Single-Lane Transitway Width Assessment

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ABSTRACT

Highway design for transitway (busway) lanes has previously been based on engineering experience and judgment. The results of bus operating tests performed on several simulated transitways at the Texas A&M University Research Annex are presented in this paper. One vehicle was parked in the transitway to simulate a breakdown, and another was driven past the "stalled" vehicle at comfortable speeds. The parked or stalled vehicles included a 40-ft transit bus and a passenger van. The width and alignment of the barriers delineating the transitway were varied to simulate several one-lane transitways with both tangent and curved sections. Bus breakdowns were simulated to determine the percentage of bus breakdowns that might close a transitway of a given width. The findings should allow transitway width in future planning and design efforts to be better determined.

A transitway is defined as a single, barrier-separated, reversible, high-occupancy-vehicle lane. The wide range of transitways design specifications makes the design of transitway difficult in itself; the restricted right-of-way and the need for complementary highway improvements further hinder design flexibility. Engineering judgments must be made as to how transitway and highway configurations can be compromised. The need for clearance envelopes for transit buses must be balanced against the reality that only a small amount of the road can be widened at most locations. In many cases, widening the road may not even be a viable alternative. The Houston region, in which over $400 million is currently committed to transitways, certainly has a need to develop design standards for transitways. Agreement on design standards will also simplify a multiple-agency highway and transit undertaking.

Transitway designers in Houston recognized that transitways must be sufficiently wide to allow vehicles to pass a stalled bus. Less importance was placed on the need to pass a stalled vehicle at a high speed. It was believed that, because passengers on a stalled bus might exit the bus onto the lane, high passing speeds were neither desirable nor safe; also, sufficient space frequently could not be provided to permit a high-speed pass. Potential collision damage to transit buses would also be minimized with slow passing speeds, especially in cases when the disabled bus was unable to park directly against the barrier.

Consequently, the issue became how wide a one-lane, reversible transitway needed to be to allow a stalled bus to be passed. Because each additional foot required for the transitway forced additional compromises in freeway design, this became a critical issue that has not yet been conclusively addressed. Therefore, one of the major objectives of this study was to determine the percentage of controlled vehicle breakdowns (those that do not result in accidents) that might be expected to block a transitway, which depends on how close a bus could come to the barrier during a controlled stop. These tests were conducted by parking a typical transit bus against a New Jersey-type concrete median barrier (CMB) in both tangent and curved roadway sections. Another objective of the study was to test the speed at which one bus could pass a parked or stalled bus within several different transitway width and layout configurations. Measurements of speed and distance were collected for each passing maneuver to determine how widening the transitway affected the potential passing speed.

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STATEMENT OF THE PROBLEM

The bus that will typically be used on the Houston transitway system is GMC RTS-04. These buses are 8.5 ft wide with an additional 0.6 to 0.7 ft on each side for mirrors. These mirrors, however, are positioned at different heights (about 5 ft above the ground on the left side and about 7 ft above the ground on the right side), which eliminates a mirror-to-mirror conflict when both buses are facing in the same direction. Therefore, for one bus to pass another on a one-way transitway, the inside clear width of the transitway would have to be between 18.0 and 18.5 ft.

The Metropolitan Transit Authority of Harris County, Texas (METRO), FHWA, and the Texas State Department of Highways and Public Transportation (SDHPT) recognized the problems presented by the possibility that a bus might block a lane and severely reduce the passing speed. It is essential that the transitway provide a reliable level of service. The volume of buses on Houston transitways is expected to generally be in the range of 50 to 100 per peak hour, with the volume of vanpools comprising another 200 to 400 vehicles per hour. Very little documentation could be found for passing speeds on one-lane busways of the type that METRO and SDHPT plan to operate. The plans for a one-way transitway in Houston include a travel lane directly in the center of the transitway (see Figure 1) as opposed to a more typical wider right shoulder, partly because of the reversible nature of the lane. The 50- to 55-mph operating speed planned for these narrow transitways is also somewhat higher than that observed on some one-lane facilities around the country.

A METRO survey of several currently operating priority lane projects (1) indicates that the revenue miles between transit vehicle breakdowns vary from 1,000 to 27,000. Applying a typical Houston priority lane trip of 10 mi results in a forecast of at least one, and perhaps five, bus breakdowns every week on each priority lane project. With breakdown

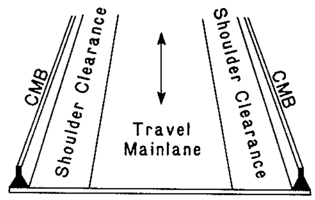

FIGURE 1 Current cross section used for one-way transitways in Houston.

rates approximately equal to that of transit buses and volumes three to eight times as great, vanpools and carpools are also a key component of the breakdown problem. It is possible that at least one breakdown per peak period could become the norm. Safety problems resulting from frequent breakdowns are also a concern in the development of an operating strategy. In addition, the complete blockage of a lane that is totally enclosed with concrete barriers and has infrequent access points (3 to 5 mi apart) would result in severe bus service and traffic handling problems; the intent of providing reliable transitway service would be defeated. Adverse publicity and negative user experiences resulting from congestion on such a frequent basis could lead to diminished ridership or even the loss of public support for priority treatment projects.

TESTING PROCEDURES

The two major objectives of this research effort, as previously discussed, were the stalled-bus parking measurements and the determination of speed profiles of the passing maneuver for various transitway widths. The data collection process for each of these operations is summarized in the following paragraphs. All testing was performed by the Texas Transportation Institute at the Texas A&M Research Annex, which is located west of Bryan, Texas. The tests were conducted during the week of July 23, 1984. The weather was generally clear and hot.

Bus Driver Selection

Two professional bus drivers were provided by METRO for the week of testing. One driver had approximately 3.5 years of experience and the other had 0.5 year of experience. Their driving skills were, according to an assessment by METRO supervisors, near the average for expected transitway drivers. Although two drivers do not qualify as a statistically valid sample of a fleet of 1,000 drivers, the cost of providing a statistically significant number of drivers would have been prohibitive. Several passes were made for each test, and several different transitway widths were measured. Time constraints precluded other drivers from participating in the study. Several shifts of drivers would have been required to discount the inevitable learning process that results from doing the same type of test over a period of a week. No available record of comparison of driving skills was available in advance of the tests. Although two drivers are not an optimum sample, they were assumed to be adequate for the conduct of this research study.

Bus Parking During Breakdown Situations

Perhaps the most important phase of the study was the initial determination of the bus-to-barrier relationship that results when a bus is parked in the transitway. A 600-ft length of New Jersey-type barrier formed of precast concrete sections was supplied by SDHPT for the tangent and curved section parking tests. The sloping shape of the sides of this type of barrier not only assist in redirecting vehicles upon impact, but also provide a warning (tire scrubbing) to drivers before the vehicle itself hits the barrier.

The drivers were instructed to accelerate their buses to 35 to 40 mph and approach the line of barriers in the center of the transitway. They were to then move to the left side of the lane and position their buses as close to the barrier as was comfortable. This parking maneuver was performed both with the bus engine on and while coasting with the engine off. The power steering was not deactivated when the power was switched off but the maneuverability of the bus was hampered by the lack of power. Parking the bus on the left side of the transitway allowed the driver to have a clearer view of the distance between bus and barrier and also facilitated the possible exit of passengers through the doors on the right side of the bus. The distance between the toe of the barrier and the edge of the far side of the bus was measured at the front and back of the bus. Four to eight attempts, with and without engine power, were made for both curved and tangent transitway sections. The difference between the transitway width and this parking distance is hereby referred to as the clear width.

Passing Maneuver Simulation

The one-lane transitway test site consisted of barrels, W-beam guardrail sections, and concrete barriers that were arranged as shown in Figure 2. The short (100-ft) section of concrete barrier and barrels on the left side of the lane was moved to pro-

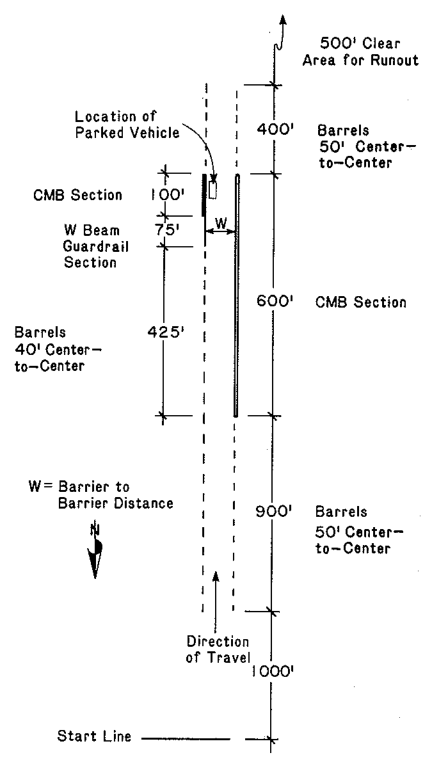

FIGURE 2 One-lane tangent and curved section passing test site configurations.

vide the appropriate transitway width for the test, whereas the long section remained stationary. Single-lane transitway widths of 19.5, 20.5, and 22.0 ft were used. Nighttime operation, without luminaire lighting, was tested for 19.5- and 20.5-ft transitways.

The bus was parked (stalled) on the left side of the simulated transitway, as will be the policy in the Houston system. The curved section was curved 3 degrees and the buses approached from the northeast and exited to the southeast. METRO advisors determined that the configuration with a bus parked inside, rather than outside, the curve represented the most difficult passing maneuver. Neither of these layouts had lane markings for the passing test; this provided less guidance to the driver than would actually be present during normal transitway operation.

The speed versus distance data were collected by attaching an instrumented fifth wheel to a bus and a van (the two types of passing vehicles). The 2,400-ft length of roadway (Figure 2) was provided in advance of the test site so the drivers could accelerate from 0 to 50 mph and then decelerate to a speed they felt was comfortable to pass the "stalled" vehicle (bus or passenger automobile). A distance of more than 500 ft was provided after the test site to allow the driver to accelerate back to at least 30 mph.

The bus drivers were instructed to pass the stalled vehicle at speeds that were comfortable for them, assuming they had a full load of passengers. They were to ignore the possibility, which is present during actual operation, that people might step out of the stalled vehicle into the path of the passing bus. This possibility would have lowered the passing speeds to less than 10 mph, for safety reasons, at any one-lane transitway width of less than 25 to 30 ft. Ignoring the possibility that passengers might exit therefore allowed the passing speed to vary strictly according to the width of the transitway.

BUS AND VAN BREAKDOWN SIMULATION

The unadjusted data that were obtained from the several bus parking tests are shown in Figure 3. The distance from the concrete barrier to the far side of the bus was measured at both the front and back of the parked bus. Because of the relationship of the shape of the bus to the shape of the concrete barrier, it is possible for the measured parking distance to be less than the 8.5-ft width of the bus. The barrier layouts and approximate parking locations for the simulated tangent section are shown in Figure 2.

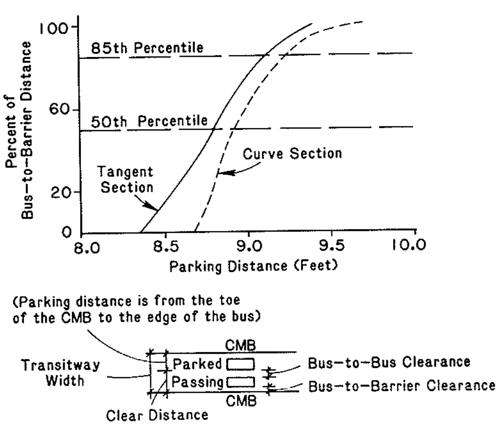

FIGURE 3 Transit bus breakdown parking test data.

The 85th percentile distance used in positioning the buses for the passing speed tests was 9.1 ft for a tangent section and 9.2 ft for a curved section. The clear widths (Figure 3) used in the estimation of passing speeds were obtained by subtracting the parking distances of 9.1 and 9.2 ft for tangent and curve layouts, respectively, from the distance between concrete barriers. This clear width could be expected for at least 85 percent of the controlled breakdowns. The impact of the variation in clear width on passing speed and the cost of transit operation during a vehicle breakdown is examined in the "Delay in the Bus Passing Maneuver" section of this paper. In that section, the costs of breakdowns that close the lane and those that only slow passing speed are estimated and conclusions are made as to minimum and optimum transitway widths.

Tests were conducted with the engine on and off. A 0.1- to 0.3-ft increase in parking distance was observed with the engine off. A decrease of a similar distance was noted between the first and last set (three to four parks per set) of tests with the engine on. A difference in performance according to level of experience was also observed in the passing tests.

Values for passenger van parking maneuvers were obtained by using an experienced van driver and show less variation than those of the bus drivers, possibly because of the relative ease of parking a van. The values also indicate that a stalled bus occupies nearly 2 more ft of lane space than a van, which led to the conclusion that during controlled (nonaccident) breakdowns, transit buses will constrict the clear width much more than vans.

BUS BREAKDOWN PASSING TESTS

Most of the study concentrated on obtaining speed versus distance data for several different transitway configurations. The learning experience of the bus operators over the week of testing previously referred to required several adjustments to be made in the actual data before expected speed-distance curves could be developed.

Adjustments to actual data were made to estimate the passing characteristics of novice and experienced transitway bus operators. The term "novice" refers to the average of the results of the two professional bus drivers at the beginning of the week of testing. The term applies to those bus drivers who have general experience, but little transitway experience. The term "experienced" is applied to those drivers who made approximately 45 test runs (passing maneuvers) in this study. Speed versus distance curves for both categories of transit driver are used in the evaluation of transitway designs in the final section of this paper.

Actual Data Points: Passing Tests

The test number in Table 1 indicates how experienced each driver was during that set of tests. Three to

TABLE 1 Actual Data Points of Bus Passing Tests

Transitway Width (ft) and Alignment	Test No.	Mean Passing Speed (mph)	Standard Deviation (mph)	Standard Deviation as a Percent of Mean
19.5, tangent	2	9	5	63
20.5, tangent	5	21	4	19
22.0, tangent	6	42	10	24
19.5 curve	13	16	8	50
20.5 curve	15	32	6	19
22.0, curve	17	38	5	13

five runs per test were conducted; therefore, each driver made about 60 passing maneuvers (17 tests) over the week of testing. The standard deviation of the average passing speed quantifies the distribution in speeds in the actual speed tests. These values could be combined with the recommended curves presented later in this paper to obtain an estimate of the range of passing speeds to be expected. The range of speeds appears to be related more to the width of the transitway than to the driver's level of experience. The narrow lane standard deviations represent a high percentage of the mean speeds; the other deviations represent half of that percentage. Driver perception of the clear width is particularly crucial at narrow clear widths; more variability will therefore be seen in the passing speeds of narrow lanes. It is also shown in Table 1 that both driver familiarity and slight changes in transitway width can result in dramatic improvements in passing speeds. This information is expanded in the following section.

The passing speed of a novice van driver, even in the narrow transitway simulation, was significantly higher than that of professional bus drivers. The relationship of van passing speeds to bus passing speeds remained constant throughout the testing period. A 50-mph van passing speed was attained in all but the narrowest transitway clearances. Therefore, the situation in which a van passes a stalled bus will not affect the operation of a transitway under breakdown conditions.

Passing Speed Adjusted for Driver Experience

Passing tests were conducted at the beginning and near the end of the week for a simulated transitway width of 20.0 ft. The difference resulting from experience gained during about 45 test runs, as shown in Figure 4, resulted in a doubling of passing speeds on a tangent alignment. The relationship shown in Figure 4 applies to the graphs that follow it in order to adjust the data actually collected to the two conditions defined in this test. For the sake of clarity, only that portion of the graph plotted below 45 mph is shown. The plot between 45 and 50 mph is long and almost identical among all the various transitway widths. However, significant differences in the amount of delay occur below 45 mph; therefore, 45 mph is used as the base line for the bus passing speed curves in a later section. The speed curve from 0 to 1,500 ft has likewise been deleted because it was insignificant.

Because operational safety is an important factor in the design of a narrow transitway, the recommendations made in this paper are derived from novice driver behavior. This should be remembered when analyzing the figures. The descriptions of curves that follow attempt to show all relevant comparisons between driver experience, transitway width, transitway alignment (curved versus tangent), and lighting conditions (day versus night) without recommending any particular widths. These curves only describe the operating behavior that could be expected under several different conditions. Not all comparisons are available due to the short testing period, but major design features and operational expectations can be ascertained.

Tangent Versus Curved Layouts

The adjusted comparisons for tangent and curved layouts are shown in Figures 5 and 6. The expected passing speeds for 19.5-ft lanes are below 10 mph for both layouts and are not significantly different. The medium-width transitway (20.5 ft) passing speeds increased to 20 mph for tangent sections and 15 mph for the 3-degree curve. The increasing speed differential culminated in speeds of 38 mph and 25 mph for tangent and curved layouts, respectively, in the wide transitway (22.0 ft).

Passing speeds of 5 to 10 mph, as observed in the tests, are possible in narrow clearances with relatively inexperienced drivers. Because of the driver's ability to perceive the clear space, the speed differential between tangent and curved layouts grows as the transitway widens. A driver must slow down to comfortably pass through a narrow gap; as the gap on

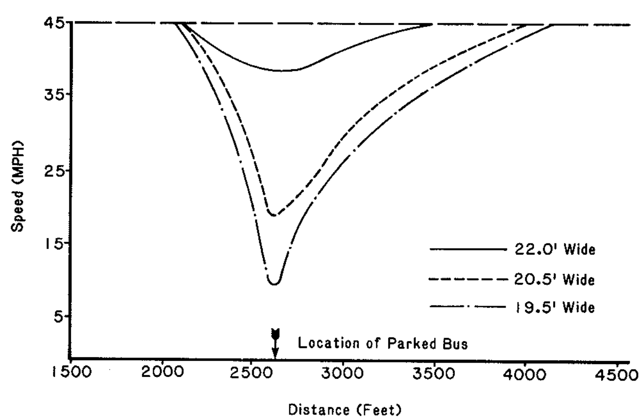

FIGURE 5 Novice driver speed profiles on tangent transitway sections.

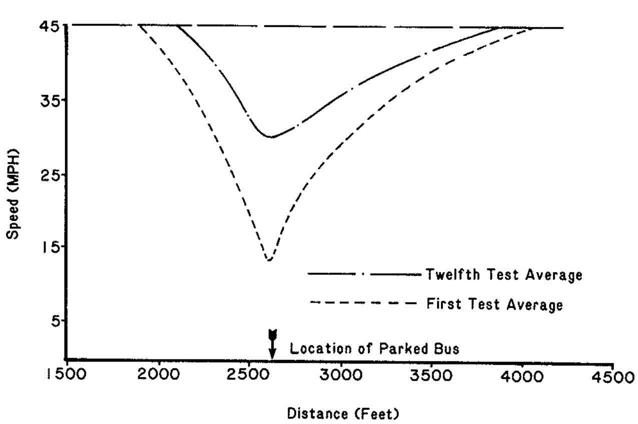

FIGURE 4 Impact of approximately 45 test passes on speed profile of transit bus on 20.0-ft tangent transitway.

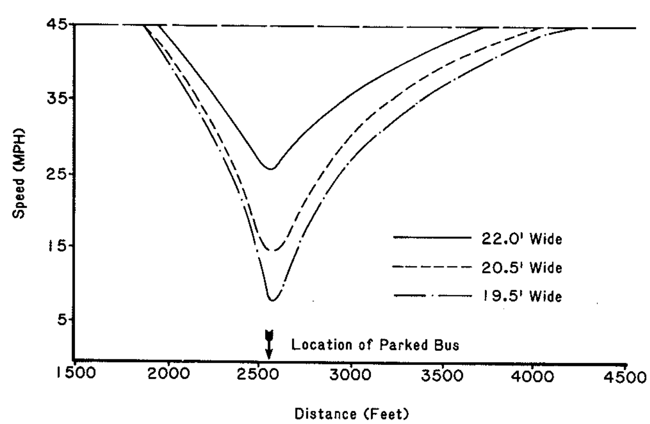

FIGURE 6 Novice driver speed profiles on transitway sections with 3-degree curves.

a tangent layout widens, the bus operator can adjust his speed accordingly. The passing maneuver on a curve, however, does not allow for such an immediate judgment to be made. The passing speeds on a 19.5-ft lane are almost identical, but the driver decelerates more gradually on the curved layout.

Day Versus Night Conditions

Two different transitway widths were tested at night. The conditions during the night test consisted of no moon, no illumination other than passing vehicle headlights and parked vehicle flashers, and no reflectors on the barriers. These are, with the exception of rain or fog, probably the worst visibility conditions that would actually be experienced. An approximate 5-mph decrease in passing speed was observed for both 19.5- and 20.5-ft tests. The more gradual deceleration observed on the curved layout was also evident in the night passing maneuver.

Novice Versus Experienced Drivers

The estimated improvements in passing speed that could be expected as a result of increased driver familiarity with transitway operations are presented in Figures 7 and 8. The novice driver curves for the tangent and curved layouts are presented in Figures 5 and 6 and the experienced driver curves were estimated by using the relationship presented in Figure 4.

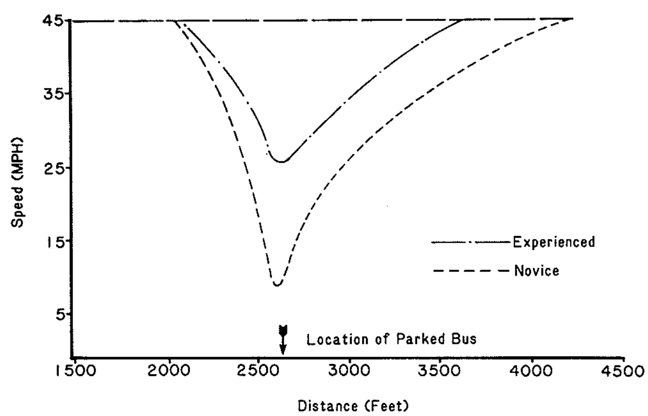

FIGURE 7 Speed profile comparison on 19.5-ft tangent transitway: novice versus experienced driver.

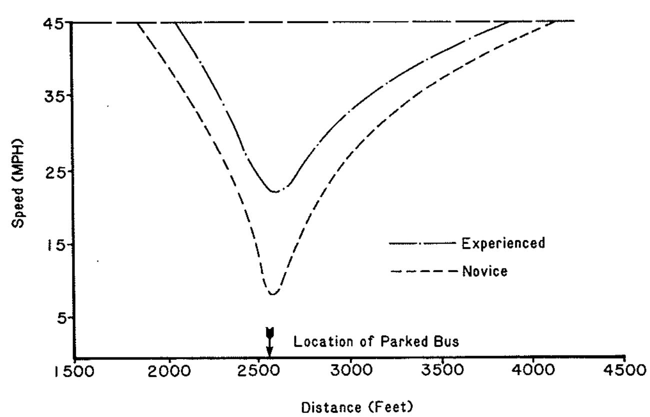

FIGURE 8 Speed profile comparison on 19.5-ft transitway with 3-degree curves: novice versus experienced driver.

Passing operations in all three transitway widths, for both tangent and curved layouts, are estimated to significantly improve according to driver experience. The narrow transitway speeds more than double for experienced drivers. Passing speeds of experienced drivers on 19.5- and 20.5-ft transitways improve by 15 mph, and the passing speed on wide transitways is estimated to be 40 mph or more.

Delay in the Bus Passing Maneuver

Although the passing speed during a breakdown situation is important, an economic estimate of the impact that lower passing speeds have on transit operation can be obtained through the use of delay estimates. The delay in passing time may be defined for transitway traffic as the difference in travel time between unconstrained operation and a situation in which a stalled vehicle is in the transitway. The additional time required to make a trip on the transitway may be estimated by measuring the area between the passing speed curve and a horizontal line at 50 mph. As was previously discussed, the 45-mph value was used in the graphs because all curves between 45 mph and 50 mph were relatively consistent. All transitway widths tested would incur approximately 20 sec of delay between a speed of 45 mph and the normal operating speed of 50 mph.

The values shown in Table 2 indicate that a breakdown on the narrow transitway would result in more than 3 min of delay for every bus driven by a novice driver. The use of experienced drivers would reduce the delay by approximately one-half and increase the passing speed by a factor of 3. Similar reductions are exhibited in medium-wide to wide transitways from the categories of novice driver to experienced driver. The delay also decreases as the lane widens. Passing a stalled vehicle on a tangent section of 22.0-ft transitway is not estimated to result in any more delay than the 20 sec between 45 mph and 50 mph. Novice drivers on a wide (22.0-ft) curved layout, however, may still experience a delay of 2 min.

TABLE 2 Estimated Bus Passing Speed and Delay

	Novice Driver		Experienced Driver	
One-Way Transitway Width (ft) and Alignment	Passing Speed (mph)	Delay (sec)	Passing Speed (mph)	Delay (sec)
19.5, tangent	9	200	26	110
20.5, tangent	20	155	35	80
22.0, tangent	38	55	45+	20
19.5 curve	7	215	23	135
20.5, curve	15	180	32	95
22.0, curve	25	120	38	50

Note: "Novice" refers to professional bus driver at the beginning of the test. "Experienced" refers to professional bus driver with approximately 45 test runs. "Delay" is the difference between a constant 50-mph speed and each estimated speed profile.

The parking distances on tangent layouts shown in Figure 3 are used in Figure 9 to estimate the percentage of controlled bus breakdowns that could block narrow transitways. According to the collected data, any transitway wider than 19.0 ft would never be blocked because of a nonaccident bus breakdown, but a 1-ft decrease in barrier-to-barrier width would increase the blockage rate above 80 percent. In addition, the use of a required clear width of 9.5 ft results in extremely slow passing speeds because an 8.5-ft bus with a 0.7-ft wide driver's side mirror

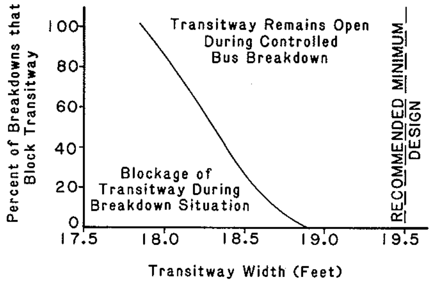

FIGURE 9 Percentage of controlled bus breakdowns that block transitway.

leaves only 0.3 ft of total clear space. The percentage of blockage would decrease somewhat over time as drivers became more familiar with the parking maneuver, but any width of less than 18.5 ft would almost certainly result in transitway closure if buses broke down.

Estimates of the cost of delay to transitway users per peak-hour breakdown can be obtained by using the data on Figure 9 and the values for delay in Table 2 to generate the delay cost estimates in Figure 10. If typical breakdown rates are assumed, 15 bus breakdowns and 75 van breakdowns can be expected each year. The delay cost is calculated by multiplying the probability of the event (lane closed or open) to the value associated with that event. Peak-hour volumes of 50 buses and 300 vanpools were combined with an incident time of 30 min. Values of $50 per bus operating hour and $7 per passenger hour were used to assess the cost of delay.

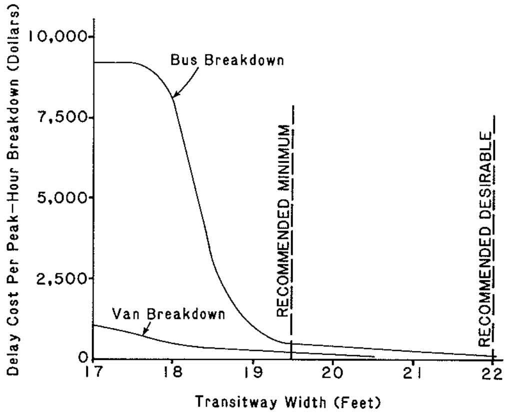

FIGURE 10 Cost of delay of a peak-hour breakdown on tangent transitway.

The stalled vehicle, whether it blocked the lane or not, was estimated to be parked for 30 min, which accounts for the time to detect the stalled bus, dispatch a tow truck, transfer passengers, and tow the disabled bus. A curve similar to that in Figure 9 was used to develop the van breakdown curve.

The sharp curve at 19.0 ft in the line representing the cost of a bus breakdown in Figure 10 reflects the increasing probability that the transitway will be blocked as the width of the lane decreases. The simulation of a lane blockage accounted for an estimated 70 vehicle-hours of delay and a queue in excess of 1 mi for each transitway closure. The probability of this occurrence was multiplied by the value of that delay ($9,250) and added to the remaining probability and an estimated passing delay if the lane was not blocked. The estimated increase in the cost of delay from less than $500 per incident on a 19.5-ft lane to $3,000 for an 18.5-ft lane and to more than $7,500 on an 18.0-ft transitway illustrates the importance of maintaining sufficient width on all sections of the transitway for stalled-bus parking. This curve can be used to determine minimum and optimum transitway widths.

MAJOR FINDINGS CONCERNING THE DESIGN AND OPERATION OF TRANSITWAYS

Data that can be used to develop guidelines for the design and operation of a transitway facility enclosed by barrier walls have been presented. Safety considerations, as well as passing speed and delay times, can also be used to develop the suggested guidelines.

Design Guidelines

Bus drivers and METRO supervisory personnel both had a strong preference for the standard New Jersey-type concrete barrier with flared bottoms. This is important because barriers with vertical walls were being considered in order to increase space in the transitway. Experience with the parking tests and passing maneuvers in tight clearance sections also suggests that the drivers used the wide bottom of the barrier as a guide to position their vehicle. As they became confident that the tire could be rubbed on the bottom of the barrier without damaging the body of the bus, the drivers were able to park the bus much closer to the barrier.

The travel speed and delay values summarized in Table 2 and the delay cost curve shown in Figure 10 were used to develop both minimum and optimum widths for reversible transitways. A minimum width of 19.5 ft allows one bus to park on the left side of the transitway and another bus to pass on the right. Parking test data indicate that, under controlled breakdown (nonaccident) situations, the clearance between the right side of the parked bus and the barrier will allow other drivers to slowly pass a parked vehicle. Increasing the width by 2.5 ft, which is desirable, would allow the passing speed to increase to almost 40 mph, which would result in little delay to passing vehicles. The optimum width also provides additional flexibility in the parking location for disabled vehicles and, thus, greater assurance that the tran- sitway will remain open when a vehicle breaks down in it.

Sections that are curved more than 2 degrees should be widened a minimum of 0.5 ft and an optimum of 1.0 ft. The increases in width of curved sections would allow passing speeds to remain consistent with those of tangent sections.

Pavement markings for the reversible transitway should delineate a 12-ft lane in the center of the transitway. A solid white, 4-in. stripe of paint should be used to delineate the lane. A disabled bus would use the left side of the transitway for parking. Striping the lane in a manner that would provide a single, wide shoulder on one side of the transitway, thereby forcing the bus operators to drive near one barrier, could lower operating speeds relative to a center lane operation. Also, because the lane is reversible, a stalled or parked vehicle would have to park on the left side of the transitway; if the bus was parked on the right side, the door would be next to the concrete barrier and passengers would not be able to exit.

Operation Guidelines

This paper dealt primarily with the case of a bus passing another bus, because this maneuver had the greatest impact on passing speed. Other passing tests indicated that little deceleration (less than 15 mph) could be expected when a van passes a bus. In all cases, a stalled van would not narrow the width of the lane as much as a stalled bus would, thereby allowing higher passing speeds.

The two bus drivers in these tests were told to ignore the possibility that passengers might disembark from the stalled vehicle into the path of the passing vehicle, thus allowing the passing speed to vary according to the clear width only. In actual operation, the concern for passenger safety would lead to slow (less than 10 mph) passing speeds for clear widths up to 25 to 30 ft. These safety considerations must be resolved before operating speeds can reach the levels obtained by experienced drivers indicated in this paper. The driver of a stalled vehicle could be instructed to keep all passengers inside until another vehicle (relief bus or van) arrives on the scene and keeps other vehicles from passing. Passengers from the stalled vehicle would then transfer to the "blocking" vehicle and resume their trip.

One of the most important results of this study is the realization of how vital previous driver training is to the successful operation of a transitway. Curves were derived to show the improvement in passing speed from the novice to the experienced driver. This increase in speed reduces delays, but, more importantly, it reduces the potential for accidents by allowing a more constant speed to be maintained. Training drivers in the parking maneuver also provides greater assurance that breakdowns will not result in a total blockage of the transitway. The cost of a lane closure is shown in Figure 10.

ACKNOWLEDGMENT

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REFERENCE

1. Transitway Operation Performance Study. Report 84-1. Metropolitan Transit Authority of Harris County, Tex., April 1984.