.70	100.0	1	15.9	53.5	6	361.8	85.5	2
Buena Park	41.6	70.3	2	4.3	63.3	3	37.3	100.0	1	2.15	30.8	6	17.5	67.5	4	331.9	73.7	3
La Habra-Brea	38.9	49.2	6	4.4	65.3	2	33.2	56.8	6	2.09	40.0	4	18.1	72.8	3	284.1	55.1	4
Westminster	38.8	50.3	5	2.9	34.7	6	35.9	85.3	3	2.01	52.3	3	14.5	41.2	7	263.8	46.9	5
Huntington Beach, East	35.1	24.5	7	3.0	36.7	4	33.8	63.2	5	2.30	7.7	7	16.2	56.1	5	188.2	17.1	6
Tustin Foothills-Tustin	32.6	0.0	8	2.6	28.6	7	31.6	40.0	7	2.35	0.0	8	19.5	85.1	2	153.7	3.5	7
Cypress-La Palma	40.1	58.6	4	1.2	0.0	8	27.8	0.0	8	1.79	86.2	2	9.8	0.0	8	144.8	0.0	8

in each area. Five criteria or measures were used in the ranking process:

1. Percentage of area population under 16 and over 64 years of age,
2. Percentage of area households without an automobile,
3. Percentage of area households with only 1 automobile,
4. Expected DRT patronage per capita [patronage estimation is summarized in Appendix B of the report (1)], and
5. Miles of fixed-route service per capita.

All areas were first ranked according to each criterion by converting the 8 raw measures corresponding to a criterion into percentiles. This conversion assigned a 0 percentile score to the worst of the 8 candidates and 100 to the best. Those in between received percentile scores proportional to their measure. The 5 percentiles for each area were then summed to give an overall area measure that was then used in establishing rank. The results of applying the ranking criteria to the 8 candidate service areas are given in Table 2.

On the basis of purely technical considerations, service should be implemented in the selected areas according to their suitability. But because of a policy requiring each city to contribute one-third of the operating deficit, it was recommended that service be initiated in an entire municipality rather than in only a portion of a municipality.

Based on this consideration and the recognition of the obligation to keep the implementation sequence as similar as possible to the suitability ranking given in Table 2, the following implementation was recommended and approved:

1. Orange,
2. Huntington Beach,
3. Buena Park,
4. Brea,
5. Westminster,
6. Tustin, and
7. Cypress-La Palma.

The city of Fullerton was later added to the list to be implemented after Cypress-La Palma as funds and vehicles become available.

PRELIMINARY SYSTEM DESIGN

A countywide DRT fare of 50 cents cash was established. Three children 6 and under may ride free when accompanied by a fare-paying passenger. Some type of discount fare may be established to encourage daily commuters.

Service hours will initially be the same in each area, but subject to change according to the requirements for each individual service area: 7 a.m. to 7 p.m., Monday through Saturday.

Emphasis will be placed on integration of DRT with existing fixed-route services. Patrons will be encouraged to use DRT as a feeder to the fixed-route services; as DRT service expands, the fixed-route schedules will be developed into express services through each DRT service area.

In general, the number of vehicles required to provide DRT service depends on the area size, the level of service desired, and the demand rate (1, Appendix C). Table 3 gives the estimated patronage, fleet size, and vehicle hours for the DRT areas. In all, including the 7 vehicles currently operating in La Habra and the 20 vehicles for Fullerton, 107 vehicles will be required to implement the first phase of the expansion program.

Commuter service will be encouraged within and between service areas. Essentially, any concentrated employment center located in one service area that employs a minimum number of people residing in that area or in another DRT service area will be encouraged to contract with OCTD to provide commuter service for its employees. The DRT bus will pick up the employees at their homes (gather) if concentrations can

Table 3. Fleet size, vehicle use, and vehicle productivity in feasible and selected candidate DRT service areas.

Area	Expected Patronage: Daily	Expected Patronage: Peak Hour	Expected Peak-Hour Demand	Fleet Size: In Service	Fleet Size: Spare	Fleet Size: Total	Vehicle-Hours: Weekday	Vehicle-Hours: Saturday	Vehicle-Hours: Annual	Passengers per Vehicle-Hour
Anaheim, Central	1,606	146	93	9	2	11	100	60	29,210	16.1
Anaheim, East	1,212	110	70	9	2	11	100	60	29,210	12.1
Anaheim, West	1,097	100	64	7	2	9	78	47	22,724	14.1
Buena Park*	994	90	58	8	2	10	88	53	25,636	11.3
Costa Mesa	2,014	183	117	14	3	17	154	93	44,875	13.1
Cypress-La Palma*	588	51	33	5	1	6	56	34	16,328	10.0
Fountain Valley	686	62	40	7	2	9	78	47	22,724	8.8
Fullerton	2,063	188	120	16	4	20	176	106	51,272	11.7
Garden Grove, East	1,472	134	86	9	2	11	100	60	29,210	14.7
Garden Grove, West-Stanton	1,305	119	76	7	2	9	78	47	22,724	16.7
Huntington Beach, East*	1,134	103	66	10	2	12	110	66	32,032	10.3
Huntington Beach, West*	1,239	113	72	9	2	11	100	60	29,210	12.4
Irvine	529	48	31	5	1	6	56	34	16,328	9.4
Laguna Niguel-Laguna Beach-South Laguna-Moulton Ranch	807	73	47	9	2	11	100	60	29,210	8.1
La Habra-Brea*	1,193	108	69	9	2	11	100	60	29,210	11.9
Los Alamitos-Seal Beach-Rossmoor	1,045	95	61	8	2	10	88	53	25,636	11.9
Mission Viejo-El Toro-Aegean Hills-Leisure World	883	80	51	10	2	12	110	66	32,032	8.0
Newport Beach	1,611	146	93	12	3	15	132	80	38,480	12.2
Orange, North-Peralta Hills-Villa Park	811	74	47	9	2	11	100	60	29,210	8.1
Orange, South*	1,222	111	71	8	2	10	88	53	25,636	13.9
Placentia-Yorba Linda-Other	973	88	56	13	3	16	144	87	41,964	6.8
San Juan Capistrano-Dana Point-Capistrano Valley-San Clemente	863	78	50	10	2	12	110	66	32,032	7.8
Santa Ana, North	1,875	170	109	10	2	12	110	66	32,032	17.0
Santa Ana, Southeast	1,260	115	74	8	2	10	88	53	25,636	14.3
Santa Ana, Southwest	1,361	124	79	12	3	15	132	80	38,480	10.3
Tustin Foothills-Tustin*	937	85	54	8	2	10	88	53	25,636	10.6
Westminster*	1,011	92	59	8	2	10	88	53	25,636	11.5
Total	31,761	2,886	1,846	249	58	307	2,752	1,657	802,313	11.5

*Selected candidate area.

Figure 1. Phasing of DRT expansion program.

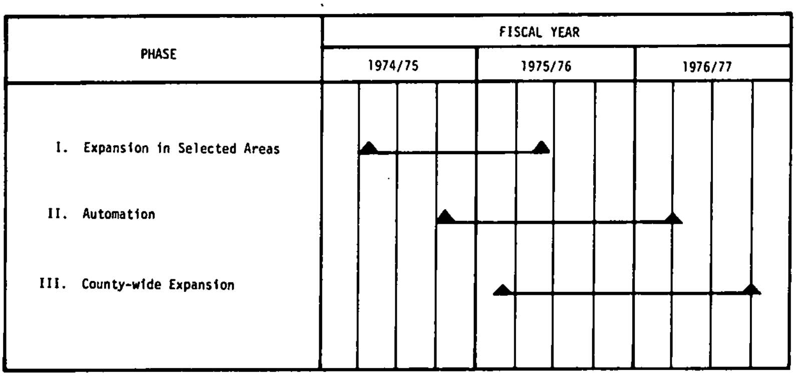
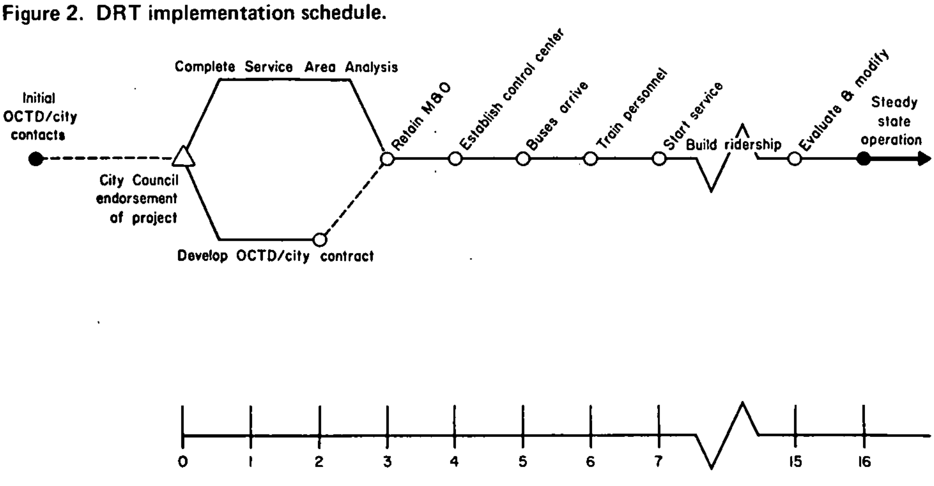


Figure 2. DRT implementation schedule.



be identified, take them by DRT express to the employment center, drop them off at several stops around the center (scatter), and thus provide a type of dual-mode service.

Park-and-ride is another alternative. Combined with DRT, people can move from one central location in the origin service area to the destination service area where they can be either scattered around the employment center or dropped off at a transfer point where another DRT bus picks them up and scatters them.

IMPLEMENTATION

The preliminary implementation schedule for DRT services in Orange County consists of 3 phases (Fig. 1): expansion in selected areas, automation, and countywide expansion. By June 1975, 107 DRT vehicles will be in service in various parts of the county. By April 1976, all of those vehicles and others are scheduled to be under computer control. By April 1977, DRT service is scheduled to be available to nearly every resident of Orange County. The implementation process requires a multitude of projects from designing equipment specifications to locating sites for the storage of vehicles and fuel.

Equipment

In May 1974, a $1.6 million amendment to OCTD's capital grant was approved by the Urban Mass Transportation Administration for the purchase of equipment for the DRT expansion. After a careful review was made of a large assortment of transit-related equipment available on the market, specifications were drawn up covering vehicles, communications equipment, fare boxes, tow trucks, service trucks, supervisors' automobiles, shop equipment, control center furniture, and bus stop signs. Concurrently, the OCTD Board of Directors approved the expansion plan and authorized its implementation in July 1974.

Subsequently, requests for bids went out for the vehicles, communications equipment, and fare boxes. Equipment arrived in April 1975, the start-up date in the city of Orange, the initial site for DRT expansion.

Communications

The Orange County Communications Department provided OCTD with technical assistance in writing communication systems specifications, with installations, and in the maintenance of all communications equipment. The communications equipment consists of UHF base stations and 2-way mobile units with a multiplex channel capacity large enough to meet all present and anticipated future transit district requirements, including a future digital communications system and computerization. This system will use base station sites and microwave links, which are also part of the fixed-route system.

As implementation proceeds for the 8 sites, OCTD will initially use 2 mountain-top UHF base stations, 1 UHF base station located centrally at the Orange County Communications Department, 3 microwave terminals, and 1 microwave repeater. As expansion develops and as interference problems may increase, base stations and terminals located at the individual sites will be installed. Because the 8 sites will be sharing only 3 frequencies, squelch tone will be necessary. For future digital communications and computerized dispatching, the mountain-top equipment can again be used, for digital communications use less air time for all 8 sites than manual communications.

For smaller DRT systems, shared use of a public works or motor carrier frequency is an alternative to the application to the Federal Communications Commission for a separate frequency. At OCTD's existing DRT site in La Habra, the VHF frequency of the Department of Public Works is being shared with OCTD. As OCTD expands the service to other areas, the service in La Habra will be shifted to UHF.

Cities Involved

Each city involved in the expansion program must be contacted and involved in the preliminary planning. The cities involved have been asked to contribute one-third of the operating deficit of the system operating in the city. This will make expansion possible into more cities than if the district were to finance the systems exclusively. Figure 2 shows the schedule of implementation. Each city council must formally endorse the DRT service and agree to pay one-third of the operating deficit before system planning will begin. A service area analysis for each area will be undertaken to pinpoint specific characteristics of the area that may affect the service design. Trip patterns, employment, clusters of the young and elderly population, trip attractors, and other service area characteristics will be analyzed. Because of the flexibility of DRT, changes from the basic many-to-many service are possible and encouraged to accommodate unique features of each particular service area. This analysis will take place concurrently with negotiations with the cities and the managers and operators.

A contract with each city has been drawn up and designed according to each individual city's service needs. Basically the contract will outline the service to be provided by the district, a formula for the determination and payment of the one-third operating deficit subsidy by the city, and the in-kind services each city is responsible to provide.

As much as possible, the cities will be asked to provide the control center and furnishings, parking for the vehicles and visitors, storage for fuel, cooperation from its local public works department, and advertising and promotional assistance. OCTD will encourage fare subsidy contracts with the cities and with private employers.

Managers and Operators

Managers and operators for the individual service areas were selected by the OCTD Board of Directors in January 1974, when the La Habra operation contract was opened to competitive bidding for the second year. The first year's operator was maintained, and 3 of the other 4 bidders were chosen to operate subsequent DRT service areas to be implemented in the expansion. Each operator will be asked to manage and to operate 1 or more modules for a minimum of 1 year, after which the operation will be opened to a competitive bid each subsequent year.

Four or more operators will operate the 8 service areas to be implemented. Each one will operate service areas in a common computerized area to avoid duplication of control room space and supervisory personnel.

A standard contract with the operators has been drawn up and will be revised to include their particular needs and those of OCTD. Basically the contract outlines the type of service to be provided. Each operator will be given a fee partially fixed and partially incentive. There will be standards by which the quality and effectiveness of each operation can be measured. Maintenance of the equipment can be undertaken in 1 of 4 ways depending on the individual operator's capabilities, proximity of the service area to the OCTD maintenance facility, and services available in the local community.

1. All minor and major maintenance can be handled by OCTD. Mobile maintenance units can travel to the DRT sites to do on-site preventive maintenance. Major work can be done at the OCTD main facility.
2. Minor work can be handled by OCTD's mobile maintenance units, and major work can be done by the operator or a local dealer.
3. Minor work can be handled by the operator, and all major work can be done at OCTD's main facility.
4. The operator can lease OCTD's mobile maintenance units or hire the units and do all minor work. All major work can be done by a dealer.

Each operator will be required to fill out weekly fuel, passenger, and revenue summaries; monthly reports describing ridership, monthly occurrences, use of vehicles, service characteristics, mileage, costs, and revenues; and quarterly reports describing level of service, demand characteristics, trip patterns, peak-hour patterns, vehicle productivity, and other characteristics indicative of the level of service. All of these data can be obtained from the trip tickets filled out for each trip. Evaluation of each operator will be based on these reports and weekly supervision by a district employee. The district will analyze all costs, ridership, mileage, and vehicle-hour statistics in a detailed monthly cost analysis. The data of each service area will be normalized to provide a basis for comparative evaluations.

Training and Evaluation

The district will develop a training contract with a private firm for the training of the personnel for the first phase of the expansion. As funds become available for a county-wide expansion, OCTD will acquire its own training staff, who will maintain the constant and careful evaluation of each operation.

The training program will consist of careful aptitude and general intelligence testing of all applicants. Operating procedures manuals will be made available containing information in the areas of safety, management information, maintenance, and service operation. Each comprehensive 2-week training period will emphasize dispatching techniques, area familiarization and street layout, communications procedures, public relations, and simulation of actual service. Each site will be supervised during the initial service. Each operator will take full responsibility of his or her own operations on OCTD approval of the recommendation of the training supervisor.

The evaluation program will consist of a monthly overview of each operation and a detailed analysis of 1 day's operation taken from data from trip tickets, drivers' sheets, and revenue and passenger summaries. Dispatching techniques and driver safety habits will be carefully scrutinized to ensure the accurate pickup and delivery time estimations, the efficient routing of the vehicles, and the safety of passengers. The level of service will be analyzed by determining average wait and ride times and vehicle productivity. Data from each service area will be normalized to establish a comparative analysis among service areas. Normalization of data will be developed from each particular service area's individual characteristics (population, density, trip attractors, income levels).

A careful review of management will take place monthly. The attitudes of the drivers and the controllers are largely the product of positive or negative direction from the manager, and day-to-day operations usually reflect those attitudes. Operational efficiency can be effected by employee attitudes, especially in DRT, which has close public contact. This attitude can encourage or discourage potential patronage.

Marketing

Promotion of each individual DRT service is essential to its success. The district will work with each city to provide direct mail brochures, newspaper coverage, and visibility through bus signs and benches. Marketing representatives will be used to promote the service in major shopping and commercial centers. Private businesses will be contacted to help promote DRT service by distributing brochures and discount ticket books. Informing the public of this service but not overselling it is one of the most difficult tasks of system operation. An initial heavy demand for service that cannot be met can lower the level of service. A slow evolution to peak capacity is desirable; as they gain experience, operators are better able to handle rush hours. The most important element in the promotional campaign is the encouragement of DRT as a feeder into the fixed-route services.

CONCLUSION

The entire implementation process contains a multitude of tasks required in the preparation of a steady-state operation of all 8 systems. At that time, a full-scale evaluation program will be undertaken. Up until that point, OCTD management will be preparing contracts, arranging control center sites, registering vehicles, overseeing training programs, and reviewing procedures for managers and operators. The development of OCTD's DRT system represents one part of an innovative and aggressive program to provide the public with new and better transportation service.

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Nigel H. M. Wilson and B. Trevor Higonnet, Massachusetts Institute of Technology

For integrated DRT and conventional transit systems, the issue of control is considerably more important than for single-module DRT systems. On the one hand the control problems are more difficult, and on the other hand more capital-intensive solutions can be considered because of the large number of vehicles under control. Unfortunately, because of the limited number of existing systems, drawing conclusions based on actual operation is difficult, although such information will soon become available from Ann Arbor and Santa Clara, in particular. This paper reviews the major control functions required and presents the alternatives that have been or are being implemented or are realistic possibilities for the near future.

The control problem may be subdivided into information transfer and decision-making functions. Decision making is related to the operation of DRT vehicles, and information transfer is related to service requests and vehicle activities. To facilitate decision making requires an information base that is continually maintained by incoming and outgoing information flows. The nature and extent of these functions depend on the operational characteristics of the service. The range is from highly decentralized decision making with minimal information flows, such as in many of the Canadian systems, to the highly centralized system proposed for expansion in Rochester. In general, the greater the degree of decentralization is the less is the need for sophisticated and expensive equipment, but the more limited is the flexibility of the system and the service.

INFORMATION TRANSFER FUNCTION

The following information transfer functions can be identified: service request (from customer to control center), driver instructions (from control center to driver), and driver progress (from driver to control center).

Service Request

In general a customer may request service either from a low-volume (e.g., home) or high-volume (e.g., shopping center, transfer terminal) location. In both cases the mechanism used will be the telephone system—in the low-volume case, general purpose lines with a standard headset and in the high-volume case probably leased lines and possibly a special input device. At the present time no digital input service request device is in use. This innovation, which would require computer control, would decrease the number of telephone operators for large systems, but is unlikely to be widely available for several years.

For integrated systems another service request option is receiving the request from the driver of a conventional fixed-route bus. This is a convenience for the passenger, who simply tells the driver the desired transfer point and ultimate destination. This requires communication either between the conventional dispatcher and DRT operators or between conventional transit drivers and the control center. Operationally either of these options may prove awkward or expensive or both, but the preferred alternative is to have direct communication between the DRT control center and the driver of any bus on a route interfacing with DRT.

Driver Instructions

Independent of whether decision making is centralized or decentralized, information on vehicle assignments must be transferred from the control center to each driver. Unless the system can be decomposed into separate subsystems, each with its own many-to-one service and with the control function at the center, radio channels are used for this information transfer. The main design choice is whether to use voice or digital information on the radio channel. Although the great majority of existing DRT (and taxi) operators now use voice communication, digital communication will become the usual option for large integrated systems because of the amount of information that has to be transferred. Digital communication is preferred basically because of the more efficient use of radio channels possible over voice transmission. To illustrate this potential, the Diamond Taxi Company of Montreal reports dispatching as many as 300 cabs per channel with its Canadian Marconi computer-controlled radio system and only 50 to 100 cabs per channel with voice communication. Of course, the amount of information passed per vehicle-hour is lower in standard taxi operations than in DRT operations, but this improvement illustrates the potential.

Although the basic information to be sent from the control center to the driver involves passenger addresses, on occasion specific additional information, such as best routing to next stop, may have to be sent. All nonstandard messages such as this would be by voice communication for the foreseeable future. The impact of digital communication then is not to eliminate dispatchers but to reduce the required number of dispatchers for large systems. To realize this reduction requires an automatic interface between the digital transmitter and a computer, which as a minimum stores all addresses. The Diamond Taxi Company system mentioned above uses such an interface; the computer is responsible for allocation and control of mobile radios and radio channels. Even though voice communication is used for all driver messages, considerable manpower saving is reported through use of this computer-dispatch operation with digital radio control.

If addresses are encoded and transmitted digitally, some on-board decoder and display unit is required. Although relatively new in DRT operations, such mobile displays have been in use for several years, most notably in police operations. The type of device available tends to be either a printer (hard copy) or alphanumeric display (soft copy). In the Rochester DRT system, digital communication is used in conjunction with mobile printers. The system operates without a computer in the control center; a card reader is used to transmit addresses to drivers. In this case the communications system has functioned well from the operator's and drivers' viewpoints, and some increase in system performance is attributed to digital communications even though no manpower savings resulted.

In the planned Santa Clara integrated DRT and fixed-route system, digital communications will be used in conjunction with mobile displays and an automatic interface with a computer used for dispatching.

At the present time, the state of the art in mobile displays is evolving rapidly, and clearly lower cost and higher performance terminals will be available within the next few years.

Driver Progress

The basic information the driver sends to the control center is the status of his or her progress. This is required if the control center is responsible for assigning future vehicle activities, but may not be required if a less centralized driver-based decision-making structure is used. For example, in many large taxi operations, requests for service are advertised to all drivers, and the dispatcher need not be aware of the status of each vehicle since there is no central decision-making role. Similarly in zonal DRT systems, the driver may have complete responsibility for deciding on the sequence of stops to make, and the dispatcher may just have to transmit new service requests from that zone, i.e., no feedback from the driver may be necessary.

More generally, however, the dispatcher will need to be aware of vehicle progress in order to make good decisions. This information is generally based on a driver's either making a stop or completing a set of stops previously sent out. This may be digital or voice; most existing systems use voice, but digital is becoming more attractive for larger systems. The Rochester DRT system, a hybrid, has the driver send a digital message whenever a stop has been made.

In these cases only 1 digital message is available to the driver, but equipment is now available for several distinct driver functions. Additional digital functions that could be used for all or that would otherwise be carried out by voice include passenger no-show and request driver breaks.

DECISION-MAKING FUNCTION

The decision process in integrated DRT and conventional systems can be divided into several functional categories:

1. Control of the simple DRT (no interaction with conventional transit),
2. Control of the conventional system (no interaction with DRT), and
3. Control of transfer trips (where both modes are used).

An important consideration that applies to all is that of centralized or decentralized control, which is a characteristic rather than a function.

Control of Simple DRT

Many systems now provide simple DRT service, usually in the context of single-module DRT systems, but there are some that are integrated with conventional transportation. Regina and Ann Arbor are prominent examples. This paper only generally describes the basic control issues involved and does not describe even a few existing systems. The control issue is to pick a vehicle to which the demand for transportation can be assigned and which provides the user with good service but does not commit so much of the system resources as to make future service unacceptable. The basic issues for such a control system are manual or automatic decision making, extent of future planning and commitment, and decentralization of decision making. In spite of the wide scope of these 3 issues, they are fundamentally independent.

Manual decision making has been demonstrated in numerous DRT systems, indeed in all except Haddonfield, which uses a computer to make all decisions during those hours of computer operation. In such systems, the dispatcher, given the customer's origin and destination, picks a vehicle that, on the basis of the dispatcher's previous decisions, will not suffer an excessive detour. In a completely automatic system, of which Haddonfield is the only example, the computer program accepts street addresses, translates them to internal coordinates, and uses an assignment algorithm to pick the "best" vehicle for that trip. The primary function of the people operating such a system is to present the computer with the basic information about the request rather than to make decisions.

There is of course a middle ground, and that is to have a computer or other equipment aid in manual dispatching either by handling the task of moving information from one point to another (e.g., from the telephonist receiving the request to the dispatcher making the decision) or by participating in the assignment by selecting a few likely vehicles that are then chosen manually. An example of the former case is the control room equipment soon to enter operation at Ann Arbor. It is designed to reduce the clerical and mechanical effort of personnel and to free them for decision-making roles. The latter case is best exemplified by the control equipment of Los Angeles Yellow Cab in which vehicles are offered to the dispatcher who picks the best one. Finally, there are 2 systems in which the assignment is automatic but address information is not given directly to the computer: Zone information is added by the telephonist, and the computer makes decisions based on these zone data. Both Diamond Cab in Montreal and the impending Santa Clara systems use this approach.

The extent to which a decision once made commits future performance of a system is an important aspect of DRT. For example, one can decide that the current customer will be picked up by a given vehicle without determining when or after whom that customer will be served. At the other extreme, decisions planning all stops in both order and time can be made for each customer as he or she calls for service. The former case is most frequently found in those systems that are decentralized to the extent that the vehicle driver decides the order of stops for those customers assigned to his or her vehicle, but this is not always true. In Ann Arbor, for example, the dispatchers typically establish a sequence for a DRT tour just before a vehicle is set to make a series of stops, the requests for service having been made long before. The case in which there is a strong future plan is best typified by the Haddonfield computer operation in which the sequence of stops once decided is rarely changed except through addition of new stops. Current analysis of Haddonfield operation indicates a need to relax this policy somewhat but without changing it fundamentally. In general, the extent of future planning and the firmness of that future plan can have significant repercussions on the manner and frequency of communication between the control center and vehicle drivers.

The degree to which decisions are made centrally can vary greatly. Usually, though by no means always, the more decentralized the decision making of a DRT system is, the more manual decisions are made. In many DRT systems that operate on a zonal basis, the driver in a zone is given a customer request and is left free to service it when he or she deems best. In such a case, the control center makes only part of the assignment decision, and the driver makes the smaller, final decision. Decentralized decision making can also involve review of decisions already made. In Ann Arbor, the dispatcher normally sequences DRT trips, but drivers may pick an order other than that determined for them. Conversely, by its very nature, a highly centralized decision process leads rapidly to the use of automatic equipment, for people have difficulty making all (or even most) of the decisions affecting numerous customers and a large fleet of vehicles. However, the ability of a computer to centralize information and decision-making rules makes automation and thus centralizing the DRT control process attractive. The best example of this is the computer at Haddonfield, which ordinarily does not allow, and in fact discourages, autonomous decisions by drivers and allows control center personnel to make decisions only in special cases (e.g., whether to wait for a customer who is late).

Control of Conventional System

Control of the conventional transit service is already well-known as the use of the word "conventional" implies. One can, however, envisage some small changes that might prove beneficial to integrated DRT and conventional systems and that would not change the conventional elements so much as to make them unrecognizable. Such a change, such as automatic means of determining the progress of a vehicle along a fixed route, might be invisible to the user and most of the system's personnel. Another change that might come about in integrated systems is varying the timetable of fixed-route services on a demand-responsive basis. Neither of these suggestions is new, but they might find considerable application in integrated systems.

Control of Transfer Trips

Control of transfer trips in integrated systems is the most challenging aspect of integrated systems, for it is obviously the core of the integrated nature of the system and the procedures for effecting these transfers have not been put to the test for want of integrated systems. Perhaps the best issues to use in analyzing this function are

1. The extent of information pertinent to one subsystem known to the other subsystem and
2. The extent of dependence of one subsystem on another.

A relatively simple way of integrating DRT with conventional transit is to establish a set of transfer points on the conventional routes where transfer passengers are deposited by DRT vehicles on the first leg of the journey and are picked up by DRT vehicles for the final leg (unless the trip ends at a transfer point located at a shopping center, for example). This can be done without knowledge of the fixed-route schedule (and, consequently, without knowledge of the time at which the second DRT leg will or should commence). Such a procedure is that planned for transfer trips in the Santa Clara system for those trips that cannot be served by a single DRT vehicle. In such a case, the control center need only inform the passenger of the appropriate fixed route to take and the place to best resume the DRT mode. Simply stated, the control procedure is to operate the conventional service and DRT service as independent systems.

It is possible, without modifying the conventional service as suggested in the discussion of non-DRT trips, to make more use of knowledge of the conventional service. In particular it should be possible for the DRT subsystem, be it manual or computer controlled, to know both the routes and schedule of the other subsystem. Such information would permit the DRT subsystem to provide equally good service (meeting the same fixed-route bus) at lower system cost (by not attempting to get the customer there as soon as possible if this is useless). In addition, knowledge of schedules would, in large complex systems, permit one of several fixed routes to be chosen as a function of the schedule of each. The proposed Rochester demonstration, which will include a fixed route connecting 2 DRT modules, plans to use such a technique, which has been developed in connection with the existing computer algorithm evolved by M.I.T.

Knowledge about the conventional subsystem can yield an unexpected benefit in the DRT subsystem. If as described above the DRT controller has cognizance of the fixed-route schedule, the same DRT controller has knowledge of the desired starting time of the second DRT leg. That is, the second DRT trip can be planned well in advance of the arrival of the passenger at the second transfer point. In such a case, the transfer can be made much less painful and discouraging by either having a vehicle wait for the passenger or arrive shortly after the passenger arrives. Such a procedure obviously presupposes that the 2 DRT modules are controlled jointly or have good means of communication. The Rochester demonstration, in which the 2 DRT modules in question are controlled by 1 computer program, expects to take advantage of such information.

In the preceding section on integration, complete autonomy of the 2 systems (but not complete ignorance) was assumed. The operations of the 2 subsystems can be meshed more closely. Since bringing the conventional subsystem under direct control would deprive it of its "convention" character, this section will be restricted to adapting the DRT subsystem to the conventional one. The best examples of such organization are Regina and Ann Arbor. In those systems, DRT vehicles are constrained to loop through a transfer point on the same schedule as the fixed-route buses. In other words, as long as the DRT vehicle is present at the transfer point when the line-haul vehicles are, integration requirements have been met. At all other times, the DRT vehicle is free to service many-to-many trips as well as to collect passengers planning to transfer at the next junction of the 2 types of vehicles. As Karl Guenther of Ann Arbor described it, "The schedule of the fixed-route buses is the gear which drives the other satellite (dial-a-ride vehicles) gears." Though this limits the freedom of action of the DRT vehicles, it makes the transfers efficient and is well suited to a decentralized operation, which is manually tractable.

As might be expected, the novelty of integrated DRT and conventional transit system services is responsible for the small number of implemented or even planned control procedures. There is little doubt that, after as much experience in the field of integrated systems has been garnered as has already been garnered in the field of simple DRT, more control procedures will appear as different groups attempt to solve the integration problem. Nonetheless, considerable work has been done, and some avenues, which appear promising, give the prospect of more integrated systems for the future.

TRANSPORTATION FOR THE ELDERLY AND THE HANDICAPPED

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By the middle of 1973 the Ontario Government was receiving an increasing number of deputations from various handicapped groups drawing attention to the services unavailable to the handicapped but considered essential by the rest of the population. Consistent among these requests was a desire for improved transportation. A cursory review of the situation indicated that this had the potential of being a costly program. To convert Toronto's existing subway stations to be accessible to the handicapped would cost $23 million. We decided, therefore, that a closer look at the situation was required. During early 1974, a number of surveys in different areas of the province were undertaken.

SURVEY OF THE PHYSICALLY HANDICAPPED

When one deals with the physically handicapped, the first thing that becomes apparent is the uncoordinated nature of their organizations and activities. Each physically handicapped group, for example, cerebral palsy or multiple sclerosis, has formed its own organization, and to find a single body able to act or speak for all handicapped groups is difficult.

As a result of surveys undertaken in 6 Ontario cities ranging in population size from 35,000 to 2 million, an assessment of the size of the physically handicapped population was obtained. No other community or social service agency already dealing with the handicapped could supply these data. The physically handicapped population identified in the survey were classified into 3 groups: those who cannot use existing public transportation facilities; those who can use public transportation with difficulty; and those who can use public transportation with no difficulty. The data from the 6 cities surveyed were extrapolated to the rest of Ontario (Table 1). Approximately 1.3 percent of the population in urban centers in Ontario cannot use public transportation, and a further 1.7 percent use it with difficulty. I will confine the rest of this paper to dealing with the group of 70,000 persons who cannot use public transportation. This group is made up of 16,000 persons who require a special vehicle, that is, with a ramp or hoist, and 54,000 persons who could be driven in an automobile.

CHARACTERISTICS OF THE HANDICAPPED

Interviews and a mail survey were used to determine some of the economic and travel characteristics of the handicapped (Table 2). The average family income is low; between 66 and 69 percent of the respondents have a family income of less than $5,000. Only 13 to 18 percent are employed full time, and only 5 to 7 percent felt that they were unemployed but could work. The introduction of a cheap, convenient public trans-

Table 1. Physically handicapped unable to use public transportation in Ontario cities.

Cities	Population	Cannot Use Public Transportation: Number	Cannot Use Public Transportation: Percent
Survey Data			
Sarnia	58,000	682	1.2
Thunder Bay	112,000	1,724	1.6
Windsor	257,000	2,895	1.1
Kingston	59,000	905	1.5
Timmins	35,000	375	1.1
Metro Toronto	2,085,000	28,182	1.3
Total	2,606,000	34,763	1.3
Survey Data Extrapolated to Ontario			
Municipalities with transit authorities, including private contracts for transit	4,551,000	60,000	
Cities with population of more than 10,000	5,398,000	70,000	

Table 2. Characteristics of physically handicapped.

Characteristic	Interview Responses: Metro Toronto (percent)	Interview Responses: Other Cities (percent)	Mail Survey Responses (percent)
Family income			
No response	0	12	13
< $1,000	10	22	13
$1,001 to $3,000	37	35	45
$3,001 to $5,000	19	11	6
$5,001 to $10,000	20	10	10
> $10,000	14	11	13
Activity status			
No response	6	8	
Employed full time	18	13	
Employed part time	6	4	
Unemployed but could work	7	5	
Retired	27	22	
Student	13	17	
Looking after house or family	13	10	
Something else	10	21	
Return trip purpose			
Work	24	24	23
Education	19	23	11
Shopping	20	13	20
Leisure	26	29	36
Medical	11	11	10

Table 3. Problems physically handicapped have in using buses and subways.

Problems	Percentage of Respondents: Subway	Percentage of Respondents: Bus
No response	0	0
Getting to and from subway or bus	12	11
Getting down to subway	14	—
Boarding and leaving	10	12
Getting in and out of seats	9	9
Standing on moving vehicle	14	14
Overcrowding	16	15
Transferring to and from bus	14	12
Needing accompaniment	12	10
Waiting time at bus stop	—	11
Knowing which bus to take	—	6

portation system for the handicapped would, therefore, in the short run not likely have a marked effect on the unemployment levels indicated. Twenty-four percent of the existing trips taken by the handicapped are work oriented.

We also asked the more severely handicapped what aspects of a bus or subway system gave them the greatest difficulty or prevented them from using the service. The results are given in Table 3. The problem of getting down to the subway platform or boarding a bus is only rated as high as a number of other perceived problems. Removing these 2 barriers would not likely ease the transportation problems of the handicapped to any great extent unless something were also done about the other barriers noted. The more severely handicapped place a heavy reliance on special vehicles, taxis, or friends in order to get around, and the less severely handicapped make more use of the bus and subway systems (Table 4).

The survey results led us to the following conclusions and justification for recommending improved transit services for the physically handicapped.

1. Significant numbers (70,000) of the physically handicapped cannot use public transportation.
2. Alternatives (taxis and special vehicle services) to public transportation have a high cost to users.
3. The handicapped have a lower than average income.
4. Taxi service is unreliable in some urban centers, especially during peak periods, and not available to the severely handicapped.
5. The handicapped rely heavily on friends and relatives to transport them on a permanent basis.
6. Mobility should be available to all groups where publicly supported transportation is available.
7. Providing transit to the handicapped removes one of several barriers preventing them from being integrated into society.

TRANSPORTATION IMPROVEMENT OPTIONS

Three basic transportation improvement options were then identified: improve existing public transportation services, pay direct subsidy to handicapped individuals, and provide new special services for the handicapped.

Table 4. Transportation limitation and modes used by handicapped.

		Mode Used (percentage of responses)					
Transportation Limitation	Survey	Automobile Driver	Automobile Passenger	Bus	Subway	Taxi	Special Vehicle
Cannot use public transportation, must use special vehicle	Metro Toronto	6	20	8	–	35	31
	Other cities	2	29	18	na	14	37
	Mail	10	25	–	na	10	55
Cannot use public transportation, but can be driven	Metro Toronto	8	37	19	5	30	1
	Other cities	9	45	8	na	38	–
	Mail	42	28	4	na	24	2
Can use public transportation with difficulty	Metro Toronto	23	27	22	12	16	–
	Other cities	4	45	25	na	21	5
	Mail	23	25	35	na	17	–
Can use public transportation with no difficulty	Metro Toronto	26	11	41	20	2	–
	Other cities	29	20	28	na	19	4
	Mail	38	18	39	na	4	1

Improve Existing Public Transportation Services

Improvements to existing public transportation services include training programs, minor operational changes, and major operational changes.

Training programs, both for operators and the physically handicapped, and minor operational changes, such as additional grab bars and designated seats, would not affect the more severely handicapped but would assist those that now use the public transportation system. Major operational changes, such as lowering the steps on regular buses, installing hoists or ramps, and providing for vertical access in subway stations, only remove one barrier experienced by the handicapped as noted in Table 3. According to preliminary estimates by the Toronto Transit Commission, to install elevators in the subway system would cost $23 million. In Ontario we are making a major effort to increase transit ridership in our urban centers. A key to the success of this program is the provision of a convenient service competitive in travel time with the automobile. Long dwell times at bus stops while handicapped persons are loaded into the bus by hoists or ramps and then strapped down would have a negative effect on the overall ridership. We have, therefore, recommended against making major changes to existing transit systems, but feel that the minor changes referred to could be implemented along with other improvement options.

Pay Direct Subsidies to Handicapped Individuals

One of the problems associated with existing services is the high cost to the individual. Special commercial van services in Toronto with door-to-door service charge an average $6.50 per trip. Direct payments to handicapped individuals were, therefore, considered as one alternative. Cash payments were rejected because the money could be used for other purposes; however, transportation tokens that could be used on taxis or special vans was considered an alternative for the smaller Ontario centers, where the demand did not justify setting up a special service by the municipality.

Provide New Special Services for the Handicapped

Special door-to-door services using both taxi and specially equipped vans or minibuses could be set up for the handicapped and operated by the Municipal Transit System or by a private operator under contract to the transit system. Although this sort of service does not provide the integration into society that some handicapped persons desire, it does provide the highest level of service and removes the problems given in Table 4. This alternative has, therefore, been recommended for implementation and is now under consideration by the government. If it is implemented as recommended, municipalities would be eligible to receive subsidies at the same rates for this service as are now available for regular public transportation services; that is, 50 percent of operating deficit and 75 percent of capital costs.

TORONTO TRANSIT COMMISSION PILOT PROJECT

While we at the provincial level have been developing a policy for transportation of the physically handicapped, the Toronto Transit Commission (TTC) has also been active in this area. In April 1973 the commission was instructed to plan a pilot project for the transportation of the physically handicapped in Toronto. A committee composed of representatives of municipal departments that had dealings with the handicapped and 2 active handicapped individuals assisted in the design of the project.

In June 1973 TTC placed advertisements in the Toronto papers requesting residents who were confined to wheelchairs or who because of special handicaps were unable to use standard automobile transportation to complete a questionnaire that appeared as part of the advertisement. In addition, a letter was sent to 59 organizations that had contact with the handicapped advising them of the survey and requesting their cooperation. As a result of this letter some 1,500 forms were distributed directly to individuals or organizations.

The 336 questionnaires that were returned were the subject of a report prepared by TTC. This report revealed that 56 of the respondents were employed and a further 69 could be employed if low-cost transportation were available.

Initially the pilot project was only to provide transportation for the home-to-work and return trips of those who were working or could work, this being a logical first step that could be introduced fairly quickly to meet the special transportation needs of persons who were trying hard to be self-sufficient. The service was to be portal-to-portal and, if possible, contracted out to the private sector to take advantage of the experience in this area. Informal discussions were held with a number of private operators who already provided special transportation services to the handicapped in Toronto, and these operators were eager to participate in the project.

In April 1974 TTC invited proposals from the private sector to operate the service and received 3 bids. These bids were evaluated by the TTC staff, and one of the operators was selected for the project, which is scheduled to run for 2 years.

The service, which started in February 1975, will provide door-to-door transportation for approximately 50 handicapped people on their work trips. The project is estimated to require an operating subsidy of $140,000 per year at a regular 25-cent fare. This is more than $6 subsidy per person trip.

OTTAWA PROGRAM

Ottawa has also moved into the field of transportation for the handicapped. Through a federal grant program, known as the Local Initiatives Program, a concerned group of individuals began providing door-to-door service to the handicapped. When the federal grant expired, the group appealed to the municipality to take over the funding of the project. The municipality agreed to do so on an interim basis and instructed the Public Transportation Commission to design a pilot project. This has been completed and approved by the council. The service will be contracted out to a private operator and will provide service for work and medical trips. The daily demand is estimated at between 300 and 400 trips and the anticipated cost is expected to be $400,000 a year. The service started in February 1975.

SUMMARY

Both our work at the provincial level and the independent work of our 2 largest operators have led to the same conclusions. Initially the most effective way of providing transportation for the severely physically handicapped in urban centers is to provide a specially equipped demand-responsive service. As the demand for this type of service grows, partial integration of services may be required, but this remains to be seen and will be the subject of some future work.

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J. Leonard Lovdahl, Handicabs of Milwaukee, Inc.

Amid the swirl of controversy and the divergence of opinion on how to meet the transportation needs of the elderly and the handicapped, I am proud to report that in Milwaukee something positive is being done. Handicabs is operating 30 demand-responsive units. We have maintained good cooperative relations with public bus transit, cab companies, and ambulance agencies.

HISTORY

Like many innovations, Handicabs was created out of personal need. In 1958, my particular problem was finding adequate transportation to medical and work facilities. Three factors created the climate for the formation of our specialized cab service:

1. The advent of the van (the first van type of vehicle, the Volkswagen Microbus, came on the U.S. market in 1957);
2. The development in Milwaukee of a comprehensive freeway system in 1958;
3. The spectacular rise in emphasis on medical services, the proliferation of the nursing home and rehabilitation center, and the expansion of hospital outpatient facilities;
4. Federal, state, county, and city funding through Wisconsin agencies to purchase transportation; and
5. The maturing of public and professional attitudes to embrace the adage, A facility is only as good as the ability of people to get to it.

PRESENT OPERATIONS

The city of Milwaukee (in keeping with the general progressive posture of the state of Wisconsin in services to the disabled) established franchise licenses—not unlike franchises covering regular cabs—to regulate the number of handicap liveries and to control fees charged. Regulations in the revised Milwaukee Code of Ordinances define handicap livery "as a vehicle for hire which shall be driven by the owner or his employee and which is especially suited for the transportation of handicapped persons who by reason of physical or mental infirmity cannot be transported in public mass transportation vehicles or in taxicabs, or who cannot drive their own automobile. This definition shall not be construed to include taxicabs or other public mass transportation vehicles."

The development of the regulation was supported by the cab companies of the area. One cab driver testified, "From my experience of arriving at a home to find a prospective 200-lb passenger living on the second floor of a walk-up flat, I am led to conclude that there is a distinct need for a specialized system to take care of this type of person." Thus, the philosophical approach to our service was from the beginning:

1. Handicabs would seek to provide wheels combined with employees trained in the "art" of handling wheelchair and disabled patients;
2. Handicabs would seek to provide door-through-door service as opposed to normal door-to-door service offered by regular cabs; and
3. Handicabs would seek to provide inconspicuous, low-cost, safe movement of passengers with dignity and ease.

OPERATING RULES

The following rules are applied to the Handicabs operations.

1. An understandable success formula is believed to be as follows:

Number of units in a given area under 1 dispatch system = price charged + on-time and lateness factor

Undervehicled or fragmented market (more than 1 company operating) = greater deadhead factor = higher per person cost

Fewer passengers = greater waiting time = lower driver compensation (by commission) = greater turnover = inferior service = few vehicles in given area = substantial operational losses = cessation of existing service

2. Users must become aware of the type of service offered, what it can do and what it cannot do. The tendency is for agencies and health facilities to expect on-demand service at demand-responsive rates. Users must understand that livery service, offered to a relatively limited market, is dependent on the share-the-ride concept.

3. The commission arrangement with the driver is absolutely necessary to the efficiency and economics of a demand-responsive service. The commission arrangement, serving as driver incentive, affects the rate charged.

4. The operator must keep the turnover rate as low as possible. The success in safety, efficiency, and passenger satisfaction is directly linked to driver retention. It takes 6 months to 1 year for a livery driver to become fully effective. Retention at Handicabs has been gained not by high guaranteed wages but by adequate commissions in a good market plus an excellent fringe benefit program, much of it provided for the employee at no cost.

5. Detailed, accurate dispatch information is critically important. Is the passenger in a wheelchair? Does he or she have a wheelchair or must we provide one? (Each of our units is equipped with a wheelchair with leg extensions.) Is the passenger on the first or second floor? Are there peculiarities to the stairway? Can the passenger ride alone? What is the name of the doctor to whom the passenger is going? What hospital department? What nursing home wing?

6. Correct billing information, including the Medicaid number, the in-force date, and the correct spelling must be obtained on the initial order.

7. Good dispatching is equal with good information gathering.

8. Adequate 2-way radio control is needed. Crowded radio channels make the achievement of the goal difficult. Sharp reporting from the driver gives the dispatcher needed information as to where the units are at any given time. Since much of a livery driver's time is consumed in passenger handling or waiting for passengers, 2-way radio is the dispatcher's only means of knowing what progress the units are making.

9. Drivers must know how to handle a wheelchair and how to assist the ambulatory disabled. Not everyone can do livery work. A driver that stays on usually has amazing patience as well as empathy for the people transported. Expert vehicle handling—easy stops and turns—is also absolutely essential.

USERS' INPUT

As our business has developed, we have come to realize that not only are we serving the health community, but we are indeed part of the health community. To keep necessary contact, Handicabs has developed

1. A nonpaid advisory group of representatives of the health care community,
2. A consultant group from the private agency field to advise on agency matters, and
3. User input aids such as addressed evaluation forms.

RATES

The following rates apply to the work we do in Milwaukee and surrounding areas:

Item	Rate
Minimum for first 30 blocks	$4.00
Extra for each additional 10 blocks and also to or from second floor	0.55
Minimum for nursing home entries and discharges (exclusive of out-patient work, which has a $4.00 minimum)	8.00
Minimum for hospital entries and discharges (exclusive of outpatient work)	8.00
Minimum to and from airport and depot	8.00
Hourly waiting time (actual operational cost, prorated 15 cents a minute)	9.00

CONCLUSION

The need for our type of livery service has been proved, and its operational success is demonstrated. In time, I believe every major metropolitan area will have a specialized transit system for the disabled.

My concern as president of Handicabs is that government, in its legislation and funding, will not preclude the private enterprise operator. The profit-making company has much to offer in the area of solving the mobility problems of the elderly and handicapped at low cost.

EQUIPMENT AND MAINTENANCE OF DEMAND-RESPONSIVE TRANSPORTATION SYSTEMS

Hector Chaput, Ottawa-Carleton Regional Transit Commission, Canada

In 1958, when the Ottawa Transportation Commission converted from streetcars, trolley coaches, and buses to an all-bus operation, tenders were requested for 107 buses. At the same time, our system was completely reorganized. One thing we agreed on was that our procedures should provide for the purchase of the best bus available based on initial cost, availability (downtime), reliability (road calls), and operating and maintenance cost—all of which could be expressed in dollars. Bus appearance, comfort, driver and passenger appeal, service, and delivery were considered as important intangibles, but we did not attempt to express these in dollars. Specifications were prepared, and tenders were invited; two were received. After an evaluation based on the above factors, the tender of the supplier whose initial cost was more than $1,000 higher than the other was accepted.

In 1961 the commission adopted a bus-replacement policy to maintain the average age of the fleet at 7.5 years. This resulted in the purchase of about 20 buses per year until 1972, when the system became regional and larger purchases were made. Again in 1961, the lowest tender (initial cost) was not accepted and in fact this has continued to be the case many times.

DATA, CONDITIONS, AND CIRCUMSTANCES REQUIRED

To make such an evaluation of tenders acceptable to all concerned requires that certain factors be satisfied.

1. The evaluation must be completely objective and unbiased and cannot include data that are not factual or substantiated.
2. The data should be based on operations and experience on one's own property so that there can be no argument with regard to weather conditions, terrain, duty, maintenance, or servicing.
3. Maintenance records must be carefully kept, for such an evaluation generally involves comparing other products to equipment owned. The more complete the records are, the better and more valid the evaluation can be.
4. Suppliers bidding should be aware that contracts are awarded based on such an evaluation. We have been using this procedure for years, and our suppliers know that it is standard practice. Even so we remind them of it in our tender forms or in a covering letter that goes out with the forms.
5. The number of buses used in such an evaluation must be sufficient to represent a "typical sample." One or 2 buses are inadequate. We have used as few as 3 to 5, but have been able to show that the performance of such a sample was consistent with the performance of the rest of our fleet.
6. The test or evaluation should be based on operations in which the buses work on

the same route during the same hours with the same group of drivers from the same garage and the same group of mechanics and servicemen. Duration of the test should be at least 1 year to ensure that all circumstances and variations of weather and exposure have been experienced.

7. If the evaluation is based on a test group of buses, suppliers are invited to participate to ensure that their buses are properly inspected and repaired. Then service representatives can call as often as they choose. We have even kept a log book in which all incidents of significance are recorded, not only matters pertaining to maintenance or equipment performance but also drivers' comments. This log is reviewed by service representatives.

8. If the evaluation indicates a significant difference in maintenance cost, road calls, or downtime, the maintenance chief should be able to account for the difference and indicate how, where, and why it happened.

9. The maintenance chief must make certain the foreman and the mechanics are not biased unfavorably against a new or different product.

10. The evaluation has to allow for product improvement. This can be done by allowances or variations in values arrived at from test programs, identification of areas of fault and cost, and agreement with the supplier on an adjustment in that element of cost.

TYPICAL EXAMPLE

Initial Cost Adjustments

The first step in the evaluation is based on the premise that tenders for the supply of buses to a specification rarely if ever meet the specifications in every respect. This in itself is probably justification for an evaluation. All the tenders must be analyzed to consider what has been included or excluded in the buses offered, and the initial cost adjusted accordingly. An exercise of this nature is generally standard procedure under any circumstances to establish to what extent the specifications have been satisfied. Also some suppliers quote a base price for a standard base bus to which the various options may be added; others quote a price that includes everything requested in the specifications.

Sometimes prices have to be adjusted; something is requested (e.g., standee windows) that cannot be supplied because of the basic construction or design of the bus. Then, too, items may be standard for the buyer but not for the bus suppliers (special instruments or sensing devices). Consider 3 fictitious tenders from companies A, B, and C whose quotes are given in Table 1. An adjusted equivalent price must be established for the bus of each supplier.

Table 1. Quoted and adjusted prices of 3 suppliers.

Item	Company A	Company B	Company C
Quoted price	45,000	47,000	48,000
Options requested			
Silicone hose	+200	Included	Included
Teflon oil lines	+200	Included	Included
Windshield washer 5-gal tank	+80	+75	Included
Windshield washer outside filler	+50	+40	Included
Air cleaner	+250	Included	Included
Bolted brake spider	+60	Included	Included
Low water indicator	+75	Included	Included
Standee windows	+1,000	+1,000	Included
Miscellaneous	+600	+300	+200
Adjusted equivalent price	47,515	48,415	48,200

Availability

From maintenance records based on 1 year of operation under conditions mentioned above (i.e., same duty, drivers, maintenance), suppose we find that the average miles per bus per year was 45,000 for bus A, 50,000 for bus B, and 55,000 for bus C. The only reason for the difference is that bus A was in the garage more often than bus B, which was in more often than bus C, because it needed more repairs and had more road calls. If the availability of bus C is 95 percent (established in years previous), then the availability of buses B and A may be calculated as 86.4 and 77.6 percent respectively.

If this tender were called to provide, say, 20 buses for service, then we would have to buy

20/0.95 = 21 of bus C

20/0.864 = 23 of bus B

20/0.776 = 26 of bus A

Or conversely, the adjusted equivalent cost per bus, taking into account service on the street (availability), may be adjusted further to become

$47,515/0.776 = $61,250 for A

$48,415/0.864 = $56,000 for B

$48,200/0.95 = $50,800 for C

These figures better represent the cost of the test buses in terms of their being able to provide service in transit operations where the test is conducted.

Road Calls

On our property, buses in service that develop some defect that may affect safety or operation are generally changed on the road, i.e., switched at some convenient point with a bus dispatched from the garage. The estimated cost to do this is $20 per bus change. This includes cost of direct labor only; no allowance is made for service adjustments if required. Suppose the maintenance record shows the following:

Bus	Miles/Road Call/Bus	Road Call Cost/ 50,000 Miles of Operation
A	3,000	333
B	6,000	167
C	9,000	111

For about every 20 bus changes, we sustain a tow-in, which costs a bit more than a bus change. This merely involves a little arithmetic for evaluation.

Operating and Maintenance Costs

In general, motor oil costs do not vary much and are not considered unless the comparative costs in other areas of the evaluation are close. Fuel consumption must be checked closely every month, for a serious discrepancy with one bus or a poor engine tune-up or malfunction could create a serious distortion in fuel costs, particularly with a small sample of 3 to 5 buses.

Suppose maintenance records show average fuel consumption as follows, where the costs are based on 35 cents/gal for 50,000 miles (80 000 km) of operation:

Bus	Miles/ Gal	Costs
A	4.8	3,650
B	5.1	3,430
C	5.0	3,500

First the maintenance costs, in cents per mile, are plotted for each month (Fig. 1). For a relatively new product, the points are generally more scattered as for company A buses. Also, for a product that is not so well designed and manufactured, the curve will generally have a steeper slope because more maintenance is required more often. When 2 products have the same slope but one is higher than the other, they generally have the same maintenance intervals but one requires more dollars in material or labor or both than the other.

Our standard procedure for many years was to plot maintenance cost of buses in cents per mile against number of years in operation (Fig. 2). When plotted these costs fall on a straight line, which increases at the rate of 1.2 cents/mile/year. This curve represents the maintenance cost standard for our property and the bus we have standardized on.

In Figure 1, the line representing the test group (company A) falls right on top of our standard maintenance cost curve in Figure 2, which indicates that the number of buses used and other conditions experienced during the test were typical and therefore completely valid.

The next step is to consider the upgrading that these buses may enjoy in the next year, apply this to the data on hand, and then plot maintenance costs typical of the next 5 years (Fig. 3). This can be done with reasonable validity if data shown in Figure 2 are available.

The company A product, which represents relatively new equipment, is allowed 0.3 cents/mile for product improvement because this product is new and has more room to move. We consider the supplier's remarks relative to product improvement when this is done. The company B product is allowed only 0.1 cent/mile for improvement. This is typical for a product that is reasonably well established and has little room for improvement. The company C product is given no allowance, for it is a well-established product and improvements would not affect cost very much. However, this does not necessarily mean that company C is making no improvement.

The projected cost curves shown in Figure 3 are based on test data shown in Figure 1 and our background data shown in Figure 2. From these curves maintenance costs in cents per mile for the first 5 years are as follows:

Years in Service	Company A	Company B	Company C
1	2.5	1.7	1.2
2	3.85	2.9	2.4
3	5.2	4.1	3.6
4	6.6	5.3	4.8
5	7.95	6.5	6.0

Figure 1. Maintenance costs for 3 types of buses under identical operating conditions.

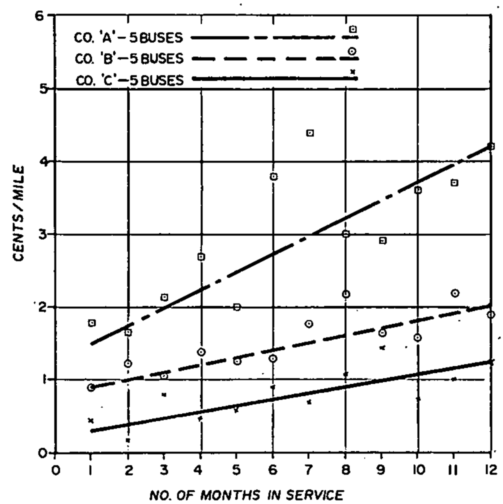


Figure 2. Average annual maintenance costs by years of service.

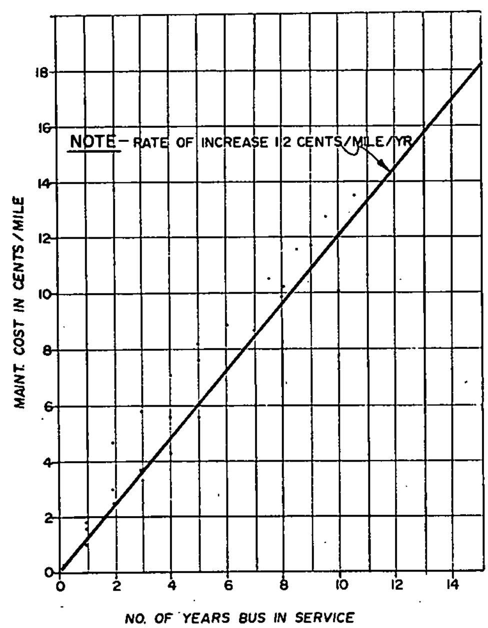
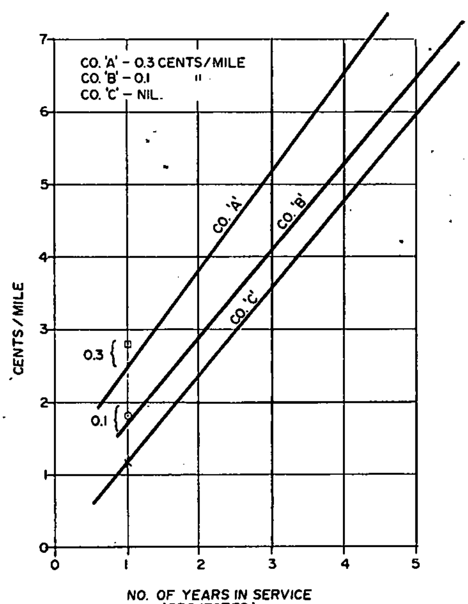


Figure 3. Five-year projected maintenance costs based on weighted test data.



Based on a demand mileage of 50,000 miles/year (80 000 km), which is normal on our property for buses in the first 5 years of service, the maintenance costs can be calculated from the data established above.

Company	Maintenance Cost
A	13,050
B	10,250
C	9,000

The projected costs developed at this point are generally sufficient to indicate with reasonable accuracy which product costs less to operate and by how much. Adjusted equivalent cost is a measure of initial cost and availability, but fuel, road calls, and maintenance costs are a function of proposed miles operated per year.

If, because of some peculiarity, the evaluation does not indicate clearly which bus costs less to buy and operate, the study can be extended over the life of the bus. This is done by extending the maintenance cost curves in a straight line. Figure 2 shows that this line does not flatten out because it represents unit cost and in later life the bus runs fewer miles per year. This drives up maintenance cost per mile inversely to miles operated (i.e., fewer miles increase cost per mile).

The maintenance costs per mile thus obtained and the fuel and road-call costs are applied to the miles operated through the life of the bus. On our property the miles operated would be as follows:

5-Year Period	Miles/Year
1	50,000
2	36,000
3	14,000

If the evaluation is carried this far, a small element of compounding should probably be applied to fuel costs and road calls (say, 0.5 and 1.0 percent respectively), for they no doubt deteriorate with age and usage. We have found that such an approach indicates quite positively which is the best product in terms of initial cost and variable cost. If this were not enough, there is no reason why resale value should not also be considered.

The above calculations are to establish relative costs. If actual costs are desired, interest and inflation percentages must be applied to the yearly costs to express them all in dollars for a given year (say, the year of purchase).

An examination of the facts and figures above establishes quite clearly which product represents the best investment in terms of initial cost (adjusted) and operating and maintenance costs. Generally, the product that has the lowest adjusted cost by virtue of more reliability and availability also has the lowest maintenance cost because components, design, and manufacture are a little better—but this is not necessarily so. We have found exceptions.

APPLICATION TO OTHER PROPERTIES

In recent years, quite a few new products have come on the market. This approach can be used for these products.

For example, suppose you have used a standard product for years. Assemble the data as suggested earlier and then "buy" in the same year a sample quantity of the types of equipment you are considering (say, 5 of each). Now you have set the stage for the test and evaluation. How good and how valid it is depends on how objective and realistic you are.

OTHER FACTORS

An evaluation of this nature is not designed to blackball any product or company. Conversely, it gives new suppliers an objective and fair appraisal of how their products compare with others. It indicates in some detail where products may be weak or superior. It permits suppliers to upgrade faster and more positively.

Under such circumstances we take the attitude that competition makes for better products as well as better prices and services. If a new product appears on the market, we say to our staff, "Let's see what we can do to make this product work and make it better." It is more than a matter of giving a new product a fair break; it is a matter of improving and helping it to develop. If it makes the grade, it will inevitably contribute in some way to improving the products we are using today.

Standardization is fine, but having only 1 or 2 products to choose from is not good. It stifles development and sometimes leaves the purchaser at a disadvantage.

George W. Heinle, Southern California Rapid Transit District, Los Angeles

The Southern California Rapid Transit District was one of the first to get involved with the small transit vehicle. When we first embarked on our small vehicle venture more than 3 years ago, few vehicles and alternatives were available on the market. The project was not strictly a DRT operation, but the vehicles used to provide the downtown circulation system in Los Angeles are in our opinion most adaptable to a variety of similar services, including DRT operations.

The project was novel in a number of respects. It marked the first time that 4 Los Angeles public agencies came together and agreed to share the cost of providing this type of service. The city of Los Angeles, the county of Los Angeles, the Community Redevelopment Agency, and the Southern California Rapid Transit District all agree to bear a part of the cost. The 3 other agencies shared the operational costs, and SCRTD purchased the vehicles. We had to develop specifications and get vehicles operating quickly because, once the public financed and supported this program, it wanted to see some action.

Therefore, we bought minibuses because we had to consider an "on-the-shelf" bus that would provide the kind of service and give the type of aesthetic appeal that we wanted. Some of the criteria that we developed included low steps for easy access by the aged and infirm, seats arranged for ready access, and natural circulation toward a rear exit door. We also wanted a sturdy, rugged small bus that had an ecologically acceptable power plant.

At the same time, we could not design a completely new vehicle and expect the operation to commence within a short period of time. So that emissions would be minimized, we decided to use natural gas as the regular fuel and gasoline as a backup fuel. The dual fuel system provides for using either gasoline or compressed natural gas. We would have used liquified natural gas, but it was not available in Los Angeles. Our estimates indicated that the compressed natural gas would be just barely sufficient with five 375-ft^3 (10.6-m^3) tanks to obtain a range necessary for our regular route operation from 9:00 a.m. to 4:00 p.m. Therefore, the gasoline backup was necessary.

We also tried to incorporate in the specifications features that would make the vehicle more durable and minimize maintenance needs. In this respect, we were only partially successful. We were able to develop, along with the Herz Erhardt Company, disk brakes that were applicable to the Dodge chassis and were a substantial improvement over the standard drum brakes.

Innovative design features in the buses were an exit door at the extreme rear of the right cantilever, perimeter fiber glass seats in vibrant colors, and no seat legs in the aisle area, removing tripping hazards and providing space for storage of packages under the seat. The arrangements contributed materially to the smooth operation of the service and the exceptional passenger acceptance.

Some of the mechanical problems that we have experienced with these vehicles are the result of heavy passenger loads that the service has attracted. Often during the noon hour as many as 50 people crowd on these 21-seat buses at one time. The air over hydraulic disk brakes have excellent stopability, but the passenger loads and the frequent stops necessitated by the downtown traffic have shortened the life of the brake linings. The average lining life is about 7,500 miles (12 000 km). As a result of this experience, we have developed a larger, more durable disk brake, which will be incorporated into buses that we currently have on order.

The dual fuel engine also proved to be a problem. The changeover from one type of fuel to another while in service frequently stalls the vehicles. This contributed to a problem with the starters, which apparently were already borderline as to their capacity. The dual fuel arrangement also necessitated a compromise in the engine timing, and thus fuel mileage is not what it should be since it is not possible to set the timing at the most desirable point for either fuel.

Furthermore, the compromise causes the engine to run hotter than it would under optimum adjustment, and overheating has been extensive. This problem has been partially resolved by replacing the original radiators with ones of a larger capacity.

Radiator troubles also abounded because of the heat problem; gaskets deteriorated, floats became distorted, and engines were hard to start. The excessive engine heat also has had an adverse effect on transmission seals, and transmission life has not been what we expected.

We have developed through our experience a preventive maintenance program. A lubricating, oil change, and normal fluid collection and engine check are done every 3,000 miles (4800 km), and a major inspection is performed every 6,000 miles (9600 km). Brakes are visually checked for lining thickness once weekly. Our maintenance costs for these vehicles are now averaging 13.68 cents/mile. This compares to a fleet average for the 45- to 50-passenger buses of 11.53 cents/mile.

On the other hand, the average overall speed on this heavily congested downtown route is only 7.5 mph (12 km/h). The average standard bus speed throughout the southern California area is 13.2 mph (21 km/h). Obviously the slow operating speed affects costs. If the vehicles were used in a less congested area and had lighter passenger loads, I am certain that the maintenance costs per mile could be reduced from 20 to 30 percent.

SCRTD now operates the buses a greater number of hours daily than originally intended; some of the buses provide shuttle service during the peak hours from the perimeter downtown parking lots. The gasoline backup system has had to be regularly used. Natural gas consumption has averaged more than 4 miles/100 ft^3 (6 km/2.8 m^3) of compressed natural gas, and gasoline consumption is 2.6 miles/gal (4 km/3.8 liter). If used for DRT, the vehicles would show a substantial improvement in fuel consumption.

After 3 years of experience with these vehicles, we have developed new specifications that provide for substantially larger, heavy-duty brake systems and fuel systems for propane gas or other nonfossil fuels.

When we purchased 40 buses in 1974, the successful bidder proposed the use of propane engines. The buses also have a heavier duty radiator with that internal combustion engine, more cooling capacity, heavier duty starters, heavier duty shock absorbers, and changes in the suspension to get a smoother ride.

The 19 buses that have been in service for more than 3 years will have to be completely rebuilt. After that we will use them for an expanded DRT service in some of the more remote communities in the Los Angeles basin.

Robert P. Aex, Rochester-Genesee Regional Transportation Authority, New York

On October 11, 1971, the demand-responsive transportation system in Batavia, New York, began operations. Initially, the system used three 23-passenger Flxible Flxettes and one 10-passenger Ford Courier. The small 10-passenger vehicle was a Ford Econo-Line body with a plastic bubble top to give adequate head room for standing.

Because of the heavier-than-anticipated demand for subscription home-to-work service and home-to-school service, it became apparent after a week of operation that the small Ford Courier could not be efficiently used in subscription service. Therefore, a fourth 23-passenger Flxette was ordered and was put into service in February 1972. Subsequently, the Ford Courier was disposed of and the fleet of 4 Flxettes has operated since the spring of 1972.

With minor variations, each Batavia vehicle travels about 600 miles (960 km) per week during the busy season from September 15 to April 15 and totals about 23,000 miles (36 800 km) each year. A preventive maintenance program was established whereby each vehicle has a maintenance check every 1,000 miles (1600 km). Because the shop operates on a 5-day workweek, 1 vehicle is in the shop about every other day each week for preventive maintenance, which includes lubrication and inspection of brakes and other critical areas.

In connection with filing an application to UMTA for new vehicles, a careful analysis was made of the out-of-revenue-service time of the vehicles and the cost of vehicle maintenance (Table 2). The cost of vehicle maintenance includes interior and exterior washing. For the total 76,383 miles (122 213 km), maintenance cost is 10.6 cents/mile (1.6 km).

An analysis of the maintenance and repair jobs on the 4 vehicles for the 12-month period is given in Table 3. Brake adjustments, relining, and so forth have contributed

Table 2. Out-of-service time and maintenance costs.

	Hours Out of Revenue Service		
Bus	Number	Percent	Maintenance Costs (dollars)
1	272	13.0	1,744
2	119	5.7	1,866
3	203	9.7	1,751
4	209	10.0	2,736
Total			8,097

Table 3. Maintenance and repair jobs.

Item	Bus 1	Bus 2	Bus 3	Bus 4	Total
Brakes	15	28	27	21	91
Ignition	8	4	5	4	21
Lights	—	7	5	1	13
Wheels	1	3	2	5	11
Suspension	2	3	3	2	10
Exhaust	3	2	—	4	9
Instruments	—	1	2	4	7
Steering	2	—	—	3	5
Carburetor	2	—	1	1	4
Air conditioning	—	4	—	—	4
Cooling system	—	2	1	—	3
Transmission	—	1	1	3	5
Engine (valve job)	1	—	2	2	5
1,000-mile (1600-km) check	13	27	23	20	83
Miscellaneous	5	—	3	1	9
Total	52	82	75	71	280

significantly to the vehicle downtime. However, the engine valve jobs are obviously mechanical failures of more significance. Similarly, the extent to which the transmissions of these vehicles have been rebuilt within a period of 3 years is equally significant.

Heavy and frequent use of brakes is required in DRT service. Friction and resulting heat warp the brake drums, causing excessive wear. Our experience with the small fleet in Batavia indicates that brakes must be relined every 5,000 miles (8000 km). Brake drums must be replaced at about each 10,000 miles (16 000 km). The heat also has an adverse effect on the brake return springs, which must be replaced at about 5,000 miles (8000 km).

Valve failure is the principal weakness in the automobile type of gasoline engines used in most of the small vehicles. These vehicles have chassis originally intended for motor homes or recreation vehicles. The manager of the Batavia garage reports that the engines in the Batavia fleet are not able to stand up under the heat and strain imposed on a 360 to 390-in.^{3} (5900 to 6400-cm^3) engine manufactured for automobiles. Frequent valve jobs are the result of this weakness.

Excessive heat caused by the frequent stops and starts in DRT service requires a better system for the cooling of the transmission oil. Here again, the standard heavy-duty transmissions, which are used in the chassis of small vehicles, cannot withstand the heat generated by DRT service. The result is frequent transmission jobs.

After 2 years of experience with this vehicle maintenance program, the management of the Batavia DRT system recommended, and the Board of Directors approved, a vehicle replacement program that calls for new vehicles after 75,000 miles (120 000 km) or 3 years of service. This decision was made in the belief that it is more economical to trade in this body-on-chassis type of vehicle at that point than to maintain it in service.

However, the decision relates to the chassis rather than to the body. The program establishes the life of the body as 6 years, and the bodies are remounted on new chassis.

The limiting factor on the chassis in Batavia is the durability of the component parts: engine, transmission, rear end, suspension, and brakes. Batavia vehicles operate in extreme weather conditions during the winter and are subjected to harsh corrosive effects of salt used on the highways. Body life in other places, therefore, might be more than 6 years.

Capital costs in 1974 were about $4,500 for the chassis and $15,500 for the body—an initial total of about $20,000. The capital cost for 2 chassis and 1 body during a period of 6 years, with about 150,000 miles (240 000 km), develops a favorable depreciation rate of $0.163/mile (1.6 km).

John B. Schnell, American Public Transit Association

I will first discuss the maintenance and operating costs for 3 fleets of buses in the city of Detroit for the fiscal year ending June 30, 1973. One is a fleet of small buses, another is a 1968 fleet of full-sized, 40-ft (12-m) diesel-powered buses, and another is a 1972 fleet of full-sized vehicles. The total maintenance cost is 34.71 cents/mile for the small vehicles, 7.54 cents/mile for the 1968 fleet of large vehicles, and 4.23 cents/mile for the 1972 vehicles. Depreciation increases the costs to 38 cents/mile for the small fleet, 5.39 cents/mile for the 1968 fleet, and 8.71 cents/mile for the 1972 fleet, giving a total cost per mile of 31 cents for the 1972 fleet, 36 cents for the 1968 fleet, and 19 cents for the small vehicles.

Many operators of small systems in small cities have said to us at the American Public Transit Association and to the U.S. Department of Transportation: "We do not need a big vehicle, and besides to operate a smaller vehicle is much cheaper." Well, certainly the cheaper operation of a small vehicle has yet to be substantiated, but logically the smaller vehicle should burn less fuel and have lower maintenance costs.

We all want competition, but I believe we have had make-believe competition in the past. In March 1974, the Bus Technology Committee of the American Transit Association met in Phoenix and decided to form the Small Bus Specifications Subcommittee.

The subcommittee met in March, April, and May 1974. After the ATA midyear meeting in May, the subcommittee members talked for 1½ days with all the manufacturers. We started out with about 70 people and 15 different manufacturers' representatives. At first I think there was some thought that we were trying to put some manufacturers out of business, i.e., not allow them to bid, but that is exactly the opposite of our wish for a maximum of real competition. We want buses that we can readily maintain and operate, for we cannot market a service unless we have a reliable service.

As a result of the Small Bus Specifications Subcommittee work, we asked for and received quite a few comments from the manufacturers in that 1½-day meeting, and we gave the manufacturers another 6 weeks for their engineers to go over the specifications thoroughly. The manufacturers gave us a lot of positive, helpful suggestions. By July we had summarized the suggestions and met again to put together a final specification for the transit industry. We have had a large response from people interested in using this specification. The first system to request use of that specification through the U.S. Department of Transportation is the one in Tucson, Arizona.

We sent out a questionnaire asking the transit industry for other systems plans for using not only 30-ft (9-m) buses but smaller buses during the next 4 years, and we have told the manufacturers that we will summarize that information and send it to them. The results will also be sent to the transit industry.

I am opposed to putting 2 buses side by side and saying, "This bus is better than that bus" or "These 2 buses are equivalent and let them be bid on an equal basis." If we do that, we will repeat what we did with the 30-ft buses. That was not all the manufacturer's fault, and it was not all UMTA's fault. The manufacturers found it necessary to compete, and competing in this sense meant to have a lower price, which meant in effect to take something out of the bus, either workmanship or material.

We certainly would aspire to do the same type of thing that, according to Chaput, is being done in Canada, i.e., evaluating bus bids on the basis of much more than low price only. I believe this would provide the incentive to bus manufacturers to provide competitive, high-quality, reliable, small buses for the market.

John H. Davidson, Yellow Cab Company, Los Angeles

Operators of para-transit vehicles many times need equipment that may be used at times for dual purposes and at other times for a single purpose with a later change to another use. The question of the need, design, development, production, and use of such a diversified-use vehicle (DUV) has elicited much conversation and some study by users, manufacturers, and governmental agencies.

The comments given here are based on the results of discussions and surveys made in the parcel, light air cargo, and passenger demand-response delivery systems in the United States. The preponderance of replies are from those actively engaged in operating those services. They are not based on theoretical studies or on operating hypotheses. Therefore, the comments are biased toward operation in a present-day, real-world environment.

A diversified-use vehicle is a vehicle that can be readily and efficiently used in the ground transportation of one or more of the following products: able-bodied human passengers, handicapped ambulatory human passengers, handicapped human passengers of restricted movement (wheelchair passengers), local-delivery parcels, and light air-cargo parcels. The DUV can also handle one or more of these products simultaneously, depending on the needs of the service. The U.S. Department of Transportation has designated this topic for study, and requests for proposals relative to study, design, and prototype construction have been distributed.

From the discussion and surveys made within the International Taxicab Association and discussions with the other users, the following basic points relative to vehicle design have come forth:

1. Unitized construction,
2. 116-in. (295-cm) wheelbase,
3. Front-wheel power steering,
4. Free-float suspension on all 4 wheels of a 4-wheeled vehicle,
5. Conventional oil over air suspension,
6. 4 doors,
7. Power disk brakes for all 4 wheels and 12-in. (31-cm) rotors,
8. 15-in. (38-cm) steel wheels and medium profile tires,
9. 6-cylinder gasoline engine coupled to a 3-speed automatic transmission,
10. Bolt-on panels where possible and none if unitized construction,
11. Capacity for a maximum of driver and 6 forward-facing passengers,
12. Capacity for at least 500 lb (227 kg) of cargo in addition to passengers, and
13. Rear-mounted power plant and transmission.

In short, the design was for a van type of vehicle that had the driver in front, and a luggage and cargo carriage in a rear compartment over a rear-mounted power plant and transmission. To these basic points must be added the safety dictates of the U.S. Department of Transportation relative to side panel strength, front and rear collision protection, internal safety protection for driver and passengers, dual braking systems, and a low-emission power plant.

The present commercial operators of transportation systems are, in many instances, handling the diverse types of products, or traffic, that the DUV could handle. This requires the use of various types of equipment, thus increasing capital and operational costs. At present vehicles that carry able-bodied human passengers may also carry parcels in the baggage area of the vehicle. If passengers have compatible origins and destinations and if legally permitted, some simultaneous use of the vehicle may occur for the transport of both able-bodied and ambulatory passengers and also parcels. But a true diversified-use vehicle is not available for use instead of the array of vehicles now used for these and other services.

The DUV must be competitive in price, have a design that allows the operator to handle the diversified traffic mentioned, and be competitive in operating cost with that of equipment used now. No move has been made by a U.S. automotive manufacturer to supply such a vehicle. Our American automotive economy depends on the mass production of vehicles with similar design and operational characteristics; the providers of such equipment have not found it economically feasible to produce a diversified-use vehicle. The U.S. Department of Transportation's request for proposals relating to study, design, and prototype construction is evidence of concrete action in this regard. The requests for proposals were opened in January 1975. What happens after the prototype construction? It is hoped that there will be sufficient interest displayed by users so that a manufacturing organization, which has an outlet network, will survey the market and secure enough affirmative replies to warrant production of such a vehicle.

The following ground transportation vehicles fulfill certain tasks that can be handled by a DUV.

1. The Checker Cab is a large box, has a conventional power plant and power train, and has a large luggage compartment but lacks the ready accessibility for handling larger amounts of parcels simultaneously with the passenger load and requires considerable conversion to be used for wheelchair passengers.

2. A vehicle also in common use is the conventional van, which is restricted in that passenger ingress and egress are limited as is its ability to handle wheelchair passengers without significant conversion. It has the advantage of being available from numerous manufacturers, has good support systems, as does Checker, and has widely understood construction and maintenance.

3. A drawing of a DUV that was originally developed in Europe in 1936 is a 2 CV Citroen with slab sides, canvas roll-back top, 4 doors, front-mounted power plant and

power train, and removable seats. This is not seriously presented for adoption as a DUV for our uses, but illustrates that this universal need was partially satisfied because of economic conditions a number of years ago by one manufacturer at least. And it still sells worldwide in significant numbers.

4. A prototype urban taxi, developed by the Industrial Design Division of the Detroit Society of Arts and Crafts, has many of the design characteristics that our surveys and discussions have shown are deemed desirable. The prototype is some 4 in. (10 cm) shorter than a VW Beetle, yet accomodates a driver and 5 able-bodied human passengers. It is of unitized construction and has a continental 4-cylinder, front-mounted diesel engine that is coupled to a VW 411 3-speed automatic transmission and housed in a Toronado front end. The rear end is of the conventional Oldsmobile trailing arm type, and all wheels are individually sprung. It is a low profile vehicle with wide profile tires. It complies with all federal safety standards in effect in 1972, the year it was designed and constructed. The estimated cost in 1972 dollars for a production run of 10,000 was $3,700 each. If some 30 in. (76 cm) in luggage space were added at the rear and the rear suspension ability was increased, this design would fit many of the attributes desired.

Discussion

QUESTION: Who maintains the communications equipment? In a computerized operation, who does hardware and software maintenance?

ROBERT AEX: We made a maintenance contract with one of the local communications firms, and it has worked all right. The contract provides emergency service on a parts plus the cost of labor basis, and the costs are reasonable. All of our software was developed for us free of any direct charge by the manufacturer of the equipment itself. We did not have to hire any consultants or put anybody on the staff directly or indirectly.

JOHN DAVIDSON: My rule of thumb is, if you have fewer than 350 mobile units, go outside for maintenance. If you have more than 350, get an in-house technician. We have one operation in which 2 technicians maintain 850 taxicabs, trucks, and buses, and we have 12 bay stations. We give each unit a frequency check and a bench check every 90 days. This is far more than the FCC requires, but it keeps us clean. We have 1 program in the taxicab operation in which we contract with the hardware manufacturer for the software program. We installed a second-generation unit in Los Angeles in the taxicab operation. Included in our contract are any programs that we need within 18 months for record keeping or management control statistics. We do have in-house programs for payroll, general ledger depreciation, schedules, and the like.

IRVING WOOD: How can manufacturers meet demands for both a minibus and DUV vehicle—2 widely divergent types of vehicles?

RONALD SWANSON: There are 2 markets. One market, which is separate from the transit industry, is the private operator who wants a vehicle for many uses. The other small-bus transit market requires a vehicle that has a longer life, is more reliable, and costs less to maintain.

GERALD LUTES: How much does it cost to keep all those records broken down by vehicle, by type, by age, by type of work? How one can keep those from overwhelming the cost of the savings?

JOHN SCHNELL: Whether you are in a trucking business or a transit business, you have to know whether a particular fleet is worthwhile or marginally worthwhile. Those costs are not difficult to obtain. If transit systems do not now keep those records, they will soon have to. The financial accounting of the U.S. Department of Transportation will soon require that all costs be kept under a unified accounting system. It costs more not to keep good records no matter whether you only have one vehicle or several. You must keep track of the productivity of mechanics and the reliability and the quantity of stock needed to prevent downtime of vehicles. If you have only 5 buses and you know that fan belts are a problem, then you must have fan belts in stock for 5 vehicles each month. But you need to keep records to have this information so that fan belts can be ordered in advance to keep the vehicles on the road.

DAN SMITH: Will diesel engines be used in small vehicles, or are they strictly for the larger coaches?

RONALD SWANSON: We are testing a small bus with a diesel engine now, and Mercedes buses have had them for some time. But the installation cost of a diesel engine is about $6,000, and many people do not want to pay that much.

JOHN DAVIDSON: In California, none of the small diesels can pass the laws relative to nitrous oxides. The vehicle must be classified as a truck or as a bus in order to have a diesel engine. The city of New York taxi system has adopted the California specifications for 1975, which has thrown the Chrysler manufacturers into a tizzy because they want a little tiny engine and no pollution.

RONALD SWANSON: We are now testing an air-cooled diesel engine that has low pollution. The U.S. Bureau of Mines has approved it for underground operation. It is almost smokeless. It has a precombustion head and is designed specifically to keep pollution to a low minimum. Two other engines are undergoing tests on highways because the AVA will not accept the certification of the Bureau of Mines.

SUSAN GRANT: We did not think diesels would be satisfactory in Orange County for DRT services through residential areas because we have found the small diesels to be extremely noisy both inside and outside.

JIM McGILL: Did AC Transit cut the size of its coaches to bring in diesel engines and to extend vehicle life?

ANTHONY LUCCHESI: Two years ago at AC Transit we planned to provide DRT service. We went out to bid and had one bidder respond. Before that, we checked many properties to get an evaluation of a small bus: cost per mile, maintenance, downtime, and parts availability. We found that this was a troubled area, so we backed off on the application and told UMTA that we had some 35-ft (10.6-m) buses that we would like to cut down to 29 ft 2 in. (9 m). UMTA's response was, "Go ahead and see what happens." We converted the buses with a great amount of success. We are operating them for DRT service. They still have the same 6V71 engines, heavy-duty brakes, ventilating and heating system, and transmission. The operating cost is as low as that for bigger buses. The buses have operated now for 2 months, have accumulated 61,000 miles and have had one failure, an alarmostat that shorted out. So unless somebody manufactures a heavy-duty small bus, we may continue cutting down buses to meet our needs in Oakland.

DAVID CONNOR: What is the approximate cost to make a modification? Has anyone analyzed the possibility of structural or mechanical failure due to loss of integrity? Has there been any discussion with manufacturers about possible design inputs for small vehicles as a result of your experience with modification?

ANTHONY LUCCHESI: The modification cost AC Transit $10,000 in labor and material. We put carpeting on the ceiling and floor, and we bought new seats and new fabric. The cost for the interior was close to $5,000. The reconversion and the painting of the outside of the bus cost another $5,000. The GM bus does not have a frame. So we took a complete section out and put it back together again. I do not believe that we damaged the construction of the bus in any way. The Flxible Company has made a move in the same direction as we have. It had a 31-ft (9-m) bus on display at a convention in 1974. The bus had the same transmission, engine, and differential.

ROBERT SCHNEIDER: I am with the Flxible Company. As manufacturers, we realize that we must respond with a vehicle to meet the needs of DRT service. However, interest in this service has just recently been generated. Our marketing department, which of course dictates to us considerably, has just recently become aware of this high interest. We will definitely respond, but the timetable is indefinite. Opinions still vary as to what the needs really are. Some want gasoline engines and others want diesels. No American manufacturer now makes a chassis and a diesel engine that are adequate for those needs. We are researching the problem, and we are trying our best to come up with an economically feasible product with options for the handicapped.

TAXIS AND OTHER PRIVATE TRANSPORTATION SERVICES

Kenneth W. Heathington, Transportation Center, University of Tennessee

The rapid decline of privately owned transit companies brought about a rapid increase in publicly owned public transportation systems. Municipalities either purchased these operations or started new ones. Many argued that public ownership of transit systems was the only solution to the rapidly declining demand for public transportation services. Many felt that unless systems were publicly owned there would soon be no public transportation in most urban areas. Even though publicly owned, many systems still have declining ridership. Costs have risen substantially. The subsidies required, both for capital and operating costs, far exceed the original estimates in many cases.

The Urban Mass Transportation Act to provide government subsidies for public transportation was written in such fashion to discourage private ownership and encourage public ownership. The original Urban Mass Transportation Act placed most privately owned public transportation systems at a disadvantage. Private operations could receive financial assistance, but the difficulties in obtaining this assistance were so great that almost no privately owned system did. Taxi systems, which are mainly privately owned and operated, could receive capital financial assistance as could publicly owned systems, providing certain conditions were met. This, however, did not seem to concern the taxi companies until municipalities began to offer demand-responsive transportation (DRT) services at low prices and to provide capital and operating subsidies to these publicly owned operations. Almost all publicly owned DRT systems offer services somewhat similar to those of taxi operations but at a substantial reduction in fares. Some taxi companies began to feel that these publicly owned and subsidized systems might become a threat to their own operations. Only after the introduction of DRT services did many taxi operators begin to take a real interest in becoming a part of the public transportation program in urban areas.

SHARED-RIDE TAXI OPERATIONS

For many years, DRT systems have existed in the private sector. Cities such as Little Rock, Arkansas, Davenport, Iowa, and Hicksville, New York, have had shared-ride taxi systems. Shared-ride taxi operations are identical to most DRT operations except that a 4-door sedan is used instead of a bus and the fares are much higher on the shared-ride taxi systems. The taxi operations generally are not subsidized. Tables 1 and 2 (1) give a summary of several DRT systems and 2 shared-ride taxi systems. The levels of service for the shared-ride taxi services (Davenport and Hicksville) are quite high, although the productivity is low. The cost per trip is much higher for a shared-ride taxi system than for a DRT system. However, no operating subsidy is provided to the shared-ride taxi operations. The demand for service is also substantially higher for the shared-ride systems than for most of the DRT systems. Only in Regina is the demand higher for DRT than for either of the shared-ride taxi systems.

Table 1. Service and equipment of demand-responsive systems.

	Service Type		Service Area			Hours of Operation		Equipment			
System	Peak	Off-Peak	Miles^2	Population	Persons per Mile^2	Days	Time	Type	Total Number	Peak Use	Off-Peak Use
Ann Arbor	Many-to-few	Many-to-few	2.3	8,872	3,857	M-F	6:30 a.m.-6:00 p.m.	10-pass. van	3	3	3
						Sa	6:00 a.m.-6:00 p.m.				
Batavia	Many-to-many[a]	Many-to-many[b]	4.3	17,338	4,032	M-F	6:00 a.m.-6:00 p.m.	23-pass. bus	4	5	3
								10-pass. van	1		
Bay Ridges	Many-to-many[a]	Many-to-many	4.0	14,500	3,625	M-Sa	5:15 a.m.-1:30 a.m.	11-pass. van	5	4	2
								19-pass. bus	1		
Davenport	Many-to-many	Many-to-many[b]	19.7	98,500	5,000	All	All	5-pass. cab	23	20	16
Haddonfield	Many-to-many	Many-to-many	10.9	40,100	3,679	All	All	17-pass. bus	12	–	–
								13-pass. bus	7		
Hicksville	Many-to-many	Many-to-many	6.8	48,100	7,074	All	All	5-pass. cab	30	26	–
Regina	Many-to-one[a]	Many-to-few	5.0[c]	32,000[c]	6,400[c]	M-F	5:25 a.m.-12:00 m.n.	15-pass. van	6	18	8[c]
			8.5[d]	58,000[d]	6,824[d]	Sa	6:40 a.m.-12:00 m.n.	23-pass. bus	5		6[d]
			9.0[e]	63,000[e]	7,000[e]	Su-hol.	1:20 p.m.-8:40 p.m.	45-pass. bus	1		5[e]

[a]Subscription. [b]Other services are also provided. [c]Peak. [d]Off-peak. [e]Evening.

Table 2. Operation and costs of demand-responsive systems.

System	Passengers/ Weekday	Demands/ Mile^2/ Hour	Passengers/ Vehicle/ Hour	Avg Time (min)		Dispatching	Competition	Goods Movement	Ownership	Union Drivers	Driver Wages/ Hour	Cost/Vehicle Hour		Cost/ Trip	Avg Fare/ Trip	Subsidy Source
				Wait	Ride							Total	Operating			
Ann Arbor	250	9.1	8	9	13	Manual	Bus, taxi	No	Public	Yes	5.50	10.59	9.91	1.32	0.45	Local[a]
Batavia	350	6.8	11.5	11	11	Manual	Taxi	Yes	Public	No	3.30	–	–	–	0.47	–[b]
Bay Ridges	600	7.5	9.7	45	7	Manual	Taxi	No	Public	Yes	3.30	–	–	0.60	0.26	Province and local
Davenport	1,269	2.7	5.0	20	10.5	Manual	Bus, taxi	Yes	Private	No	2.65	4.97	4.67	0.99	1.03	na
Haddonfield	1,331	4.7	5.4	25	15	Computer	Taxi	No	Public	Yes	7.79	15.40	13.81	2.85	0.30[c]	Federal and state
Hicksville	900	5.5	3.0	9.5	9	Manual	Bus, taxi	Some	Private	No	2.29	3.70	3.53	1.23	1.79	na
Regina	3,400	25	19.5	22.5	17.5	Manual	Taxi	No	Public	Yes	5.75	11.00	7.00	0.56	0.32	Local

[a]2.5-mill property tax. [b]Operating costs and portion of fixed costs are covered by system revenues. [c]15 cents for senior citizens.

INTEGRATION OF TAXI OPERATIONS WITH PUBLIC TRANSPORTATION SERVICES

DRT services are costly because of low demand, capital intensiveness, high labor rates, restrictions on work rules, and few economic incentives. These characteristics are prevalent in most DRT systems, and many are now rethinking the position of public ownership as a solution to most public transportation problems. Some are now suggesting that efficient services at low operating costs can be provided better by private enterprise than by publicly owned systems. Private companies can diversify operations to engage in goods movement, charter services, and various other activities that often may not be engaged in by public companies.

A publicly owned system that uses federal money under a 13-C agreement is locked into a type of operation in which change is difficult. The operating cost may continue to increase substantially but few means are available for lessening the amount of responsibilities of the urban municipalities. More thought is now being given to seeking contractual arrangements through private enterprise for providing certain types of public transportation services.

This paper does not examine the many ways in which an urban area could provide public transportation services solely through the private sector. However, the opportunities are there, and only the initiative of the private operator and the municipal government is required to integrate private operations into public services. The taxi firms have shown little, if any, enthusiasm for becoming involved with municipal services. In the past neither the municipal governments nor the taxi operators determined what role taxis could play in helping to solve public transportation problems. Only recently have they begun to discuss the potential that exists for cooperative ventures of the 2 groups.

SUMMARY

This conference was designed to provide a forum for taxi operators and municipal governments to discuss the benefits that could result to each from the integration of services. Many transportation services can be performed better by the private sector. However, without the cooperative efforts of the private sector, municipal governments will not permit or encourage the integration of services. A change is needed in the manner in which financial support is provided to various public transportation services. This does not imply that direct operating or capital subsidies should be provided to private enterprise. However, from a contractual point of view, there is much to be gained by the use of private operators in an urban area.

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Charles Boynton, Salt Lake City Taxicab Association

The taxi industry has 190,000 vehicles and carries more than 2.5 billion trips a year. They carry 25 percent of the commuter traffic and serve 3,400 cities of all sizes.

The taxi serves the tourist, who is uncertain about the use of other public transportation facilities. We are in competition with rent-a-car companies at airports, and we are the backup system to many families when they have car failures.

Not so obvious but equally important to our industry is shared riding or group riding or demand-responsive transportation. We have school contracts under which we carry school children almost door to door, but sometimes corner to corner.

We have special education school contracts for carrying mentally retarded, deaf, and blind children and adults who need the care of one-to-one relations. We also have a few long-distance contracts. We are involved in programs to carry welfare recipients to nutrition, hospital, and health care centers. We also provide wheelchair transportation. We are active in the package delivery business and in jitney service.

One of the problems in the taxi industry is the retention of accumulated revenues. It results, I believe, from the tremendous impact of labor. In my own case, 95 percent of the money from the taxi meter goes to drivers, dispatchers, and clerical and maintenance people. When fuel costs go from 5 to 10 percent of revenue, that is critical.

During the past 10 years, the taxi industry has moved from employer-employee businesses to a lessee relation in which the company provides licensed system insurance, dispatching, and coordination and rents the car to the driver. We have spent a long time trying to determine the relation of the driver to the provider of the service. We have had ongoing battles with the Internal Revenue Service on whether we should withhold taxes because of this relation. Should we pay FICA taxes? We have now defined that situation, and that is to the good of the industry and, therefore, the public. But some uneasiness persists.

The frequent entry-exit problem is best illustrated by the taxi service in Washington, D.C. That city has 8,000 licensed taxis and an estimated 1,500 on the streets in the best of times for the industry and, therefore, the worst of times for the rider. That city is full of part-time people. What does that do to the industry? I think it gives us a bad reputation. The problem in Washington is that there has been a loss of aim, a loss of purpose in what taxis are trying to do. There is no central coordination, and to improve the situation is difficult.

New York City has no less a problem. Painting all the cars yellow is a wonderful idea for making 17,000 illegal operators legal. An incredible situation! The people who have the fleet operations in New York tell us that most of the equipment that is used in the illegal operation is ripped off from them and then employed against them.

The taxi industry is moving from an emphasis on having 1 or 2 persons in the car to shared riding. Our conventions during the last 3 years have indicated an amazing trend toward change. We want to be around, and so we are adjusting fast—but we must have some financial help in one form or another.

Robert Samuels, Yellow Cab Company, Chicago

Governmental regulation emanates from every level of government and spans the entire spectrum from statutes to ordinances, from regulations to taxes. Federal regulation includes antitrust, social welfare, minimum wage, labor, equal employment opportunity, ecology, vehicle design, and fuel allocation. Federal taxes include income tax, withholding tax, social security tax, unemployment compensation tax, and gasoline tax. State regulation includes vehicle and chauffeur licensing, insurance regulation, unemployment compensation, workmen's compensation, labor, and minimum wage. State taxes include income tax, withholding tax, vehicle tax, use tax, real estate tax, personal property tax, gasoline tax, and unemployment compensation tax. Local regulation includes vehicle and chauffeur licensing, liability insurance, method of operation and fares to be charged, record keeping, inspection of vehicles, and regulating vehicle numbers. Local taxes include vehicle tax, inspection tax, income tax, head tax, gross receipts tax, and use tax.

All in all they constitute a melange of regulation, taxation, and reporting obligations that are difficult to administer, impossible of total compliance, and frustrating of any attempt by the industry at modernization of demand-responsive transportation service or meeting the swiftly intensifying needs of every community.

For most of 3 centuries, the regulated taxi industry has provided demand-responsive transportation, entirely by limousine and taxicab! That is to say, there has literally been no other legal DRT service! True, there have been a few legitimate jitneys, and only a few cities, such as the District of Columbia, Baltimore, and Chattanooga, have permitted taxicabs to group load at will. Lately, there have been a few DRT experiments whose legal authority is not always clear.

Governmental regulation at every level must be reviewed to permit the inclusion of more modern concepts of the 3 major areas of regulatory concern: chauffeurs, vehicles, and service. This review must come soon because the almost invariable thrust of recommendations of academia and legislators alike is to provide additional DRT service by some illegal or antisocial device or other rather than to provide the means for existing businesses to meet the problem, as reason, logic, or practicality suggests. Recommendations are largely the result of lack of reliable information concerning the capabilities of the industry.

REGULATION OF CHAUFFEURS

Few, if any, chauffeurs of DRT service are subject to federal regulation (49 CFR 391.1 and 391.2). These regulations are detailed and organized; if they were ever enforced in toto in the DRT industry, the already grave shortage of chauffeurs would be even further increased.

Similarly, few chauffeurs are regulated by state governments except those that drive school buses, for example. But most states license chauffeurs, and here the regulations run the entire gamut. In some states you can be a chauffeur if you are as young as 16 years or as old as Methuselah. Some states bar mental degenerates, narcotics addicts, and drunkards; others do not. Some states bar ex-convicts; others do not.

At the municipal level, where virtually all chauffeurs of DRT vehicles are licensed and regulated, wider variations are found and need to be reevaluated. For example, great effort is expended on rehabilitating criminals and finding jobs for them. A severe shortage of chauffeurs exists, but most cities bar felons from being chauffeurs for a long time or forever. Reason suggests that this sort of restriction is overly simplistic. For my part, I would rather take a chance with a felon check-forger as a chauffeur than with a person who has a string of misdemeanors for drunken driving. And I have never seen a 16-year-old who has the maturity to drive a public passenger vehicle with all of the concomitant responsibilities. Moreover, few regulations restrict the issuance of licenses to persons with a history of (or, indeed, confinement because of) mental illness. I recognize that there are all kinds of mental illnesses and all kinds of confinement, but some kinds could render a person totally unsuited to be a public chauffeur.

Adequate and reasonable regulation must be in force everywhere because too many licensees depend entirely on the licensing procedure to screen their chauffeurs. Indeed, some licensees never even see their chauffeurs, for example, those who are hired to drive a second shift.

REGULATION OF VEHICLES

Few types of DRT vehicles and equipment are subject to federal regulation (49 CFR 393).

State regulation of DRT vehicles is the subject of a current study by the International Taxicab Association. Except for school buses and ambulances, DRT vehicles have little regulation by the states. Regulations concerning design and construction of school buses range from less than adequate to deplorable, being, all too often, limited to color of the body, size of letters in the signs, flashing lights, and seating capacity. Requirements of seat and head restraints, safe design of seats, and physically safe construction of the vehicles are few. I have seen van type of vehicles used by schools and day camps as buses that are best described as rolling coffins, but perfectly legal vehicles nonetheless.

Municipal regulation of the vehicles used to provide DRT service is also the subject of a research project of the International Taxicab Association now in progress. The preliminary results indicate that regulation of the design and construction of vehicles, other than limitation of seating capacity, is practically nonexistent. Regulations concerning age and condition of vehicles is common but is generally left to administrative judgment.

Too much emphasis cannot be put on the fact that lack of design and construction regulation has permitted poorly designed and uncomfortable vehicles to be used to render DRT service in far too many cities. In short, municipal regulation of vehicles rendering DRT service has largely been limited to seating capacity and equipment. Passengers are usually limited to a maximum of 7 in taxicabs, 8 in limousines, and more than 12 or 16 in buses. In most cases, the van type of vehicle has been omitted, and as a result vehicles rendering jitney and DRT services often go unregulated.

REGULATION OF DRT SERVICE

And now I come to the core of the whole topic of DRT service: Taxicabs and limousines are virtually the only unsubsidized forms of transportation of any sort, and, aside from ambulances and school buses, taxicabs and limousines render virtually all of the existing demand-responsive transportation service.

The problem of rendering new kinds of or additional demand-responsive transportation stems from a lack of information available to regulatory bodies of the underlying restrictions that inhibit the existing potential of the industry to render DRT service. Taxicabs and limousines have historically been vehicles for transporting 1 person or a self-created group of persons privately to their destination. This industry has decades of experience, financial stability, radio and vehicular equipment, administrative staffs, and know-how to operate any type of demand-responsive service. It must follow, therefore, that this industry should, at least, have the opportunity to provide any additional or new DRT service.

To fill the obvious and rapidly growing gap between public transit and DRT has been the subject of a great deal of research and study. Clearly, taxicabs cannot furnish individualized service at public transit prices. And, just as clearly, public transit cannot furnish individualized service at any price. Unfortunately, to fill the gap attention seems to be focused on types of services that in most localities are illegal, rather than on modifying existing regulations so that existing facilities are permitted to try.

Rendering Innovative DRT Service

A taxicab, under almost every regulation, is a vehicle for hire by 1 person or 1 group of persons, whom it will transport wherever desired within the limits prescribed for a prescribed fare. It usually is equipped with a meter to measure the fare and a radio through which it can be dispatched to the passenger.

Whether it is hailed on the street or ordered by telephone, it becomes the private vehicle of the person who hires it. Only a few cities permit group riding, i.e., the indiscriminate taking on of additional passengers [District of Columbia, Rules and Regulations, Title 14, Sec. 310.1(a)]. The obvious possibilities of improper charges or passenger molestation have impelled most cities to prohibit this practice (e.g., Minneapolis, Sec. 264.030; Chicago, Ch. 28.29; Cleveland, 9-4316; and Houston, Sec. 45-11).

A type of demand-responsive service has been considered as a supplement to public transit. Indeed, the U.S. Department of Transportation, through the Urban Mass Transportation Administration, has spent some $7.4 million on experimentation with proposed DRT services. But with rare exception (8) has a taxicab operator been called on or, indeed, permitted by existing regulation to provide them. The vehicles were available; the equipment was in existence; the expertise was available; but regulations prevented the rendering of the service.

It has been demonstrated that the average DRT vehicle load is well within taxicab vehicle capacity. (The Davenport DRT system carries 4 to 5 passengers/hour in Checker Motors Corporation taxicabs.) Operating costs of buses are substantially higher than taxicabs (1, p. 202). For that matter, a jitney service could easily be rendered by a taxicab, as is being demonstrated daily in cities where illegal jitney service is being rendered. The perplexing (and, to the taxicab operator, the frustrating) aspect is the repeated advocacy of illegal operations by legislators (in contrast to revision of inhibitory regulations) as a means of solving this social problem.

Others have alluded to services such as package delivery for which taxicabs are so well suited if the package is small and time is important. In some communities this activity is forbidden; in some, certificates of public convenience and necessity are required and are difficult to obtain. Taxi drivers have often been arrested while carrying emergency deliveries of blood!

A partnership with public transit is another possibility often mentioned. Yet a project suggested by a congressman to provide transportation from a rail rapid transit terminal to residences during late hours when buses were sparsely operated never got off the ground, even though the small subsidy necessary to try the idea was readily available. It would have required cooperation from the public transit agency and a change in the law.

Limitation of Numbers of Vehicles

A second major regulatory feature of the industry concerns the limitation of the number of vehicles to be licensed. The number is usually fixed by a finding of the public convenience and necessity for licenses and the effect of additional licenses on traffic, safety, and earnings of chauffeurs and licensees. In Chicago, an unusual provision permits additional licenses to be issued (as an alternative to reduction of the rates of fare) whenever operators' earnings exceed a certain rate [Municipal Code, Sec. 28.22.1(c)].

However, the operation of the licensing regulatory process is often so slow that progress is impeded. An inquiry of taxicab operators showed a nearly unanimous agreement with that statement; only those regulated by state public utilities commissions dissented. Moreover, regulation of the number of existing licenses has had the unintended effect of inhibiting the licensing of previously unknown or unused forms of DRT service. Certainly improvement in these areas is necessary and long overdue.

Financial Responsibility

A third major regulatory feature of the industry is the requirement of financial reliability. This is achieved by requiring insurance policies to assure the public that the licensee will be able to respond in case injuries are sustained as a result of the operation of the licensed vehicle. The regulations for the most part need updating since verdicts of $100,000 commonly occur and verdicts of $1,000,000 are not unknown. The required limits generally vary from $10,000 coverage for 1 person, $20,000 coverage for more than 1 person and $5,000 for property damage (the most common) to $100,000/$300,000/$25,000 (the most rare). One state requires only $5,000/$10,000/$5,000 and allows a fleet to self-insure if it has $15,000 to deposit! Regulations that require that the insurers be solvent are rare indeed, and those that do exist are seldom effective.

The facts are that in large urban centers the population is "claim-conscious," ambulance chasers flourish, verdicts are high, and insurance premiums are costly.

Unfortunately, regulation has chosen, by accident or design, to remain behind the reality, behind the times, and behind the verdicts. Thus a recently published report notes that "... the regulations in this respect often do not have sufficient bite to protect the public adequately." And it comments on the habit of fragmenting fleets in New York City to avoid paying damages in excess of the $10,000 bond (1, p. 141). The limits simply must be raised to be in line with the verdicts.

I cannot leave this topic without remarking that the one way to reduce accident costs (and premium costs at the same time) is enactment of no-fault insurance legislation. Even in the few communities where such laws are in effect, they could be improved. It is surely remarkable to note the amount of resistance to the passage of these laws—from the legislators themselves and, of course, the bar.

Rate Regulation

A fourth major regulatory feature of the DRT industry is the fixing of rates of fare. In general, rates of fare are fixed by the regulatory body and are "reasonable" in terms of either operating ratio or return on capital investment. A study by an accounting firm indicates that the operating ratio method is more common and more reasonable (1, p. 100). In this industry (unlike the transit industry with large investment in fixed and movable assets), rates of fare are related of necessity solely to operating ratios.

In spite of the fact that the industry suffers from an endemic and chronic shortage of drivers in all but a few communities and in spite of the fact that economists uniformly urge that larger earnings would attract more drivers, only a few regulations such as those in New York City (Sec. 2304) and Chicago (Sec. 28.22.1) take earnings of employees into account in fixing rates of fare or numbers of licenses.

Taxicab passengers are charged a fare, which is calculated by distance traveled, time, and occasionally number of passengers in excess of one. Limousines usually charge a fixed fare for the trip or time. In a few communities, taxicabs calculate the fare on the basis of zones traversed, but the possibility of improper charges has made this method comparatively rare. (Of cities having more than 200,000 population, only Washington, D.C., has zone rates in effect; of cities having more than 100,000 population, 8 cities have zone rates.)

This uniformity of method of charging indicates its general acceptance by the various communities. However, the emergence of more innovative DRT modes may create the necessity for an entirely new approach to the subject.

The obvious distinction between taxicabs and limousines on the one hand and other proposed DRT service on the other is the sharing of the ride. The vehicle and the administration of the service remain the same, the administrative expertise and financial responsibility of taxicab operators are available at lower unit cost, and the vehicle is therefore available to render service at comparatively lower cost. Clearly, any innovative DRT service that takes advantage of unused taxicab or limousine seating capacity takes a practical approach to the problem, and any DRT service that takes advantage of the expertise and financial investment already made in the taxicab industry can render its type of service at a financial advantage and at a lower cost to the community. But only if governmental regulation permits.

Rate structures must be revised so that any new DRT service can be provided, at the outset at least, by taxicabs or limousines of existing operators or other vehicles provided by those operators. Every rate-making body should keep in mind a most appropriate comment made by Avery (2) a few years ago: "It was not understood that those powers are of little avail where the carrier is so preoccupied with maintaining basic viability that seeking to extract innovation or a bold approach to risky new ventures is completely unrealistic."

CONCLUDING REMARK

After the preparation of this necessarily sketchy presentation of a broad and most important topic, I found its theme well stated in the paratransit report to which I have referred previously (1, p. 16): "An important operating characteristic of taxi, dial-a-ride, and jitney services is that, regulations permitting, they can all be provided by a common and very pervasive public transportation vehicle, the taxicab."

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Donald G. Greyshock, All American Cab Company, Huntington Park, California

I believe that shared riding and door-to-door service will be the future in transportation no matter how sophisticated and exotic the fixed transit program becomes. I believe the taxicab industry has the flexibility, the diversification, and the expertise to provide a great portion of this door-to-door service.

In 1966 the City Council of Huntington Park, which has a population of 33,000 and is located 7 miles southeast of Los Angeles, became transportation conscious. The mayor at that time made a survey of what facilities the citizens needed, and public transportation was high on the list of needed services. That was rather strange because the Southern California Rapid Transit District runs 7 bus lines with approximately 700 buses a day through Huntington Park. It is a transportation hub.

Redwood City is close and has a fixed bus system that is operated by private carrier under contract to the city. Huntington officials thought this might be its answer, but realized after a year or so of study that door-to-door service would be more applicable.

In July 1973, the city asked for bids on a DRT program with 2 vehicles. The All American Cab Company was the low bidder. Because of my belief in shared riding, I wanted this program; and we bid at $8.25/hour. The only other bidder, the Southern California Rapid Transit District, bid $23.25/hour. I wish I had known that. We included no profit at all and no salaries for dispatchers or order takers because they were already on the job.

The DRT operation is so compatible with the taxicab operation that it is second nature. It took no more than 3 hours for our people to become adjusted to the program and after that it was as though they had always been dispatching, taking orders, and handling DRT.

The city uses federal revenue sharing funds to buy our services. [In Los Angeles County, we are part of the Southern California Rapid Transit District (RTD). RTD has the first choice of funds from state gasoline tax that can be used for transit.] We supply the vehicles and the drivers and maintain the vehicles. The city pays on an hourly basis and promotes the program. The original advertising and promotion was good and then it declined. However, the program is running fairly successfully.

The rates started at 25 cents for children under 12 and senior citizens and 50 cents for adults and are now 25 cents for everybody. We operate 2 buses from 9:00 a.m. until 6:00 p.m. We average about 95 passengers/day/bus, 75 percent of whom are senior citizens. During the RTD strike, we were allowed to put a third bus on and ridership increased considerably. As the ridership grows, we should add a third bus; otherwise, growth stops. But the city has no funds for the third bus.

We had planned to use a taxicab, but the city wanted a different vehicle, and we have a 16-passenger van with air conditioning and music.

My conclusion after 9 months of operation is that, no matter how high the volume is, at our rate structure we will probably never have a profitable operation. When I first submitted my bid, I thought that at some time it would be, but we now have the highest ridership we can possibly have during the 9 hours we operate. During the RTD strike, we handled approximately 100 passengers/day/vehicle and our subsidy per passenger dropped to 60 cents, which is still not a profitable operation.

We are now trying to add a van with a lift for handling of the handicapped, particularly those in wheelchairs. But we must find funding.

Ronald F. Kirby, The Urban Institute

A number of services that could be offered by taxicabs are currently prohibited in U.S. cities by regulations enacted by public service commissions. Although relaxation of such restrictive regulations has been advocated on numerous occasions by transportation researchers, planners, local government officials, and taxicab operators themselves, little regulatory change has occurred to date. Moreover, the taxicab industry is rarely considered a potential provider for publicly supported transportation services where these are deemed socially desirable.

One of the major reasons why little innovation has taken place in the public regulation of taxicabs appears to be that little experience is available that regulators and policy makers can use to evaluate proposed changes. In a recent study (1), which reviewed experience and assessed the potential for transportation services referred to as paratransit, the authors concluded that a demonstration program was needed to evaluate the potential of taxicabs for providing various paratransit services. (Paratransit includes all intraurban passenger transportation that is available to the public, is distinct from conventional scheduled bus and rail transit, and can operate over the highway and street system.) This paper pursues this conclusion further and specifies in general terms a program of empirical investigation and experimentation designed to test and evaluate promising service innovations for taxicabs.

SERVICE INNOVATIONS AND FARE STRUCTURES

In most U.S. cities service standards and fare structures for taxicabs are designed to facilitate regular taxi service, in which 1 or more travelers hail or phone a taxicab to convey them directly from one location to another. Fares are usually computed by a meter, which typically registers 50 cents for the first ½ mile or 0.8 km and 10 cents for each additional ⅙ mile or 0.3 km (while the cab speed exceeds 10 mph or 16 km/h) or for each minute (while the cab speed is less than 10 mph or 16 km/h). For group riding, in which 2 or more passengers travel between the same origin and destination, the total fare is computed as the meter reading for the first passenger plus a flat rate of perhaps 40 cents for each of the additional passengers. In some cities the fare structure is based on geographical zones, and fixed fares per passenger are set for travel between each pair of zones. In these cases fares for group riding are usually set at a flat rate per passenger and are 10 to 30 percent lower than the single passenger rates.

Regulations seldom deal adequately, however, with the various shared-ride services that taxicabs can provide. Four types of shared-ride services can be identified (1):

1. Jitney, in which the vehicle travels relatively fixed routes on short (but unscheduled) headways and is hailed by prospective passengers;
2. Dial-a-ride, in which the vehicle is requested by telephone, and vehicle routing is determined as requests are received;
3. Hail-a-ride, in which the vehicle is hailed, but travels no fixed route, and may display a destination sign or simply stop to request a potential passenger's desired destination; and
4. Subscription, in which passengers agree to ride together on a regular basis along a route determined by prior arrangement between the travelers and the provider.

A number of variations to these service types are possible: Dial-a-ride services, for example, require that requests for service be made at least 2 hours in advance of the trip time to facilitate matching of riders, and hail-a-ride services might make use of taxicab stands and depart on relatively fixed schedules.

The zone or meter fare structures for regular taxicab services are almost always set to ensure that revenues cover costs and yield a profit to the taxicab operator. This is in sharp contrast to conventional bus and rail services in the United States. Revenues of these services generally fall far short of costs, and the resulting deficits are covered by public funds. In almost all cases where small buses are used to provide dial-a-ride, subscription, and scheduled services, fares are also set well below the level that would produce sufficient revenues to cover costs, and again public funds are used to supplement fare-box revenues.

The use of public funds to subsidize public transportation services has been justified as a means to achieve 2 widely accepted social objectives:

1. Attract private automobile drivers to public transportation and thus reduce congestion, pollution, and fuel consumption; and
2. Provide adequate mobility for those who are unable to use a private automobile, especially the young, the elderly, the poor, and the handicapped.

But though these objectives are widely accepted, the way in which they can best be achieved is still the subject of much uncertainty and debate. In particular, it has been argued (1) that taxicabs should be given greater consideration as potential providers of publicly subsidized transportation services.

Since taxicabs are operated entirely by the private sector, they have not been eligible to receive public funds under the major federal subsidy program, the UMTA Capital Grant Program, which may disburse funds only to "public bodies and agencies thereof," according to the Urban Mass Transportation Act of 1964, as amended through October 15, 1970. Technically, a public body could acquire capital equipment for taxicabs (such as vehicles, meters, and radios) and then lease that equipment at low rates to private operators, thus passing on the subsidy. Apparently UMTA capital grants have never been used in this way, however, and neither public transportation authorities nor taxicab operators have expressed much enthusiasm to date for this subsidy mechanism.

Two more promising subsidy mechanisms, however, have been implemented in a few locations. Under the first mechanism, the public body negotiates a contract with a transportation provider to offer certain specified services at reduced fares; public funds are paid to the operator to supplement fare revenues. This mechanism is particularly useful where the public authority can readily specify the services required, such as the operation along a relatively fixed route or on a fixed schedule, for monitoring the performance of the transportation provider under these circumstances is relatively easy. However, where the services, such as regular taxi, dial-a-ride, hail-a-ride, and even jitney, are required to respond to traveler requests, the provider can ignore some requests in favor of more profitable ones, and this kind of response (often termed the service-refusal problem) is rather difficult to police.

A second subsidy mechanism that should fairly well overcome this problem is the use of transportation tickets sold to target group travelers at reduced rates and redeemed at the full fare value by the transportation provider after use by the travelers. This mechanism has a number of advantages for subsidizing services provided by taxicabs.

1. Passengers with tickets look like other customers and, therefore, receive as high a level of service as other passengers.
2. Tickets can be issued at different discounts to different target groups, thus offering a great deal of flexibility for directing the transportation subsidy to particular groups of travelers.
3. Because the provider receives no subsidy funds unless service is provided to target group travelers, he or she is motivated to tailor service carefully to the demand.
4. It can easily be ensured that the provider is compensated fully for each service offered. If costs are higher to serve the handicapped (because of the need to handle wheelchairs, aid passengers, or use special vehicles), for example, the provider can be allowed to redeem tickets issued to the handicapped at higher values than those for other groups.
5. The possibility of fraud can be policed relatively easily by numbering the tickets, recording the ticket numbers issued to each individual, and monitoring where and when tickets are used.

Meyers (2) has suggested a variation on this second mechanism that would ensure high-quality service to certain groups and offset losses on other services: Allow the provider to redeem certain tickets at a premium value significantly above the cost of the service offered. The difference between this premium and the cost, which would probably exceed 50 cents/trip served, would be a provider bonus and would have to be used by the provider to cover the costs of other unprofitable services. Just how the use of these bonus funds should be monitored is unclear at present, however, and the merit of this technique relative to other subsidy schemes is the subject of a separate inquiry being conducted for UMTA by the Urban Institute (3).

The fare structures corresponding to the 2 subsidy mechanisms described above might be quite different.

For the contract case, a public agency can ensure through the contract rate that the taxicab operator receives adequate compensation for the services provided. The fare revenues might be part of that compensation or might simply be turned over to the public agency and all of the taxicab operator's revenue might be received through the contract rate. In either case, the fares could be set fairly well independently of the cost of the services provided; a flat fare of 50 cents might be charged for all trips, for example.

For the ticket case, however, the costs of the various services provided should be known with some degree of accuracy, and the fare structure should be set to reflect these costs. Fares might be based on a meter or zone scheme, for example, and additional charges made for handling wheelchairs, assisting passengers, and so on. In the zone case, a surcharge may be necessary to reflect additional costs of operation during rush hours (handled under the meter scheme by the time element). The passengers "pay" these fares through the use of 50-cent tickets, say, which they purchase at varying discounts depending on the target group to which they belong. The taxicab operator then takes these tickets to the public agency in charge of the program and receives payment corresponding to their face value. The passengers thus pay a proportion of the cost of the services they use. As a result, they should be motivated to use the least costly service that meets their needs (which is usually not the case under a flat-fare system).

BENEFITS AND POTENTIAL PROBLEMS

Service specifications, subsidy mechanisms, and fare structures can be designed in a variety of different ways, and each is likely to offer certain benefits and some real or potential problems. For most of the shared-ride services mentioned earlier and for the subsidy mechanisms discussed, the nature and magnitude of the benefits under different urban conditions are uncertain, though they appear to be sufficiently large to warrant full investigation and evaluation. Some potential problems with these services and subsidy mechanisms are readily apparent, and others will surely arise when a public agency attempts to have them implemented. In the following paragraphs the likely benefits and problems of these innovations in taxicab services are listed. The final section of the paper then discusses the kind of empirical investigation that appears to be needed to resolve the major uncertainties surrounding these innovations.

In providing jitney services, taxicabs could generate the following benefits:

1. Improved mobility along well-traveled routes, such as home-to-work corridors and streets within business and commercial districts;
2. Increased vehicle occupancy through a shift of private automobile drivers to high-occupancy jitney vehicles and consequent reductions in congestion, pollution, and fuel consumption; and
3. Reduced crowding on rush-hour buses through a shift of some bus riders to jitneys.

The following potential problems are associated with jitney services, however:

1. Street congestion and accidents might increase because of an influx of taxicabs pulling to and from the curb to discharge and pick up passengers;
2. If jitney services have to operate without public subsidy, potential riders might find the fares too high relative to bus fares, and the service might fail financially; and
3. Transit authorities might protest the operation of jitney services along transit routes and might be able to persuade regulatory authorities to retain existing regulations prohibiting taxicabs from offering formal jitney services.

Dial-a-ride and hail-a-ride services provided by taxicabs also offer some important benefits:

1. Improved mobility within suburban and small town areas (dial-a-ride) and within business and commercial districts (hail-a-ride),

2. Lower costs per trip than those of dial-a-ride services provided by small buses, and
3. Potential for substitution (along with regular taxi services) for poorly patronized conventional bus routes.

There are also some potential problems.

1. Diversion of a substantial number of passengers from regular taxi services might require an increase in fares for those services.
2. Accumulation of operating losses during the introduction of the services might cause severe financial problems for the taxicab operator.
3. Transit operators might resist the substitution of taxicab services for existing bus services.
4. Where ambitious dial-a-ride services are offered over wide areas, costs and fares might be almost as high as regular taxi services. A major problem might be deciding how to limit the services offered to keep costs down.
5. If a zone fare scheme is used for the shared-ride services together with a meter scheme for regular taxi services, shared-ride services for some short trips might have higher fares than those of regular taxi services and result in an awkward anomaly in the fare structures for taxicab services.

Subscription services provided by taxicabs appear to offer the following benefits:

1. Improved mobility for users making trips with regular routes and schedules, particularly during rush hours;
2. Increased vehicle occupancy during rush hours through a shift from private automobile use (although some riders might be diverted from buses) and consequent reductions in congestion, pollution, and fuel consumption;
3. Reduced parking requirements at employment locations served; and
4. Low fares achieved through negotiation (between the users and the provider) of special rates for regular, high-occupancy services.

There are some limitations on subscription taxicab services.

1. As for other prearranged ride-sharing services (car pool, van pool, subscription bus), the individual is faced with a route and a schedule that are essentially inflexible. Unless some convenient arrangements can be made for days when travel needs depart from the regular schedule, this inflexibility may make the service unattractive to many travelers.
2. If a large fraction of the users of subscription taxicab services are diverted bus riders, some increase in traffic congestion might result.

The 2 subsidy mechanisms discussed above, contract and reduced-rate tickets, offer improved mobility for those unable to use a private automobile, particularly the young, the elderly, the poor, and the handicapped. Each also has some potential problems.

1. For the contract option, to ensure that the target groups receive adequate service may be difficult. If the provider is being paid on an hourly or mileage rate essentially independent of the passengers carried, he or she has little incentive to tailor services to meet special needs of particular target groups.
2. For the reduced-rate tickets, the problem of fraud may arise. That is, passengers not belonging to the target groups may somehow obtain and use the reduced-rate tickets, or providers may obtain and redeem tickets without providing the required services. Further, many target group members may regard the use of such tickets as demeaning and refuse to use them, thus limiting the effectiveness of the ticket mechanism.

Substantial uncertainties surround each of the above innovations of taxicab services at present and are likely to deter most public agencies and taxicab operators from attempting to implement these innovations. Steps need to be taken then to resolve these uncertainties so that those innovations that do offer significant benefits for urban residents will be well enough understood by planners, public agencies, and transportation providers to permit their implementation.

WHAT NEEDS TO BE DONE?

Transforming worthwhile innovations in taxicab services from the idea and discussion stage to implementation in urban communities involves 2 major steps:

1. Broadening the knowledge base about the benefits and problems of these innovations by empirical investigation of existing data on taxicab services, case studies of innovations already in operation in a few locations, and experimentation with innovations that have not been tried to date; and
2. Disseminating information on these innovations to planners, policy makers, and transportation providers by means of planning guidelines and, in some cases, exemplary demonstration projects.

For the service innovations and subsidy mechanisms discussed in this paper, we are still concerned with broadening the knowledge base, the first of these 2 steps. Specifically, we need to conduct detailed empirical investigations, through case studies or experiments, of the following forms of taxicab operation.

1. Taxicabs could be used to provide jitney services on short headways (less than 10 minutes) along well-traveled corridors. Ideally, the investigation should include some corridors that currently have transit services and some that do not.
2. Dial-a-ride and hail-a-ride could be introduced as new services to be provided by taxicab operators currently offering only regular taxi services. Regular taxi services would continue, and the shared-ride services, with new specifications and fares, would be introduced to supplement existing services.
3. Taxicab services (regular taxi, dial-a-ride, hail-a-ride, or possibly subscription) could be substituted for some poorly patronized bus routes.
4. Well-planned and well-promoted subscription services could be introduced.
5. Taxicab services, such as feeders to line-haul transit services, and convenient transfer mechanisms, such as sheltered terminals and joint fares, could be used.
6. Subsidy mechanisms, such as the contract and reduced-rate ticket schemes described above, could be used to provide high-quality service at low cost to target groups.
7. Taxicabs could be used for goods movement.

The purpose of the present research effort for UMTA is to specify particular case studies and experiments that will permit empirical investigation of the above forms of taxicab operation and help to clarify the uncertainties and problem areas discussed earlier. The analyses conducted in these empirical investigations should ultimately provide a basis for the development of planning guidelines and exemplary demonstrations, the second essential step toward the implementation of worthwhile innovations in taxicab services for urban communities.

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Stanley Hirsch, Orange and White Taxi Systems, Hicksville, New York

I am vice-president of the following enterprises: Orange and White Systems, which operates 100 shared- and group-riding taxicabs; White Carriage Corporation, which operates more than 100 school buses; and STAT Ambulance Service, which is the largest ambulance company on Long Island. All of these businesses are privately owned, and none of them receives direct subsidies. I and my associates are seldom accused of altruism. On the other hand, we are not money hungry. We are simply attempting to sustain a good living for ourselves and our employees. Economic and political pressures aimed toward destroying our profit-making ability are constant. Yet, in each of our transportation companies, we have managed to keep the ledgers in black ink.

I hasten to add that we are not tycoons of industry. Our growth beyond the taxi business has been forced on us, both to enhance our buying power and to achieve maximum economical use of facilities, personnel, and vehicles. We remain solvent by working hard—7 days a week and 365 days a year—at the things we know best.

We strenuously resist the trend toward socialization of transportation. We find that not all but a significant number of politicians are anxious to give away the same services that we sell. For example, last year several of our county legislators borrowed a van and ran a free DRT experiment in the Brentwood, Long Island, area. The experiment was conducted for 2 weeks during which time all volunteer workers were used. The program was not properly insured, was not properly licensed, violated the previous sanctity of a CB radio channel, and spent no money for salaries and employee benefits. All this was done in an area served by 2 taxi companies, who had no prior knowledge of the experiment and whose cooperation was not requested. When interviewed by reporters, the perpetrators of this farce termed the experiment a huge success in attracting riders. Thus, these unverified newspaper accounts succeeded in keeping the legislators' names in the newspapers. Thus encouraged, they even wrote a 60-page report that compared taxicab fares, transit fares, census tracts, and so on.

On a less grand scale, I would suppose that this sort of thing is repeated almost daily in the United States. Local politicians seem to love to get up and give away anything, particularly DRT systems. Even UMTA has published an operating manual, which I sometimes think was intended as a primer for politicians to learn how to get government money for anything.

The creation of such a climate, particularly on Long Island, has brought a bonanza to consultants and consulting firms. Unfortunately, some of these consultants are hired not to make professional surveys, studies, or recommendations, but to produce reports that will lend credence to the current boondoggle. Sometimes they do not even take time to ascertain entry regulations, jurisdictional rights, or local custom. Source material for demographic profiles is often years out of date. A favorite gambit for consultants during a developmental study is to form an advisory council of local business people and residents. These councils meet irregularly, if at all, but the names of the members are always used to dignify, by implied endorsement, the final published report. I know of one instance in which members of a technical advisory group were not even given the courtesy of receiving a draft and final copies of the consultant's report.

Most everyone knows that every DRT system in existence has been, as a financial experiment, a complete failure. In some cases, the word disaster is not too strong. Even as an experiment in innovative transportation, regardless of cost, most systems cannot be termed a demonstrable success for the population they are supposed to serve.

The marketing of low-fare transportation systems, without ridership, becomes an expensive experiment and places an unwarranted burden on the taxpayer. The life-styles necessary to support any transit system will not be changed overnight. We can force motorists out of their cars by raising sales taxes on automobiles, by creating gasoline shortages, by elevating parking fees and use taxes, and by emphasizing ecology problems. Whether most of the existing transit systems would be able to sustain the passenger burden is questionable, however.

On Long Island, we think that our industry is perhaps doing something right. For more than 25 years our taxicab business has, in fact, been a DRT system. It has paid its own way; fares have risen, but in proportion to those of other products and services. In fact, on the basis of cost per mile, our fares are still almost one-third lower than those of the most efficient DRT systems in America. We have done this while working within the confines of our existing socioeconomic system and without any direct subsidy through transit bills, tax relief, or price support for inequitable fuel costs.

Fortunately, on Long Island, we do have some public servants and politicians who are trying to do the right thing. For these people, we have the utmost respect and we demonstrate it daily by working with them to create the best and most economical transportation possible. These people are rare, but my industry is doing its best to educate more government people to the realities of public transportation. Meanwhile, we spend an enormous amount of time fighting the giveaway artists, and we fight doggedly to persuade politicians and technical committees that it is impossible for us to continue to exist if there is to be a proliferation of unfair subsidized competition. This nation's needs for demand-responsive transportation can be met by independent tax-paying businesses.

Discussion

KENNETH HEATHINGTON: Will shared riding or group riding be more pronounced in certain urban communities than in others or with a certain size of taxi operation than with others? For example, will it be the same for an operation of 1,000 vehicles in Chicago as for an operation of 100 vehicles in Little Rock?

CHARLES BOYNTON: The emphasis will be different in different cities depending on the size of the business involved. Because of regulations, what one cab company does in the town, the others do. Maybe in the future that barrier ought to be knocked down. But, if one cab company is allowed to share rides, that benefit passes on to other cab companies. The service being offered is proliferated.

NICK PINE: What percentage of systems now lease vehicles?

CHARLES BOYNTON: Leasing is occurring throughout the country. In 4 years we have gone from about 25 percent leasing to nearly 40 percent. The pension act and the passage of a national health insurance plan will push the emphasis because of increased labor costs.

ROBERT BERMAN: In the city of Fairfield, California, drivers under the leasing plan do not seem to get the same benefits as bus operators. Is this a union problem?

CHARLES BOYNTON: A self-employed driver pays less FICA taxes than one that is employed by someone else. It is just a matter of revenue sharing. I think unions are reluctant to see companies turn to lessee operations.

TOM SHREVE: Have taxi companies stopped public promotion and advertising?

CHARLES BOYNTON: We have not done a good job with that at all. I think the reason is money. We are trying to sell a service to 25 percent of the public and we have got to advertise to maybe 150 percent of the public. We spend between $9 and $22 per thousand people for advertising in Salt Lake City.

DANIEL ROOS: Is there an example of a taxicab company being provided with financial assistance on a local, regional, or statewide basis? How is that done? Is money given directly to the individual, or is money given to the company and then passed on to the individual? How successful are these operations, if they do exist?

CHARLES BOYNTON: I know of no specific cases in which a ride has been subsidized as opposed to subsidizing some portion of a taxi company.

KENNETH HEATHINGTON: I know of specific examples in which taxi companies are aided by contracts and by subsidy to the individual. I was in a city not long ago that wants to start a special transportation service for senior citizens. Of course, I always try to talk cities into using the existing taxi company to provide those services and to subsidize individuals so that they can purchase taxi transportation on the open market. The taxi company in that town refused to discuss the issue with the city council and the mayor. So the city is going to provide the service with its own buses and hire its own people.

JOHN KOIZIM: How do you settle the accountability problem with shared cabs? In other words, if 5 passengers go to 5 different destinations, the driver might report all of these? How can you set up an equitable, fair selection in each city and overcome any possible union disagreement with regard to shared cabs?

ROBERT SAMUELS: I think that one of the reasons there has been so much reluctance to allow shared riding is the fear that drivers may not charge the correct fare or may overcharge the customers. There is no way to get a proper accounting, and one of the reasons that many communities have gone to leasing is that the driver then keeps all of the money collected from the passengers.

ROBERT BERMAN: I noted quite a lot of agreement that taxi sedan vehicles could do the job for DRT and that there was no need to go to the small buses and vans. But it seems to me that as ridership increases, at some point, there is a need to have a larger vehicle. Have any cost studies been done to determine when it becomes more cost effective in terms of trips per day or per hour to go from the sedan to the 15- or 16-passenger vehicle?

STANLEY HIRSCH: In private industry wherever we can evolve a profit, we are going to do it. If that means larger capacity vehicles to make more profit, we will go to larger vehicles.

KENNETH HEATHINGTON: We did some economic analysis about 3 years ago and found no difference in annual cost of a small vehicle and the largest transit vehicle because of the difference in the life and in the maintenance.

ROBERT SAMUELS: The cost of running the "stretch-out" vehicle is somewhat higher than the cost of a 4-door sedan but somewhat less than the cost of a bus.

FRANK GALLUCCI: It seems to me that the real cost in going to a new bus or larger bus versus the cab. The savings are really in personnel costs. The initial capital investment is a fixed sum, and having to pay for 1 driver for a 16- to 25-

passenger bus versus having to pay 2 or 3 drivers to haul this same number of people is where the problems occur.

ROBERT SAMUELS: The fact is, a conventional vehicle will be used in more than 1 mode and, besides, the DRT average loads are well within the capacity of a taxicab.

KENNETH HEATHINGTON: The productivity of all DRT buses, with the exception of those in Regina, is about the same as or sometimes lower than that of a traditional cab. If DRT buses carried a standing load or were filled to capacity, the wait time and travel times would greatly affect the service.

SANGER: As a cab driver, if I were to get X amount of dollars per hour, I would not care how far I drove my vehicle each day. One of the abuses that occurs in DRT is that people get on the bus and ride all day long with 1 ticket. A simple method is needed similar to that in a parking lot, where the user gets a numbered ticket that can be stamped by a simple time machine where passengers get on and off. The rate could be set at, say, 2 cents a minute or a minimum fare of 25 cents. Was any investigation made to establish a rule of thumb to set rates by time instead of by miles or some other way?

RONALD KIRBY: An hourly rate looks good to the employer but not to the user. The user is not paying to be carried around for a period of time in the cab but to get from A to B. If it takes longer, he or she is not happy. The hourly rate does not motivate the cab driver, at least from the user's point of view. The cab driver's motivation becomes just to drive the cab around and not necessarily to serve users. Another problem is mechanical. In a shared ride, how do you keep a record of everybody that gets on the vehicle? You have to have a clock for each person. This is the reason I have not seen any way of using a meter until now.

DWIGHT BAUMANN: At Carnegie-Mellon, we decided to learn about the transportation system in the same way that agricultural academicians learn about agriculture—by corn plots at the Agriculture Extension Services. So, we acquired a taxi company. We have a relatively perfect market in that the driver on a percentage basis makes a perfect marketer today. If you want to handle the problem of transportation, just make the prices right. One of the problems with transportation systems is that we expect to use it as an income-transfer mechanism. Why not let each person charge according to what the cost is to provide that service and transfer income by a slip of paper? We are working on a taxi meter that gives the fare when the passenger gets in. We expect to give each person in a shared ride his or her own display, which will also take care of the estimated travel and the exact mileage distance.

RICHARD BAUMAN: In Scotsdale, Arizona, we have the handicapped and the elderly whose transportation we need to subsidize and the other residents who would pay full fare. We are considering issuing credit cards to residents and using a variable fare-pricing system, particularly if we charged on a time basis. The machine would keep track of how much time and how many people are in a particular ride and charge different groups different prices. Is this feasible?

KENNETH HEATHINGTON: We have done research on user attitudes toward credit cards, and most of this is published in the Transportation Research Record. Of all the items—tokens, exact fare with change, subscription—credit cards are the lowest in terms of consumer preference. I understand that credit cards were used in Tulsa but only for 6 months.

THOMAS HIGGINS: One of the chapters in the Urban Institute report by Kirby et al. is about free entry. I would like to have some comments on that.

RONALD KIRBY: The question of free entry is a sensitive one. At the Urban Institute, we came out in favor of it, as defined in a narrow sense: placing no limit on the number of taxicab licenses that are available in an area. The defense of the limited-entry regulations has typically been that it is a way of keeping out fly-by-night operators, unqualified people, Chevy vehicles, people who are not financially reliable, and so forth. I think it is absolutely essential to regulate financial responsibility, vehicle conditions, driver qualifications, service standards, and so forth and to regulate them strictly. However, I have yet to be convinced that it is necessary to limit the number of taxicabs. In many areas in this country we have illegal or pseudo-legal operations, and public utility commissions do not bother to do anything about them.

ROBERT SAMUELS: Unlimited entry also means unlimited exit. If anybody can come, anybody can go; and this hit-and-run method is a splendid one and plenty of operators in plenty of industries have made a fortune doing it. But no legitimate company ever worked on such a theory because you never catch the operators fast enough to collect personal injury or property damage claims. No insurance company of any standing in the United States would write the public liability insurance under those conditions. This is a fine thing in theory and is just absolutely impossible in practice.

CHARLES BOYNTON: In the cab industry, we generally agree that limiting entry is a regressive line of thinking and perhaps flies in the face of the realities. There are alternatives. One is compensation to past carriers for past service. Another is future systems of free exit. The ICC argument about regulations on trucking can be applied to the taxicab industry, and I think there will be pressure for limited access to be eliminated.

THOMAS HIGGINS: Do you think UMTA will get into this regulation area at all?

RONALD KIRBY: I think UMTA is certainly interested in what kind of regulations are appropriate and funded research that was conducted in this area. I would not say that UMTA is advocating free entry. But the National Transportation Report in 1971 does mention relaxing entry positions.

NICK PINE: How would you compensate companies for past performance?

CHARLES BOYNTON: One way could be to recognize franchise values and their marketability and to allow the deduction on tax returns of the costs of franchises and of getting into business.

JOHN ROSSONI: In the setting of fares, has the user's point of view been considered? How much does it cost the user to wait for a DRT vehicle? That is time spent by the user on the system and ought to be represented in the cost function.

RONALD KIRBY: We bypassed that question in a sense by saying that those factors are a part of a service. The customer looks at the service and its waiting time and riding time and makes a decision on what mode to take. The provider offers a service at a certain price. If service is poor and the user is not prepared to pay for it, the provider will not serve. We are quite happy to let nature take its course in that respect.

RESEARCH AND DEVELOPMENT IN DEMAND-RESPONSIVE TRANSPORTATION

John H. Davidson, Yellow Cab Company, Los Angeles

The concept of using electronic data processing (EDP) equipment as a tool in the dispatching of demand-responsive transportation (DRT) vehicles is not new. Numerous studies and simulations have been carried out on the use of EDP equipment in dispatching demand-responsive service, some of which incorporated algorithmic formulas relative to trip length, vehicle availability fare structures, and other factors. EDP equipment has been used in the operations of certain publicly funded demand-responsive systems and of a few taxicab operations. The results have varied.

In 1971, the Los Angeles Yellow Cab Company started using an NCR 100 disk-oriented unit with 32K capacity memory; the program was written in NEAT III language. This system allowed input from as many as 12 and dispatching from as many as 3 CRT positions. Simple orders only, i.e., no advance orders, emergency orders, or call-backs (repeats of previous orders that had not been serviced) could be processed through the system. Other orders continued to be handwritten on an order blank and physically processed to the dispatcher—called an order-sender in this instance.

The result was that the EDP equipment handled approximately 75 percent of the incoming orders. Those orders handled by the EDP equipment are received, processed, and displayed in a matter of seconds. The system validates the received order, assigns it to an area within the service area, assigns it a "stand" or physical cab dispatch location, and routes it to the appropriate order sender position. The system eliminates to a large degree the attitude of proprietorship of certain individuals, who, because of their knowledge of the large service area involved (some 425 $miles^2$ or 1105 km), quite literally held the dispatch organization between their ears and who, when they did not desire to operate efficiently or failed to show for work, caused a distinct deterioration in the quality of service rendered.

Faced with declining orders, a situation not unique to this operation but experienced nationwide in the taxicab industry, and the limitations imposed by equipment and software, we made a review in 1973 of available equipment and software that would improve response time, eliminate paper work in handling orders, and still maintain the economic advantages that had resulted from eliminating some personnel and not having to rely on a select few. These improvements more than balanced the cost of the EDP equipment.

As a result of this review, we installed equipment that receives and validates all types of incoming orders: simple orders, advance calls, call-backs, cancellations, and emergencies. Orders are automatically routed to the appropriate order sender, and the first, second, and third alternate stand calls are displayed along with the address. The system automatically displays advance calls before the required service time. In the case of call-backs or repeat calls, the system checks the status of the original call and gives the order sender the option of calling the original cab sent or, if the call has not been sent, flagging the call as a repeat call. Cancellations are automatically eliminated from the active order file or displayed with the appropriate vehicle number if a unit has already been sent. Other special and emergency calls are given order file priority. Also, as an option to the order sender, the system processes and displays cab status, which is manually input by the order sender. Vehicle status retains an automatic drop time and also is removed automatically from status screens when the vehicle number is used on an order. All disk access times have been accelerated with advance programming technology to ensure that operators are not "waiting" for the system to respond to a command.

Several business-oriented reports monitor the total communications operation and the individual performance of the operators. The computer hardware consists of 2 Data General Nova series minicomputers of 32K each, 2 dual disk driver units, 1 line printer, 1 teletype, 14 Hazeltime CRTs, and appropriate switching gear to enable the system to be fully backed up in case of computer hardware failure.

Some conclusions may be drawn from this operation:

1. The use of EDP equipment in dispatching demand-responsive vehicles is technically feasible;
2. It is economically feasible for an operation in which a minimum of 2,700 orders per day are handled;
3. It gives management greater flexibility in the utilization of personnel;
4. It improves service to the public; and
5. When the day of economically feasible AVM arrives, the circle of control of the historically independent taxicab driver will be more nearly complete.

Nigel H. M. Wilson, Massachusetts Institute of Technology

From 1967 to 1971, much research at M.I.T. and elsewhere was devoted to the potential use of computers in the control of demand-responsive transportation systems. Two of the most tangible outputs of these efforts were

1. A computer simulation model to test alternative computer control algorithms and to predict system performance; and
2. A recommended set of computer control procedures in which (a) the immediate assignment of each request was made to the current "tour" of the best vehicle, (b) the assignment was based on feasibility conditions, under which each user receives service within specified bounds, and (c) the determination of the best assignment was based on the minimization of total service times for current and future passengers.

These control procedures were tested by a simulation model and were found to perform well on intuitive grounds (i.e., an examination of individual assignments and their comparison with judgment) and relative to other proposed algorithms. However, since no optimal-solution algorithm has been developed, absolute statements about their performance were impossible.

One result of this research program was the decision to mount a demonstration project of the concept in Haddonfield, New Jersey, to obtain a market test of the service concept and to obtain data on the potential of computer dispatching. The system (which has been extensively described elsewhere) has just terminated; its demonstration project phase provided valuable data in both of these areas. In particular the computer control system used in the latter stages of Haddonfield was developed by the Mitre Corporation using the control algorithms previously developed at M.I.T.

M.I.T. is now the recipient of a university research and training grant from the Urban Mass Transportation Administration to develop advanced DRT control procedures based on the experience gained in Haddonfield and to look explicitly at the problem of controlling integrated DRT and fixed-route transit services. This presents a rare opportunity to evaluate academic research in light of subsequent operational experience and specifically to validate the simulation model and to analyze and improve on the operation of the total system. An additional benefit of the Haddonfield experiment has been the collection of extensive data on a similar manual system (the characteristics to the user are identical) that will permit evaluation of the quality of computer assignment. This paper presents preliminary results of this research and concentrates on the single DRT system.

ASSUMPTIONS IN DESIGN OF SIMULATION MODEL

Numerous assumptions and simplifications of the real-world system were required in the design of the simulation model. This model was designed to provide the analyst with the ability to simulate a wide range of systems. The input parameters include area dimensions, demand rate, demand pattern, number of vehicles, vehicle size, and vehicle speed. However, as the model was originally designed, 2 major assumptions warranted further investigation in light of Haddonfield operating experience:

1. A constant number of vehicles are in service continuously throughout the simulated period, and
2. The demand rate is constant during the simulated period, although the time between successive demands is selected from a user specified distribution.

To investigate the validity of these assumptions, 2 new options that relax these 2 simplifications have now been implemented in the model. The first option allows the analyst to use either completely random demand inputs or a fully specified set of demands that occur at known times between known origins and destinations. This allows the simulation of an actual set of demands from a day's operation at Haddonfield, for example. The second option allows vehicles to enter or leave service at any times specified by the analyst or to use a constant, continuous supply of vehicles. These options provide a great deal of flexibility and power in validating the simulation model. Simulation experiments were then run of the Haddonfield system; real and approximate demand and vehicle input were used.

FINDINGS ON MODELING ASSUMPTIONS

Comparing an actual demand stream simulation as obtained from Haddonfield transaction tapes with random demands based on approximations of the Haddonfield demand showed that approximate and random demands are quite satisfactory for the prediction of system performance. This implies that estimating the approximate spatial distribution of demand and level of demand is sufficient to predict future performance in a demand-responsive transportation system. This is fortunate, for if this assumption were not valid, prediction of future systems performance would have been infeasible.

However, the assumption of a constant and continuous supply of vehicles was found to result in significant overestimation of vehicle productivity or overestimation of the quality of service that can be provided or both. The reason for this is that, when a vehicle enters (leaves) service, it is significantly underused in the hour immediately following (preceding) the change. The greater the number of changes are in vehicle status, the greater the overall impact is; and, since fully demand-responsive operations occur in the base period of the schedule, vehicle status changes are frequent because of shift changes and driver lunch breaks.

To approximate Haddonfield results by using the basic unmodified simulation model with the constant number of vehicles equal to the average number of vehicles actually operating was impossible. However, by using actual vehicle in-service times, we were able to closely approximate actual Haddonfield quality of service. The operations from 9 a.m. to 3 p.m. on September 19, 1974 were as follows:

Item	Number
Passengers	262
Vehicle productivity (passengers/vehicle/hour)	5
Vehicles in service	10 to 12
Distinct vehicle shifts	34

The statistical analysis of actual and simulated quality of service is given in Table 1. The constant number of vehicles in continuous service demonstrates that similar service can be provided with about 30 percent fewer vehicles if they provide continuous service. The results from the third assumption reflect actual vehicle in-service times and show close correspondence with the actual operation.

The conclusion must be that, although the simulation model was sophisticated by any standard, it was not, as originally designed, realistic enough to provide reliable estimates of productivity and service quality. At the time the simulation model was developed, not enough was known about the transient behavior of the system to recognize this as a significant factor. The implications of this behavior are

1. The new model should be used in planning new systems in conjunction with expected (and realistic) vehicle in-service times (indeed the model can be an important factor in planning driver shifts), and
2. From a control procedure and operation viewpoint, more attention must be given to system performance under transient supply conditions.

ALGORITHM PERFORMANCE

In general the algorithm used in Haddonfield has performed well although no definitive comparison of the system performance with computer and manual assignments has yet been made. Preliminary evaluation indicates that the quality of service provided is at least as good under computer control as under manual decision making, and probably somewhat better; however, a fuller evaluation is now under way.

Based on operational experience in Haddonfield, the following are areas in which improved performance might be achieved:

1. Inflexibility of hard constraints,
2. Objective function as a true reflection of customer utility,
3. Handling of advanced and periodic requests,
4. Constraint of vehicle position at future time,
5. Restriction of certain vehicles to given zones,
6. Preassignment capability,
7. Scheduling at start and end of driver and vehicle shift, and
8. Gearing of algorithm to underused system.

Each of these areas is described, and, where appropriate, possible remedial actions are suggested.

Table 1. Statistical analysis of quality of service.

Operation	Assumption	Vehicles	Time	Mean	Standard Deviation	Max
Actual	–	10 to 12	Wait	9.5	6.0	34
			Ride	9.5	5.4	32
Simulated	1	Constant 8	Wait	6.7	5.0	22
			Ride	9.6	6.0	31
	2	Constant 7	Wait	8.9	6.8	31
			Ride	10.4	6.8	34
	3	In and out of service	Wait	7.4	6.5	34
			Ride	10.2	6.5	36

Inflexibility of Hard Constraints

The algorithm was designed to minimize total service time (for current and future passengers) within fixed constraints on wait, travel, and total service times.

Any assignment in which no constraint is violated is preferred to any assignment involving a constraint violation, independent of the value of the objective function. This constraint was developed to reduce the number of passengers experiencing unreasonably long service times; the effect of some increase in the mean service times was acknowledged and expected. To achieve this goal requires that the constraints be set about 50 percent above the mean service times. In practice, 2 problems arise with this approach.

1. Because the short-run demand rate varies widely during the course of the day and because mean service times are sensitive to the recent demand rate, a constraint set correctly for some time of the day may be incorrect for many other times of the day. The problem is that the constraints are not dynamically set as a function of the number of passengers currently on the system and the number of vehicles currently in service. This problem could be solved by using a short-memory heuristic to compute the current constraint set.
2. More basic is the problem that assignments that may be far superior from the objective function's viewpoint will be rejected if a constraint is violated. This introduces a perturbation in performance and can lead to short-sighted decisions that tend to waste system resources. This problem cannot be solved by any useful setting of the constraints, and its existence argues for a reduction in the role of constraints in future algorithm development work. This is possible only if the individual customer utility function can be equally or better represented by some other construct.

Objective Function as a True Reflection of Customer Utility

The objective function implies that users of the system associate with the service a utility function that is linear in service time. This seems to be an inaccurate and simplistic representation of actual passenger satisfaction, and hence its use can result in customer dissatisfaction. Although the actual utility function associated with DRT service has not yet been identified, clearly measures of the distribution of service time, other than the mean, are also important, e.g., standard deviation. It is also probable that the uncertainty in service is also an important characteristic. One measure of this is the difference between estimated and actual pickup and delivery times. Once again the means and standard deviations of these distributions should be considered.

That actual utility functions will vary not only from customer to customer but from area to area is highly likely. For these reasons, the next generation of algorithms must incorporate a richer mix of elements in the objective function and provide the user (operator) with ways to manipulate the objective function to achieve desired service characteristics. If the objective function is more realistic, the service constraints can then be used as a means to reduce computation (by eliminating unpromising assignments early) rather than as an integral part of the algorithm.

Handling of Advanced and Periodic Requests

At present, advance requests (this term will be used to include periodic requests) are assigned a fixed period before their desired pickup times and have a special set of (tight) constraints. A modified objective function that attempts to minimize the time between expected and desired pickup time is used. All subsequent assignments to a tour, including the advance request, are made as if the tour consists of only immediate service requests. This results in service for the advance request being no better than service for immediate requests, an unsatisfactory state of affairs, for advance requests should be easier to schedule and serve than immediate requests. This is an important area for future work.

Constraint of Vehicle Position at Future Time

The system was designed for the dynamic many-to-many case in which scheduled or repetitive demands or both on the system are not a major factor. In actual operation, vehicles may frequently have to make regularly scheduled or one-time appearances at specific locations, even though no originating service requests have been made (e.g., PATCO station in Haddonfield for scatter operations). This capability is an integral part of current algorithm development work at M.I.T.

Restriction of Certain Vehicles to Given Zones

For ease of use at high-density demand generators, specifying service zones is desirable so that passengers know immediately which vehicle serves their destinations—each vehicle can then post 1 or more zone numbers. For this operational technique to be compatible with computer dispatching, the computer system must be able to restrict a vehicle to serve only limited origin-destination pairs. This capability does not exist in the Haddonfield system, but recently M.I.T. implemented a scheme whereby vehicles can be restricted in terms of the origins and destinations served in the simulation model.

Preassignment Capability

The Haddonfield computer system does not have a passenger reassignment capability except when a vehicle breaks down, in which case the tour (including both collected and uncollected passengers) is shifted to the end of the vehicle that can first reach the breakdown point empty. Passenger reassignment as an element of the algorithm was investigated previously by M.I.T. and found to be of only marginal benefit. However, it may well be worth implementing specifically just for vehicles that break down and for vehicles that suffer large delays en route.

Scheduling at Start and End of Driver and Vehicle Shifts

As discussed previously, the computer should be able to efficiently build up tours and stop further assignments at specific times so as to maximize system productivity.

Gearing of Algorithm to Underused System

The previous algorithm development research was geared heavily to system (and hence algorithm) performance at or near the point of maximum system use. This resulted in higher vehicle productivities than typically observed in Haddonfield, and so the algorithm has been operating at much lower productivities than previously studied. As it turns out, both through observations in Haddonfield and through simulation experiments, the algorithm may not perform most effectively in this situation. Specifically the increase in tour length in the objective function can lead to significant imbalances in the use of vehicles; i.e., the probability is high that a new request will be assigned to an already highly used vehicle, and once a vehicle becomes unassigned it tends to remain so. The best objective function may well depend on the current use of the system.

CONCLUSIONS

The simulation model can accurately predict system performance providing that vehicle in-service times are used; otherwise, system performance can be significantly overestimated. With this caveat, the control algorithm performed as predicted by previous simulation modeling. However, much of the previous research and performance prediction was at significantly higher demand densities than have been observed at Haddonfield or most other demand-responsive systems. The implication of these lower demand densities is that the economies of scale possible with these systems cannot yet be realized—and that productivities of 5 to 8 passenger trips per vehicle hour are more realistic than previously cited ranges of 9 to 13. Stress must now be on making the service more attractive to potential users so that economies of scale can be achieved and at the same time increasing productivity for a given quality of service. With regard to integrating DRT and fixed-route transit, the computer must be used to make the overall service more attractive and to enable larger systems to be operated. Current research at M.I.T., which is addressing all these issues, strongly suggests that it is both feasible and desirable for the computer algorithms to achieve better service and to allow the operation of large integrated DRT and conventional transit systems.

Roy E. Murphy, Phillip L. Paisley, and John N. Siersema, LEX Systems, Inc.

Few people deny that one of the major problems today is the satisfaction of demand for an attractive, practical, economic alternative to the door-to-door transportation service offered by the automobile. Although much public and private money has been spent on the conveyance aspect of transportation, this expenditure has not brought us much closer to the development of an alternative to the automobile.

Many people think that the personalized transportation service offered by demand-responsive transportation technology provides this alternative to the automobile. If this is so, why has this new technology not been adopted by professional transit people to any great extent? The fact remains that most current DRT systems have serious defects for the practical transit operator.

DEFECTS IN DRT TECHNOLOGY

What are some of these defects? We suggest that too little attention has been paid to the economic efficiency of vehicle use in DRT applications. The current pressure to maintain high DRT service levels and the labor-intensive cost structure have reduced vehicle economic efficiency to such an extent that no conventional transit operating budget can long sustain such a DRT system.

The second defect in current DRT technology is its inability to provide practical DRT services to a large geographic area where, for example, door-to-door travel times could be as long as 2 hours. Another aspect of this defect is the current lack of DRT technology to truly integrate with express bus or rail transit facilities in a large area.

The third weakness in DRT technology is the poor accuracy of current scheduling methods. Given fixed resources, promised response times grow less and less reliable as demand increases. This fault is not so much due to the inability of current scheduling methods to cope with DRT demands as to the lack of scheduling tools that can assist in carrying out the methods while keeping up with the demands. Therefore, the scheduling of increasing numbers of vehicles or passengers or both, plus the introduction of other complexities such as the integration of DRT and other forms of transit, is hard to imagine without some automated scheduling assistance.

AUTOMATED SCHEDULING ASSISTANCE

To assist the scheduling (and dispatching) functions of DRT control and to help overcome the defects, LEX has developed various levels of automated control system technology for the newest DRT designs. This technology is based on a minicomputer, which has proved to be a relatively low-cost, highly reliable, and tireless DRT scheduling "assistant." Depending on control needs, such a service area size and population density, one or more of these minicomputers can be used to control (i.e., schedule and dispatch) 6 to 75 vehicles each. Furthermore, when more than one computer is required because of system size, they can be interconnected to provide mutual backup in case one machine fails.

Of course, there is nothing new in using a computer to schedule vehicles. So what is new? Basically, what we have done is add the dimension of adaptive control to the computer programming. To put it more simply, we have programmed the computer to tell the transit operator how the system is doing and how to make it perform better.

Adaptive control systems vary in sophistication from the household thermostat to complex control systems that process chemicals automatically in huge plants. Whether control systems measure one operation or several operations such as temperature, viscosity, and volume, they have in common the fact that all points of measurement are manually set or programmed. Standard control systems, in other words, check the process functions against an absolute standard like the temperature setting on a furnace thermostat.

Although the setting on a thermostat is a standard control point system, we can change this absolute control point at will. The thermostat gives us the ability to adapt the heating system instantaneously to our changing personal needs. In fact, a thermostat is an adaptive control instrument with which to change the household environment.

LEX has applied this same adaptive control methodology to its latest vehicular control system designs. Our adaptive control methodology is based on a management information system (MIS), which is an automatic feedback by-product of a computer-assisted scheduling and dispatching system. We use the MIS to tell how the transit system is doing and how to change the control points by means of what we call a parametric screen so that the system performs against goals, or control points, that reflect expectations.

The MIS records operational transit statistics. For example, it records quoted pickup and delivery times directly from the reservationist's video input screen. Actual pickup and delivery times are recorded from the dispatcher's screen when he or she receives the transmission from the bus driver that a stop has been completed. Because a clock in the computer documents each transaction, the dispatcher is only required to mark the trip completed on his or her screen by hitting a key on the keyboard. The management information system has now documented quoted times and actual times so that the level of service and deviation from quoted time analyses can be made. All this valuable documentation is done with no additional control-room personnel effort. The information is always complete and accurate, although accuracy of actual times is dependent on the driver's contention for radio time.

Analysis of the MIS reports is the first step in our adaptive control methodology. It is analogous to realizing that 70 F (21 C) temperature is making you too warm. Changing certain control points or parameters is the adaptive part of an adaptive control process. Supervisory personnel can use the parametric screen to easily make corrections. Changing control points is just as easy as inputting normal reservation data into the system. Examples of the control points that might be changed by supervisory personnel are travel time goals, necessary rendezvous times with other transit systems, and estimated travel times between reference points in the system.

The MIS also identifies when and where trips begin and end by each zone or reference point in the service area. Thus, one can identify where the more cost-effective alternatives to DRT services, such as bus pooling or express routes, may be established.

This level of adaptive control methodology is required if a DRT system is to meet the expectations of the public and is to be integrated with other available transit services. In addition to what I have described as an "instantaneous" adaptive process, the management information system maintains the data over time and summarizes them, which allows DRT system management to consider adaptive changes that may only be evident by comparing the data assembled during long periods. Such an example may be the travel patterns of users during times of the month that would indicate how critical resources (vehicles) should be allocated between service centers by days of the week and times of day. Proper allocation of resources will bring certain economies to DRT systems. Management information is systematically accumulated by the computer on the vast Santa Clara County DRT project, currently the largest integrated DRT system in the world, and the system generates sufficient data to enable adaptive optimization of all performance parameters over time. In other words, based on past performance, the system is constantly improved.

A second level of control technology has been programmed into our computer-assisted scheduling and dispatching system. It can best be described as an automated adaptive control process. The system can perceive a problem and immediately reset its own controls to adapt to the situation.

We are now using this adaptive control system to guarantee pickup times and, to a lesser degree, any quoted delivery times. Some understanding of our unique scheduling control program is required to understand the use of this control system. In our computerized system, we preset a scheduling requirement for pickups to be made within 15 minutes. We call this a goal, and we refer to the process as goal-oriented scheduling. A vehicle scheduled by this method may not be the closest to a pickup point, but it will be the vehicle most likely to reach that point in 15 minutes (±5 minutes, which is what we currently allow in the system). If no vehicle can meet these expectations, then a new time is set for that pickup, if it is acceptable to the customer. Most important, the system has, as its primary objective, reliability of quoted pickup times. If the passenger also has a delivery time constraint, that time becomes part of the computer scheduling "test" and also a part of future tests for future scheduled stops on that vehicle so that the quoted delivery time will not be violated. This automated adaptive control system works for individual stops.

A second application of automated adaptive controls in our scheduling system occurs when heavy demand makes reliance on 15-minute pickup times infeasible. As this situation is identified by the system (as a result of several new-time quotations previously described), the system will alert the supervisor via the supervisor's video screen.

The control supervisor can introduce new buses into the system or, in the case of a multiple service area system like that in Santa Clara County, he or she can reallocate buses from another service area experiencing less current demand.

If, however, resources cannot be increased, the system will set a new control for the pickup time, in this example, perhaps 20 minutes. All control center personnel are notified automatically on their video screens of this change, and the change stays in effect until events require an adaptive control reset to 15 minutes. These are automated adaptive control situations because no one is required to change control points, although it can be done via the parametric screen. The system corrects itself based on historical knowledge and, of course, will reset based upon the preset goals, in the case of Santa Clara County, a 15-minute pickup time.

We believe that the large number of "no-shows", which may be as many as 250 out of 700 trips in some DRT systems, result from vehicles arriving too early. Either the passenger cannot respond because he or she is in some state of unpreparedness or he or she does not expect the vehicle and, therefore, in the case of some elderly users, does not hear it.

We believe provisions for easily changing control points and system parameters and the resulting constant system tuning are fundamental to the development of reliable, fully integrated transit systems. These systems require modern computer technology. Together with computer contributions to the scheduling and dispatching functions, these systems are capable of supporting DRT services that not only serve low-mobility people but that offer the time-sensitive people a reliable alternative to the automobile.

The cost of data capture and reporting alone indicates the economic feasibility of some form of data processing in every DRT system. If improvements in scheduling accuracy are required, at the least, a minimal computer-assisted DRT control system should be used. A truly integrated DRT and express bus system, in which multiple demand-responsive trips are coordinated with the express bus schedules, requires a substantial computerization of the entire operation.

Computerization of a DRT system is not so expensive as previously thought. Current cost data on the operation of manual and computer-assisted DRT systems indicate that manual control systems may not be cost effective if more than 5 or 6 vehicles are operated because computerized control systems are less labor intensive after a minimum number of controllers are employed. Computer-assisted scheduling and dispatching can effectively schedule more passengers per vehicle mile, and that reduces operating costs and ultimately the need for more capital equipment.

The hardware system configuration used in Santa Clara County and our research (although differently configured) are capable of growing without added equipment from a system to control 5 to 15 vehicles to one that controls 50 to 75 vehicles. The cost of the computer, of course, remains the same, and as the system grows hardware cost becomes an increasingly small percentage of the total operating cost. When capacity is reached, hardware costs are only 1 to 5 percent of all costs.

Table 2 gives some typical cost figures generated from our paratransit model and 4 months of actual simulation service in Santa Clara County. Manual system data come from the Haddonfield system (shorn of demonstration costs) and one of the service areas in Santa Clara County that uses manual control.

Given this economic cost structure, manual control systems may not be so economical as computer-assisted systems, particularly when one considers the ease of obtaining accurate and timely performance data captured automatically by the computer. These data and a statistical program can supply much of the adaptive feedback required to ensure that the system will meet its current system goals or to modify those goals if the statistical analysis so indicates.

Because of the advent of microprocessor electronics, the outlook for adaptive DRT computer-controlled systems looks even better than the current economics indicate. Substantial reductions in the cost of digital hardware are forecast by leading electronic market research institutes. These reductions in cost, coupled with the inevitable rising cost of labor, tilt the scale even farther toward the advent of fully computerized DRT control systems, regardless of their size. Current advanced research in applying microprocessor electronics promises to reduce the cost per vehicle of computerized scheduling, including digital vehicle instruction displays, to a level below the cost of, for example, the air-conditioning apparatus in the current DRT vehicles.

Table 2. Costs of manual and computer-assisted scheduling and dispatching.

Type	Number of Vehicles	Number of Controllers Per Shift	Control Labor Cost[a]	Control Equipment Cost[b]	Real Control Cost	Scheduling Effectiveness Factor[c]	Effective Vehicles	Imputed Control Cost[d]	Effective Control Cost[e]	Effective Control Cost Per Vehicle
Manual	5	2	64	–	64	0.85	4.25	45	106	21.8
	10	4	128	–	126	0.75	7.5	150	278	27.8
	15	6	192	–	192	0.50	7.5	450	642	42.8
Computer-assisted	5	2	64	32	96	0.90	4.5	30	126	25.2
	10	3	96	32	128	1.00	10	0	128	12.8
	15	4	128	32	160	1.00	15	0	160	10.7
	15	4	128	48	176	1.00	15		176	11.7
	20	5	160	48	208	1.00	20		208	10.4
	25	6	192	48	240	1.00	25		240	9.6
	30	6	192	48	240	1.00	30		240	8.0
	60	7	224	108[f]	332	1.00	60		332	5.5

Note: All costs are in thousands of dollars.

[a]Based on 2 shifts of $16,000 per year per employee; includes overhead plus benefits.

[b]Based on a small minicomputer installation; includes hardware and software, amortized over 5 years.

[c]Based on several controlled experiments at Haddonfield about 1½ years ago.

[d]Based on an operating cost per vehicle per year (15 dollars per hour for a 4,000-hour year) times the difference between actual and effective vehicles.

[e]Sum of "real" control costs plus "effective" control costs.

[f]Digital communications equipment required at this level.

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Demand-responsive transportation is one of the advanced new transportation concepts that the U.S. Department of Transportation investigated as an urban transit system. In this respect, the Urban Mass Transportation Administration granted the New Jersey Department of Transportation a research, development, and demonstration grant to undertake the Haddonfield, New Jersey, DRT demonstration. Even though the DRT concept was known to transportation specialists for many years, only in recent years has adequate command and control technology been developed for demand-activated transportation systems to provide door-to-door, personalized, and shared-ride service at a reasonable price.

The Haddonfield demonstration was preceded by an experimental design that specified the following objectives for this demonstration (1):

1. Determine public attitudes toward and acceptability of the DRT concept;
2. Measure public use of the system and forecast demand for DRT, both in the Haddonfield area and in other communities in which it may be tried;
3. Determine the economic feasibility of a DRT system;
4. Test and evaluate the technical feasibility of the DRT concept; and
5. Measure and evaluate the impacts of DRT on the community.

PUBLIC ATTITUDES TOWARD DEMAND-RESPONSIVE TRANSPORTATION

Public attitudes toward DRT were assessed prior to and during the demonstration in Haddonfield through a series of surveys. These surveys also provided information on the trip-making behavior of the Haddonfield residents under different operating conditions.

In a predemonstration survey, about 75 percent of the PATCO High Speed Line users interviewed thought that they would use the service for the portion of their work trips between their homes and the PATCO station. Many of these residents were willing to use DRT for their work trips if the travel time was less than 20 minutes and the fare was less than 50 cents. On the other hand, the percentage was small for fare levels of 75 cents or more, and practically nobody was willing to use the system between home and the PATCO station if travel time was 40 minutes, regardless of fare level. This survey also indicated that the public attitude toward DRT was favorable if one considers that half of the households interviewed responded that they would make an average of 2 additional trips per week. It also showed that a high percentage of children's trips made as passengers in private automobiles might be made by riding DRT buses to the library or special school events. Those who indicated they might use the system ranked waiting time, amount of fare charged, door-to-door service, and attractiveness and comfort of the vehicle as important considerations. These public attitudes were the same for both work trips to the PATCO High Speed Line and for personal trips within the service area, such as those to the Cherry Hill Mall. The majority of those who responded negatively to the use of DRT felt that neither DRT nor the high-speed line goes near their places of work nor connects with transportation modes that do or responded that they were satisfied with driving or walking (2).

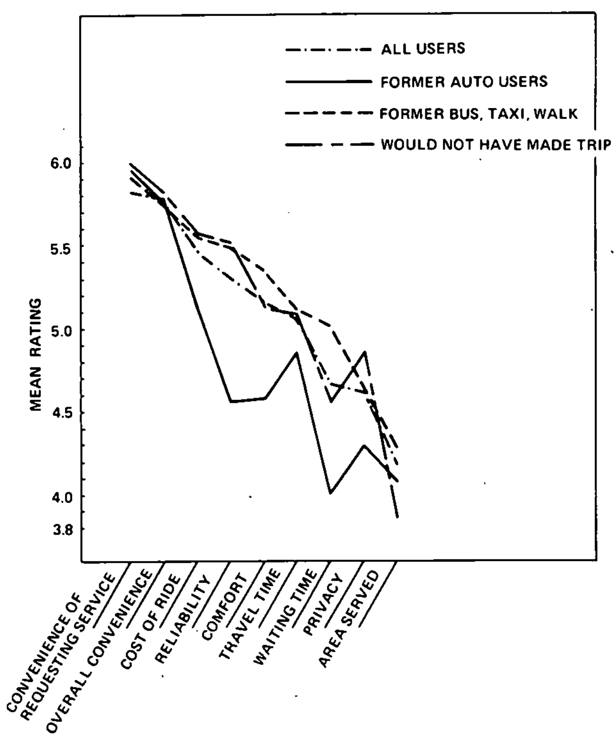
Table 3 gives the characteristics of DRT users and service area population according to surveys undertaken during the demonstration period (3). These on-board surveys also indicated that the percentage of nonwork trips made by DRT increases steadily with the age of the users and the percentage of work trips decreases steadily with the age of the users. This suggests that the system is serving 2 markets: the young people for work trips and the older people for nonwork trips (4). These users stated that convenience, cost, and reliability of DRT are the major determinants in the use of the system. The usual characteristics of wait time and travel time that are used to measure the quality of the service offered by DRT have little influence on the users.

Furthermore, a comparison was made of users' perceptions of the influence of DRT

Table 3. Characteristics of DRT users and service area population.

Characteristic	Users (percent)	Population (percent)
Age		
<15	4	29
15 to 19	14	9
20 to 24	13	5
25 to 64	54	48
>64	15	9
Income		
<$4,000	24	5
$4,000 to $10,000	33	22
$10,000 to $15,000	22	28
$15,000 to $20,000	12	15
>$20,000	9	30
Automobiles in household		
0	24	7
1	40	44
2	31	42
>2	5	7

Figure 1. Mean ratings of DRT characteristics.



characteristics and their perceptions of their former modes of transportation (5). This analysis indicated that former automobile users were not strongly influenced to use the system by the characteristics of DRT—which might explain the reason for not having a high modal shift from automobile to DRT. Former users of other modes and those who formerly did not make trips were influenced similarly to use the system by the characteristics of DRT (Fig. 1).

Surveys also indicated that the reasons DRT was not used often for work trips were the availability of automobiles and the trip destinations, which were outside the service area. Those who did not use the system because of availability of automobiles had a higher automobile ownership ratio. This fact seems to conform with the general attitude of urban travelers toward transit use and their preference for the automobile. This preference stems from the desire of these travelers to use a more convenient, comfortable, private, and flexible mode of travel, whose perceived cost of operation is low.

PUBLIC USE OF DRT

From February 1972 to September 1974, the total ridership of the Haddonfield DRT system was 657,761. On the average, about 80 percent of those trips were on weekdays, 13 percent were on Saturdays, and 7 percent were on Sundays. The monthly ridership trends of the system have been changing during the different phases of the demonstration as a result of changes in operating characteristics and seasonal effects.

Effects of Area Expansion

The initial DRT service area was 6.4 $miles^2$ (16.6 km^2) and had a population of 24,300. During the demonstration period, 3 area expansions occurred and resulted in different effects on system ridership.

The first expansion occurred on September 23, 1972, when 1.7 $miles^2$ (4.4 km^2), having a population of 3,112, was added to the original service area. The service area was increased by 26.5 percent and population increased 12.8 percent. This area expansion was not accompanied by an increase in vehicle supply, thus causing a significant increase in wait and ride times. Ridership increased from a weekly level of 3,000 to about 4,500 after the expansion as a result of both area expansion and the opening of schools and the arrival of the holiday season. The number of DRT trips increased 19.6 percent after the expansion, and the number of households increased by only 12.4 percent. This difference was due to the increased number of major trip generators available to the users (4). Because of increase in area but steady state of vehicle supply, the quality of service decreased, and this might be an important reason for the decline in ridership that occurred after the sharp increase following the area expansion.

This same situation occurred after the March 31, 1973, area expansion, which also was not accompanied by an increase in vehicle supply (Figs. 2 and 3).

The third area expansion of August 18, 1973, preceded by an addition of 6 buses to the fleet size, resulted in a sharp increase in ridership. In fact, ridership increased from about 750 to 1,000 on an average weekday and from about 525 to 950 on an average Saturday.

Effects of Changes in Mode of Operation

The most important changes in mode of operation, in terms of effects on ridership, were the introduction of the shuttle service and the reduction of fare from an average of 55 to 25 cents on October 20, 1973. Because of the introduction of these 2 changes on the same date, the advent of the holiday season, and the energy crisis, it was impossible to attribute the increase in ridership to either one of these parameters. Ridership increased by 40 percent (from 896 to 1,260 daily riders) after the fare

Figure 2. Daily DRT ridership from February 1972 to September 1974.

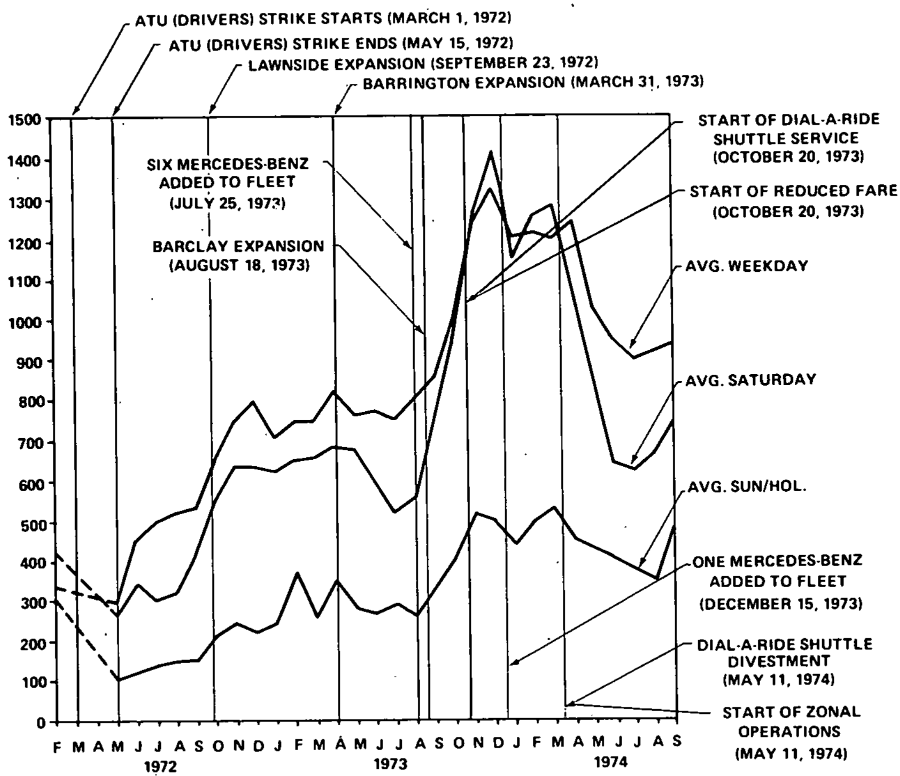
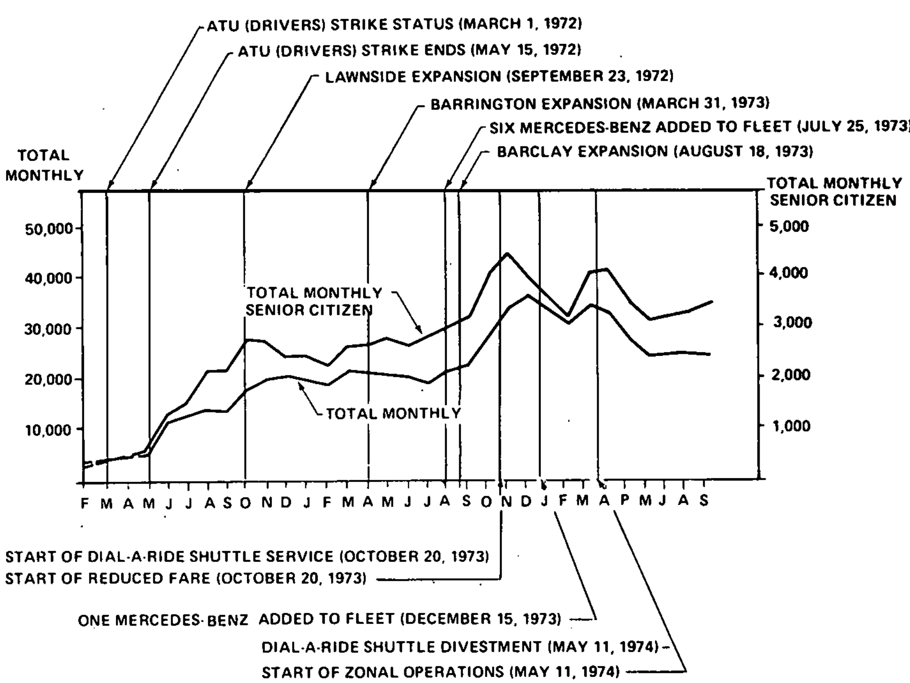


Figure 3. Monthly DRT ridership from February 1972 to September 1974.



reduction and introduction of shuttle service. However, this high ridership decreased to about 925 daily riders when Transport of New Jersey (TNJ) assumed the shuttle service (6). This decrease implies that the riders were more affected by the shuttle service than by the fare reduction. This fact seems to be in conformance with conventional transit systems, whose riders are more sensitive to service quality changes than fare changes. However, the attitudinal surveys regarding fare effects showed that the price elasticity of demand for DRT is similar to conventional transit systems at about the 60-cent fare level (6).

The introduction of zonal mode of operation and computer scheduling caused longer wait times, ride times, and pickup deviation times, which, in turn, seem to have affected ridership. An evaluation of these changes will be undertaken to determine the effects on ridership.

The ridership trend of senior citizens seems to be similar to the total ridership trends (Fig. 3). This implies that, on an aggregate basis, the senior citizens using the Haddonfield DRT system (about 12 percent of the users) seem to be equally sensitive to changes in the operating parameters of the system.

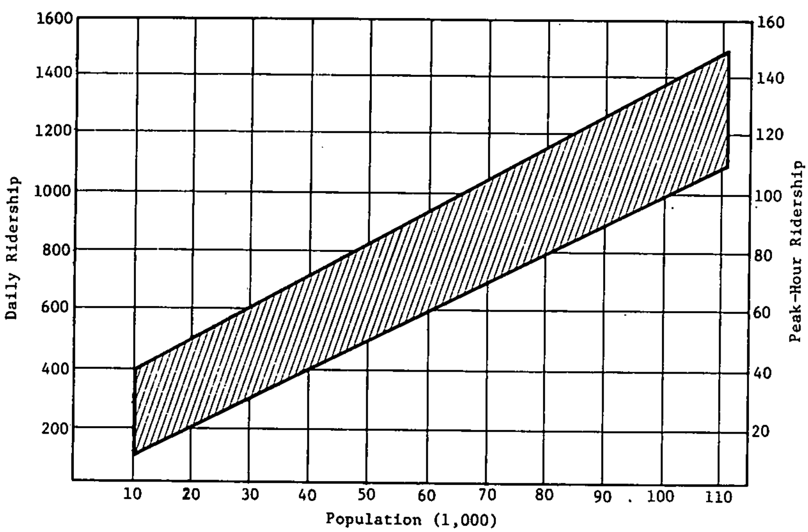
Comparison With Other Systems

In the process of evaluation of the Haddonfield DRT system, a comparison was made with other DRT systems operating in the United States and Canada (7). On an average basis, the Haddonfield DRT ridership seems to compare favorably with the range of the other DRT systems. This comparison was made after the same base line was established for the operating conditions—i.e., 16 hours of operation per day, 5 hours of peak period, and about 30 minutes wait time and 30 minutes ride time. For the period prior to the shuttle service and fare reduction, the adjusted ridership level was about 700, which is approximately in the upper range level when compared with the other systems (Fig. 4).

ECONOMICS OF DRT

The evaluation of the economic feasibility of the demand-responsive transportation concept as demonstrated in Haddonfield includes analyses of costs, revenues, and financing.

Figure 4. Daily and peak-hour ridership versus population.



The results include effects of experimentation and local conditions, and their application to other areas should be undertaken with care.

The costs of the Haddonfield DRT demonstration include the actual cost of the system, the costs of data collection and analysis, and management costs associated with the experimentation. A complete separation of the actual cost of operating the system from the experimentation is not possible; however, attempts were made to do so.

The largest percentage of the actual cost of the system is the operating cost, which is largely labor costs. In fact, labor costs consist of about 75 percent of the operating cost of the Haddonfield DRT system, and about 55 percent is for drivers. Thus, similar to conventional bus systems, DRT is a labor-intensive transit system and, therefore, its operating costs are highly related to wages. The average monthly operating cost of the Haddonfield system through June 1973 was about $33,000 for the fleet size of 12 vehicles (each having 17 seats and costing about $23,500) and 23 drivers. This monthly operating cost increased to more than $100,000 when the 6 buses (each having 10 seats and costing about $16,700) were added, the service area was expanded, and shuttle service and computer scheduling were introduced. Inflation—especially the higher cost of gasoline and wage increases—and the increases in hours of operation of each vehicle contributed to this increase in operating cost.

The average cost of operating a bus in Haddonfield was about $16.40 an hour with the manual scheduling-dispatching operation. This figure is lower than the average cost of $17.10 an hour to operate a TNJ fixed-route bus during 1973 (8). This comparison should not imply that any one method of operation is better than the other because each operates in an optimal fashion (in terms of unit costs) under different demand densities. The average cost per ride of the Haddonfield DRT service was about $3.28 from February 1973 to January 1974 and about $3.86 from February to June 1974. During the first period, the fleet size was increased and the service area was expanded; during the second period, computer scheduling was introduced.

The average revenue per trip on the Haddonfield DRT system varied between 52 and 56 cents prior to the fare reduction from 60 to 30 cents on October 20, 1973. Average revenue then dropped to about 28 cents per trip from November 1973 to May 1974, when the shuttle service was assumed by TNJ. Despite the drop in revenue per trip, the total monthly revenue remained approximately within the range of $9,000 to $12,000 because of the increase in ridership during the shuttle service. For 1973, the average revenue was 47 cents per ride, which results in approximately $2.80 in subsidy per ride. This subsidy could be reduced by increasing system productivity, imposing a more realistic fare level, attracting additional revenues from advertising, and operating efficiently with minimum experimentation.

TECHNICAL ASPECTS

The technical feasibility of the DRT concept as demonstrated in Haddonfield has been evaluated in terms of the effects of the operating parameters on the quality of service and vehicle productivity.

Vehicle Productivity

The vehicle productivity of the Haddonfield DRT system experienced variations from as low as 4 passengers per vehicle hour to as high as 11.4 passengers per vehicle hour on Saturdays during the shuttle service and reduced-fare operation. During the first 11 weeks of the demonstration, the average productivity was only about 4.09 passengers per vehicle hour because ridership was low and the fleet size was relatively high as dictated by the experimental nature of the project (9). This productivity was highest during the conventional off-peak periods of 9:00 a.m. to 4:00 p.m. and 7:00 to 11:00 p.m., which explained the relatively higher use of DRT for nonwork trip purposes.

With the service area expansion, ridership increased while the number of vehicles remained constant. This caused the average productivity to increase from 4.6 to 6 passengers per vehicle hour on weekdays and from 5.1 to 7.5 passengers per vehicle hour on Saturdays. It was hoped that ridership would increase sufficiently such that the service quality would decline to a level that causes a negative effect on ridership, passing through the point of optimal balance between vehicle productivity and ridership. This near-capacity condition did not occur because ridership did not increase enough to saturate the system operating under scatter-gather and many-to-many modes at a basic fare of 60 cents (10).

During the second year of operation, the average weekday productivity increased to a peak of about 6.6 passengers per vehicle hour and to an average of 6.3 passengers per vehicle hour. Lower productivities were experienced after the increase in fleet size because it caused a 39 percent increase in vehicle hours; monthly ridership picked up at much slower rates until the introduction of the shuttle service and fare reduction. Weekend productivities also increased from 7.7 to 11.4 passengers per vehicle hour on Saturdays and from 5.1 to 6.4 passengers per vehicle hour on Sundays. During this same period, a free-fare day was instituted on March 16, 1973, and the basic fare of 60 cents was eliminated. Productivity during that day increased to a maximum of 10 passengers per vehicle hour during the 7:00 to 9:00 a.m. morning peak and 16 passengers per vehicle hour during the 4:00 to 6:00 p.m. evening peak. On the average, productivity increased 50 percent during that day (11).

In 1974, the average monthly productivity remained at about 6 passengers per vehicle hour until the shuttle service was assumed by TNJ and the zonal mode of operation was instituted on May 11. During the first 2 months of zonal operation, monthly productivity dropped to about 4.5 passengers per vehicle hour. This decrease in productivity was due to the loss of shuttle ridership and the oversupply of buses for the zonal experimentation. In fact, normally the many-to-many mode of operation required 10 buses on weekdays and 7 buses on Saturdays during the same time that the zonal mode was in operation. On the other hand, during the weekday zonal periods (7 to 9 a.m. and 4 to 6 p.m.), 12 buses were in operation; during the Saturday zonal period (10 a.m. to 5 p.m.), 9 buses were in operation.

Quality of Service

The quality of service of the Haddonfield DRT system was measured by 3 easily computable measures: average wait time, ride time, and pickup time deviation. Wait time is defined as the time elapsing from the end of the telephone call requesting service to the time the vehicle arrives to pick up the customer. Ride time is the time the passenger rides on the vehicle from pickup to delivery. Pickup deviation is the difference between the pickup time promised to the passenger by the telephonist at the time the trip is requested and the actual pickup time. A positive deviation indicates that the vehicle arrived later than promised and a negative deviation indicates that it arrived earlier.

These measures depend on the number of vehicles available, the size of the service area, the number of requests for service in the area, and the ability of the control center to efficiently route vehicles to serve requests.

During the 11 weeks of the demonstration, these measures were 12.5 minutes mean wait time, 10.0 minutes mean ride time, and -2.1 minutes pickup deviation time. These figures were then reduced to 11.9, 9.4, and -2.5 minutes respectively because of improvements in control room procedures in estimating wait time and reducing telephone time to book a trip. After the service area expansion of September 23, 1972, these measures were 17.2, 11.7, and -0.2 minutes respectively, which implies that wait and ride times increased with the increase in ridership under constant vehicle supply. During the second year of operation, the average wait and ride times increased to about 20.8 and 12.6 minutes respectively. This increase is attributed to the substantial increase in ridership resulting from 2 service area expansions and from the introduction of shuttle service and fare reduction. Average pickup deviation changed from -0.2 to -0.3 minute during that period.

The effect of increased ridership on service quality was also significant during the free-fare day, when wait and ride times increased to about 39 and 20 minutes respectively during the 4:00 to 10:00 p.m. period. On the other hand, with the institution of the zonal mode of operation and the decrease in ridership, the quality of service deteriorated during the first 2 months of zonal operation. This deterioration is expressed by a 30 percent increase in wait time and a 24 percent increase in ride time. The increase in wait time is caused by fixed headways of zonal cycles and the transfer time required to go from one zone to another.

IMPACTS ON OTHER MODES OF TRAVEL

Significant impacts on other transportation modes were experienced during the Haddonfield demonstration. On-board diversion surveys were conducted to estimate these impacts. The users were asked to state the mode of transportation they would have used for the trip they were making if DRT did not exist. Twenty-six percent of the users indicated that they would use the automobile as their alternative mode; about a third of them stated that they would drive, and the remainder stated that they would be passengers. Another 25 percent of the users stated that they would use taxis, which provide door-to-door service at significantly higher fares. These diversion surveys also showed that about 11 percent of the users would have used the fixed-route bus system including TNJ, 15 percent would have walked, and 22 percent would not have made the trip at all if DRT did not exist.

CONCLUSION

This brief summary of the evaluation of the Haddonfield DRT demonstration indicates that the concept was well received by the residents of the area. It indicates also that the system was not used more often for work trips because it did not reach desired destinations and because of automobile availability.

Area expansion caused ridership to increase; however, the quality of service decreased when the vehicle supply was not increased to offset this ridership increase. The introduction of the shuttle service and fare reduction caused a significant increase in ridership and system productivity without deterioration of service quality.

The effects of zonal mode of operation and computer scheduling have not been evaluated, although the information regarding the first 2 months of zonal operation indicates a deterioration of service quality and productivity.

The Haddonfield DRT evaluation also indicates that significant impacts on other modes of travel occurred—especially on the automobile and taxi, whose users shifted to DRT.

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MARKETING AND PROMOTION OF DEMAND-RESPONSIVE TRANSPORTATION

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The Haddonfield, New Jersey, demand-responsive transportation (DRT) system has been in operation since February 1972. It is a demonstration sponsored by the New Jersey Department of Transportation under a research, development, and demonstration grant from the Urban Mass Transportation Administration. The objective of this demonstration is to determine public attitudes, economic and technical feasibility, and community impacts of the demand-responsive concept (1). Several controllable parameters were changed during the course of the experiment to determine their effects on the system's performance. One of these parameters, fare, was changed twice during the experiment to determine its impact on public attitudes and its effect on ridership, quality of service, productivity, and economics of the system. This paper summarizes these fare changes and their effects on the system.

DESCRIPTION OF FARE STRUCTURES

There have been basically 2 fare structures and a free-fare day since the inauguration of the demonstration. Until October 1973, the average fare was 55 cents, and the basic fare was 30 cents and 15 cents for senior citizens. This drop in fare was accompanied by the introduction of a shuttle service to carry passengers between the PATCO High Speed Line Station and the Cherry Hill Mall; intermediate stops were made at Cherry Hill Hospital and Ellisburg Shopping Center (Fig. 1). This service remained in operation until May 1974, when it was assumed by the Transport of New Jersey (TNJ) bus system, and a zonal mode of operation was introduced during peak hours; the basic reduced fare structure was not changed. Thus, the changes that occurred in the operating parameters are the combined effects of the reduction in fare and the introduction of the shuttle service or of the reduced-fare condition and the zonal operation.

Another fare change occurred on March 16, 1973, when the basic fare was dropped from 60 to 0 cents for that day only in an attempt to attract more ridership and, consequently, test the performance of the control room staff under increased demand.

EFFECTS OF FREE-FARE DAY ON SYSTEM PARAMETERS

The free-fare day of March 16, 1973, had a substantial impact on the DRT ridership, vehicle supply, productivity, and public attitudes toward the system.

Effect on Ridership

A substantial increase in daily ridership occurred during the free-fare day. For the

Figure 1. DRT shuttle service route.

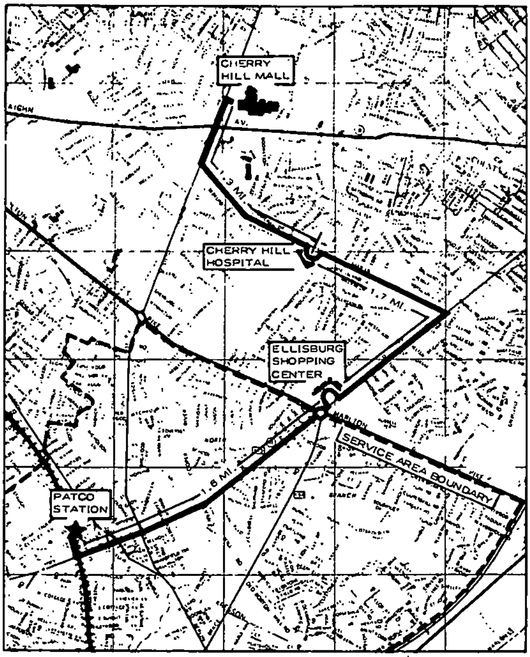
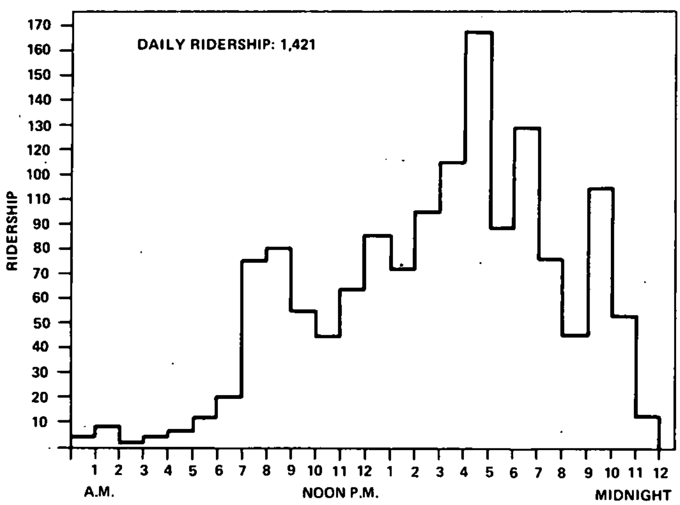


Figure 2. Hourly distribution of free-fare day ridership.



24-hour period, the ridership totaled 1,421, which is almost twice as high as the average weekday ridership of 734 for the preceding period, October 30, 1972, to March 15, 1973. The hourly distribution of this ridership, shown in Figure 2, indicates that ridership peaked between 3:00 and 7:00 p.m.; the maximum level was 170 riders for the hour ending at 5:00 p.m. Ridership started increasing beyond the normal weekday levels only in the afternoon, after the widespread publicity of free fare took its full course (2). This increase in ridership implies that DRT demand in Haddonfield is highly price elastic and had an elasticity of about -0.94 when the average fare level dropped from 55 to 0 cents/ride. (The elasticity of demand with respect to price is a dimensionless measure equal to the percentage change in demand resulting from a 1 percent change in fare.) This increase is a result of a larger frequency of trip making of the previous DRT users as well as of an attraction of new users to the system. An on-board survey conducted that same day indicated that most riders were not making the trip because of the free fare and that they had used the system in the past and planned to use it in the future. In fact, a closer examination of this survey shows that most of the interviews were conducted prior to the midafternoon hours when the information concerning the free-fare day had reached the public fully. On the other hand, an analysis of the trip tickets and the telephonist's log of calls showed that nonusers of the system were attracted that day. In fact, the number of calls resulting in trips was 1,421 for the free-fare day as compared with the mean number of 493 for the period July 26, 1972, to January 26, 1973. Similarly, the number of information calls received was 5 times as high as the corresponding previous daily average, and the rate of calls received that day from outside the service area was 4 times higher than that for daily regular operation during the July 1972 to January 1973 period.

Effect on Vehicle Supply

Vehicle supply increased during the free-fare day by 26 percent over the average weekday for the period October 30, 1972, to March 15, 1973. During the 24 hours of free fare, the vehicle supply was 151.5 vehicle hours as compared with the average of 119.5. Hourly distribution of the vehicles during the free-fare day, shown in Figure 3, indicates that, for 5 hours of that day, 10 vehicles or more were in operation. At no hour of the day during the period August 1, 1972, to January 31, 1973, were 10 vehicles in operation. During the free-fare day, 8 vehicles out of the fleet of 12 were in operation for 12 hours, as compared to 4 hours for the average weekday of the period August 1, 1972, to January 31, 1973 (3).

Effect on Productivity

Average productivity during the free-fare day increased by 50 percent over the average weekday for the period of October 30, 1972, to March 15, 1973. It increased from the weekday average of 6.2 to 9.38 passengers/vehicle hour and was above 10 passengers/vehicle hour for most of the afternoon and evening hours of the free-fare day. A peak of 17.67 occurred between 9:00 and 10:00 p.m., as shown in Figure 4. Peak productivity on the average weekday for the period August 1, 1972, to January 31, 1973, was 8.10 passengers/vehicle hour, and this occurred between 7:00 and 8:00 a.m. The afternoon peak of 7.12 passengers/vehicle hour occurred between 1:00 and 2:00 p.m. (4).

Effect on Quality of Service

The increases in ridership and productivity of the system during the free-fare day were accompanied by a decrease in the quality of service, as measured by promised pickup time. The telephonist's log of calls indicates that 117 calls were made on the free-fare day in which customers did not make the trip because the promised pickup time was more than 30 minutes; that situation rarely occurred on regular days. In total, refusals

Figure 3. Hourly distribution of free-fare day vehicle supply.

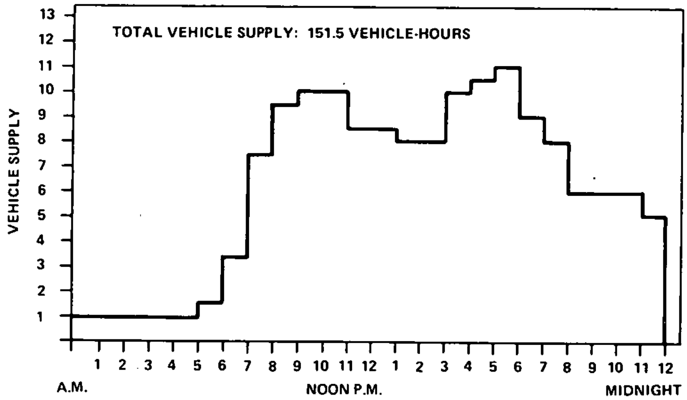


Figure 4. Hourly distribution of free-fare day productivity.

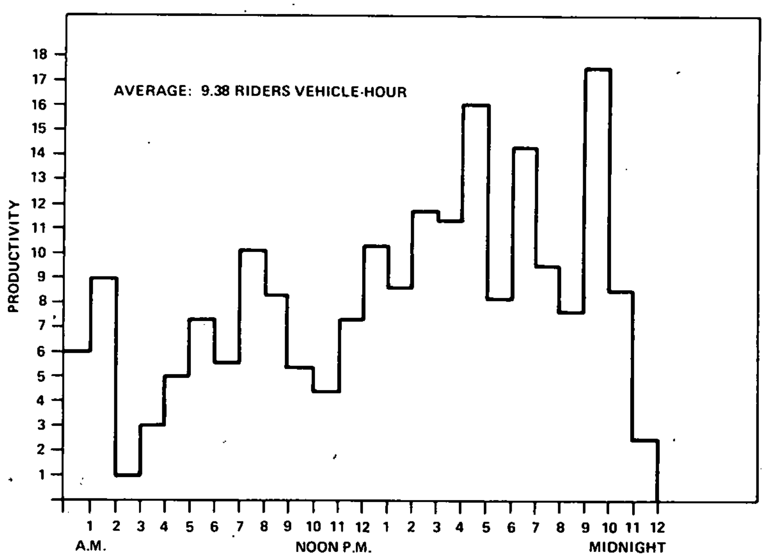
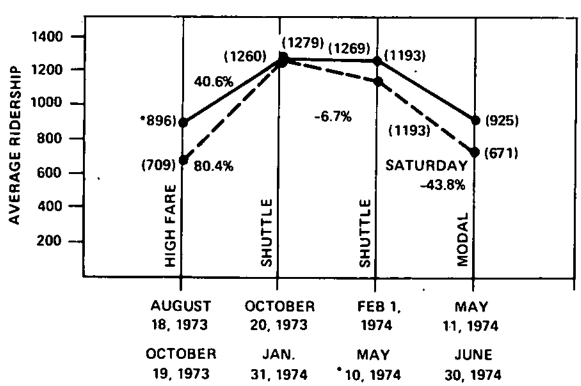


Figure 5. Effect of reduced-fare structure on daily ridership.



because of excessive wait times were about 10 percent of the trips actually made, of which about 8.5 percent were because the promised wait time exceeded 35 minutes (2).

Another measure of service quality is the number of cancellations and no-shows at the pickup point. During the free-fare day, the number of cancellations and no-show customers was about 11 percent of the number of trips actually made, a rate 3 times higher than that for the period of July 1972 to January 1973. This measure confirms the unacceptability of excessively long wait times that resulted from the increase in ridership and productivity on the free-fare day. This measure also suggests that higher ridership levels might have been achieved if quality of service had been maintained at its previous standard. The availability of a larger fleet size would have helped alleviate this problem, and possibly reduced productivity levels.

EFFECTS OF FARE REDUCTION ON SYSTEM PARAMETERS

The reduction in fare from an average of 55 to 25 cents, accompanied by the introduction of the shuttle service, caused substantial increases in ridership and productivity of the DRT system. This combined condition of reduced fare and shuttle service remained until May 11, 1974, when the shuttle service was assumed by TNJ.

At that time, the zonal mode of operation was instituted during peak hours (7:00 to 9:00 a.m. and 4:00 to 6:00 p.m. on weekdays and 10:00 a.m. to 5:00 p.m. on Saturdays) and began at the PATCO station, where transfer was made for many-to-many trips between zones. The reduced-fare structure was still maintained with a slight change of senior citizens' fares (books of 10 tickets for $1.50). These tickets were not being honored by TNJ; instead, a 15-cent cash fare entitled them to a free transfer to the DRT system (4).

Effect on Ridership

The reduction of fare and the introduction of shuttle service resulted in a 40 percent increase in average weekday ridership and an 80 percent increase in average Saturday ridership. In fact, the average weekday ridership increased from the August 18 to October 19, 1973, level of 896 riders to the October 20, 1973, to January 31, 1974, level of 1,260 riders. Average Saturday and Sunday ridership increased from 709 to 1,279 and from 317 to 488 riders respectively. These high levels of ridership were maintained until the assumption of the shuttle service by TNJ (Fig. 5). This increase in ridership should not imply that the Haddonfield DRT has a high elasticity of demand with respect to fare because this increase is the combined effect of fare reduction and improvement or addition to the service quality. As a matter of fact, shuttle ridership alone consisted of about 30 percent of the average weekday and about 42 percent of the average Saturday figures. When the shuttle service was assumed by TNJ and the zonal operation instituted, the average ridership was reduced to 925 riders on weekdays and 671 riders on Saturdays (Fig. 5). This reduction was paralleled on the 3 TNJ routes by an increase of 435 riders to the total weekday ridership and 550 riders to the total Saturday ridership.

Even though the effect of fare reduction on ridership cannot be completely isolated from the effects of the shuttle or zonal modes of operation, nonshuttle hourly ridership distributions indicate that the effect of the shuttle service on ridership is highly significant (Figs. 6, 7, and 8). Thus, the reduction of fare alone did not significantly affect the increase in ridership, and the Haddonfield DRT demand is more elastic in the improvement or addition of the shuttle mode of operation than in fare reduction.

Effect on Vehicle Supply

The reduced fare and shuttle service did not seem to affect the vehicle supply. The average weekday number of vehicle hours for the DRT system was about 173 vehicle

Figure 6. Hourly distribution of average weekday nonshuttle ridership for high-fare and reduced-fare periods.

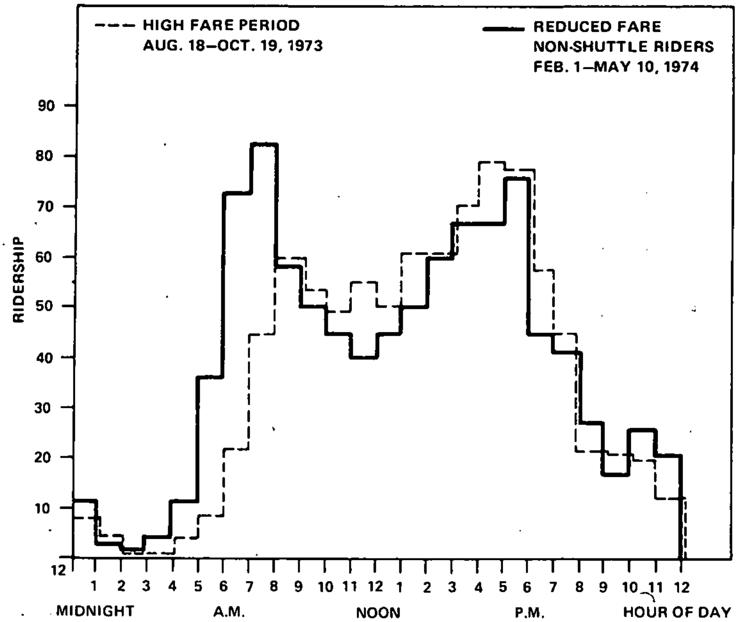


Figure 7. Hourly distribution of average Saturday nonshuttle ridership for high-fare and reduced-fare periods.

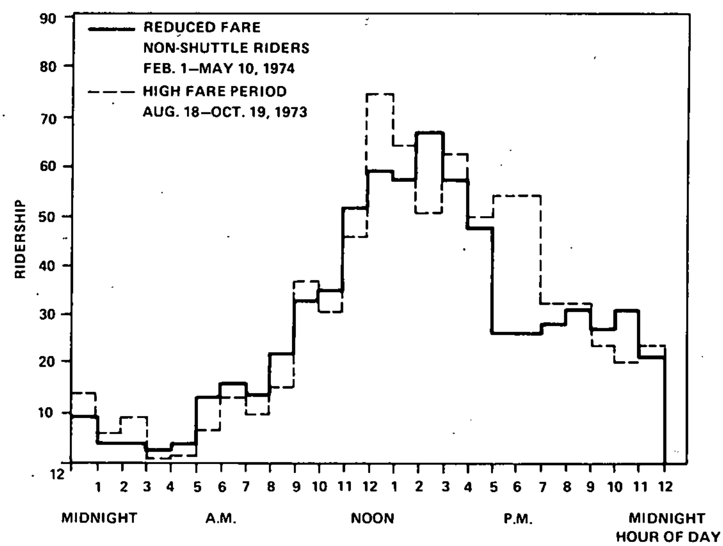


Figure 8. Effect of reduced-fare structure on weekday hourly ridership distribution.

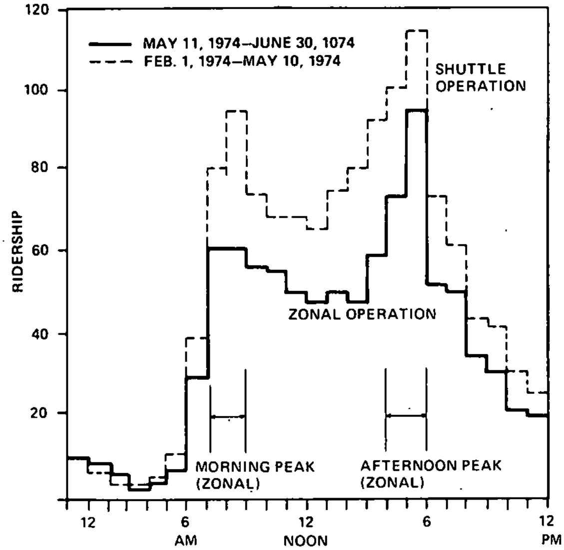
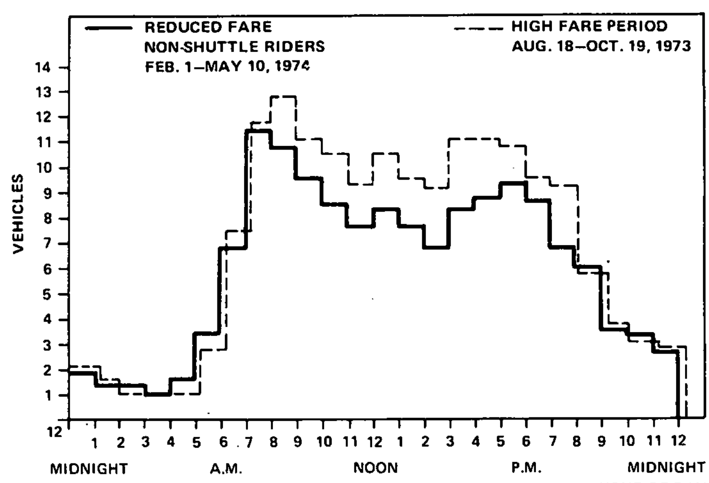


Figure 9. Hourly distribution of average weekly vehicle supply for high-fare and reduced-fare periods.



hours during the shuttle period and about 177 vehicle hours for the previous period of May 11 to June 30, 1974. The nonshuttle vehicle supply was, however, about 145 vehicle hours on the average weekday and 177 vehicle hours after the shuttle service was assumed by TNJ. Hourly distribution of vehicle supply for the preshuttle high-fare period and reduced-fare shuttle periods also shows that the vehicle supply for nonshuttle riders was lower in the latter period (Figs. 9 and 10).

Effect on Productivity

The productivity of the entire DRT system increased substantially after the fare was dropped and the shuttle operation introduced. The average weekday productivity increased from 5.5 to about 7.7 riders/vehicle hour. However, when the shuttle service by TNJ and the zonal operation began, the average daily productivity dropped to about 5.2 riders/vehicle hour. On Saturday, the productivity increased from 7.7 to 11.4 riders/vehicle hour when the shuttle began and decreased to 5.4 riders/vehicle hour when the zonal operation began.

A breakdown of the productivities by mode of operation shows that the shuttle mode had productivities of 13.1 and 18.8 riders/vehicle hour and the nonshuttle mode had productivities of 6.2 and 7.8 riders/vehicle hour on the average weekday and Saturday respectively. These nonshuttle productivities occurring during the reduced-fare shuttle operation were higher than the average weekday and Saturday productivities of 5.2 and 5.4 riders/vehicle hour after the shuttle service was assumed by TNJ. Thus, the nonshuttle mode productivity increased with the reduction in fare and the introduction of the shuttle because of the decrease in vehicle supply that was allocated to the shuttle service.

COMPARATIVE ANALYSIS OF PRICE-DEMAND ELASTICITIES

The previous observations of effects of fare on ridership suggest a comparison of DRT elasticities with those of other transit modes. This comparison is descriptive and, thus, should not be generalized. These limitations arise from the relatively scant knowledge of effects of fare on demand for transit systems and especially for demand-responsive systems.

Available data indicate that, for most current conventional transit systems in the United States, the elasticity of demand tends to be about -0.3 at 25-cent fare, -0.6 at 40-cent fare, and -1.0 at 75-cent fare. These elasticities imply that demand is price inelastic at low fare levels and unit elastic or more around 75-cent fares. Conversely, scattered data on taxi systems seem to indicate that taxi demand is unit elastic or higher and that average taxi fare is around 95 cents (5, 6). Figure 11 shows these elasticities of demand for different fare levels and for a limited number of fare changes.

The Haddonfield DRT system free-fare day resulted in a ridership ratio of 1.98. The attitudinal on-board survey of riders during January 1973 resulted in ridership ratios of 0.72 for a fare increase from 60 to 85 cents and of 1.49 for a fare decrease from 60 to 35 cents (7). Similarly, the Ann Arbor DRT system fare change resulted in a ridership ratio of 1.48 for a fare reduction from 60 to 25 cents (8). Finally, in the Bay Ridges DRT system, a fare increase from 25 to 30 cents did not result in any change in ridership.

Comparison of these limited DRT system fare changes with the conventional transit system relation seems to indicate that DRT system elasticities of demand with respect to fare are similar to those of conventional transit systems at about the 60-cent fare level (Fig. 11). This implies a rough elasticity of demand ranging between -0.6 and -0.75 at a fare level of about 60 cents/ride.

Figure 10. Hourly distribution of average Saturday vehicle supply for high-fare and reduced-fare periods.

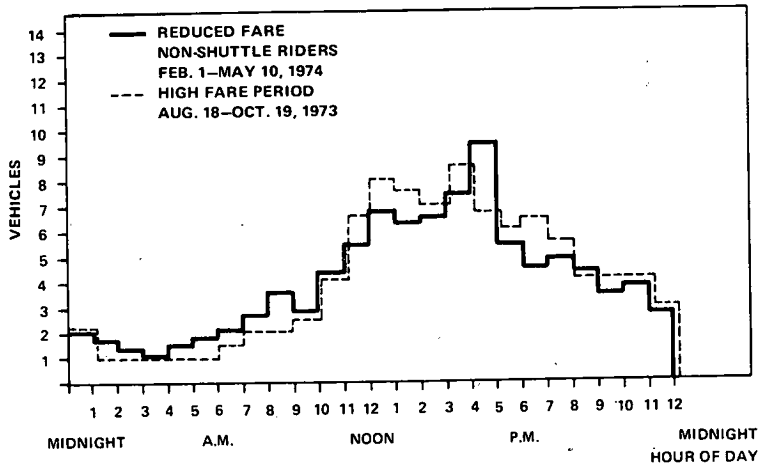
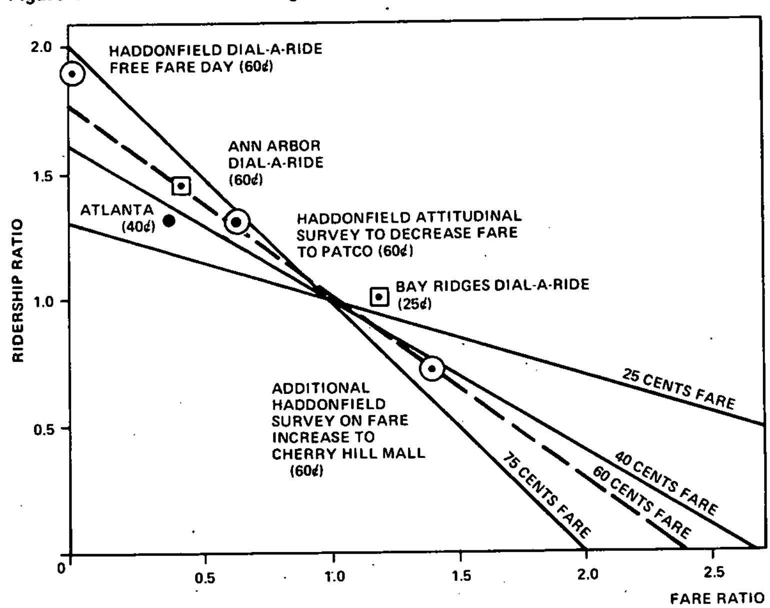


Figure 11. Effect of fare change on transit demand.



CONCLUSION

This brief description of the fare policy in the Haddonfield DRT demonstration indicates that the reduction of fare from 60 to 0 cents/ride substantially increased the ridership and productivity of the system. It also shows that the effect of fare reduction from 60 to 30 cents per ride could not be isolated because of the parallel changes in the mode of operation (shuttle, zonal, computer scheduling) and, possibly, the energy crisis. However, the effect of fare reduction and improvement or additions to the service resulted in high elasticity of demand. This fact seems to conform with experiences of conventional transit systems, whose riders are more sensitive to service quality or travel time changes than to fare changes.

The comparison of the DRT systems with conventional transit systems indicates that the riders of DRT respond to fare changes (at the 60-cent fare level) similarly to riders of conventional transit systems.

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James E. Reading, Regional Transportation District, Denver

This discussion is based largely on experiences gained in Rochester, New York, where a DRT system was implemented in August 1973. I will also mention a new service in Denver.

Marketing transit, as I view it, is the dynamics of making a beneficial service available to the communities served for value received. It is a total concept—not just advertising or public relations. It requires that goals and objectives be established. To understand the transportation problems of people is absolutely essential if meaningful solutions are to be provided for their mobility needs.

As early as 1968, when I began dreaming of setting up a system by which people could telephone for transportation service, it was understood that such service would be economically unfeasible. It is and has been my belief that DRT cannot pay its own way through the fare box. To justify the system requires some trade-offs. For one thing, there should be a solid base of ridership in the peak periods. This could be persons going to and from work or to and from school. Also, new service must not compete with but should extend, complement, and supplement existing transit service—or, better, replace fixed-route transit in high-loss areas to provide greater mobility for a greater number of persons while cutting back on expenses. This approach has

has successfully been demonstrated in Regina.

The Rochester system was entirely locally financed, and rather high fares ($1) had to be established. We, therefore, developed a flexible fare policy:

Service	Single Trip, 1-Way Fare	Discounted Weekly Passes
Dial-a-bus	1.00	
Home-to-work	0.80	7.00
Home-to-school	0.65	5.00
Feed-a-bus	0.85	7.50

Passes are purchased on Mondays from drivers; the necessary amount (bills and change) is deposited directly in the fare box.

In addition, groups of 2 or more persons have the opportunity to ride for even less. The only qualification is that everyone in the group have a common origin and destination. The fare for the first person is the regular 1-way fare, but all others pay just 25 cents each. For a group of 4 going to a shopping plaza, for example, the total fare of $1.75 averages just 44 cents/person. Families, senior citizens, and employee groups of as many as 25 persons have taken advantage of this reduced fare.

Other promotional fares included Rider Appreciation Week, when home-to-work passes were reduced to $5; 50-50 Week, when the regular $1 fare was lowered to 50 cents; and shopping plaza promotions in which retail stores aid a shopper's return-trip fare. All of these reduced-fare programs materially increased ridership during the promotion. More important, in the days and weeks following, a percentage of the newly acquired passengers continued to use the service.

Another successful fare promotion, which was called "Let's Split," was designed to introduce DRT to residents of a new service area by splitting the $1 fare with them. Personalized checks that were valued at 50 cents were mailed to all homes. Some newspaper and radio advertising was used, but the major part of each marketing effort consisted of direct mail pieces. All promotions were not successful. One promotion I recall really bombed. The idea was to offer a free week's pass for home-to-work service for every person talking a nonrider into purchasing a pass at the regular rate of $7. We had only 1 taker.

The Regional Transportation District in Denver has committed itself to what is probably the most ambitious DRT service yet planned for the elderly and handicapped. Newly designed buses have lower floors, wheelchair lifts and tie downs, and an extending entrance step. Fares for this highly specialized door-to-door service will be the same as those charged on regular transit routes: 35 cents during peak periods, 25 cents during off-peak periods, and 15 cents for an additional zone. Our purpose is to make possible job and educational opportunities and increased mobility to the 11 percent of our population who are handicapped. We expect to have a flexible fare policy to make this new service a meaningful success to the greater Denver area.

Warren H. Frank, Central New York Regional Transportation Authority

Since my appointment as executive director of the Central New York Regional Transportation Authority, my goals and the goals of our subsidiary company, CNY Centro, Inc., of which I am president, are to zero in on special transportation services and to implement marketing programs to improve the image of the total transit system. Our initial target has been the isolated, vulnerable elderly and handicapped who reside in central New York. Our objective is to increase their mobility and decrease their isolation so that they can get to and from employment, shopping, health services, entertainment, recreation, and social and cultural activities.

This objective is being met through Call-a-Bus, a door-to-door bus service for the elderly and disabled residents who live in Syracuse and Onondaga County and who find it difficult or impossible to use regular transit service. This project is made possible by a grant to the Central New York Regional Transportation Authority from the Urban Mass Transportation Administration. Through the diligent efforts of the authority, Syracuse was chosen as 1 of only 3 sites in the country for this extensive project demonstration. With this privilege came a responsibility for the authority to market and promote the finest demand-responsive system in the nation.

We are proud of the progress we have made. Our marketing strategy goes beyond the usual buttons used for identification of DRT riders and umbrellas used to keep elderly and disabled patrons dry during inclement weather. From the very beginning of Call-a-Bus, our marketing functions included the following.

1. Marketing research. Our intention is to have a definite positive impact on the lives of the people who use the Call-a-Bus system. A survey of transportation needs of the elderly and disabled was completed. Group transportation needs were researched. A great deal of latent demand had been uncovered as a result of this research. Some 60 social service agencies are continually surveyed to assess the need for special transportation services. The results are overwhelming: Most agency programs are operating below capacity. With this vital information, we can adjust our service to allow the handicapped to again become participating members of society, to give the elderly a feeling of independence, and to improve the efficiencies of the social service agencies.
2. Pricing policy. Because of the subsidized nature of the project, Call-a-Bus rates vary from 50 cents to $1, depending on the mileage of the bus ride. In the case of charter service, Centro finances half of the costs incurred by the organization that orders the service. These charters include service to local shopping centers. Our Call-a-Bus rates are so reasonable that in one case an elderly woman with failing eyesight sent a $5 donation for gas to help with her frequent rides to the hospital.
3. Bus design and equipment. In an effort to streamline Centro, which already has the lowest operating costs of any transit system in the state, we ordered 4 specially equipped Mercedes Benz minibuses. These minibuses have been designed for the elderly and handicapped and will be equipped with a wheelchair lift, 2-way radios for prompt dispatch service, and a bottom step that lowers to 6 in. (15 cm) from the ground when the door is opened. After modification, each bus will be capable of carrying 8 passengers and 4 wheelchairs.
4. Monthly Call-a-Bus newsletter and literature. Each month a Call-a-Bus newsletter is mailed to local and county officials and all the social service agencies to keep them informed of programs and events. The newsletter articles cover special events such as free concerts or cultural programs, announcements, and introductions of Call-a-Bus staff members. In addition, the Central New York Regional Transportation Authority staff works closely with our ad agency in developing graphics, newspaper ads, and other literature.
5. Program activities. Much of the Call-a-Bus success is directly attributed to the authority's organization of the project advisory committee. This committee, composed of representatives from community agencies and elderly and disabled persons, is the major policy-making body for the project. It meets monthly to establish the major guidelines by which the project is operated. The committee provides the elderly and disabled an opportunity to play a role in guiding their own destiny. This working committee keeps the social service agencies involved and informed about the Call-a-Bus project, and it serves as a communications link among various agencies. The advisory committee aids in the coordination of project activities, the dissemination of project information, and the exchange of external information and ideas. These types of program activities result in excellent customer relations, press relations, and consumer follow through.

6. Special promotions and services. Special promotions and services are always good news for senior citizens and the disabled in these times of rising prices. For example, the authority induced a local theatre chain to offer a $1 admission for Saturday matinees to anyone who arrives on Centro's Call-a-Bus. This is a substantial saving from the $3 regular admission, increases Saturday Call-a-Bus ridership, and is excellent public relations. In another example, the authority convinced the Merchants' Association of a local shopping center to sponsor a Call-a-Bus shopping trip on an experimental basis. The response was so successful that the merchants have requested a continuation of this program on a regular basis.

Marketing and promoting our demand-responsive element became a catalyst to implement other marketing programs to improve the image of the total transit system. The Central New York Regional Transportation Authority is the only authority to have initiated numerous successful marketing programs improving public transportation in our region. We have not only halted the decline of transit, but we have registered real increases in ridership and revenues while other transit systems in the state have experienced declining ridership and revenues.

In its first year of operation, Centro was one of the few transit companies in the nation, and the only one in New York State, to show consistent ridership increases since the Central New York Regional Transportation Authority took over the former Syracuse Transit Corporation. The failing transit company was losing passengers at the rate of 9.5 percent per month. Centro, after stemming this decline of ridership and reversing the downward trend, boasts an impressive 4 percent increase for the fiscal year ending March 31, 1973, and a 5 percent increase for the fiscal year ending March 31, 1974. Centro has consistently increased ridership since.

The following successful projects have improved the image of our total transit system and have become responsive and responsible to the social services and commercial enterprises in our region.

1. Transit Tuesday. Super Shopper's Special (April 4), Transit Tuesday (May 7), and Transit Tuesday (July 16), sponsored by Centro and the Downtown Development Council of the Greater Syracuse Chamber of Commerce, were the first major promotions involving Centro and the downtown merchants. Nearly every downtown business participated in the events, offering special sales and free rides home to their customers. Approximately 6,000 people took advantage of the July 16 Transit Tuesday. Centro's ridership increased 30 percent over the same Tuesday in 1973 and was up 10 percent over an average Tuesday of 1974. Centro carried 40,000 passengers on July 16, 1974, compared with 30,940 riders the same Tuesday in 1973. The enthusiasm and participation on behalf of the chamber, the newspapers, and the downtown merchants have closed the gap between private enterprise and public transit in Syracuse.

2. Farmers Market bus. The Farmers Market was inaugurated last summer by the Downtown Development Council of the Greater Syracuse Chamber of Commerce to bring together nearly 65 central New York farmers each Tuesday in Clinton Square to sell fresh produce, plants, and crafts. Centro provides an extremely popular free shuttle service (subsidized by the Syracuse Chamber of Commerce), looping the downtown area to accommodate office workers on limited lunch schedules who want to shop at the Farmers Market. Country music is played over a loud speaker system, and a specially signed bus loops the downtown area every 15 minutes. Again, the support of local newspapers, merchants, and the Chamber of Commerce has been phenomenal.

3. Carrols promotion. Carrols Corporation has recently agreed to work with Centro in a joint promotion to the mutual benefit of the bus rider, Centro, and Carrols. A Centro bus rider is now able to purchase a package of 10 tokens for $3.50 at any of Centro's 44 distribution points. This token packet will include 4 coupons good at any Carrols restaurant and totaling $1.50 in value. A total value of $5 is, therefore, provided with the purchase of 10 tokens for $3.50. This promotion incurs no cost to Centro or the authority. To the best of my knowledge, this exclusive 1-year arrangement is the first of its kind in New York State and the nation. I expect this promotion to substantially increase our token sales, stimulate additional ridership, and establish

a precedent in total cooperation between private enterprise and public transit.

4. Centro park-and-ride. On Monday, June 3, 1974, 5 parking lots began operating as Centro park-and-ride lots under the management of Dutch Parking Systems. Daily or monthly parking permits can be purchased along with bus-ride coupon books of 20 rides for $1 or 5 cents/ride. This enables the automobile driver to take a bus downtown and return for only 5 cents each way. The goal of this new parking venture is to provide low-cost parking on the outskirts of the downtown business district combined with bus service for shopping and downtown employment.

5. Subscription service. A popular fuel-saving operating implemented and designed to save thousands of gallons of gasoline allows workers to board express buses in parking lots near their homes and ride directly to work and back. Fifteen of the largest corporations in Syracuse are being aided by Centro in expressing their employees to and from work. This popular mode of travel is expected to grow as gasoline becomes increasingly more expensive.

6. Technical sophistication. Major improvements in equipment and service have hurled Centro into becoming the nation's showcase transit system.

Centro's new Keene fare-box system automatically counts coins when deposited, removes them by vacuum to a holding box, sorts, recounts, and stacks them away without their being touched by human hands. The computerized Arcom system can relay information such as the speed of the bus, fuel consumed, oil used, temperatures, and any other area Centro would want to monitor.

Centro's newly installed 2-way radio system provides constant contact between drivers and the dispatcher at all times. This enables Centro to make immediate adjustments in route schedules to better serve the rider. The radio system also monitors the mechanical performance of the buses and immediately informs the dispatcher of problems in oil, water, and air pressure. The radio also features a silent alarm whereby the driver can signal the dispatcher when trouble occurs.

Run cutting and scheduling (RUCUS) and systems inventory and management (SIMS) hold the high-priority value at Centro, for they enable improvements to be made in the scheduling operations and inventory efficiency. The use of RUCUS is expected to save Centro 2 or 3 percent of its annual transportation costs, or about $100,000/year. In addition to these cash savings, we will have the mechanical aspects of the transportation department computerized, making this department flexible and freeing the staff for supervision and design of service improvements. RUCUS and SIMS are indispensable management tools providing efficient operation of the transit system and more managerial information for decision making. Additional improvements in routes, shelters, buses, and schedules have combined to produce a higher level of service for the community's bus riders.

7. 1974 Fleet Owner's Maintenance Efficiency Award. Centro was recently named as the 1974 winner of the Fleet Owner's Maintenance Efficiency Award. The criteria for the award were conserving fuel, obtaining fuel, and getting maximum use from existing equipment. For 1973, maintenance costs were 11.98 cents/mile. Centro operated 6,239 miles/road failure, and fuel economy was 4.51 miles/gal.

8. Centro-go-Patrol. Special hot-line telephone numbers have been established between the previously mentioned radio dispatcher and local radio stations. In this program, drivers who belong to the Centro-go-Patrol can report over the radio system to the dispatcher traffic flow, detours, accidents, impassable routes, and other problems, which are in turn broadcast over the network during rush hours. The radio stations reward the Centro-go-Patrol driver of the month with a plaque, and Centro provides another needed service for the community.

9. Newspapers on buses. Centro has been putting entertainment into bus riding since December 1973, when it began systemwide newspaper sales. The convenience of reading the day's news, sports, and entertainment, while being spared the headache of negotiating rush-hour traffic has won the favor of the Centro riders, who have helped the buses become major distributors of Syracuse newspapers. Centro now has newspaper racks on 165 buses and is selling the Herald-Journal and Post-Standard on all routes. Centro sells more than 6,000 copies of these newspapers a month. The racks, located on the dashboard next to the driver's seat, were custom-designed by Centro's

assistant maintenance supervisor, Fred Hafner, and were built by workers at Manpower Industries. Centro is the only transit system in the state to have newspapers available on buses. Newspaper sales are a source of revenue to Centro. The availability of newspapers on all buses, including Call-a-Bus, will enhance the service for riders.

The success of any marketing promotions is best measured in terms of ridership and revenues. The Central New York Regional Transportation Authority not only has halted the decline of transit use but has registered substantial increases in ridership and revenues. The approach of other transportation systems to increase ridership and revenues has been counterproductive because they have tried to increase ridership by reducing fares.

The alternate approach to increasing revenues has been to increase fares, and that is also counterproductive because the increased fares decrease ridership. Centro has increased ridership without increasing fares.

At Centro, we are beginning to convince people that transit is essential. It aids the consumer, senior citizens, and the handicapped in times of soaring fuel costs.

Howard W. Gates, Rochester-Genesee Regional Transportation Authority, New York

In 1973 we began to set into motion a new form of public transit service, which we called PERT (personal transit) Dial-A-Bus. While our traditional fixed-route system was struggling to survive and facing a quickening financial crisis, we were about to offer the public a totally new transportation concept. We carried 745 people during the first week of operation. We now carry that many each day. The new system has flourished and increased ridership, while overall transit ridership has continued to decrease.

Why? The answer is simple. We offer the public a logical alternative, one that permits them to have the convenience of their automobiles without the high cost and aggravation of driving. A phone call will bring a clean, comfortable public transit vehicle to the front door and take the caller to work, to school, to shop, or to any one of a multitude of places at a fraction of the cost of driving. Acceptance and use of the PERT Dial-A-Bus, therefore, were achieved with a minimum of effort and expenditure on a marketing and promotional program.

A well-planned and carefully carried out marketing program will

1. Inform the public about how the system operates and what the advantages of its use are,
2. Motivate those persons in the service area to use the new system, and
3. Retain ridership once it has been achieved.

Several months before the projected starting date, the first phase of what has been a continual marketing effort began with the drafting of the basic marketing plan and a projected budget. The plan addressed 3 main questions:

1. Who are we attempting to reach?
2. How and when are we to do so?
3. What will the cost be?

SERVICE AREA

The initial service area, which was defined by a team of consultants from M.I.T., encompassed approximately 10 miles^2 (26 km^2), primarily within the large suburban town of Greece, adjacent to the northwest section of the city of Rochester. A small segment of the city was also included. Since that time several small expansions have increased the size of the area to approximately 12 $miles^2$ (31 km^2). The factors that led to the selection of this particular area include

1. High population density (50,000),
2. Heavy industrial employment within the area (Eastman Kodak has 7,000 to 8,000 employees living and working in the service area and providing a market for home-to-work subscription service),
3. High percentage of senior citizens (5,000 to 6,000),
4. Several large shopping centers, and
5. Large public and private school systems, for which home-to-school service could be provided.

SERVICES OFFERED

The various types of service offered by the PERT Dial-A-Bus system are discussed below. Each one required specific marketing techniques.

Home-to-Work Service

Home-to-work service is a weekly subscription service that provides transportation from the doorstep to a designated plant gate and from that gate home again. A round trip each day for 5 days is offered at a cost of $7. The subscriber calls in and arranges his or her particular trip. Service then begins and continues until canceled. Daily, single-trip service is also available as long as the caller places a request with the control center by 2:00 p.m. the previous afternoon so that the trip can be worked into a route. Payment is handled through the fare box on the first day of each week when the subscriber pays the full amount for the week and is given a color-coded pass good for that week.

Home-to-School Service

Home-to-school service fills the void left for those who are ineligible for Yellow School Bus service because of distance limitations. In our service area there are several sections that do not have sidewalks, and some of the smaller school children have rather long and hazardous walks. Parents have demanded some kind of service, and thus we developed this specialized service. It is handled in the same manner as home-to-work service, at a rate of $5 per week, for most school trips are shorter than work trips. The children pay on the first day and receive their passes for the week. Single trips are also available if arranged for the preceding day.

Feed-a-Bus Service

Feed-a-bus service is so named because it is feeder service to regular bus routes in the service area. It too is handled on a weekly subscription basis or a daily, single-trip basis. The weekly rate is $7.50, which includes transfer to the regular route bus.

Dial-a-Bus Service

Dial-a-bus service, of course, is the general point-to-point service within the service area.

MARKETING TECHNIQUE

Two basic marketing and promotional approaches have been employed throughout the various phases of the program.

1. The "rifle" approach consists of elements that are directed exclusively toward residents within the service area and that include direct mail, local newspaper advertisements, on-board handouts, appearances before groups and organizations, and reduced-fare incentive program.
2. The "shotgun" approach uses advertisements in mass-circulation daily newspapers and on radio and television, outdoor advertising, and news releases and press conferences.

The rifle approach has been used far more extensively than the shotgun approach because it was felt that 90 percent of the subscribers to the widely circulated daily papers and a similar broad audience of radio and television do not live in the service area and much of the high cost of areawide mass media advertising would be lost. A better approach seemed to be the concentration of our efforts and budget directly within the service area. Only recently have we begun to place an occasional advertisement in the daily papers and on radio.

All during the preservice marketing and promotion program, we received heavy areawide newspaper, radio, and television coverage. Since then, coverage has been sporadic, and occasional areawide advertising is used not only to increase ridership but also to continue a general awareness of our unique service and perhaps sharpen the desire for it to expand.

MARKETING PROGRAM

The initial marketing plan called for 3 phases encompassing a period of about 5 months. Service was set to begin on August 6, 1973, and marketing activities began in April, building to a 4-week, areawide promotional campaign before the start of service and a follow-up or continuing initial program extending some 6 weeks after the start of service.

Phase 1

Phase 1 covered the period from April through June and centered on direct contact with the various publics involved: public officials (state, county, town), employers within the service area, community groups and organizations, and the news media. Each was fully informed of all aspects of the new service. A slide presentation about Dial-A-Bus and how it works was prepared and presented before more than 50 community and industrial groups and also public officials.

Special note should be given to preservice efforts with the Eastman Kodak Company, the major employer in the service area. Kodak's central production complex, known as Kodak Park, is situated in the southern corner of the service area and presents a ready home-to-work market. Early contact was made with company officials, and they agreed to cooperate by mailing a Dial-A-Bus survey to all Kodak employees living in the service area and working at Kodak Park. We supplied the survey material, and Kodak did the rest. The positive responses then gave us a mailing list for initial promotion by direct mail. Kodak also permitted us to place home-to-work subscription registration cards and other materials at central locations throughout the large industrial complex and included good coverage of the new service in the heavily read Kodakery, the company's internal weekly paper. This early phase 1 work with a major employer laid a solid groundwork for home-to-work subscription service, which has become a vital part of daily PERT service.

Phase 2

The major preservice promotion began 4 weeks before the start of service. Direct mail took a major part of our overall budget, but we were determined to reach every man, woman, and child within the PERT service area. A well-designed brochure mailed to every home in the service area accomplished much of that aim. The multicolor brochure gave full information about PERT Dial-A-Bus, including a map and pressure-sensitive telephone tabs.

Several other brochures were developed during this period to promote the specific services. They were distributed at meetings and from plastic "take one" holders, which were distributed to all stores and professional offices in the service area.

A series of newspaper advertisements on a central theme, "We're Coming to Get You," appeared in all 3 local publications during the preservice promotional period; each one added new information. Outdoor billboards were also used with the same theme and the same style of gradual addition of information.

Something absolutely basic to our entire approach to marketing is that we are marketing personal service, and all our marketing efforts carefully and with premeditation dwell heavily on the personal pronouns "we" and "you." It makes a significant difference in overcoming the built-in resistance most people have to public transit in general and bus service in particular.

As the mailing and advertising were carried out, phase 1 activities continued. Appearances were made before groups and organizations, and promotion was prepared of the first cooperative, reduced fare to be offered after the start of service to the area's largest shopping center. Meetings were held with the Merchants' Association and owners of all shopping centers in the service area to inform them about the service and to elicit their support in terms of promotion and special programs for reduced fares and free telephone installation for customer use. The 2 largest centers agreed to free telephones at their expense, and the initial reduced-fare special in the form of a late August half-fare discount coupon available at all stores in the largest plaza was agreed on.

Preparations were made to introduce the first vehicles to the community. A "Lunch by Bus" invitation was prepared for all news media representatives and key public officials. On a hot summer day about 2 weeks before service started, 2 of the first air-conditioned Dial-A-Bus vehicles picked up the guests at a central downtown location and carried them on the inaugural ride to a restaurant within the service area. During lunch the service was described by transit officials and M.I.T. consultants. Press kits with complete information and photos were distributed before the return trip. The effort resulted in good coverage by all media, including strong editorial support.

Phase 2 of the initial program concluded with the first day of PERT service. A ribbon-cutting ceremony at the door of the first vehicle to go into service brought public officials from state, county, and town levels to a main Kodak Company gate to participate with Kodak and transit representatives. Again, the news media gave good coverage not only to the public relations but to the first day of service itself. About 100 passengers were carried on the first day and, as stated earlier, 745 rode during the first 5-day service week.

Phase 3

The initial marketing plan and budget called for postservice activities to encompass a 6-week period. Newspaper ads were continued, and industrial subscription service sign-up work went on within Kodak.

In addition, contact was made with public and private school officials and PTA groups to secure their support and assistance for home-to-school service. Several meetings were held with various groups and individuals, distribution of the home-to-school brochure was agreed on as was a detailed article on Dial-A-Bus service in the central school newsletter, which was mailed to all residents before the start of school. Specific newspaper advertisements were also used in the 2 weeks before the start of school.

This year a new dimension to school service was created: A Dial-A-Bus plan is available to those taking evening adult education courses at one of the large high schools in the service area. All literature issued by the school district pertaining to courses offered contains promotion of a package Dial-A-Bus program. The students may sign up for home-to-class and return service once a week for the 10-week course and pay the additional amount. The number now taking Dial-A-Bus to evening sessions is steadily growing.

Details of the first incentive program were worked out in early August with the major shopping centers. It was offered during the last days of August, coordinating with the shopping mall's "Back to School Days." Half-fare coupons were available in all stores and were good for the return trip. Drivers were instructed to accept them only from passengers boarding at the mall. At the end of the special week the Merchants' Association was billed for all coupons taken in during that period.

In the weeks following the start of service, plastic telephone dialers in the PERT yellow and blue colors were given wide distribution at shopping centers and in stores and offices. They were printed with the PERT telephone number. Along with the continuing distribution of telephone stickers, they put the Dial-A-Bus message in the home at the telephone.

INITIAL EFFORTS COMPLETED

By mid-September all 4 services were in operation, and ridership was growing. The 5-month period of planning and implementation of an initial marketing and promotional plan had been completed. Major goals of widespread awareness of the service and initial acceptance had been achieved. The continuing task of creative marketing designed to build the doorstep transit service ridership now presented the challenge during the ensuing months.

INCENTIVE MARKETING

The first major effort to gain increased ridership with a systemwide discount fare came in November as the weather worsened, making the driving more of a chore. A household direct mailing was made to 17,000 homes in the service area. The oversized postcard announced Half-Fare or 50/50 Week. Anyone calling for a bus during the promotion week rode for half fare during the off-peak hours of 9:00 a.m. to 3:00 p.m.

The promotion brough significant results, lifting the overall weekly level of ridership at that time from approximately 1,700 to more than 2,000. More significant was the fact that ridership remained at the new level after the promotion and never again fell below 2,000.

Two similar half-fare promotions have been offered since the first one a year ago, and each time the overall weekly ridership settles back to a significantly higher level after the promotion than had been experienced prior to its start. Other specific fare incentives have produced increased ridership. A special discount week for home-to-work subscription service brought new riders as did a similar incentive fare for use of feed-a-bus service.

SENIOR CITIZEN PROGRAMS

Since the start of service, 2 major senior citizen high-rise housing developments have been occupied.

A shopper's special program was developed shortly after the first residents moved in, and a local supermarket chain paid the full cost of a weekly shopping trip from the developments to a shopping center in the service area. Demand has grown to the point that 3 vehicles are now being used each Thursday morning for the shopping trip.

SPECIAL CHARTERS AND GROUP RIDERSHIP

Other markets, such as industrial and school charter work, have been explored to advantage. Eastman Kodak groups and other industrial employees in the area often take Dial-A-Bus to lunch or a special meeting, using the group travel fare that has been developed to encourage multiple ridership. With group ridership, the first person pays the full fare of $1. Each additional rider pays 25 cents when all are traveling to the same destination. This way, a group of 20, for instance, rides for $5.75. It costs us no more to pick up 1 passenger or 20 when called, and, therefore, it is a tremendous marketing device, which also means additional revenue. Schools within the area also take advantage of the Dial-A-Bus charter for class field trips, such as retail training at stores in the area. Chartering a Dial-A-Bus for special trips is less expensive than chartering one of the yellow buses.

EXPANSION AND INTEGRATION

The original service area has been expanded several times, and Dial-A-Bus service has been integrated with fixed routes in the service area. Each action has called for specific marketing and promotion for those affected. Direct mail still serves as the central technique. In addition, on-board informational pieces, newspaper advertising, and news releases have also been used.

SUMMARY

In marketing Dial-A-Bus, we attempted to sell a service but we also attempted to persuade those who would use it to change their habits and life-styles. This is a particularly challenging task in view of the entire country's love affair with the automobile. We had to show them that Dial-A-Bus is a logical alternative.

Our experience in Rochester, where a growing number of persons are making the transition to PERT each week, proves that it can be done. Nothing, however, is harder to sell than a "gold brick," and it is far more difficult without a sound, well-planned and financed marketing program.

We found the rifle approach to marketing to be the most successful one. As our service area grows, we will turn more to mass media.

We found that laying a strong foundation of support and cooperation from the various publics involved before the start of service does much to enhance success. Strong lines of communication must also be maintained on a constant basis.

Effective fare-incentive promotion, we found, can produce ridership increases that last as more people try the service.

EVALUATING DEMAND-RESPONSIVE TRANSPORTATION SYSTEMS

Nigel H. M. Wilson, Massachusetts Institute of Technology

This paper discusses some of the important elements in the evaluation of a demand-responsive transportation (DRT) system. Evaluation is and must remain primarily a local issue. Decisions on whether to provide demand-responsive service, who is to operate the service, what the quality of service is to be, and how the operation is to be financed will all be resolved at the local level. Different communities will use different mechanisms for arriving at these decisions, and clearly a set of decisions appropriate for community A may not be preferred for community B, even if the choice mechanism is the same. These mechanisms may range from public referenda on one or more proposals to a single all-powerful decision maker, though generally some pluralistic process is used.

This paper is not directly concerned with the choice mechanisms, but focuses instead on the actors affected by implementation of a service and the type and degree of impact. Because evaluation is a local issue and because statements on the degree of some impacts may not yet be possible, this paper is oriented more toward an identification of the elements involved and less toward sweeping statements about the appropriate role of these systems. Some 50 U.S. communities have made positive decisions on implementing demand-responsive services, and this number has increased exponentially during the past 4 years.

ACTORS INVOLVED

A gross aggregation of the actors who are potentially affected by decisions to implement some form of demand-responsive service is as follows:

1. Users of demand-responsive service,
2. Nonusers of demand-responsive service,
3. Operators of demand-responsive service,
4. Operators of other transportation services, and
5. Managers of other businesses and activity centers in the area.

Within each of these broad categories of potentially affected groups will generally be significantly different subgroups, each of which will be subject to a range of impacts. These issues are discussed for each of the major groups in the following sections.

Users

The users of any transportation service are the fundamental reasons for providing the service at all. If there are no users, then there are no benefits arising from use of the system. If there are users, then there are benefits derived from the system, and those benefits accrue to users and to other actors in the process. Because of this simple fact, some measure of ridership is usually a major factor in the evaluation of a service—the more people using it, the greater the benefit. This should not be the sole measure of effectiveness, but it should be an important one.

Users benefit either from the new service allowing them to take advantage of urban activities that they were not previously able to (induced demand) or from the new service being preferred to the one previously used. In both these cases the user benefit is bounded by the difference in service provided by the new service and the previously available service. If the new service is similar to a previously existing service but a little better, then induced demand may be small but the number of riders who had previously used the similar mode may be large. In this case the average benefit for each user would be small. Conversely, and this is more likely to be the case for demand-responsive services, the type of service may be significantly different from previously available services, resulting in significant levels of induced and diverted demand.

The extent of induced demand is an important factor in evaluation because for these users mobility has been increased and opportunities have been made available in the urban area that were not previously practical. These opportunities range from an unemployed person being able to take a job to previously lonely people becoming more fully involved in the community's social and economic life. People with good access to alternative modes such as automobile, bus, and taxi will be unlikely to significantly increase their trip making, but those without an automobile, without bus service, or too poor to use taxis may benefit considerably from the new service. In particular these people, currently mobility handicapped, may receive significant benefits from the new service. Diverted demand also involves a benefit to the user, and the degree of this demand indicates how well the new service competes with other services for current trips.

In either case, the estimation of the total user benefit is a function of the number of users and the difference between this service and the best of the previous services. Different users would otherwise have preferred different modes because of the range of individual utility functions; if everyone had identical utilities, they would all use the same mode for a given trip. After implementation, to determine the number of users of a new service is easy, but to estimate the average user benefit is difficult. The traditional approach is to develop a generalized cost for each service based on monetary cost and the product of an assumed value of time and the service time. The difference in generalized costs then is used as an estimate of the benefit for a user of the new service.

Evaluating existing demand-responsive services is difficult because many travel decisions are based on long-run household and individual decisions such as home location, job selection, and automobile ownership. Before the real benefit can be estimated, the system must be in operation long enough for these long-term decisions to be made. System ridership will likely increase as these longer term decisions are made.

The preceding discussion has assumed that the demand-responsive service is in addition to the previously available services; however, this may not always be the case. For example, if the service partially or completely replaces fixed-route bus service, there may be increased user costs incurred by those who previously used the fixed-route bus service and who preferred it to the new service. This may be an important factor if there is a significant fare increase involved. However, where fixed-route services are heavily subsidized, the user may have been in an untenable position from the outset; and the choice may well have been between no service at all and the new demand-responsive service.

In general, however, the number of riders is a reasonable proxy for user benefits and is one important element in evaluation. For demand-responsive transportation in particular, many users have low frequencies of use, which implies that the service is being used in unusual situations. For this reason both number of trips and number of distinct users should be considered as proxies for user benefits. The second important element in user benefits is the difference between the new service and the previous best service for each type of user. This will usually be highly correlated with level of usage.

Figure 1. User benefits from demand-responsive service.

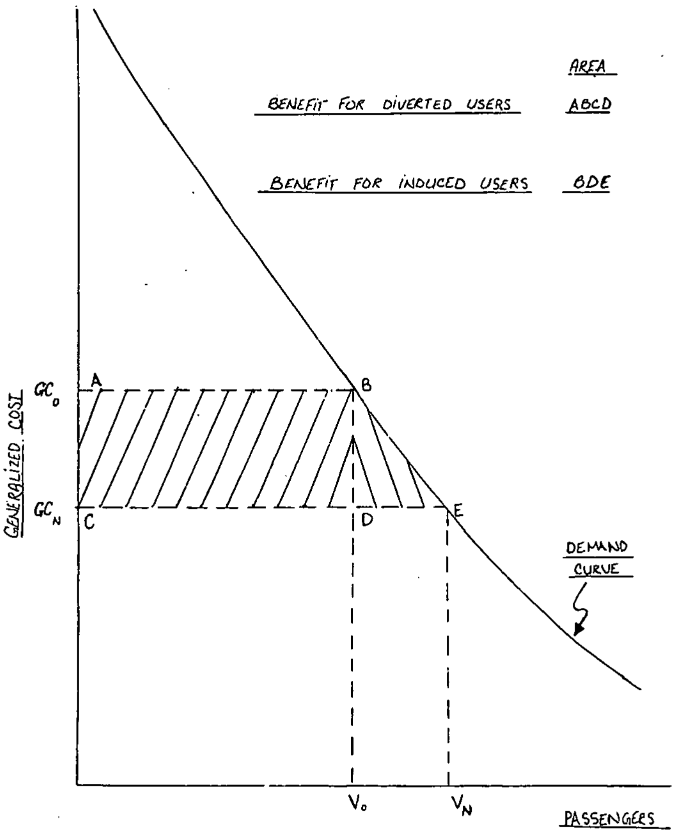


Figure 1 shows this concept of user benefits. The users of the new system are assumed to have a demand for service. The generalized cost of the new service is GC_N, that of the previous preferred mode is GC_0, and new and old number of passengers are V_N and V_0 respectively. The user benefit associated with each diverted user is then simply $GC_0 - GC_N$, and there are V_0 such users; the user benefit for each new user is uniformly distributed between $GC_0 - GC_N$ and 0, and there are $V_N - V_0$ such users. This is a grossly simplified representation of the construct but does indicate the importance of the number of users and the improvement in quality of service in the total user benefit.

Clearly, then, one way of increasing user benefits is to reduce the fare charged or increase the quality of service—but both actions will result in a greater net cost of service. This clearly requires the evaluation of the alternatives from a multiobjective viewpoint.

Nonusers

Nonusers of the new service are potentially affected in a number of ways through externalities associated with the system. Classic transportation externalities include air pollution, congestion, and community disruption. In demand-responsive transportation, externalities tend to be much less significant than in systems involving major constructed facilities. In demand-responsive services, the major externality is generally the cost of supporting the system and that cost is not borne by the users directly. If service fares are set below cost, which will in general be to achieve some welfare objective, then nonusers will be paying the difference. The fare level and financing of the net cost will determine the extent to which certain groups of nonusers will have to pay. This decision in particular is a local responsibility and must be resolved through the political process. The key question is to what extent the social welfare objectives justify subsidization and how the subsidy is raised.

In some cases the effect of subsidization could be regressive, for example, where the service is provided only in high-income suburbs and the subsidy is based on an areawide tax. There is a real question about whether this situation can be justified or, more basically, whether nonusers should be expected to subsidize service to this user group. Subsidization in this case does not meet a social welfare objective. In the case where service is provided in low-income areas or to mobility-handicapped markets, a strong case can be made for subsidization on an areawide base.

Indications from existing demand-responsive services strongly suggest that other externalities are quite minor. Specifically it is unlikely that there will be a significant reduction in automobile use, so no improvement in air quality or reduction in congestion should be expected.

Operator of the Service

A basic decision is whether the operator of the service should be public or private, transit based or taxi based. This decision has a major impact on the economics of the system and may also dictate the fare level. Existing demand-responsive systems can be divided into profit-making taxi-based services and subsidized transit-based services. The taxi-based services typically have lower cost per vehicle hour of operation combined with higher fares resulting in the profit-making service. A necessary result is that the service is not oriented primarily to social welfare objectives and serves a smaller share of the total transportation market. The total user benefit will be smaller if this option is selected, but there will be no nonuser financial burden.

The transit-based option has higher costs largely because of higher wage rates and better benefits prevalent in the transit industry. However, one result of this is that driver turnover is much lower in the transit industry than in the taxi industry. Additional advantages of the transit option are the ease of coordination between DRT and fixed-route services and the flexibility to be achieved by shifting some drivers from fixed-route service in the peak hours to demand-responsive service in the off-peak hours.

The impact of the service on the operator is the profit (or net cost) associated with providing the service. This may be simply passed through the operator as, for instance, in the case where a subsidy is provided by the public. An additional impact is the employment directly associated with provision of the new service. In some localities it may be politically feasible to subsidize private operators of demand-responsive services to achieve the advantages of lower operating costs combined with increased user benefits associated with reduced fares.

Other Operators

There may be significant impacts on other transportation services when demand-responsive service is introduced. For example, fixed-route transit and taxi service will likely both lose ridership if demand-responsive service is introduced into an area previously providing both. These negative impacts must be recognized in the evaluation process. In particular, to compensate directly or indirectly the operators of competing services may be desirable. This is, of course, part of the local political and decision-making process.

Managers of Other Business and Activity Centers

In general, business and activity centers of all types will benefit from the new services through increased levels of activity and increased pools of potential employees. This impact will be skewed so that positive benefits will accrue to activities previously poorly served by transportation (they will become more accessible) and decreasing benefits will be associated with previously well-served activities (their relative advantage is decreased by the new service). The extent of this impact will depend on the number of users of the new service.

TOTAL EVALUATION

The total evaluation of demand-responsive services is, as previously discussed, a local process, and the factors entering the process and their relative weights will vary greatly. However, several factors now evident must be considered in the evaluation of a proposed system.

1. As previously determined in research and now confirmed by operation, there are increasing economies of scale in DRT ride operation. This in itself can be an argument for providing subsidized operation. Specifically, more productive operations can be provided at higher demand densities; however, to achieve higher demand densities requires subsidy.
2. Even in subsidized DRT services to date, demand densities have been in the range of 2 to 10 passengers/mile^2/hour. At these demand densities, to expect productivities of greater than 5 to 7 passenger trips/vehicle/hour is unreasonable.
3. If it were possible to increase demand density to the 20 to 30 passenger/mile^2/hour range, productivities in the 9 to 12 range are achievable. But the service provided must be made more attractive; subsidization alone will not suffice.

Jerry D. Ward, Office of Research and Development Policy, U.S. Department of Transportation

This paper briefly reviews some of the development trends in cities and their implications for urban transportation systems. The conclusion is one we already know well: The CBD-focused, fixed-route transit systems common today are badly mismatched to the evolving needs of increasingly low-density and multinucleated cities. The principal significance of flexible-route systems such as DRT is that they have been the missing element that lets this mismatch be overcome, permitting us to think in new terms about public transit systems. Regionwide door-to-door systems such as we are beginning to see in Orange and Santa Clara Counties, in Rochester, and in Ann Arbor are the leading edge of this trend. For the first time since Henry Ford, it may not be ridiculous to think in terms of modal splits of 30 to 50 percent of all nonwalking person trips rather than 3 to 5 percent.

The second part of the paper presents some conjectures as to how these regionwide systems might evolve. The conclusion is that, although the flexible-route elements are what make these new systems possible, the major growth is likely to be in proliferation of the fixed-route structure.

The promise of these new systems is great, and success in bringing about a major shift to transit could be of substantial importance to the nation, but it is not going to be easy. We know little about these systems and the public reaction to the kinds of service we think they can offer. In my opinion, the next 5 years are the critical ones for the future of urban transportation.

REGIONWIDE, DOOR-TO-DOOR SYSTEMS

The purpose of this brief discussion, which is more fully developed in another report

(1), is primarily to emphasize that DRT or flexible-route systems are being looked at not as special-market or neighborhood systems but as enabling elements of regionwide integrated systems consisting of both flexible-route and fixed-route elements. It is intended to ensure that we are all talking about the same thing.

Terminology can be a problem. I use the term "flexible-route systems" to encompass the whole gamut: automobiles, van, or minibuses operating in either the telephone-responsive, prearranged (subscription) mode or the street-hail mode. It includes single-passenger taxis at one end of the service scale and many-to-many demand-responsive minibuses at the other. One may prefer the term paratransit (which also includes fixed-route jitney), but the basic rationale being developed is not altered.

Figure 2 shows a typical transit system. It is primarily CBD oriented, whereas less and less travel is. The service in the suburbs is poor or nonexistent. If it is available, it never seems to go where it is needed and its service frequency is low. Roughly half of the population now live in these suburbs.

The problem is economics. Good fixed-route service implies close headways and route spacing. At low ridership density, this means most buses run empty or nearly so. Good service with fixed-route systems is just not affordable in low-density suburbs.

Every morning almost half of the nation's trips start in the suburbs, and they start in a car because there is not an adequate alternative available. The consequence is too many cars downtown, along arterials, and in suburban high-density developments.

The car, if one is available, is superb in trips that are confined to low-density areas; but in high-density areas where land is at a real premium, it takes up too much space. (Its energy and pollution problems are curable—at a price.) The bus and rail that are much more space efficient are poor at the low-density end of the trip. If congestion is to be cured, the car must be kept out of high-density areas. The options to do so are (a) park-and-ride, which requires parking facilities and 2 cars; (b) kiss-and-ride, which requires free labor; and (c) flexible-route system, which requires subsidization.

Each option has its place, and all should be encouraged. Except for the few DRT systems in place, the taxi is the only flexible-route system available, but it (in common with any unsubsidized system) is too expensive to attract the level of ridership for which we should strive. The subsidy issue for both privately and publicly owned systems is discussed more fully later.

We might appropriately also list as an option controls on car usage—car management—because it is likely to be an important and necessary element in system design. This alone is not enough unless the alternative transportation service offered in its stead is reasonably good.

The obvious answer is a mix of systems, acting cooperatively. These are schematically shown in Figure 3, which depicts an expanded fixed-route network forming the backbone of the high-density service and variants of flexible-route elements serving the lower density suburbs. The alternative of park-and-ride is also offered.

The phrase "acting cooperatively" should be stressed. It does not imply necessarily common ownership of all elements, nor should the service offered in any particular neighborhood be restricted to a single kind of system element. A neighborhood or area may have many kinds of different transportation needs, and a mix of system variants within that area may be appropriate.

SYSTEM EVOLUTION

It is not precisely clear what we mean by a successful system. Some criteria for success are

1. Double current transit ridership,
2. Achieve full decongested traffic flow without car disincentives,
3. Achieve mostly decongested flow with some car disincentives,
4. Increase current transit ridership 10 times, and
5. Provide 99 percent availability in time and space.

Figure 2. Typical transit today.

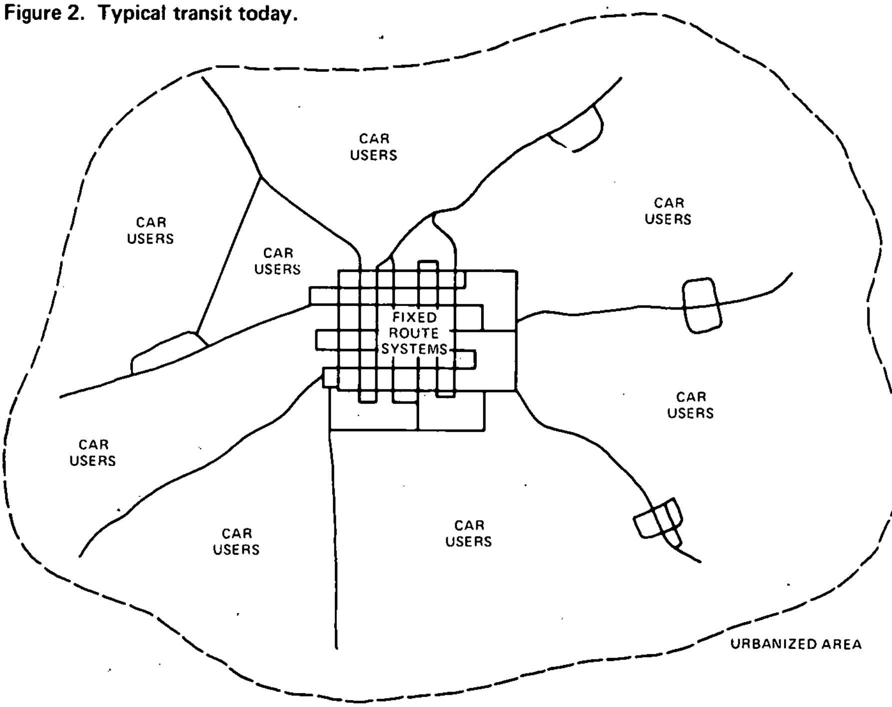
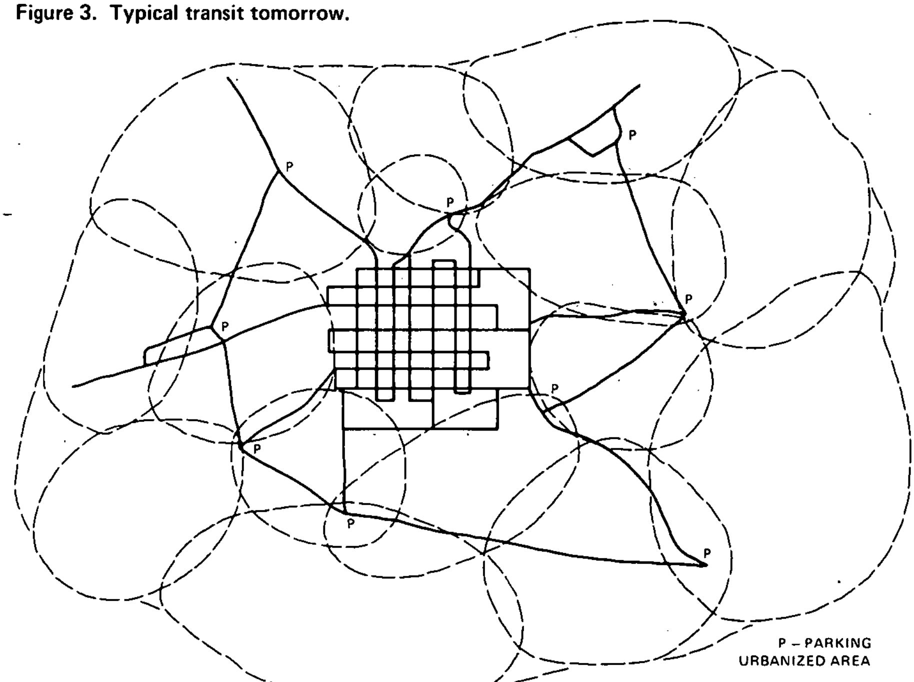


Figure 3. Typical transit tomorrow.



To double transit ridership is not enough to affect congestion and energy problems; we start from too small a base. Criterion 5 implies a system that serves essentially all the urbanized area and provides at least some kind of service on a 24-hour basis. If we try to do this without getting a much more dramatic increase in ridership than just doubling, poor economics would ultimately doom the system.

Criterion 2 expects too much. These new systems are clearly more attractive "carrots" than we are used to, but some "stick" to control automobile usage will be needed. To wean people from automobiles is hard. Criteria 3, 4, and 5 recognize that substantial improvement in public systems will require some car disincentives and restrictions on their usage, that we are aiming at much larger modal splits than we normally think in terms of, and that the suburban nondriver will finally have a good alternative to staying home.

I have no basis other than natural optimism for thinking these criteria are realistic. I am unaware of any in-depth work to estimate the service and cost characteristics of the multielement, integrated systems at large modal splits—the supply side of the problem. The demand side of estimating ridership for various carrot-stick combinations is almost pure guesswork.

We are not used to thinking about how these systems would behave at large modal splits. In the following, some thoughts on this subject are developed, and their implications for how the system might evolve are inferred. At least some of the impact of increased ridership implies either better service or lower costs with system growth: shorter wait times, more direct routes, and more express fixed-route service.

Figure 4 shows a comparison of a flexible-route system and a fixed-route system offering the same level of service, defined as the ratio of walk, wait, and trip time to the best no-wait direct route. (There is no walk or wait time for the flexible-route system, but the route is circuitous.) This figure, based on data developed in another report (2), is presented here to be illustrative, not definitive. At lower ridership densities, fixed-route bus is much more expensive than flexible-route bus, but the situation reverses as ridership climbs. Even though flexible-route systems are the cheapest way to supply service at low ridership density, such service is still more expensive than high-density service.

Figure 5 adds similar curves for an improved level of service. The principal point is that the range of ridership density where flexible routing is preferred is extended. Thus, at a given ridership density, the curves imply that flexible-route elements become, at some service level, preferred to fixed route. Thus, the higher the service level is, the greater the proportion is of flexible-route elements in the total system. Not surprisingly, better service costs more money.

In a total regionwide system, there is a distribution of ridership densities that range from low in sparse suburbs to high in downtown areas and in high-density suburban complexes. If the various elements that make up the total system are optimally tailored to the desired level of service at the ridership that exists at that time, every system will be a mix of different variants of fixed- and flexible-route elements.

Figure 6 shows raising the level of service will increase flexible-route elements in proportion to fixed-route elements. Off-peak, the distribution of ridership densities that represent the system shifts to the left, so that more flexible-route elements are appropriate. As the system grows, the distribution moves to the right, lowering costs and adding more fixed-route elements. As ridership density increases, more vehicles are needed to serve the flexible elements, and more flexible-route vehicles are also added; but the dominant growth is in fixed-route elements.

Figure 7 expands on the point that these systems should adapt their modes of operation with the time of day. Since systems are sized largely by peak-capacity requirements and off-peak costs are essentially fixed costs, almost any revenue generated off-peak is marginal income. Thus, a high level of off-peak service is affordable and desirable at well below what might be called its instantaneous cost.

Work-hour staggering is a trade-off. It hurts car pooling and helps transit. According to a U.S. Transportation Systems Center analysis, staggering is net benefit from a purely transportation cost point of view. It obviously has commercial and other impacts that need to be considered.

Figure 4. Fixed-route and flexible-route trade-off at the same level of service.

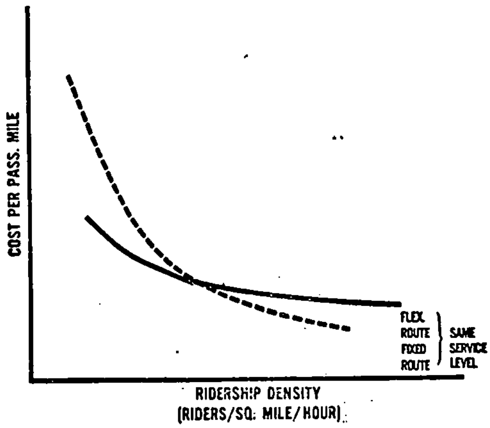


Figure 5. Fixed-route and flexible-route trade-off at improved level of service.

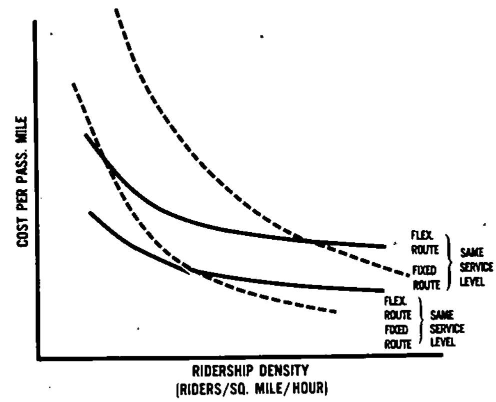
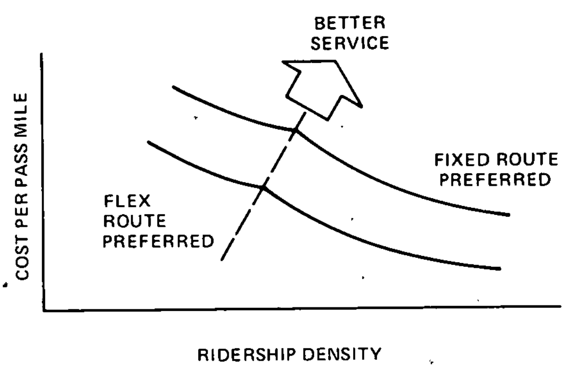
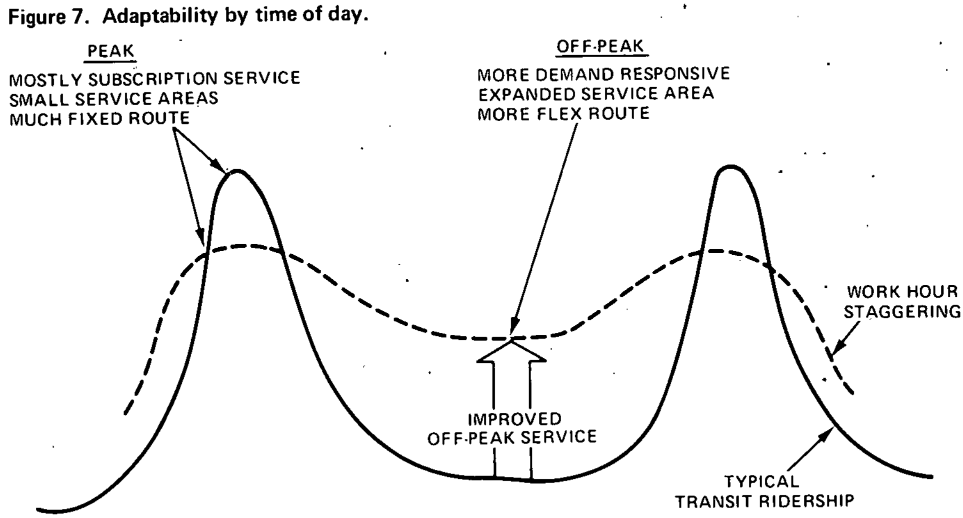


Figure 6. Summary of fixed-route and flexible-route trade-off.



- FOR A GIVEN RIDERSHIP DENSITY, BETTER SERVICE MEANS HIGHER COSTS, MORE FLEX ROUTE IN PROPORTION TO FIXED ROUTE.
- FOR A GIVEN SERVICE LEVEL, GROWING RIDERSHIP MEANS LOWER COSTS/PASS MILE, MORE FIXED ROUTE ELEMENTS
  - OFF-PEAK: MORE FLEX ROUTE
  - GROWTH OVER TIME ADDS MORE FIXED ROUTE ELEMENTS

Figure 7. Adaptability by time of day.



The evolution of these systems over time is shown in Figure 8. The first phase is that in which coverage of the low-density suburbs is being added. The second is the growth phase after complete coverage has been achieved. These two phases are discussed in turn.

The new flexible-route elements that are added to evolve from a limited-coverage, fixed-route system to an integrated, full-coverage system have higher costs and lower productivity than the already existing fixed-route elements (Fig. 6). Figure 9 shows that, without overall ridership growth or better peak and off-peak use or both, average costs per passenger will rise. This occurs at the same time as a multitude of new management problems are being experienced. This initial expansion phase is most critical: Public attitudes are still largely unconverted, car ownership habits are unchanged, management and operators are pioneering innovation, and the overall concept is unproved. It may require a lot of faith on the part of the supporting authorities to survive misjudgments that are easy to make with the relative lack of experience with such systems, particularly if costs per passenger are rising. It would appear to be important to select initial flexible-route elements where the opportunities for good ridership response are greatest.

Figure 10 shows the next phase of growth. We have assumed success: The system is in place. Now growth provides the opportunity for incremental improvements and proliferation. The central point is that growth now occurs not primarily by expansion of flexible-route elements (although some may be added in high-density areas as supplements to fixed-route elements). Many special point-to-point express elements could become feasible, offering a high level of continual service between high- and medium-density activity centers. These are all high-productivity elements, so now system economics improve on a per trip basis.

This is an important conclusion because, if it is correct, it implies that the vehicle management problem may not be so formidable as often depicted and that ridership growth leads to continually better service and more flexibility of choice, encouraging still further growth. At some point in growth, marked improvements in congestion should begin to appear. Success should breed success.

The overall problem of cost allocation and fare pricing is beyond the scope of this paper, but the subject of subsidy for the flexible-route elements should be mentioned. Experience to date suggests that these new elements cannot be expected to pay for themselves and still attract the much higher level of use we are trying to encourage. Passing over, for the moment, the problem of an appropriate level of overall subsidy, there should be an internal-to-the-system cross subsidy between high- and low-productivity elements. If there is a single fare for the total trip, then this is accomplished.

There is no inherent reason why private taxi operators could not attract substantially more business and offer more variant service if they are not constrained to price their services to cover costs. If it is accepted that subsidy to the flexible-route service in low-density areas is necessary to make the whole system work, then the possibility of paying that subsidy to a private operator should be carefully considered. This is a complex subject that must be equitably handled to prevent public subsidy from competing unfairly with private capital.

These systems lend themselves ideally to incremental planning and implementation. Origin-destination patterns are determined by the system, so adapting the system to changing demand is straightforward: They almost plan themselves.

Although Figure 10 suggests a rosy picture, there are several sticky unknowns, as shown in Figure 11. When the decision is made to initiate expansion of coverage by adding the higher cost flexible-route elements, it is a gamble as to whether overall costs per passenger will rise or whether ridership increases and better peak and off-peak matching will compensate. Assuming the system survives this phase and further growth brings down average costs per passenger, the total deficit will still rise as shown. Whether it is realistic to think these costs will decline sufficiently for the overall system to pay for itself is an open question.

Figure 8. System evolution.

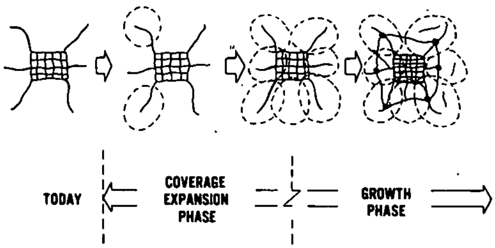
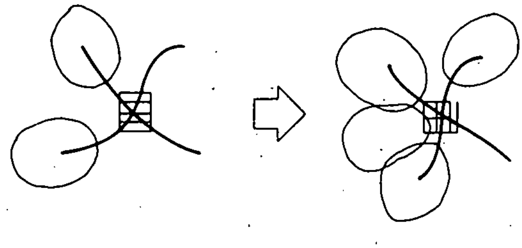
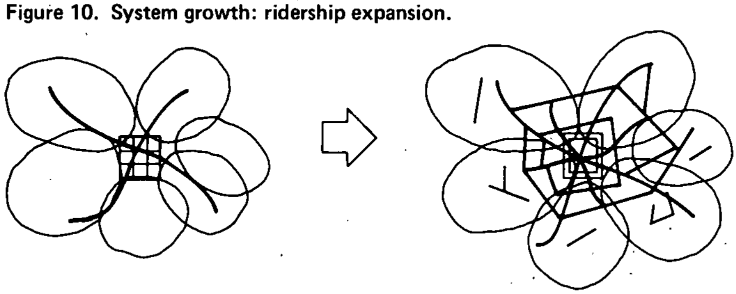


Figure 9. System growth: coverage expansion.



- ADDING LOWER PRODUCTIVITY FLEX ROUTE ELEMENTS: $/PASS MILE RISE
- MAY BE BALANCED BY BETTER OFF-PEAK UTILIZATION, HIGHER OVERALL RIDERSHIP
- MANAGEMENT/CONTROL PROBLEMS GROW FASTER THAN RIDERSHIP

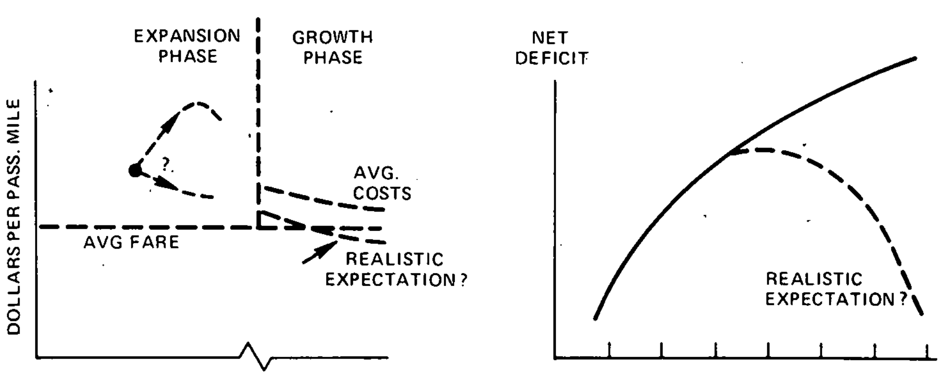
Figure 10. System growth: ridership expansion.



- ADDING HIGHER PRODUCTIVITY FIXED ROUTE ELEMENTS: $/PASS MILE DECREASE
- OVERHEAD AMENITY COSTS (TRANSFER FACILITIES, INFO SYSTEMS) SMALLER PERCENT OF PASS MILE COSTS
- MANAGEMENT/CONTROL PROBLEMS MAY GET EASIER: MORE MANAGEMENT OVERHEAD AFFORDABLE, NUMBER FLEX ROUTE VEHICLES GROW SLOWLY, NEW FIXED ROUTES PLAN THEMSELVES.

Figure 11. The problems.

- ABSOLUTE COSTS MAY LOOM LARGER AND LARGER IN LOCAL BUDGETS



- PUBLIC ACCEPTANCE ? (WHAT SIZE INCENTIVE ?)

CONCLUSIONS

The promise of these kinds of systems is substantial, and it is hard to identify acceptable alternatives. The major points are

1. DRT (flexible-route) systems permit a different concept of public transit—service that is door-to-door, almost indoor, and regionwide, if major patronage can be attracted; and
2. If successful, it could be a national decongestant, provide mobility for the nondriver, contribute to energy conservation, lead to fewer multicar families, and create lots of jobs.

The desirability of fewer multicar families and labor-intensive systems lies, like beauty, in the eyes of the beholder. I suspect even the automobile makers would not take violent issue with the overall desirability of better public transportation and fewer cars downtown, even though it is probably a net decrease in vehicle investment. It will happen slowly and may well result in desirable side effects.

Labor intensiveness may not be all bad, except that it clearly makes the systems vulnerable to labor disruption. Although the trend is still embryonic, from the national view labor is increasingly becoming a fixed cost. Systems that require only moderate capital (which will continue in short supply) and provide socially desirable, important, and productive jobs may be a plus for the nation's economy.

The DRT concept was the starting point. If we can put it all together and make these regionwide systems really happen, it would be of truly significant national importance.

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Panel Discussion

Before the general discussion, Daniel Roos, session chairman, asked a panel to comment on several prepared questions. Panel members were Richard V. Gallagher, International Taxicab Association; Karl W. Guenther, Ann Arbor Transportation Authority; Jerry D. Ward, U.S. Department of Transportation; Nigel H. M. Wilson, Massachusetts Institute of Technology; and Eldon W. Ziegler, Urban Mass Transportation Administration.

DANIEL ROOS: What comments do you have on the evaluation process?

KARL GUENTHER: I wish I had written Jerry Ward's paper because he said some things that some of us have been trying to say for a long time. He pulled concepts together that needed to be pulled together. In our local DRT operation, our evaluation comes once a year at our annual budget time. Each year as we sit down to decide how much service we are going to give, how much it is going to cost, and what our annual deficit is going to be, we go through this evaluation process.

ELDON ZIEGLER: To evaluate the transit system, we are seeking some rough guidelines from data on items such as the annual subsidy per capita for the area served. In general, the reaction has been that these tend to run a bit high, although we are now seeking compatible numbers on the fixed-route systems. The Washington, D.C., system, for example, is estimating an annual deficit on the order of $55 million for a population of 2.5 million, roughly 20 cents/capita. This tends to lead one to the view that, for the same fixed number of dollars, it becomes possible to provide a much higher level of service by making adjustments in the mix of the service.

In the evaluation of demand-responsive transportation as a mode in comparison to other modes, factors are again the incremental costs of ridership productivity of one mode against another mode under the same circumstances. We have good data on the performance of the demand-responsive services, but poor data on incremental performance of conventional services. In many cases, little is known about the performance of specific lines within a transit system, what the productivities are, what riderships are on parts of the line, and how that varies by time of day.

DANIEL ROOS: When any new concept is introduced, particularly one that has a fair degree of innovation, it takes a long period of time before it can be properly evaluated. A concept like park-and-ride, for example, is really a simple concept, but think of the period of time that has been required to introduce the park-and-ride concept throughout this country. If an evaluation of park-and-ride in Rochester had been performed after 6 months or after 1 year according to a strict financial cost-benefit ratio, that service would have been discontinued. Now, if one looks at the experience of park-and-ride in Rochester during the second and third years, the results are dramatic in terms of what the ridership and the decrease in cost per trip are. During the 3-year period, the level of service was constantly rising, the community was learning what to do, and it was tailoring the system. If it took 3 years to find out what the full impact of park-and-ride is, one can certainly multiply that by any factor one chooses to get some idea of how long it is going to take before we fully understand what the impacts of these other systems are. Evaluating at this point is important if it is done in the proper way. One has to differentiate between a bad idea and a good idea that is implemented in a bad way. Of the 50 DRT systems that have been implemented, some are good and some are bad implementations. If one looks at the bad implementations and concludes that the concept is bad, there is a real danger.

One other point occurred to me. Demand-responsive transportation has a possible role as an incremental planning tool. A tremendous amount of money is being spent now on planning studies and engineering design studies before any facility ever gets implemented. Much of that money in many cases turns out to be money down the drain in some respects because that facility either is never implemented or is implemented but never produces the results that were proposed during the various studies. Rather than spending hundreds and thousands of dollars doing extensive planning studies for services and facilities of an order of magnitude greater than what we have today, one could take a more incremental approach and invest some of that money in various types of facilities such as demand-responsive services. That is, put the service in and see what happens. I am not implying that one should stop doing planning and technical design work, but there is a close tie between planning and implementation and there should be a close feedback between the two.

The next question is, What have we learned about demand-responsive transportation?

RICHARD GALLAGHER: This is my first opportunity to attend a demand-responsive transportation conference, but I have come to the conclusion that taxicabs are a demand-responsive system and that those of us in that business have a place here. We have made the move gradually during the last several years, but we also recognize that DRT is no typical taxicab operation. We have had group riding for many years. We have had shared riding, exclusive service, and jitney operations in the taxicab industry. So, from the operational and managerial viewpoint, we think we are in a position to be of service to the communities that determine the mode of transportation that they desire. In fact, I believe that the industry will invite discussions with almost every transit authority and every community where we operate taxicabs.

We are a cost-conscious industry. We are a profit-making industry, and we intend to remain in that category. We face many problems. In a 14-month period, one of the major taxi companies had a 220 percent increase in gasoline. So, we have to adjust to the circumstances of the time.

In the taxicab industry, almost everything is measured on a vehicle-per-mile basis. Those at the conference talked about vehicle-per-hour measurements. We have to find some common unit to measure the same things.

My feeling is that our industry will remain flexible. We will do everything possible to become responsive to the needs of the community. We have some regulations that control much of what we would like to do, and many innovations must be delayed. In fact, leadership in innovations is being done in the DRT systems that have been implemented under government sponsorship. We feel that the benefits from them will eventually come down to our industry.

There are some shortcomings. The proper vehicle has not been designed for the handicapped, elderly, and school children. Nor has the proper service. Shared riding will require a variable fare structure, which may require special equipment and specially designed computers. We have not gone far enough in integrating services between taxicabs and other modes and integrating schedules among the transit industry, the airlines, the railroads, and all other modes of transportation. We feel this is one of the areas in which the greatest good could be accomplished in the shortest time if we worked together.

KARL GUENTHER: The 5 years of DRT conferences reflect what we have learned. In the third conference at Ann Arbor, we reached sort of a puberty level in demand-responsive systems. People began to accept DRT as a real, somewhat legitimate mode. At the fourth conference in Rochester, we were in the adolescent stage—people going off in one direction believing blindly, and people going off in another direction doubting. But at least we were together in the same room. At this fifth conference, I think we were undergraduates in college. We were much more mature about our approach. We had some history and some experience, but we also had some serious and deep doubts.

There have been some massive failures of the demand-responsive systems. Metro Toronto is probably the biggest one in terms of dollars, expectations, and results. I was disappointed that there was not a session at this conference on failures. That would have been a good session to have because there is a great deal to be learned from system failures because they cost too much. I somewhat disagree that a DRT system fails because it is implemented badly. In some cases, we just did not know before we started that the place was wrong for demand-responsive service. We should learn from those failures.

The UMTA technology display at this fifth conference was heartening because 3 or 4 years ago UMTA would not attend the DRT conference. There seemed to be a feeling that demand-responsive system service was not yet legitimate enough to be recognized at the federal level.

Having the taxicab industry participate so fully is another sign of maturing and recognizing that there is room for everybody. We have a lot of expectations for the taxi industry. Some of us have tried for a long time to work with taxi operators both locally and nationally without too much success. But they were at this conference. We listened to them, and they listened to us.

NIGEL WILSON: We have learned that demand-responsive service can be attractive to the community. It can attract voter support, and it can attract subsidy from the community at large. Four or 5 years ago, some of us thought it was a panacea, but few of us think so now. We have to look no farther than Toronto to see some of the limitations. DRT is one element of the system. We have to look at other transit modes to determine under what conditions DRT is an effective strategy.

JERRY WARD: One of the things we have clearly learned is that people like the personal touch they get from this kind of service. It is uniquely suited to the aged, the handicapped, and the young. In the guided tour of Arcadia during the conference in 1973 in Rochester, on the DRT bus I was on, we were listening to the open mike of a report from another bus that was delivering a 7-year-old school kid to her home. The bus driver said to the dispatcher, "Susie's mother is not home. What do I do with Susie?" The dispatcher replied, "Keep Susie, and I'll try to find her mother." Four minutes later he came back on, "Mother's home. Take Susie home." That is trivial—and terribly important.

General Discussion

JOE KATZ: Toronto seems to be held up as an example of a failure. The thing that happened is that the minister of transport changed, and the new minister did not realize the kind of experiments that had been set up. Another experiment had been set up close to Toronto and penetrated half the market.

I do not think we are yet in the adolescent stage. We are still in a baby stage, and I think we should keep our sights much higher. About 1960 I suggested one of the first Dial-A-Ride experiments in Washington as part of the transit system there and it took about 10 years for it to start. We should consider all the experiments now as a means of amassing experience and not be so quick to judge them.

KARL GUENTHER: I apologize to anybody who took affront about Toronto. The point I was trying to make is that there was a grand plan that was not going to be carried out as it was originally conceived. The reasons (and I have done considerable work on this) are much more complex than a simple change in ministers. They have to do with ridership, productivity, costs, and all sorts of social and labor implications as well as the change of ministry. The point is to learn what was done so that perhaps the same things can be corrected the next time. Toronto and Ontario are still the hub of what is going on in DRT.

AARON ISAACS: Does anybody have cost information on voice radio versus digital communications? In one of the conference sessions, someone said that digital communications were cheaper.

DANIEL ROOS: I made that comment based on a limited test that was carried out by Karl Guenther at the Ford Motor Company and with Motorola in Batavia, observations on the operation of the Rochester system, and also some speculations and projections of what the impact of digital communication might be, given the availability of a computer system.

I recall in the Batavia experiment that there was an indication of a productivity improvement of 10 or 11 percent. An economic analysis indicated that either 13 or 14 vehicles would be the point at which it was more economical to go to digital communications as opposed to voice communications. That does not take into account any of the indirect benefits of digital communications, such as fewer errors and safer operation. The Rochester system is a difficult one to evaluate from that perspective simply because digital communications were used from the start. In Batavia, we started with voice and switched to digital. We have not really had the opportunity to analyze the difference. The indications are certainly that, if a computer is introduced, the economics would improve even more markedly because the computer would directly transmit the message to the vehicle and thereby eliminate to a large extent, but not totally, the need for human intervention.

I believe that figure of about 13 or 14 is reasonably accurate. But several things should be borne in mind. What type of digital communication system is it? That is, is it just a printer or an alphanumeric delay device, which is more expensive? In addition, the price of electronic technology is dropping markedly. You can now buy desk calculators for $35 or $40. The same is true of computers and communication equipment. So we have a situation that will get better because, although labor costs are increasing, technology costs are decreasing. Another critical point is channel availability. To get channels allocated by the FCC is difficult.

STANLEY HIRSCH: There is one DRT system that has been successful: That is our taxi system in Hicksville. Our average fare is $2.15 per person, which includes trips that exceed 30 miles and the costs of capital equipment, amortization, and appreciation. I challenge any DRT system in any municipality to match those costs.

DANIEL ROOS: Batavia, New York, is one DRT system that has lower costs. Several Canadian systems also do. However, people got hung up with the whole question of what the costs are and what the benefits are, and I think that has gotten us into a lot of trouble. This is not to say that one should not be conscious of economics. The best illustration is the Interstate Highway program in which decisions were made solely on a cost-benefit basis for many years. A number of people now regret that those decisions were made strictly on a dollar cost-benefit analysis.

The cost of DRT service is important and so is the fare. But that is not the whole story. One has to define the system. We must be concerned about the integration of the DRT component into a larger total system and what the impacts are on that larger system. We must be concerned with social benefit. The community has to be aware of what the dollar and cents implications are, and it also has to make value judgments as to how important it is to provide service to various groups.

In September, the Rochester vehicle fleet size was increased. The cost per trip went up but now, as ridership is increasing, the cost per trip is decreasing. The average cost was $3.30 but is going down by an average of 25 or 30 cents a month.

STANLEY HIRSCH: But the Rochester system only serves a small area. We serve an area of 30 miles.

DANIEL ROOS: DRT in Rochester is not a regional transit system. It is one component of the regional transit service. That is the point I tried to get across. If one wants to choose an isolated portion of a total system and set certain ground rules, one can reach certain conclusions. One can also set different ground rules and define systems in different ways and get entirely different conclusions.

RONALD COUSINEAU: As a representative of General Motors, I was confronted by a lot of people throughout the conference. So I would like to present a manufacturer's question and a challenge.

UMTA is involved with specifications for Transbus, the state-of-the-art car for light-rail systems, and has let contracts for magnetically levitated vehicles and air-suspension buses. UMTA has not talked about, has not awarded contracts, or even discussed specifications for DRT vehicles. The manufacturers had a representation of a DRT vehicle on display at the conference, and many people told me that the vehicle was not representative of their wants and needs. Therefore, here is the challenge from the manufacturers: Can you get organized to confront the manufacturers with what your wants and needs are?

The American Public Transit Association data indicate that the transit coach fleet size is about 50,000. I have done some limited research in the DRT area, and I estimate the small bus fleet to be about 1,000. The question is, What is the fleet size going to be in 1980, and what is it going to be in 1985?

KARL GUENTHER: I used to work for one of the big three vehicle manufacturers, and I am damned sick and tired of that question. I have heard it for 5 or 6 years. I used to get asked that question by our corporate production planning people. I used to get asked that question by our field sales people. Now, as a buyer of equipment, I found that it is necessary to find somebody who will be responsive to what you want and work with you on development of a vehicle. Our responses from the major suppliers have been poor. But fortunately, a few people have been responsive, and some of the vehicles are giving a lower repair frequency and a lower cost per hour of operation than GM transit coaches.

I think that there is no way that either the aggregate of DRT operators or UMTA is going to be able to bring giant General Motors and giant Ford Motors into the small bus business. I am glad that there are people who are willing to take a base production and convert it into something we need. I do not think it is either the government's responsibility or the American Public Transit Association's responsibility or my responsibility as an operator to help the big 3 define a market size.

DAVID RYNERSON: How does one handle a large transit modal split of 30 to 50 percent? How will higher modal splits lead to more efficient, higher productivity operations?

JERRY WARD: We are initiating some research to understand this better. As we increase the fixed-route system (higher ridership, density), productivity goes up for both fixed- and flexible-route systems. You can plan systems more efficiently because the flexible-route system allows you to monitor designations so you can put in the fixed route a much surer demand for those elements. You probably should be able to improve a load factor, but we really do not know.

We also do not know whether we can induce those kinds of modal splits. You can only go so far on paper in predicting behavior. From then on, you have to do it and see what happens and how people react.

SALLY COOPER: We have high-density areas in Philadelphia where there is also low mobility. In those high-density areas we have concentrations of existing transit but, because of inability to get to that transit or fear of getting there, the situation is similar to that in suburban areas where there is no transit. Is there a federal policy to encourage demand-responsive service in high-density areas as in low-density suburban areas?

JERRY WARD: The best estimate we have now is that the demand-responsive systems may make more sense at higher density than we previously thought. I think it would make sense to have flexible-route elements serving high-density areas. In fact, I suspect that the downtown circulation system will end up being a combination of flexible-route elements and fixed-route elements. If we can succeed in keeping the total number of vehicles down so that traffic can flow, we can provide good service from the nonshared taxi ride to whatever one wants to buy.

I think our policy is to encourage doing what appears to make sense and tailoring the system to solve particular problems. We do not really have a policy of encouraging one approach over another.

ROBERT McMANUS: After the 1966 and 1967 riots and civil commotion in the cities, there was an urgent concern on the part of the administration at that time to address transportation in inner-city neighborhoods as a way to alleviate conditions. In fact, the managers of transit resources at that time were considering using the entire resource—the mass transportation resource, the capital grants resource, the planning program, the demonstration program—to address that question, not on a theoretical research-oriented basis but on an action basis.

As things quieted down, we seem to have narrowed our sights too much with respect to special user groups to the point that we seem to be talking almost entirely about the aged and handicapped. In our policy discussions now, we are changing that thinking and are eager to get some demonstrations going.

With respect to meaningful transportation service in the inner-city neighborhoods, the HUD Model Cities program attempted to get at that situation in an operational sense. The Model Cities program and other community development programs have now been merged into a block grant delivery system, and the cities themselves must now sort out how they want to use that resource. They may choose to use it for transportation service focused on the needs of the inner-city neighborhood.

I frankly think we have gone to sleep on that issue and that at this time is a dangerous thing to do because of unemployment and the economy. But it is not so much a technical research-oriented issue as much as an action issue that can be addressed by using available physical resources and what we currently know about demand-responsive system modes.

DANIEL ROOS: Caracas, Venezuela, has high densities and extensively uses jitney transportation. Jitneys carry 40 percent of all people who use public transportation in the Caracas area. Paratransit services can play a role in the high-density areas, but we have to be realistic and mix them with conventional system services.

I think it is healthy that we are showing concern and raising questions about DRT systems. One of the biggest problems we have had in public transportation and specifically in new systems is a lack of credibility. People have been promised many things, and many of those promises have been false. In developing demand-responsive systems, we must be honest with ourselves and honest with the public.

This conference for the first time brought together taxicab people and transit people, and that was a positive forward step. My concern is that we do not get so hung up with the question of who operates these services that we lose sight of the services that we should operate. The linkage between taxicabs and traditional public transportation can be extended even further: as car pooling operations, van pooling, taxicab in its pure form, subscription bus, and DRT and then fixed route. There is quite a continuum. One could imagine some public agency tying together all of these various concepts, starting out with the car pooling program and, when the car became full, moving the people into a van. When the van became full, the people would be moved into a subscription bus operation and so on. The point is that for the first time I think we are starting to see certain commonalities among a number of ideas, concepts, and service methods that in the past we viewed separately and operated under totally different corporations.

POLITICAL AND PUBLIC POLICY ISSUES RELATED TO DEMAND-RESPONSIVE TRANSPORTATION

Walter M. Ingalls, Assemblyman, East Riverside County, California

It is encouraging to see a growing interest in demand-responsive transportation (DRT). Problems of congestion and pollution, immobility of the poor and the elderly, and slow progress in the direction of reducing vehicle emissions require us to find alternatives to our heavy reliance on the automobile. Demand-responsive transportation is our only current major attempt at providing transportation services that have many of the advantages of automobiles. As such it offers hope that transit can be made a workable and an attractive part of solutions to congestion and immobility. And I emphasize attractive because that must be a key if we are to educate people away from the automobile.

I have always lived in California in the suburbs. I have known no other form of transportation except the personal automobile, except for an occasional airplane ride and a train ride at Disneyland on the monorail. Because I understand our conditioning toward automobile transportation, I am convinced that we must have an attractive as well as a workable solution to our transportation problems if we are going to get people out of their automobiles.

Many of my colleagues in the state legislature would have us believe fixed-rail transit can solve our environmental and transportation problems. I would suggest that the experience with Proposition A in Los Angeles should be instructive to those with high hopes for fixed-rail transit. Here the voters showed their opposition to any further local transaction of such systems. It was a countywide proposition put on the ballot in Los Angeles County, which has nearly 8 million people. The proposition was to add an additional 1 percent to the sales tax, which is already 6 percent in California. Half of that additional 1 percent or 1 cent on the dollar was to be used for the construction of fixed-rail systems or construction of transit systems, and the other half for operational costs. It was rejected by the voters. My hunch is also that the public feels that such transit systems either cannot do the job or are simply too costly, or some combination of both.

Of course, one interpretation of the results in Los Angeles—as well as similar results in Orange County, which had a similar proposition on the ballot—is that the public is irrevocably wed to the automobile. I think the more accurate interpretation is that the public will accept realistic transportation alternatives that are accessible, quiet, and low polluting. People want solutions to problems of congestion, pollution, and immobility. People are immensely concerned with our dependence on foreign cartels for energy and look to transportation analysts and decision makers to help ease our energy dependence. A statistic that frightens me is that 19 percent of the world's monetary reserves are now being held by the few countries that are major oil producers. We in this country are going to have to do something to stop the flow of dollars abroad for the purpose of purchasing oil.

Our job then is not to ignore or deride the public's affair with the automobile, but to create transportation that combines the attractive features of the automobile with the capability to reduce energy and transportation problems. In so doing we must be realistic and efficient in our approach. We should realize, for example, that most DRT systems have not generated demands greater than 10 requests/mile^2/hour. Furthermore, many ridership surveys show that the majority of rides have not replaced automobile trips. Even those forms of demand-responsive transportation, such as car pools and subscription buses, that do seem to replace automobile trips have limited potential to attract a great volume of riders. Therefore, to promise the public that demand-responsive transportation will solve all the problems of pollution and congestion under present economic conditions is unrealistic. Only as economic circumstances make automobile usage more unattractive—as would be the case under fuel shortages and higher gasoline prices—can we honestly promise the public more demand-responsive transportation ridership and significantly less congestion and pollution.

Efficiency must be another of our concerns if demand-responsive transportation is to have a future in California. Many in the California legislature opposed DRT because of its labor-intensive nature and the resulting costs. Clearly, the more cost-effective demand-responsive transportation modes such as jitneys and certain taxis, which may operate with modest or no subsidies, will stand in more favor with legislators than highly subsidized public DRT systems.

In this regard it is most encouraging to see several communities in California developing contracts with the private sector to transport the immobile, particularly the elderly. Even though there might be debate about the impact of DRT on pollution and congestion, there is hardly any question that the relatively low-cost demand-responsive taxi provides valuable service to the elderly and to low-income people.

It is also encouraging to see the city of Los Angeles taking steps with respect to the private sector. The city has attempted to increase the supply of taxicabs in its franchise areas and is also experimenting with the provision of jitney services. Both of these innovations are admirable and deserve replication wherever feasible.

Santa Clara County has inaugurated a countywide DRT and arterial bus system. This substantial experiment, perhaps larger than any previous DRT system implemented both in area covered and equipment deployed, raises a powerful competitive image to the Bay Area Rapid Transit (BART) as a means for solving metropolitan transportation services. However, demand-responsive transportation is not the entire answer to mobility needs of major cities and suburban areas, just as rail systems are not the complete answer. Yet this image of an areawide, integrated system of extensive DRT zones and arterial bus services now poses a contrast with BART as a competing remedy of transportation ills. It is risky to go this far this fast with DRT, and Santa Clara's transportation planners and political leaders seem to sense this. But there are great risks also in being too timid or too distant in our search for alternative means of urban transport.

We in the legislature will debate the role that the state may play in cooperating with local and federal agencies in sharing the risks that fall to the innovators. We feel, for example, that neither UMTA nor the federal government for that matter possesses all of the wisdom in this country on what service characteristics should be desired by local jurisdictions in defining the future directions of research, development, demonstration, and implementation of advances in transit service. We will seek means of bridging the needs of local jurisdictions and the strengths of the federal government, with resources of our own, and thereby share in the risks that innovations in transit service and technology will entail for all of us.

I do not wish to imply that fixed-rail transit cannot be part of the solution to transportation problems. It has a role to play. So too might there be a role for reasonable disincentives to automobile usage. The point is that no one can solve all our problems, and no one unit of government or sector of the economy can solve all the problems. Only with the cooperation of the state and local governments—meaning both cities and counties—and the private sector can we begin to clear our air, help the immobile, and still provide the quick and accessible transportation so essential to the public interest.

Kenneth Orski, Associate Administrator for Policy and Program Development, Urban Mass Transportation Administration

The utility of demand-responsive transportation requires no further proof. More than 50 DRT systems in some 22 states testify to the popularity of this concept. Thanks to it, many communities are enjoying for the first time the benefits of public transportation service. In many other towns, demand-responsive transportation has placed personalized, door-to-door service within the reach of many persons who earlier were totally dependent on others for automobile transportation or had to rely on infrequent and inconvenient bus service.

But my purpose is not to extoll the virtues of demand-responsive transportation. Those already active in the field do not need to be convinced of its value. Those who want to learn about this concept stand a better chance of becoming converted by reading the experts and by examining the lessons of past experience.

My purpose is to focus on the future—to offer some thoughts about how we in UMTA view the potential of demand-responsive transportation and to discuss some of the policy implications. In talking about the subject I shall drop the phrase "demand-responsive transportation" and adopt the shorter, more generic term "paratransit." I realize that in so doing I will be trespassing into a wider arena, but I do so deliberately, for I believe that we must focus on the generic form—the small-vehicle transit system concept—in order to understand the full potential of this form of transportation.

What, then, does the future hold for paratransit? It is safe to assume that further growth of this concept in its best known form is virtually assured. By "best known form" I mean community paratransit service, characterized by the flexible routing and scheduling of small vehicles to provide shared-occupancy, door-to-door, personalized transportation service within smaller communities and suburban neighborhoods. This concept lends itself well to the diffuse travel patterns prevailing in low-density areas. With the help of more sophisticated techniques of dispatching, better route algorithms, and more sensitive pricing policies, demand-responsive paratransit service is in an excellent position to become the dominant form of local public transportation in many small communities across the nation.

But, important as this function may be, the main opportunities for paratransit do not lie in the provision of local neighborhood service. The biggest scope for the future expansion of paratransit lies in its becoming an element of integrated metropolitan transportation systems. My view is based on the now generally accepted notion that no single transportation mode or technology can be expected to satisfy the many different transportation needs of a metropolitan area. The land uses, ridership densities, and travel patterns of a present-day urban area are simply too diverse to be served efficiently by a single form of transportation. Thus, although private automobiles are good at low densities, their performance and utility drop drastically in high-density conditions. The bus or rapid transit, although efficient in high-density situations, is poor at the low-density end of the trips. Good service with fixed-route vehicles is based on both dense coverage and short headways. But, as ridership density decreases, more and more transit vehicles run empty or nearly so to maintain an acceptable level of service. At some point, the use of small vehicles that can be flexibly routed and can respond to individual calls becomes both cheaper and more efficient than the use of large vehicles on fixed routes and schedules.

The conclusion thus seems clear that an effective urban transportation system—one that will provide a high level of service at the least cost—requires a mix of vehicles, service levels, and operating regimens, tailored to the different demand conditions, ridership densities, and travel patterns prevailing in particular corridors and subareas of the metropolitan region.

The above concept—long accepted as a precept of sound metropolitan transportation planning—is finding its way into UMTA's thinking in many ways. For example, we will be expecting future applicants for capital assistance to give greater emphasis to multimodal strategies. In the past, too many transportation improvement programs have been focused on the construction of regionwide, single-mode transportation systems. In the future the accent will be on tailoring transit service more closely to a particular market. Thus, an urbanwide strategy may call for a rail rapid transit line in a corridor of heavy demand, a network of light rail cars or buses operating on exclusive rights-of-way in lower density areas and corridors, and fleets of paratransit vehicles acting as suburban feeders to these systems, all working cooperatively as components of an integrated, interconnected, regional transportation system. Underlying this philosophy is the recognition that no single transportation mode could possibly combine all the attributes desired by urban travelers. Each form of transportation has certain unique features enabling it to serve particularly well certain transportation needs. The goal of an urban transportation plan should be to exploit each mode and each technology for the purpose for which it is best suited—in other words, to assure that the right kind of transportation is available in the right place for the right purpose at the right price.

We will encourage applicants to be more mindful of the immediate and near-term transportation needs of the metropolitan areas. Much of the past transportation planning effort has been focused on the problems of the future and has ignored the current inadequacies of the transportation system. This has produced master plans for vast fixed-guideway regional networks whose completion date extends 20 to 30 years into the future, while current needs go begging. In the future we will expect urban areas applying for federal assistance to pay closer attention to short-term improvements. For example, although there may be ample justification for an urban area to embark on the construction of a regional rapid transit system, this does not absolve the city from undertaking transit improvements designed to benefit urban residents in the short term. These can take the form of less capital-intensive measures, notably the provision of better line-haul bus service and of flexibly routed suburban collection and distribution service. As patronage builds up, these systems may be progressively upgraded to higher capacity fixed-route systems.

We will be interested in knowing to what extent long-range transportation plans can be implemented in a more time-phased, incremental fashion. Typically, past tendency has been not only to plan extensive systems but also to bring into operation as much of them as possible from the day the systems first open. This is only natural, given the nature of the prevailing financing mechanism—the area referendum. The influence of the referendum on plan implementation can be seen from actual cases. San Francisco, Washington, Atlanta, and Los Angeles all required referenda and all proposed extensive regionwide systems to be completed as a package so that all areas would receive service more or less simultaneously. On the other hand, Toronto began its rapid transit system with some surplus funds so that no referendum was required, and the first section was only 4 miles (6.4 km) long. Similarly, Baltimore, which obtained financing for its system through state legislation and needed no referendum, is beginning with one line.

This is not to say that the referendum is the wrong approach to financing transit development. I am simply suggesting that good planning, prudent use of financial resources, and just plain common sense might dictate in many areas a more leisurely implementation schedule—one which began with the construction of segments or lines where they are most urgently needed and then continued to build on them slowly but steadily until a full regionwide rapid transit network was achieved.

I am intentionally dwelling in some detail on these planning concepts because they portend a much greater future role for paratransit. Even under the most optimistic assumptions as to the availability of federal and local funds, I see small-vehicle public transportation as a growing element in the overall strategy to maintain and improve metropolitanwide mobility. Areawide systems, such as we are beginning to see emerging in Orange and Santa Clara Counties, Rochester, Regina, and Ann Arbor, are the prototypes of this trend. More are likely to follow.

But much still remains to be done. Although paratransit has come a long way since the first conference on demand-responsive transportation, the concept is still in its infancy and is untested in many of its potential applications and more sophisticated forms and variations. Consider the following examples of potential new applications.

1. Late-hour and weekend jitney on bus routes. At low-demand times, such as in the early morning and late evening and during weekends when ridership is not sufficient to justify the use of conventional transit buses, paratransit could be used to provide

public services along the bus routes. The jitneys would run at fairly long but regular intervals, stopping only when hailed. The service would cater to those whose work schedules begin or end in the late evening or early morning and to all those who have no access to a car or cannot drive, especially the elderly and the young.

2. Jitneys at peak hours in major corridors. Jitney service could be provided at peak commuter hours in heavily used travel corridors as a premium transit service for those who are willing to pay an extra price for the comfort of riding in a small group and without frequent stops. Such service might actually benefit regular transit by reducing peak requirements for transit vehicles and drivers.

3. Package delivery. If rapid delivery is desired but the volume of deliveries is too small to warrant operation of a delivery van, a retailer will willingly contract for delivery service. In large cities demand is usually sufficient for such services to support a specialized delivery business, especially if it can be combined with other services, such as telegram delivery, "meals-on-wheels" programs, emergency delivery of medicines, and private mail service.

4. Transportation of handicapped in wheelchairs. Vehicles especially fitted with wheelchair lifts and other special features could provide demand-responsive service to wheelchair-confined persons in part fulfillment of the congressional requirement that public transportation systems be fully accessible to the elderly and handicapped.

These are just a few examples of the many possible ways in which paratransit could complement existing transportation services and fulfill latent transportation needs that go unmet today.

I stress the word "complement," for none of us wishes to see paratransit become engaged in a destructive competition for customers. We recognize that in many communities the local taxicab company has been providing people with personalized, on-demand, door-to-door service for many years and has been doing so quietly, efficiently, and without fanfare. Introducing a separate paratransit operation into such communities could be a wasteful, disruptive, and counterproductive step and result in ruinous competition between the 2 systems, from which neither enterprise would emerge victorious. It is not UMTA's intention to promote or encourage this type of situation.

But this is not to say that the existing private taxi services leave no room for innovation. Many communities need and are entitled to a greater variety of—and less costly—paratransit services. We believe that the local taxicab companies are the logical purveyors of such services and that they should be given a first option to demonstrate their capability in this field. We further believe, although this needs additional testing and experimentation, that paratransit services do not have to be money-losing propositions. Some local taxi operators have joined the ranks of innovators and have done so without the benefit of federal subsidies while maintaining, to my knowledge, a profitable operation.

We would like to see more such initiatives. In particular, we would like to know whether prearranged paratransit feeder service to line-haul commuter buses and trains could be provided by private operators at a cost that commuters could afford and would be willing to pay. If such feeder service can be so provided, we believe that all steps should be taken at the local level, including changing local ordinances, to permit the local taxi fleet operators to become active in the paratransit business. However, if this appears beyond the realm of economic feasibility, UMTA will be prepared to consider what type of federal assistance should be extended—to private as well as to public operators—to make paratransit service available to those communities that have a real need for it.

This brings me to my final point, and that is the impact of paratransit on conventional transit. As I said earlier, our aim is to promote paratransit services that complement rather than compete with or supplant other transportation modes. We believe, in other words, that paratransit can work in a productive partnership with conventional transit by serving as feeders to line-haul transit, by relieving some of the peak-hour pressure on transit vehicles and labor, and by building up new transit ridership through the provision of wider area service coverage. Thus, we think the present guarded attitude of the transit industry toward paratransit is unfounded and, we hope, will be dispelled once the service attributes and the operating environment of paratransit become better known.

In a recent article, paratransit was called "the forgotten alternative." I wonder whether this description is still appropriate. Certainly, we in UMTA do not consider paratransit to have been ignored. Our capital grants and demonstration programs reflect our growing respect for this form of transportation. We are making sure that the full range of paratransit options is being explored. These include the so-called hail or phone alternatives, such as the dial-a-ride and the jitney; the prearranged ride-sharing alternatives, such as the car pool and the subscription bus; and the hire-and-drive alternatives, such as the short-term rental car. Each category has certain unique attributes, and each deserves serious consideration.

Of late there has been quite a bit of talk about how jitneys might prove to be the answer to all our transportation ills. Critiques have been written and studies have been commissioned purporting to demonstrate conclusively that jitney transportation can do the job and do it better and more efficiently than any other mode. This view, it seems to me, is but another manifestation of that old human reaction in the face of complexity—a yearning for easy answers, a harking back to simple solutions in a world that is anything but simple. I will be the first to admit that paratransit has a rightful role to play in the total urban transportation system—a role that has been until now probably considerably underestimated.

But to go on from there to imply—as some are doing—that jitneys are going to solve all our transportation problems is a giant step into the world of unreality. Single-mode transportation systems, except in small communities, are a mirage. An all-jitney system in a place like the San Francisco Bay Area or even in Oakland itself is no more realistic than an all-rail or an all-freeway or an all-PRT system.

I would urge all of us to exercise a bit more restraint in our rhetoric, lest paratransit, a form of transportation that shows genuine promise, become embroiled in a false controversy about the "ultimate transportation solution"—a debate that could do a disservice to all those who are genuinely committed to the cause of paratransit.

Robert H. McManus, Associate Administrator for Transit Planning, Urban Mass Transportation Administration

We have been reconceptualizing the Service and Methods Demonstration Program since an UMTA reorganization in 1973. It may be useful to put the demonstration program in a somewhat broader perspective before a description of it is given.

UMTA now has legislative authority for a program to financially assist transit operating costs. The range of activities encompassed by our program authority includes research, development, and demonstrations; capital grants and loans; planning grants; university research and training; managerial training; and operations.

Sometimes exaggerated claims are made for federal programs. For example, at the hearings on the Urban Mass Transportation Assistance Act of 1970, which essentially provided a quantum increase in resources for capital grants, a prominent witness said that this piece of legislation alone would alleviate traffic congestion and air pollution, increase property values, promote business activity, stop community decay, and ensure access to jobs, schools, medical care, and recreation for millions who were too old, young, poor, or handicapped to drive cars. The political process happens to be quite tolerant of such statements. After all, there is the hope that they will turn out to be correct, and the problems will in fact be solved.

The truth is that the politician is willing to accept limited results. He recognizes instantly when the expert is being clear, and when he is babbling. Though he is not averse to putting a program on trial for its life, if it falls short of initial expectations he is more apt to want to know why, and what it will take to get results.

The program manager has the interesting job of balancing political relevance and technical credibility. Statements of purpose have to acknowledge the perceived problems, such as congestion, environmental concerns, and social equity. But in attempting to approximate broad purposes with the available tools, the program manager is also subject to the judgment of his or her peers and must remain credible. If not, he or she gets done in because it turns out that all the politicians are not elected. Some of them work for universities or are consultants and what not and are quite adroit, if not mischievous, in affecting the life of the program manager in the political process.

Sometimes the technical world itself overburdens a program with expectations to produce various effects, when in fact the program manager through published guidelines has been careful not to overreach. This has happened to our capital grant program with respect to external effects such as urban development patterns and environmental improvements. We have only said that, when such goals are clear and dominant in local planning, the capital grant program can assist in implementing a transit-oriented development strategy to substantially improve the amenities of urban living. The dominance of such goals would be manifested in particular by actions that clearly favor the transit mode and are the exclusive province of local authorities, for example, bold use of the powers of traffic management, pricing, and land use control. Such use is in fact encouraged by the priorities established for making grants. Despite misunderstandings, this is one example of trying to be politically relevant as well as technically credible in the sense of devising an operational basis for performance.

The demonstration program is another case in point. I shall use the term "service and methods demonstrations" to characterize that part of the demonstration program exclusive of demonstrations related to technology development (hardware components and systems). The term subsumes activities identified in the past as service development, intermodal integration, corridor demonstrations, and others. The purpose of the program is to bring about the imaginative use of traffic management and marketing techniques, pricing, service variations, and technology to attain clearly described objectives. We consider the elements of the subsumed activities such as intermodal integration (i.e., integration of institutional, operational, and physical aspects of urban transportation) to be quite important. However, they do not provide an easily understood basis for structuring, explaining, and carrying out a program plan. Conferences with candidate demonstration cities under the intermodal integration program revealed that they were considering service improvements, fare variations, and methods changes, but not in ways to gain leverage on meaningful objectives.

As a digression, I am impressed in general that local authorities, though interested in research, development, and demonstration, tend to have an interest in specific projects that they perceive as a service to the community or to a resident industry or institution or as a source of prestige useful in economic development of the area. They are not apt to be primarily interested in the research design of a project or the transferability of outputs to other places. Furthermore, political reprisals for failure are a severe constraint to innovation at the local level. Negative results, useful and constructive in an organized research and development program, are not well understood in local affairs. This means essentially that a demand-responsive posture for demonstration program management (i.e., one responsive to applications from local governments) is not apt to be fruitful. It also means that we cannot always have our own way. To organize truly meaningful demonstration projects in the context of our federal system of government is just plain difficult.

In any case, we are now working with a number of cities involved in the earlier intermodal integration effort to achieve a better definition of their demonstration projects. A prime consideration in attempting to increase the effectiveness of our total demonstration effort has been to identify objectives that are clearly attainable by virtue of actions taken as part of the demonstrations, independent of exogenous actions. By this criterion, certain politically relevant objectives were judged to be nonoperational, for example, conserving energy, reducing air and noise pollution, and improving urban design and the quality of life in the community. Attempts might be made to describe such effects in demonstration cities, but it would be difficult to impute causation. (The chances of being able to describe such effects could be enhanced, however, if a demonstration site also happened to have, for example, a severe air pollution problem.) On the basis of their being operational, technically credible, and supportive of the more rhetorical objectives cited above, the following objectives were selected for program planning purposes:

1. Reduce travel time for transit users,
2. Increase coverage of transit service,
3. Improve reliability of transit service,
4. Improve transit vehicle system productivity,
5. Improve transit service for the elderly and handicapped,
6. Increase convenience of using transit, and
7. Reduce congestion.

The last objective may be border line with respect to "doability," but we have in mind the possible use of congestion pricing, automobile-restricted zones, public automobile rental systems, and similar devices to make the attempt. These concepts are being studied in the current fiscal year for possible use in a subsequent year.

Simultaneously with identifying the operational objectives of the program, we had to come to grips with its underlying purpose. Was it actively to induce change and diffuse innovation or to build a knowledge base and be more passive with respect to a change-agent role? We concluded that both elements had to be present and that the percentage of the resource allocated to each role would vary from year to year.

In considering whether to opt for a change-agent element, I was impressed with the time lag required for widespread adoption of new ideas. In the education field, for example, the average American school lags 25 years behind the best practice—the diffusion of ideas being much slower than in farming and medical practice. The lack of change agents was cited as a likely factor as was the lack of an economic incentive to adopt. Well, how about the transit field?

To implement the change-agent role, we are establishing a category of demonstrations termed "exemplary" demonstrations. They will focus on providing a means for getting a person from his or her origin to a desired destination as quickly, efficiently, and comfortably as possible. In most cases this will require a combination of techniques and modes working together to provide a variety of services for various users, trip purposes, and routes. These projects will provide specific examples of how immediate transit service improvements can be attained and will be designed to make the techniques used and the information obtained transferable to other locations. There will also be turnover in the case load of such exemplary demonstrations for the purpose of positively inducing change in as many places as possible. In essence, these are demonstrations that have a high likelihood of success and that use methods and techniques already tested to a reasonable degree (though not in the same combinations) on an experimental basis.

To expand the knowledge base, we are establishing an experimental demonstration category. Since the experimental demonstrations are, in essence, the research for the exemplary category, they may encompass a broader range of objectives than those cited earlier. The experiments will tend to focus on specific questions or on particular services rather than to adopt the more comprehensive service philosophy of the exemplary demonstrations.

To develop the basis for experimental demonstrations, we will use a part of the resource for analytical studies. For example, attitudinal surveys may be conducted to increase understanding of how results from questionnaires, administered before system implementation, correlate with actual public acceptance of a service. Increased knowledge of these relations could prove invaluable in designing potential new services and in determining areas for their application. In other cases, the analyses might be feasibility studies to investigate the potential for implementation of an experimental demonstration or evaluations of demonstrations funded by various sources.

We have a number of studies in progress or about to begin, among them an analysis by the International Taxicab Association of regulatory impediments to the more efficient and varied use of that mode.

Examples of projects of an experimental nature are demonstrations of innovative fare collection and billing systems (e.g., using credit cards), automated transit information systems, integrated fare structures for multiple transit operators with appropriate revenue-sharing formulas, differential pricing of transportation supply through taxes and tolls, limitation of access to certain parts of the urban area or to specific facilities by licensing or prohibition, and modification of travel demand periods by alteration of working hours.

With respect to resource allocation, approximately 80 percent of the 1975 program level is accounted for by the exemplary demonstration category and 20 percent by the experimental. The 1974 program level for these demonstrations was $16.25 million. In 1976, perhaps 60 percent will be used for the exemplary category and 40 percent for the experimental on the theory that more experimental demonstrations designed in 1975 will be operational in 1976. As results are proved, the desired practice will be diffused through the exemplary category, and commensurate changes will be made in the program proportions.

The 2 categories will be managed quite differently; the exemplary requires a significant local share (perhaps 50 percent when averaged over the term of the project), a specific schedule for federal disengagement, and a local commitment to continuation of the practice. Resources of the capital grant program will also be brought into play so that the effective program level could well be a factor of 2 or more times the appropriation for the demonstrations per se.

The experimental demonstrations will not have the constraints just described, nor can capital grant program resources be used unless the likelihood of continued use of the physical assets is apparent. Physical assets can indeed be acquired, but they will have to be financed by the demonstration program resource.

For both types of demonstrations, UMTA will put together the project designs and assume responsibility and the full cost for evaluations. There will, of course, be collaboration with demonstration sponsors, who will be responsible for actual data collection. We hope to avoid inconsistency in data from project to project and problems such as the simultaneous changing of too many variables in the course of the demonstrations—commonly known faults of earlier projects.

For the time being, we intend to concentrate on service demonstrations rather than transit-pricing (i.e., fare variation) projects. We are not against fare variations, but we simply do not want to support them with this program resource at this time. Our reasons are, in brief, that informed opinion at least justifies the hunch that demand is more responsive to service level than to fare level. In addition, we could easily consume our scarce program resources in even fewer projects than we currently plan, for fare variation projects are costly. We hope to segregate markets better through research currently in progress and then address fare policies more discretely.

Let me return to our objectives and at least for some of them cite techniques that seem to promise success. Time does not permit review of complete project concepts. To recapitulate, the principal objectives relate to time, coverage, reliability, productivity, and service to the elderly and handicapped.

The truth is that in actual practice the objectives and their supporting techniques will run together, particularly as a demonstration may become more comprehensive in scope. Certainly the objectives of reducing travel time for transit users and increasing the coverage of transit tend to run together. Time reduction can be accomplished through increased service frequency, decreased number of and time involved in transfers, and increased vehicle speeds. We want to concentrate especially on minimizing time spent outside the vehicle.

Expanded transit coverage provides and requires a choice of transportation modes and increases the flexibility and efficiency of urban travel and service to those who do not have an alternative mode. Another pair of objectives are improving the reliability of transit service and improving transit vehicle productivity. Techniques that can serve these objectives include segregating transit vehicles from other traffic; monitoring vehicle location, progress, and status; improving routing and scheduling; and upgrading the quality of maintenance.

I particularly want to comment on the objective of improving transit service for the elderly and handicapped. We are initiating a rule-making action on our approach to this purpose in the UMTA programs, and my opinion is that the demonstration program will in the end win the day with appropriate answers for communities of various sizes. Up to now, service development projects have produced a variety of models in the categories of cost-sharing arrangements, service concepts, and equipment design, providing easy ingress and egress.

There is a need to attempt demonstrations built on incentives to providers of transportation service rather than just on needs of special user groups to see what service responses might be induced. Variations could include a special service subsidy to a conventional transit system modified to accommodate needs of the aged and handicapped, taxi driver premiums, and transportation stamps in the possession of the user and redeemable at a premium by the provider of the service, irrespective of the mode. We also have ascertained that the size and the nature of the information program needed to serve adequately special user groups have been misjudged and should be further addressed. And the subject of vehicle modifications also needs more attention.

Perhaps this gives a general impression of what we have in mind for the service and methods demonstration program. However, I want to be as clear as possible about the respective roles of the various UMTA offices in conducting demonstrations. Three offices have a piece of the action: the Office of Research and Development, which emphasizes technology development (in particular, hardware components and systems); the Office of Transit Management, which concentrates on marketing and managerial efficiency; and my own shop, which concentrates on service concepts, traffic management, pricing techniques, and managing the planning grant program, which I have not mentioned.

The bailiwick of the Office of Research and Development is relatively clear; its demonstrations relate specifically to testing and perfecting technology. There may, nevertheless, be times when final development of a system or components may be completed in a demonstration managed by my office—when such development is subordinate to a primary objective such as reducing travel time. An example might be a demonstration of waterborne transit.

The line of demarcation between the Office of Transit Management and my office is not so precise, but we expect the Office of Transit Management to be most active in projects related to the objectives of improving transit system productivity, schedule reliability, and convenience of using transit. We would also look to that office for a major role in information dissemination to our transit operator constituency.

The demonstration resource, employed as just outlined and in conjunction with other UMTA programs, offers these major possibilities:

1. Identification of vanguard practices for emulation and diffusion of best practices through a change-agent role by collaterally using the planning assistance program as a resource to help a much larger number of cities evaluate promising new ideas, undertaking the early planning for demonstrations, and ultimately possibly using an operating assistance resource to ease the transition to fully established improvements;
2. Development of service standards and determination of costs to meet them; and
3. Possible simulation of service levels of advanced technologies (e.g., dual mode) by using available systems, or, failing that, establishing service levels approximating those of advanced technologies to judge the merits of incurring the incremental costs to achieve the higher service levels.

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The National Academy of Sciences was established by a congressional act of incorporation signed by President Abraham Lincoln on March 3, 1863, to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance. It is a private, honorary organization of more than 1,000 scientists elected on the basis of outstanding contributions to knowledge and is supported by private and public funds. Under the terms of its congressional charter, the Academy is called upon to act as an official—yet independent—advisor to the federal government in any matter of science and technology, although it is not a government agency and its activities are not limited to those on behalf of the government.

To share in the task of furthering science and engineering and of advising the federal government, the National Academy of Engineering was established on December 5, 1964, under the authority of the act of incorporation of the National Academy of Sciences. Its advisory activities are closely coordinated with those of the National Academy of Sciences, but it is independent and autonomous in its organization and election of members.