Methodology for Evaluating Out-of-Direction Bus Route Segments

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Out-of-direction (OOD) travel is a deviation from the main line of a fixed-route bus service. Deviations can help improve accessibility to potential riders along the OOD segment, but they can also lead to loss of through riders because of increased travel time. This is especially true of discretionary riders, for whom travel time is important in the decision to use transit. The issue is how to objectively evaluate the trade-off between increased accessibility and impact on through riders. The San Diego Metropolitan Transit Development Board contracted with Crain and Associates to develop a formal methodology for evaluating OOD segments. The development of the methodology is discussed, and examples of how it works are provided.

Out-of-direction (OOD) travel is defined as a deviation from the main line of a fixed-route bus service (see Figure 1). An OOD segment is the portion of the route that deviates. OOD segments improve accessibility to areas off the main line, benefiting riders who wish to travel to or from places along the OOD segment. Such deviations generally cause higher operating costs and inconvenience to through riders (passengers already on the bus who do not alight along the OOD segment) as a result of longer travel times.

Implementation of OOD segments may provide better access to persons along the segment, but it may also lead to the loss of through riders. On routes with a high volume of through riders, deviations from the main travel path may deter ridership and may prevent the discretionary rider, for whom travel time is an important consideration, from choosing to use transit. OOD travel complicates bus routings for the user, which is a further disincentive to the use of transit. A cost/benefit analysis of an OOD segment, therefore, must assess the trade-off between accessibility and the effect on through ridership. The question is how to objectively evaluate this trade-off.

The San Diego Metropolitan Transit Development Board (MTDB) recently hired Crain and Associates, a consulting firm, to develop a formal methodology for assessing OOD segments. MTDB staff will apply the methodology to existing deviations and future requests for such deviations. The development of the methodology and how MTDB will use it for route evaluation are discussed.

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DESCRIPTION OF MTDB

MTDB was created in 1975 to plan and construct transit guideway facilities in the southern urban portion of San Diego County. MTDB is also the policy-setting and coordinating agency for all transit services and facilities in its jurisdiction.

MTDB is an independent agency governed by a board of directors, whose 15 members include representatives of the various local jurisdictions and the county and one representative appointed by the governor of California. The two largest operators in the region, San Diego Transit Corporation (SDTC) and San Diego Trolley, Inc. (SDTI), are wholly owned subsidiaries of MTDB.

Complementing SDTC and SDTI in providing fixed-route services in the MTDB area are Chula Vista Transit, National City Transit, San Diego County Transit System, and contract operators. Whereas these other operators are separate entities, all fixed-route operators are part of the Metropolitan Transit System (MTS). MTS was designed to provide a unified transit system to the public. The MTS logo is displayed on all transit vehicles, public timetables, and information brochures so that the user is aware that a coordinated route, fare, transfer, and information system is available.

SDTC, which has 100,000 daily riders on 31 routes and is the region's largest carrier, was the focus of the OOD methodology development. Its routes serve 1.6 million people over a 390-mi^2 area.

BACKGROUND OF THE SAN DIEGO EXPERIENCE

Topography and land use patterns are often at odds with providing convenient, easily accessed transit service. The MTDB service area is made up of many canyons and mesas, which have led to circuitous street patterns and to the location of many neighborhood and commercial areas off main arterials. Combined with this is the growing suburban nature of much of San Diego's development, with low-density land uses and "walled-in" neighborhood designs. The result is that many areas are not within a convenient walking distance of the major arterials, where bus routes would normally operate.

Not surprisingly, MTDB and SDTC receive numerous passenger requests to deviate a bus route to neighborhoods and areas where commerce, employment, and institutions are con-

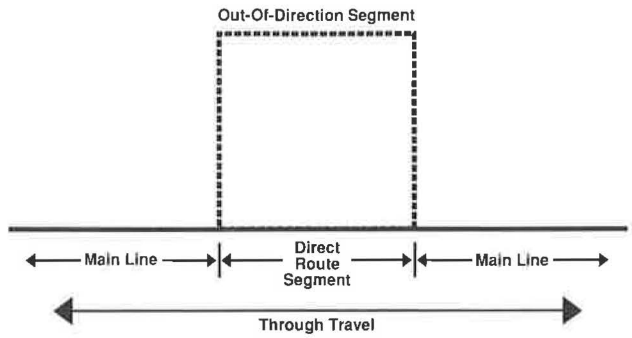

FIGURE 1 OOD segment.

centrated. Many such changes have been implemented. Over time, the result has been that some routes have developed up to five OOD segments.

Recent MTDB direction has been to discourage additional route deviations and to eliminate some existing OOD segments. These actions have been taken to improve operating efficiency and encourage more through ridership. As in many other transit systems, the problem has been the lack of a formal methodology for evaluating OOD segments. To remedy this situation, MTDB hired Crain and Associates to develop such a methodology. The goal was to incorporate the methodology into a formal MTDB policy that would guide MTDB in evaluating existing and proposed OOD segments.

METHODOLOGY

Any OOD segment, whether existing or proposed, should be evaluated by an objective set of criteria. The evaluation method presented here consists of three steps for existing OOD segments (see Figure 2):

1. Rate OOD segments on the basis of time delay to through passengers.
2. Determine whether not operating an OOD segment could save bus operator resources.
3. Analyze the operating cost and productivity of the OOD segment and consider qualitative factors that may influence the decision to retain or discontinue the segment.

For a proposed OOD segment, the goal is to assess whether the potential OOD ridership would justify its addition. The time delay formula developed as part of Step 1 would be used in the determination.

Step 1—OOD Impact Index

Index Formula

The first step in the analysis is to measure the trade-off between the time-inconvenience of OOD deviations to through passengers and the benefit of the deviation to OOD riders. The trade-off is a function of the number of through passengers, the additional time for the OOD segment, and the number of passengers served by the segment. An OOD impact index measures the trade-off in this relationship. The index is a measure of the extra travel time that through passengers face for each OOD passenger served. It is equal to the ratio of through riders to OOD riders multiplied by the additional travel time:

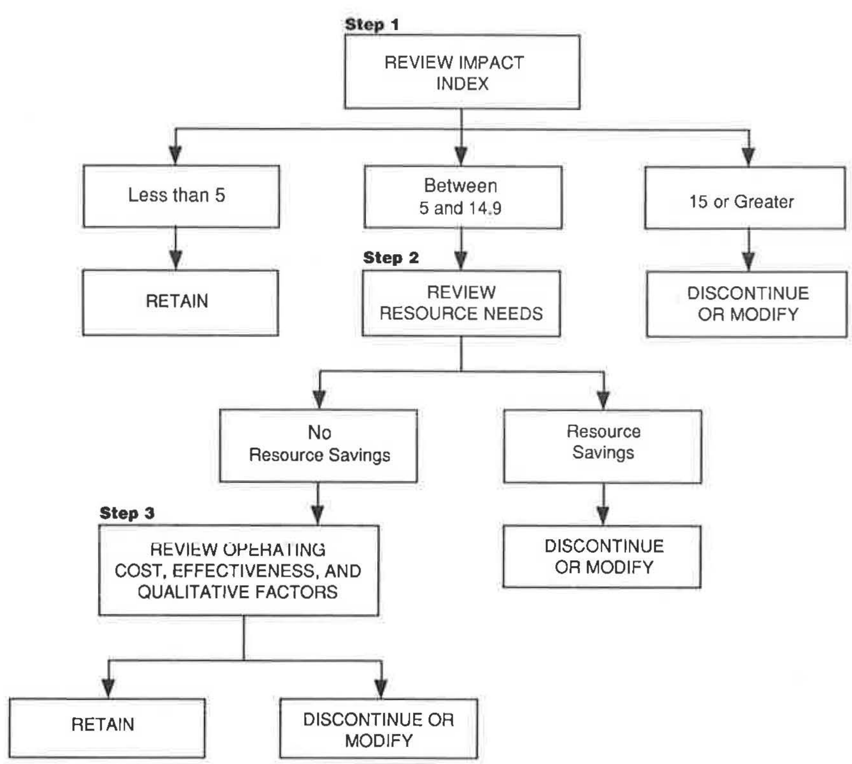

FIGURE 2 OOD travel analysis methodology.

OOD impact index

= (through ridership × OOD travel time)/OOD ridership

where

OOD impact index = a weighted measure of time expressed in minutes,

through ridership = the difference between the number of passengers on the bus before the OOD segment and the number of passengers alighting on the OOD segment,

OOD travel time = the net increase in travel time required to operate the OOD segment rather than the direct alignment, and

OOD ridership = all boardings and alightings on the OOD segment beyond 0.25 mi from the main line. Passengers boarding and alighting within 0.25 mi of the main line are considered to be served by that line, with or without the OOD segment.

The following are examples of the index.

Consider an OOD route segment midway in a route that adds 4 min of travel time. One hundred passengers board and alight the bus on the OOD segment each day, and 500 passengers travel through the segment to reach points on either side. The OOD impact index for this segment is calculated as follows:

OOD impact index

= (500 passengers × 4 min)/100 passengers = 20 min

An index value of 20 min is high, representing a significant inconvenience to through passengers. The index may be more clearly understood if it is viewed as through-passenger delay per unit of OOD level of activity. Through-passenger delay is high at 2,000 passenger-min in this example, and OOD activity is low at 100 passengers. Consequently, much delay to through passengers is being caused to provide service to a few OOD passengers.

Consider another OOD segment of similar length in which through ridership is 100 and OOD activity is 200. This segment might be near the route's terminal, where ridership is relatively light. However, the OOD segment itself is highly productive, with 100 boardings and 100 alightings daily, for a total of 200 passengers. The OOD impact index is calculated as follows:

OOD impact index

= (100 passengers × 4 min)/200 passengers = 2 min

The index value for this segment is low, as indicated by the minimal inconvenience caused to through passengers relative to passenger activity on the segment.

The OOD impact index is valuable in part because it provides a quantitative reflection of passenger perceptions. A long detour through a neighborhood where few passengers board or alight is likely to be perceived more keenly than a detour through a neighborhood where boarding and alighting activity is intense.

High OOD impact indexes are likely to be found (*a*) where through ridership is high and OOD activity is low and (*b*) where through ridership is high and a lengthy route detour is required. Low indexes are likely to be found (*a*) in an OOD segment requiring little travel time where OOD passenger activity is moderate and through ridership is modest and (*b*) in a highly productive OOD segment serving a major activity center, such as a trolley station or employment complex, located a short distance from the route.

Interpretation of Index Values

The OOD impact formula used here was taken from the formula used by the Tri-County Metropolitan Transit District (Tri-Met) in Portland, Oregon. Other transit agencies in the United States and Canada reportedly have similar measures. Tri-Met uses the equation to help it determine whether to operate an OOD deviation. If the index value is greater than 5, the deviation will generally not be operated unless there are mitigating circumstances. This limit was chosen by Tri-Met as the maximum delay to which through passengers should be subjected under normal circumstances.

The Tri-Met guidelines and field testing conducted during the study suggested three groupings of the OOD index for MTDB:

- An index value between 0 and 4.9 indicates that the number of OOD passengers is large compared with the number of through passengers, or that the diversion time is small, or both. Segments with indexes in this range are not likely to deter through ridership.
- An index value between 5 and 14.9 indicates some inconvenience to through passengers that may affect through ridership.
- An index value of 15.0 or above indicates that the OOD deviation is inconvenient to through passengers and has an adverse impact on through ridership.

The upper range values were not established by quantitative analysis. It was believed that a general range of values should exist in which factors other than the OOD impact index influence the decision to retain or delete an OOD segment. The 5-to-14.9 range and Steps 2 and 3 of the process, discussed later, are used. The value 15 was chosen as the cutoff point that clearly indicates unacceptability.

Existing OOD Segments For existing OOD segments, the OOD impact index is a good indicator of the acceptability of an OOD deviation to through passengers. Continued service for segments with indexes below 5 is probably well justified, and segments with indexes of 15 or more should be discontinued. In the 5.0-to-14.9 range, other factors, such as resource needs, operating costs, service effectiveness, and qualitative factors, should be considered in making the determination. These factors are addressed in Steps 2 and 3.

New OOD Segments During the evaluation of a new OOD segment, potential ridership on the segment is unknown. In this case, the OOD impact index formula is used to determine how much ridership is required to justify implementation. An OOD impact index value of 4.9 represents the upper limit for a segment that clearly does not deter through ridership, so the formula for determining that ridership level is

OOD ridership needed

= (through ridership * OOD travel time)/4.9

If such a level of OOD ridership can reasonably be expected, the OOD segment should be considered for implementation.

Step 2—Resource Needs

A review of resource needs is the second step in the OOD evaluation process. Transit routes require a certain number of vehicles and operators to provide service. SDTC estimates that saving one vehicle operator translates into average annual labor cost savings of $45,000. The resource savings are calculated by determining the route running time with and without the OOD segment and then determining whether the running time saving is sufficient to reduce the bus operator requirement.

Bus operator reductions are likely under three circumstances:

1. Single lengthy OOD segments,
2. Several OOD segments on the same route where the combined running time saving results in a reduction of resources, and
3. OOD segments on routes with recovery times in excess of the 7 min required by SDTC's labor agreement.

Lengthy OOD segments can produce an operator saving if the extra running time is equivalent to the headway between buses. For example, an 8-min OOD segment could save one bus if the route operates 15-min headways, because the 8-min impact occurs twice per round trip. In practice, such OOD segments are unlikely to occur, and if they do, they are likely to have a high impact index, which would eliminate them in the first step of the evaluation process. However, several routes have more than one OOD segment. The combined travel time penalty of several segments may be equivalent to a running time saving that allows a reduction of one or more bus operators.

Routes with excess recovery time provide another opportunity to save resources. Excess recovery time is the extra time at the end of each bus trip that is not required for driver layover or other operating needs. Currently, SDTC requires 7 min of recovery time at each terminal. Most routes have extra time, because vehicle requirements are based on a stepwise progression that adds an operator if the overall running time exceeds an even multiple of the headway. There is an opportunity for saving resources when the excess recovery time is high in relation to the route headway. In such cases the time saved by not operating an OOD segment, combined with excess recovery time, may reduce resources. For example, a route with a round-trip running time of 185 min (including required recovery time) and service at 30-min intervals would require seven vehicles. If 5 min per round-trip could be saved by not operating an OOD segment, running time would be reduced to 180 min, requiring only six vehicles to operate the route.

In many situations the time saved is not sufficient to reduce the number of bus operators. However, the cumulative effect of discontinuing multiple OOD segments may be that sufficient time is saved to reduce the bus operator requirement. In addition, even a small time saving may provide a margin that can be used to improve on-time performance, schedule timed transfers, or extend the route. These qualitative benefits are considered in Step 3.

The purpose of Step 2 is to determine whether there are resource savings associated with the OOD segment. If resources can be saved, the segment should be considered for discontinuance or modification. If resources cannot be saved, the analysis proceeds to Step 3.

Step 3—Cost, Effectiveness, and Qualitative Factors

A review of operating cost, effectiveness, and qualitative factors of OOD segments is the third step in the evaluation process. OOD segments that have an impact index between 5.0 and 14.9 and cannot yield resource savings would be evaluated according to these criteria. The purpose of this step is to determine the savings in operating cost that can be achieved by discontinuing the OOD segment and whether a route is more or less productive without the segment. The indicator of productivity used for this analysis is the number of boarding passengers per revenue mile (PPM). The measure is calculated at the route level rather than for the OOD segment. Route-level calculation of productivity has advantages and a disadvantage. The advantages are as follows:

- The combined effect of multiple OOD segments can be easily calculated because the passengers and miles data base is common to all segments.
- Point deviations (in which a route deviates from and returns to the main line at the same location) can be measured. It is impractical to measure productivity at the OOD level for a point deviation OOD segment because the direct-route mileage is zero.
- New ridership produced by travel time reductions is measured at the route level because it originates at many points along the route, not just on the OOD segment.

The disadvantage of calculating productivity at the route level is that OOD passengers and miles may be small compared with route passengers and miles, and a change in productivity that is significant at the OOD level may appear insignificant at the route level. As long as this limitation is understood, the advantages of route-level calculation of productivity make it preferable to OOD-level calculation.

Operating Cost

SDTC annual operating costs by route were used to establish the existing cost of each route. The operating cost of the route without the OOD segment was determined by calculating the annual operating miles saved and multiplying the value by the marginal operating cost. Marginal operating cost is the cost related exclusively to miles operated: fuel, lubricants, tires, and maintenance. SDTC currently estimates the marginal cost to be $0.50/mi.

Effectiveness

Effectiveness was assessed by measuring route productivity with and without the OOD segment. PPM was selected as the effectiveness indicator for the following reasons: (*a*) revenue miles will change with the discontinuance of any OOD segment, whereas revenue hours will generally change only if there are resource savings; and (*b*) running times generally vary throughout the day, depending on traffic and demand, which complicates measurement of the indicator.

The formulas for measuring productivity (PPM) for the OOD segment and direct alignments are as follows:

PPM (with OOD) = (OOD segment existing annual boarding passengers) ÷ (annual revenue miles for OOD segment)

PPM (without OOD) = (existing route annual boarding passengers − OOD segment annual boarding passengers + direct routing annual boarding passengers + through riders added annually because of travel time savings) ÷ (existing route annual revenue miles − OOD segment annual revenue miles + direct routing annual revenue miles)

Passengers Passenger boarding volumes for existing routes with OOD segments were drawn from ride check data. Passenger volumes without the OOD segment are based on passenger gains and losses resulting from discontinuing the OOD segment: new ridership on the direct route that replaced the OOD segment, ridership loss from discontinuing the OOD (on the basis of existing ride check data), and gain in through ridership from reducing travel time.

Through ridership on the main line is likely to increase because of travel time savings. The increase can be estimated by using the following travel time–demand elasticity formula:

Additional through ridership = (difference in travel time between OOD segment and direct routing * through ridership * 0.30) ÷ (average passenger trip length for entire route)

where the difference in travel time and the average passenger trip length are in minutes and 0.30 is an elasticity coefficient, meaning that the percentage increase in through ridership is 0.30 times the percentage decrease in travel time. For example, a 25 percent decrease in travel time would produce a 7.5 percent increase in ridership. This factor was used because of the lack of a local elasticity factor; it is a common standard.

Revenue Miles The lengths in miles of OOD segments and direct route segments were determined from field checks. The mileage saving for discontinuing the OOD segment was calculated by subtracting direct route miles from OOD miles. The mileage saving was multiplied by daily trips to produce daily mileage, which was annualized. The annualized mileage saving was then deducted from annual route revenue miles provided by SDTC to produce the net revenue miles to be operated if the OOD segment were discontinued.

Effectiveness Assessment The PPM measures for the route with the OOD segment and with the direct alignment were compared to determine any productivity improvements. If productivity improves when an OOD segment is eliminated, the segment should be considered for discontinuance or modification. If route productivity declines when an OOD segment is eliminated, continuation of the segment is reasonable. In all cases, qualitative concerns should also be addressed, as discussed next.

Qualitative Concerns

Qualitative factors should be considered in the final step of the evaluation process for questionable OOD segments.

One of the goals of any transit system is to provide transportation to captive riders (riders who depend on transit for personal mobility because they lack an automobile or the ability to drive). Service to an area that includes a large number of captive riders should be analyzed carefully. If an OOD segment to such an area is to be discontinued, it may be desirable to explore ways to maintain accessibility.

Consideration should also be given to activity centers that are served by an OOD segment. Such centers may include hospitals and clinics, social service agencies, supermarkets, and schools. It may be desirable to maintain a minimal level of transit service to these locations. Nonetheless, these factors must be weighed against the disadvantages of continuing the OOD segment.

EXAMPLES

Three examples demonstrate how the methodology works. The first OOD segment has a low OOD impact index, and the second has a high OOD impact index. The third segment has an OOD impact index in the midrange, so Steps 2 and 3 are required to fully assess the segment. Quantitative results from the analysis are given in Table 1.

Low OOD Impact Index

Convoy Court is an OOD segment on a local route (Route 25) connecting Clairemont Mesa with San Diego's Centre City. The OOD segment is shown in Figure 3. The main route deviates a block from the main line to serve employment locations on Convoy Court and a Kaiser Permanente clinic at the junction of Shawline Street and Clairemont Mesa Boulevard. Passenger boardings and alightings on the segment

TABLE 1 OOD SEGMENT ANALYSIS

	OOD Segment		
	Route 25: Convoy	Route 16: Aero	Route 25: Linda Vista
STEP 1: IMPACT INDEX			
Time Factor (in minutes)			
o OOD Segment	3	6	6
o Direct Routing	2	2	2
o Net Time for OOD Segment	1	4	4
OOD Segment Passengers	104	86	117
Through Passengers	274	298	825
OOD Impact Index*	2.6	13.9	28.2
STEP 2: RESOURCES			
Resource Savings (Bus Operator)	None	None	None
STEP 3: COST EFFECTIVENESS			
Marginal Cost Savings**	$2,200	$6,400	$10,400
Passengers per Revenue Mile			
o OOD Segment	1.90	2.18	1.90
o Direct Routing	1.92	2.28	2.01
o Percent Change	1.1%	4.7%	5.6%

** - OOD Impact Index is the net through rider time impact per unit of OOD travel.*
*** - Marginal "out-of-pocket" operating costs calculated at $45,000 per bus operator and $0.50 per revenue mile.*

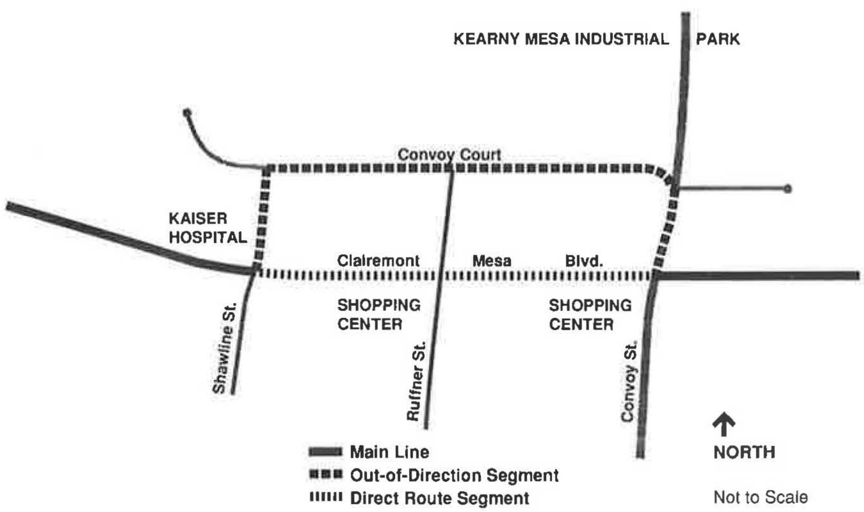

FIGURE 3 Convoy Court OOD segment.

are high. Through passengers on the main route are relatively low because the segment is located near the outer terminal. These circumstances result in a low OOD impact index of 2.6, which indicates that the segment should be retained and that no further analysis is necessary. It is interesting to note, however, that the results of Steps 2 and 3 (given in Table 1) indicate that no resource savings can be achieved with such a short OOD segment and that route productivity will increase negligibly if the segment is discontinued. This is consistent with the low OOD impact index, based on a small OOD time penalty and high OOD productivity.

High OOD Impact Index

Linda Vista is an OOD segment located on Route 25 between two major activity centers: the Fashion Valley Transit Center and the Kearny Mesa employment complex (see Figure 4). Passenger boardings and alightings on the segment are relatively low. Through ridership on this segment of Route 25 is heavy. Finally, the time penalty for the OOD segment is high, because a significant deviation is required.

The combination of the three factors substantially affects through riders. Not only is the segment a lengthy deviation from the main route, but also it is perceived as unproductive because of the absence of strong passenger activity. The resulting OOD impact index of 28.2 indicates that this segment should probably be discontinued. Although Steps 2 and 3 are not required in this case, neither step contradicts the findings of Step 1. Whereas Step 2 indicates that no resources could be saved by discontinuing the segment, Step 3 indicates a significant marginal cost savings and a potential improvement in service effectiveness.

Midrange OOD Impact Index

Figure 5 shows Aero Drive, an OOD segment near one end of Route 16. The OOD impact index for this segment is 13.9. This value is well above 4.9, which would indicate retention of the segment, and below 15, the level at which it would be automatically considered for discontinuance or modification. The high index value is caused by three factors: the segment is long, there is relatively little boarding and alighting on the segment, and through ridership is relatively high.

The high value indicates that the lengthy deviation, combined with low OOD passenger activity, is an inconvenience to through riders. Step 2 in Table 1 indicates that no resource savings are achieved by discontinuing the segment. The deviation is too short to reduce the route operating requirement by a full bus operator.

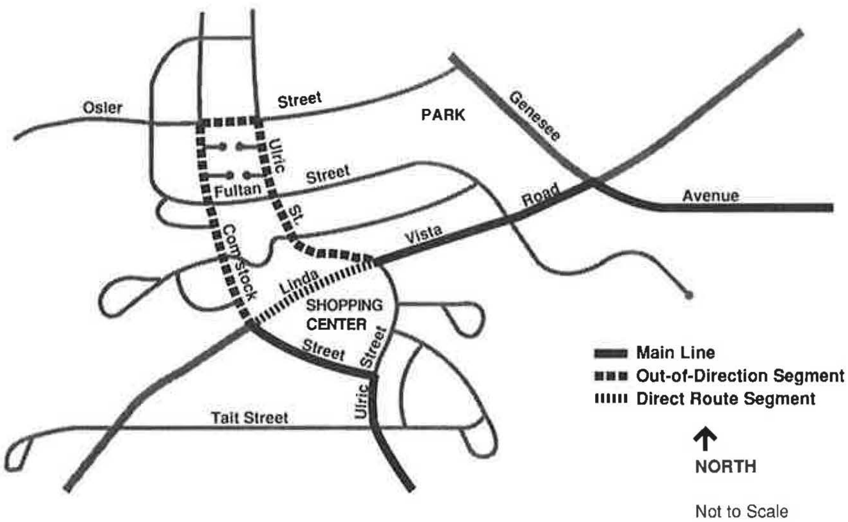

FIGURE 4 Linda Vista OOD segment.

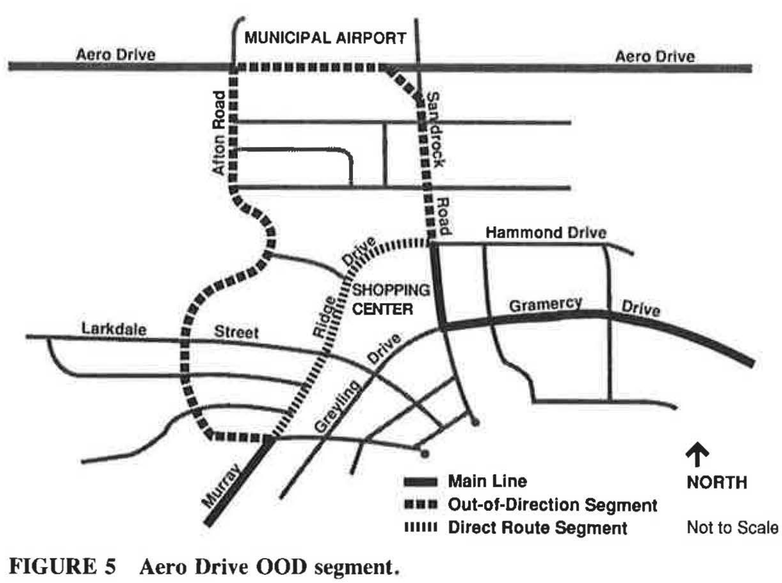

FIGURE 5 Aero Drive OOD segment.

Step 3 indicates that the service effectiveness of Route 16 would improve if the OOD were discontinued. PPM will increase by nearly 5 percent, because more miles will be saved than passengers lost. The saving in miles is evident from the length of the OOD segment. The small net change in passengers is the result of three factors: (*a*) most existing passengers will continue to walk to the main route, (*b*) the direct-route segment will generate additional riders at a neighborhood shopping center on the direct alignment, and (*c*) the time saving from operating on the direct alignment will produce a significant increase in through riders.

The cost analysis in Step 3 indicates that there are significant marginal operating cost savings to be gained from discontinuing this OOD segment and that the service effectiveness of the route will also improve. The findings indicate that the segment should be considered for discontinuance unless qualitative factors indicate otherwise. Qualitative factors further support discontinuance of the segment:

- The 4-min time saving will improve on-time performance on Route 16 by reducing running time.
- A bus resource can potentially be saved if Aero Drive is discontinued concurrently with another Route 16 OOD segment in Mission Valley. This resource could be used to improve service frequency on Route 16.
- Passenger transfer connections with Route 25 at Aero Drive are negligible, and an alternative transfer connection with Route 25 is available at a nearby transit center.
- Direct service to the neighborhood shopping center can be provided if the segment is discontinued.
- Low-income housing in the neighborhood is as close to the proposed direct alignment as it is to the current OOD alignment, thereby affording accessible service for transit-dependent residents.

NEXT STEPS

As indicated earlier, MTDB intended to develop a formal policy for evaluating OOD segments. Such a policy was adopted by the MTDB's board of directors in August 1990 (MTDB Policy Number 39, "Out-of-Direction Bus Routings Policy"). The policy informs the public on how such service requests are to be analyzed and provides the board of directors with a valuable tool in deciding an OOD segment's value. During the coming months, the methodology will be applied to several existing OOD segments identified by the board of directors for analysis. On the basis of the results, the board will decide whether to retain, delete, or modify them.

Whereas this methodology will provide a basis for analyzing the merits of an OOD segment, deciding which travel time elasticity factor to use remains a problem. No local elasticity factor exists, and limited research in this area is available nationwide. Given the lack of better data, the standard elasticity coefficient of 0.30 was used. However, as the methodology is applied and decisions are made on eliminating existing OOD segments or adding new ones, an opportunity to assess the local travel time elasticity factor for such service changes will arise. MTDB plans to monitor this area closely during the next few years in the hope of developing a local elasticity factor that can be used to strengthen both the OOD methodology and MTDB's route evaluation process in general.

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