

PARATRANSIT SYSTEMS

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Summary

Paratransit is the name given to all forms of passenger transit that operate on schedules and follow routes determined by the demands of individual passengers, hence the name *demand-responsive transit*. It is the fastest-growing transit mode, due in part to its ability to provide mobility to persons whose disabilities make it impossible for them to use conventional transit. It also serves other low demand-density markets. Low-density markets make paratransit systems relatively costly to operate, although these costs are less than those of providing conventional transit for these markets. Sometimes it may be appropriate to offer services that mix paratransit with certain attributes of conventional transit. While taxi and paratransit services are closely related, only taxi services in which passengers share vehicles are considered as paratransit.

Because paratransit adapts to passenger demand in real time, managers may find it hard to reconcile service quality, as seen by the users, and efficiency of operations, as measured by costs. Maximizing vehicle/trip effectiveness and efficient scheduling and dispatching all require astute management and effective performance monitoring. Computer and communication technologies have a wide range of applications in helping streamlining paratransit operations.

1. Description of Paratransit Services

1.1. What Is Paratransit?

Literally, “paratransit” means “alongside-of” transit. It includes all public and private mass transportation provided in the spectrum between private automobile travel and conventional, fixed-route, fixed-schedule bus and rail transit. The broad definition includes carpools and vanpools (shared ride modes), limousines, public autos (station cars), charter buses, shuttle buses, exclusive and shared-ride taxicabs, livery vehicles, and bus transportation operating on flexible routes and flexible schedules in response to individual requests for service, the latter being termed “demand-responsive” or “dial-a-ride” services. Although they are not shared-ride services, conventional exclusive-ride taxi services are often considered paratransit services, because of the similarity of their operations to other demand-responsive service and because historically they have served older persons and persons with disabilities—markets traditionally served by other paratransit. Some authors have also included other vehicular modes of travel, including bicycles and pedi-cabs, because they operate alongside conventional transit.

The original definition of paratransit was offered in the publication that coined the word, as follows:

...those forms of intra-urban passenger transportation which are available to the public, and distinct from conventional transit (scheduled bus and rail) and can operate over the highway and transit system.

(Kirby, 1974)

A modernized definition is used in this article, as follows:

Any form of ground, passenger transportation that is demand-responsive, that requires the passenger to place a request with the service provider (by hail, telephone, or other electronic means), and that operates with flexible routes and/or flexible schedules tailored to the passengers’ trips.

1.2. Types of Paratransit Service

In the 25 or so years since the term “paratransit” was first coined, there have been many regulatory, social, and technological advances. Although these advances have had an impact on paratransit, basic paratransit service modes have remained the same, although a few new variations or name changes have come to be recognized:

- commercially viable general public transportation,
- exclusive-ride taxi,
- shared-ride taxi,
- commercially viable target market transportation,
- children’s services,
- subsidized general public transportation,
- general public dial-a-ride,
- fixed-route feeder services,

- “night owl” service substituting for fixed route transit,
- flex-routes (also known as checkpoint or point deviation),
- route deviation,
- service routes,
- subsidized target market transportation,
- people with disabilities (called “ADA Complementary Paratransit” in the United States),
- senior services,
- low-income workers (called “welfare-to-work” or “access to jobs” in the United States),
- subsidized medical care recipients, and
- other health and human service agency clients.

In North America, paratransit primarily serves target markets of specially identified subsets of potential transit users. However, in the 1970s paratransit was thought to be an answer to providing general public transit service for persons located in areas of low-density land use and transit demand: in other words, areas not served cost-effectively by conventional transit. Many of these systems still exist in small towns. Paratransit in many developing countries competes directly with fixed-route transit, providing a more flexible alternative. In the early 1900s these services in the United States were known as *jitneys* after the name of the 5-cent coin, which was the fare. Jitneys were made illegal in the US at the urging of the transit operators, although some systems still operate illegally. These services are still very prevalent throughout Latin America, where they are often named after the coins of the fares, and in Asia. The very colorful vehicles in Manila are called jeepneys; in Jakarta they are mikrolet; in Thailand, silor lek.

These general public paratransit services serve a number of markets, and function as:

- the sole public transportation service;
- a direct competitor for public, fixed-route transit;
- a replacement service for unproductive fixed routes;
- a feeder/distributor service to a fixed-route service; or
- an experimental strategy to test or develop the public transportation market in a new area or for the first time.

The last-named has proven to be a useful strategy that sometimes provides unexpected results. In a number of cases paratransit services were implemented and subsequently changed to fixed-route services as demand and the patterns of trips developed. Sometimes this was not a strategic change but a response to market growth, but now it is recognized as a means of introducing transit services into new areas and to new patrons.

The primary niche for paratransit, then, is to provide transit services in areas of low housing density, such as in the suburbs, or to small markets, such as to older persons or persons with disabilities in urban areas. Whether paratransit serves target markets or operates for the general public in low-density areas, most paratransit services in North

America are provided either by transit agencies or municipalities with some form of public or private subsidy to offset the cost to the customer.

Most services in developing countries are operated by private entrepreneurs, who may bring order to their independent operations by forming organizations. Daniel B. Klein and Adrian T. Moore report (in an article named *Curb Rights* appearing on the Internet site www.AllBritannica.com) that:

Often the jitney operators form a route association, an informal organization to bring order and regularity to service by means of extralegal norms and explicit rules. The jitney literature suggests that route associations largely governed transit services in Lima, Hong Kong, Istanbul, Buenos Aires, Manila, Calcutta, and Caracas. The route association becomes a regulatory body, similar to government but more local and entrepreneurial. The association lays down rules against interloping and deviating from schedules. It also fixes fares on the route, which may vary with time of day. Associations create enough order to control destructive conflict, but they also operate as cartels.

1.3. ADA Complementary Paratransit

Paratransit service for persons with disabilities warrants further discussion because of its widespread growth as a result of being mandated by governmental regulation. ADA *Complementary Paratransit* is the term used in US legislation is provided for persons with disabilities who are unable to use fixed-route services. The relevant US legislation, the Americans with Disabilities Act of 1990 (ADA), mandates that as of January 1997, US public transit agencies were to be in full compliance with provisions that include the following:

Each public entity operating a fixed-route system shall provide paratransit or other special service to individuals with disabilities that is comparable to the level of service provided to individuals without disabilities who use the fixed-route system.

“Persons with disabilities” are defined as those who are unable to use fixed-route services because of the nature of their disabilities and/or the inaccessibility of regular transit. The ADA regulations further specify the service criteria required for a service to be considered in compliance (for example, service area, days and hours of service, and fares), as well as the eligibility requirements for individuals with disabilities desiring to use the paratransit system. Although specific service criteria have been established, a great deal of local flexibility remains with respect to the exact configuration of services provided, as long as they are compliant with the ADA regulations.

1.4. Paratransit Operating Functions

Offering paratransit operations requires the execution of a core set of functions that are termed the *operating functions*, including *trip reservations* (order taking and confirmation of a trip request), *scheduling* by assigning a pick-up time to patron trip requests, and *dispatching* of vehicles to provide the promised service. For target-market

systems serving a restricted clientele, *eligibility determination* is an additional core function usually performed in combination with trip reservations. In some systems, actual street *routing* is calculated and given to the driver. Finally, *reporting* is also included as a core function because it is necessary to manage paratransit systems effectively. A diagram indicating the relationship of these functions is shown in Figure 1. Some or all of these functions may be automated.

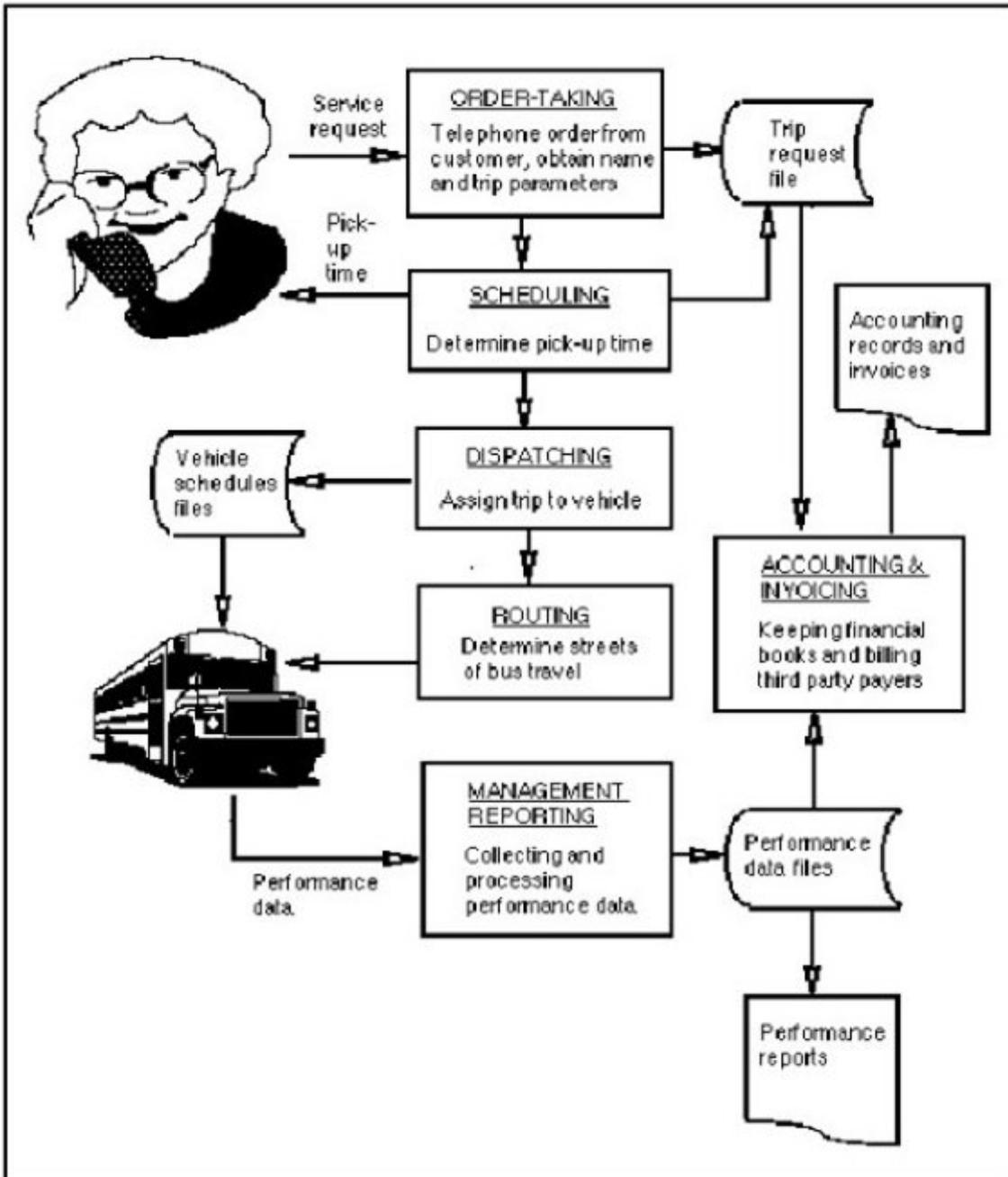


Figure 1. Overview of functions of paratransit operations. Source: Lave R.E. (1996). *A Handbook for Acquiring Demand-Responsive Transit Software*, TCRP Report 18. Washington, D.C.: Transportation Research Board.

In addition to the operating functions noted above, a number of *administrative functions* are required by paratransit systems as well. These are not unique to paratransit, however, and general business or transit computer software is available to perform them. They include accounting and invoicing, maintenance scheduling, purchasing and inventory control, and project management.

1.4.1. Eligibility Determination

In many target-market paratransit systems, prospective patrons must meet certain eligibility criteria before they are permitted to use the system. These may involve age, physical condition, agency affiliation, income, and certification of eligibility. Whatever the criteria, only those who have previously been registered as eligible riders are allowed to utilize the service.

In such systems, it must be established at the point of contact between prospective rider and system that an individual is eligible. Typically this involves a search of a database of eligible patrons in an attempt to locate the individual who is requesting service. If records for corresponding individuals are found in the registration database, they can then be processed into the system.

Often eligibility determination is performed as part of the trip reservation or order-taking function, which is described next.

1.4.2. Trip Reservations (Order-Taking)

The terms *trip reservation* and *order-taking* are often used interchangeably. In paratransit systems that provide immediate service (service as soon as possible), the term order-taking is more appropriate, whereas in a prescheduled operation a customer is truly making a reservation for service to be delivered at some point in the future.

In either case, the essence of this function is for the order-taker/reservationist to obtain the parameters of the trip request from the patron, and to advise the patron whether the system is able to accommodate the trip request and when the vehicle will arrive. The trip parameters might include pick-up point, drop-off point, desired pick-up or delivery time, number of passengers, and any special requirements (such as wheelchair accessibility). If the trip cannot be accommodated due to unavailability of resources for this specific request, the order-taker/reservationist must indicate to the patron the reason for the problem. The reservationist must then interact with the customer and attempt to find trip times that the system is able to accommodate. If the trip reservation can be accepted, either initially or at subsequent attempts, the order-taker/reservationist then informs the patron of the estimated pick-up time, typically using a time window rather than a single point estimate: stating, for example, that the vehicle will arrive between 1130 and 1150.

1.4.3. Service (Trip/Vehicle) Scheduling

Scheduling is the process of inserting a trip request into a schedule in such a way that no system constraints are violated. *Scheduling is the core function that distinguishes*

paratransit systems from conventional transit. In conventional transit, buses are scheduled by the clock, and patrons adapt their schedules to the bus schedule. In paratransit service, the transit schedule adapts to patrons calling for service.

The system constraints typically include maximum ride time, maximum wait, and promised pick-up and delivery times for already scheduled trips. Once a trip has been scheduled, it has an estimated time of arrival—also typically stated as a time window—at the patron’s pick-up location.

It is important to note that once the trip has been scheduled, the paratransit system has entered into an implicit contract with the customer to deliver service as specified. That is, the system is pledging that it will accomplish pick-up within a certain time window, delivery by a specified time if this is one of the requirements of the trip, and a maximum ride time that depends upon system policies..

The process of scheduling individual trip requests while the customer is on the phone is called *interactive* or *on-line scheduling* by the industry. This term refers to a scheduling system in which accepting or denying a trip request is based to some extent on available system capacity, and an estimated time of arrival of the vehicle is given to the requester if the request is accepted. Although the actual assignment of this passenger trip to a vehicle (the dispatch) may not yet have been made, or may subsequently be changed, the time window for vehicle arrival will only be changed in exceptional circumstances. Interactive scheduling is *not* real-time or immediate service. Interactive scheduling determines the pick-up time immediately while the trip may be scheduled for any time in the future, in contrast with immediate service, which accepts requests for a trip as soon as possible. Real-time or immediate service requires interactive scheduling, but the converse is not true. Many prescheduled operations use interactive scheduling: in other words, they provide an estimate of pick-up times to the patrons.

The issue of whether drivers should be allowed to exercise discretion in changing the schedule they are given by dispatching arises. Factors that support allowing driver discretion include the facts that they are first-hand observers of the situation on the road, and often know their patrons as well. On the other hand, the fact that the driver sees only his or her own situation means they do not have the system-wide view that the dispatching operation has. If drivers are given discretion, they must report changes to the dispatcher so that the system schedule can be adjusted.

1.4.4. Vehicle Dispatching

Vehicle dispatching is the process of assigning a trip to an actual vehicle that has previously been scheduled by the system and communicating that assignment to its driver, including notifying him/her precisely when during the vehicle tour this patron will be picked up and dropped off.

Although the dispatching process places a trip onto a vehicle in a prescheduled operation, the vehicle tours may subsequently be revised and trips reassigned to other vehicles. Trip cancellations and situations in which the patron does not show up (“no-shows”) will almost always require some alteration in the assignment. The dispatching

process is responsible for accomplishing these dynamic trip/vehicle reassignments. In an immediate-response paratransit system trip reassignment may also occur, although it is somewhat less frequent because there are fewer cancellations due to the high proportion of trips that are made in response to requests for immediate service. Whatever a system's mode of operation, every trip request must be assigned to a specific vehicle, and the driver of that vehicle must be informed of the sequence of addresses to visit to pick up and drop-off patrons.

In real-time scheduling/dispatching, a new trip request can be added to an existing schedule and trip assignment. One way of doing this is to seek the best vehicle assignment for the new trip without changing any other assignments. This procedure will not necessarily find the best schedule/dispatch arrangement from a global point of view, however. It may be possible that a better arrangement exists if all assignments are thrown up in the air and made over again. This procedure is called *dynamic rescheduling*, although it is more accurately called *dynamic redispatching* because vehicle assignments may be changed but the promised schedule of pick-up times is maintained. This is accomplished by moving already-scheduled trips from one vehicle tour to another—or creating an entirely new set of vehicle tours—within the constraint that pick-up and delivery time windows cannot be violated. The purpose is to free time on one or more vehicle tours, thereby enabling more trips to be scheduled and thus improving system productivity. The advantage of dynamic redispatching is that it may find assignments that are preferable to merely appending a new trip to an existing dispatch. The price paid is the time that it takes to redispatch. It may not be possible to do this within a reasonable time, even using a computerized system. A compromise may be to redispatch after the addition of several new trips. It is not possible to say categorically whether or not dynamic redispatching is a worthwhile feature. The improved arrangements may not be significant, given the normal uncertainties involved in meeting a schedule. Moreover, if subscription patrons are promised that they will get the same driver and there are many such trips, or if certain patrons must be given a specific vehicle, these factors constrain the ability of a redispatching system to improve on a given arrangement.

For systems in which trip requests can be made weeks in advance, these end-of-day schedule refinements may be done on a daily basis for future days on which significant numbers of trips have already been scheduled.

1.4.5. Vehicle Routing

The routing function finds the best route between pick-up and drop-off points in terms of the actual roads taken, and not merely the sequence of points. The theoretical routing task usually requires solving the mathematical “shortest path” problem, in which the shortest path may be measured in several different ways: mileage, least operating cost, or fastest path in terms of travel time. Approximate best routes could be prescribed by control-room staff, based on their knowledge of the street network without the use of the mathematics, but these operatives would merely be substituting their knowledge—which may or may not be superior—for that of the driver. The mathematical solution can be performed using a number of procedures, but to perform routing in systems of any practical size the solution procedure requires automation.

1.4.6. Management Reporting and Statistics

While not a core function for the paratransit control system per se, management reporting is clearly a key component of the overall paratransit operation, as these reports provide feedback on how effectively the system is performing. Management reporting consists of collecting data on all major system functions, and analyzing that data to provide system managers with indicators of the efficiency and effectiveness of various system processes and policies. Indicators such as average length of time to book a trip, average ride time, average pick-up time deviation, passengers per vehicle service hour, and the like are very important in informing management of how well the system is operating. Most paratransit software packages provide this information, although they tend to be weakest for indicators that depend on the collection of real-time operational data.

1.4.7. Accounting/Invoicing

Accounting/invoicing is not a function that is unique to paratransit operations, but it is of course necessary to these operations. Other functions such as maintenance, inventory, and purchasing are also not unique to performing paratransit functions, and may be integrated with operational procedures or performed as stand-alone procedures.

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A few systems are now beginning to experiment with these new possibilities. As these efforts, and others, proceed along the development path, how DRT is organized and delivered is likely to change significantly, though gradually, from the current practice.]

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Wilson N.H.M. (1976). Coordination and control of paratransit services. *Transportation Research Board Special Report No: 164*, 174–182. [This resource paper which summarizes the current state of development of coordination and control procedures and raises issues relating to future developments, has as its basic premise, the concept that paratransit services should be designed to complement one another as well as other transportation services. The more significant technological developments are reviewed and issues relevant to their evaluation are raised. The principal areas in which work has reached the point of implementation are computer control and communication. The potential of automatic vehicle location systems is also reviewed.]

Biographical Sketches

Dr. Roy Lave is a research specialist in policy analysis and program evaluation with particular emphasis in the field of transportation and economic development. He received B.Sc., M.Sc., and M.B.A. degrees from the University of Michigan, and a Ph.D. from Stanford University in operations research/industrial engineering. He held a tenured joint appointment on the Industrial Engineering and Engineering-Economic Systems faculty at Stanford for ten years and served as Associate Head of Industrial Engineering. While at Stanford he created and administered an internship program with the federal government, and a transportation research program. Milestone SYSTAN projects include the design of a program of interlending among credit unions in the US and Latin America, an implemented plan for the consolidation of independent demand-responsive transportation services in a county under the umbrella of a transit agency (predating but predicting the requirements of the ADA), an authored manual on paratransit software procurement, analysis of supplementary business opportunities for a community hospital, and development of a methodology for transportation program and project evaluation including a rigorous statistical approach. Additionally, he authored a network-planning model and managed its application to develop master transport plans in Brazil, Portugal, Saudi Arabia, Costa Rica, and the Central American Common Market region. He is a past Chair of the National Academy of Science/Transportation Research Board's Committee on Paratransit. In addition to his research and analysis background he has extensive experience in policy decision-making, having serving as mayor, city council member, and regional and county transportation commissioner. Currently he is the chair of the board of directors of a community bank, and serves on the boards of a local theater, the community YMCA, a sister county (Moscow region) commission, and an AIDS education corporation (of the local Rotary Club). He spends much of his time as founding president of a two-city community foundation, and he was the founding chair of a (now defunct) not-for-profit corporation for public service exchanges with the Komi Republic, Russia.

Rosemary G. Mathias is currently working toward completion of a Ph.D. in Applied Anthropology from the University of South Florida in Tampa, Florida. Her dissertation focuses on public transportation issues for persons with disabilities. She also holds two Masters' degrees including a Master of Business Administration in Health Care Management from Boston University (1984) and a Master of Public Affairs in Health Care Policy from Indiana University, Bloomington, Indiana (1983). She also holds a Bachelor of Arts in Journalism and Geography from Indiana University (1978). Ms. Mathias has more than 23 years experience in this field and is nationally recognized as an expert in the area of specialized transportation, particularly services for seniors and persons with disabilities. She currently works as a Senior Associate at Multisystems, Inc., a transit-consulting firm based in Cambridge, Massachusetts. Much of her work focuses on fixed-route transit and paratransit accessibility issues for persons with disabilities under the Americans with Disabilities Act of 1990 (ADA). For the Federal Transit Administration (FTA), she reviews fixed-route, paratransit, and key rail stations to assess their compliance with the ADA regulations. She also manages projects dealing with welfare reform and

transportation, coordination of transportation services, and the development of databases to capture operating information about paratransit services provided under the ADA. In a previous position, she directed the specialized transportation research program at the University of South Florida. She also has managed a large paratransit brokerage in the City of Philadelphia, Pennsylvania. Prior to that, she worked for the Regional Public Transportation Authority in Phoenix, Arizona. She began her career under at the Indiana University Institute for Urban Transportation. Ms. Mathias chairs the Transportation Research Board (TRB) Committee on Paratransit, and the Work Group on Senior Transportation for the American Public Transportation Association (APTA) Access Committee. She also has served on the Steering Committee for the Eighth International Conference on Mobility and Transport for Elderly and Disabled People, held in Warsaw, Poland, as well as the Seventh International Conference, held in Perth, Western Australia. When she is not working on transportation-related projects she is a puppy-raiser for Canine Companions for Independence, a national non-profit organization that breeds and trains assistance dogs for persons with disabilities. She and her husband are raising their fifth puppy. Primarily a consultant and practitioner, Ms. Mathias has made many presentations and published several articles dealing with paratransit, and transit issues related to persons with disabilities and seniors.

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SAMPLE CHAPTERS