CHARACTERISTICS, ATTITUDES, AND PERCEPTIONS OF TRANSIT NONUSERS IN THE ATLANTA REGION

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Immediately after transit fares in Atlanta were reduced, transit ridership increased dramatically, exceeding the previous estimates by 50 percent. Total ridership for the 6-month period following the March 1, 1972, fare reduction was almost 15 percent greater than that for the equivalent period in 1971. The fare reduction program of the Metropolitan Atlanta Rapid Transit Authority (MARTA) generated considerable local and national interest, and research was designed to measure the effect of the fare reduction and subsequent transit service improvements on ridership. The study effort consisted of two surveys: (a) an on-board interview of transit riders and (b) an in-home survey of households in the two-county transit service district. This paper deals exclusively with the in-home survey. The MARTA in-home survey dealt with two principal areas of inquiry to complement the on-board survey findings. The first area consisted of the characteristics of transit nonusers as well as their attitudes toward and perceptions of transit. In addition, the in-home survey was designed to determine whether the characteristics, attitudes, and perceptions of nonusers were significantly different from those of transit users. The second area dealt with why the increase in ridership was not even higher and what actions would be necessary to attract additional riders.

•THE MARTA in-home survey focused primarily on the characteristics, attitudes, and perceptions of transit nonusers but also sought responses from transit users. For additional comparison, several questions were identical to those that appeared on the on-board survey questionnaire.

The in-home survey form was designed to require a minimum of conditional responses and was worded to maximize objectivity. The survey form was divided into three parts. Part one included questions addressed to all persons interviewed. Items such as perceived convenience of transit, perceived quality of service, and priority of service improvements were contained in this section. The second and third sections were directed toward nonusers and users respectively.

Determination of sample size and actual sample selection for the MARTA in-home survey were made in conjunction with the Atlanta Regional Transportation Planning Program (ARTPP) update. All interviews were conducted in Fulton and Dekalb Counties and spanned a 6-month period from October 1972 through March 1973. A sample size of 0.5 percent of the total number of dwelling units was set as the standard for the survey.

Before the in-home survey was initiated, an official letter was sent to each household selected explaining the purpose of the study and requesting cooperation. Interviews were conducted between 9:00 a.m. and 9:00 p.m., Tuesday through Saturday. Interviewers were provided with identification cards, which they showed to each person interviewed. Only responsible persons 15 years of age or older were interviewed. If no members of the household were present when the interviewer arrived, arrangements were made to contact the most qualified adult to provide the information.

After completion of field work, approximately 1,400 coded interview forms were returned for editing and processing. All survey data were sorted by geographical zone: a central zone, which basically conformed to the city of Atlanta and four suburban zones. All zones were designed to conform to 1970 census tract boundaries.

Of the 1,239 usable interviews, about half (618) were conducted in the Atlanta zone and the remainder in the four suburban zones. Location of geographical zones within the two-county study area is shown in Figure 1. Figure 2 shows the transit service area as of March 1, 1973, in relation to the five geographical zones.

After final editing of survey data, survey records were sorted by 1970 census tracts and checked to ensure both a random and proportional distribution throughout the study area. In addition, the number of survey records in each tract was divided by the number of dwelling units to determine the sample proportion. Of the 190 census tracts in Fulton and Dekalb Counties, only six did not contain any usable interviews.

The data were tabulated by applying a general-purpose system similar to that used to tabulate the on-board survey data. The system allowed the user to specify up to three parameters for tabulation and had the additional capability of separating transit user-nonuser responses. Because of the small numbers in some sample cells, three-level stratification was rarely used.

Based on the sampling techniques used, it is felt that the information derived from the survey is reliable and that the percentage distributions found are within ±3 percent of true at a confidence level of at least 90 percent and within ±4 percent at a 95 percent confidence level. These indications of statistical reliability are based on a standard assumption that a random sample of dwelling units was made throughout the study area. Stated confidence levels apply to observations made by persons classified as nonusers of transit.

GENERAL SUMMARY

1. More than 25 percent of the nonusers interviewed stated that they would be either very likely or somewhat likely to ride MARTA if service were sufficiently improved. This represents a potential increase in ridership from a substantial portion of the nonuser market. Slightly more suburban nonusers than Atlanta nonusers indicated likelihood of becoming bus patrons.

2. Nine of every 10 nonusers and virtually all (99 percent) users felt that MARTA was necessary or valuable to Atlanta.

3. The nonusers interviewed generally expressed a favorable opinion of MARTA's service quality. About half of those responding rated bus service as good, and only one out of 10 judged service as poor. These percentages compare favorably with those of transit users interviewed in both the in-home and on-board surveys.

4. About one-third of the in-home survey respondents stated that they ride MARTA either regularly or occassionally. More than three-fourths (78 percent) of these bus riders reside within the Atlanta city limits.

5. In general, transit was perceived as less convenient by nonusers than by MARTA users. Only 30 to 35 percent (depending on trip purpose) of the nonusers judged transit to be either very convenient or somewhat convenient. This is roughly one-half the proportion of favorable responses (60 to 65 percent) from MARTA users.

6. In Atlanta, a higher proportion of both transit users and nonusers felt transit was more convenient for shopping or personal business trips than for work trips. Almost two-thirds (63 percent) of the interviewees rated MARTA as convenient for shopping trips, closely followed by personal business trips (59 percent). Only 51 percent rated transit as convenient for work trips.

7. Suburban respondents perceived very little difference in the convenience of transit for various trip purposes. In addition, as expected, both transit users and nonusers in the four suburban zones generally perceived transit as less convenient than did their counterparts in Atlanta. For shopping trips 12 percent of the suburbanites judged transit as very convenient, and another 18 percent felt transit was somewhat convenient—roughly one-half the proportion of Atlanta respondents.

8. Public awareness of the regular 15-cent MARTA fare was quite low. Only 55 percent of the nonusers interviewed correctly stated the fare. The remaining 45 percent either declined to respond to the question or incorrectly stated the fare. This happened in spite of the fact that the fare reduction had been widely publicized for some

time prior to the in-home survey.

9. In response to the survey question on most needed service improvements, both transit users and nonusers ranked greater frequency of bus service first and bus shelters second. However, there were some notable differences in the perception of other transit service priorities. Getting a seat on the bus was more important to transit users, who ranked it third, than to nonusers, who ranked it seventh. Nonusers ranked schedule reliability third in importance, and users ranked it fifth. The greatest difference in the perception of service improvement priorities was in the ranking of increased weekend service. Transit users ranked it fourth whereas nonusers considered it least important.

10. Transit service priorities were perceived differently by Atlanta and suburban nonusers. As expected, park-and-ride service was more important to nonusers residing in the suburban areas, who ranked it fifth, than to Atlanta nonusers, who ranked it tenth. Improved transfer efficiency was also significantly more important to suburban nonusers than to their counterparts from Atlanta (fifth versus ninth). On the other hand, Atlanta nonusers placed more emphasis on seat availability (fifth) and weekend service (sixth) than did suburban respondents (eighth and tenth respectively).

SUMMARY OF FINDINGS

What are the characteristics of nonusers, and what are their attitudes toward and perceptions of transit? Are the characteristics, attitudes, and perceptions of nonusers significantly different from those of transit users?

As expected, the majority (78 percent) of survey respondents who indicated either regular or occasional use of transit resided in Atlanta. About two-thirds (66 percent) of all nonusers resided in the suburban areas. Respondents from Atlanta reported more frequent use of transit for work trips than did respondents from the suburban zones. About 17 percent of the Atlanta respondents stated that they regularly rode the bus for work trips compared to only 4 percent of the suburban respondents. Overall, 447 of the 1,239 survey respondents were classified as transit users. Table 1 gives the numbers and percentages of users and nonusers.

From the survey tabulations, mean household automobile ownership rates were calculated for comparison. The average for transit users was 1.2 automobiles per household; the average for nonusers was 1.9 automobiles per household. Only 4 percent of the nonuser households did not own an automobile compared to more than a third (34 percent) of transit user households. As expected, the average ownership was higher for suburban respondents (1.93) than for Atlanta respondents (1.29).

A larger percentage of transit users than nonusers live in multifamily structures. This is related to the fact that better transit service is more compatible with areas of high density. It should also be noted that the majority of transit users reside in the city of Atlanta where population and housing densities are the highest in the two counties. More than one-third (37 percent) of the transit users surveyed resided in apartments compared to 26 percent of the nonusers. The difference was even greater for single-family residences. Almost two-thirds (64 percent) of nonusers resided in single-family dwellings compared to less than half (47 percent) of transit users.

Distribution of interviewees by age group was similar to the two-county distribution of that portion of the population. Comparisons were not made for those age groups under 17 since less than 1 percent of the in-home survey respondents were under 18.

Overall, almost 35 percent of the persons interviewed in the survey were black. This proportion is slightly higher than the actual percentage for the two counties combined. Two-thirds (67 percent) of the Atlanta transit users were blacks and a little more than one-third (35 percent) of the suburban transit users. On the other hand, whites made up a disproportionate percentage of nonusers: 61 percent of the Atlanta respondents and 89 percent of the suburbanites.

Distribution of household income for the sampled dwelling units reveals significant differences between transit users and nonusers. Only one-fourth (25.1 percent) of the users reported annual incomes in excess of $10,000 compared to almost two-thirds

(62 percent) of the nonusers. The relative difference between Atlanta respondents and suburban respondents was almost as great (32 percent versus 67 percent respectively).

The proportion of respondents who did not drive a car at the time of the survey was significantly greater for transit users than for nonusers. More than 38 percent of the transit users interviewed did not drive an automobile compared to only 6 percent of the nonusers. This relative difference was greatest in Atlanta and somewhat less in the four suburban zones where larger percentages of both transit users and nonusers stated they were automobile drivers.

Nonusers were questioned on the necessity of having a personal automobile available during the day for making business trips. Of those responding, about 26 percent (or 30 percent of those respondents who were employed at the time of the survey) stated that they needed their car on the job.

All transit users were asked whether they rode the bus before the fare reduction. For all trip purposes, the proportion of prior users from Atlanta exceeded that from the suburban areas. The proportion of prior users from Atlanta ranged from about one-fourth (23 percent) for school trips to nearly three-fourths (74 percent) for shopping trips; the percentages were somewhat lower for suburban respondents. The distribution of prior bus use by trip purpose is given in Table 2.

Nonusers of transit were asked whether they had ever attempted to ride the bus for any reason. Of the 792 nonusers, 48 stated that they had ridden the bus at least once. These respondents were questioned on why they no longer used transit. The most common response was that they rode the bus out of necessity when their personal automobiles were inoperative. Most of the other responses had to do with particular circumstances rather than some unpleasant aspect of riding a bus. Three other common responses were

1. Purchased a private automobile and subsequently decided to use it for trips previously made by bus,
2. Changed personal travel characteristics (e.g., the person no longer shopped downtown), and
3. Found that bus service was not close enough to place of residence (or destination) to warrant continued use.

Based on survey results, only 55 percent of the nonusers interviewed correctly stated the regular MARTA bus fare. The remaining 45 percent either gave the wrong answer or declined to respond to the question. It is difficult to know exactly what percentage of the no-response category actually knew the correct fare. For purposes of tabulation, it was assumed that no response indicated the person had no knowledge of the reduced fare. Regardless of the exact percentage, it is evident that a significant portion of nonusers were unaware of the 15-cent bus fare at the time of the survey. This occurred despite ample publication of the fare and radio and newspaper advertising and public service announcements.

Transit nonusers perceived a lower overall quality of bus service than users did. Table 3 gives a breakdown of responses to the question, In your opinion, is the bus service good, fair, or poor? In both Atlanta and the suburban areas, the majority of transit users gave a favorable opinion of transit service. Overall, about 60 percent of the users interviewed rated bus service as good—about twice the proportion of nonusers. According to survey results, geographical location was not an important factor in comparing the responses of nonusers. The ratings for service quality by percentage of nonusers responding are as follows:

Quality	Atlanta	Suburbs
Good	48	47
Fair	42	42
Poor	10	11

Figure 1. Survey study area.

Figure 2. Regular bus service area as of March 1, 1973.

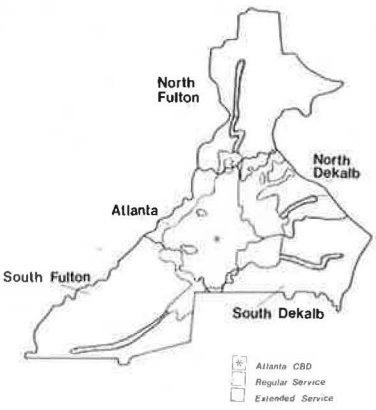

Table 1. Distribution of transit users and nonusers by geographical zone.

Area	Population		Interviews		Transit Users		Nonusers	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Atlanta	501,500	48	618	49.9	349	78.1	269	33.9
North Fulton	91,600	9	80	6.5	6	1.3	74	9.3
North Dekalb	241,300	23	256	20.7	50	11.2	206	26.0
South Dekalb	129,100	12	170	13.7	25	5.6	145	18.3
South Fulton	88,700	8	115	9.2	17	3.8	115	14.5
Two-county total	1,052,200	100	1,239	100	447	100	792	100

Table 2. Percentage of prior use of transit by trip purpose.

Prior Use of Transit	Shop		Personal Business		Social-Recreation		Work		School	
	Atlanta	Suburbs	Atlanta	Suburbs	Atlanta	Suburbs	Atlanta	Suburbs	Atlanta	Suburbs
Regular	39	25	36	25	20	18	33	27	16	14
Occasional	35	28	29	29	28	26	12	11	7	5
Never	26	47	35	46	52	56	55	62	77	81

Table 3. Perception of service quality.

Quality of Service	Atlanta		Suburbs		Total	
	Number	Percent	Number	Percent	Number	Percent
Users						
Good	216	62	52	53	268	60
Fair	110	32	31	32	141	32
Poor	15	4	7	7	22	5
No response	8	2	8	8	16	3
Total	349	100	98	100	447	100
Nonusers						
Good	92	34	153	29	245	31
Fair	81	30	138	26	219	28
Poor	19	7	35	7	54	7
No response	77	29	197	38	274	34
Total	269	100	523	100	792	100

In general, nonusers perceived transit as less convenient than users did. More than half (51 percent) of the users felt transit was either very convenient or somewhat convenient for work trips compared to less than one-third (32 percent) of the nonusers. There was an even greater difference in the perception of convenience for making shopping trips by transit; about 71 percent of the transit users indicated some level of convenience compared to 33 percent of the nonusers. Survey responses of nonusers were about the same for all trip purposes (Table 4). This indicates a tendency on the part of the nonuser to view transit as equally convenient (or inconvenient) for any type of trip. Manual editing of the survey forms confirmed this observation.

Geographical location was also an important factor in the perception of transit convenience. Transit was perceived as more convenient by Atlanta respondents than by their suburban counterparts for all trip purposes. More than half of the Atlanta respondents (51 percent) felt that transit was either very convenient or somewhat convenient for making work trips compared to 27 percent of the respondents in suburban areas. Details are given in Table 5.

The vast majority of persons surveyed felt MARTA was either valuable or necessary to Atlanta (Table 6). Favorable responses were obtained from most residents regardless of whether they used MARTA.

All persons interviewed were asked to select the most needed service improvement from a list provided by the interviewer. The 11 possible choices indicated a wide variety of improvements ranging from greater frequency of bus service to improved attitudes of bus operators. The largest segment of both users and nonusers (27 and 19 percent) felt that greater frequency of transit service was most important. Surveys of a similar nature conducted in other cities have revealed that schedule reliability is the most important service improvement. Respondents to the MARTA on-board survey ranked schedule reliability second in importance. In-home survey respondents ranked schedule reliability as less important; nonusers ranked it third and transit users ranked it fifth. Table 7 gives the ranked responses.

Perhaps the most important question directed solely to nonusers was, If bus service were improved, would you be very likely, somewhat likely, not very likely, or not at all likely to use a bus? The responses to this question are given in Table 8. The more favorable responses (very likely or somewhat likely) were chosen by 49 percent of the respondents in North Fulton and 20 percent in South Fulton. This difference is interesting in view of the fact that North and South Fulton both had the lowest perceived level of transit service convenience and the least amount of actual service at the time the survey was conducted.

Additional tabulation was generated by stratifying nonuser responses by income level. Table 9 gives a breakdown of responses by level of income, from which the following observations can be made.

1. Potentially, the greatest relative increase in ridership is from the upper middle-income ($20,000 and more) households. In this income group, 37 percent indicated some likelihood of future transit patronage if adequate improvements in service were made.
2. Higher income respondents were more likely to have a fixed, definite idea of how they would react if transit service was improved. More than one-third of the highest income group (37 percent) stated that they were either very likely or not at all likely to ride transit.
3. Lower income groups generally exhibited more indecision in their responses. Only 15 percent of the respondents whose annual household incomes were less than $5,000 stated definitely that they would or would not ride transit if service was sufficiently improved. It is interesting to note that the $5,000 and under income group accounted for 13 percent of the nonusers.

Why was the increase in ridership not even larger? What actions would be necessary to attract additional riders to transit?

Although there is no single answer to the question of why ridership was not higher, several indications can be derived from the survey results. There was the lack of

le 4. Perception of sit convenience by :entage of users and users.

Degree of Convenience	Work	Shop	Personal Business	Social-Recreation	School
Users					
Very	34.0	45.6	38.9	33.3	25.5
Somewhat	17.2	25.5	23.5	19.5	11.6
Not very	9.2	8.3	8.5	7.8	8.1
Not at all	30.2	13.9	18.6	25.7	41.1
No response	9.4	6.7	10.5	13.7	13.4
Nonusers					
Very	12.9	14.0	13.5	13.5	13.1
Somewhat	18.9	19.3	19.2	18.4	17.8
Not very	18.4	18.1	17.8	18.2	17.8
Not at all	40.7	39.1	40.0	40.2	41.5
No response	9.1	9.5	9.5	9.7	9.7

le 5. Perception of sit convenience by graphical location.

Degree of Convenience	Work	Shop	Personal Business	Social-Recreation	School
Atlanta					
Very	30.6	38.5	35.1	31.4	26.9
Somewhat	20.2	24.9	23.8	21.4	14.9
Not very	13.1	12.1	12.1	12.3	12.5
Not at all	21.2	20.0	24.0	28.3	39.1
No response	4.9	4.5	5.0	6.6	6.6
Suburbs					
Very	10.5	12.4	10.3	10.0	8.4
Somewhat	16.4	18.2	17.7	16.3	16.3
Not very	17.1	16.9	16.7	16.6	16.1
Not at all	42.5	40.1	40.6	41.5	43.8
No response	13.5	12.4	14.7	15.6	15.4

le 6. Perception of ie-necessity of transit by anta users and nonusers.

	Transit Users		Nonusers		Total	
Perception	Number	Percent	Number	Percent	Number	Percent
Valuable, necessary	442	98.8	708	89.4	1,150	92.8
Not valuable, necessary	1	0.2	45	5.7	46	3.7
No opinion	4	0.9	39	4.9	43	3.5

le 7. Service rovement priorities.

	Users		Nonusers		Total	
Service Improvement	Rank	Percent	Rank	Percent	Rank	Percent
Seat availability	3	12	7	4	5	7
Greater frequency	1	27	1	19	1	22
Air conditioning	9	3	8	4	8	4
Bus shelters	2	16	1	13	2	14
Weekend service	4	8	10	2	7	5
Later service	8	4	9	4	9	4
Schedule reliability	5	8	3	13	3	11
Transfer efficiency	5	8	5	5	6	6
Schedule information	7	5	4	10	4	8
Park and ride	10	2	6	4	10	3
Good driver attitude	10	2	11	2	11	2
No opinion		6		21		15

le 8. Percentage of lihood of transit ronage by geographical e.

Likelihood	Atlanta	North Fulton	North Dekalb	South Fulton	South Dekalb	Suburbs	Nonusers
Very	9.3	28.5	8.7	7.7	11.7	12.0	11.1
Somewhat	14.5	20.3	15.5	13.3	12.4	14.9	14.8
Not very	54.6	35.1	36.4	53.1	45.2	41.9	46.2
Not at all	8.6	13.5	31.1	20.4	29.7	26.2	20.2
No response	13.0	2.7	8.3	6.1	1.0	5.0	7.7

le 9. Percentage of lihood of transit ronage by income level.

Likelihood	To $5,000	$5,000 to $10,000	$10,000 to $20,000	More Than $20,000	Total
Very	8	12	7	14	10
Somewhat	15	17	12	23	16
Not very	69	61	58	40	57
Not at all	8	10	23	23	17

knowledge of the reduced fare as demonstrated by the high percentage of respondents who did not state the regular fare when asked. This occurred in spite of the fact that the fare reduction was widely publicized before and after implementation on March 1, 1972. It is possible that, if all nonusers had been aware of the fare reduction, a portion would have used transit to take advantage of the savings.

It is possible that additional riders could be attracted to transit if there was an improvement in the perception of convenience by nonusers. As shown in Table 4, not all transit users perceived transit as very convenient or even somewhat convenient for various trip purposes. However, the general perception of transit convenience of users is significantly higher than that of nonusers, regardless of geographical location. For example, even though transit was perceived as more convenient by Atlanta respondents than by suburban respondents, transit was perceived as significantly more convenient by both Atlanta and suburban users than by their nonuser counterparts. Several comparisons of users and nonusers residing approximately the same distance from regular transit service confirmed the survey findings. Perception of transit convenience, therefore, is not solely related to proximity to regular transit service. Further analysis of individual and travel characteristics will be required to determine all the factors influencing one's perception of transit convenience. In the meantime, the MARTA in-home survey findings do point to the importance of the perception of transit convenience and the need to communicate this concept to the general public.

A significant increase in the perception of transit convenience may certainly help increase ridership, but there are limitations to this approach since about 30 percent of all nonusers stated that transit was either very convenient or somewhat convenient for various types of trips. Obviously, additional measures must be taken to encourage people to use transit, but taking steps to improve nonusers' perception of transit convenience is very important.

Several types of service improvements were ranked higher by nonusers than by transit users, and those should be carefully evaluated even though four of the top six choices were selected by both users and nonusers. Further ranking of service improvement priorities by geographical zone reveals significant differences in the perceived needs of both transit users and nonusers.

Improved park-and-ride service ranked sixth in importance for Atlanta nonusers and fifth for suburban nonusers. Users ranked park and ride least important along with driver attitude. It is interesting to note that more importance was placed on schedule reliability by nonusers than by transit users. More than 13 percent of the nonusers ranked it most important compared to 8 percent of transit users, collectively ranking third in importance after greater frequency and bus shelters. Nonusers also placed more emphasis on better schedule information than transit users did (fourth versus seventh). Responses of Atlanta nonusers were similar to those of suburban nonusers with two exceptions. More emphasis was placed on increased weekend service by nonusers in Atlanta (sixth) than by suburban nonusers (tenth). On the other hand, suburban nonusers ranked park and ride fifth, and Atlanta nonusers ranked it tenth.

Based on the ranking of service improvement priorities, there appears to be a great deal of interest in park and ride by suburbanites and nonusers. However, only 6 percent of the suburban interviewees and 4 percent of all nonusers ranked park and ride as most important.

It is evident from the survey results that geographical location, income, and other factors have a direct bearing on the perceived priority of service improvements. Implementation of service improvements should have the greatest positive impact on increased transit ridership if they are carefully tailored to the needs of the transit market.

From the survey findings, it appears that a large segment of nonusers already perceive service quality as good, although one of every three failed to state their opinion. It is interesting to note that two (somewhat different) potential transit markets were identified as a result of the transit fare reduction study. The first consists of new riders identified and described in the on-board survey who responded to the significant decrease in transit fare. About one-half of all new riders (on-board survey) stated that the sole reason they had started riding transit was the reduction in fare.

On the other hand, only a small portion (less than 5 percent) stated that they were riding transit entirely because of improvements in service. The in-home survey questions were directed more toward the service responsive market. Of the 792 nonusers who were interviewed, 205 (26 percent) stated that they were either very likely or somewhat likely to use transit if services were improved. Because much of the in-home interviewing took place after the completion of the on-board survey, it may be likely that the percentage of new riders responding solely to the fare reduction had reached its peak and future diversion of persons would relate directly to service improvements.

This service-responsive market holds the key to further gains in transit ridership in the MARTA service area. Evidence points to the fact that the significant reduction in transit fare had a short-range effect on ridership. The point has passed where the majority of new riders are attracted to transit in Atlanta on the basis of a reduced fare. Large numbers of survey respondents in both counties have indicated some likelihood of riding transit in the future if service is sufficiently improved. It is a difficult task to predict what level of service will be required to divert additional automobile drivers to transit, but any program of improvements in service should continue with the individual needs of the market in mind, particularly those of the nonusers. In addition, steps should be taken to improve communications with the residents of metropolitan Atlanta so that they may better understand the benefits associated with MARTA's transit service.

TRAVEL PATTERNS ON A NEW REGIONAL RAPID TRANSIT SYSTEM: CLUES FROM THE EARLY STAGES OF OPERATIONS ON BART

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This paper reports on some of the traffic patterns that developed on the Bay Area Rapid Transit (BART) System from November 1973 to August 1974, when only portions of the BART network were open to traffic. Data from fare gates at stations, counts on trains, transfer tickets, and highway traffic counts were compared to BART estimates made in 1971. Indications are that BART will attract far fewer short trips (less than 6 miles or 10 km) in San Francisco and Oakland than had been anticipated. Short trips in some outer areas with less surface transit and trips greater than 10 miles (16 km) long may have been underestimated. This suggests that the forecast inaccurately evaluated submodal split between rail and bus transit over short distances and may have weighted cost differentials too highly for long trips. On peak shopping days, BART attracts shoppers to downtown areas and to regional shopping centers near BART stations. BART is quite successful in attracting those who commute to industrial and commercial areas and to universities outside downtown areas who use feeder buses at their trip ends. In one corridor BART appears to have caused an increase in total transit use, partly by diverting travelers from the automobile and partly by generating new trips. When a surface transit system in BART territory ceases to operate, some additional short trips are made on BART, but there is a loss of longer trips that used feeder buses.

•THE Bay Area Rapid Transit (BART) System is the most extensive rapid transit system developed in the United States since before World War II. Twenty years in the planning and construction stages and $1.5 billion went into this first rail transit system west of Chicago. BART is the largest system to attempt a technological leap forward in automation, construction methods, fare collection, and integration with the automobile.

Although BART is still not fully operational, it is being watched with great interest in many parts of the world. Although many are interested in evaluating the technological innovations, others are asking how the public is responding to this new transportation network. Final judgments must be postponed until the complete system is operating at frequent and reliable headways, but some indications are apparent from the partial operation in 1974.

This paper briefly describes the extent of BART service as of mid-1974, some of the available data, and some of the patterns emerging in these data. It must be emphasized most strongly that during the period covered in this report operations were far below the ultimate standards of service. Therefore, relative numbers in the data and how they follow or deviate from the patterns predicted during the planning of the system, rather than absolute numbers, are of significance here.

BART IN MID-1974

Figure 1 shows the BART routes open for service before September 16, 1974, as well as those yet to be inaugurated. Opening dates were as follows:

Route	Date Opened
Fremont to Richmond	
South of MacArthur	September 11, 1972
North of MacArthur	January 29, 1973
Concord to MacArthur	May 21, 1973
Montgomery to Daly City	November 5, 1973

Each of these lines operated independently, but there was a direct transfer between the first two lines at MacArthur station. Service was scheduled at 10-min headways from before 6 a.m. to after 8 p.m. (10 p.m. between Thanksgiving and Christmas) Mondays through Fridays. There was no weekend service. Because of mechanical difficulties in some of the cars, the number of train failures per day was rather high, resulting in some irregularity in the headways. The public was aware of this and, presumably, took this factor into account.

The ultimate network, for which traffic estimates were made, involves joining the Concord-MacArthur and the Montgomery-Daly City routes into a single trans-Bay route between Concord and Daly City. This and the Fremont-Richmond routes will operate 20 hours per day, 7 days per week. Direct trains will also operate between Richmond and Daly City and between Fremont and Daly City except nights and Sundays. Typical headways at that time will be on the order of 2 minutes in the peak periods between Daly City and West Oakland and between downtown Oakland and MacArthur and 4 to 6 min elsewhere. Oakland West station was added to the network when partial trans-Bay service began on September 16, 1974. Embarcadero station, still under construction, was not in the original plans or in the original traffic estimates.

Fares charged on BART are 30 cents for the first 6 miles (9.6 km), 35 cents plus 3 cents/mile (1.6 km) for the next 19 miles (30.6 km), and 1 cent/mile beyond that distance to a maximum fare of $1.25. There are some variations to this formula. All fares are rounded to the nearest nickel. (A 10-cent surcharge is added for trans-Bay trips.)

TRAFFIC ESTIMATES

Four sets of estimates for BART patronage were made during the planning and construction stages of the system. The first figures, on the basis of which the plan was presented to the voters for approval, were developed by Parsons, Brinckerhoff, Tudor, Bechtel (1). This work, done before the days of modern modal-split techniques, used a set of diversion curves stratified to consider the difference between regional and intracity trips, between trips involving one of the major central business districts and those not originating or terminating there, and between peak and off-peak trips. In 1967 a new projection was made as a part of the federally financed Northern California Transit Demonstration Project, which actually was a planning exercise looking at the problems of coordinating BART with the two major existing local transit systems (2). Simpson and Curtin, the consultants in this project, developed a transit trip generation model based on social data and on factors describing the accessibility of analysis zones to the two CBDs by BART and by automobile. It "produced very conservative estimates of BART trips in areas not now served by an extensive transit system. For example, the estimate of daily transit trips from Central Contra Costa to San Francisco in 1975 has already been exceeded by the existing transit service" (3). (Central Contra Costa County is the area served by the Concord line from Orinda eastward.) In 1970 BART

requested Wilbur Smith and Associates to prepare another projection of patronage based on previous work in estimating total Bay area travel for the California Division of Bay Toll Crossings. As described (3), this was done by a modal-split technique in which total trips were split among BART, surface transit, and automobiles on the basis of comparative out-of-pocket costs and travel times. Finally, that estimate was revised by BART staff based on the previous three efforts and the collective judgment of the staff (3). In the comparisons made in this paper, the revised estimate is used.

DATA SOURCES

Data on BART patronage and related traffic behavior are becoming available in various forms.

Passenger Trip Ends

BART passenger trip ends are recorded by the fare collection system. Each entry and exit gate has counters that record the number of passengers processed and the number of dollars "extracted" from tickets of passengers. These counters are read by station personnel at the start and end of each day's service and also at the end of the morning peak and the start and end of the evening peak. Generally these data are reliable, although some readings may be recorded incorrectly or may be postponed or skipped when station personnel have more important duties to attend to. Occasionally, a fare gate gives erroneous information because of faulty operation.

BART is in the process of installing a data acquisition system (DAS). Each exit gate now reads the station of origin on a passenger's ticket in order to extract the correct fare. The DAS will save this information so that the central computer can poll all gates at regular intervals (up to 10 or 12 times per hour) and obtain a complete origin-destination matrix of passengers who have left the system since the previous poll. The system will furnish data of much higher quality.

Passenger Surveys

BART passenger surveys were conducted in early May 1973 and in May 1974. In the latter survey, passengers entering the system between 6:30 a.m. and 1 p.m. received questionnaires, and about 25 percent of the total riders responded. However, there were substantial differences in the response rates for different times of the day and for different areas, and at the time this paper was written the necessary statistical expansion factors had only been approximated. The survey contains origin-destination, access mode, trip purpose, previous travel mode, and trip maker characteristics data.

BART Train Occupancy Counts

Train occupancy counts are costly and therefore are not made regularly. When DAS becomes operational, an algorithm will be able to compute traffic volumes on any link of the network.

Transfer Data

Transfer data reveal the use of free transfers available to BART passengers continuing their trips via a bus of the Alameda-Contra Costa Transit District (AC Transit). Transfers issued by ticket "spitters" show the station, date, and time of issue. The tickets are collected by the bus driver and then turned in to the accounting section of AC Transit still sorted by the route on which received. Inasmuch as analysis showed

little, if any, misuse of transfers, the transfer data are probably quite accurate. Passengers transferring from AC Transit to BART pay the regular fare on each system. Because the transfer arrangement results in unsymmetrical use of buses toward and away from BART, the available data cannot be expanded to show the pattern for the reverse direction. (During the period covered by this report, no transfer arrangement had been inaugurated between BART and the Municipal Railway of San Francisco.)

Highway Traffic Data

The highway traffic data used in this paper were obtained by standard traffic counters that are connected to detectors embedded in the highway pavement and that record subtotals at 6-min intervals. Passenger car occupancy rates were obtained by manually recording a sample of about 30 percent of these vehicles.

The data described are the only ones used in this paper. However, large quantities of other data are being collected as part of a major BART impact project financed jointly by the California and the U.S. Departments of Transportation and administered by the regional comprehensive transportation planning agency, the Metropolitan Transportation Commission. These will include (a) extensive highway traffic data on routes paralleling BART and on some routes feeding BART stations perpendicularly, (b) travel time data on major highway routes, and (c) intensive, though limited, home-interview data as well as information on retail sales, real estate values, and noise and air pollution.

BART PATRONAGE ON A TYPICAL DAY

The average patronage observed during 4 weeks of April-May 1974 was taken to represent normal usage of the system at that time. Table 1 gives a comparison of these numbers to the predictions in the revised estimate. Because the revised estimate (3) is based on the full operating conditions described earlier, all trans-Bay trips and all trips with one end at Oakland West station were subtracted so that the data would be comparable with the 1974 counts. The revised trips in Table 1 were based on a rider survey conducted December 20, 1973. The following trans-Bay trips transferring at MacArthur station to or from AC Transit were deducted:

Station	Number
South Hayward	10
Union City	40
Fremont	105
Orinda	335
Lafayette	315
Walnut Creek	380
Pleasant Hill	515
Concord	400
Total	2,100

An energy crisis was also unanticipated. Therefore, comparisons of absolute quantities of patronage are not meaningful, but comparative patterns may be.

The numbers at individual stations are sums of passengers moving in and out of the system, and the subtotals and totals are trips; i.e., the subtotals and totals are half the sums of the sets of figures to which they refer. Because some trips in the East Bay are actually trans-Bay trips (described below), they have been subtracted from the field data. (Actual average East Bay trips were 42,118, and the actual system total was 68,566.) Comparison of the predicted and actual figures suggests several usage trends.

Figure 1. BART network.

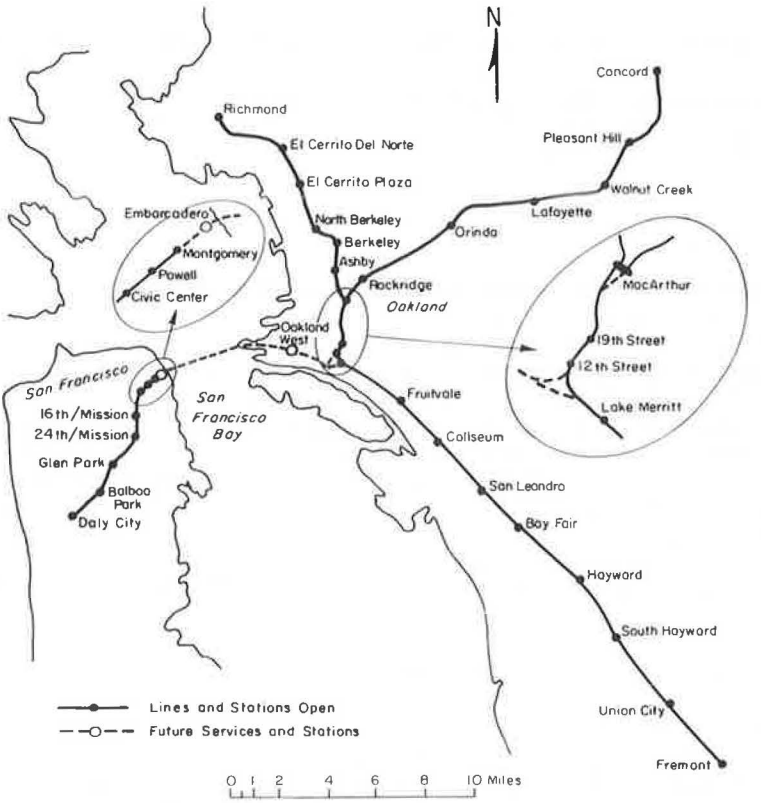


Table 1. Comparison of BART station usage in January 1974 and 1975 revised estimate.

Station	Daily Patronage[a]			Average Fare Paid[b]		
	Predicted	Actual	Actual-Predicted	Predicted	Actual	Actual-Predicted
Montgomery	26,665	15,581	0.60	0.311	0.334	1.07
Powell	11,705	8,640	0.74	0.308	0.339	1.18
Civic Center	10,726	4,553	0.42	0.308	0.320	1.04
16th/Mission	13,162	2,287	0.17	0.300	0.306	1.02
24th/Mission	11,093	3,848	0.35	0.300	0.304	1.01
Glen Park	10,127	4,758	0.47	0.300	0.302	1.01
Balboa Park	12,597	4,786	0.38	0.300	0.302	1.01
Daly City	11,465	11,753	1.03	0.342	0.349	1.02
San Francisco total	53,770	28,103	0.52	0.309	0.328	1.06
MacArthur	3,880	2,601[c]	0.67	0.385	0.546	1.42
19th Street	12,754	8,823	0.69	0.483	0.539	1.12
12th Street	13,838	6,417	0.46	0.474	0.536	1.13
Lake Merritt	8,075	2,664	0.33	0.433	0.518	1.20
Fruitvale	9,243	2,724	0.29	0.374	0.456	1.22
Coliseum	3,395	2,195	0.65	0.357	0.469	1.31
San Leandro	5,967	2,982	0.50	0.413	0.524	1.27
Bay Fair	2,451	2,681	1.09	0.476	0.521	1.09
Hayward	4,417	4,365	0.99	0.531	0.602	1.13
South Hayward	971	1,946[c]	2.00	0.640	0.630	0.98
Union City	1,737	1,813[c]	1.04	0.717	0.765	1.07
Fremont	3,840	3,422[c]	0.89	0.849	0.858	1.01
Ashby	3,796	1,473	0.39	0.369	0.445	1.21
Berkeley	7,971	8,144	1.02	0.380	0.475	1.25
North Berkeley	2,389	1,742	0.73	0.340	0.420	1.24
El Cerrito Plaza	1,812	2,508	1.38	0.345	0.400	1.16
El Cerrito Del Norte	2,282	2,964	1.30	0.380	0.417	1.10
Richmond	5,131	1,793	0.35	0.469	0.532	1.13
Rockridge	2,213	1,342	0.61	0.359	0.517	1.44
Orinda	867	1,396[c]	1.61	0.421	0.443	1.05
Lafayette	608	1,827[c]	3.00	0.571	0.547	0.96
Walnut Creek	1,049	2,675[c]	2.55	0.674	0.635	0.94
Pleasant Hill	853	2,144[c]	2.51	0.723	0.690	0.95
Concord	3,400	2,489[c]	0.73	0.898	0.817	0.91
East Bay total	51,470	36,565	0.71	0.471	0.550	1.17
System total	105,240	64,668	0.61	0.388	0.455	1.17

[a]On and off. [b]Arriving passengers. [c]Revised.

1. The average trip on BART is longer than predicted. This can be seen by analyzing East Bay data; in San Francisco, data are less conclusive because of the short route operated. The average East Bay fare was 55 cents or 8 cents above the estimate. The estimated average fare of 47 cents corresponds to a 10-mile (16-km) trip, but the actual average trip length was 12.5 miles (20 km). This is confirmed by preliminary analysis of the passenger survey data, shown in Figures 2 and 3. Because of the skew in the trip length distributions, the difference in the median trip length values is even greater, 3.5 miles (5.6 km).

2. The missing trips are mostly those that were to take place within the cities of San Francisco and Oakland. As Table 1 shows, the ratio of actual to predicted trips at all stations within 6 miles (10 km) of the two CBDs—16th/Mission, 24th/Mission, Glen Park, and Balboa Park in San Francisco and Fruitvale, Coliseum, MacArthur, Ashby, and Rockridge in the East Bay—is below the average for their side of the Bay. Conversely, those stations that exceed average system performance and, in 13 cases, the 1975 predictions, are 7 miles (11 km) from the nearest CBD. Figure 2 also shows that the actual number of trips longer than 13 miles (21 km) generally exceeded estimates for 1975. The patronage record of Daly City indicates that on the west side of the Bay, too, the longer trips are attracted to BART, but the shorter ones are not. Evidently, the automobile or surface transit or both are more competitive than the estimating procedures supposed when the access effort to BART becomes disproportionately large in relation to total door-to-door trip length. Also, for short trips the waiting time for trains operating at 10-minute headways is a deterrent. When BART reduces headways to 2 or 4 minutes, perhaps an increase in shorter trips will result.

3. In certain situations in outlying areas, the record of short trips exceeds estimates. Data from passenger surveys indicate that the patronage between Berkeley and the two El Cerrito stations exceeds the 1975 estimate by a factor of two or more. This partly accounts for the high usage of these stations and may be explained by the fact that between Berkeley and El Cerrito the BART alignment is roughly diagonal to the grid pattern of streets and bus routes, thus offering more time advantages than elsewhere.

4. The activity record at stations from Orinda to Pleasant Hill is so much above the 1975 estimate that the explanation must lie in the shortcomings of the estimate and, specifically, in the effect that the Simpson and Curtin model had on the revised estimate. On the other hand, the predicted average fares (and, hence, trip lengths) were slightly on the high side. In this area the potential for short trips was also somewhat underestimated. Activity at the Concord station is near the system average but below that of the next four stations to the west. Perhaps the tributary area for this terminal was assumed to be somewhat greater than is the case.

5. The low activity at Richmond was partly because, as of early 1974, redevelopment plans in downtown Richmond had not been implemented. It also appears possible that the estimate included patronage from the north, which, because of the location of the freeway in the area, has much easier access to El Cerrito Del Norte than to Richmond.

6. Daly City patronage exceeded both 1975 predictions and activity at adjacent stations. This is because (a) the area surrounding and beyond it is densely settled, (b) commuting by transit to San Francisco had been well established previously, and (c) it is the only station west of the Bay with parking facilities. Activity here was second only to Montgomery station in the entire system and would probably have been even higher were it not for capacity constraints in the parking facilities and approaches and inadequacy in feeder bus service.

7. Downtown stations include 19th and 12th Street stations in Oakland and Montgomery, Powell, and Civic Center stations in San Francisco. There has been relatively poor use of the Civic Center and 12th Street stations. The proximity of Civic Center to adjacent stations probably explains the low actual-predicted ratio. The revised estimate calculated that almost 5,000 trip ends per day at Civic Center station would be 2 miles (3.2 km) or less in length. These may be entirely missing because of the long BART headways and the high frequency of service on alternate surface bus and streetcar routes. The low patronage at 12th Street is attributable to the Oakland City Center Redevelopment Project, which has cleared much of the adjacent land but which

Figure 2. Comparison of estimated and actual trips.

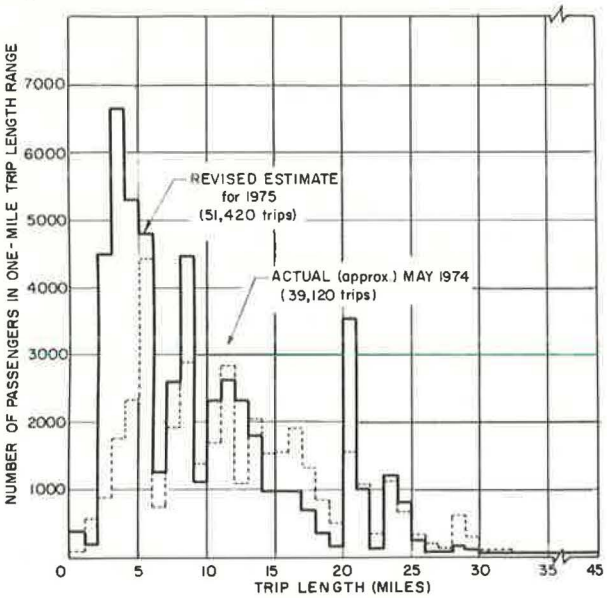
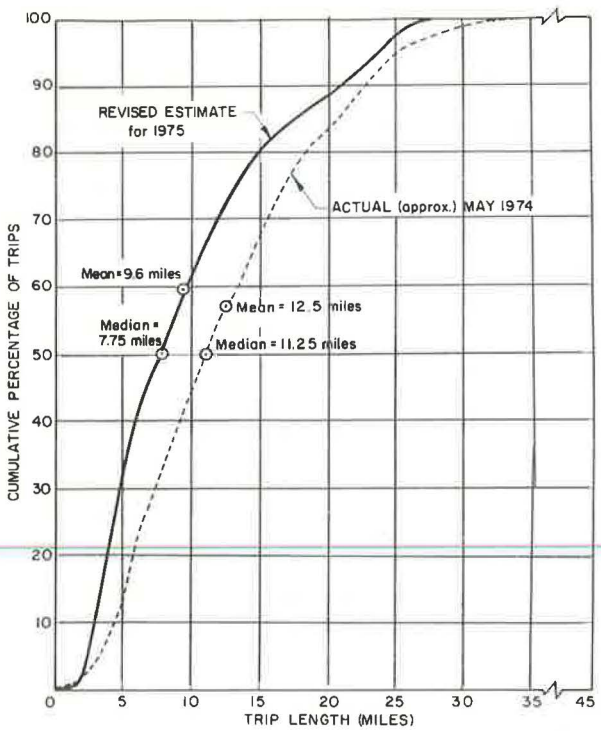


Figure 3. Comparison of estimated and actual trip length distribution.



has so far completed only one of the many buildings planned.

8. Lake Merritt station represents a borderline case, on the edge of the Oakland CBD, that was designed (with parking lots) to attract trips from residential areas in parts of the city of Alameda and around Lake Merritt in Oakland. The revised estimate matrix showed large quantities of off-peak trips between this station and points as southward as Hayward (2,815 trips versus only 1,465 trips during peak periods), suggesting the possibility of a computational error or an aberration in one or more of the estimating models.

BART PATRONAGE ON A PEAK SHOPPING DAY

Traffic on BART set a record to date on Friday, November 23, 1973. This day after Thanksgiving is the traditional start of the Christmas shopping season and a school holiday. Subtotals of morning peak-period patronage indicate that many employees were given the day off. However, these subtotals are not available for some of the major stations. Also, BART personnel were kept so busy assisting passengers that they had no time to read the fare gate counters, so it is not possible to provide exact data. Indications are that commuting was at about half the normal rate and represented only 20 percent of the day's traffic instead of a normal 55 to 60 percent; off-peak travel for shopping, sightseeing, and other purposes was about three times the normal rate.

Data for November 23 are given in Table 2, which also compares them to the normal average observed in December 1973 and to predicted patronage. Again, the revised figures refer to trans-Bay peak-hour trips transferring at MacArthur station to or from AC Transit. The deductions are as follows:

Station	Number
Fremont	50
Orinda	150
Lafayette	150
Walnut Creek	200
Pleasant Hill	250
Concord	200
	1,000

There were probably some trans-Bay trips for shopping during the off peak, but the quantity is unknown and was therefore not subtracted.

It is important to note that, except for Thanksgiving Day itself, this was the first school holiday and partial work holiday on which the Montgomery-Daly City line was open to the public. Traffic on the west side of the Bay therefore included a large number of sightseers.

The data in the table and the partial data on trips in the morning peak and the middle of the day point some interesting trends.

1. The stations closest to major shopping areas in the East Bay are 19th Street and 12th Street in downtown Oakland and Bay Fair and El Cerrito Plaza adjacent to regional shopping centers. The two downtown Oakland stations attracted about 5,000 midday passengers on this day, double the normal amount. Bay Fair had 1,550 arrivals between the morning and afternoon peaks, compared to 350 on a normal day, and El Cerrito Plaza had 1,150 compared to a normal 450.
2. In San Francisco, only a very rough guess is possible because of missing data. It may be that 16,500 persons arrived at the Montgomery and Powell stations during the off-peak period compared to 4,000 on a normal day.
3. Fremont and Concord showed the largest passenger increases in the East Bay.

Probably this represents a large group of shopping trips from residential areas beyond the BART terminals. Even though the lines involved had been open for 14 and 6 months respectively, including all summer, there may also still be a substantial sightseeing element.

4. All stations on the Concord line from Orinda outward already perform well in excess of 1975 predictions and were among those showing the highest surge on the day after Thanksgiving.

The patronage records for the remainder of the Christmas shopping season showed no such sharp increases in BART traffic. Perhaps the public was particularly concerned about parking problems in downtown and at regional shopping centers on the day after Thanksgiving. In past years newspapers have highlighted traffic congestion and parking problems on this peak shopping day.

TRANSFERS FROM BART TO AC TRANSIT

The concept of a regional rapid transit system, such as BART, assumes that many passengers will use other modes of transportation for access to and from the system. The long distance between stations decreases the probability of large proportions of the population living within walking distance of BART and, if they do not work in a CBD, working within walking distance.

One of the two major access modes is the surface transit system. Considerable study has been made of the need for feeder bus routes on both sides of the Bay (2). In the East Bay, the AC Transit system has served the area between Richmond and South Hayward since 1960 and was therefore available for coordination with BART. However, other areas of the East Bay in southern Alameda County (Union City and Fremont) and in central Contra Costa County had virtually no feeder bus service as of mid-1974.

As mentioned earlier, free transfers are issued from BART to AC Transit but not in the opposite direction. It is apparent that travel patterns are not symmetrical because of this cost difference. Some passengers who use the free transfer outbound from BART walk inbound or find automobile rides to BART stations. This lack of symmetry should be kept in mind when the data are reviewed.

A summary of all transfers from BART to AC Transit on a day in May 1974 is given in Table 3. The striking characteristic is the extensive use of transfers at the job end of home-to-work trips. If passengers changing at MacArthur station to trans-Bay buses (for which they cannot transfer) were included, the total number of transfers would be about 1,600, and the percentage of arriving passengers would be 70. Total transfers for all stations would be 8,400 and 30 percent. Systemwide, there is more use of transfers in the morning peak than in the afternoon peak. This leads to several tentative conclusions.

1. Although BART was designed primarily to transport workers to the San Francisco, Oakland, and Berkeley CBDs, it is also performing this service to major industrial and military areas west of the Fremont-Richmond route, including the Port of Oakland, and to universities.

2. The high use of transfers in the morning at MacArthur, Coliseum, San Leandro, Ashby, and Rockridge stations confirms, as noted earlier, that these stations generate relatively few trips into and out of downtown Oakland. For example, of a total of 746 arriving passengers at Rockridge, 30 percent did so between 6:30 and 9:30 a.m. and transferred to buses. Thus, trip production by residents of the Rockridge area was even less than the station activity totals suggest.

3. Characteristics mentioned in 1 and 2 above are confirmed by the percentage of all arriving passengers at each station who use transfers (Table 3). These percentages are lowest where the bus network feeding the station serves residential areas (Bay Fair, South Hayward, the two El Cerrito stations) and highest in the vicinity of industries and universities. The bus feeder system, as it operates at present, provides good links to these types of clustered employment centers but can cover only portions

Table 2. Comparison of BART station usage on the day after Thanksgiving to normal average use and predictions.

Station	Patronage on Nov. 23, 1973	Ratio: To Normal Day's Patronage	Ratio: To Predicted Patronage	Remarks
Montgomery	22,346	1.41	0.84	Morning peak arrivals off more than 25 percent
Powell	34,146	2.68	2.92	Nearest to downtown stores
Civic Center	7,592	1.52	0.71	
16th/Mission	4,225	1.41	0.32	
24th/Mission	7,633	1.58	0.69	
Glen Park	8,799	1.74	0.87	
Balboa Park	9,925	1.77	0.79	Holiday at City College
Daly City	24,038	1.83	2.10	
San Francisco totals	59,354	1.82	1.11	
MacArthur	3,333[a]	1.44	0.86	
19th Street	10,042	1.06	0.79	Morning peak arrivals off 52 percent
12th Street	6,312	0.96	0.46	Morning peak arrivals off 57 percent
Lake Merritt	4,054	1.34	0.50	
Fruitvale	3,350	1.22	0.36	Morning peak arrivals off 67 percent
Coliseum	2,679	1.24	0.79	Morning peak arrivals off 72 percent
San Leandro	2,870	0.97	0.48	Morning peak arrivals off 85 percent
Bay Fair	4,800	1.72	1.96	Adjacent to shopping center
Hayward	4,115	1.02	0.93	Holiday at Hayward State University
South Hayward	2,145	1.12	2.21	
Union City	2,379	1.30	1.37	
Fremont	8,741[a]	2.61	2.28	
Ashby	1,508	0.96	0.40	
Berkeley	6,595	0.86	0.83	Holiday at University of California
North Berkeley	2,358	1.31	0.99	
El Cerrito Plaza	4,313	1.58	2.38	Adjacent to shopping center
El Cerrito Del Norte	3,715	1.25	1.63	
Richmond	2,347	1.32	0.46	
Rockridge	1,855	1.51	0.84	
Orinda	2,463[a]	1.90	2.84	
Lafayette	2,893[a]	1.64	4.76	
Walnut Creek	5,826[a]	2.20	5.55	
Pleasant Hill	4,054[a]	2.06	4.75	
Concord	6,467[a]	2.72	1.90	
East Bay total	49,815	1.36	0.97	
System total	109,169	1.58	1.04	

[a]Revised.

Table 3. Use of transfers from BART to AC Transit.

Station	Morning Peak: 6:30 to 7:30	Morning Peak: 7:30 to 8:30	Morning Peak: 8:30 to 9:30	Afternoon Peak: 3:30 to 4:30	Afternoon Peak: 4:30 to 5:30	Afternoon Peak: 5:30 to 6:30	Transfers Used	Arriving Passengers	Percentage Using Transfers	Predominant Land Use Served by Feeder Buses
MacArthur	85	101	28	46	42	38	514	2,291	22.4	Industrial, medical
19th Street	47	75	28	45	73	32	468	4,153	11.3	Commercial
12th Street	180	154	59	64	58	69	970	3,108	31.2	Industrial, military, commercial
Lake Merritt	13	7	8	5	6	5	72	1,183	6.1	Mixed
Fruitvale	31	91	39	61	83	83	620	1,298	47.8	Industrial, residential
Coliseum	53	170	24	47	48	47	607	1,029	59.0	Industrial, airport
San Leandro	58	93	17	51	51	40	423	1,461	29.0	Industrial, commercial
Bay Fair	13	28	11	31	41	29	213	1,245	17.1	Residential
Hayward	89	256	160	44	45	52	992	2,075	47.8	Industrial, university
South Hayward	1	7	0	19	16	25	96	888	10.8	Residential
Ashby	30	25	13	20	17	8	158	617	25.6	Industrial, residential
Berkeley	28	56	82	89	100	116	912	3,173	28.7	Residential, university
North Berkeley	12	47	14	21	38	18	203	749	27.1	Residential, commercial
El Cerrito Plaza	9	19	7	19	42	36	202	1,168	17.3	Residential
El Cerrito Del Norte	21	17	17	30	50	27	239	1,388	17.2	Residential
Richmond	41	30	19	34	23	34	269	828	32.5	Industrial, residential
Rockridge	65	109	86	12	18	16	404	748	54.0	University, residential
Total	776	1,285	612	638	748	675	7,362	27,402	26.9	

Table 4. Change in morning peak travel from central Contra Costa County.

Time	Bus Riding Before BART: To San Francisco	Bus Riding Before BART: To East Bay	Bus Riding Before BART: Total	Transit Riding After BART: To San Francisco: Via Bus	Transit Riding After BART: To San Francisco: Via BART	Transit Riding After BART: To San Francisco: Total	Transit Riding After BART: To East Bay via BART	Transit Riding After BART: Total
6:30 to 7:00	1,025	45	1,070	695	25	720	405	**1,125**
7:00 to 7:30	2,000	100	2,100	1,945	225	2,130	730	**2,900**
7:30 to 8:00	1,535	200	1,735	1,245	300	1,495	685	**2,230**
8:00 to 8:30	560	75	635	460	250	685	360	**1,070**
8:30 to 9:00	110	30	140	185	100	275	210	**495**
Total	**5,230**	450	5,680	4,530	900	5,305	2,390	**7,820**

of widespread residential areas. The automobile seems to be the preferred access mode at the home end of BART trips.

One would expect use of feeder buses to be low in downtown Oakland, since many trip ends are within walking distance of a BART station. The fairly high figure at the 12th Street station is explained by the fact that the previously mentioned land clearing there has eliminated many nearby trip generators and that bus routes to much of the Port of Oakland and to military bases in Oakland and Alameda go past this station.

CENTRAL CONTRA COSTA COUNTY CORRIDOR

Traffic on the Concord line is surprising the estimators. The line's popularity entitles it to a closer look. This route connects the center of the metropolitan area with a series of cities and unincorporated communities with more than 200,000 population. Some of the area is strictly residential and is the bedroom community for the region. In Concord and north thereof are some industrial areas. Orinda, Lafayette, and the area south of Walnut Creek are wealthy; the median family income in 1970 was $17,000 to $20,000. Families in Concord, Pleasant Hill, and Walnut Creek have incomes 10 to 30 percent above the median for BART counties as a whole, which is $11,000.

Topography confines traffic between this area and the center of the region to one freeway, which penetrates the Berkeley Hills via the Caldecott tunnels. The roads across the top of the ridge are few and inadequate. It is therefore easy to get a complete picture of traffic in this corridor. Studies made over the years have shown not only the usual increase in automobile flow but also a remarkable rise in bus riding on the Greyhound buses. This growth has been continual since 1959, when the California Public Utilities Commission required Greyhound to improve service drastically as a condition for permission to increase fares. Total patronage doubled in the 5-year period from 1959 to 1964 and doubled again by 1972. This growth has been entirely in peak-period commuting to and from San Francisco, but commuting to and from points in the Oakland-Berkeley area and during off peak has been virtually static.

The data given in Tables 4 and 5 show that BART has had a large effect on commuting from central Contra Costa to the East Bay. The before BART data were collected on a typical weekday in April 1973. The after BART data for automobile and bus traffic were collected on a typical weekday in October 1973. The total BART count was made on November 13, 1973. The breakdown for destination (to San Francisco and to East Bay) was estimated based on transfer activity at MacArthur station. Greyhound was permitted to drop all peak-hour service to and from Oakland and Berkeley. So BART presumably is transporting the 450 commuters who previously used these buses. But it has also attracted about 2,300 additional peak-period riders. If this portion of the transit market had grown since 1959 at the same rate as the demand to and from San Francisco, current bus patronage might have been just about what BART's patronage has turned out to be.

The failure of East Bay commuters to avail themselves of Greyhound service, while those working in San Francisco did so, may be due to two reasons.

1. The Bay Bridge presents an unpleasant driving experience in rush hours, which East Bay workers from the central Contra Costa County do not have to face. Parking charges in San Francisco have risen more rapidly than elsewhere.
2. East Bay work locations are more scattered than those in San Francisco, and Greyhound routes did not serve many of them. BART provides closer and much faster access to employment in industrial areas, especially in East Oakland, San Leandro, and Hayward, than did the previously available transit services.

There was a net increase of 1,600 peak-period trips. Transit riding increased by roughly 3,400 trips, and automobile person-trips dropped only about 1,800. There was a 15 percent reduction in total trips before 7:00 a.m., suggesting that the relief of congestion at the height of the peak permitted some commuters to leave home later than before BART operations started.

The growth pattern on Greyhound had pointed to a strong tendency by downtown San Francisco workers who live in this part of Contra Costa County to use transit rather than drive. On the day that the Concord line opened, about 250 commuters used BART to MacArthur station and transferred there to an existing trans-Bay AC Transit line. By the end of the third week, the number of riders had risen to 500, after 7 months there were almost 1,000, and on the first anniversary there were about 1,400. AC Transit responded to this unexpected demand by instituting shuttle service between MacArthur and San Francisco and conducted several surveys of the riders on these buses. The results of the last survey taken are given in Table 6. Cost and time data are given in Table 7. It was determined that 70 percent of the riders had switched from Greyhound, representing 13 percent of the before BART bus riders. Another 24 percent previously used automobiles, and the remaining 6 percent, who did not check either answer, may have been new riders who did not previously make this commute trip.

The survey also found some riders from southern Alameda County, a scattering of riders from other BART stations, and 50 shuttle bus riders whose origins were in the neighborhood of the MacArthur station.

Based on the number of riders originating at each of the five BART stations, the attractiveness of this trans-Bay route alternative tends to increase as total trip length and travel time savings increase (while varying inversely with savings in fare!). However, no data are available on the total number of commuters from each of these five areas, and it can therefore not be said whether proportions of riders attracted to the BART-AC Transit alternative varied in the same manner as the absolute numbers.

EFFECT OF A BUS STRIKE ON BART PATRONAGE

The AC Transit System was closed by a strike from July 1 to August 31, 1974. The effects of this on BART patronage are given in Table 8. (Differences in station activity shown as before strike in this table and in Table 1 are primarily caused by school and college vacations.)

As might be expected, BART gained passengers. However, it also lost some. The chief gain was in that part of the AC Transit service area that is most densely developed from Richmond to the southern city limits of Oakland. The percentage gain was greatest at stations near downtown Oakland and Berkeley and tapered off as distance from these centers increased. The substantial drop in average fare paid at these stations shows that the gain was in short trips and again underlines the competitive advantage of surface buses (when they are running) over BART for trips shorter than about 6 miles (10 km).

The major loss was in the trans-Bay traffic described earlier (excluded from Table 8). Other losses occurred within the AC territory south of Oakland, where development densities are low, and in areas not served by AC Transit. This patronage loss probably comprises commuters who had been using feeder buses at the work end of their trips before the strike. MacArthur, Coliseum, San Leandro, Ashby, and Rockridge presumably lost most of this traffic (although some informal car pooling between BART and work places doubtlessly took place) and gained even more patronage generated within walking distance than the figures in Table 8 indicate.

The final result of the strike was an increase of about 3,500 trips per day—6,700 added East Bay trips minus 3,200 trans-Bay trips. Total revenue per day, however, dropped; the large number of East Bay trips at an average fare of only 50 cents versus the 55 cents average in June produced only about $1,440 per day in additional revenue. The disappearance of the trans-Bay traffic caused a loss of about $2,090 per day, or a net reduction of $650 for the entire East Bay operations. The trip length distribution during these months was doubtlessly closer to the revised estimate curve in Figure 3 than the May 1974 pattern, but the average fare collected suggests that the average trip was still about 1 mile (1.6 km) longer than estimated. Hence, even the absence of the competing surface transit service did not produce the anticipated number of short trips.

Table 5. Change in person-trips from central Contra Costa County during morning peak.

Time	Person Trips Before BART			Person Trips After BART			
	By Automobile	By Bus	Total	By Automobile	By Bus	On BART	Total
6:30 to 7:00	5,030	1,070	6,100	4,670	695	430	5,795
7:00 to 7:30	5,480	2,100	7,580	5,270	1,945	955	8,170
7:30 to 8:00	5,110	1,735	6,845	5,220	1,245	985	7,450
8:00 to 8:30	4,550	635	5,185	4,270	460	610	5,340
8:30 to 9:00	3,060	140	3,200	3,380	185	310	3,875
Total	23,230	5,680	28,910	22,810	4,530	3,290	30,630

Table 6. Trans-Bay passengers from central Contra Costa County using BART and AC Transit via MacArthur station.

Origin	Total Passengers	Previous Mode (percent)		
		Greyhound	Automobile	No Response
Orinda	165	68	21	11
Lafayette	160	72	21	7
Walnut Creek	190	65	28	7
Pleasant Hill	255	72	22	6
Concord	200	72	27	1
Total	970	70	24	6

Table 7. Cost and time comparisons for BART-AC Transit and Greyhound.

Origin	Cost per Ride (dollars)		Estimated Travel Time (min)		Headways (min)	
	BART-AC	Greyhound	BART-AC	Greyhound	BART-AC	Greyhound
Orinda	0.80	0.83	27 to 37	29 to 32	10	1
Lafayette	1.05	0.975	32 to 42	42 to 44	10	4
Walnut Creek	1.15	1.043	36 to 46	46 to 48	10	2
Pleasant Hill	1.20	1.115	39 to 49	50 to 52	10	2
Concord	1.35	1.18	44 to 54	58 to 60	10	2

Table 8. Effect of bus strike on BART daily patronage.

Station	Before Strike		During Strike	Changes			
				Actual		Revised[a]	
	Actual	Revised[a]		Number	Percent	Number	Percent
AC Transit territory							
Richmond	1,933		2,113	+180	+9.3		
El Cerrito Del Norte	2,897		3,110	+203	+7.0		
El Cerrito Plaza	2,625		3,297	+672	+25.6		
North Berkeley	1,616		2,625	+1,009	+62.4		
Berkeley	7,068		9,310	+2,242	+31.7		
Ashby	1,379		2,831	+1,452	+105.2		
MacArthur	5,482	2,282	3,654	-1,828	-33.4	+1,372	+60.1
19th Street	9,186		11,471	+2,285	+24.9		
12th Street	6,854		7,495	+641	+9.4		
Lake Merritt	2,430		4,094	+1,664	+68.5		
Fruitvale	2,829		4,274	+1,445	+51.1		
Coliseum	2,695		3,309	+614	+22.8		
San Leandro	3,462		3,210	-252	-7.3		
Bay Fair	3,157		3,041	-116	-3.7		
Hayward	3,745		3,148	-397	-10.6		
South Hayward	2,294	2,279	1,802	-492	-21.4	-477	-20.9
Rockridge	1,204		1,670	+466	+38.7		
Subtotal	30,339	27,124	35,322	+4,983	+16.4	+6,590	+24.3
Other East Bay areas							
Union City	2,090	2,030	1,766	-324	-15.5	-264	-13.0
Fremont	4,107	3,947	3,532	-575	-14.0	-415	-10.5
Orinda	1,913	1,403	1,437	-475	-24.8	+35	+2.5
Lafayette	2,380	1,900	1,744	-636	-26.7	-156	-8.2
Walnut Creek	3,506	2,931	2,793	-713	-20.3	-138	-4.7
Pleasant Hill	2,942	2,142	2,054	-888	-30.2	-88	-4.1
Concord	3,472	2,872	2,598	-874	-25.2	-274	-9.5
Subtotal	10,205	8,612	7,962	-2,243	-22.0	-650	-8.2
East Bay total	40,534	37,334	43,284	+2,750	+6.8	+5,950	+15.9
East Bay revenue, dollars	22,588	20,554	21,587	-1,001	-4.4	+1,033	+5.0
Average fare, cents	55.72	55.05	49.87	-5.85	-10.5	-5.18	-9.4

[a]Revised by deducting from the June counts 3,200 trans Bay trips transferring at MacArthur to or from AC Transit, based on the proportions used in Tables 1 and 2.

CONCLUSIONS

The pattern of BART trips made in mid-1974 suggests that the system will attract relatively few riders for trips shorter than 6 miles (10 km) long, but projections for the longer distance market may be exceeded. This is due to the long station spacing in the system generally and in the inner cities of Oakland and San Francisco specifically and to the competitiveness of the automobile and surface transit lines in these areas. Cost and time savings on rapid transit are minimal or negative when access to and from the nearest station becomes a major proportion of the trip. As total trip length increases, the time savings become obvious and cost savings reach substantial levels in comparison to single-occupant cars.

The public is showing a willingness to use BART for shopping trips, at least on peak shopping days when they face the possibility of parking problems in downtown areas and at shopping centers. Much of this shopping traffic seems to be generated beyond the ends of the BART lines.

BART users are also willing to use feeder buses on their way to non-CBD workplaces, such as industrial areas and universities. By comparison, patronage of feeder buses at the residential end of trips has been below expectations.

In one corridor that has a history of steady growth in bus riding well above regional patterns, BART immediately attracted riders from automobiles and from the parallel bus service and generated new trips.

When competing surface transit is removed, as happened during a bus strike, some of the shorter trips are made on the rapid transit system, but some of the long trips that depend on feeder bus lines at the work end of the trip are lost.

These trends have interesting implications for designers of future regional rapid transit systems. If the decision is made to use the same design criteria as in BART—average speed of 45 mph (70 km/h) and, hence, average station spacing of more than 2 miles (3.2 km)—the number and location of stations within 6 miles (10 km) of the CBD need careful review. They may have to be located primarily in relation to workplaces along the route or accessibility to feeder buses, provided that a sufficient market of travelers from outlying areas served by the system exists. The relationship of these stations to the homes of downtown employees would be of less importance.

Conversely, if one criterion is to connect downtown with residential areas located less than 6 miles (10 km) away and to compete with or replace surface transit, area coverage will have to be increased by providing closer station spacing and, perhaps, more routes. Within a few years, a streetcar subway will open in San Francisco and will serve the southwest part of the city with five surface routes that converge on a new tunnel immediately above the BART downtown route. This network will succeed in attracting short trips much more than will the BART line.

BART is likely to fulfill the main purpose for which it was designed—to link the San Francisco and Oakland CBDs with outlying suburbs where many downtown workers live. It, however, may not attract travelers within the inner cities. It may exceed expectations in serving industry, universities, and other dispersed employment centers. When the three patterns are added, the total performance will not be far below estimates and, with the energy crisis as an added stimulus, may actually exceed them.

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REFERENCES

1. H. D. Quinby. Traffic Distribution Forecasts—Highway and Transit. Proc., Thirteenth Annual Meeting of Institute of Traffic Engineers, Western Section, San Francisco, 1960, pp. 85-96.
2. Coordinated Transit for the San Francisco Bay Area—Now to 1975. Simpson and Curtin, 1967, Chapters 8 and 10.
3. BART Interstation Fare Schedule Report: Draft. San Francisco Bay Area Rapid Transit District, Oakland, May 18, 1971, Chapter 4.