Modal Alternatives for Transit-Oriented Communities

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I. Introduction

Discussions of urban form invariably lead to discussions of urban transportation. This is understandable, as transportation has proven to be among the most influential factors affecting the density and shape of metropolitan areas. This topic is of particular interest to those involved in the design of new communities or in the redevelopment of older ones. These individuals may not have a background in urban transportation nor be aware of the variety and suitability of the many options for mobility. For this reason, this paper compiles, in concise form, descriptions of the transportation modes and families in use today, particularly those classified as public transportation. Moreover, an emphasis is placed on the fit between forms of public transportation and forms of urban development. For simplicity, three types of development are cited herein: (1) the neighborhood, an urbanized area containing a concentration of residences and supporting activities; (2) the district, an urbanized area specialized around one predominant activity; and (3) the corridor, an area between the boundaries of neighborhoods and districts (Fig. 1).

For those desiring more detailed information, the writings of Professor Vukan Vuchic of the Department of Systems Engineering of the University of Pennsylvania are highly recommended. His book, Urban Public Transportation Systems and Technology (Prentice-Hall, 1981), was a source of much of the material contained in the following pages. Some modifications have been made here to emphasize the relationship between transportation and land use. In most cases, however, the essence of the descriptions remains the same.

II. Modes of Transportation

The various forms of urban transportation described below can be classified into a number of discrete modes and modal families. As explained by Vuchic, there are three defining characteristics of a mode of transportation: technology, right-of-way, and type of service. As a convenience, the general technology of the vehicle is often the only characteristic used in distinguishing between modes, but the situation is really more complex. For example, the bus-commonly spoken of as a distinct mode of transit-is actually a generic term with many variations and applications. For example, buses can:

* vary in their technological characteristics (being powered by diesel engines, alternative fuels, and electricity, and offered in a variety of sizes and configurations);
* operate on many types of rights-of-way (such as city streets in mixed traffic, freeways, reserved lanes and transit malls, or busways);
* serve different kinds of transit routes (as locals, limiteds, expresses, or short-range shuttles), be available only for chartering, or be privately owned for the transport of one

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particular group.

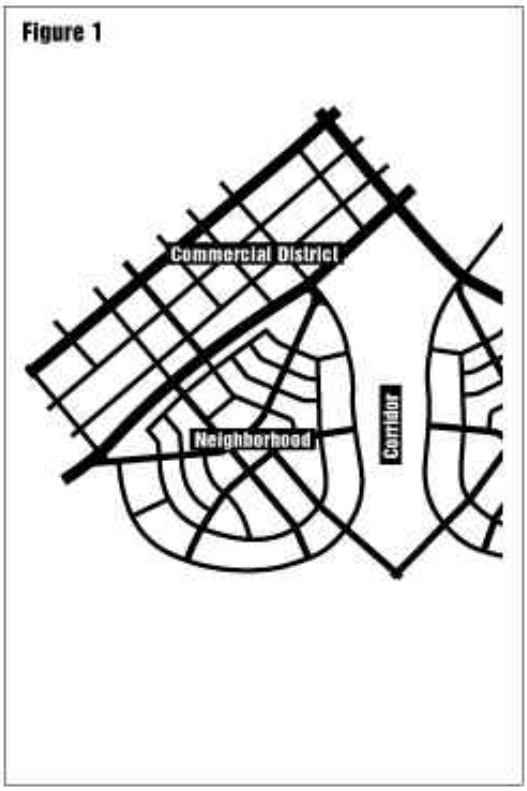
Thus, what is apparently one mode is really several related modes centered around one general technological family.

Sometimes the differences among the modes within one technological family are greater than the differences between modes in two different families. For example, a streetcar operating in traffic on city streets may resemble light rail transit, but it generally offers service that is more akin to a local bus. Moreover, there may be drastic changes in the character of a transportation service over the course of its route (such as a bus line operating as an express on a freeway but as a local on city streets at either end of the line). In such cases, the mode of operation that is most prevalent is the one generally used for its classification.

In the final analysis, it is important to remember that the operation of various forms of transportation is fluid and often defies classification. The descriptions given here are a convenient way of summarizing the most common modal characteristics, but they should not serve to limit a possible useful application.

III. Components of Urban Transportation

Urban passenger transportation consists of the movement of people in cities and metropolitan areas. It therefore excludes intercity and rural transportation, as well as the transportation of goods and commodities. Urban passenger transportation has the following principal components:



* ***Private transportation*** is the movement of people on foot or in vehicles not available to the general public. Private transportation encompasses walking, cycling, driving, and carpooling. It is the most prevalent form of urban transportation.

* ***Public transportation*** is the movement of people in vehicles that are available to the general public, usually at prescribed rates of fare. Public transportation, in turn, has two sub-categories:

* ***Paratransit*** encompasses diverse forms of public transportation that fill the niche between private transportation and transit. It includes such modal families as internal circulators, subscription transportation, for-hire transportation, and public paratransit. Specific modes include vanpool, taxi, jitney, dial-a-ride, and peoplemover.

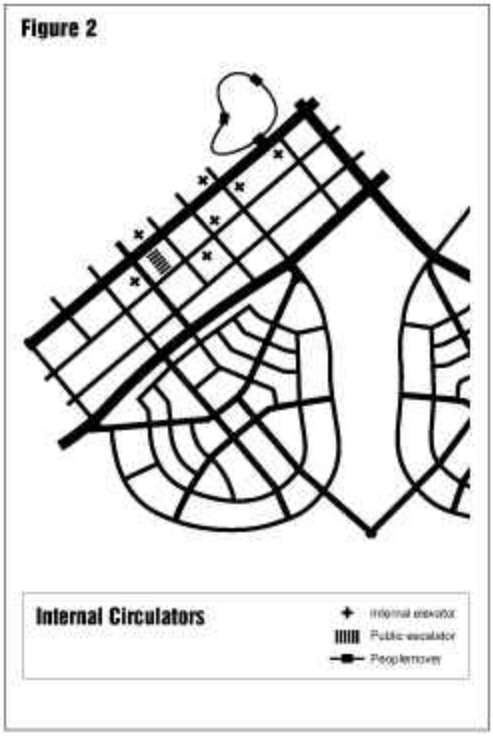
* ***Transit*** (or mass transportation) is public transportation utilizing relatively large vehicles operating on fixed routes and schedules, serving prescribed stops. Transit includes the modal families of street transit, semi-rapid transit, rapid transit, regional rail transit, and special transit. Specific modes include local bus, streetcar, semi-rapid bus, light rail, rail rapid transit, and regional rail.

Because it is the most common and familiar form of urban transportation, private transportation is not discussed further in this paper. Rather, for the purposes of fostering an understanding of public transportation, the focus is on modes of paratransit and transit.

IV. Public Transportation: Paratransit

Paratransit is harder to define than it is to describe. It is really a catch-all category for many forms of transportation which are available to the general public, or segments of it, short of those modes which provide regular scheduled service on fixed routes. Four modal families can be distinguished.

Internal circulators includes a variety of modes often unrelated in technology but all aimed at transporting people over relatively short distances. They are customarily located in buildings, on



private property, or in contained activity centers like theme parks. Many are operated without fares. Elevators, escalators, and moving sidewalks are utilized in both indoor and outdoor settings to extend the range of pedestrians and to overcome barriers such as differences in grade. Chairlifts and gondolas use seats or small cabins suspended from aerial cables to perform this function over slightly longer distances. Peoplemovers (or group rapid transit systems) use automated guideway technology for transportation within busy activity centers, particularly airports. The vehicles generally operate on rubber tires running against flat surfaces. Some peoplemovers utilize monorail technology, with cars that operate along a single beam or rail. Internal circulator transport systems vary widely in cost and operating characteristics, but they can be useful or even essential in particular situations. Their application, however, is typically in private and semi-public settings, rather than in the public realm (Fig. 2).

Subscription transportation consists of service provided to predetermined segments of the public to connect specified points of origin with a particular destination. It includes vanpools, bus pools, and school bus service. A fee may or may not be charged; if so, it is typically collected on a weekly or monthly basis. Subscription transportation is most often used to accommodate work and school commuter travel. Its flexibility and infrequency does not generally require special urban design treatments.

For-hire transportation entails the movement of people in vehicles that are available for rent or charter to the general public but reserved for the exclusive use of the party renting them. For-hire transportation includes taxi, rental car, and charter bus. As with most forms of paratransit, no special urban design accommodation is necessary. A developmental form of transport called personal rapid transit (PRT) could be considered as for-hire transportation, since it entails riding in an automated vehicle which is scheduled and routed exclusively for the party that summons it. Since guideways are utilized for PRT, the same urban design considerations that apply to other guideway modes (such as light metro, described later) should be observed.

Public paratransit consists of vehicles in public service that generally do not run on fixed schedules. Jitneys are vans or small buses that ply regular routes for standard rates of fare. They customarily queue at designated areas and depart when the driver judges that patronage is sufficient to make the run profitable (Fig. 3). Many airport limousine services operate in a similar manner. Unless subsidized, jitneys operate only at times and places considered by their owners to provide a reasonable return on their investment. Shared-ride taxis are similar, except that they use standard taxicabs and are not restricted to one particular route. Like jitneys, they serve major travel corridors where many people share common trip ends. Both modes are more common overseas, due to restrictions in US cites designed to protect regular transit services. Being market-driven, they operate mainly on busy streets. Days and hours of service may not be guaranteed.

Dial-a-ride is a demand-responsive form of public paratransit with neither fixed routes nor schedules. Users telephone in advance to be picked up at or near their point of origin and delivered to or near their desired destination. The ride may be shared with others and thus involve some out-of-direction travel. Taxicabs, vans, or minibuses can be utilized. This form of service is sometimes employed by public transit agencies at times or places where conventional transit service would not be cost-effective. It has also been used extensively to transport disabled passengers who cannot use regular bus or rail service. In this application, ridership is usually restricted to this one

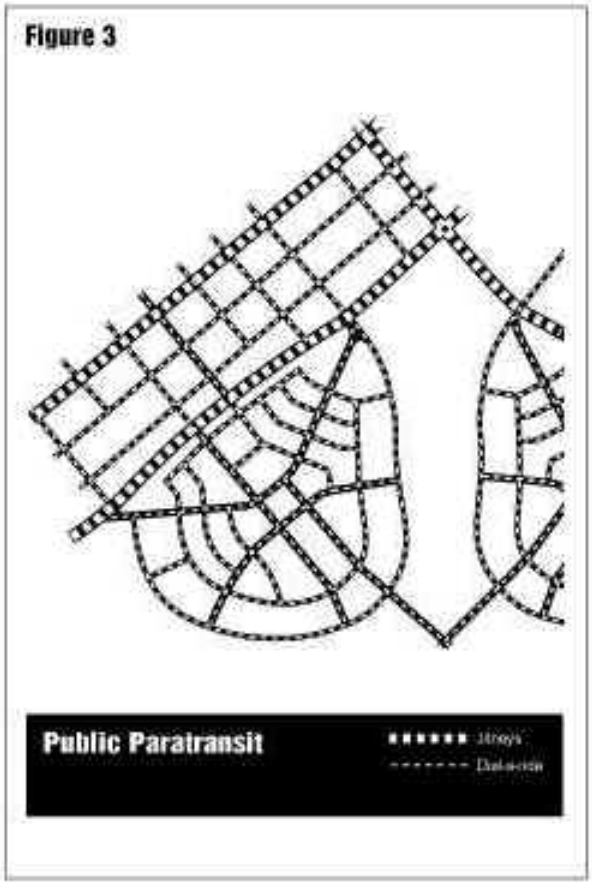
segment of the population. Dial-a-ride is attractive because it can be operated unobtrusively on even the most narrow of streets. Unfortunately, the low vehicular capacity inherent in this mode makes its operating cost per passenger relatively high. Dial-a-ride may also impose constraints on users' travel times or result in circuitous trips.

When used as a supplement to regular transit service, public paratransit can easily penetrate all parts of an urban area. Problems occur when it is the chief form of public transportation, as in many developing nations. A large number of small vehicles is needed to provide adequate capacity, leading to traffic congestion. Market-based paratransit is limited by operators' perceptions of profitability to those parts of the community with higher travel demands. In contrast, government-subsidized paratransit service can be offered anywhere but is usually limited by the availability of funding.

V. Public Transportation: Transit

Of the principal components of urban transportation, transit should be of particular interest to the urban designer. With a few exceptions, the other components--private transportation and paratransit-use vehicles that are accommodated in most kinds of development. Transit, however, has more specific demands that must be met to ensure its viability. It also has specific constraints that may prevent its use in particular urban settings. It is important for these to be understood, particularly since the operation of the transit system is usually outside the control of the community designer or developer.

Transit (or mass transportation) uses relatively large vehicles on fixed routes and schedules to move people through urban areas. There are generally prescribed stations or stops en route. A diverse and somewhat confusing array of transit modes is currently operated in urban areas. One way of reducing this confusion is to consider each mode along with others of similar characteristics. As mentioned earlier, technology (e.g., road-based rubber-tire systems, rail-based systems, and automated guideway systems) is often used as the basis of comparison. Perhaps a more useful characteristic for the purposes of urban planning is the degree of separation from traffic customary for each mode. This parameter influences such factors as speed of travel, length of vehicles (or trains), and passenger capacity. Of more relevance to this discussion is that the degree of separation also affects the cost and likelihood of a mode's implementation, as well as its compatibility with various forms of development.



Four principal modal families, based upon their degree of separation, are distinguished here: street transit, semi-rapid transit, rapid transit, and regional rail transit. A fifth category, special transit, encompasses several minor urban transit modes not classified elsewhere. The discussion below describes each of these families of transit and the modes customarily included within them. For all but the most common, an example is provided in brackets of one city where the mode is currently in operation. [For foreign applications, the following country codes are used: CA=Canada, CH=Switzerland, DE=Germany, FR=France, GB=Great Britain, and TT=Trinidad & Tobago.]

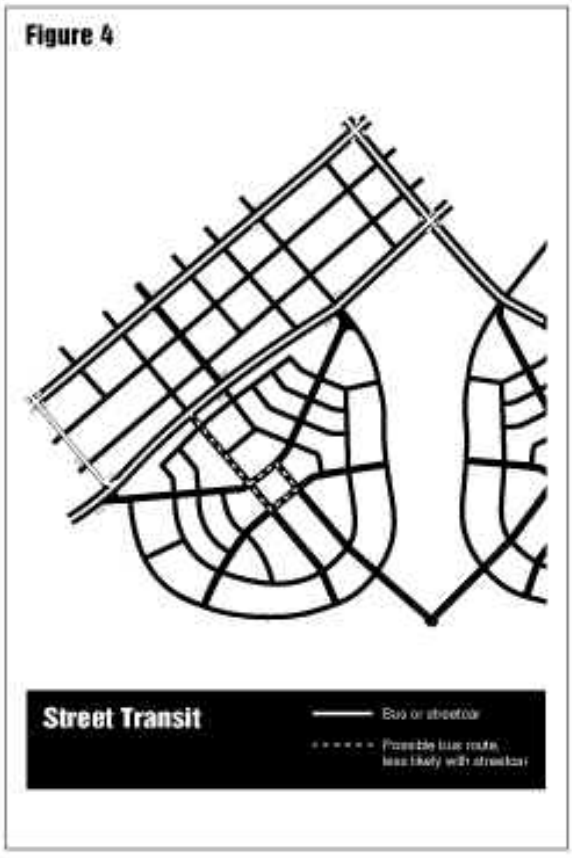
A. Street Transit

Street transit designates modes operating on public

thoroughfares in mixed traffic. This category originally consisted of horse-powered streetcars and coaches, later evolving into electric trolleys and buses. It now constitutes the most widespread family of transit modes because of its versatility and relatively low cost of implementation. Street transit modes are excellent candidates for integration into all kinds of urban environments (Fig. 4). The close spacing of passenger stops results in a high level of accessibility to adjacent development. However, this same characteristic, when combined with interruptions by traffic and pedestrians, can result in relatively low speed and reliability. This latter situation can be improved by the provision of priority treatment (e.g., exclusive lanes, signal preemption, etc.) for transit at strategic points on major thoroughfares.

Bus transit service consists of relatively large rubber-tired, multi-passenger motor vehicles operating along fixed routes on fixed schedules. Buses have customarily been powered by diesel engines, but concerns over emissions have prompted the development of motors running on a variety of alternative fuels, electric batteries, or even flywheels. Regardless of the power source, buses come in many sizes that can be suited to their function in the region. The standard transit bus is 40 feet long, but minibuses half that length are available for short feeder routes, while heavy trunk lines can be served by 60-foot articulated (hinged) units or by double-deckers. Needless to say, the high-capacity buses are more appropriate on main streets at the edge of neighborhoods than at their centers. Traffic calming devices and narrow streets can effectively bar even standard buses from these centers. Conversely, small buses can penetrate neighborhood centers, but their lower capacity reduces their cost-effectiveness and range. On heavily-used bus routes, limited-stop service can supplement regular local service and offer more attractive travel times. Express bus service with even fewer stops can be offered on both city streets and freeways.

Electric Trolley Buses are similar to conventional buses but are powered by electric motors. Energy is transmitted to the motors through a pair of trolley poles on the roof of the vehicle, contacting a pair of overhead wires. This mode emerged in the 1930s as a way for transit companies to utilize their investment in electric power systems while divesting themselves of the burden of maintaining tracks and worn out streetcars. In North America, the few systems that remain are the result of the ability of these vehicles to overcome steep grades [Seattle] or operate in tunnels [Boston]. Electric trolley buses have most of the operating characteristics of conventional buses, except for their need for overhead wires. Concerns about the visual obtrusion of these wires and support posts makes them undesired in many residential areas. Conversely, quiet operation and smooth acceleration make trolley buses quite popular on older, established routes. Dual-mode buses are a variation that can be operated either as trolley buses or as conventional diesel buses. In the U.S., they are currently in service only in Seattle to take advantage of that city's downtown bus tunnel.



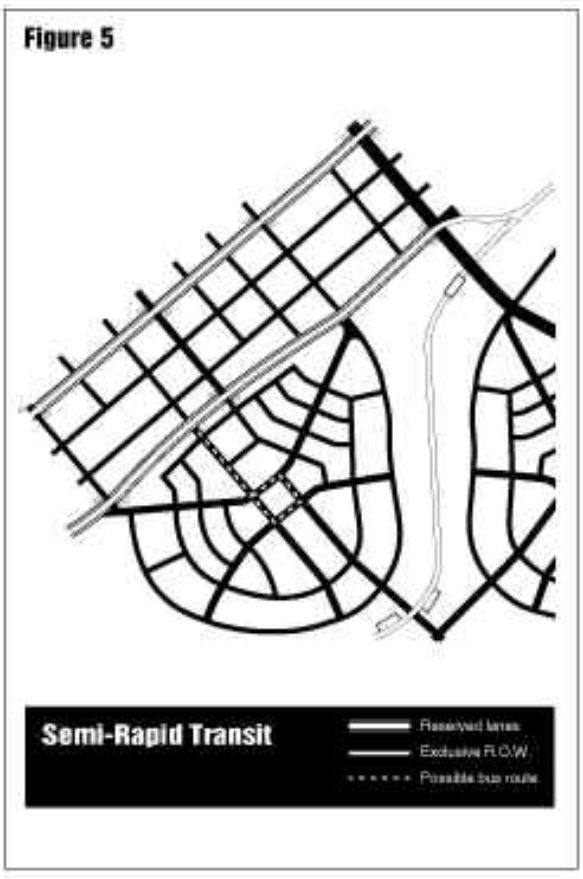
Streetcars (or tramways) are electrically-powered rail transit vehicles operating predominantly on city streets, often in mixed traffic [Toronto, CA]. These vehicles are customarily smaller rail cars operating singly, but this mode occasionally utilizes articulated cars or short trains of cars. Streetcars share buses' ability to provide fine-grained local service. Their low noise levels and lack of pollution make them particularly suited to the edges of residential areas, and they are popular with passengers. However, streetcars have relatively high implementation costs. They also lack the operating flexibility of buses to by-pass obstructions in the street environment. For this reason, they can be slower and less reliable than buses unless some preferential

treatment is given to them over general traffic. Streetcars are best suited for operation on heavily-used transit routes. It is possible for them to penetrate neighborhood centers, particularly those located near the end of the streetcar line, if they are carefully planned into the infrastructure of the community. However, construction costs and concerns about the visual impacts of tracks and wires generally dictate against this. Heritage streetcar lines use vintage streetcars [Dallas] or replicas of them [Galveston]. Their popularity may gain them more acceptance for operation within certain districts than conventional streetcars.

B. Semi-Rapid Transit

Semi-rapid transit designates bus and rail modes using alignments that are separated longitudinally from other traffic but which may allow grade crossings by traffic and pedestrians. Devices such as curbs, barriers, or even simple pavement markings are commonly adopted for this purpose. Short sections of exclusive transit lanes do not constitute a semi-rapid transit mode. Rather, substantial portions of the route used by the transit vehicles must be separated, though there may be some sections where the vehicles are operated as street transit and others where they are entirely grade-separated. Typically, stations are more substantial than with street transit and more widely separated. This latter attribute reduces local access but improves speed and reliability. Due to the use of physical facilities needed to by-pass traffic, most semi-rapid modes are best suited for providing corridor and edge service, though their operating flexibility allows them to penetrate high activity areas (Fig. 5).

Semi-rapid bus service encompasses several methods of operating buses in high-capacity service. One such method utilizes continuous sections of exclusive bus lanes in city streets [Curitiba, BR]. This form of operation is appropriate in major travel corridors where automobile traffic can be displaced onto adjacent streets. Another version uses busways, which are off-street rights-of-way reserved exclusively for buses. Some busways are entirely grade-separated, but the buses enter and leave them at certain points for on-street collection and distribution of passengers [Ottawa, CA]. Other busways allow for some at-grade crossings of intersecting streets [Port-of-Spain, TT]. Busways are generally located in the edges between districts, minimizing many impacts but offering less accessibility to activity centers. A third form of semi-rapid bus service features express buses operating primarily on high-occupancy vehicle (HOV) lanes on freeways, along with carpools and vanpools [Houston]). Such applications typically offer only peak-hour service, with local access to stations provided mainly through park-and-ride lots. These freeway bus operations can be a useful part of a region's mobility strategy. However, they are less able to shape future growth patterns because of their lack of off-peak service, their orientation to a limited number of destinations, and their dependence upon automobile access. Moreover, the freeway portions of these express bus services are physically divisive to the urban fabric. They must be restricted to the corridors, edges, and interstices of the community. An important advantage of all forms of semi-rapid bus, however, is the ability of the buses to leave the express facilities at various points to provide more localized service in particular neighborhoods or districts.

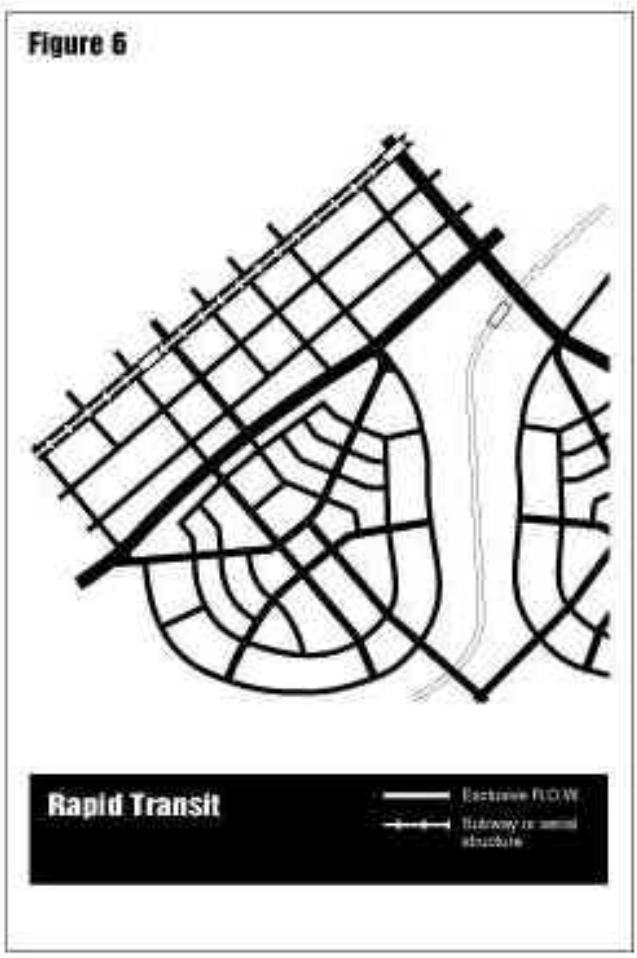


Light rail transit (LRT) utilizes electrically-powered rail transit vehicles operating predominantly in reserved rights-of-way but with the capability of operating on city streets [San Diego]. Cars are typically high-capacity articulated units and can be coupled into short trains.

Common rights-of-way include exclusive off-street alignments (generally with grade crossings) and reservations in city streets. However, many other configurations are possible, including sections of tunnels and aerial structures. Light rail transit involves a level of investment higher than that of buses and streetcars. This expense makes it appropriate only for routes in the urban area which handle relatively high levels of ridership. Thus, it is well-suited for major travel corridors, special-purpose districts, or major streets at the edges of neighborhoods. Penetrating these neighborhoods, however, is more challenging than with the semi-rapid bus modes. While light rail may be operated in these areas like a streetcar, it faces similar concerns about local impacts, as well as compromises in speed and reliability. Nonetheless, this strategy may be acceptable under special circumstances.

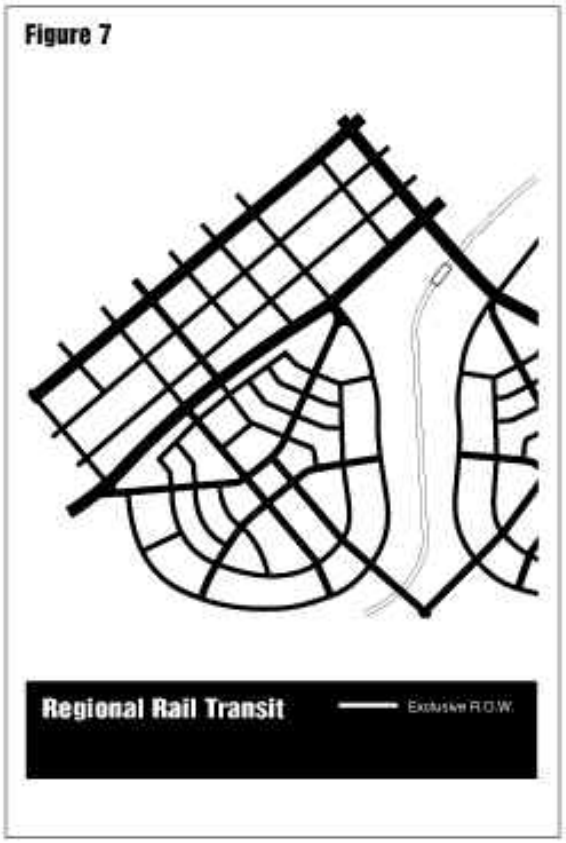
C. Rapid Transit

Rapid transit refers to modes using rights-of-way that are fully grade-separated. Rapid transit can accommodate high volumes of riders and is appreciated because of the quick and traffic-free service it provides. Accomplishing this requires the use of subways and aerial structures, or ground-level alignments with grade-separation for cross traffic and pedestrians (Fig. 6). Subway operation allows unobtrusive penetration into the heart of high activity centers, though the costs and disruption of construction may be significant. Aerial alignments are less expensive to build, but they may create visual or noise disruption and must be designed with care. Exclusive surface-level alignments without grade crossings are generally the least expensive but the most divisive. For this reason, they should be located where they do not impede the physical and social connections between neighborhoods and districts. Rapid transit stations are typically the most substantial of any form of transit. When siting such stations, it is important to avoid disrupting pedestrian-oriented areas with auto traffic destined to passenger pick-up or park-and-ride facilities.



Bus rapid transit consists of buses operating entirely in their own exclusive rights-of-way with grade-separated crossings. Such operations are rare [Runcorn, GB], and most of the busways that are commonly described as rapid transit are actually the core of semi-rapid bus operations, discussed earlier. This is because buses typically enter and leave these facilities to operate on local streets. In fact, this characteristic is considered to be a hallmark of the mode, though it may result in lower capacity and speed overall than true rapid transit. Even a facility like Seattle's downtown bus tunnel does not constitute a bus rapid transit system because of its short length (about 1.3 miles) in relation to that of the dual-mode bus lines using it (12 miles and more). While true bus rapid transit is technically possible, the large number of buses required to match the high capacities of the other forms of rapid transit would make it less cost-effective.

Light metro embraces several different technologies, all of which share the characteristics of grade-separation and moderately high capacities. This mode is embodied by many systems which employ automated guideway technology and medium-sized vehicles. In some, the vehicles utilize steel wheels running on steel rails [Vancouver, CA], while others have vehicles with rubber tires running on flat surfaces [Lille, FR]. These are distinguished from light-duty, internal circulator guideway systems



because they are an integral part of the urban transit system. Another variant of light metro is sometimes known as light rail rapid transit. It involves the operation of conventional light rail transit vehicles travelling entirely in exclusive rights-of-way [Newcastle-upon-Tyne, GB]. Operating economies are achieved by using short trains and on-board fare collection when conditions warrant. Lastly, there are a few monorails in public transit service, with the cars either straddling a beam [Seattle] or suspended from a trackway [Wuppertal, DE]. Most other monorails, however, operate entirely within specialized activity districts as internal circulators. Light metro systems can be substituted for rail rapid transit in medium sized cities that desire grade-separated service but do not have the required passenger volumes. They can be integrated into most urban environments with the cautions cited above for other rapid transit modes.

Rail rapid transit (or metro) systems utilize high-capacity electric rail cars that can be coupled into relatively long trains in exclusive rights-of-way [New York]. Capacity and service frequency are the highest of any transit mode. Subways, aerial structures, open cuts, embankments, and fenced alignments on the surface are all commonly utilized. However, the creation of these exclusive rights-of-way can result in some of the highest construction costs of any mode. To be cost-effective, therefore, rail rapid transit must be operated in corridors with substantial volumes of riders, generally found only in large cities. A variant of this mode is rubber-tired rapid transit [Montreal, CA]. Other than the fact that the vehicles are supported by rubber tires running on flat surfaces, the operating characteristics of this mode are similar to those of rail rapid transit.

D. Regional Rail Transit

Regional rail transit utilizes the urban portions of railroad lines for transporting large numbers of passengers relatively long distances within metropolitan regions. Exclusive rights-of-way are used, generally with a mixture of at-grade and grade-separated crossings. Because of its reliance on existing railroad lines, and its use of large vehicles, regional rail is almost always found in the edges and corridors of urban areas (Fig. 7). Often these have an industrial character due to the presence of railroad-dependent businesses along the trackway. Even in central business districts, regional rail terminals tend to be located at the fringes, although grade separation in tunnels has been used successfully to penetrate such areas in recent years [Munich, DE].

Regional rail originated as commuter rail, in which locomotives hauled trains of passenger cars in peak-period travel between jobs in a central business district and homes in its suburbs. However, the dispersal of work places and other activity centers has resulted in many systems now offering two-way, all-day service [Philadelphia]. Compared to rail rapid transit, trains are typically longer, service frequencies lower, and stations spaced further apart. Regional rail can be an economical way of initiating high-capacity service in corridors with underutilized railroad lines. A variation of this mode uses self-propelled vehicles powered by diesel motors (diesel multiple units or DMUs) or electric motors (electric multiple units or EMUs).

Diesel rail cars and ***railbuses*** are lower-capacity modes of regional rail transit utilizing self-propelled diesel units configured for single-car operation. These can serve lines with lighter travel demands. Some of the vehicles in use are quite similar to light rail, though powered by diesel engines instead of electric motors, and are capable of operation on city streets. While a new line

with these lighter units could be operated almost anywhere that light rail could, the reliance of this mode on existing railroad corridors to achieve cost economies generally results in locations in corridors and edges.

E. Special Transit

Special transit is the collective term for a variety of modes that do not easily fit into other categories. Several of them employ technologies similar to those used for internal circulator transport, but they apply them to regular transit service. Aerial tramways are suspended from overhead cables like gondolas but use substantially larger cars that can be as shuttles between two points in the city [New York]. Funiculars or inclined planes [Pittsburgh] use small rail cars hauled by cables in the trackway to overcome steep grades. Cog railways [Zurich, CH] are another mode for negotiating hills, incorporating a geared wheel to grip a rack in the trackway.

Urban ***ferries*** **[Hamburg, DE]** are vessels that breach the travel barrier created by bodies of water. Some use waterways as alternatives to parallel congested highways. Ferries may utilize very large vessels and carry vehicles as well as passengers. In urban areas, they are most often used in point-to-point shuttle service. Finally, aircraft in the form of helicopter shuttles have been used from time to time to transport passengers within very large metropolitan areas [formerly Los Angeles]. Their use has been short-lived, but new developments in aircraft technology could result in more viable systems.

Figure 8

Summary of Forms of
Urban Passenger
Transportation

- Private Transportation
- Public Transportation
  - paratransit
    - internal circulators
    - subscription transportation
    - for-hire transportation
    - public paratransit
  - transit
    - street transit
    - semi-rapid transit
    - rapid transit
    - regional rail transit
    - special transit