San Francisco-Oakland Bay Bridge Trans-Bay Bus Riders Survey

CHARLES E. ZELL, Urban Planning Department, California Division of Highways

This survey was conducted to determine if an exclusive bus lane provided in 1961 on the Bay Bridge caused a significant number of people to change from auto to bus travel. The findings are not directly applicable to the question of capacity of freeways with reserved lanes for buses because the buses shared a lane with other vehicles at the actual bottleneck, the 2-lane approach to the traffic signal at Yerba Buena Island. Also, we did not determine how many bus riders switched from bus to auto travel during the test period.

The study indicated that patronage increased 6 percent from 1961 to 1962, coinciding with the inauguration of the exclusive lane, but also increased 6 percent from 1960 to 1961, before the exclusive lane was established. There is no evidence that the exclusive bus lane caused a major increase in bus patronage or a significant reduction in auto traffic on the bridge. Three percent of the bus passengers interviewed had switched from auto travel during the exclusive lane period. Of these, 38 percent said they switched to bus travel because it was more convenient, and 23 percent said they did so because the bus was faster. Only one out of 239 former auto users said specifically he switched because of the exclusive bus lane.

Changes in place of employment or residence caused large shifts in bus patronage. Twenty-three percent of all interviewed bus riders were new during 1962, but the net increase in patronage was only 6 percent and the "switches" from auto travel were only 3 percent. The increase (1962 over 1961) in the number of people crossing the bridge in autos was greater than the increase in bus riders; 533,000 bus riders accounted for 46 percent and 636,000 auto users for 54 percent of the total increase.

•WHEN THE rail transit operation on the San Francisco-Oakland Bay Bridge was discontinued in April 1958, it became necessary to pave the former track area on the lower deck and to reconstruct the decks in the Yerba Buena Island Tunnel, an integral part of the overall bridge between San Francisco and Oakland. During reconstruction in the tunnel, the capacity of the upper deck was reduced and the lower deck was restricted to two very substandard lanes at the approach to a temporary traffic signal at the east end of the tunnel (Fig. 1). All of this caused delays and queues of mixed autos, buses, and trucks on the lower deck, especially in the eastbound direction during the evening peak hour.

In December 1961, pavement on the lower deck had been completed on the portion of the bridge west of the Island, so that in the eastbound direction there were three 12-ft lanes available for evening peak traffic approaching the 2-lane section in the tunnel. The queue lined up three abreast, but the capacity of the signal was still limited

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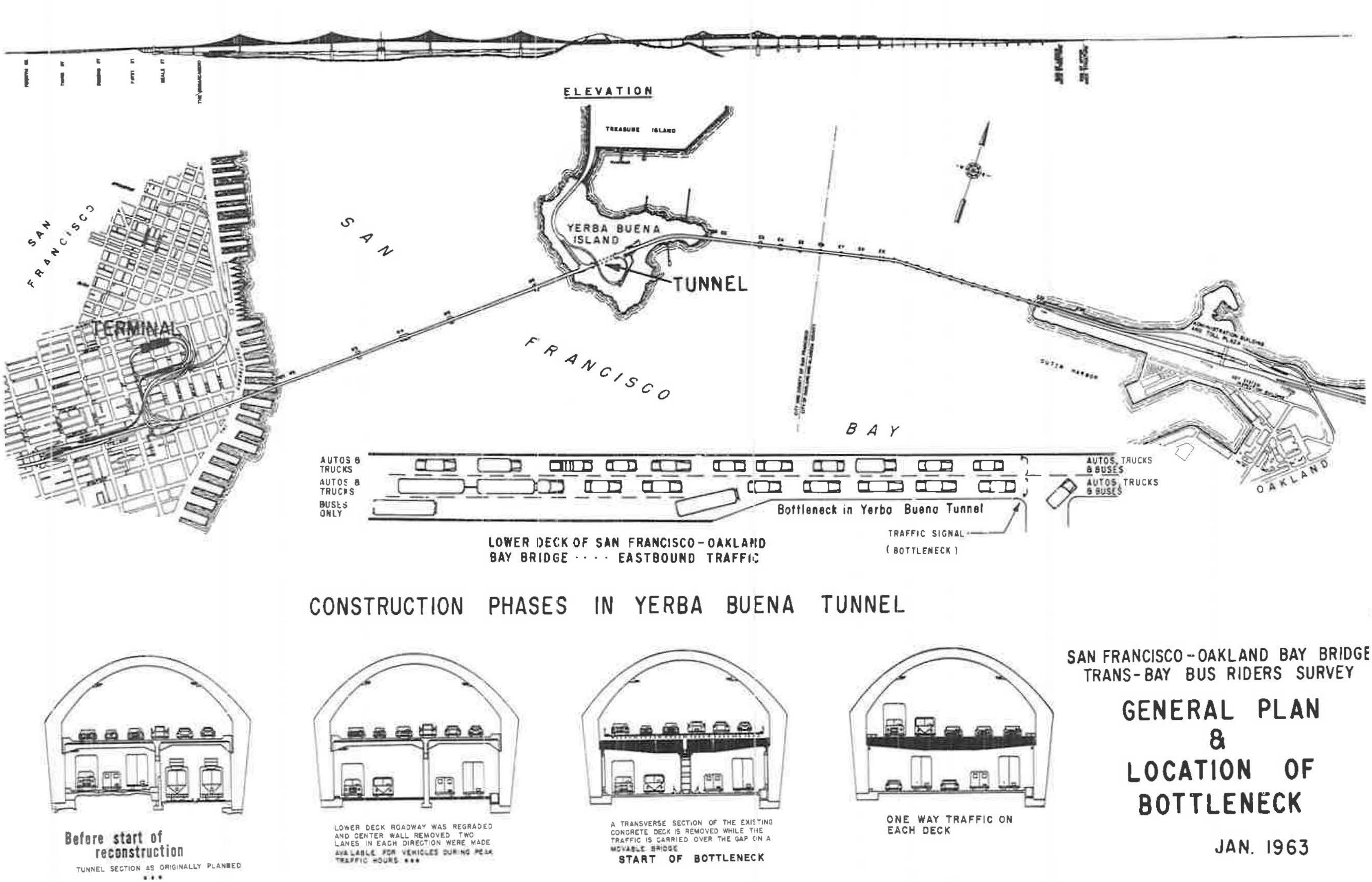


Figure 1. General plan and location of bottleneck.

by the two lanes at that point; in other words, the signal at the east end of the tunnel was a bottleneck with far less capacity than even two of the three lanes west of the tunnel.

In January 1962, an order was issued restricting the eastbound shoulder lane of the west bay crossing for the use of buses only (Fig. 2). This did not change the capacity of the signal at Yerba Buena Island, but it enabled the buses to bypass the queues of autos and trucks which now had to line up two abreast on the west bay crossing while waiting for their turn to go through the bottleneck. This gave the buses an advantage of about 9 min as compared with the autos and trucks which were bypassed, and it was hoped that this would induce sufficient auto riders to switch to buses to reduce vehicular volume to a figure more comparable with capacity of the bridge.

PURPOSE OF STUDY

During the period in which the exclusive bus lane was in operation, bus patronage did increase. This study of the bus riders was made to determine if the exclusive bus lane caused a significant number of people to change from auto to bus travel across the Bay.

STUDY PROCEDURE

In October and November 1962 a survey of bus patrons was conducted to determine how many of them had changed from auto travel and the reasons for the change. Eastbound bus commuters using the San Francisco Terminal Building were interviewed between 4:00 to 6:00 p.m. on Tuesdays, Wednesdays, and Thursdays only. Generally, only two bus lines were surveyed on a given day. The interviewing started on Oct. 23 and was completed on Nov. 7.

The bus riders were interviewed while waiting in line for their bus. Some of the riders arriving just as the bus was leaving were not interviewed. Ninety-one percent of the 11,000 bus riders were interviewed.

From the interview it was determined if the bus rider was a regular commuter. If so, did he become a regular bus commuter in 1962? Was he a new commuter or a former auto commuter? If he was a former auto commuter, the following questions were asked:

Figure 2. Exclusive bus lane.

1. How did you commute across the Bay before you became a regular bus commuter?
2. How did you get to the Terminal Building?
3. Where did your trip begin in San Francisco?
4. How will you travel to your destination after you get off this bus?
5. Where is your destination?
6. Why did you start riding the bus?

Postcards were distributed to former auto users when time did not permit a complete bus-side interview; 62 percent of the 187 distributed postcards were returned.

Travel time studies of eastbound buses and autos were also made during the evening peak period. Bus passenger statistics received from Alameda-Contra Costa Transit District and Greyhound were analyzed. Traffic volume and classification data from the Bay Bridge toll records and the University of California Institute of Transportation and Traffic Engineering were also analyzed.

FINDINGS

Changes in Mode of Travel

It was found that 3.1 percent of the peak hour patrons using buses in October and November 1962 had changed from autos to buses during the 10 months since the exclusive lane was established. The number of former auto users who had been drivers or had shared driving in car pools (as distinguished from riding as passengers) represents five bus loads of passengers or a 1.6 percent reduction in the evening peak eastbound vehicular traffic. The increased number of buses or the reduction in total traffic volume was not significant enough to be recognized by the average bridge user.

Reasons for Changing from Auto to Bus Commuting

Approximately one-third of the former auto users gave more than one reason for changing to bus commuting. Convenience was the most frequently mentioned reason (38 percent) for changing to the bus. In addition to the exclusive bus lane, the new buses and expanded service could have been strong factors influencing convenience.

Figure 3. Bus loading, San Francisco Terminal Building.

Another factor influencing convenience of bus riding is the inconvenience of parking an automobile in downtown San Francisco.

Twenty-seven percent of the former auto users said that they changed to bus travel because the bus was cheaper. The fact that the bus travel is cheaper than auto travel for some people may bear little relation to the exclusive bus lane.

Twenty-three percent of the former auto users said that they changed to bus travel because the bus was faster. The bus trip may be slower in some cases than the auto trip when the total time from trip origin to destination is considered. All time savings can be lost if more than a few minutes are spent waiting for the bus. Even on two lines operating with the shortest headways, some passengers had to wait in line for five or more min (Fig. 3).

Seventeen percent of the former auto users said that the car pool in which they were riding broke up. Some of these people further stated that they would return to pool riding as soon as they could get another started.

Among the miscellaneous reasons stated for changing to the bus was the congestion on the bridge or approaches (8 percent). Some of the bus riders said they no longer had a car available or they could no longer drive. Only one person out of 239 mentioned the exclusive bus lane as a reason for changing to bus travel.

Former Mode of Commuting

Approximately half (51 percent) of the former auto users drove their own cars. The remainder either shared driving in a pool (28 percent) or were always auto passengers (20 percent). One percent was undetermined.

Increase in Bus Patronage

Bus Riding Trend. —The trend in Trans-Bay commuter bus riding has been counter to the national trend. On both the Alameda-Contra Costa Transit and Greyhound Bus Company's Contra Costa lines the patronage has shown significant increases in the past 3 years (Fig. 4). The increases on the two bus lines and for autos crossing the bridge during common 10-month periods are given in Table 1.

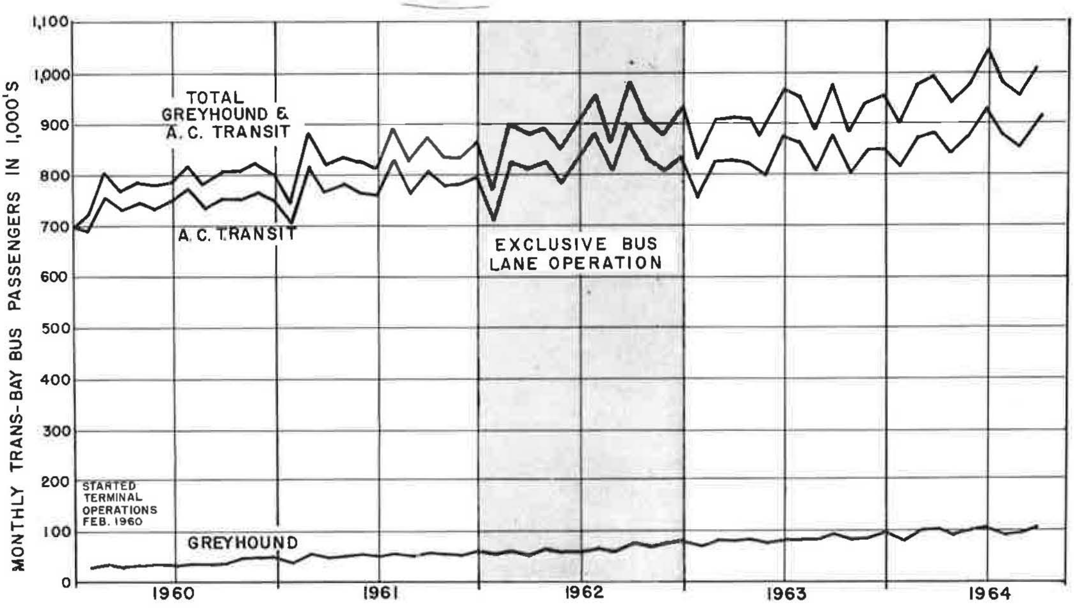


Figure 4. Monthly Trans-Bay bus passengers using San Francisco Terminal Building.

TABLE 1

TRANS-BAY COMMUTER TRAVEL INCREASE

Travel Method	Percent Increase		
	1960-1961	1961-1962	1960-1962
A-C Transit	4.50	5.40	10.14
Greyhound	37.46	18.86	63.39
Total Bus Riders	6.28	6.34	13.02
Autos	3.64	1.32	5.01

New Bus Riders. —The new bus riders are new commuters who have changed jobs or place of residence in the first 10 months of 1962 and former auto users who were either auto drivers or riders in 1961. The new bus riders account for a little less than one-quarter of the bus riders. This ratio was about the same for both A-C Transit and Greyhound (Table 2). The former auto users were 3.1 percent of all bus riders and 14 percent of the new bus riders. These percentages are about the same for both bus companies (Table 2).

Following is an estimate of the change in the number of persons crossing the bridge between comparable periods in 1961 and 1962 (Feb. 1 to Nov. 30). The daily commuters are about two-thirds of all Trans-Bay bus riders. For this estimate, it is assumed that they are representative of all bus users.

1. Change in bus patronage:

Former auto users	+ 278,000
Other new bus riders	+1,769,000
1961 bus riders lost in 1962 (computed)	-1,514,000
Net gain in 1962 (from bus passenger records)	+ 533,000

2. Change in auto users:

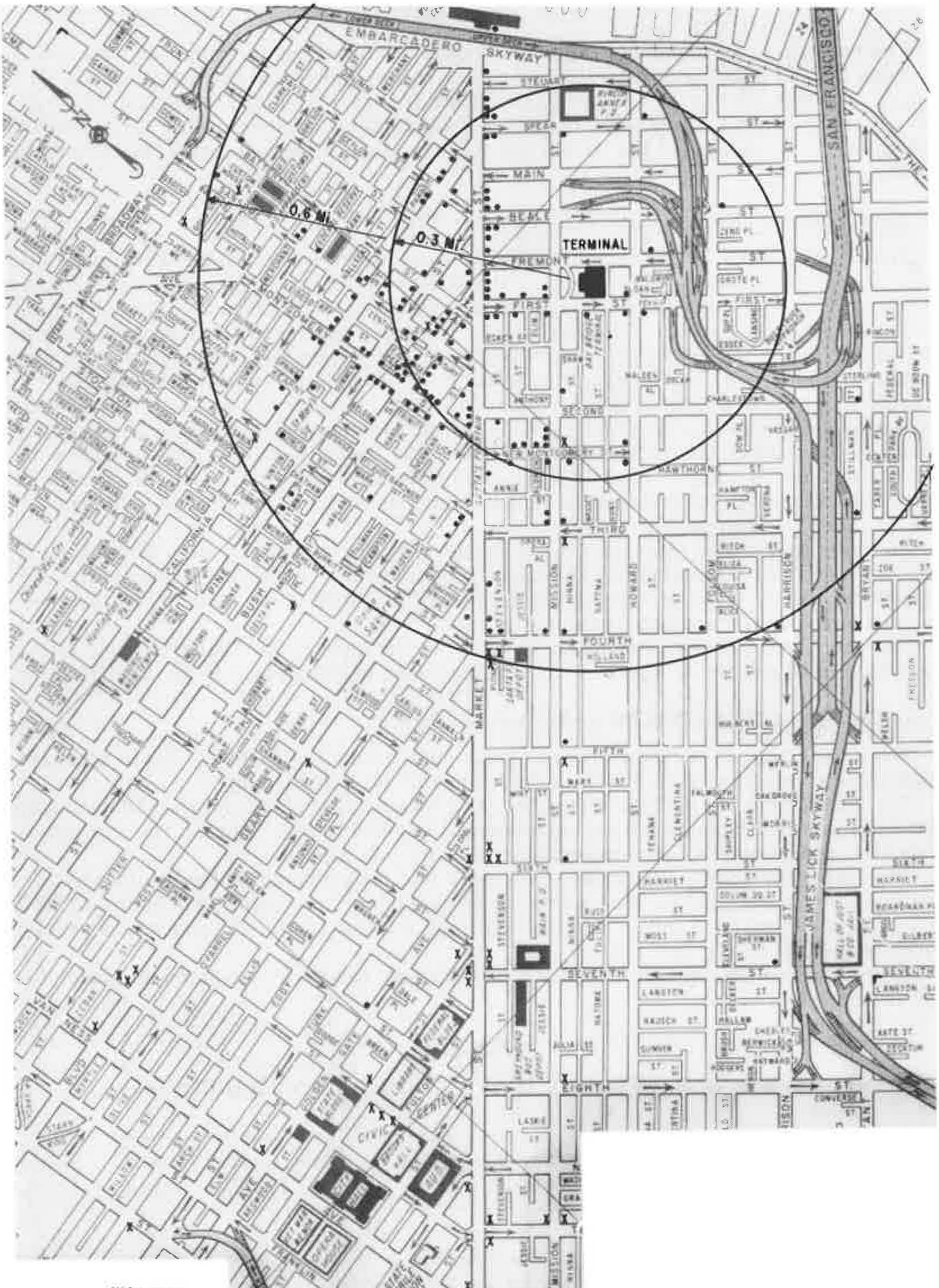
Former auto users now in buses	- 278,000
New auto users	+ Unknown
1961 auto users lost in 1962	- Unknown
Former bus users now in autos	+ Unknown
Net gain in 1962 (from SF-OBB toll records)	+ 636,000

3. Total net gain in bus and auto riders +1,169,000

TABLE 2

NEW BUS RIDERS, TRANS-BAY, 1962

Bus Line	New Bus Riders		Former Auto Users		
	No. Interviewed	Percent Total Interviewed	No. Interviewed	Percent of All New Riders	Percent of All Bus Riders
A-C Transit	1,863	23	256	14	3.1
Greyhound	415	24	54	13	3.1
Total	2,278	23	310	14	3.1



NOTE: 7% OF ORIGINS ARE OFF OF THIS MAP.

BASE MAP COURTESY OF CALIFORNIA STATE AUTOMOBILE ASSOCIATION

Figure 5. Origins of former auto riders.

The net gain in auto and bus riders in 1962 is 2.07 percent as compared with 1961.

Less than 18 percent of the 1961 bus riders (1,514,000 in the estimate) are no longer crossing the San Francisco-Oakland Bay Bridge. Some of the person trips no longer riding buses undoubtedly are included among the auto users. The large losses and gains in the number of bus riders are an indication of the mobility of the Bay Area population.

Mode of Travel at Ends of the Trans-Bay Bus Trip

In San Francisco, 71 percent of the former auto users walked to the Terminal Building. Eighty-five percent of those who walked listed their trip origin as being less than 0.6 mile from the Terminal Building. This area includes the financial district and the area of high parking costs. The 1961 traffic survey data from the San Francisco-Oakland Bay Bridge* was revealing. Approximately 2,400 auto trips crossing the bridge between 4 and 6 p.m. had destinations in the area served by Trans-Bay buses and originated within 0.6 mile of the Terminal Building. It is not known how many of these have changed to buses or are potential bus users. Figure 5 shows the location of 93 percent of the known trip origins in San Francisco. In the East Bay, 50 percent of the former auto users walked from their bus stop to their destination. The distribution of trip destinations for walkers did not indicate any particular concentration as in the San Francisco origin area.

Auto was the second most used mode (35 percent) for continuing trips in the East Bay. Three lines accounted for 57 percent of this mode. These bus lines are the longest and serve areas of lower population density. None of the former auto users arrived at the San Francisco Terminal by auto.

The use of a local bus, streetcar, or jitney at the ends of the Trans-Bay bus trip amounted to 25 percent of the trips in San Francisco and 8 percent in the East Bay.

Trip Time Across San Francisco-Oakland Bay Bridge

The travel time of eastbound evening peak hour buses was checked. Their average speed on the bridge was 27.6 mph, with a range of 11.8 to 35.2 mph.

The travel time for autos on the upper deck was measured by timing eastbound autos and making travel time and delay trips during the evening peak hours. The average speed by each method was approximately the same, 21 mph.

The travel time for autos on the lower deck (the deck containing the bus lane) was measured by making travel time and delay trips during the evening peak hours. The average speed was 15.2 mph. The average time lost for traffic stoppages was nearly three times that on the upper deck.

Table 3 shows the average speed and travel times based on a common distance of 5.3 miles.

TABLE 3

AVERAGE SPEED AND TRAVEL TIMES, SAN FRANCISCO-OAKLAND BAY BRIDGE

Vehicle	Avg. Speed (mph)	Avg. Time (min)	Min Slower Than Buses
Buses	27.6	11.5	—
Autos on upper deck	21.0	15.1	3.6
Autos on lower deck	15.2	20.9	9.4

*Origin and destination survey of bridge users was made by the Division of San Francisco Bay Toll Crossings as part of their study of additional bay crossings. The original O-D survey cards for the SF-OBB were analyzed for the bus riders survey.

TABLE 4

COMPOSITION OF BRIDGE TRAFFIC EASTBOUND, OCTOBER 1962 (WEEKDAY), 4 TO 6 P.M.

Deck	Veh Type	No. Veh	No. Persons	Persons/Veh
Upper	Auto	8,044	13,031	1.62
Lower	Auto	2,448	3,966	1.62
	Lt. truck	292	380	1.30[a]
	Truck	564	620	1.10[a]
	Local bus	280	10,724	38.30
	Other bus	60	1,200	20.00[a]
	Misc.	17	21	1.25[a]
	Total	3,661	16,911	4.62
Both	Total	11,705	29,942	2.56

[a]Estimated occupancy.

TABLE 5

SUMMARY OF COMPOSITION OF BRIDGE TRAFFIC EASTBOUND, OCTOBER 1962 (WEEKDAY), 4 TO 6 P.M.

Veh Type	Vehicle		Person		Persons/Veh
	No.	Percent	No.	Percent	
Auto	10,492	89.64	16,997	56.77	1.62
Bus	340	2.90	11,924	39.83	35.07
Other	873	7.46	1,021	3.40	1.17
Total	11,705	100.00	29,942	100.00	2.56

TABLE 6

AUTO-PERSONS OCCUPANCY[a]

Persons/Auto	Percent of Autos	Percent of Persons
1	63.95	39.43
2	22.39	27.61
3	6.26	11.58
4	4.02	9.91
5	2.30	7.08
6	0.75	2.76
7	0.23	0.99
8	0.05	0.28
9	0.00	0.00
10	0.05	0.36

[a]Average occupancy 1.62 persons/auto.

Composition of Eastbound Traffic, San Francisco-Oakland Bay Bridge

Between 4 and 6 p.m. on an average weekday, buses carry 40 percent of the eastbound persons in 3 percent of the vehicles and autos carry 57 percent of the persons in 90 percent of the vehicles. The remainder are in trucks (Tables 4 and 5). The average number of persons per vehicle is 35.2 for buses, 2.56 for all vehicles, and 1.62 for autos (Table 6).

CONCLUSIONS

Patronage increased 6 percent from 1961 to 1962, coinciding with the inauguration of the exclusive lane, but patronage also increased 6 percent from 1960 to 1961, before the exclusive lane was established. There is no evidence that the exclusive bus lane caused a major increase in bus patronage or a significant reduction in auto traffic on the bridge.

Three percent of the bus passengers interviewed had switched from auto travel during the exclusive lane period. Of these, 38 percent said they switched to bus travel because it was more convenient, and 23 percent said they did so because the bus was faster. Only one out of 239 former auto users said specifically he switched because of the exclusive bus lane.

Changes in place of employment or residence caused large shifts in bus patronage. Twenty-three percent of all interviewed bus riders were new, but the net increase in patronage was only 6 percent and the "switches" from auto travel were only 3 percent. The increase (1962 over 1961) in the number of people crossing the bridge in autos was greater than the increase in bus riders.

RESERVING BUS LANES ON FREEWAYS

The findings of this study cannot be directly converted into an answer to the question of what effect an exclusive bus lane on a freeway would have on total capacity or total person-minutes. On the Bay Bridge, a lane was not reserved in the bottleneck (Fig. 1).

Because the demand rate of flow exceeded the capacity of the bottleneck, long queues of vehicles formed on the 3-lane approach. Buses could bypass the queues because a lane was reserved for them on the approach to the bottleneck. This resulted in great time savings for the buses and some loss in time for the autos and trucks, but it did not significantly change the capacity or the number of vehicles passing through the bottleneck. Each bus occupied about 5 sec of time in the traffic stream at the bottleneck, and thus added about 5 sec of delay to all other vehicles in the queue at the particular instant that the bus arrived at the bottleneck. However, other vehicles were allowed to use the bottleneck at all times between bus arrivals, about 75 percent of the time. If a lane had been reserved for buses in the bottleneck itself, the total vehicular flow would have been drastically reduced; in fact, it would have been little more than half of what it actually was, because the bus lane would have delivered only about 25 percent of its vehicular capacity.

If there is a delay, it can be only shifted from buses to autos; almost invariably, total delay increases by the assignment of an exclusive lane to buses. The delay cannot be eliminated because as soon as it is, the exclusive lane would be meaningless to the buses. The assignment of an exclusive lane to one class of vehicle which is not used to a capacity equivalent to those of the remaining lanes will reduce the total capacity of the freeway.

It is very possible that a section of road could be operating well within capacity with mixed traffic so that an exclusive lane is unnecessary, but that this same section of road could become a bottleneck incurring huge delays to autos if one lane were reserved for buses, even though the traffic volume and number of buses remained constant. In short, the assignment of an exclusive lane could well introduce a large amount of delay where none now exists.

1964—TWO YEARS AFTER

The bottleneck in Yerba Buena Tunnel was removed in January 1963 and the exclusive bus lane was opened to all traffic. In October 1963 the lower deck of the bridge was made one way for westbound traffic and the upper deck was made one way for eastbound traffic.

The average evening peak period eastbound bus speed was 32.4 mph in December 1964, an increase of 4.8 mph or 17 percent from the average speed recorded during the operation of the exclusive bus lane. The number of bus riders increased by 9.4 percent in the 2-year period since the exclusive bus lane was eliminated. The growth was 13.0 percent for the previous 2 years. The number of autos crossing the bridge increased by 15.4 percent in the past 2 years and 5.0 percent in the previous 2-year period.

Discussion

KARL MOSKOWITZ, Assistant Traffic Engineer, California Division of Highways—In any discussion of the advisability of reserving a freeway lane for the exclusive use of buses, one of the factors to be considered is the effect of an exclusive lane on average delay for all persons, whether they ride buses or not. With a given percentage of all persons traversing a bottleneck riding buses, if the vehicular capacity is exceeded, all persons will be delayed a calculable amount if buses and autos share all lanes. With the same number of persons and the same percentage riding buses but with one lane reserved for buses only, delay to those riding buses will be eliminated but delay to those in autos and trucks will be increased. Diversion from auto riding to bus riding in this situation would have to be enough to reduce overall delay before an exclusive bus lane would prove advantageous.

Enough is known about highway capacity to make a close estimate of this overall delay, based on various stipulations. For example, it could be stipulated that the demand (or desired through-put) at a bottleneck is 20,000 persons/hour. A chart can then be drawn showing person-minutes of delay for various percentages of people riding buses with and without an exclusive bus lane. Figure 6 is such a chart, based on a stipulated demand of 20,000 persons/hour at a bottleneck where four lanes are available for one direction of travel. Other stipulations are four lanes in direction of major flow, 40 passengers/bus, 1.75 persons/auto and truck, uniform rate of demand for 1 hr, and total delay computed for the first 20,000 persons.

Two calculations can now be made:

1. Mixed traffic, no exclusive bus lane—If 12.5 percent (or 2,500 persons) ride in 62 buses, 17,500 persons will ride in 10,000 cars and trucks. The total number of vehicles required for the first 20,000 persons after the queue begins to form will be 10,062. Since each bus is known to be equal to about two cars on level grade, the equivalent number of vehicles will be 10,125. Since the capacity of the section is 7,200 veh/hr, in a mixed traffic stream the 10,125th vehicle will enter the bottleneck 10,125/7,200 = 1.41 hr after the queue starts to form, and the maximum delay will be 0.41 hr or 24.5 min. Based on a uniform demand rate, the average delay is 24.5/2 or 12.25 min, and the total delay is 12.25 × 20,000 or 245 person-minutes. This is shown in Figure 6 as point "A."

2. With an exclusive bus lane—The 2,500 bus riders will suffer no delay, but there will only be three lanes with a capacity of 5,400 veh/hr for the other 17,500 persons in 10,000 veh. The 10,000th vehicle will enter the bottleneck 10,000/5,400 = 1.85 hr after the queue starts to form, and the maximum delay will be 0.85 hr or 51 min. The average delay will be 25.5 min for 17,500 persons, or 447,000 person-minutes. This is shown in Figure 6 as point "B."

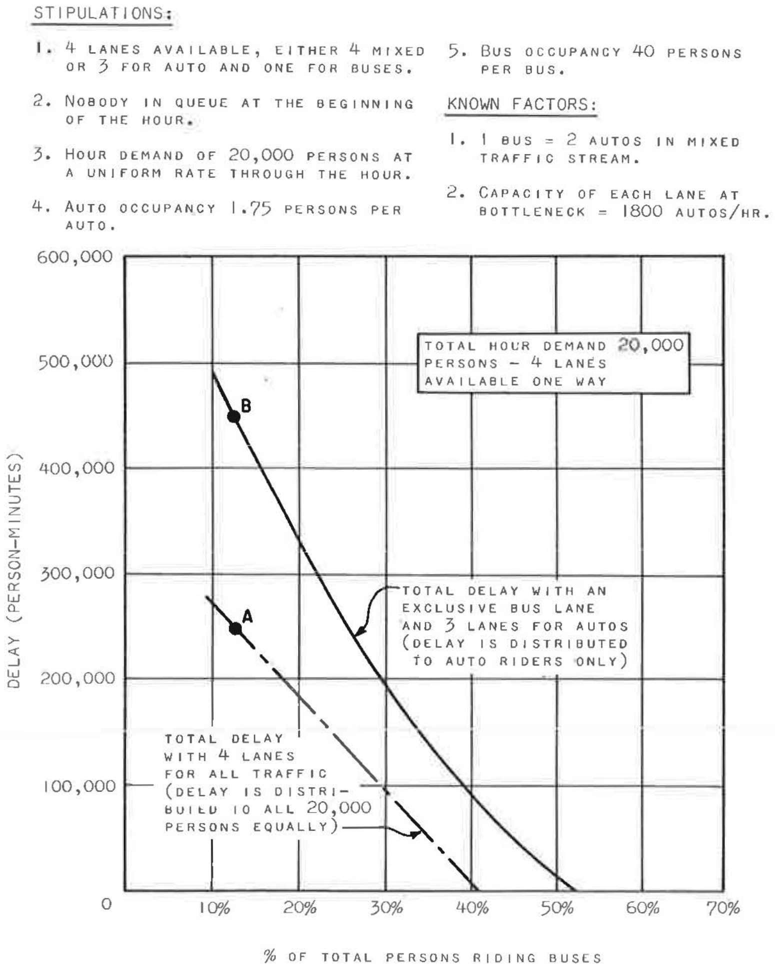


Figure 6. Relation between delay, assignment of lanes, and percent of total demand riding buses.

Enough other points were calculated for different percentages of persons riding buses to draw both curves in Figure 6. It will be noted that if 40 percent of the persons ride buses, there will be no delay for anybody if mixed traffic is allowed on all four lanes, but there will be approximately 100,000 person-minutes of delay if one lane is reserved for buses and the other vehicles are confined to three lanes.

Under the stipulated conditions, 53 percent of all persons must ride buses to eliminate delay if one lane out of four is reserved for buses. However, if 53 percent rode buses and mixed traffic were allowed on all four lanes, there would be no delay for anybody and there would be considerably more freedom of movement in the traffic stream; in other words, the freeway would be operating at about 82 percent of capacity with mixed traffic in all four lanes, but at 100 percent of capacity with one lane for buses and three lanes for autos and trucks.

Other charts can be drawn for other stipulated demands or widths of freeway. Examples are shown in Figures 7 and 8. A more sophisticated approach would involve a rising and falling rate of demand spread over a 2-hr period.

There is no question that if demand exceeds capacity, delay will be reduced as the proportion of bus riders increases. However, it appears that reserving an exclusive lane for buses, under such circumstances, would normally increase total delay although

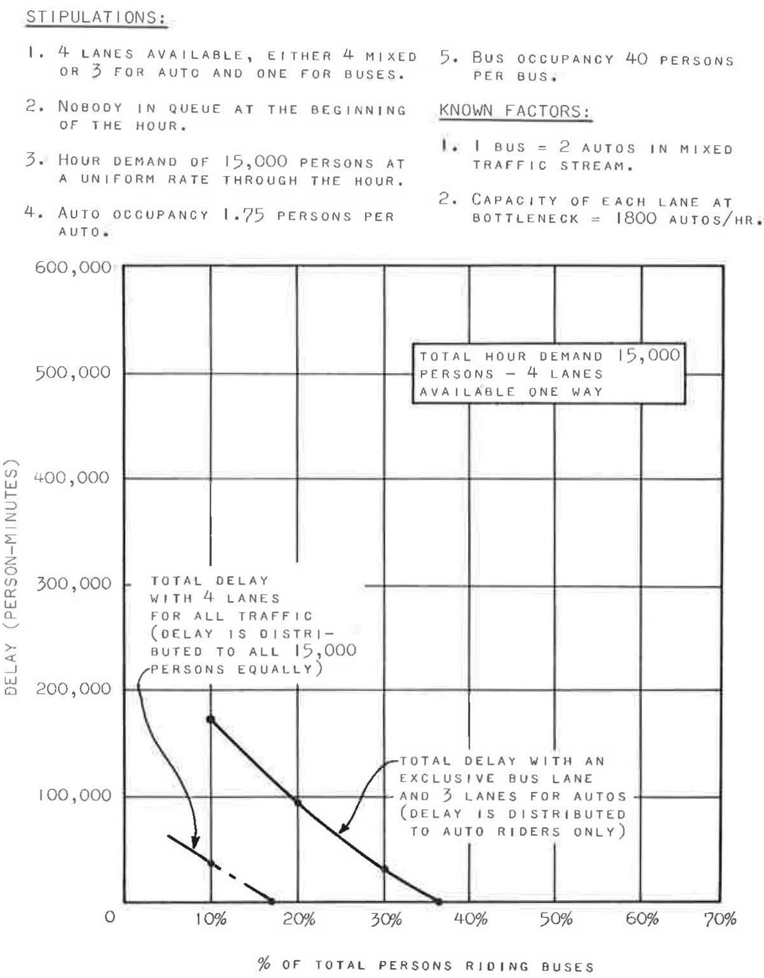


Figure 7. Relation between delay, assignment of lanes, and percent of total demand riding buses.

reducing it for some. The only result of the reserved lane that could be considered "beneficial" would be the possible coercion of auto riders to switch modes of transportation, and thus reduce the demand-capacity ratio.

Philosophic questions would have to be resolved regarding the equity of delaying one group of people more than another group before it could be stated that this was a "benefit," and the question of which group is paying most for the facility should enter into such a philosophic decision.

It must be kept in mind that if there is no delay, there is no point in setting aside an exclusive lane, and if there is delay, it can only be shifted by the assignment of an exclusive lane. It cannot be eliminated because the minute all delay is eliminated, the exclusive lane is meaningless to the buses. It is certain, however, that assignment of an exclusive lane for one class of vehicles will reduce the vehicular capacity of the bottleneck.

It is very possible that a section of road could be operating well within capacity with mixed traffic so that an exclusive lane is unnecessary, but that this same section of road could become a bottleneck incurring huge delays to autos if one lane were reserved for buses, even though the traffic volume and number of buses remained constant. In short, the assignment of an exclusive lane could well introduce a large amount of delay where none now exists.

STIPULATIONS:

1. 3 LANES AVAILABLE, EITHER 3 MIXED OR 2 FOR AUTO AND ONE FOR BUSES.
2. NOBODY IN QUEUE AT THE BEGINNING OF THE HOUR.
3. HOUR DEMAND OF 15,000 PERSONS AT A UNIFORM RATE THROUGH THE HOUR.
4. AUTO OCCUPANCY 1.75 PERSONS PER AUTO.
5. BUS OCCUPANCY 40 PERSONS PER BUS.

KNOWN FACTORS:

1. 1 BUS = 2 AUTOS IN MIXED TRAFFIC STREAM.
2. CAPACITY OF EACH LANE AT BOTTLENECK = 1800 AUTOS/HR.

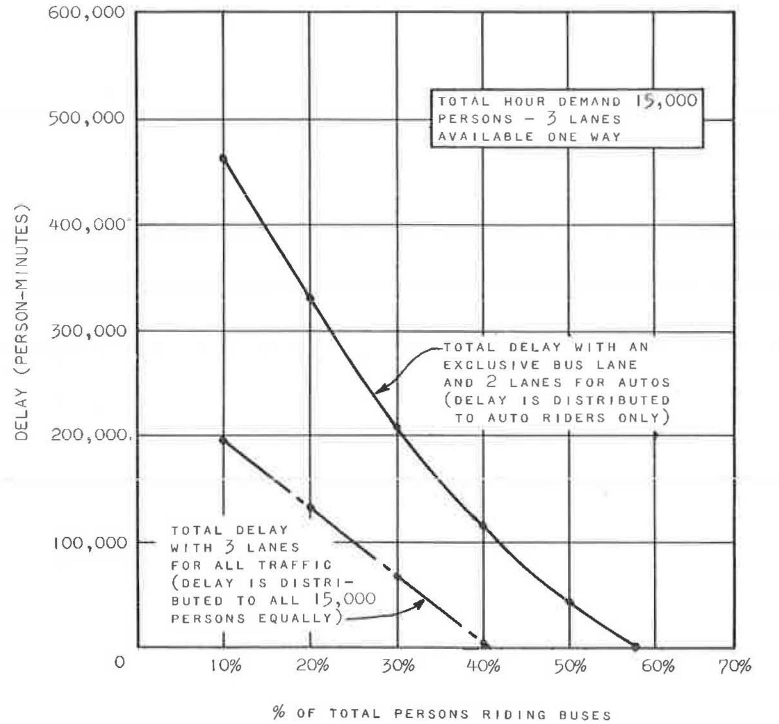


Figure 8. Relation between delay, assignment of lanes, and percent of total demand riding buses.

The same reasoning would apply to the design of a future freeway. For example, a freeway could be designed for three auto-and-truck lanes and one bus lane in each direction, but would probably cost as much as five lanes for mixed traffic in each direction. (The separate bus lane design would include separation strips and a few pedestrian overcrossing and station platforms.) The three-lane plus one-lane alternative could well produce gigantic delay for the autos and trucks, whereas the mixed five lanes could accommodate all the autos, trucks, and buses, with no delay for anybody. And the more people riding buses, the more excess capacity the five lanes would provide.

If a way could be found for buses and autos to share all lanes at a short bottleneck, but at the same time for the buses to be able to by-pass the queue of autos waiting upstream of the bottleneck, total delay would not be increased. However, it appears that it would almost always be less expensive to widen the bottleneck than it would be to provide a separate roadway enabling this type of operation.