Bus Route and Service Design Strategies for Major Radial Bus Routes

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ABSTRACT

The length and downtown orientation of the peak period transit market of typical radial bus corridors make possible efficient route design through the use of routing strategies that are targeted to particular submarkets. These strategies include conventional local and express service, along with the zonal express, restricted zonal local, semi-restricted zonal local, and limited-stop zonal local strategies. While all of these strategies have been used in U.S. transit operations, guidelines for applying these strategies are sketchy at best. This paper documents the first stage of a project whose purpose is to develop formalized methods for use and design of these strategies. It describes each of the strategies, discussing their relative strengths and weaknesses for different situations, and cites examples of applications in several U.S. transit systems.

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1. Introduction

Background

With growing pressure on transit agencies and localities to narrow the gap between revenues and costs, some properties have moved in the direction of service cuts and fare hikes. The potential detrimental effects of such actions on ridership and on public mobility are significant concerns. Another approach to cost reduction is to use route-level service standards, such as minimum boardings per vehicle-hour, to identify "substandard" services. Measures can then be taken either to eliminate them or modify them to improve their performance.

An important class of routes typically left unaddressed in the application of service standards is the CBD-oriented radial routes that serve moderate- and high-demand travel corridors. Because such bus routes serve strong natural transit markets, their performance is rarely substandard by most conventional indicators (e.g., boardings per bus-hour or average loads). However, high demand routes frequently offer great potential for increasing service efficiency because of the markets they serve and the large number of buses needed to meet capacity requirements. The high concentration of transit demand found on these routes facilitates the segmentation of the transit market into submarkets that can each be served very efficiently by a route designed to serve that particular submarket. The result can be a system of routes that requires fewer buses overall than the existing route, with little or no overall deterioration in the level of service. In many cases, service can in fact be improved.

Serving a heavy-demand bus route with a combination of services is a concept used by major transit systems in the forms of local and express services, short-turns, deadheading and other operating strategies. The operating strategies described in this report are, therefore, "classic" in the sense that they have been used in many large pro- perties for years. However, documentation of these strategies is sorely lacking. This paper summarizes the efforts to date to formalize guidelines and procedures transit operators can use in designing service on major bus routes. The work is sponsored by UMTA and TSC and is being developed under review of a study panel consisting of representatives from nine U.S. transit properties.

The service strategies discussed are intended for moderate-to-high demand routes that have a strong directional orientation (i.e., toward the CBD or a rapid transit station). As a rough guide, a route has "moderate demand" if the cumulative passenger volume for all the services on the route during its busiest period and in the peak direction is 8 or more busloads per hour. (Therefore, if only one route operates in a corridor, its average head- way should be 7.5 minutes or less to qualify as a moderate-demand route.) The strategies discussed in this paper tend to be useful only during periods in which corridor demand meets this headway qualification.

Service Design Objectives

The strategies described in this paper aim at improving the efficiency of service along a route by accomplishing the following objectives.

1. Increase the average operating speeds of buses, and thereby reduce the number of vehicles (and vehicle-hours needed per hour) to operate at a given service headway. The speed increase is achieved by designing non-stop trip portions that can be performed on high-speed roads such as expressways; by scheduling buses to make certain stops and to skip others; by deadheading vehicles in the reverse (light) direction; or by making it unlikely that buses will have to stop at all scheduled stops along a route.

2. Reduce the total number of vehicle-miles of service. The number of vehicle-miles operated on a route is directly reduced by designing service in which some buses do not travel all the way to the end of the route to complete their trips ("short-turns"). Through-routing (joining radial routes that emanate in different directions from the CBD) can also reduce costly downtown mileage.

3. Eliminate unnecessary schedule slack through interlining. Allowing vehicles to make successive trips on different routes (interlining) can lead to schedules that require less layover while maintaining regular headways.

4. Maintain the highest acceptable, and most uniform possible, vehicle loadings on all route segments. High and uniform vehicle loadings along a route mean that the equipment is effectively used since the service capacity is well matched to the level of demand at any point along the route.

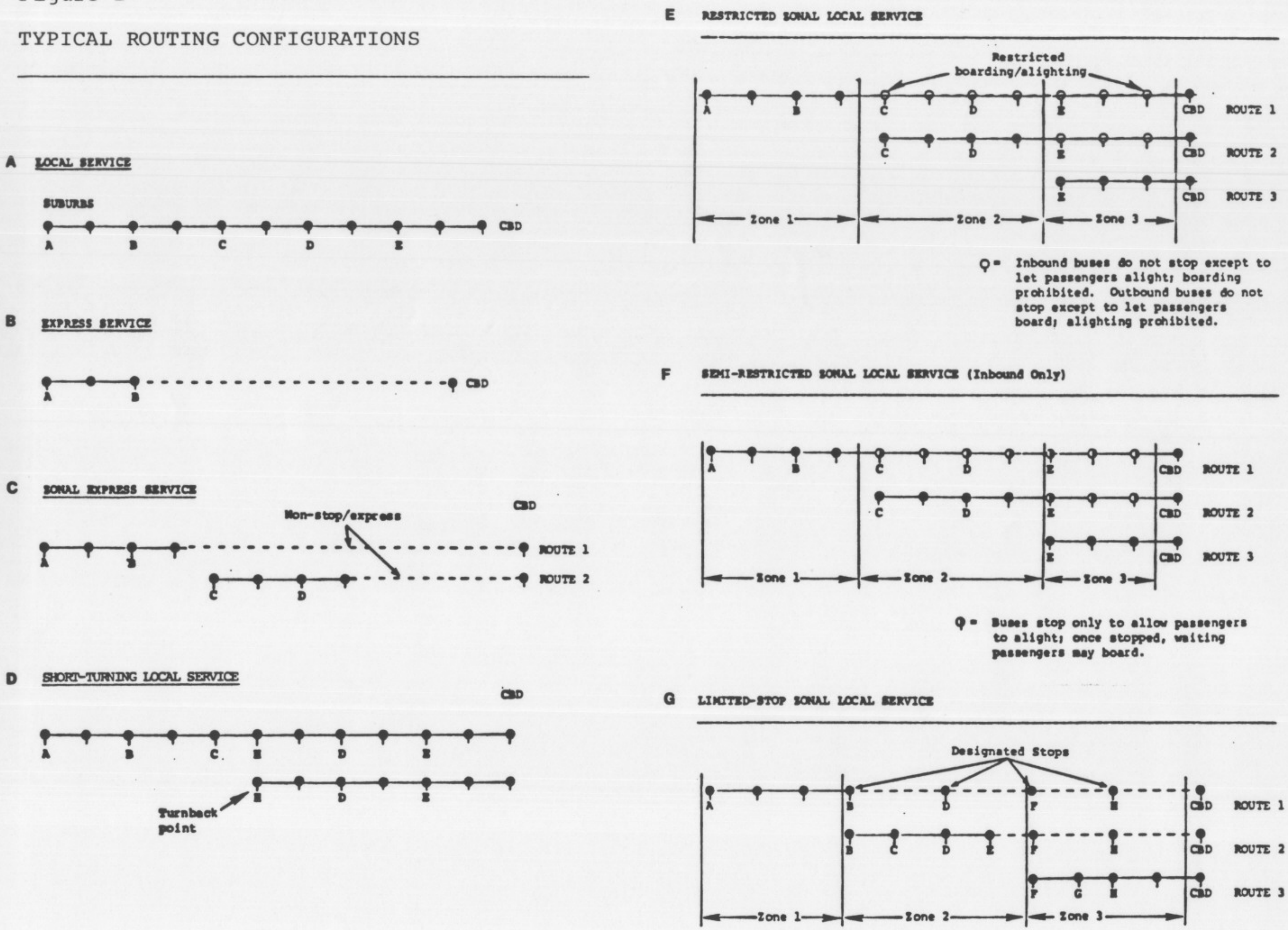
If the number of peak buses or pieces of work can be reduced through these design objectives, then cost savings can result from the route's redesign.

2. Express Service Design

An express route is defined here to mean non-stop operation between a designated collection area and a downtown area of distribution. Routes that meet this description except for a few stops in their line-haul portion are also considered express routes. However, there are routes known in some cities as express routes which, during their "express" portion, make regular stops less than a mile apart or permit buses to stop on demand to let passengers alight; such designs are considered to be a type of local service and are discussed in the next section. To operate express service, a reasonable concentration of trips destined for the downtown must obviously already exist. Figure 1(a) and (b) illustrate the typical local and express configurations.

Figure 1

TYPICAL ROUTING CONFIGURATIONS



Express service has a substantial speed advantage over local service because: (1) express routes have fewer stops, and (2) express routes are free to use the fastest path available during their line-haul and return portions. Thus, the presence of an expressway, while not a requisite for express service, can enhance efficiency considerably.

Five common factors that can significantly affect efficiency and cost-effectiveness of express route design are the following:

1. Downtown routing. In general, the downtown routing should minimize time spent on local streets. Some ways of accomplishing this are extending a route only part of the way into downtown; using an expressway for half of the CBD loop; and through-routing with a local route (see Section 3) or with an express route that makes reverse commute trips (see below).

2. Adding stops to express portion. When providing stops to the line-haul portion of an express route, these stops should serve more as destinations than origins during the inbound peak so that they do not significantly increase vehicle loads in the inner segment of the route; otherwise these stops will raise capacity requirements and result in empty seats in the long outer portion of the route. The added stops also should have a minimal impact on travel time. Typical intermediate stops would be a university, medical complex, or other employment center near the CBD, or a junction with a major crosstown route.

3. Reverse commuting. Express service, while aimed primarily at the CBD-commuter market, should be sensitive to potential demand for reverse-commute service to outlying industrial and commercial areas. Often the reverse trip can be modified at a small extra cost to serve an outlying employment or retail center and thereby attract new passengers and gain new revenues.

4. Fares. A fourth common issue in express service design is whether express routes should have premium fares. One line of reasoning is that since passengers value express service more because of its greater speed, and hence are willing to pay more, they should be charged more than their local counterparts. It has also been observed that express passengers can more readily afford a higher fare. However, some operators have found that passengers paying premium fares expect not just higher speeds but also less crowding and newer coaches--demands that cannot easily be accommodated without extra cost. Another line of reasoning is that since express service is a less costly way of serving downtown passengers (as long as high loads are maintained), fares should be no higher (and perhaps lower!) than local fares if the two types of services are in competition with each other.

The second line of reasoning is most important when express routes are in competition with local routes. Since their higher speeds make express routes a less costly way of serving downtown passengers than local routes, an operator will want to divert as many passengers from local to express service as possible, and therefore may not want to create the barrier of an express premium fare. On the other hand, if the express time savings is so great as to prevent serious competition from local service, a modest fare premium appears to be a way of reducing operating deficits with very small adverse impacts on ridership and level of service. A fare premium is all the more justified if safety considerations require that express service have few or no standees, since this requirement reduces the relative cost advantage.

5. Local service impacts. Finally, when considering expansion of the area now receiving express service into an area that now enjoys local service only, impacts to local service passengers must be considered. If some local passengers are diverted to the new express service, local service headways may have to be increased because of the smaller resulting passenger volumes. In the worst case, local service would be eliminated in the outer part of the corridor, forcing non-CBD travelers originating there to begin their trip on an express route and later transfer to a local route.

Zonal Express Service

An efficient way of providing express service in a corridor is through a zonal express system, shown schematically in Figure 1(c). For zonal service, the express service portion of a route is split into two or more zones, with a separate express route service created to serve each zone. Each zonal route then provides collection/distribution service only within its particular service zone, and travels non-stop between the closest-in stop of its service zone and the downtown. If the non-stop portion of the route is on an expressway, it is natural for expressway access points to serve as zonal boundaries.

A major advantage of the zonal system is that the average speed increases, since buses make fewer stops and spend less time in collection/distribution. This speed increase translates into shorter travel times for passengers (except those in the innermost zone) and lower operating costs for the transit agency through shorter turnaround time. This travel time savings offsets the longer wait times caused by zoning, either wholly or in part.

Another major advantage of the zone system is that, as with short-turning, the number of vehicle-miles (and consequently vehicle-hours) of operation in the corridor is reduced since only the route serving the outermost zone covers the full length of the corridor, and buses serving the inner zones travel only a fraction of the corridor's full length. This reduction in vehicle-miles can result in the savings of one or more vehicles.

One disadvantage of zonal service is that as the corridor is split into zones, the average route market size decreases, and so average headways must increase if peak bus loadings are to be kept up. With longer headways, of course, come longer wait times. This factor serves to limit the number of zones into which a very long corridor can be split.

A second disadvantage of zoning is that it may confuse riders, particularly in the outbound direction when they must be careful to board only their zone's bus.

In summary, then, zonal express service produces higher average speeds for buses and reduced in-vehicle time for most travelers. Zonal express service results in a reduction in the number of vehicle-hours of peak period service needed and can thereby reduce the number of peak vehicles required. However, zoning of express service leads to longer wait times, which must be weighed against travel time reductions.

Example: Zonal Express Service

An example of express route zoning is found in the Sheridan Road-Outer Drive corridor along Chicago's north shore, where the Chicago Transit Authority operates a complex system of zoned branching routes. For the sake of illustrating potential savings of this service strategy, a simplified routing system is assumed, as shown in Figure 2. Because of this simplification, the number of buses required for each route configuration do not exactly match the current operating requirements in the corridor, but reflect a realistic approximation of the resources needed to serve the demand were it a simple (i.e., non-branching) corridor.

The Sheridan Road corridor consists of a local street (Sheridan Road) and an expressway (Outer Drive). Local service in the corridor would require roughly 80 buses to meet capacity requirements. In contrast, conventional express service, pictured in Figure 2(b) as a single express route, would require about 72 buses; and the zonal express service with four routes, as would require only 47 buses. The zoned system would reduce overall average passenger wait time plus in-vehicle travel time by 22% compared to conventional express service. As these figures are based on a simplified routing system compared to the one actually operating in the corridor, they are only suggestive of the size of operating savings achieved with existing service.

3. Local Service Design - Peak Direction Strategies

During peak periods, the travel along a radial bus route typically has directional imbalance, enabling one direction to be designated as the peak direction of travel and the other as the light direction of travel. Because demand in the light direction is often only a fraction of peak direction demand, it makes sense to design service to match the directional demands to reduce the required number of peak vehicles. This section discusses a variety of strategies aimed at making peak direction service more efficient. The following section then discusses strategies to apply to light direction travel. If a corridor has no directional imbalance (e.g., for midday design), the strategies discussed in this section apply to both directions.

On a typical heavy demand bus route, local service can be improved in two ways. First, conventional local routes are slow; speeding them up by allowing buses to skip some stops would benefit the operator and most passengers. Second, because the demands for service along a route typically peak near the downtown and taper off towards the outer terminus, a conventional single route that offers uniform capacity along the entire length of the corridor provides far more capacity than is needed in the outer segments of the route in order to avoid overcrowding in the inner segments. Reducing offered capacity in the outer portions of radial corridors by turning vehicles back short of the end of the corridor can substantially reduce operator costs.

The following sections describe four peak direction strategies aimed at reducing vehicle-miles in the outer segments of a corridor or increasing speeds. These local service strategies are:

- short-turns
- restricted zonal service
- semi-restricted zonal service
- limited-stop zonal service

Figure 2

ZONAL EXPRESS SERVICE IN THE SHERIDAN ROAD CORRIDOR (Simplified)

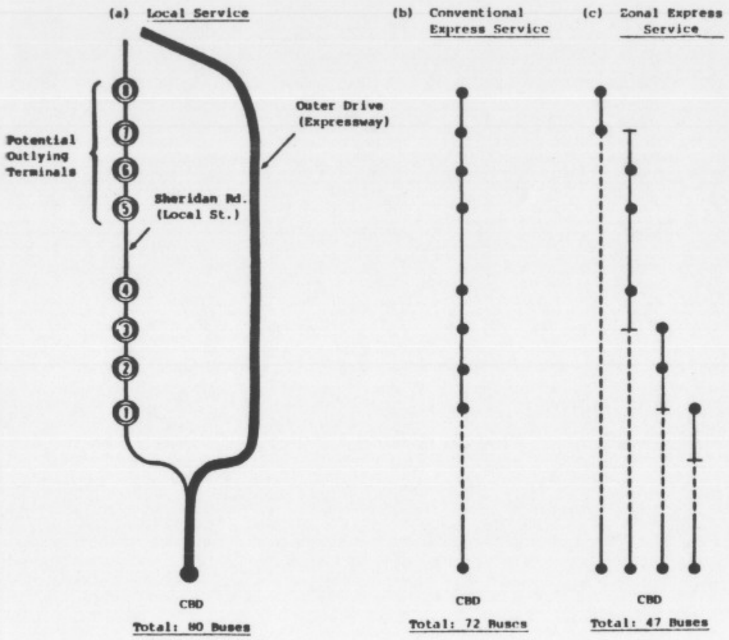


Figure 3

RESTRICTED ZONAL EXAMPLE: ARLINGTON HEIGHTS

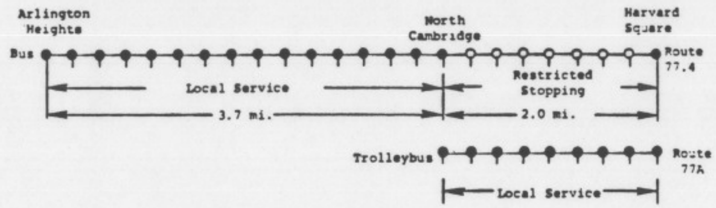
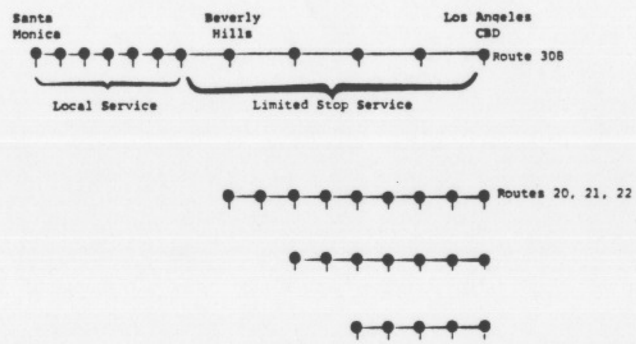


Figure 4

LIMITED STOP ZONAL EXAMPLE: WILSHIRE BOULEVARD



Short-Turning Local Routes

The short-turn strategy consists of a system of two or more routes that operate along the same corridor, in which the shorter routes are entirely overlapped by the longer routes (See Figure 1(d). No boarding or alighting restrictions are imposed on any sections of the routes. The shorter routes are commonly referred to as "short-turn" or "turnback" variations of the longest route. For our purposes, each service is treated as a separate route, even though all the routes in a short-turn system may be considered as variations of a single route for operations or public information purposes.

With the short-turn strategy, inner segment passengers can use a bus on any of the overlapping routes, and will naturally take the first to arrive, unless it is too crowded. Inbound, buses serving the longer routes will reach the inner segments already heavily loaded, while buses serving the shorter routes will begin empty at the same point. Unless each longer route bus is closely preceded by a shorter route bus, buses on the longer route will tend to become overcrowded. Of course, once the longer route buses reach their capacity, they can no longer pick up passengers (except to replace alighting passengers), creating a natural deterrent that forces inner segment passengers to use shorter route buses. There is the same tendency for crowding to occur outbound on longer routes during the evening peak. However, in the outbound direction, this kind of systematic crowding can prevent passengers destined for the outer segments from boarding the longer routes. Therefore, route schedule coordination is necessary in the evening peak and strongly recommended in the morning peak as a means of encouraging inner segment travelers to use the shorter routes.

Efficient schedule coordination is most easily attained if each route has the same headway. In this way, each longer route bus trip can be scheduled to follow closely behind a shorter route trip so that few inner segment travelers will be waiting when a longer route bus arrives. If larger capacity vehicles (i.e., articulated buses) are used on the longer routes, the shorter routes buses should not precede them as closely, but schedule coordination is just as important. It is also possible to efficiently coordinate schedules when the longer route headway is a multiple of the shorter route average headway. In either case, the short-turn strategy restricts scheduling possibilities and requires strict schedule adherence.

The use of short-turn operation presents a good opportunity to replace a flat-fare structure with a more distance-based fare. Successively higher fares could simply be charged for the routes according to their length, since people making longer trips must use longer routes. By imposing a small fare difference (say, 20 cents), inner segment passengers for whom a longer route bus arrives first would have the choice of taking that bus and paying the premium or of saving money by waiting for a shorter route bus. Depending on the percentage of passengers who would choose to pay vs. wait, the schedule offset between the longer and shorter routes would simply have to be lengthened to preserve the longer route's market.

This strategy lengthens wait time for outer segment travelers since fewer trips go the entire length of the corridor. Wait times will also increase slightly in the inner segment because, although passengers can use the buses of any route, trips will not be evenly spaced since shorter route buses will closely precede longer route buses. In-vehicle time remains essentially unchanged since speeds are unaffected.

Restricted Zonal Local Service

The main difficulty with the short-turn strategy is the need for strict schedule coordination and adherence in order to prevent too many inner segment passengers from using the longer route. One way to alleviate this requirement, and at the same time to improve speed, is to impose restrictions on boarding and alighting.

For restricted zonal local service, as for the zonal express strategy, the corridor is divided into two or more zones, with a particular route designed to serve each zone. Inbound, buses on a restricted zonal route begin at the outer boundary (farthest outlying stop) of their service zone, operate locally within the zone, and then they remain on the local street as they continue toward downtown. Unlike zonal express service, the buses may stop at any stop on the trip inbound to allow passengers to alight. Similarly, outbound, buses will stop at any stop to allow boarding only (no alighting) between the downtown and their service zone; they then operate locally within their service zone. This arrangement is called a local service strategy since it makes it still possible to travel directly between any pair of bus stops in the corridor. Figure 1(e) illustrates a restricted zonal configuration.

Restricted zonal local service, like zonal express service, lengthens wait times throughout the corridor since all passengers must wait for the one route that serves their origin-destination pair. However, speeds increase for outer segment travelers, since their buses will be able to skip many inner-segment stops. In long, high-demand corridors, the reduction in travel time can sometimes offset the longer wait times for outer segment travelers.

Like the short-turn strategy, the restricted zonal strategy reduces the number of trips operating in the outer segments of the corridor, thus reducing vehicle requirements. Higher speeds on the longer routes can further reduce vehicle-hours needed. However, some of these advantages are offset by the effect this strategy has on the turnover of seats. For example, once an inbound bus leaves its service zone, no one may board to replace alighting passengers. (The mirror-image behavior occurs on outbound buses.) The peak load of a restricted zonal route will therefore occur at or before the inner boundary of its service zone. Thus, the load on the bus as it enters the downtown will be less than the load it carried leaving its service zone because of the alighting that occurs as the bus operates in a restricted mode. If there is significant travel destined for points before downtown, buses serving all but the shortest route will reach the downtown with considerable excess capacity. To transport a fixed number of people into downtown in these circumstances, more trips would be needed than would be required for other local service strategies. Therefore corridors whose markets show a strong downtown orientation stand to benefit more from the restricted zonal strategy than those with a weak downtown orientation. The semi-restricted and limited-stop strategies, discussed later in this Section, as well as the short-turn strategy, are better suited to a corridor with a weak downtown orientation because they provide for the replacement of inbound passengers alighting before the bus reaches downtown.

Operationally, restricted zonal service is a relatively simple strategy since each route operates independently of the others (unless they are interlined). There is no need for schedule coordination, or of paying special attention to schedule adherence. However, this strategy relies on longer route buses being able to overtake shorter route buses, a concern in some corridors with narrow streets.

From a public information and user acceptance viewpoint, this strategy has three problems. One is that outbound passengers must be sure to board a bus whose zone includes their destination stop. Confrontations can occur between passenger and driver, as with express service, when a passenger desires to alight at a stop the bus passes but the bus is not supposed to allow alighting there. A second is that waiting inbound passengers may wonder why buses coming from more distant zones won't pick them up, particularly when they stop to allow someone to alight. (This concern motivates the semi-restricted strategy discussed subsequently.) A third problem is that if the peak to base volume ratio in the corridor is high, the zonal configuration that is most efficient in the peak may differ from the preferred configuration for the base. (Unless base volumes are high, a conventional local route, which is a single-zone system, will probably be preferable.)

Semi-Restricted Zonal Local Service (Inbound Only)

Semi-restricted zonal local service operates in a zone configuration similar to restricted service, but permits buses to pick up passengers if they are stopping to allow passengers to alight (Figure 1(f)). Thus, passengers who alight an inbound bus after it leaves its service zone are replaced by waiting passengers who are allowed to board as long as there is room on the bus. By allowing the longer zonal routes to carry some of the demand generated in inner zones, their loads are kept higher throughout the inner segments, overcoming the inefficiency of the restricted zonal strategy which does not allow for alighting passengers to be replaced.

The wait time and in-vehicle time under this strategy will be between the average wait and in-vehicle times of the short-turn and the restricted zonal strategies. This strategy is a particularly attractive alternative where there is significant demand along the route to destinations other than the downtown.

This strategy does not work in the outbound direction of travel. The mirror image of the inbound strategy would be that outbound, a passenger traveling on a longer route bus and desiring to alight at a particular stop in the inner zone would be permitted to alight there only if his bus stops to pick up a waiting passenger. With this kind of uncertainty, nobody traveling within the inner zone could be expected to use the longer route. Outbound, therefore, some other routing strategy must be used.

Operationally, this strategy is as easy to use as the restricted zonal strategy. Like the restricted zonal strategy, however, public confusion can result, especially if a semi-restricted zonal system is used inbound along with a different system outbound.

Limited-Stop Zonal Local Service

Like other zonal routes, a limited-stop zonal local route has a service zone in which passengers may freely board and alight at any stop. However, outside the service zone, buses stop only at designated stops, spaced at least one-half mile apart, at which passengers may both board and alight. A limited stop zonal service configuration is illustrated in Figure 1(g).

The limited-stop strategy differs from the other local service strategies in that it does not provide for direct service between every pair of stops in the corridor.

This strategy resembles the short-turn strategy in that inner segment travelers originating at designated stops may use either a longer or a shorter route, and will presumably try to board the first to arrive.

Efficient service design requires that the number of inner segment travelers using longer routes be limited to approximately the number needed to replace alighting outer segment travelers. To accomplish this objective, a few different measures might be considered:

1. If there is a lot of turnover in the inner segment, no special action may be needed because the longer route buses will have room for many inner segment travelers.

2. When outbound travel is dominant (the evening peak), schedule longer route buses to closely follow shorter route buses in the downtown area (where most boarding occurs), as is necessary for the short-turn strategy. This approach will not usually work in the inbound direction, however, since longer route buses will be making limited stops and hence overtaking shorter route buses.

3. When inbound travel dominates (the morning peak), crowding can be used as a natural deterrent, keeping inner segment travelers from boarding unless there is room for them.

4. Charging a higher fare on the longer route will reduce the number of inner segment travelers who will use a longer route bus if it arrives first, and will thus strengthen the above approaches. Higher fares on the longer routes will also raise revenue, of course, and will make the fare system more distance-related. They will also probably be received by the public with less objection than higher fares on longer routes in the short-turn strategy because passengers will get higher-speed service.

5. Increasing the spacing between designated stops, and leaving some downtown stops undesignated, will also strengthen the other approaches. However, it will increase walk distance for passengers going from the outer zone to the limited-stop area.

In most applications of this strategy, then, operational considerations would include the ability of buses to overtake each other; the likelihood of regular crowding during the morning peak; and the need for close schedule coordination and adherence in the evening peak. Another operational consideration is that this strategy should not be applied on streets where traffic requires buses to stop at every intersection, since the strategy will then have no value to either passenger or operator.

The passenger impacts of this strategy are mixed. Some passengers will have longer walk distances and some may be induced to transfer to avoid these longer walks. Wait time will increase in the outer segments as in other zonal strategies, and will also increase slightly in the inner segments. However, in-vehicle time will be significantly reduced for many passengers.

Another advantage of the limited-stop strategy is its can be of value in corridors that show little peaking, and thus can increase the efficiency of midday and crosstown services as well as the typical peak period, CBD-oriented services.

Example: Restricted Zonal Service

Local service along Massachusetts Avenue between Arlington Heights and Harvard Square in suburban Boston is provided by two restricted zonal routes operated by the Massachusetts Bay Transportation Authority (MBTA). The shorter route, Route 77A, operates locally between the North Cambridge terminal and Harvard Square. The longer route, Route 77.4, acts as a local route between Arlington Heights and North Cambridge and then goes into restricted operation between the North Cambridge terminal and Harvard Square. Figure 3 illustrates these two routes. During the morning peak, Route 77A, which uses trolleybuses, makes 12 trips per hour with a cycle time of 40 minutes, requiring 8 trolleybuses. Route 77.4, using diesel buses, makes 20 trips per hour with a cycle time of 75 minutes, requiring 25 buses.

The benefits of this service design can be seen by comparing it to the operation of a hypothetical single local route in the same corridor. This full-length local route would have a cycle time of about 80 minutes, and would have to make 30 trips per hour. (The frequency of this single route is slightly lower than the combined frequencies of Routes 77A and 77.4 since it would not prevent alighting passengers from being replaced as the restricted zonal system does). Thus, a single local route would require about 40 buses, 21% more vehicles than the dual route restricted zonal system now in place.

Average wait time in the corridor is only one minute longer under the zonal service than it would be under the alternative local service (2.2 minutes vs. 1.2 minutes), while in-vehicle time is about 5 minutes less under the zonal service for passengers originating upstream of the North Cambridge terminal and unchanged for those originating inbound from North Cambridge.

Example: Limited-Stop Zonal Local Strategy

A partial application of limited-stop zonal local service strategy is used in the Wilshire Boulevard corridor of Los Angeles, where Route 308 is a limited-stop local zonal route between Santa Monica and downtown Los Angeles, 12 miles east (see Figure 4). Between Beverly Hills and downtown, a distance of 6 miles, Route 308 stops only at designated stops about one-half mile apart. Route 308 is overlapped by a system of short-turning local routes that originate at points between Santa Monica and Beverly Hills and do not have limited stop operation. Nevertheless, during most of the morning peak, Route 308 provides the only local service on Wilshire Boulevard in Santa Monica, so that travelers going from Santa Monica to points on Wilshire Boulevard between Beverly Hills and downtown must use Route 308 and either walk a (potentially) longer distance from one of the designated stops or transfer at Beverly Hills to one of the other local routes in the corridor. Compared to a simple short-turning route system, the limited-stop configuration has the benefit that it discourages inner segment travelers from using Route 308 and encourages them instead to use the shorter local routes, enabling the operator to reduce vehicle-miles in the outer part of the corridor. It also reduces one-way bus travel time by 12 minutes, resulting in reduced passenger travel time and significant cost savings for the operator.

Summary of Local Service Peak Direction Operating Strategies

Table 1 summarizes the advantages and disadvantages of the four operating strategies described in this chapter. Both operator and passenger considerations are included. Actual wait time impacts are highly dependent upon the specific route design; the impacts given in the table are for a typical application. The table also summarizes the conditions under which each strategy would be the most promising for reducing vehicular requirements.

4. Local Service Design - Light Direction Strategies

Means by which to improve local service efficiency through service adjustments in the light direction of travel include vehicle "deadheading" (the practice of running a bus non-stop, out-of-service from terminal to terminal in the light direction of travel) and "interlining", the practice of scheduling buses to make successive trips on different routes.

Complete or Partial Deadheading of Selected Routes

If local service is provided by a system of short-turning or zonal routes, it is often possible to have all buses on some routes deadhead in the light direction of travel, while buses on the remaining routes stay in service. For example, in a corridor that has both a short-turning local route and a longer local route, all the short-turning trips could deadhead, leaving only the longer route buses to provide light direction service (provided that the light direction demand is less than half the peak direction demand). This policy will reduce the round trip time of the shorter route, saving vehicle-hours and possibly saving one bus or more.

If a local route has a particularly short headway, it may be advantageous to have only a fraction of the runs on this route return in service in the light direction while the remainder deadhead. This strategy is called "partial deadheading".

More finely tailored partial deadheading schedules can also be designed to respond to changes in demand levels and traffic congestion during the peak period. These schedules would not be systematic in their use of deadheading, but would deadhead runs selectively whenever (1) the light direction demand allowed it, and (2) the run time savings could be effectively used to enable the deadheading vehicle to more quickly begin another peak direction trip. Coordinated scheduling is necessary to keep in-service departures in each direction regularly spaced.

Considerations in Deadheading Design

Whether applied completely or partially, the use of deadheading should recognize the following considerations.

First, deadheading a vehicle that cannot be scheduled to make a subsequent trip saves no operator cost in many cases because labor contract provisions often require that the driver be paid the same whether his trip ends a few minutes earlier or not. In such cases, it is usually wiser to return the vehicle in service, improving passenger service and perhaps generating a little revenue.

Second, many properties have made it a practice to deadhead only on streets that have no local service to avoid angering waiting passengers by passing them with an empty out-of-service bus. (Some properties call such deadheading "off-routing.")

Third, deadheading facilitates interlining since vehicles that are returning out-of-service can be rerouted directly to other terminals without inconveniencing or confusing passengers. Therefore, opportunities for effective interlining should be sought when comtemplating the application of deadheading.

Table 1

ADVANTAGES AND DISADVANTAGES OF LOCAL SERVICE OPERATING STRATEGIES

	Short-Turn	Restricted Zonal	Semi-Restricted Zonal	Limited-Stop Zonal
Need for schedule coordination and strict adherence	valuable in a.m. vital in p.m.	none	none	unnecessary in a.m. valuable in p.m.
Reliance on overtaking	none	strong	moderate	strong
Wait time impact*	up by 90% in outer segment, by 20% in inner segment	up by 90% throughout	up by 90% in outer segment, by 20% in inner segment	up by 90% in outer segment, by 20% in inner segment
In-vehicle time reduction	none	considerable	moderate	considerable
Walk-distance impact*	none	none	none	up by 0.2 mi. for some outer segment passengers
Difficulty in public comprehension	little	considerable	considerable	moderate
Most favorable conditions for vehicle savings:				
corridor length	short	long	any	long
fraction of local (non-CBD) travel	moderate to high	small	moderate	moderate to high
outer segment volume	low	low	low	any

*Average impact to peak direction travelers in typical application