Transit Technology Capabilities and Comparisons

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Thesis

The selection of a technology for public transportation improvement in an urban area corridor is sometimes made based on incomplete information or unnecessarily restrictive assumptions. A selection made on this basis may be viable but far from optimal. This paper is offered to encourage the transportation planning profession to place the best information possible before those who ultimately make transportation improvement decisions – agencies, stakeholders, and the public at large.

The Truth, the Whole Truth, and Nothing But the Truth

As discussed by Steve Colman, Chair of the ITE Transportation Planning Council in a recent newsletter, we as professionals have an ethical responsibility to avoid too-limited characterization of potential transportation modes or other aspects of transportation improvements.[1] In addressing this subject he quoted from ITE and NSPE codes of ethics, which are consistent with this extract from the AICP Code of Ethics:

> "The planner must strive to provide full, clear and accurate information on issues to citizens and governmental decision makers."

This is a principle clearly relevant to plan-making as a whole, not merely to particular planning or engineering affiliations. I add that this applies not only to consultants, but also to transportation and related professionals in government agencies or private transportation endeavors. The general public may be predisposed toward certain views, but we should all do our best to represent the capabilities and consequences of possible transportation solutions as fully and correctly as possible.

An Ideal Process

In an ideal study, great care is taken at the outset to make sure the general public understand the range of transit alternatives that might be considered – not only by mode (vehicle type), but in terms of the rights of way in which they may operate, and the operational alternatives that may exist. A broad-ranging educational effort can be useful in dispelling incomplete or erroneous views about transit modes.

This would be followed by scoping of the study, designed to be as comprehensive as possible, and work planning that will avoid premature screening out of alternatives that may have merit under conditions that will be better understood later in the study.

It is not unusual for a professional's experience to be oriented more toward one mode than another. In such a case there may be, in spite of a sincere effort to be objective, a tendency to see the advantages of one mode and the limitations of another. If budget permits, it could be valuable to set up a "mode advocacy team" for each modal alternative that is to be examined in a study, and to assign that team the task of designing the best possible infrastructure and service conditions for their mode. In other words, each mode would be optimized through a process that put the right resources at work for that purpose. A further, independent “referee” role within the team would assure that each mode’s definition and evaluation followed consistent assumptions and methods. “Form follows function” should be a guiding principal.

Inadequate Information; Imperfect Solutions

When those in the decision-making process are deprived of adequate knowledge, sub-optimal solutions result. Some of that adequate knowledge results only from systematic analysis of specific cases, but other information is available “off the shelf”, to transportation professionals if not to the public at large. It is this latter body of knowledge that is specifically addressed in this paper.

This paper focuses particularly on light rail transit (LRT) and bus rapid transit (BRT) as technologies that have much in common and are often examined as alternatives between which a choice is to be made. They have similar average speeds if line, station, and passenger entry/exit conditions are similar; it is possible to use identical route designs and operations plans in some cases; both can use electric motors for propulsion, and overhead wires for power supply. Both can be steered by the guideway rather than by the driver. Buses can, if need be, have doors on both sides, to allow use of center as well as conventional right-side platforms[2]. Both can employ low-floor vehicles.

The two modes may be more broadly competitive than is usually recognized. At the same time, there may be advantages that make either mode the better choice for a specific application. For example, a line that is suited to express operation is likely to be better served by bus than LRT. The required capacity ceiling may in other cases favor LRT. In between these and other attributes lie cases in which either mode is suitable.

Physical and operational characteristics of these technologies are discussed in this paper, particularly with regard to ranges of criteria that may be useful and acceptable in various corridor applications. There may be a tendency to over-specify requirements with regard to maximum operating speed, shortest or longest acceptable headway, station length, passenger capacity, operational effects of curves, clearance envelope relative to movable objects, slowed operation due to grades, desired and acceptable station platform width, vehicle width, or other features.

Opportunities for cost savings or cost deferral through incremental development or staged upgrading of fixed guideway corridor projects can be important. Possibilities such as adding a line in another corridor, when more capacity is needed may be considered. An example of incremental development is found in a recent study for the Dulles Airport corridor proposing BRT as an interim step in light rail implementation.

What are the realistic requirements with regard to initial and ultimate capacity, potential extensions, maximum speed, or other attributes of a transportation solution? Sometimes corridor studies neglect the relationship to area-wide plans, omitting provisions for future system expansion. In other cases corridor studies may be unrealistically constrained, introducing design or specification restrictions based on system-wide criteria that may never be essential for a particular corridor. Portland provides a positive example in its use of a different light rail vehicle (LRV) for its new intra-city “Portland Streetcar” line, rather than the larger, faster vehicles employed on the main radial lines. They concluded, doubtless with good reasons, that the new line will not have any need to be integrated with the “Tri-Met” Eastside and Westside MAX lines.

Is it better to assume future branching and extensions of an in-street urban light rail line onto suburban reserved rights of way, or plan to use separate new lines to serve the suburbs? Either solution may work, but there may be better service and fewer design compromises if each distinctly different service type is kept separate, just as express and local bus routes are distinct from one another, and often use different kinds of vehicles. The decision has a bearing on the extent of difference between LRT and BRT alternatives.

Some Observations

Better information can take various forms, including the quality of general descriptions of the available transit technologies and their characteristics. One should avoid limiting a transit mode's description to the characteristics of one example. An Ottawa busway, for example, is designed for high bus volumes, high speeds, and multiple bus routes. This requires features such as at least one added lane at stations for buses that do not stop, or to allow stopping buses to overtake one another, and generously-spaced stopping locations, to allow buses to pull in ahead of or pull out from behind other stopped buses. Under different operating conditions, the number of lanes could be reduced, even to the extent of providing only a single lane in each direction of travel. This might work quite well for a busway in which bus headways are not particularly close. In the same or other settings, lower design speeds might be accepted[3], with significant savings in geometric design criteria, related right of way requirements, and project costs. A range of busway usage strategies may be investigated, including assignment of multiple routes that enter and leave the busway at various locations, or the other extreme, a single route that operates only within the busway, much as does a light rail line.

Applicable cross sections in exclusive and shared rights of way are another case in point. In Los Angeles, the Blue Line uses a 22-foot cross section for its two tracks in Washington Street, after designers were unable to achieve other lane width and sidewalk width objectives while reserving the desired 24 feet for light rail[4]. While it may sometimes be imprudent to modify criteria early in the planning process, recognition that such compromises are possible and workable can materially influence the search for solutions when transportation improvement concepts are being developed. Route alternatives that might be discarded on the basis of preferred alignment or other design criteria might well be carried far enough into the study process to determine whether they have service, cost, environmental, or other advantages sufficient to warrant relaxation of design criteria.

A general description of busways, BRT, or light rail should encompass all relevant ranges of configurations and operating strategies.

In the case of light rail, there are many kinds of operations and consequent infrastructure requirements, just as there are for BRT. Light rail configurations range from total grade separation, like heavy rail rapid transit, to the opposite extreme, operation in city streets in lanes shared with other vehicles, like ordinary bus service.

Any discussion of BRT and LRT should address the pervasive idea that buses are somehow a “second-class” mode, compared with rail, and if that is true, cannot attract the same level of ridership, nor serve as well as a focal point and catalyst of “transit-friendly” development. The literature contains examples indicating this to be the case, but without irrefutable documentation. There are also studies concluding that there is no recognizable difference between light rail (or other rail transit) and high quality bus service, in terms of user response and influence on development.[5]

For those who conclude that there is a difference, reasons for the difference are given. They include the sense of permanence associated with the presence of the visible infrastructure including rails, stations, and electrification; the assurance such infrastructure gives to riders (especially those new to the city or the system) that they will reach their intended destination; the greater predictability of arrival time and overall travel times associated with transit operating in a reserved right of way; the ease of use resulting from the naming of stations; the security (in some cases) of knowing that the vehicle will stop at every station without depending on the passenger’s signaling the operator; and ride comfort factors related to the quality of the alignment and the effect of guidance by means of rails.

Given the possibility that all of these factors are significant and do in fact enhance the attractiveness and use of rail transit compared with ordinary bus service, it is reasonable to consider the extent to which similar attributes can be achieved in a BRT system. In fact, if this is a deliberate objective in designing a BRT system, it can be made to mimic essentially all of these characteristics, even including the use of electric power and guideway-steered vehicles. New-passenger insecurity about where the vehicle is going could be mitigated by designing the system as a guideway-only route, just as is an LRT system. This simple and understandable approach might be of sufficient advantage to offset the loss of routing flexibility usually associated with and valued in bus systems. Examples of this approach among the FTA project cities include the Boston Silver Line and the Lane Transit District's East-West BRT Corridor in Eugene, Oregon.

The FTA program of BRT projects[6] may, with its variety of examples, help to clear up some of these debates, and could provide examples that will expand public and professional understanding of what is possible and will be successful. We look forward to learning from these projects. In the meantime, they can serve to demonstrate a range of BRT concepts, partly defining the BRT spectrum. A matrix on page six identifies differences and similarities among the 16 cities that make up FTA's BRT consortium, which includes ten demonstration projects and six participating projects.

General Description of Bus Rapid Transit (BRT)

This terminology has not been in use over an extended period, and there is no concise definition of the mode, although an FTA statement describes objectives and means of addressing those objectives. One means of understanding how these objectives can work out in practice is to examine the Federal Transit Administration's Bus Rapid Transit Demonstration Project, to discover the characteristics implemented or planned in each case. This may be better than examining pre-existing BRT projects, which are few in number. We reviewed information about the projects available through the FTA BRT web site (http://brt.volpe.dot.gov), and compiled the matrix of features of the projects. The matrix may not be entirely consistent or complete with regard to each project, since the projects are not all fully defined. It is more likely that the table contains omissions than incorrect inclusion of any project feature. Bearing this in mind, the table should be valid in representing the range of BRT features or characteristics, and how pervasive these are in BRT practice within the United States.

SELECTED CHARACTERISTICS OF BRT PROJECTS IN THE USA (FTA BRT PROGRAM)

Source: Compiled by PB from FTA BRT Data

		FTA Demonstration Projects										Other Participating Projects					
		Boston: The Silver Line	Charlotte: Independence Corridor	Cleveland: Euclid Corridor BRT	Dulles Corridor Rapid Transit Project	Eugene: East - West BRT Corridor	Hartford: New Britain - Hartford Busway	Honolulu: BRT Projects	Miami: South Miami - Dade Busway	San Juan: Rio Hondo Connector	Santa Clara: Line 22 Rapid Bus Corridor	AC Transit: San Pablo Corridor	Albany: Best Bus Program	Chicago: Western Avenue Express	Los Angeles: Rapid Bus Demonstration Project	Montgomery County: Veirs Mill Road	Pittsburgh: West Busway
vehicles	minibus								●	●						●	●
	40-foot		●			●	●	●	●			●	●	●		●	●
	60-foot (articulated)	●	●	●	●	●	●	●	●		●	●				●	●
	low floor	●	●	●		●	●	●	●		●	●	●	●	●		●
	doors on both sides			●													
	electric (trolley)	●		●		●											
	electric (no wires)					●		●									
	internal combustion	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●
	dual energy source	●															
line	shared lane	●		●	●	●		●			●	●	●	●		●	●
	exclusive lane, in street (or freeway)	●	●	●		●		●		●					●	●	
	exclusive lane, separate right of way	●					●		●						●		●
	curb-guidance lanes					●											
	some use of reversible single lane					●											
stops	ordinary bus stops			●	●		●	●	●		●	●	●	●		●	●
	stations or "super stops"	●	●	●	●	●	●	●		●	●	●			●	●	●
	passing lanes at stations				●		●										●
priority	signal priority or preemption	●		●		●	●	●	●	●	●	●	●	●	●	●	●
	queue jumps		●			●		●			●	●	●			●	
	bus bulbs or turnouts										●	●	●				
information	AVL (automated vehicle location)	●	●	●	●	●	●	●	●		●	●	●	●	●	●	
	information in stations	●	●	●	●	●	●	●			●	●	●	●	●	●	●
	information in vehicles	●	●	●									●				
fares	in vehicle			●					●		●			●		●	●
	in vehicle advanced		●		●			●		●		●	●				
	in station				●	●					●	●					●
operation	express		●		●		●		●	●			●				●
	rapid bus (fewer stops than limited stop)								●						●		
	limited stop	●		●	●	●	●	●	●			●		●			●
	local		●		●				●		●	●	●				
development	encourage station-related development			●	●		●	●					●				●
image	special color/livery				●							●			●		
	special signing													●			
	unique vehicle	●		●	●	●						●					
staging	possible future conversion to LRT		●		●	●			●								●

Thus the matrix demonstrates the following:

1. Most BRT projects use conventionally-powered buses (internal combustion engines); 40-foot and articulated 60-foot vehicles are common, and most are using or planning to use low-floor buses. (Double-articulated buses approximately 80 feet in length are possible, although we believe them to have been deployed thus far only in Curitiba, Brazil.)
2. Both in-street shared lane and exclusive lanes are being used. Exclusive-lane BRT includes not only facilities in streets or freeways but also the use of off-street right of way (most commonly abandoned rail lines). Some BRT routes include portions that are totally grade-separated, including elevated or underground alignments.
3. Most use stations or at least a few "super stops" rather than or in addition to ordinary bus stops; the latter may be shared with local bus service or may be exclusively for BRT use.
4. The most common type of service is "limited stop", but a number of projects include other types of service – express or local. Some projects operate the BRT service as a single route, much like a light rail route, while others use the corridor as an opportunity for various routes to enter and leave the BRT alignment.
5. Most BRT projects give signal priority (in at least one case, pre-emption), generally making use of Automatic Vehicle Location (AVL) capability in doing so. AVL also is widely used to provide real-time information for management of operations, and to provide information to passengers, either or both in stations and on board buses.

Other BRT characteristics occur in only a few of the cases in the FTA program. Most significant among these are:

6. Electric or dual-powered buses, used to avoid mobile-source emissions or reduce noise.
7. Buses with doors on both sides, to allow use of center-platform stations as well as normal curb-side stations or stops.
8. Guided bus technology (curb-guidance). This allows the use of narrower lanes, or higher speeds for a given lane width. It may also allow achievement of a small enough gap between bus doorways and station platform edges to accommodate wheelchair access without requiring a bridge plate. This improves the convenience and speed of passenger ingress and egress.
9. "Rapid transit" station spacing (stations spaced farther apart than for limited-stop service). This is the BRT definition being developed in Los Angeles.
10. Passing lanes in stations, to facilitate express bus operation or to facilitate high bus volumes.
11. In-station fare collection, primarily to expedite passenger boarding.
12. Encouragement of station-related development.

13. Use of unique vehicles, signing, or color schemes to distinguish BRT service from other bus service.
14. Provision for later conversion from BRT to LRT.

The application of these various features can be characterized as representing two alternative philosophies in BRT applications. One philosophy is to develop facilities in a corridor to expedite and make more attractive and efficient all or most of the bus services that make use of that corridor. The other philosophy is to develop facilities, equipment, and service plans for a specific route, for its optimal performance. Possible advantages and disadvantages of these two approaches will be touched upon later in this paper.

General Description of Light Rail (LRT)

Although light rail, like BRT, has no concise definition, the range of features is not as diverse as found in BRT. This results primarily from the fact that LRT is of necessity confined to the routing of the tracks. Even so, a light rail system may include multiple branches, and may “short-turn” some trips, to serve busier parts of the system.

Most light rail systems in the United States have the following characteristics:

1. Electrically-powered vehicles receiving energy via overhead wires are used. Both monobody and articulated vehicles are used, the articulated type predominating. Most recent vehicle procurements in the USA are of the partial low floor type. Most LRT systems run trains of two to three (sometimes four) vehicles coupled together, rather than single vehicles. Light rail vehicles (LRVs) are most often reversible, to allow changing direction without requiring a turnaround loop. Reversible cars have provisions for a driver at each end of the car or train, seating divided between directions, and doors on both sides.
2. Both in-street shared lane and reserved or exclusive lanes are being used. Exclusive-lane LRT includes the use of off-street right of way (most commonly abandoned rail lines, or in some cases, rail lines shared with other rail service, usually time-separated). Some light rail lines have totally grade-separated route sections, including elevated and underground alignments.
3. Most use stations rather than minimal stops.
4. The most common type of service is “limited stop”.
5. Most LRT systems have signal priority (sometimes pre-emption), generally making use of AVL capability in doing so. AVL also is widely used to provide real-time information for management of operations, and to provide information to passengers, either or both in stations and on board buses.

Certain features are outside the norm. These include:

6. The use of diesel-powered light rail cars.
7. Single-ended (non-reversible) LRVs (requires turnaround loops at the ends of lines).
8. Two-direction use of single-track sections (where right of way is limited, or as a cost-saving method for low-frequency service).

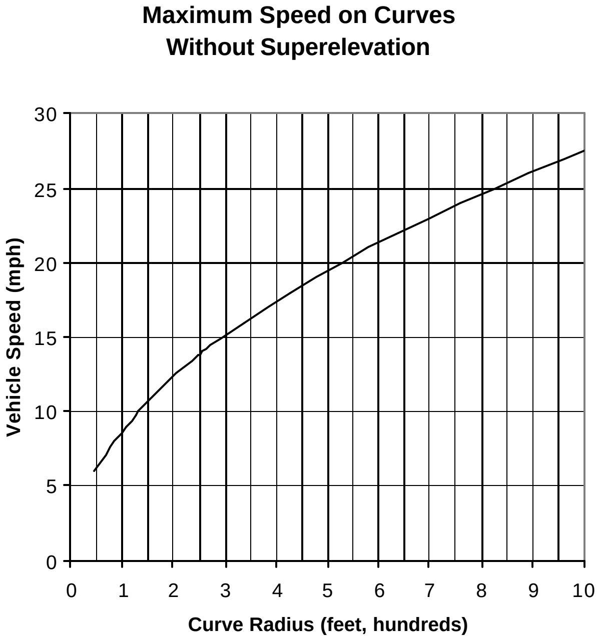
Design Guidelines

The following discussion provides general information regarding several design aspects important in planning BRT or LRT applications.

- LRT station and train length: Maximum usable train length is governed by the vehicle design, which may limit the number of cars that can be coupled together in a train, and by the station length; normally all stations on a line have the same length, corresponding to the length of the longest train operated. Station length cannot exceed the distance between adjacent traffic crossings along the line, at any location where trains may have to stop. A common maximum LRT train length is about 270 to 300 feet, which is the length of three articulated LRVs and a typical city block. Ideally, a train is somewhat shorter than the distance between adjacent crosswalks, so as to avoid interfering with pedestrians and to allow enough distance for 1:12 ramps from street level to station platform level without unduly restricting access to any train doors. The needed station length may be less if ridership forecasts and operations plans result in satisfaction of service needs with shorter trains, for the foreseeable future. For information on a variety of station configurations, see sources such as the monograph noted at the end of this paper[7].
- BRT station length: The maximum acceptable station length is generally the same as for light rail, although in certain cases a station might be divided between adjacent city blocks. The actual requirement is a function of operating conditions, including the required number of buses per hour per direction during peak hours, and the maximum number of those buses that may be expected to accumulate at any single station during that period. The maximum accumulation is a function of headway, dwell times, the “bunching” effect imposed by traffic signal cycle lengths, and possible additional irregularity due to traffic-related delays. Dwell times are discussed under “average running times”, below. Accumulations and the capacity to accommodate them also will be influenced by the routing strategy (single or multiple routes), and roadway configuration at stations, e.g., a single-lane in each direction, or a stopping lane and a passing lane in each direction. In the latter case, the reliable throughput of buses may be higher due to the fact that any bus can enter or leave the station independently of the others.
- BRT guideway (curb-guided bus): The simplest guided bus system of which we are aware is the curb-guided bus developed in Germany and deployed there and in Adelaide, Australia. This system uses small guide wheels mounted on the bus steering arms. The guide wheels, located a few inches above the road surface, project slightly beyond the front wheels so as to contact and run along a curb of about eight inches in height. At guideway entry locations, the curbs are flared, to form a “funnel” into which the driver steers the bus. Advantages of this technology stem from the precise steering of the vehicle. This (a) allows the bus to operate safely within a narrower dimension than would be acceptable for a driver-steered bus, (b) provides better ride quality due to the absence of inadvertent irregularity in the vehicle path, and (c) may allow achievement of ADA-compliant platform – bus floor dimensions without resort to a bridging plate, if the guidance system is continued through stations. Some guided bus systems discontinue the

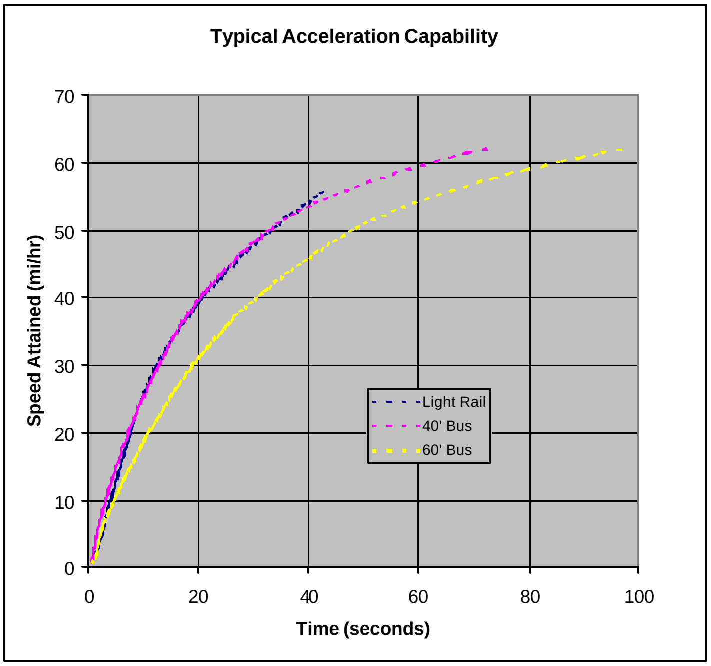
guide curbs in the stations, to allow buses to use a passing lane within the station area. A known disadvantage of this guidance system is that a bus cannot be backed up or pushed backwards (because the tires tend to ride up over the guide curb), and this limits strategies for dealing with vehicle failure and recovery. Also, the curb is an effective barrier, preventing vehicles from entering or leaving the guideway – an advantage or disadvantage, depending upon the aspect of operations being considered.

- Low floor vehicles: Most LRT or BRT studies will assume the use of low-floor vehicles. These are commonly of split-level design, to allow a higher floor in part of the vehicle, to provide clearance for the running gear or other mechanical or structural components. Some buses provide a sloping floor without steps, and there are LRV designs that achieve a 100-percent low-floor configuration[8]. Those currently in service have a lower maximum speed than is usually accepted in US light rail systems (the Portland Streetcar is one exception among new systems). Low floors in both LRVs and buses are generally about 12 to 14 inches above the guideway surface. Advantages of the low-floor vehicles include easier satisfaction of ADA requirements, and greater speed and convenience of passenger entry and exit from low station platforms (see discussion of stations in this section).
- Curve radii; superelevation; curves in stations: Engineering preference in light rail design is to use the longest-radius curves possible, because short-radius curves require restriction of vehicle speed, tend to cause increased track and vehicle wear, and may result in noisy operation due to wheel squeal. These difficulties are reduced if superelevation can be used, but this may not be possible for in-street alignments. Speed restriction is also a factor in bus operation through curves, again with superelevation being a possible source of relief. Despite these preferences, it is possible to use short-radius curves if there is sufficient reason to do so. An example would be the need for an in-street track to turn at a street corner without having to acquire property or use the entire width of the intersecting streets. In such cases, light rail systems may accept minimum radii of around 80 feet (less in a few cases). Buses can achieve tighter turns, equivalent to a "centerline" radius of about 40 feet, but with a wider path. Vehicle speed through curves is governed by passenger comfort, as measured by the extent to which lateral acceleration is accepted. For flat curves (i.e., with no superelevation), the figure illustrates the relationship between curve radius and speed. The significance

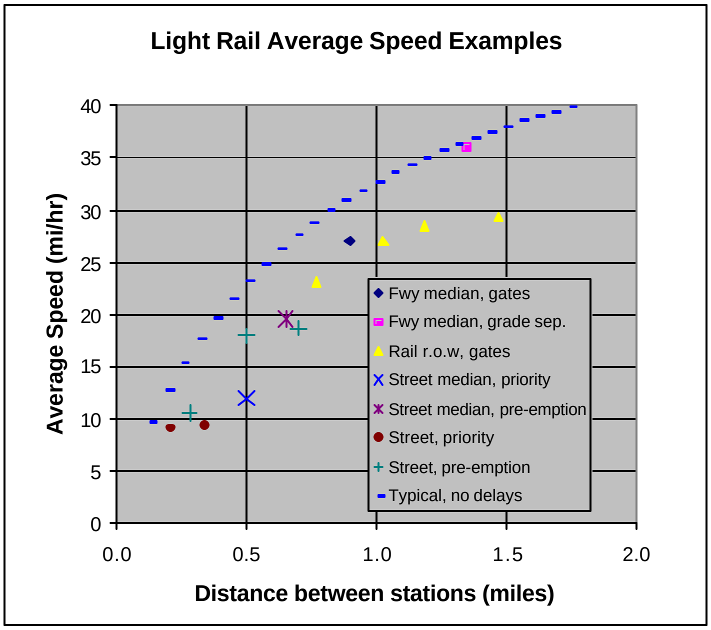


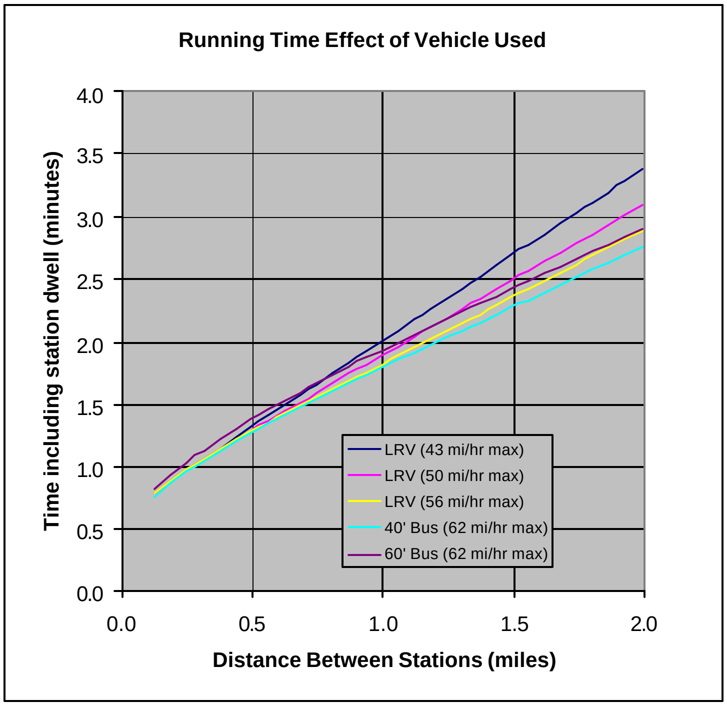
of the speed limit in curves is affected by circumstances, such as the proximity of the nearest passenger station or other mandatory stop, and any speed restriction on adjacent straight track. The absolute effect of any speed restriction is also influenced by the length of the vehicle or train being operated, since the entire length of the vehicle or train must not exceed the limit while occupying that portion of the line.

- Maximum grades, line and stations: Because vertical grades are generally undesirable, criteria often place low limits on acceptable grades (e.g., four percent or less), citing reasons such as the need for one vehicle or train to be able to push or pull a stalled vehicle that has lost the use of its propulsion system. In practice, light rail systems are found with gradients of as much as eight percent or more. Buses, especially trolley buses, can tolerate equal or greater vertical grades. Steep grades result in reduced acceleration and maximum speed capability when climbing, and may require reduced speed downhill as well, due to braking limitations. Grades normally are limited to about one percent in stations.
- Maximum speeds: Maximum vehicle speed may be governed by vehicle capability or by characteristics of the operating environment which include civil speed limits, distance between stations, requirements to slow or stop at traffic crossings, vertical gradients, and horizontal curves. For buses, the maximum attainable cruising speed is commonly 60 to 70 miles per hour; for LRVs in the USA, it is usually 55 to 60 miles per hour. For some types of LRVs, especially in Europe, the maximum speed is in the 40 to 45 miles per hour range. For applications with few station spacings exceeding three-fourths of a mile, the ability to exceed 45 miles per hour is of little value, and the same is true for lines that operate in city streets where higher speeds would not be allowed, or where other conditions restrict opportunities to achieve higher speeds.
- Acceleration and braking: For most LRT or BRT operating regimes, these differences are not likely to be of much consequence in terms of running times. The maximum initial acceleration rate for a loaded LRV is likely to be three to four feet per second per second, and a similar deceleration rate can be assumed. Acceleration rates are similar for typical LRVs and 40’ urban transit buses, but the latter achieve a higher maximum speed as noted above. Articulated (60’) buses accelerate less rapidly but attain a maximum speed similar to that of a 40’ bus. Acceleration performance of these types of transit vehicles is shown in the figure[9].



- Average speed achieved: The average operating speed attained in normal service is a function of vehicle acceleration and deceleration rates, the distance between stations or other stops, the maximum allowable or attainable speeds, and the amount of time at stops. Attainable speeds and the extent of slowing or stopping other than at stations are affected by characteristics of the alignment, which may include gated crossings, cross streets with other forms of traffic control, curves, and grades. Stopped time at stations is governed mainly by passenger entering and exiting time, including the time required to open and close doors. Entering and leaving flow rates can vary widely, and are influenced by factors such as conflicts between the on and off movements, whether or not floor-level platforms are used, and the fare collection method. Total dwell time is influenced by the number of passengers using each "lane" of each doorway. Consequently the number and width of doors is significant. In practice, the North American LRT systems demonstrate average platform speeds (operating speeds excluding layover time) ranging from 9 to 27 miles per hour[10]. The lower end of this range is for in-street urban systems, while those at the higher end are generally more suburban in character and include use of reserved right of way, longer station spacing, and fewer at-grade vehicular traffic crossings. The figure above shows reported average speeds for segments of the Portland, San Diego, and Sacramento systems[11], and an example (identified as "typical, no delays) of what might be expected if there were no effects of traffic conflicts, curves, or grades. We have no comparable data for BRT systems, but similar results can be expected. The figure at right[12] provides a comparison of running times for different vehicle types running on an exclusive right of way. As





one can deduce from the previous figure, these differences may or may not materialize in actual practice, due to the various conditions that affect travel times.

Passenger Capacities

The potential line capacity of LRT and BRT is in most cases a differentiator between the modes, although both modes may in some cases exceed the capacity level required to meet demand forecasts. The determination of practical capacity requires consideration of a number of factors including vehicle capacity, train capacity in the case of LRT, station length, required dwell time at the busiest station, station configuration in the case of BRT, train control capability in the case of LRT, and traffic signal and intersection traffic characteristics for both modes. These factors will determine the attainable vehicle loading (passengers per vehicle) and the practical maximum number of vehicles per hour. Typical resulting passenger capacities for in-street applications in North America, as measured by the peak-hour peak-direction passenger volume at the maximum load point of a line, are up to 8,000 or more for LRT, and up to 5,000 or more for BRT, if the latter is restricted to operation within a single lane per direction at stations.

Concluding Comment

As a final way of considering the capabilities of these two modes, we might compare them as in the following simple matrix:

Attribute	LRT	BRT
Confined to tracks (guideway)	Yes	Yes if desired
Tracks provide "presence" or certainty of route	Yes	Possible, especially if guided-bus technology is used
Vehicles are unique	Yes	Possible
Stops at all stations	Possible	Possible
Stations have names	Possible	Possible
Operation is quiet	Yes (some have noise problem on short-radius curves)	Possible (can use electric propulsion)
Ride is smooth and of high quality	Normally	Possible, especially if guided-bus technology is used
Stations are comfortable and have amenities	Possible	Possible

While there may be good reason, in any specific application of either of these modes, to depart from some of the attributes tabulated above, we conclude that LRT and BRT can be virtually identical in terms of the features that most clearly distinguish them from ordinary public transit bus service.

We may also note some other ways in which LRT and BRT can resemble one another, in adapting to particular constraints:

Constraint	LRT	BRT
Operate in 11-foot wide lanes	Yes, under certain conditions	Yes, under certain conditions
Use center-platform stations	Normally yes	Yes, under certain conditions
Share guideway with conventional railroad (time-separated operation)	Yes	Yes, under certain conditions
Place stations on curves	An acceptable minimum radius must be determined, and may affect means of meeting ADA requirements	An acceptable minimum radius must be determined, and may affect means of meeting ADA requirements
Share guideway with mixed traffic	Possible	Possible

In using this kind of information, we as planners will do well to begin with the best possible functional descriptions of alternatives, based on the perceived needs of a corridor or system. From the functional descriptions will come the forms of potential solutions: as in any technical solution, let form follow function.

Following this approach, the first step is to define the service objectives and opportunities, and then see how these requirements affect the choice and definition of mode. We use both “choice” and “definition” to recognize that each vehicle technology is not restricted to a single operating mode, but may be able to take advantage of a variety of circumstances that enable the vehicle and system to function optimally in addressing a particular problem. In its ideal form this approach results in “inventing the mode” by making the right combination of stop or station spacing and locations, right of way characteristics, fare system, propulsion system, use of guidance or not, and ultimately, the vehicle type and size. If these definitional steps do not yield a single candidate vehicle and system technology, then multiple technologies can be carried forward, and more detailed evaluation will provide the basis for a final decision.

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[1] Some Thoughts on the Ethical Use of Data, Steve Colman, TPC Chair, ITE Transportation Planning Council Newsletter, August, 2000.

[2] This is intended in the Cleveland, Ohio Euclid Corridor BRT, which will have both curbside (side platform) and median (center platform) stops/stations (see footnote 6 for source).

[3] Reinventing Mass Transit—A Solution for Karachi, Tahir Soomro (Karachi Development Authority) and David B. McBrayer (Parsons Brinckerhoff), presented at the Transportation Research Board, session of the Committee on Transportation Planning, Land Use and Technology for Developing Countries, January 1991.

[4] Creating a Light Rail Transitway within Existing Arterial Street Right of Way, Paul S. McCauley and James W. Swanson, Transportation Research Record 1361, 1992.

[5] Special Forum on Bus Rapid Transit, March, 2001 in Seattle, presentation by Sam Zimmerman, DMJM-Harris, referring to Demand Model Estimation and Validation, Talvitie et al, University of California at Berkeley, 1977, and

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Comparing Ridership Attraction of Rail and Bus, Moshe Ben Akiva and Takayuki Morikawa, MIT, 1991; also giving examples of BRT-economic development relationships

[6] The BRT program, http://www.fta.dot.gov

[7] The Planning and Design of On-Street Light Rail Transit Stations, Mark C. Walker, Parsons Brinckerhoff, 1993

[8] A Worldwide Review of Low Floor Light Rail Vehicles, PB Transit & Rail Systems, January, 1999

[9] Derived from data provided by PB Transit & Rail Systems

[10] Status of North American Light Rail Transit Systems, Year 2000 Update, John Schumann, LTK Engineering Services, for the Eighth TRB-APTA Joint Conference on Light Rail Transit, November, 2000

[11] Derived from data tabulated by John Schumann, LTK Engineering Services

[12] Derived from data provided by PB Transit & Rail Systems