bart impact program

TRANSPORTATION AND TRAVEL IMPACTS OF BART: INTERIM SERVICE FINDINGS

The BART Impact Program is a comprehensive, policy-oriented study and evaluation of the impacts of the San Francisco Bay Area's new rapid transit system (BART).

The program is being conducted by the Metropolitan Transportation Commission, a nine-county regional agency established by state law in 1970.

The program is financed by the U.S. Department of Transportation, the U.S. Department of Housing and Urban Development, and the California Department of Transportation. Management of the Federally-funded portion of the program is vested in the U.S. Department of Transportation.

The BART Impact Program covers the entire range of potential rapid transit impacts, including impacts on traffic flow, travel behavior, land use and urban development, the environment, the regional economy, social institutions and life styles, and public policy. The incidence of these impacts on population groups, local areas, and economic sectors will be measured and analyzed. The benefits of BART, and their distribution, will be weighed against the negative impacts and costs of the system in an objective evaluation of the contribution that the rapid transit investment makes toward meeting the needs and objectives of this metropolitan area and all of its people.

DOCUMENT NO. FR 6-3-75

CONTRACT NOS. DOT-OS-30176
CA-09-0025
CA-09-0042

BART IMPACT PROGRAM

TRANSPORTATION AND TRAVEL IMPACTS OF BART: INTERIM SERVICE FINDINGS

APRIL 1976

PHASE I FINAL REPORT

DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VIRGINIA 22151

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION

AND

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

WASHINGTON, D.C.

The preparation of this report has been financed in part through a grant from the U.S. Department of Transportation, Urban Mass Transportation Administration, under The Urban Mass Transportation Act of 1974, as amended.

NOTICE

BART Impact Program
Transportation System and Travel Behavior Project
Phase I Final Report

Prepared by
Peat, Marwick, Mitchell & Co.

April 1976

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FR 6-3-75		

4. Title and Subtitle	5. Report Date
Transportation and Travel Impacts of BART: Interim Service Findings	April 1976
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Raymond Ellis, Alistair Sherret	FR 6-3-75
9. Performing Organization Name and Address	10. Work Unit No.
Peat, Marwick, Mitchell & Co. 1777 Murchison Drive, Burlingame, California 94010 The Metropolitan Transportation Commission Hotel Claremont, Berkeley, California 94705	Task Order 3
	11. Contract or Grant No. DOT-OS-30176 ~~CA-09-0025, CA-09-0042~~
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation and U.S. Department of Housing and Urban Development Washington, D.C.	Phase I Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

The Metropolitan Transportation Commission is the prime contractor for the BART Impact Program. Peat, Marwick, Mitchell & Co. is the subcontractor responsible for the Transportation System and Travel Behavior Project.

16. Abstract

The 71-mile Bay Area Rapid Transit (BART) System, serving San Francisco, Oakland, Berkeley and their suburbs, is the first regional-scale rapid transit system to open in the United States in 50 years. The final link of the System opened for service in September 1974.

This report summarizes BART's initial impacts on regional transportation system performance and travel patterns. The report deals with the effects of interim BART service over the period September 1972 through June 1975. Impacts are assessed in terms of BART's design and operating characteristics; its service levels; changes in accessibility; the level and nature of BART's ridership; impacts on travel by bus and automobile; impacts on the service provided by the rest of the transit system; and impacts on traffic congestion. BART's capital costs, interim operating costs and revenues, and interim energy consumption are also analyzed.

17. Key Words	18. Distribution Statement
Bay Area Rapid Transit (BART) System BART Impact Program, rail rapid transit, public mass transit, urban transportation planning, transportation program evaluation.	Document is available to the public through National Technical Information Service, Springfield, Virginia 22151

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	192	

Form DOT F 1700.7 (8-69)

ACKNOWLEDGMENTS

This report summarizes the Phase I findings of the Transportation System and Travel Behavior (TSTB) Project of the BART Impact Program. The work reported was undertaken by a Project Team staffed by the following members of Peat, Marwick, Mitchell & Co.: Richard Worrall, Raymond Ellis, Alistair Sherret, Henry Fan, and Stephen Cohn; by staff of JHK & Associates, San Francisco, California, under the direction of Robert Hubenette; by staff of Market Facts, Inc., Chicago, Illinois, under the direction of Richard Ross; and by staff of Jefferson Associates, Inc., San Francisco, California, under the direction of James Jefferson.

Many individuals and organizations assisted the TSTB Project Team in the course of the study and in preparing this report. In particular, the report has benefited from the comments of those who reviewed an earlier draft. Thanks for their helpful and constructive reviews are due to:

- Members of the National Research Council, BART Impact Program Advisory Committee
- Mr. Thomas Deen, Vice President, Alan M. Voorhees and Associates
- Staff of the Bay Area Rapid Transit District, especially Ms. Miriam Hawley for her assistance in preparing sections of Chapter III describing the BART System
- Staff of the U.S. Department of Transportation and U.S. Department of Housing and Urban Development, especially Mr. Edward Weiner and Mr. George Grainger of the Office of the Assistant Secretary for Policy, Plans and International Affairs, U.S. Department of Transportation
- Staff of the Metropolitan Transportation Commission, BART Impact Program, especially Dr. Henry Bain, Dr. Gordon Shunk, Mr. Joel Markowitz, and Mr. Andrew Ungar.

The contributions of these and many other individuals and organizations are gratefully acknowledged. However, responsibility for the contents of the report rests with Peat, Marwick, Mitchell & Co.

Metropolitan Transportation Commission

SAN FRANCISCO BAY REGION

CENTRAL AREA

SUMMARY

The BART System

The Bay Area Rapid Transit (BART) System is the first regional-scale rail rapid transit system to open in the United States in 50 years. All but 0.2 miles of the 71-mile system are within the three Bay Area Counties of San Francisco, Alameda, and Contra Costa (combined population 2.4 million). The 34 stations of the System serve the central cities of San Francisco, Oakland, and Berkeley with four lines--to Fremont, Concord, Richmond, and Daly City--radiating from Oakland and serving most of the suburbs of the three-county area. An important link in the System is the Transbay Tube beneath San Francisco Bay joining San Francisco and Oakland.

The System was designed to provide fast, comfortable, high-quality transit service which would be competitive with the automobile. To achieve this objective, designers specified maximum train speeds of 80 mph, relatively large station spacing, trains with a high seating capacity, direct "no-transfer" service to San Francisco and Oakland from all lines, short headways, and a high degree of automatic train control to allow safe, high-speed operation.

The BART Impact Program

In many respects, BART is a prototype for "heavy" rail rapid transit systems currently being built or proposed in a number of other areas. Thus, an assessment of BART's impacts is valuable to those currently concerned with evaluating rail rapid transit and alternative transportation investments elsewhere.

The BART Impact Program is a comprehensive policy-oriented study of the whole range of potential rapid transit impacts, including impacts on travel patterns, urban development, the environment, the regional economy, and public policy in the Bay Area. The Program is divided into several project areas, one of which is the Transportation System and Travel Behavior (TSTB) Project.

The TSTB Project's objectives are to assess the impacts of BART on the characteristics and performance of the transportation system including BART, local feeder bus service, and the related highway system; and the impacts on travel patterns brought about by diversion of trips to BART from bus and automobile. The impact assessment is designed to develop findings and conclusions about BART, and rail rapid transit in general, that can be used in both the San Francisco Bay Area and other metropolitan areas.

Interim Findings

This report summarizes the findings of Phase I of the TSTB Project. The findings result from analysis of large quantities of data collected before and after the start of service, including several surveys conducted as part of the Project. Nevertheless, the report must be regarded as interim in two important respects.

Much of the Phase I work was exploratory and concerned with assembling data on different aspects of BART's impacts. The costs and benefits of the various impacts were not analyzed together in a comprehensive way, and the impacts of the fixed-route BART rail system were not compared with the possible impacts of hypothetical alternative transit systems which might have replaced BART. Further analyses and, hopefully, more definite conclusions will result from later phases of the TSTB Project.

The first line of the BART System opened for revenue service in September 1972. The final link of the System, the Transbay Tube between San Francisco and Oakland opened in September 1974. Thus, the findings of the report, covering the period through June 1975, are for an early period of System operation when BART's service was much below that ultimately planned. As of June 1975, direct service was not yet operating between all stations of the System, no regular weekend or evening service was operating, and train frequencies were lower than ultimately planned. Since the first line opened, the System has been plagued by problems of equipment availability and reliability (only about half the full complement of transit cars are currently available for service). These problems continue to affect the quality of service provided. As full, reliable BART service is approached, considerably greater BART ridership and impacts can be expected.

Other Bay Area Transportation Services

Bus service in the BART impact area is provided by the San Francisco Municipal Railway (MUNI) within the City of San Francisco and by the Alameda-Contra Costa Transit District (AC Transit) in the areas of the East Bay served by the Richmond and Fremont BART Lines. Many MUNI and AC Transit routes act as feeder services to BART. AC Transit also provides transbay bus service between the East Bay and central San Francisco. Greyhound commuter buses serve the area of Contra Costa County served by the BART Concord Line.

Major freeways parallel all the BART lines fairly closely. Most important of these is the heavily-traveled San Francisco-Oakland Bay Bridge paralleling the BART Transbay Tube. At its early planning stages, BART was predicted to effect major reductions in Bay Bridge traffic volumes--which averaged about 94,000 vehicles per day in each direction at the time transbay BART service began.

BART Service Provided

Travel Time Accessibility. Although BART's service is still affected by start-up and equipment reliability problems, the System is basically doing what it was primarily designed to do--provide high-quality, long-distance commuter service to central San Francisco and Oakland. For many of those living in remote suburbs, especially on the Concord and Fremont Lines, travel time accessibility to work locations in the downtown areas has improved (especially relative to travel by bus).

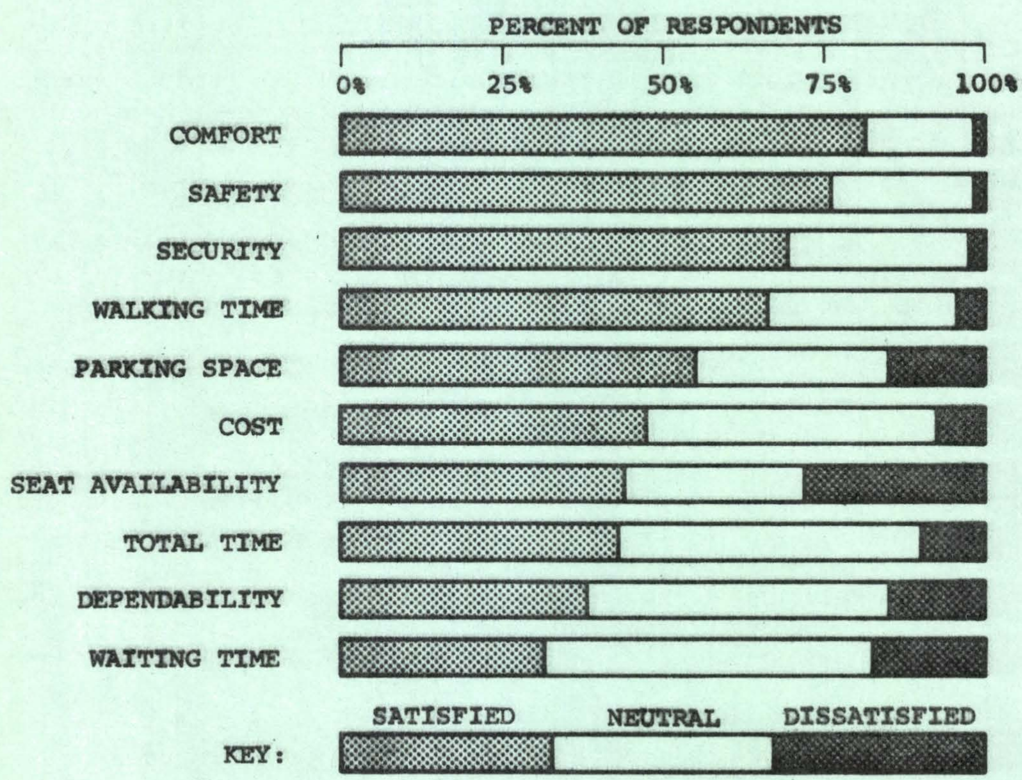
But only long-distance travelers and people who have convenient access to the BART stations are enjoying these improvements. BART offers less travel time advantage for short trips where getting to and from the station forms proportionately more of the journey time. In spite of BART's 80-mph trains (which provide an average speed of about 40 mph, including stops), its improvements in door-to-door travel times have been significant only for a relatively small percentage of areawide residents.

Methods of Access to BART. In San Francisco, most people walk to and from BART. According to the results of a TSTB Project survey of transbay BART travelers, walking is the access mode at the West Bay end of the trip for 77% of transbay trips. Bus access is used by 10% of trips; only 9% use automobile. In the East Bay, the pattern is very different. Most transbay trips (60%) are made to and from BART stations by automobile, 22% by walking, and 16% by bus. The differences between the two distributions clearly reflect the different nature of development on the two sides of the Bay.

Since travelers typically spend a high proportion of their total journey time in getting to and from BART, convenient access is very important to a fixed rail system such as BART. Limited parking space at BART stations is currently constraining the service offered to many travelers, and bus access services are only now being introduced to some stations (although many, especially those in the MUNI and AC Transit service areas are relatively well served by conventional bus). Unfortunately, the Phase I analyses do not allow a definite conclusion about the extent to which opportunities exist for improving overall BART service by increasing access services.

Fares. BART's fare schedule varies with trip distance, ranging from a minimum of $0.30 to a maximum of $1.25 (as of June 1975). BART's fares are generally slightly higher than bus fares for corresponding journeys. For example, for the typical transbay journey in October 1974, the total trip cost by BART (about $1.30) was between $0.05 and $0.10 more than the bus trip cost. However, BART is much less expensive than automobile. Clearly, the cost difference varies widely as a function of travelers' perceptions of the cost of driving, but the total trip cost by BART was perceived by travelers as being between $1.00 and $1.50 less than by automobile for typical transbay journeys in October 1974. In November 1975, BART fares were raised by an average of 21%.

Quality of Service. Travelers' perceptions of BART's quality of service largely reflect the equipment availability and reliability problems which continue to adversely affect some aspects of service. In general, BART's service levels are below people's expectations; nevertheless, most travelers perceive aspects of the System favorably. Travelers are generally satisfied with BART's comfort, safety, and security (although attitudes regarding security may change when night service is introduced). But many travelers are dissatisfied with BART's reliability, seat availability, the time they must spend waiting for trains, and the availability of station parking space.



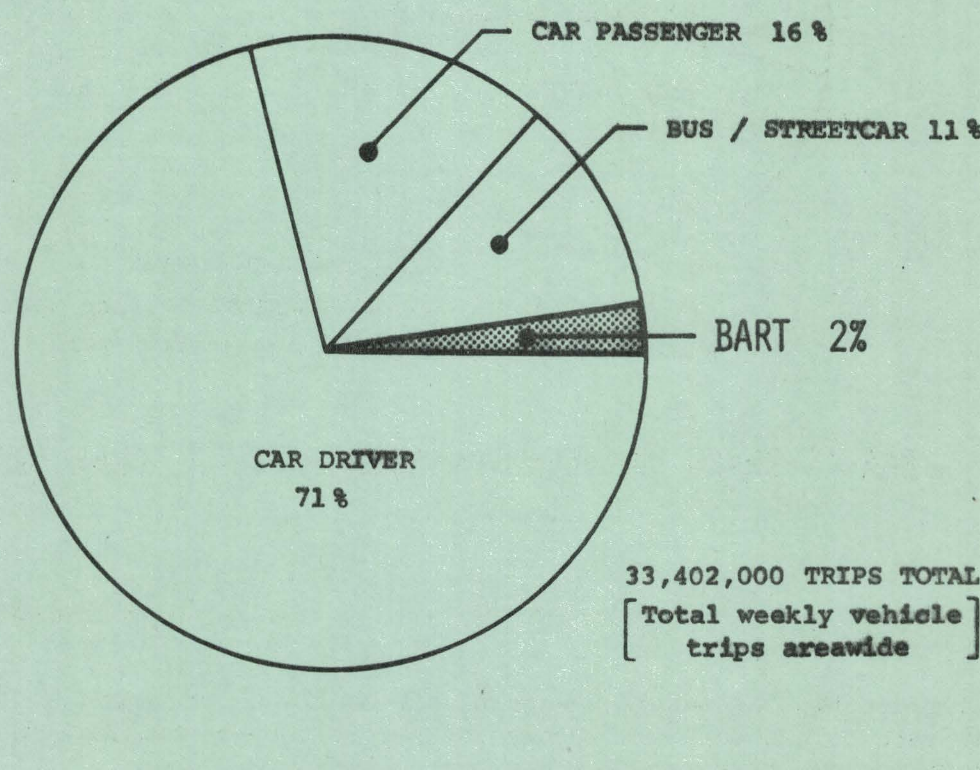
SATISFACTION WITH BART: TRANSBAY TRAVEL, OCTOBER 1974

The findings of the Phase I analyses do not allow firm conclusions on the extent to which the various aspects of BART service affect people's decisions to use the System. However, the interim results indicate that relative travel time and reliability are the most important factors The Phase I analyses do not allow the conclusion that qualitative aspects of service such as comfort are important in persuading travelers to ride the System, although much of the investment in the BART System was in providing comfortable and attractive trains and stations to attract ridership.

Impacts on Travel Patterns

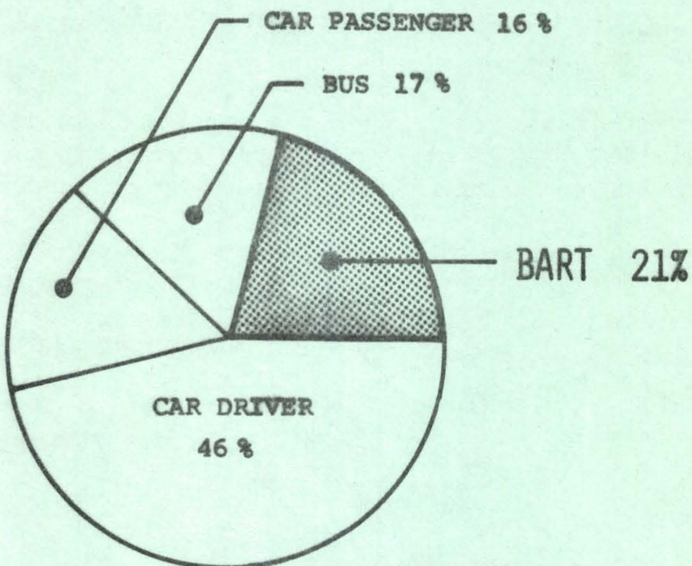
Aggregate Ridership on BART. In total, BART's ridership is well below the original forecast. Current (June 1975) ridership of about 120,000 trips daily is only about one-half of the original forecast for full-system operations.

BART's ridership is also low when compared to total travel by automobile and transit areawide. BART's average weekly ridership of 590,000 trips represents under 2% of all vehicle trips made by residents of the BART Impact Area.



BART'S SHARE OF AREAWIDE TRIPS, MAY 1975

However, there are different ways of looking at BART's share of the "trip market." If only weekday travel between 6:00 a.m. and 8:00 p.m is considered, BART's share is about 3%. If only daytime weekday trips to and from work are included, BART's share increases to 8% of areawide trips. If BART's potential trip market is defined in terms of trips people consider could reasonably be made by BART--roughly 10% of all trips--its share rises to 19% of trips for all purposes and 29% of trips to and from work. For transbay work trips made between 6:00 a.m. and 8:00 p.m. BART's share of trips is about 21%.



170,000 TRIPS TOTAL
[Daily transbay trips to or from work, weekdays 6:00 a.m. - 8:00 p.m.]

BART'S SHARE OF TRANSBAY WORK TRIPS, OCTOBER 1974

BART ridership has not increased significantly on the various lines of the System since each was opened for service, even though (bus) transit ridership has increased over the same period.

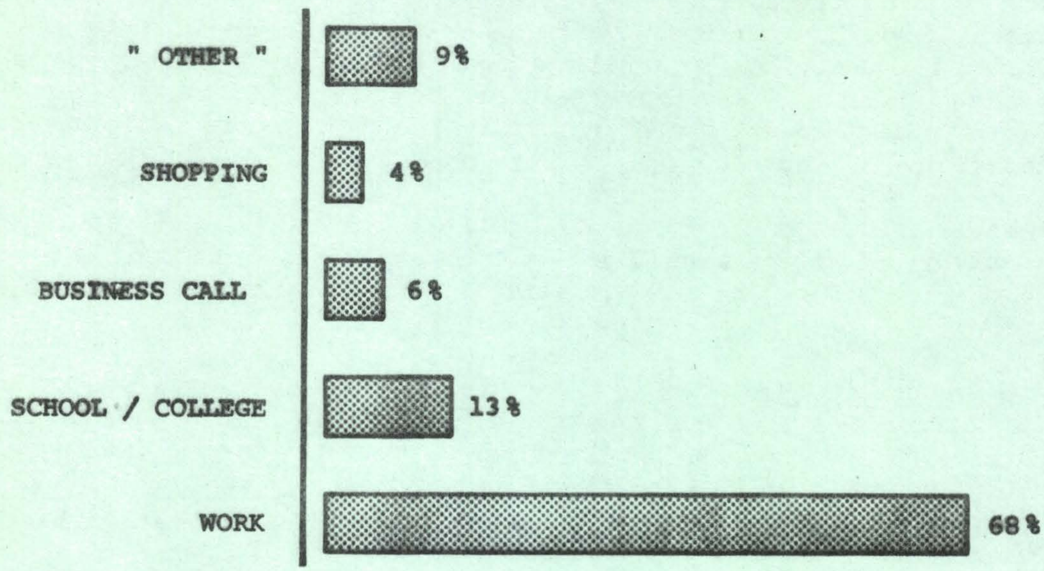
BART's apparently low ridership is explained in part by BART's (1) restricted hours of service and passenger-carrying capacity, and (2) equipment reliability and other operating problems which affect service levels. Ridership will increase as evening and weekend service are introduced, service frequency and reliability improved, and peak-period seat availability increased. The difference between BART's actual and forecast ridership is also explained in part by the overly optimistic nature of the original forecasts.

However, the reasons for the apparently low usage of the System--especially at off-peak periods--must be explained by primarily analyzing the service offered by BART relative to travel by bus and automobile.

Reasons for Use of BART. The reasons for traveler's use or nonuse of BART have not been analyzed fully in the Phase I analyses of the TSTB Project, but apparently door-to-door journey travel time is the dominant factor in most peoples' travel choice. As discussed earlier, BART offers a door-to-door travel time advantage to relatively few travelers (especially when compared to travel by automobile).

There may be opportunities for decreasing door-to-door travel times by improving bus service to BART stations. Waiting times will be reduced as service frequencies increase. Introduction of direct Richmond-Daly City service will also reduce journey times for some travelers. However, these improvements will probably only have small effects. Overall journey times by BART in the future will probably not be much below existing levels. BART's opportunity for increasing ridership must, therefore, be with improving the quality of service offered--in terms of peak-period seat availability, parking space at the stations, and above all, the reliability of service.

Characteristics of BART Trips and Riders. On average, BART trips are long and mainly made between workplaces in downtown Oakland or San Francisco and the more remote residential suburbs. Relatively few trips are made in the reverse commute direction, at off-peak times, or for nonwork purposes.



PURPOSE OF BART TRAVEL, 1974

The characteristics of BART riders reflect in part the high proportion of BART commute trips made from the more affluent suburbs to downtown San Francisco work locations. For example, 25% of transbay BART riders have annual family incomes of $25,000 or over, compared to 13% for East Bay riders and 10% for San Francisco riders. But overall, the characteristics of BART riders are not very much different from the characteristics of travelers in the Bay Area as a whole. BART riders in total have only a slightly higher average income than the average for the population and have a slightly lower proportion of racial minorities than are present in the areawide population.

Besides the problematic aspects of BART service that affect all travelers, the slightly lower use of BART by low-income and minority groups may be explained by the higher average BART fares (relative to bus) and the small door-to-door travel-time advantage offered by BART for many short trips to central areas from the closer-in suburbs--the trips most often made by low-income and minority persons.

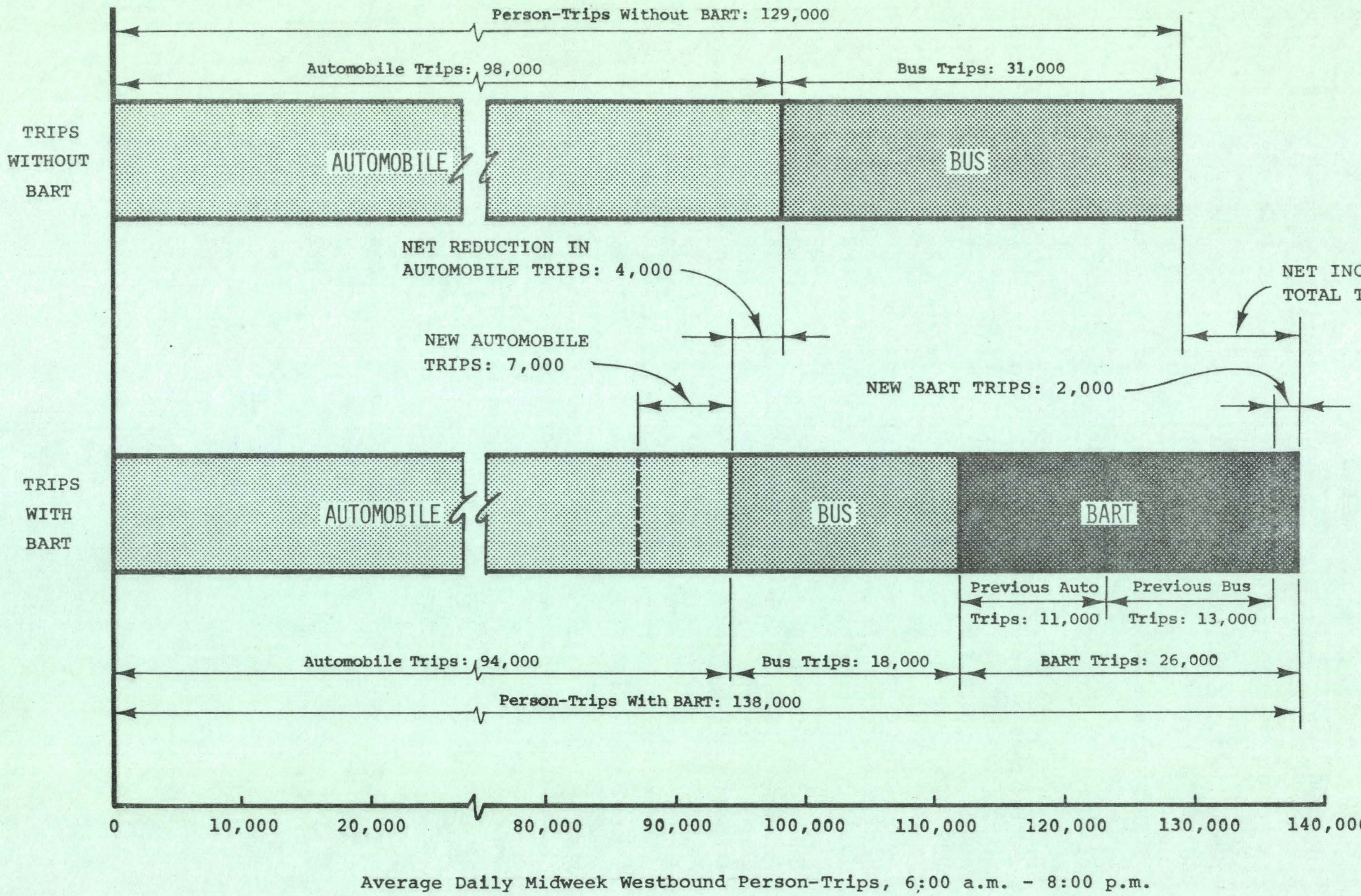
Use of BART by the Physically Disabled. Use of BART by physically disabled people is much lower than their representation in the population as a whole--in spite of BART's large investments in elevators and other facilities provided specifically to allow disabled people to use the System. To some extent, this apparently low use of BART by disabled people reflects the difficulties they experience in getting to and from the stations and, in some cases, using BART itself. However, it is unclear whether use of BART is, in fact, particularly low or whether it simply reflects a lower trip-making rate of physically disabled people in general.

Impacts on Travel by Bus and Automobile. Overall, BART has attracted most of its ridership from bus; of transbay BART trips, 54% were previously made by bus and only 35% by automobile. Trips reported as not made before by either means made up the remaining 11% of trips.

Study of the San Francisco-Oakland Bay Bridge corridor suggests that reductions in the number of bus trips is similar to the number of BART trips reported as previously made by bus (see the following page). However, the actual reduction in trips by automobile has been much less than the reported diversion of trips from automobile to BART, suggesting that "new" automobile trips have appeared to replace some of those removed by BART. Although about 11,000 daily person-trips were diverted to BART at the start of transbay service, the net reduction in automobile trips was only about 4,000 per day. The "new" 7,000 automobile trips may actually be trips diverted from other destinations or routes (rather than truly induced trips), but in either case, their effect has been to reduce automobile vehicle traffic by much less than anticipated.

Separating the impacts of BART from the many other factors affecting travel patterns--such as the increase in gasoline prices--is difficult. However, a net reduction in daily Bay Bridge traffic of between 3,000 and 5,000 vehicles per day in each direction is estimated as attributable to the start of transbay BART service. This reduction is small in relation to the dramatic reductions in traffic volumes predicted by early planning studies. Although significant, statistically speaking, it is also small in relation to the total volume of transbay vehicle trips--about 94,000 vehicles per day traveled across the Bay Bridge in each direction before transbay BART began service.

The traffic reduction represents about two years historical growth in Bay Bridge traffic and is of the same order as normal week-to-week variations in traffic.



TRAVEL IN THE SAN FRANCISCO - OAKLAND BAY BRIDGE CORRIDOR, 1974

Effects of Induced Travel. The source of the 7,000 "new" automobile trips that appeared after BART began service cannot be stated with certainty. However, it seems reasonable to hypothesize that the alleviation of Bay Bridge traffic congestion brought about by the diversion of travel to BART has been a factor. Some potential transbay automobile trips may have been suppressed previously; improvements in travel conditions now allow these suppressed trips to be made. In addition, an estimated 2,000 new trips are being made on BART itself, giving a total increase in transbay travel of 9,000 trips per day.

These impacts of BART in the Bay Bridge corridor are rather different from those originally anticipated, but similar impacts can be expected whenever a major increase in transportation capacity is provided--whether by rapid transit or some other form of transport--in a heavily traveled and congested corridor. The benefits of increasing transportation capacity will be primarily in (1) providing faster and higher-quality service to those already traveling and (2) allowing previously suppressed trips to be made. Where automobile traffic levels are already high, reductions in traffic will generally be much less than might be predicted from a simple analysis of travel diversion.

Impacts on Service Provided by Bus and Automobile. AC Transit, MUNI, and other bus operators have introduced or increased bus service on a number of lines acting as feeders to BART. In general BART's impacts on parallel bus services have been small. Services have been cut back only where BART clearly duplicates and improves service.

BART impacts on the service provided by the highway system are also apparently small--although difficult to assess in the context of the many other factors affecting highway traffic volumes. Only on the Bay Bridge can a reduction in highway travel times be attributed to BART with any degree of confidence, and this reduction is small relative to total travel times, estimated increase in average speed from 16 mph to 18 mph at the most congested time.

BART's Costs and Revenues

Capital Costs. The total capital cost of the BART System, including the transit cars, is now estimated to be $1,608 million (in current dollars). This is an average of $23 million for each mile of the System, and must be considered high by most standards.

The $1,608 million estimate compares with $994 million contained in the original (1962) BART planning report, an increase of 62%. The major part of this increase can be accounted for by inflation in the cost of constructing the System, combined with severe delays to the original construction program. If the actual cost of constructing the System (exclusive of changes in scope) is compared to the original cost in terms of 1960 prices, BART's actual capital cost is only 6% greater than originally estimated. Increased capital costs are also accounted for by increased costs for the BART cars and by high preoperational testing costs.

Expressing costs in terms of constant (1974) dollars, BART's capital costs ($32.1 million per mile) are similar to estimates for the proposed rapid transit systems in Baltimore ($27.1 million per mile) and in Atlanta ($30.2 million per mile). BART's costs are substantially less than the latest estimates for the Washington, D.C., METRO System ($45.9 million per mile, expressed in 1974 dollars).

Operating Costs. Conclusions about BART's operating costs must be tentative, since costs continue to reflect System start-up expenses and interim operating levels. However, analysis of costs to date suggests that the high initial capital cost of BART is not being offset by correspondingly low operating costs. BART's interim operating costs ($2.12 per car-mile, or $0.10 per passenger-mile) are similar to much older and less automated rapid transit systems such as the New York MTA. Expressed on a seat-mile basis, BART's operating costs appear to be similar to the operating costs of a bus system such as AC Transit (about $0.03 per seat-mile).

BART's operating costs are much higher than originally projected, but as with the capital costs, most of the increase is accounted for by inflation--particularly in labor costs--at much higher rates than expected. (The average increase in operating costs per car-mile for the New York, and Cleveland rapid transit systems was by a factor of 2.65 between 1960 and 1975.) BART's current staff is also much greater than originally estimated, largely as a result of maintenance staff needs, and possibly because of unrealistic original expectations of the way in which automation of the System would allow low staffing levels.

A high percentage (47%) of BART's interim operating costs are for maintenance, including costs associated with start-up and "debugging" problems; and a relatively low percentage (20%) are for transportation. As the System approaches full operating levels, this situation is expected to reverse, and operating costs per car-mile will decrease.

Revenues and Deficits. In the first six months of 1975, BART's average revenue per passengers was $0.59, and the average operating cost per passenger was $1.90, leaving a deficit of $1.31 per passenger. This may be compared with the operating profit of $0.14 per passenger originally forecast (in 1962). In part, this difference is largely explained by the optimistic ridership forecasts of the original report and cost increases much higher than anticipated. But it is mainly accounted for by the fact that since the original estimates were made, fares have increased by a much lower factor than operating costs, contrary to the assumptions of the original financial projections.

The difference between BART's operating costs and revenues is comparable with the deficits of other transit properties. In a recent report, BART's total fare revenues were estimated as 35% of total operating expenses for the 1974-1975 fiscal year. This compares with corresponding estimates of 34% for AC Transit and 30% for MUNI.

BART Energy Consumption. Like its operating costs, BART's interim energy consumption per car-mile reflects the short hours of operation and low number of car-miles operated. Traction energy per car-mile is currently about 10% higher than the average for rapid transit systems in the U.S. At full-system operations, traction energy per car-mile is predicted to decrease to about 10% below the national average, reflecting, among other factors, BART's relatively lightweight cars. However, even at full operating levels, BART's traction energy consumption is likely to be substantially more than express bus service when compared on a seat-mile basis. At full-system operation, BART will consume an estimated 810 Btu per seat-mile for express bus. This conclusion contradicts the widely held assumption that steel-wheel-on-steel-rail modes of transport are more energy-efficient than rubber-tired vehicles (although many factors, such as the higher maximum speed of BART, must be taken into account in making the comparison).

Limitations of the Report

This report summarizes the findings of Phase I of the BART Impact Program, Transportation and Travel Behavior Project. The report must be regarded as interim in three important respects:

Interim Nature of the Results Reported. The Phase I report examines initial effects of early stages in BART operations. The System and the conditions under which it operates are still evolving and interim conclusions could be revised as a result of later changes or events.

Partial Nature of the Results. The report presents findings in one of several areas of investigation of BART's Impacts. No overall evaluation of the impacts reported can be reached until all of the investigations have been completed.

Lack of a Basis for Comparison. A key element of the BART Impact Program is an analysis of the effects of alternatives to BART which might have been implemented instead. No overall conclusion on BART's Impacts can be drawn until the likely consequences of alternatives, such as not building BART, have been studied.

TABLE OF CONTENTS

Table of Contents (cont.)

LIST OF TABLES

List of Tables (cont.)

List of Tables (cont.)

LIST OF FIGURES

List of Figures (cont.)

LIMITATIONS OF THE REPORT

This report summarizes the findings of Phase I of the BART Impact Program, Transportation and Travel Behavior Project. The report must be regarded as interim in three important respects:

Interim Nature of the Results Reported. The Phase I report examines initial effects of early stages in BART operations. The System and the conditions under which it operates are still evolving and interim conclusions could be revised as a result of later changes or events.

Partial Nature of the Results. The report presents findings in one of several areas of investigation of BART's Impacts. No overall evaluation of the impacts reported can be reached until all of the investigations have been completed.

Lack of a Basis for Comparison. A key element of the BART Impact Program is an analysis of the effects of alternatives to BART which might have been implemented instead. No overall conclusion on BART's Impacts can be drawn until the likely consequences of alternatives, such as not building BART, have been studied.

I. INTRODUCTION

The BART Impact Program

A Case Study of Rail Rapid Transit. In recent years, there has been a resurgence of interest in public transportation in general and in rail rapid transit in particular as an approach for achieving urban transportation, environmental, energy, and urban development objectives. At present, many metropolitan areas within the United States are proposing, planning, or implementing rail rapid transit systems. As a result, political leaders, citizens, and professional planners at all levels of government are seeking sound data and information on the costs and benefits of rail rapid transit investments and the impacts of such investments on the communities where they are made.

The Bay Area Rapid Transit (BART) System is the first new regional-scale rail rapid transit system to open in the United States in 50 years. In many respects, it is a prototype for the "heavy" rail rapid transit systems currently under construction in the Washington, D.C., Baltimore, Maryland, and Atlanta, Georgia, metropolitan areas or proposed for a number of other areas. In this context of BART as a prototype for a new generation of regional rail rapid transit systems, a case study of BART's impacts is valuable to those concerned with evaluating rail rapid transit investments elsewhere.

BART Impact Program Goals and Objectives. The goal of the BART Impact Program is to develop a clearer understanding of (1) the relationships between public transportation and other elements of community development, and (2) the costs and benefits of public transportation, specifically rail rapid transit. This overall program goal translates into the following objectives:

- Measure and document what the impacts of the BART System are on travel patterns, the economy, the environment, land use patterns, and life-styles in the San Francisco region.
- Assess the incidence of BART's impacts on Bay Area residents to determine who is affected by BART.
- Explain, and document why these impacts have taken place and why some anticipated impacts did not occur or occurred in a lesser or different way than anticipated.
- Determine and document how answers to the first three questions can be used to improve the planning, design, and operation of transit systems in San Francisco and other urban areas. Determine and document how this knowledge might improve federal, state, and local transportation decision making.

Organization of the BART Impact Program. The BART Impact Program is a comprehensive program divided into six major project areas:

- Transportation System and Travel Behavior
- Environment
- Land Use and Urban Development
- Economics and Finance
- Institutions and Life-Styles
- Public Policy

This report is concerned only with the first of these areas.

The Transportation System and Travel Behavior Project

TSTB Project Objectives. The overall BART Impact Program objectives of what, who, why, and how form a context for the specific objectives of the Transportation System and Travel Behavior (TSTB) Project. These TSTB Project objectives are to assess (1) the impacts of BART on the characteristics and performance of the transportation system, including BART, local bus service, and the related highway system; and (2) traveler responses to BART, including changes in mode of travel, route, scheduling, and number of trips. This impact assessment is designed to develop findings and conclusions about BART, and rail rapid transit in general, that can be used in both the San Francisco Bay Area and other metropolitan areas.

TSTB Project Research Program. Three factors determine the research program of the TSTB Project:

1. Impacts which have been anticipated for, or attributed to, BART at successive stages in its planning, development, and operation.
2. The information requirements of those concerned with formulating transportation policy at all levels of government, and those concerned with the planning, design, and operation of transit.
3. A conceptual framework describing the way transportation and travel impacts arise.

Based on these factors, the research program for the TSTB Project was organized to assess BART's impacts in the following areas:

- Cost of providing transportation service
- Energy consumed in providing transportation service
- Changes in accessibility and travel impedances
- Changes in traveler attitudes
- Traveler choice behavior resulting from changed impedances and attitudes
- Aggregate travel pattern impacts
- Impacts of changes in travel patterns on highway congestion
- Impacts of BART on the travel behavior of specific transportation disadvantaged groups

A full explanation of the research program for the TSTB Project is given in the TSTB Research Plan.[1*]

Scope of the Report

This report presents an interim assessment of BART's impacts on the transportation system and travel behavior in the Bay Area. It is an interim assessment in two respects: (1) the TSTB Project has not had an opportunity to complete the data collection and analyses necessary for a complete assessment of BART's impacts, and (2) BART is at an interim stage of operation and has not achieved its planned full-system operating levels.

Most of the research strategies used by the TSTB Project incorporate some form of "before" and "after" design with appropriate controls to allow for various confounding influences. During the period when most of the "after" data given in this report were collected, BART was operating about 2,000,000 car-miles and serving about 40,000,000 passenger-miles per month. It was operating only three of its four planned services (Fremont-Daly City, Concord-Daly City, and Richmond-Fremont, but not direct Richmond-Daly City service) on a 14-hour-a-day, 5-day-a-week basis, with 12-minute headways during peak periods. At full-system operations, BART plans to operate approximately 4,300,000 car-miles and serve about

---

*Superscript numbers refer to references listed at the end of the report.

80,000,000 passenger-miles per month. Service will be provided on all four BART lines 20 hours a day, 7 days a week, with 6-minute headways during peak periods. Thus, the findings and conclusions presented in this report must be interpreted in light of the fact that BART is currently operating at about half its planned service level for full-system operations.

The material in the report provides initial assessments of what BART's impacts have been and who has been impacted. An effort is also made to assess the implications of these findings and conclusions regarding the BART experience for future transportation decisions. However, many of these assessments should be viewed as preliminary. Subsequent reports of the TSTB Project will more fully assess responses to the what, who, and how questions as BART approaches the planned full-service level.

Organization of the Report

The organization of the report into chapters attempts to conform to the following "conceptual framework" of the way in which transportation impacts arise. BART directly changes the characteristics of transportation service provided. In response to these changes, travelers divert to BART from bus and automobile, giving rise to changes in the pattern of travel on the transportation system. These may be termed travel impacts. In addition, diversion of travel to BART causes changes in the level of service provided by the rest of the transportation system. These may be termed system impacts.

Chapter II briefly describes the transportation system and land use activity in the San Francisco Bay Area to provide a context for the description of the BART System and its impacts. A summary of the history of the BART System is also provided.

To appreciate the impacts of BART on the transportation system and travel behavior, it is first necessary to understand the design and operating characteristics of BART at its current (interim) stage of operations. Accordingly, Chapter III focuses on the physical features and operating characteristics of BART and its associated access services from the perspective of the supplier of the transportation service.

Chapter IV describes the most important of BART's service characteristics (such as travel time, cost, and reliability) from the perspective of the consumer or user of the service. BART's travel times and costs are compared to those of bus and automobile.

Also described are the conclusions of an exploratory analysis of BART's impacts on areawide accessibility derived from network representations of the transportation system before and after BART.

Chapter V (1) discusses BART ridership in terms of its historical development, origin-destination distribution, travel purposes, and access modes; (2) considers BART's ridership share of various travel markets in the Bay Area and current constraints on ridership; and (3) compares the demographic characteristics of BART travelers to the demographic characteristics of the BART impact area population as a whole. Reasons for use or nonuse of BART are also discussed in terms of traveler attitudes about BART and alternative modes.

BART's impacts on travel by bus and automobile are analyzed in Chapter VI. The discussion of BART's impacts on automobile travel focuses on traffic volumes on the four major bridges across San Francisco Bay, particularly the one most affected by BART. The analysis attempts to separate BART's impacts from the effects of changes in gasoline prices, seasonal variations, and other confounding factors.

Chapter VII then presents an initial examination of BART's impacts on the mobility of three transportation-disadvantaged groups--ethnic minorities, low-income households, and the physically disabled.

Chapter VIII discusses BART's impacts on the characteristics of, and service provided by, the rest of the transportation system. BART's impacts on highway travel times and on parallel bus service frequencies are emphasized.

Much of the debate concerning rail rapid transit centers on the capital and operating costs of such services relative to their revenues. Chapter IX briefly describes BART's costs and revenues.

Finally, Chapter X presents the conclusions of the TSTB Project's first phase. The chapter draws together the findings presented in Chapters II through IX and assesses the implications of these interim findings for BART, the Bay Area, and other metropolitan areas.

Development of BART Since Original Time of Writing

The first draft of this report was completed in August 1975, and all analyses are based on the most recent data available when the draft was written. Since then, a number of changes have occurred in BART's services. Most important of these are:

- Effective November 3, 1975, BART changed its fare schedule. The maximum fare (Fremont to Daly City) was raised from \$1.25 to \$1.45; the fare for a typical-length commuting journey (Concord to Montgomery Street in downtown San Francisco) was raised from \$0.85 to \$1.15; the fares for some very short journeys (within central San Francisco and Oakland) were lowered from \$0.30 to \$0.25. Overall, fares were raised by an average of 21%.

- Effective November 28, 1975, BART extended operations to include weekday evening service from 8 p.m. to approximately 12 midnight. Evening service became permanent on January 1, 1976, so that BART now operates Monday through Friday from 6 a.m. to 12 midnight.

A number of less important changes have also taken place. For example, BART now operates small (three- and four-car) trains during off-peak periods, rather than full-size (up to ten-car) trains throughout the day; feeder bus services to the Concord and Walnut Creek BART stations have been expanded; parking lots have been slightly enlarged at some stations. These changes have probably had only minor effects on BART service and ridership. Since August 1975, BART's train schedule has not changed significantly, nor has the reliability of service.

The combination of these and other factors has resulted in some changes in BART ridership over the period since June 1975, the last month included in the analyses of Chapter V. Average daily ridership on BART in June 1975 was 121,300. By October 1975, it had increased to 125,200. In November 1975, following the fare increase, average daily ridership dropped to 121,400, a decrease of 3.0% from October. In December 1975, following the start of evening service, average daily ridership increased to 126,600, an increase of 4.2% over November. Average daily ridership in December 1975 (126,600) was almost exactly the same as in December 1974 (126,500).

The analyses and conclusions in this report have not been updated to account for these changes, but the changes should be borne in mind by the reader. Where events since the time of writing may have changed findings in a significant way, attention is drawn to the relevant events in footnotes.

Further documentation of changes in BART's service, other characteristics of the Bay Area transportation system, and accompanying changes in travel patterns will be included in subsequent reports of the TSTB Project and other projects of the BART Impact Program.

II. BART AND THE BAY AREA

BART and the Regional Transportation System

The BART System. A map of the 71-mile, 34-station BART System is shown in Figure 1. The System lies within the three Bay Area counties of San Francisco, Alameda, and Contra Costa, except for about 0.2 miles of line and the Daly City BART Station which are in San Mateo County. Four BART lines radiate from the central Oakland section of the System. These are the Concord, Richmond, Fremont, and San Francisco* Lines to the east, north, south, and west, respectively. Table 1 shows the distribution of BART's mileage and stations on the lines of the System.

Other Transit Services in the Bay Area. The area served by BART is also served by four other major transit operators.

Alameda-Contra Costa Transit District (AC Transit). As the major bus operator in the East Bay, AC Transit serves an area of approximately 150 square miles and a population of about 1,000,000. Eighteen BART stations are in AC Transit's East Bay service area: all the BART stations on the Richmond and Fremont Lines (except Union City and Fremont) and the Rockridge Station on the Concord Line. Some AC Transit services act as feeders to BART stations; others parallel the BART lines. In addition to local and express bus service in the East Bay, AC Transit operates extensive bus routes across the San Francisco-Oakland Bay Bridge to the transbay bus terminal in downtown San Francisco. AC Transit operates a fleet of about 800 buses over a total one-way route mileage of 1,570 miles. Weekday ridership in the year ending June 30, 1974, averaged about 200,000 person-trips. BART has had major impacts on AC Transit's ridership, particularly the transbay lines, as discussed in Chapter VI.

San Francisco Municipal Railway (MUNI). MUNI serves the City and County of San Francisco, an area of 47 square miles with a population of about 700,000. The area is served by the eight stations of the San Francisco BART Line (excluding Daly City). In the year ending June 30, 1974, MUNI operated a fleet of 1,015 vehicles--530 buses, 330 trolley coaches, 115 streetcars, and 40 cable cars. Sixty-seven lines were operated over a round-trip line mileage of 786 miles. In the first quarter of 1975, weekday ridership on MUNI averaged 360,000 trips. Again, possible BART impacts on MUNI ridership are discussed in Chapter VI.

---

*The San Francisco Line is also named for its terminal station, Daly City.

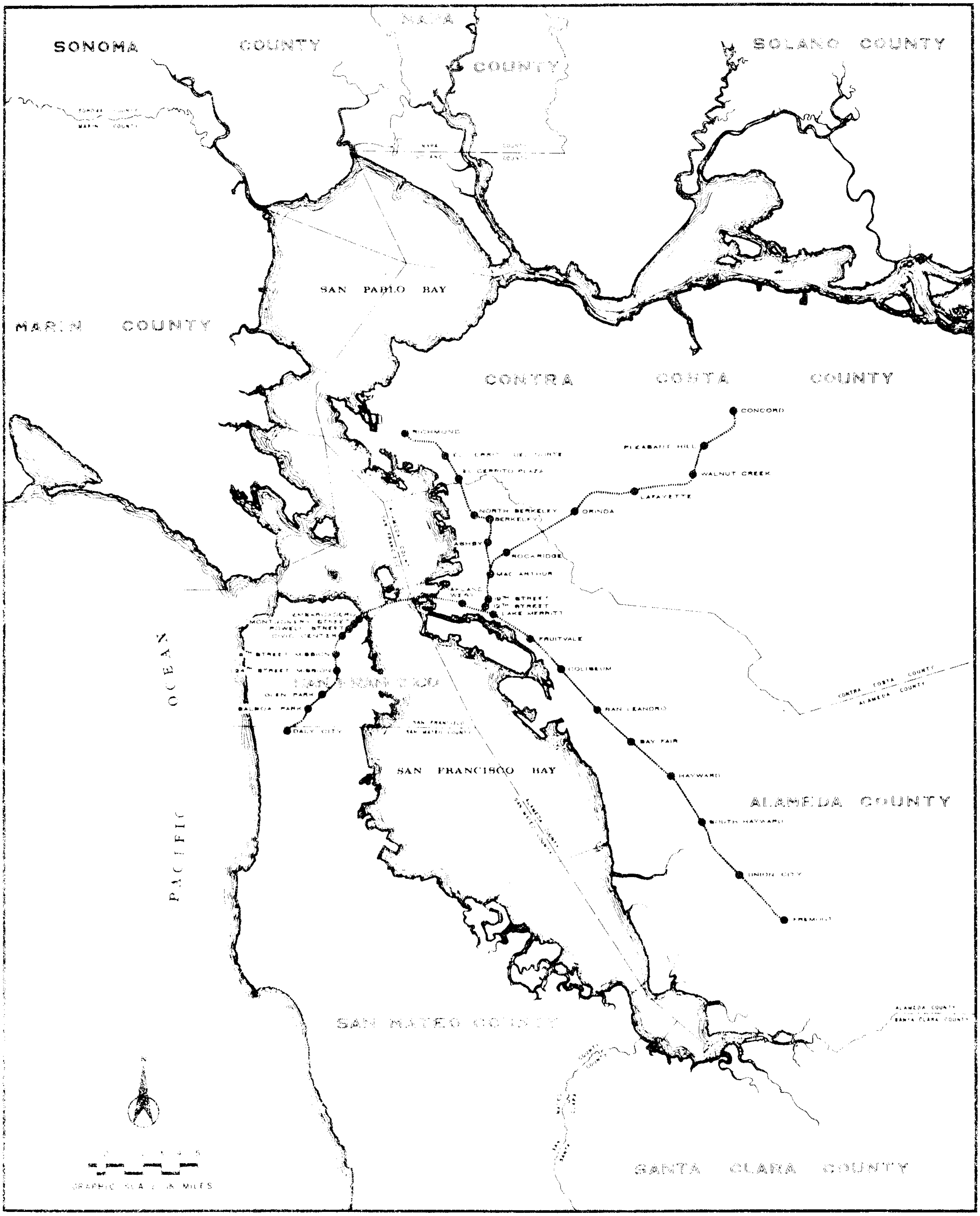


FIGURE 1

BAY AREA RAPID TRANSIT SYSTEM

Table 1

COMPOSITION OF BART LINES

BART Line	Route-Miles	Stations
Concord Line (including Berkeley Hills Tunnel)	19.1	Concord Pleasant Hill Walnut Creek Lafayette Orinda Rockridge
Richmond Line	10.3	Richmond El Cerrito del Norte El Cerrito Plaza North Berkeley Berkeley Ashby
Fremont Line	23.2	Fremont Union City South Hayward Hayward Bay Fair San Leandro Coliseum Fruitvale
Oakland Section	4.6	Lake Merritt MacArthur 19th Street Oakland 12th Street Oakland Oakland West
San Francisco Line (including Transbay Tube)	13.8	Embarcadero[a] Montgomery Street Powell Street Civic Center 16th Street Mission 24th Street Mission Glen Park Balboa Park Daly City
Total	71.0	34 stations

a. Embarcadero Station not open yet.

Greyhound Bus Lines. Greyhound buses serve the area east of the Berkeley Hills in central Contra Costa County, which is also served by the BART stations on the Concord Line (except Rockridge). Greyhound service consists mainly of express service between terminals in Orinda, Lafayette, Walnut Creek, Concord, and downtown San Francisco. As discussed in Chapter VI, transbay BART service has greatly reduced Greyhound ridership, and Greyhound has filed a request with the State of California Public Utilities Commission to discontinue the services. Immediately before the start of transbay BART service, an average of 9,400 daily trips were made by Greyhound buses between central Contra Costa County and downtown San Francisco.

Greyhound also provides bus service between cities in San Mateo County and San Francisco. However, these services are effectively outside the area of BART's potential influence and are not considered in this report.

Southern Pacific Railroad. Southern Pacific provides commuter rail service between San Francisco and cities on the San Francisco Peninsula in San Mateo and Santa Clara Counties. Weekday ridership to or from San Francisco averages about 16,000 trips. Again, the area served by Southern Pacific is only marginally served by BART, and interaction between the two systems is probably negligible.

The Highway System. As shown in Figure 2, major freeways more or less parallel each of the BART lines. The San Francisco Line is paralleled by I-280 and Route 101, the Richmond Line by I-80, the Concord Line by Route 24, and the Fremont Line by Route 17 (and to a lesser extent I-580). Oakland and the other East Bay cities are linked to the San Francisco Peninsula and Marin County by three major highway toll bridges:

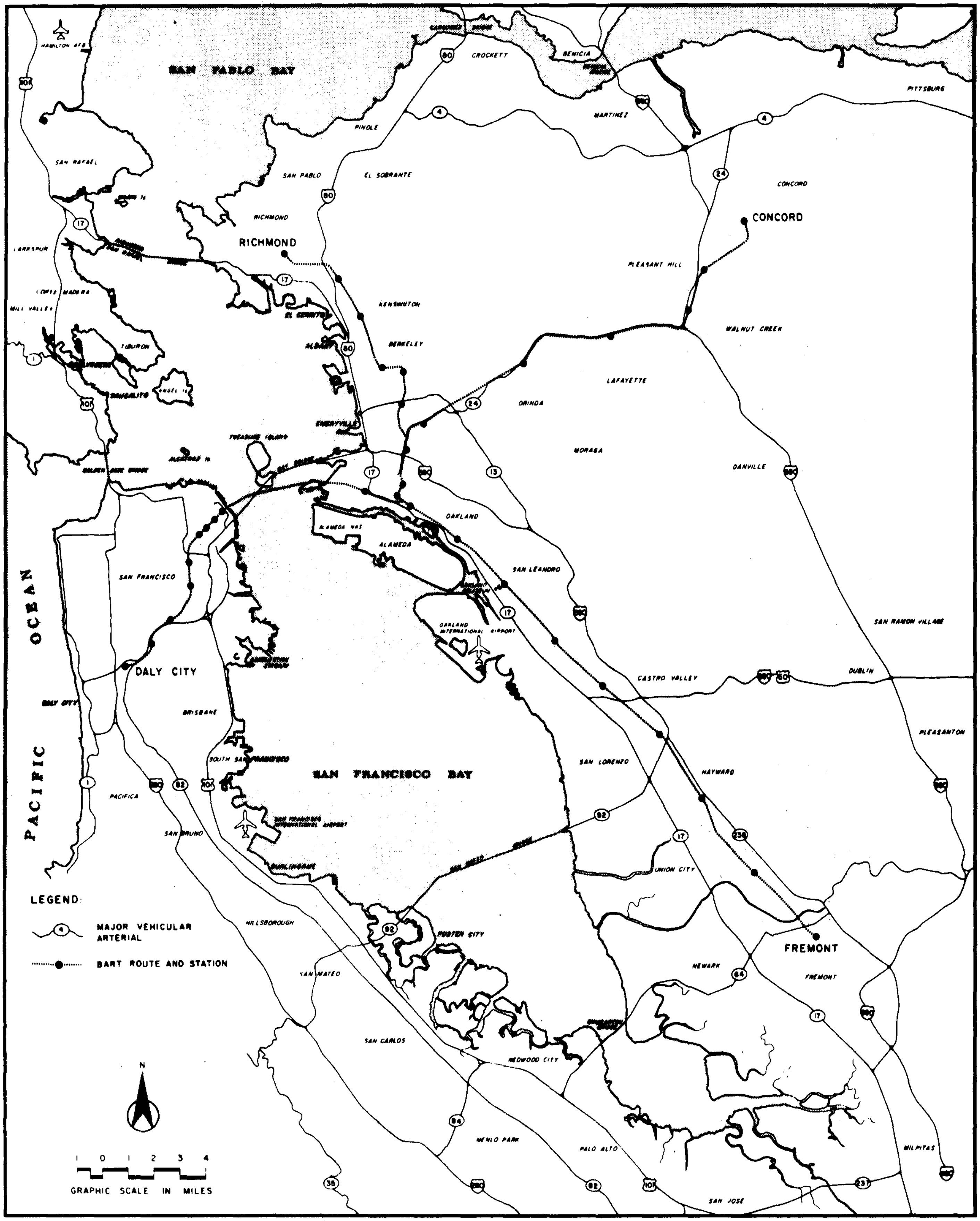


FIGURE 2

RELATIONSHIP OF BAY AREA HIGHWAY SYSTEM TO BART

Bridge	Total Lanes In Both Directions	Total Toll Charge for Both Directions*	Average Daily Vehicles In Each Direction
San Francisco-Oakland Bay Bridge	10	$0.50/$0.40	90,000
San Mateo-Hayward Bridge	4 (6 at center span)	$0.70/$0.40	15,000
Richmond-San Rafael	6	$1.00/$0.60	10,000

The most important of these is the San Francisco-Oakland Bay Bridge (generally referred to as the Bay Bridge), which parallels the BART Transbay Tube and connects the freeways of the San Francisco Peninsula and the employment centers of San Francisco directly to Oakland and the major freeways leading to the industrial and residential areas of the East Bay. The four freeways radiating from the eastern terminus of the Bay Bridge (I-80, Route 24, I-580, and Route 17) have a total of 32 lanes in both directions where they intersect.

Characteristics of the BART Service Area

This section presents data on population and employment in the three counties constituting the BART District. Corresponding information is given for San Mateo, Santa Clara, and Marin Counties to provide a regional context. Table 2 shows historical population growth, Table 3 the distribution of population according to ethnic category and family income, and Table 4 the density distribution of employment and population together with data on BART. Figures 1 and 2 display geographic location of the various jurisdictions.

---

*The first number is the normal toll for passenger cars; the second is the charge for prepaid commuter ticket books. Tolls are paid in the westbound direction only. On the first two bridges, cars containing three or more persons pay no toll at peak periods.

Table 2

HISTORICAL POPULATION GROWTH IN THE SAN FRANCISCO BAY AREA

Unit	Total Population						Compounded Annual Population Growth Rate (percent)		Share of 6-County Population (percent)
	1930	1940	1950	1960	1970	1974	1930–1974	1970–1974	
San Francisco City and County	634,394	634,536	775,357	740,316	715,674	675,600	0.14%	-1.43%	16%
Alameda County									
Alameda	35,033	36,256	64,430	63,855	70,968	73,100	1.68%	0.74%	
Berkeley	82,109	85,547	113,805	111,268	116,716	108,900	0.64	-1.72	
Castro Valley	--	--	--	37,120	44,760	n.a.	--	--	
Fremont	--	--	--	43,790	100,869	120,700	7.51[a]	4.59	
Hayward	5,530	6,736	14,272	72,700	93,058	94,700	6.67	0.44	
Newark	--	--	1,532	9,884	27,153	28,700	12.99[b]	1.39	
Oakland[c]	284,063	302,163	384,575	367,548	361,561	342,400	0.43	-1.35	
San Leandro	11,455	14,601	27,542	65,962	68,698	67,800	4.12	-0.33	
Others	56,693	67,708	134,159	136,082	189,401	261,100	3.53	8.36	
Total Alameda County	474,883	513,011	740,315	908,209	1,073,184	1,097,400	1.92%	0.56%	25
Contra Costa County									
Concord	1,125	1,373	6,953	36,208	85,164	91,600	10.52%	1.84%	
El Cerrito	3,870	6,137	18,011	25,437	25,190	24,050	4.24	-1.15	
Richmond[c]	20,093	23,642	99,545	71,854	79,043	75,800	3.06	-1.04	
Walnut Creek	1,014	1,587	2,420	9,903	39,844	48,050	9.16	4.79	
Others	52,506	67,711	172,055	265,628	329,148	350,600	4.41	1.59	
Total Contra Costa County	78,608	100,450	298,984	409,030	558,389	590,100	4.69%	1.39%	14
TOTAL THREE BART COUNTIES	1,161,783	1,247,997	1,814,656	2,057,555	2,347,247	2,363,100	1.63%	0.17%	55%
Marin County	41,648	52,907	85,619	146,820	206,038	215,500	3.81%	1.13%	5
San Mateo County	77,405	111,782	235,659	444,387	556,234	571,100	4.65%	0.66%	13
Santa Clara County	145,118	174,949	290,547	642,315	1,064,714	1,167,000	4.85%	2.32%	27
TOTAL SIX COUNTY AREA	1,425,954	1,587,636	2,426,481	3,291,077	4,174,233	4,316,700	2.55%	0.84%	100%

a. 1960–1974.
b. 1950–1974.
c. Decrease in population between 1950 and 1970 due to annexation to other cities.

Source: U.S. Census of Population and Housing.

Table 3

DISTRIBUTION OF HOUSEHOLDS IN THE SAN FRANCISCO BAY AREA
BY ETHNIC CATEGORY AND FAMILY INCOME

Unit	1970 Total Population	1970 Census Ethnic Categorization: White Other Than Spanish	Negro	Spanish Surname	Other	1970 Family Income (percent of families): $0–$4,999	$5,000–$9,999	$10,000–$14,999	$15,000–$24,999	$25,000 and Over	Mean Family Income
San Francisco City and County	715,674	57.2%	13.4%	14.2%	15.2%	18.7%	28.4%	25.7%	27.2%	7.2%	$12,507
Alameda County											
Alameda	70,968	80.5	2.6	9.8	7.1	16.7	29.4	27.5	21.2	5.2	11,768
Berkeley	116,716	62.2	23.5	5.5	8.8	21.2	28.9	22.1	19.1	8.7	12,362
Castro Valley	44,760	87.4	0.5	10.1	2.0	9.0	20.1	33.7	29.6	7.6	14,227
Fremont	100,869	80.6	0.4	16.2	2.8	7.1	21.2	39.1	27.9	4.7	13,414
Hayward	93,058	73.5	1.8	20.3	4.4	12.4	28.7	35.0	21.2	2.7	11,655
Newark	27,153	72.2	0.7	22.4	4.7	8.8	23.6	40.5	24.8	2.3	12,409
Oakland	361,561	49.3	34.5	9.8	6.4	21.5	30.7	24.7	17.8	5.3	11,279
San Leandro	68,698	78.4	0.1	18.6	2.9	10.9	24.7	34.4	25.4	4.6	12,909
Others	189,401	79.8	1.8	14.4	4.0	10.7	23.1	34.7	25.4	6.1	13,560
Total Alameda County	1,073,184	67.2	15.0	12.6	5.2	15.4	26.9	30.2	22.0	5.5	12,340
Contra Costa County											
Concord	85,164	90.8	0.3	7.1	1.8	8.3	21.5	37.8	28.8	3.6	12,960
El Cerrito	25,190	79.0	5.5	7.3	8.2	7.7	21.5	29.9	30.4	10.5	15,249
Richmond	79,043	49.8	36.2	10.1	3.9	18.1	29.3	30.3	19.1	3.2	11,027
Walnut Creek	39,844	93.8	0.3	4.3	1.6	7.3	18.2	26.4	37.1	11.0	15,936
Others	329,148	84.0	3.4	10.4	2.2	11.6	22.0	30.2	26.6	9.6	14,243
Total Contra Costa County	558,389	80.7	7.5	9.3	2.5	11.5	22.7	31.0	26.7	7.9	13,778
TOTAL THREE BART COUNTIES	2,347,274	67.3	12.7	12.3	7.7	15.4	26.3	29.1	22.7	6.5	12,752
Marin County	206,038	90.1	2.4	5.8	1.7	9.6	19.1	27.1	30.4	13.7	16,136
San Mateo County	556,234	68.7	4.7	11.3	4.0	8.8	20.7	31.3	39.2	10.1	15,138
Santa Clara County	1,064,714	76.8	1.7	17.5	4.0	11.2	20.7	32.0	28.6	7.5	13,644
TOTAL SIX-COUNTY AREA	4,174,233	72.6	8.3	13.2	5.9	13.1	23.7	30.0	25.4	7.8	$13,482

Source: 1970 U.S. Census of Population and Housing.

Table 4

DENSITY DISTRIBUTION OF POPULATION AND EMPLOYMENT
IN THE SAN FRANCISCO BAY AREA

	1970 Population	1970 Population Density: Residents per Square Mile of Gross Area	1970 Population Density: Residents per Square Mile of Urban Area	1970 Population Density: Residents per Square Mile of Residential Area	1970 Employment	1970 Employment Density: Employees per Square Mile of Gross Area	1970 Employment Density: Employees per Square Mile of Urban Area	System Miles of BART Within Jurisdiction	BART Stations Within Jurisdiction
San Francisco City and County	715,674	15,200	22,500	48,500	504,500	10,700	15,900	10.8	8
Alameda County									
Alameda	70,968	7,400	9,400	22,500	32,700	3,430	4,340	—	—
Berkeley	116,716	17,300	18,400	29,600	22,700	6,220	6,620	3.7	3
Castro Valley	44,760	3,600	6,000	7,800	4,800	490	820	—	—
Fremont	100,869	1,300	6,600	10,200	24,500	310	1,610	2.6	1
Hayward	93,058	3,100	8,800	14,400	36,100	960	2,760	6.2	2
Newark	27,153	3,300	6,300	11,400	5,800	700	1,350	—	—
Oakland	361,561	10,000	10,400	27,700	134,500	8,840	9,190	18.2	8
San Leandro	68,698	8,600	9,600	16,800	39,600	2,730	3,070	3.6	2
Others	189,401	300	3,100	5,600	169,000	310	2,800	6.3	1
Total Alameda County	1,073,184	1,500	7,800	14,000	469,700	650	3,420	40.6	17
Contra Costa County									
Concord	85,164	4,600	6,300	10,200	17,900	980	1,340	2.9	1
El Cerrito	25,190	7,400	11,700	25,200	6,500	1,110	1,270	2.8	2
Richmond	79,043	3,200	5,800	14,600	41,100	1,050	1,920	2.0	1
Walnut Creek	39,844	3,100	4,900	7,400	17,900	950	1,520	2.8	2
Others	329,148	500	3,900	8,300	59,400	90	710	8.9	2
Total Contra Costa County	558,389	800	4,100	8,200	142,800	190	1,050	19.4	8
TOTAL THREE BART COUNTIES	2,347,247	1,600	7,700	14,800	1,117,000	740	3,660	70.8	33
Marin County	206,038	400	5,100	7,700	54,600	100	1,350	—	—
San Mateo County	556,234	1,000	6,200	11,200	223,500	410	2,500	0.2	1
Santa Clara County	1,064,714	800	5,500	12,200	432,800	330	2,230	—	—
TOTAL SIX COUNTY AREA	4,174,233	1,100	6,600	13,000	1,829,000	470	2,910	71.0	34

Sources: 1. 1970 U.S. Census of Population and Housing.
2. Association of Bay Area Governments/Metropolitan Transportation Commission, Series 2 Population Projections, September 1974.

City and County of San Francisco. Of the three counties making up the BART District, San Francisco is the major employment center with 45% of the jobs and 29% of the three-county population. San Francisco is the most densely populated, although its population has been declining since 1950. The City contains a higher proportion of nonwhites (43%) than the other two counties, but the mean family income in 1970 ($12,500) was not much below the mean for the three-county area as a whole ($12,700).

Alameda County. Alameda County is the largest of the three BART counties with 46% of the population and 42% of the jobs. Oakland and San Leandro are the major employment centers. In total, the County's population continues to grow, although the populations of the densely populated central cities of Oakland and Berkeley have declined since 1950. In 1970, the County contained a 33% nonwhite population and had a mean family income of $12,300, but in the central city of Oakland (which contains about 34% of the Alameda County population) the proportion of nonwhites and low-income families is much higher. In Oakland, 51% of the 1970 population was nonwhite and the mean family income was $11,300.

Contra Costa County. Contra Costa County is predominantly residential, containing 25% of the three-county population but only 13% of the employment. The County as a whole is the richest ($13,800 mean family income in 1970), the least densely populated, the fastest growing, and has the lowest nonwhite population of the three BART counties. However, the differences between the cities of El Cerrito and Richmond in western Contra Costa County (served by the Richmond Line) and the more recently developed areas of Walnut Creek and Concord to the east of the Berkeley Hills (served by the Concord Line) should be noted.

Historical Development of BART

This section discusses selected aspects of BART's history to provide a context for the description of BART's services and traveler responses to these services given in later chapters. A complete description of the history of the BART System is provided in another BART Impact Program report.[2]

Specification of BART's Performance Characteristics. A report submitted to the BART District (BARTD) by their engineering, financial, and economic consultants in 1962 contained the first comprehensive proposals for the present BART system. This report is generally known as The Composite Report.[3]

The dominant theme of the Composite Report and other early planning reports was the concept of BART as a regional rapid transit system which would offer a quality of service equivalent to that of the private automobile--particularly to the central business districts of San Francisco, Oakland, and Berkeley. The objective that BART provide a level of service competitive with the automobile implied:

- Travel times competitive with those by automobile
- A seat for every passenger
- Travel from origin to destination without a transfer

These requirements necessitated a set of relatively stringent design specifications for the System. To achieve competitive travel times, it was necessary that suburban stations be located approximately two miles apart and that trains have a maximum speed of 70 mph and an average speed of 45 mph to 50 mph. Relatively short headways (90 seconds) were specified to make BART convenient and minimize traveler waiting times. To avoid carrying standing passengers and to meet peak hour demands, the BART designers wanted trains to be as long as possible without adversely affecting operations. They concluded that a ten-car train approximately 700 feet long was the maximum train length which could be accommodated by a platform in an urban area. (Taking an assumed train capacity of 720 seated passengers and the design requirement for 90-second headways, gave a system capacity of 30,000 passengers per hour.) Finally, to eliminate transfers, the System had to have the capability of high-speed merging of all three East Bay lines into the single line of the Transbay Tube.

These design specifications for the BART System, in turn required (1) an automatic train control system and (2) a lightweight transit car capable of high rates of acceleration and deceleration and high maximum speeds. The planned headways, operating speeds, and train sizes were such that the engineers considered manual control to be infeasible. Further, an automatic train control system was essential to allow merging of planned high-speed, low-headway trains from the three lines entering the Transbay Tube. The engineers concluded that the transit cars needed to be lightweight in order to achieve the performance requirements of the System, while minimizing power consumption and track maintenance costs. Thus, the requirement of advanced transit technology for both the automatic train control system and the transit vehicle was a direct result of the perceived need to provide a regional rapid transit system competitive with the automobile.

The bond issue financing the BART System was approved by the voters in 1962. As detailed systems engineering proceeded following this vote, it became clear that existing transit technology was incapable of meeting the specifications set for the BART System. BARTD consequently embarked on a program to develop and produce new rapid transit cars and train control systems to meet their specifications. The development and production program has encountered many problems, not all of which have yet been resolved. These problems have been well publicized and documented elsewhere,[2] and as discussed in Chapter IV, they continue to adversely affect operation of the System. The various problems have also delayed the dates of service introduction several years beyond those scheduled in The Composite Report.

Dates of Service Introduction. BART service was introduced in the following stages:

- September 11, 1972--Opening of the Fremont Line
- January 29, 1973--Opening of the Richmond Line
- May 21, 1973--Opening of the Concord Line
- November 5, 1973--Opening of the Daly City Line to San Francisco's CBD
- September 16, 1974--Start of transbay BART service

Currently,* three direct BART services are operated: Fremont-Daly City, Concord-Daly City, and Fremont-Richmond. Direct service is also planned eventually for Richmond-Daly City; but at present, travelers between stations on the Richmond and San Francisco Lines must transfer. Service is operated on the three lines from 6:00 a.m. to approximately 8:00 p.m., Monday through Friday. Scheduled headways between trains are 12 minutes on each of the three services until the end of the evening peak period, after which headways are scheduled at 20 minutes. The combined headways on the San Francisco and Fremont Lines are 6 minutes, and 10 minutes after the evening peak. Trains vary in length by line and time of day, with a current maximum train length of 9 cars (650-seat capacity). Planned future service improvements include extending the hours of operation; opening the Embarcadero Station; providing direct Richmond-Daly City service; providing weekend service; reducing headways; and increasing the train sizes as required to serve passenger demands. Details of BART's design and operating characteristics are given in the following chapter.

---

*See Chapter 1 for major changes in BART service that have occurred since the time of writing (August 1975).

III. BART DESIGN AND OPERATING CHARACTERISTICS

Routes and Guideways

Station Spacing. Figure 3 shows the lines of the BART System and the distances between stations. The average distance between stations is 2.1 miles. This is, by design, relatively high compared to other rapid rail transit systems to allow high average speeds without requiring express or skip-stop train operations. Distances between stations range from less than 0.5 miles in downtown San Francisco and Oakland to over 3 miles in the outlying low-density areas.

Train Speeds. Maximum and average train speeds between BART stations (taking station dwell-times into account) are presented in Figure 4. The BART System is designed for a maximum train speed of 80 mph. Maximum scheduled speeds are 70 mph. Maximum speeds may be less than scheduled when:

- Adjacent stations are so close together that it is impossible for trains to reach the maximum speed within the distance, given maximum acceleration and deceleration rates of 3 mph per second.
- The segment contains curves requiring reduced train speeds.
- Lower speeds are required for safe operation (such as at the approaches to yards).
- Water, frost, or oil on the rails dictates train operation in the "impeded mode" (75% of normal speeds).

In general, the maximum scheduled speed is 70 mph on outer sections of the Richmond, Concord, and Fremont Lines, and through the Transbay Tube. On the San Francisco Line, the maximum scheduled speed is generally 60 mph instead of 70 mph because of the relatively close station spacings, and is lower still in central San Francisco and Oakland for the same reason. Average scheduled speeds on the outer sections of the Fremont and Concord Lines and through the Transbay Tube are generally in the 50-mph to 60-mph range; average speeds on the Richmond and San Francisco Lines are in the 30-mph to 50-mph range; and average speeds in central San Francisco and Oakland are in the 15-mph to 30-mph range.

Station dwell-times for trains depend on the volumes of passengers boarding and exiting the trains and vary from 18 seconds to 45 seconds. Considering the average speed on each segment of the System and the station dwell-times together, the average scheduled station-to-station travel speed for a trip on BART is about 38 mph. The average speed for a given BART trip will, of course, vary significantly from this average depending on the origin and destination stations.

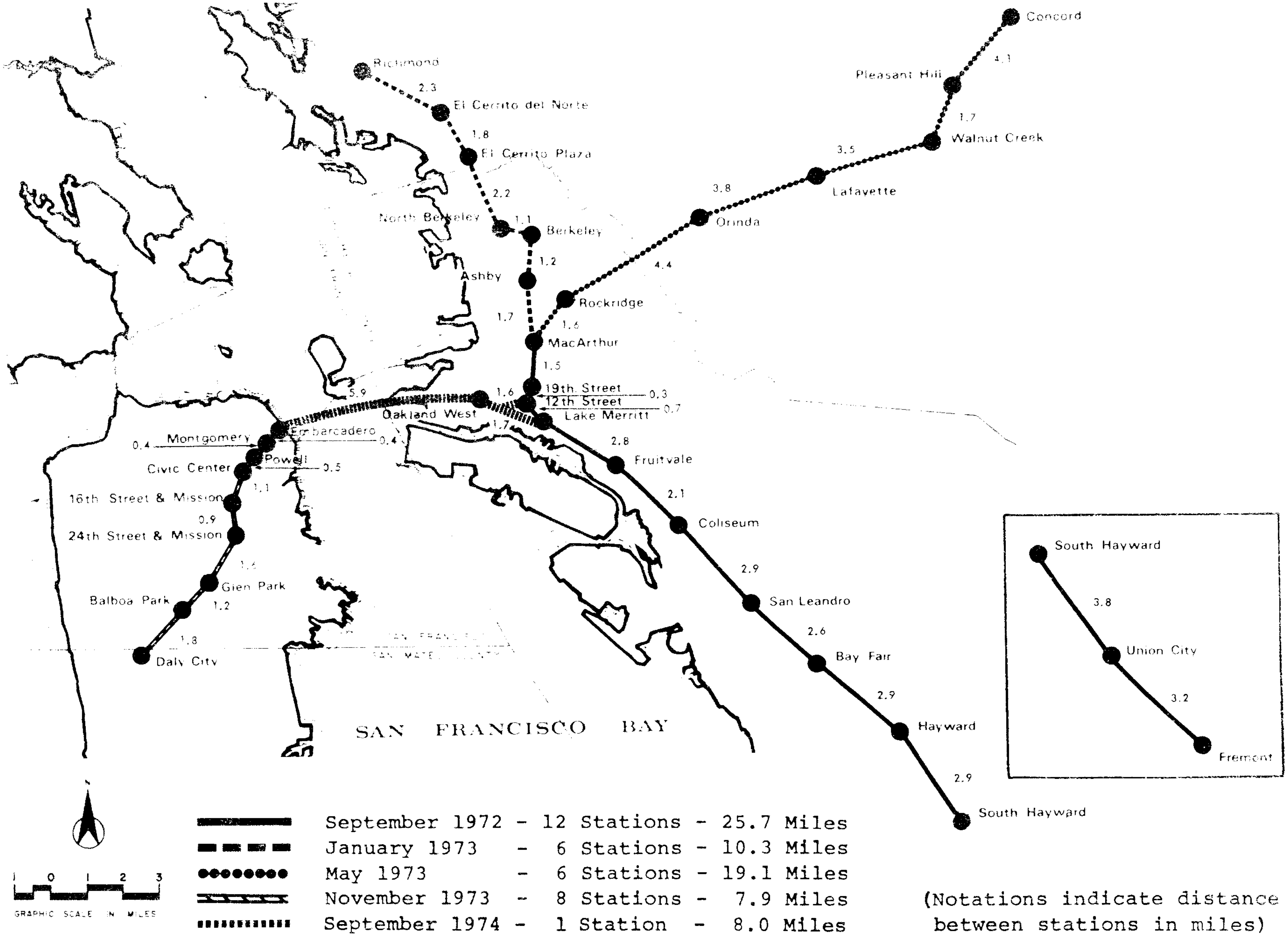


FIGURE 3

BART SYSTEM: INTRODUCTION DATES AND MILEAGE

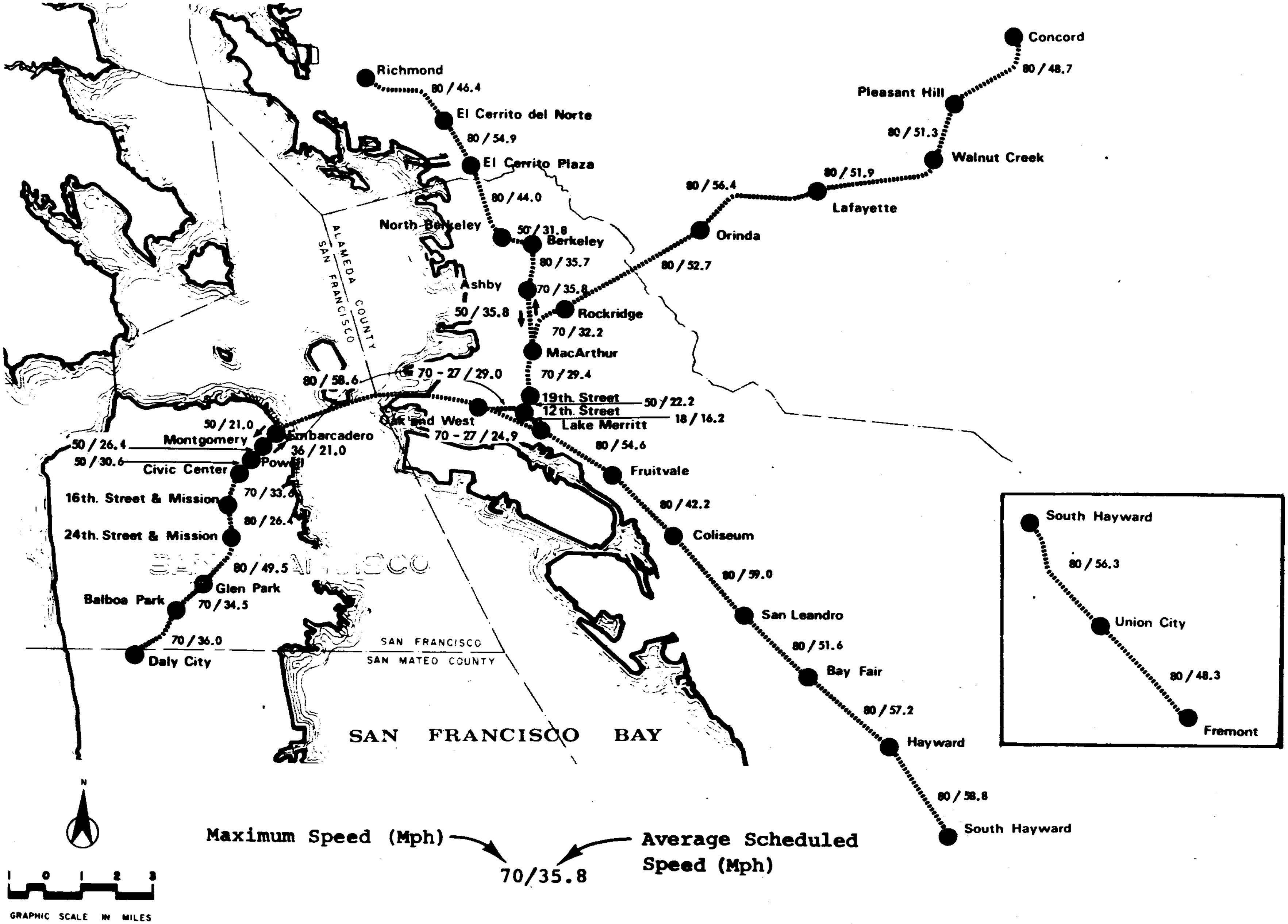


FIGURE 4

BART SYSTEM: TRAIN SPEEDS BETWEEN STATIONS

Track Gauge. BART uses a track gauge of 5 feet 6 inches. This may be compared with the gauge of 4 feet 8-1/2 inches, which is standard for railroads in the United States. BART's wider gauge was selected primarily to increase the stability of the lightweight cars at high speeds.

Track Layout and Yard Locations

Track Layout. The BART System basically consists of one track for trains operating in each direction throughout. A third track is available to store trains temporarily at only two locations: between the Lafayette and Walnut Creek Stations on the Concord Line, and between the Bayfair and Hayward Stations on the Fremont Line. Trains which experience mechanical failure while in service must, therefore, generally be taken to the nearest yard for repair, adversely affecting the service provided by other trains on the System.

Special crossovers are installed at 21 locations to permit trains to reverse direction or to operate on the track normally assigned to trains traveling in the opposite direction. These crossovers are located so that BART service can be maintained at 20-minute intervals in each direction using one track between a given pair of crossovers if, for any reason, the second track cannot be used.

The track layout allows trains on different lines to merge at two places in the System. At MacArthur Station, trains from the Richmond and Concord Lines merge. At the Oakland "Wye" complex, Richmond-Daly City, Concord-Daly City, and Fremont-Daly City trains can merge (1) into the Transbay Tube or (2) with Richmond-Fremont trains.

Yard Location. BART has three principal maintenance and storage yards located toward the end of each of the three East Bay BART lines. The South Hayward Yard is located between the South Hayward and Union City Stations on the Fremont Line. This is the main BART maintenance and repair facility and has a current capacity of 160 cars and sufficient land to allow expansion to an ultimate capacity of 250 cars.

The Concord Yard is located on the Concord Line between Pleasant Hill and Concord. This facility currently has a capacity of 150 cars and sufficient land available to expand capacity to 200 cars. Only light maintenance and car storage are accomplished at this facility.

The Richmond Yard is constructed as an extension of the line immediately north of the Richmond Station. This arrangement enables trains to be dispatched directly onto the line and for train removals to be conducted with minimum disruption of existing service. This yard currently has a capacity of 150 cars and sufficient land for expansion to 250 cars. Only light maintenance and car storage are accomplished at the Richmond Yard.

On the San Francisco Line, only limited storage facilities are available at the Daly City Station for temporary storage of trains, and no maintenance facilities are provided. Thus, BART trains operating to Daly City must return to the East Bay yards to modify train consists in accordance with variations in passenger demands during the day and at the end of the day's service. BART has estimated that the "deadhead" car mileage associated with these movements is about 2% of total car mileage.

Each yard dispatches the trains required for service on its line. Two trains are kept in reserve in each yard to enable service to be restored following nonscheduled train removals. When imbalances develop because of nonscheduled train removals, yard "balancing" is conducted during nonrevenue hours to provide the correct number of cars for service on the subsequent day at each yard.

Stations

BART has expended a great deal of effort and expense to ensure that the System's stations are pleasant for travelers and architecturally attractive to the communities where they are located. Generally, efforts have been successful and well received. The stations are built in a variety of styles (14 different architectural firms were employed to design the stations individually); standards of design, construction, and finish are high (many stations contain artwork) and the areas around stations are landscaped. Table 5 summarizes the facilities and characteristics of each of the 34 BART stations.

Structure. As shown in Table 5, 8 BART stations are located at-grade, 12 are located on aerial structures, and 14 are located in subways (of these, Glen Park and Balboa Park are a combination of subway and surface structure). Station passenger platforms are either centrally located between the two tracks or on either side of a central track well. Twenty-two stations utilize a center platform configuration; this allows passengers to transfer between trains in opposite directions without descending or ascending to a mezzanine level. Twelve stations utilize a side platform arrangement; this is more suitable for aerial structures because of the structural efficiency of centralizing the heavy loads of the trains.

Internal Access. Escalators are provided in all stations to help patrons transfer to and from the train platforms. In general, either two or three escalators are provided in stations serving residential areas. More are provided in the downtown San Francisco and Oakland stations.

In response to legislative mandate, in 1969 BART began installing elevators in all stations to enable the System to serve the physically disabled more effectively (although elevators are now available for anyone

Table 5

BART STATION FACILITIES

BART Station	Structure: Elevation	Structure: Platform Type	Internal Access: Elevators	Internal Access: Escalators	Automatic Fare Equipment: Faregates 1973	Faregates 1975	Ticket Vendors 1973	Ticket Vendors 1975	Change Machines 1973	Change Machines 1975	Add-Fare Machines 1973	Add-Fare Machines 1975	Other Facilities: Public Restrooms	Other Facilities: Bus Shelters	Station Usage (2/75): Daily Entering Patrons	Station Usage (2/75): Peak Period[a] Entering Patrons
Fremont	Surface	Center	1	2	3	6	2	4	2	4	1	2	2	2	3,047	1,79[illegible]
Union City	Aerial	Side	2	2	3	8	2	3	2	2	1	2	2	1	1,811	1,273
South Hayward	Surface	Side	2	2	3	4	2	3	2	2	1	2	2	1	1,560	1,049
Hayward	Aerial	Side	2	2	6	8	3	5	3	4	1	3	2	--	2,992	1,213
Bay Fair	Aerial	Center	1	2	3	8	2	3	2	3	1	2	2	1	2,532	1,332
San Leandro	Aerial	Side	2	-	4	5	4	5	3	3	1	2	2	2	2,119	913
Coliseum	Aerial	Center	2	2	8	13	3	10	5	6	1	3	2	3	1,658	587
Fruitvale	Aerial	Side	2	-	6	7	5	4	4	4	1	3	2	1	2,610	1,09[illegible]
Lake Merritt	Subway	Center	2	-	6	8	5	7	5	5	2	3	2	--	3,276	848
12th Street Oakland	Subway	Side	2	13	9	16	3	8	6	6	3	6	2	--	3,979	1,73[illegible]
19th Street Oakland	Subway	Side	2	13	9	16	3	7	6	6	3	6	2	--	5,633	2,461
MacArthur	Surface	Center	2	1	3	6	2	3	3	2	1	2	2	2	1,895	869
Ashby	Subway	Center	1	2	3	4	2	3	1	3	1	2	2	--	1,282	481
Berkeley	Subway	Center	2	3	12	12	4	6	5	7	3	6	2	--	5,915	2,632
North Berkeley	Subway	Center	1	2	6	10	2	3	2	4	2	3	2	1	1,558	593
El Cerrito	Aerial	Side	2	2	3	8	1	3	1	3	1	2	2	--	1,413	702
El Cerrito Del Norte	Aerial	Side	2	2	6	8	2	4	1	5	1	3	2	--	1,891	1,202
Richmond	Surface	Center	2	2	3	4	1	2	1	3	1	2	2	2	1,098	565
Concord	Aerial	Center	1	2	3	7	1	4	2	4	1	3	2	2	3,751	2,781
Pleasant Hill	Aerial	Side	2	2	3	6	1	4	2	3	1	2	2	1	3,047	2,513
Walnut Creek	Aerial	Side	2	2	3	6	1	4	2	4	1	3	2	2	3,150	2,063
Lafayette	Surface	Center	1	1	6	8	2	3	3	3	1	2	2	1	1,919	1,434
Orinda	Surface	Center	1	1	3	8	1	3	2	3	1	2	2	--	1,668	1,166
Rockridge	Surface	Center	1	3	3	4	2	2	2	2	1	2	2	--	1,690	892
Oakland West	Aerial	Side	2	2	3	4	1	2	2	2	1	2	2	1	965	387
Embarcadero[b]	Subway	Center	2	14	12	16	--	12	--	--	--	4	2	--	--	--
Montgomery	Subway	Center	2	13	26	37	25	27	16	17	3	6	2	--	19,639	14,332
Powell	Subway	Center	2	10	12	24	4	10	7	10	3	5	2	--	8,093	3,856
Civic Center	Subway	Center	2	10	9	16	4	7	7	7	3	6	2	--	5,848	3,226
16th Street Mission	Subway	Center	2	3	4	8	1	3	2	2	1	2	2	--	1,541	476
24th Street Mission	Subway	Center	2	3	5	8	1	3	2	2	1	2	2	--	2,057	919
Glen Park	Subway	Center	1	2	4	5	1	3	2	3	1	2	2	1	2,633	1,863
Balboa Park	Subway	Center	1	2	4	5	1	4	2	3	1	2	2	1	3,060	1,285
Daly City	Surface	Center	2	3	3	14	3	6	3	5	1	3	2	2	6,835	5,206

a. Four-hour peak period. (Approximately 6:30 a.m.-8:30 a.m. and 4:30 p.m.-6:30 p.m.)
b. Embarcadero Station not yet open.

Source: BARTD Transportation Department.

who wishes to use them). The elevators are accessed by contacting the station attendants either directly or by use of a telephone located adjacent to the elevator doors at each level. (Chapter VII summarizes the use of these elevators by physically disabled people.)

Automatic Fare Equipment. At the early stages of planning, BART decided to adopt a fare structure where fares vary with distance traveled. Recognizing that high labor costs required an automatic fare collection system, BART adopted a collection system based on a concept of "stored fare." Passengers can buy tickets in any amount from \$0.30* to \$20.00 and use the same ticket for one or more journeys on the System until its value is used up. Tickets can be bought at local banks in values of \$10.00 and \$20.00 as well as at BART stations.

BART's automatic fare collection system involves four types of equipment: faregates, ticket vendors, add-fare machines, and change machines. Table 5 gives the number of units of each type of fare collection equipment at each station.

Faregates. When a passenger enters the station, the faregates accept either a BART ticket or \$0.30 in coins. If coins are inserted, the faregate releases a BART ticket. If a BART ticket is inserted, the following information is magnetically encoded on the ticket:

- The time of entry into the System.
- The station of entry.
- An entry code which ensures that a ticket is used in the proper sequence. (If a ticket has been used to enter the System, it must be used to exit the System before it can be used to enter the System again and vice versa.)

The ticket is then returned to the patron in about one second.

On exiting the System, the passenger again inserts the magnetically encoded ticket in the faregate. The equipment automatically reads the code of the origin station, deducts the proper fare, and returns the ticket. If the value remaining on the ticket when it is inserted at the exit faregate is less than the fare for the trip, the ticket is returned, the faregate remains closed, and a sign flashes indicating that the passenger should go to the add-fare machine to add to the value of the ticket.

---

*Since the recent fare changes (November 1975), minimum fare tickets of \$0.25 are available. See Chapter I.

Ticket Vendors. BART tickets can be purchased at ticket vendor machines in amounts from $0.30 to $20.00 in $0.05 increments. The machine will also accept a previously purchased ticket with less than $4.00 remaining. After cash (or cash and a previously used ticket) are inserted, the ticket vendor machine dispenses a plastic coated card on which the value of the ticket is printed and magnetically encoded.

Add-Fare Machines. The add-fare machine is used to increment the value of a ticket. The new value of the ticket is magnetically encoded, as well as printed on the ticket. If no space remains on the card for printing the new fare, the add-fare machine issues a new ticket with the correct value printed.

Change Machines. These standard units dispense change for coins or one dollar bills and are located beside ticket vending machines and add-fare machines.

Other Facilities. All stations have at least one station agent on duty at all times in booths near the entrance to provide information, help passengers with ticket problems, and operate the elevators. The station agents can be called from courtesy telephones elsewhere in the stations. Two restrooms are provided at each station and are available for use by contacting the station agent who can unlock the door automatically from the booth. All train platforms have seats or benches for waiting passengers.

Transit Vehicles

BART operates two types of cars: "A" cars which have a control cab at one end to house the train attendant and train control equipment, and "B" cars which do not have a control cab. Trains are made up of two "A" cars with up to eight* "B" cars between them. Both "A" and "B" cars have 72 seats, are 10 feet 6 inches high, 10 feet 6 inches wide, and provide interior headroom of 6 feet 9 inches. "A" cars are 75 feet long and "B" cars are 70 feet long.

The cars are extremely comfortable. Seats are upholstered and are cantilevered from the car sidewalls to increase legroom and allow easier maintenance of car interiors. Floors are carpeted, the windows are tinted, and the cars are air-conditioned. Interiors contain sound-absorbent material to lessen interior noise levels. A public address

---

*As of the time of writing (August 1975) the maximum train size in regular service was two "A" cars and seven "B" cars.

system is used to announce station stops and to advise passengers on transferring between lines. An intercom system also connects each car to the control cab of the train, and passengers can use this system to communicate with the train attendant in the event of an emergency.

The original design of the transit vehicles did not include grab rails or straps for standing passengers, since BART's planners intended that System capacity be sufficient to seat all passengers. In fact, passenger loads are such that twice as many standing passengers as seated passengers are often carried at peak periods on some sections of the System. Consequently, BART is installing grab rails on interior ceilings to increase the safety and comfort of standing passengers.

"A" and "B" cars are assembled on the same main body structure. Cars are mounted on two trucks with two axles per truck. Each car is powered by four 150-horsepower motors, mounted one to each axle. Propulsion power is provided by a 1,000-volt direct-current (d-c.) third-rail. The transit vehicles are equipped with a dynamic (regenerative) braking system (which uses the propulsion motors as generators to return power to the third rail and to brake the train) and a friction braking system. In general, the dynamic braking system is used at speeds above 15 mph, and the friction braking system is used at speeds below 15 mph and as an emergency and parking brake system.

Automatic Train Control System

An automatic train control (ATC) system was judged necessary for BART to assure safe and reliable operation of trains running at the planned high speeds and short headways, especially for the complex operating pattern required at the Oakland Wye.

Automatic Train Control Equipment.

The ATC system automatically dispatches and routes trains, regulates their speeds, and maintains safe distances between them. It also controls the opening and closing of doors, the duration of station stops, and the display of information on platform signs. Equipment for the ATC system consists of:

1. A central computer control complex with a redundant back-up computer, display boards, and consoles ("Central Control").

2. Thirty-six local train control centers (one at each passenger station and yard), with associated wayside equipment.

3. Vehicle control equipment on-board all trains.

4. A trans[illegible] information between the central [illegible] remote locations (which include the [illegible] train control centers).

The ATC system is intended [illegible] coordinated operation of all trains. At the start [illegible] day, a predetermined schedule of departure times from [illegible] of the System is established for each of the trains [illegible]. The central computer constantly monitors the progress of trains compared to the schedule. When deviations from the schedule [illegible] computer attempts to adjust the speed and station stop [illegible] affected trains until operations again conform to the schedule.

Each train is assigned a unique identification number for route control. This identification is transmitted continually by the train. At interlockings (i.e., where tracks diverge and converge), the transmitted identification number [illegible] an automatic route request. Train destination information is [illegible] the local control center where verification is made that [illegible] exist before track switches are aligned for the requested [illegible] Central Control can cancel a route request and substitute an alternate route request if necessary because of track blockage or maintenance work.

If some part of the ATC [illegible] malfunctions, trains can be routed manually from each of the local train control centers. The train attendant can override automatic controls by commanding an emergency stop if he observes some unsafe condition [illegible] obstruction of the right-of-way. In the event of a malfunction, [illegible] of operation can also be put into effect under direction of Central Control.

The 71-mile BART System is divided into sections of track called "Blocks" which are 100 feet to [illegible] long. Electric signals carrying speed commands are transmitted through track circuits within each block. These circuit signals are [illegible] on-board train equipment via coils mounted in front [illegible] which sense the current in the rails. The on-board train equipment compares the speed command with the train's actual speed and modifies the train speed accordingly. The speed command associated with a [illegible] block can be modified by Central Control. When a train [illegible], the signal is diverted from the rails through the [illegible] train, and an "occupancy" is indicated. A "safe [illegible]" is then generated behind the occupied block to maintain a safe distance between the train and the following train.

Trains are stopped [illegible] on station platforms by signals transmitted to the train [illegible] equipment on the approach to each station. This equipment [illegible] determines the train's position and speed and causes [illegible] to be applied to stop the train smoothly at the correct [illegible] doors are opened and closed in accordance with commands from the [illegible] computer. Dwell times assigned for each station may be adjusted in accordance with schedule needs. The automatic door controls may be overriden by the train operator.

Problems Encountered with the Control System. BART has experienced a number of problems with the ATC system. These have included:

1. Wrong speed commands being generated by the on-board train equipment from track circuit signals. (This was the cause of a train overrunning the Fremont terminal station shortly after the System opened.)

2. Train detection circuits indicating that a block was vacant when it was occupied, giving rise to the possibility of collisions between trains. (This problem has been detected only under test conditions and in rare circumstances as described below.)

3. Train detection circuits indicating that a block was occupied when it was vacant, causing following trains to be delayed unnecessarily.

4. Failure of communication between wayside equipment and trains, causing trains to lose the capability of maintaining speed automatically.

5. Failure to enter train identification data into the on-board train equipment correctly, causing among other things, the possibility of trains being wrongly routed.

As of the original date of this report (August 1975), the first of these problems had been corrected, and solutions to the remainder are being developed, tested, and implemented by BART as matters of high priority.

The second of the above problems has resulted in the most far-reaching modifications to the automatic control system. A few weeks before the start of regular BART service, operational tests indicated that the ATC system would occasionally fail to detect the presence of a car within a block if all the car's power was turned off and if the train coasted to a stop on a section of dirty or rusted rail which prevented good electrical contact between wheel and rail. This has been called a "dead train" condition. Intermittent lack of detection of dead trains during normal operation is considered an extremely unlikely situation, but the California Public Utilities Commission (PUC) concluded that the possibility must be eliminated before BART could rely totally on the ATC system.

BART attempted to rectify the problem by installing wheel "scrubbers" to scrape the wheel surface clean and so improve electrical conductivity between wheel and track. Attempts were also made to improve the track conductivity by welding stainless steel beading to prevent rusting of infrequently used or critical track areas such as the maintenance crossovers.

In addition, the tracks were cleaned to improve electrical conductivity. In spite of these modifications, further testing did not consistently detect the presence of an unenergized transit car within a block. The PUC, therefore, concluded that a back-up control system was required to provide additional train detection capability. Four back-up systems of increasing levels of sophistication have been or are being developed and implemented by BART. Each of these systems is briefly described below.

Manual Block Procedure. A manual back-up procedure was first adopted to allow BART service to begin. Under this procedure, supervisors were assigned to every second station platform on the System and at the four terminus stations. The platform supervisor's job was to phone ahead to ensure that the track was clear two stations forward on the line before releasing the train at his station. All lines of the System with the exception of the transbay link were opened to revenue service under the manual block procedure. Train operations were significantly constrained under the manual procedure since a minimum headway of about 10 minutes was implied.

Computer Automated Block System II (CABS-II). This system uses BART's central computer to automate the manual block procedure, still maintaining a two-station separation between trains. In October 1973, BART began operating trains on the Concord Line under CABS-II in parallel with the manual block procedure. After several months of demonstration, the PUC granted BART permission to operate the Concord Line under CABS-II alone. Authorization to operate under CABS-II was given in April 1974 for Richmond-Fremont service and in May 1974 for San Francisco-Daly City service. Although CABS-II performed more efficiently than the manual block procedure, operations were still restricted to a minimum headway of about 10 minutes.

Computer Automated Block System-I (CABS-I). Operation of BART at headways of about 5 minutes was considered necessary for transbay operations. (Under CABS-II, if trains from both the Concord and Fremont Lines were to use the Transbay Tube, minimum headways of about 20 minutes on each line would have been implied. This was considered unacceptable.) Consequently, BART began development of CABS-I. This is a back-up system which operates in a manner similar to CABS-II, but permits a minimum train separation of only one station, or approximately 5 minutes. (Control computer software logic ensures that a train is held at a station platform if the previous train has not been positively detected departing the station ahead.)

An additional safety feature not included in CABS-II was added to CABS-I. A specially designed "zero speed gate" was installed at the exit from each station to overcome possible problems with trains running through stations without stopping or being inadvertently released by the computer without proper clearance. The function of the "zero speed gate" is automatically to stop any train that inadvertently runs through a station and holds it until the next station down the line has released its train. The PUC granted approval for CABS-I train operations on all lines of the System, except the transbay line, in July 1974.

Two additional modifications to CABS-I were required before transbay BART service could begin. To allow 5-minute headways in the long Transbay Tube, "pseudo-stations" were established at intermediate points in the Tube. Second, a method of regulating train movements through the track interlocks at the Oakland Wye was incorporated in the computer back-up system to avoid the possibility of trains merging at the same time. Trains were held at the three stations adjacent to the Wye--12th Street, Lake Merritt, and Oakland West--while route requests are processed on a first-come, first served basis. A train is not released from the station at the entry to the Wye until the previous train has left the station at the exit from the Wye.

In August 1974, BART successfully completed a full-scale, systemwide test of CABS-I. Several weeks later, the PUC approved systemwide operations using the CABS-I system, thereby allowing BART to start transbay service from two of the three East Bay lines at 6-minute intervals in September 1974.

<u>Sequential Occupancy Release System</u>. Further expansion of BART service, including direct Richmond-Daly City service and a reduction in the intervals between trains, is contingent upon the PUC's approval of the permanent back-up control system being implemented by BART to replace CABS-I. The Sequential Occupancy Release (SOR) system employs a series of minicomputers installed in redundant pairs at each of 26 control points to provide for automatic check-in and check-out of trains through blocks. Once a train has been detected in a block, the track circuit for that block remains "locked up" until the train is detected in the next block. Although SOR normally locks up two block circuits at a time, the system will not result in significant degradation of the performance level provided by the basic ATC system. At stations, particularly the closely spaced San Francisco stations, where the two-block lock-up would have increased the minimum feasible headway, special circuits will lift the SOR second block lock-up outside a station when a train has been detected in the station and has returned a doors-open indication. It is intended that, when the SOR system is in full operation, BART will have a capability for headways as low as 2 minutes. As of the date of this report, initial installation and testing of the SOR system is under way.

Reliability of BART Equipment and Service

Both the level and dependability of BART service have been adversely affected by unexpectedly high failure rates in many components of the

System. Many of these failures have occurred in the components of transit vehicles themselves, particularly propulsion motors and brakes.

Many historical factors in the development and manufacture of the technologically innovative and complex BART System have contributed to the current high equipment failure rate. (These are documented and discussed in Reference 2.) Among them are the facts that (1) designs were based on performance specifications reflecting a desired set of attributes rather than the actual performance characteristics of existing equipment, (2) BART had no experienced operating and maintenance departments to provide feedback on the designs proposed by the engineers and manufacturers, and (3) manufacturers' prototypes were not subjected to full-scale testing before production of the equipment.

BART has alleged that design inadequacies and poor quality control in manufacture are the root causes of current reliability problems. Efforts to improve reliability have also been hampered by allegedly inadequate documentation of equipment configurations and design parameters by the System's engineering consultants and equipment suppliers. To resolve these allegations, BART has filed a major lawsuit against the organizations which designed and built the System.

BART has also encountered significant difficulties in maintaining and repairing its equipment, particularly the transit vehicles. These difficulties appear to be the result of several factors. First, the development of an effective method for predicting spare parts needs has been complicated by the unexpectedly high failure rates. Because of this, and because of the requirement for competitive bidding for any order exceeding $3,000, many cars cannot be repaired due to an absence of routine spare parts. Second, until recently a formal system for establishing repair priorities and a regular program of preventive maintenance had not been implemented. Finally, the large backlog of vehicles awaiting repair exceeds the capacity of the maintenance facilities to repair them in a timely manner--whether or not the parts are available.

Transit Car Availability. The status of the cars in the BART fleet between July 1974 and May 1975 (the period immediately before and after the start of transbay BART service) is presented in Figure 5. During this period, the proportion of BART's cars available for revenue service varied between 45% and 60%. At the end of the period shown, car availability was at 52%. This compares with BART's ultimately anticipated availability of at least 80%.

Because of the higher than anticipated transit vehicle failure rates and the problems encountered in repairing and maintaining the cars, BART has had difficulty making the desired number of cars available for revenue service. The number of "A" and "B" cars that BART wanted to have available, and the number actually available for service from April 1974 through April 1975 is presented in Figure 6. BART planned

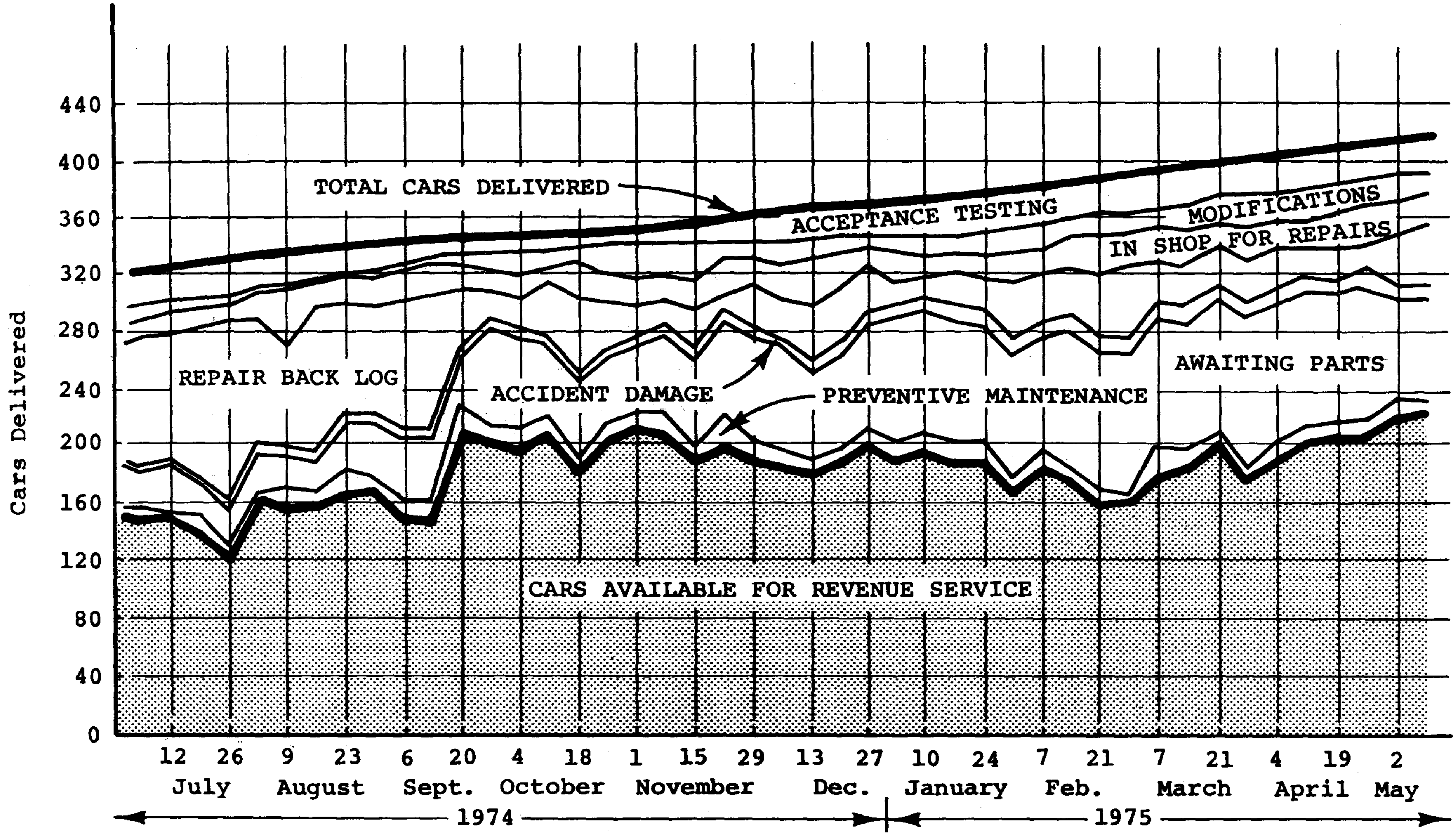


FIGURE 5

BART CAR FLEET STATUS

Source: ● BARTD Department of Quality Control.

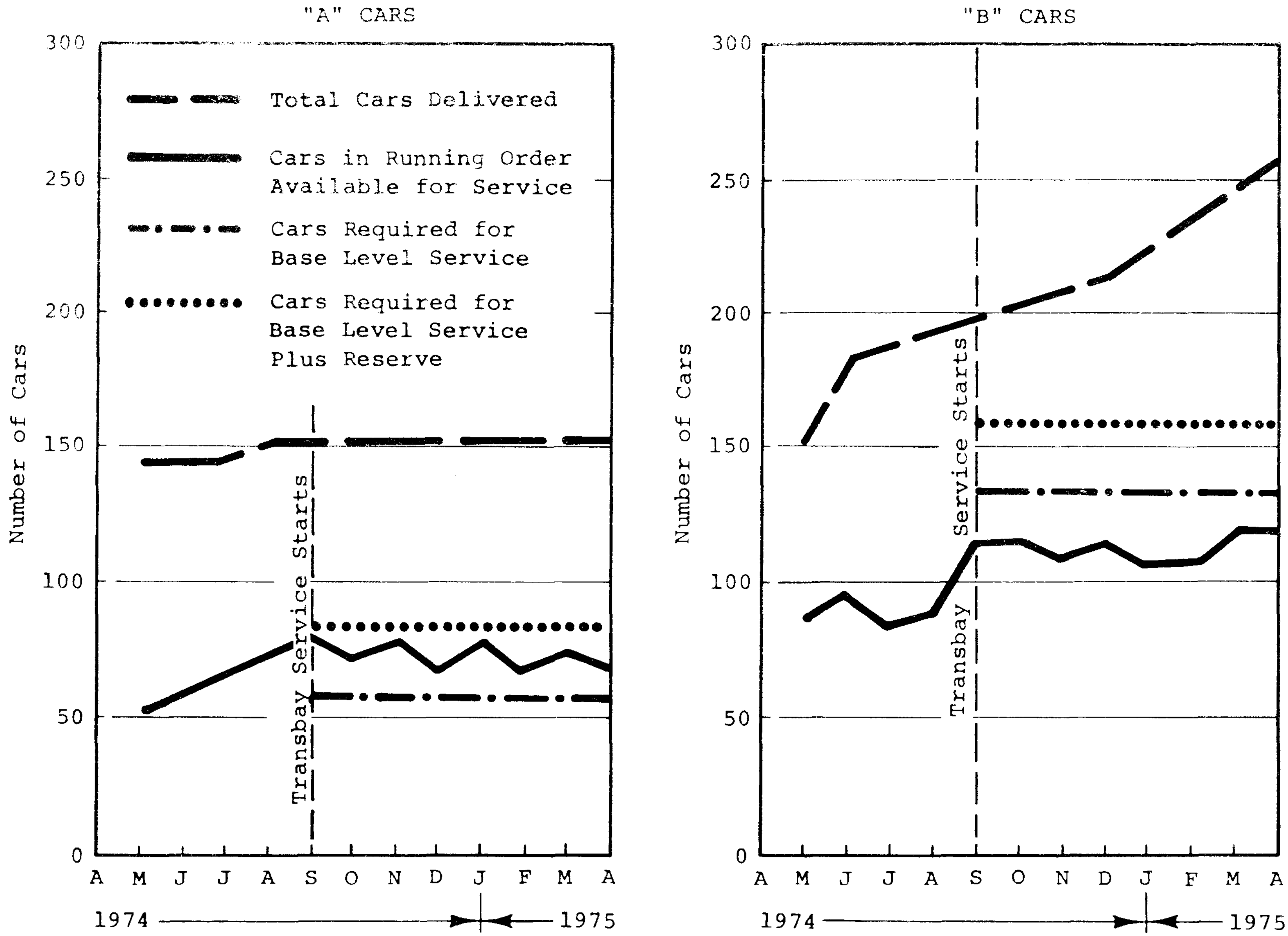


FIGURE 6

BART CAR AVAILABILITY COMPARED WITH REQUIREMENTS

Source: • BARTD Department of Quality Control.

to have a reserve fleet of 18 "A" cars and 20 "B" cars which would be used to replace trains removed from service due to malfunctioning equipment. As shown on the figure, the availability of "A" cars in the period following transbay service has been sufficient to provide the desired level of operations, although it has not been sufficient to provide the desired number of cars for the reserve fleet. However, the number of "B" cars available in the period following transbay service was less then the number required to provide the desired level of service, much less to maintain a reserve fleet.

BART's current ability to increase its passenger-carrying capacity by increasing train size is constrained by the availability of sufficient "B" cars. Until the train control system modifications now being implemented are completed and the system accepted by the California Public Utilities Commission, current restrictions on BART's operations require that trains remain separated by at least one station. This makes it impossible to provide more frequent service at peak periods. Together with this constraint, BART's current car availability problems have contributed directly to crowding of trains, especially on the Concord Line. These crowding levels are discussed in Chapter IV.

<u>In-Service Train Failures</u>. BART's equipment failures have resulted in a significant level of in-service train failures. BART's operating policy is to remove a train containing malfunctioning cars from revenue service to a yard so that the trouble can be diagnosed and malfunctioning car(s) removed as necessary. A new train is then dispatched. In the last quarter of 1974 (following the start of transbay BART service), an average of 13 trains a day were removed because of malfunctions. These represent nearly a quarter of all trains dispatched (including replacement trains).

If all equipment operated correctly, the BART System would complete the number of train round trips specified in the central computer's master schedule for the day. However, removing trains and modifying speeds result in fewer round trips being completed than scheduled on many days of operations. The relationship between the number of scheduled round trips and the number completed provides one measure of BART's operational performance. Figure 7 presents information on the number of scheduled and completed round trips for each month since the start of BART service. On average, BART completed approximately 90% of the round trips scheduled for the entire period.

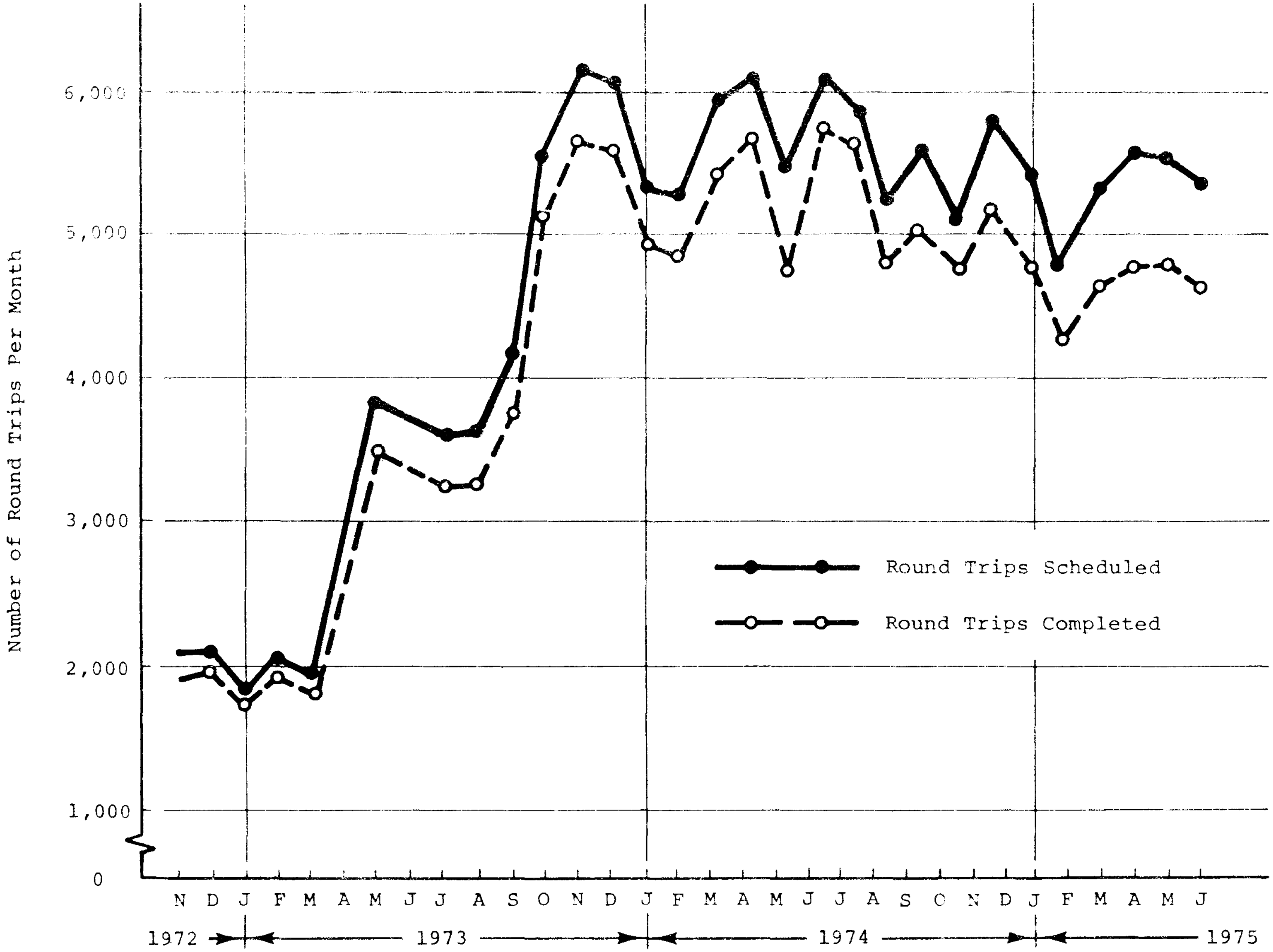


FIGURE 7

SCHEDULED AND COMPLETED TRAIN ROUND TRIPS

Source: • BARTD General Manager's Report.

Schedules and Train Sizes

Current and Planned BART Services. Table 6 shows scheduled frequencies for trains on each of the BART lines for current and planned full-service operations.* Presently, three routes are operating 14 hours a day, 5 days a week, with 12-minute headways on each route. The routes are Fremont-Daly City, Concord-Daly City, and Richmond-Fremont.** Since there are two routes on each of the Fremont and San Francisco Lines, the average headway on these lines is 6 minutes. Incremental service improvements planned for the future include extending the hours of operation to 20 hours (5:00 a.m. to 1:00 a.m.) each day, 7 days a week; providing more frequent service; and operating trains directly between Richmond and Daly City. In addition, a 34th station will be opened, the Embarcadero Station in downtown San Francisco. When the System is operating at full levels of service, trains will travel on each of the four BART routes every 6 minutes during the peak periods. Since three of the routes will operate through the Transbay Tube and in San Francisco, trains will operate every 2 minutes on this line. In the late evening hours between 8:00 p.m. and 1:00 a.m., trains will operate on only two routes, between Richmond and Fremont and between Concord and Daly City. Patrons will be able to transfer between the two routes at any of three Oakland stations. Similarly, only these two routes will operate on Sundays, at headways of 15 minutes between 5:00 a.m. and 8:00 p.m.

Number and Size of Trains in Service. Figure 8 shows the number and size of the BART trains in service on each line. When service was inaugurated on the Fremont-MacArthur segment in September 1972, only six trains were in operation, with train lengths of two and three cars. Currently, ten trains are in operation on each of BART's three routes, with train lengths of four to nine cars. The train lengths on each route are governed by the patronage on each line and by car availability. The Concord-Daly City route, which has the highest peak-period patronage, also has the longest trains. Five- to nine-car trains are operated on this line. The Fremont-Daly City route, which has the next highest patronage, operates five- to six-car trains. Four- to five-car trains operate on the Fremont-Richmond route.

In total, approximately 40% of available cars are in service on the Concord-Daly City route, and 30% of cars are in service on each of the Fremont-Daly City and Fremont-Richmond routes.

---

*See Chapter I for changes in BART service since the time of writing (August 1975).

**Passengers traveling between San Francisco and points north of Oakland must transfer in Oakland to trains running on the route between Richmond and Fremont.

Table 6

BART SCHEDULED HEADWAYS
(Minutes)

	Current Service[b]		Planned Ultimate Service[a]				
			Weekday			Weekend	
				Off-Peak			
BART Line	Peak	Off-Peak	Peak	To 8 P.M.	8 P.M.-1 A.M.	5 A.M.-8 P.M.	8 P.M.-1 A.M.
Fremont	6	6	3	6	20	15	20
Concord	12	12	6	12	20	15	20
Richmond	12	12	3	6	20	15	20
San Francisco	6	6	2	4	20	15	20

a. Source: BARTD Planning Office.
b. August 1975.

DATE	LINES IN OPERATION	TRAINS IN SERVICE
9/72	Fremont-MacArthur	8
1/73	Fremont-Richmond	12
4/73	Fremont-Richmond	12
	Concord-MacArthur	6
11/73	Fremont-Richmond	12
	Concord-MacArthur	6
	Daly City-San Francisco	4
9/74	Fremont-Richmond	10
	Concord-Daly City	10
	Fremont-Daly City	10

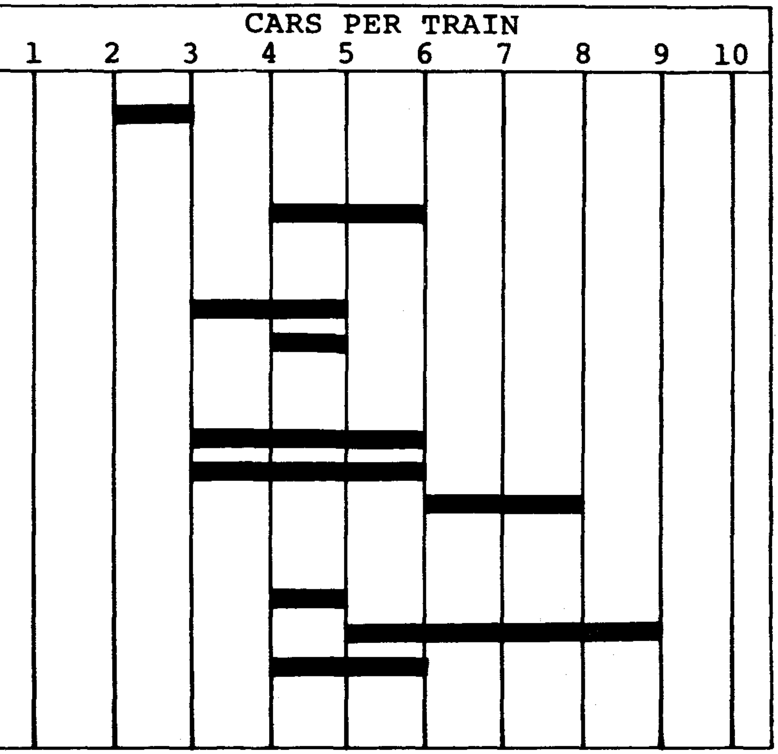


FIGURE 8

NUMBER AND SIZE OF TRAINS IN SERVICE

Source: • BARTD Transportation Department.

Bus Access to BART

Aside from the downtown stations, walking is not a major means of access to BART stations. Providing access by bus and automobile is, therefore, an important part of the System's design.

Bus Routes. Aside from a few express bus routes which are operated by AC Transit on contract to BART,* all the feeder bus services to BART are operated by agencies which are organizationally and financially separate from BART. The principal operators of service to BART--AC Transit in the East Bay and MUNI in San Francisco--also operate bus lines which, to varying degrees, parallel the BART routes and services. (Some of the routes discussed below as feeder services might, in fact, be more appropriately described as parallel.)

Some feeder bus service is provided to all BART stations. AC Transit operates most of the feeder bus service in the East Bay, but city-operated bus systems provide services to the Walnut Creek and Union City Stations. The Santa Clara County Transit System operates one route to the Fremont BART Station. In the West Bay, most feeder services are provided by the MUNI system. The Northgate Transit System operates feeder bus services to the Daly City BART Station, which is located outside the MUNI service area. The remaining feeder bus services are small privately operated shuttle services.

Currently, 255 bus routes provide bus service to BART stations--155 routes in the East Bay and 100 routes in the West Bay.** These routes make up a relatively extensive feeder bus network, particularly for BART stations located in the AC Transit or MUNI service areas. Of the 155 BART feeder bus routes in the East Bay, 64 (41%) are regular bus routes which now provide feeder service to BART stations without any modification to their original (pre-BART) route; 52 (34%) are routes which were modified to serve BART stations; and 39 (25%) are routes which specifically began as feeder services to BART. Of the 100 feeder bus routes located in the West Bay, 94 are regular routes which serve BART stations without having required modification; 4 are regular routes which were modified; and 2 are newly initiated routes.

In general, the best feeder bus service is provided to BART stations in the AC Transit and MUNI service areas. BART stations located outside

*"BART Express Bus" services are operated to the Concord, Walnut Creek, Bay Fair, Hayward, and El Cerrito del Norte Stations.

**These figures contain "double-counting"; a single bus route serving two BART stations is counted as two feeder routes.

these service areas (Fremont, Union City, and South Hayward on the Fremont Line; Daly City on the Daly City Line; and Concord, Pleasant Hill, Walnut Creek, Lafayette, and Orinda on the Concord Line) are generally less well served. A number of proposals for both fixed route and demand-responsive services to these stations are presently being considered.

"BART Express Bus" Service. To serve those portions of the BART District (BARTD) outside the AC Transit district and beyond the immediate service area of BART stations, the BART District implemented a program to provide feeder bus service to BART. BARTD has assumed financial responsibility for these "express" bus services, although the buses themselves are operated by AC Transit on contract. Service on five feeder bus routes began in late 1974: From the Pinole area in northern Contra Costa County to the El Cerrito Del Norte BART Station; from Dublin, San Ramon, Danville, and Alamo to the Walnut Creek Station; from Martinez and Pleasant Hill in central Contra Costa County to the Concord Station; from Brentwood, Oakley, Antioch, Pittsburg, and West Pittsburg to the Concord Station; and from Livermore, Pleasanton, Dublin, and San Ramon in central Alameda County to the Hayward and Bayfair Stations.

Bus Service Frequencies. Figure 9 summarizes the total number of buses providing service to each BART station during the morning peak, evening peak, and midday period. The stations closest to downtown San Francisco and Oakland are best served by bus, but less service is provided during midday than at peak periods.

Transfer Procedures. Travelers using AC Transit or MUNI to reach BART pay only half the normal round-trip bus fare. Different transfer procedures have been adopted for the two systems. AC Transit passengers pay the regular bus fare for their trip to the BART station. On their return trip, they can obtain a free transfer ticket in the BART station for a bus ride to any destination within the same fare zone. MUNI passengers can purchase a two-part ticket for the cost of one regular ticket ($0.25) in BART stations. One part of the ticket is valid for the transfer from BART to MUNI, and the second part is valid for a return trip. The ticket bears the name of the BART station where it was issued and is valid for three days.

Automobile and Bicycle Access to BART

The importance of providing adequate and accessible facilities for automobile parking was well recognized in early planning reports. The 1962 Composite Report, for example, proposed a total of 36,000 spaces for the System.

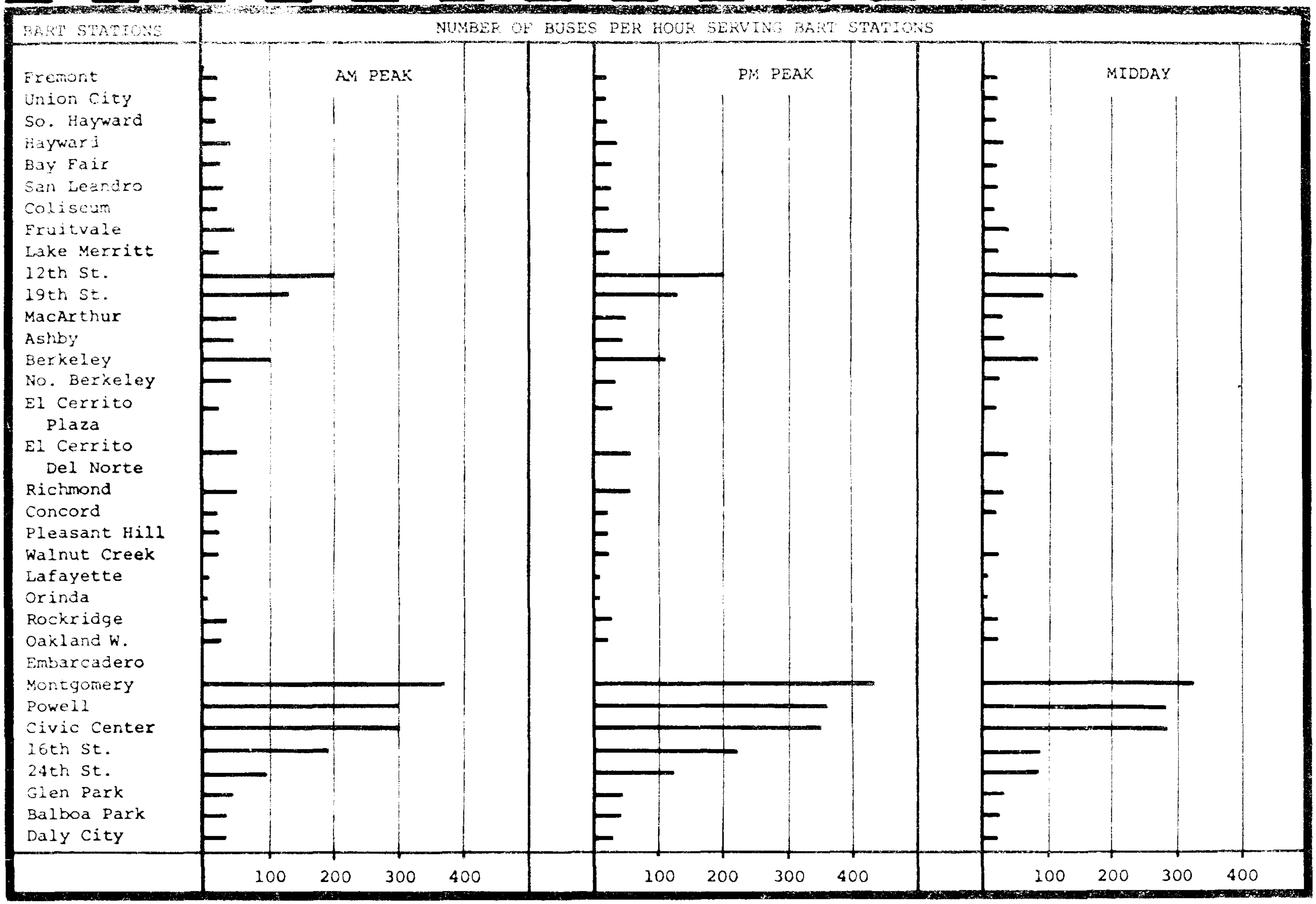


FIGURE 9

SERVICE FREQUENCIES OF BART FEEDER BUSES

Source: • JHK & Associates' Compilation of AC Transit, MUNI, and Other Operator's Published Schedules.

Current BART Parking Facilities. Table 7 summarizes the parking facilities currently available at each BART station. A total of 18,300 parking spaces is available at 23 BART stations, much less than originally planned. The capacity of individual parking facilities ranges from 230 to 1,390 spaces. Most of the parking facilities are provided on the East Bay lines; Daly City is the only station on the San Francisco Line with parking facilities. Eleven BART stations do not have parking facilities. Seven of these stations are in the downtown areas of San Francisco, Oakland, and Berkeley. Eight are in San Francisco, where City policy prohibited development of BART parking facilities.

All but one of the BART stations with parking spaces reserve some spaces for midday parking; a total of 1,550 such spaces are provided at 22 stations. The midday parking facilities have two functions: to provide space for drop-off passengers at peak hours and to accommodate BART patrons who might otherwise find that the parking lots were filled between 9:00 a.m. and 4:00 p.m.

There is currently no charge for parking in BART station lots, except at Lake Merritt Station in Oakland, where a small charge is levied.

Parking Lot Use. Table 7 gives the percentage occupancy of parking facilities at each BART station on an average weekday in January 1975. Overall 82% of BART's parking spaces are occupied. Ten BART parking lots, with a combined capacity of about 8,000 spaces (42% of BART's total parking capacity) are currently fully utilized. These are, with the exception of Lake Merritt, the stations at the extremities of the Fremont, Concord, and San Francisco Lines. There is also extensive parking by BART patrons on city streets surrounding these stations, particularly at Daly City and Walnut Creek.

Plans are under way to increase the capacity of the Daly City parking lot to 1,700 spaces by constructing a second level over the present lot; this structure is currently being designed. Plans have also been developed to expand the capacity of the Fremont, South Hayward, and Lafayette parking lots. BART is, however, currently reevaluating its parking policy in light of the trade-offs between providing feeder bus access service and parking lots.

Bicycle Facilities. Table 7 summarizes bicycle storage facilities at BART stations. BART travelers initially experienced two problems using bicycle as an access mode to BART: insufficient bicycle storage facilities and a high rate of bicycle theft. To resolve these problems, additional bicycle storage facilities designed to discourage theft were installed. BART also intends to relocate the bicycle racks to areas within view of station attendants.

Table 7

BART STATION PARKING AND BICYCLE FACILITIES

BART Station	Total Parking Spaces 1973	Total Parking Spaces 1975	Midday Parking Spaces	Percent Occupancy of Parking Facilities (January 1975)	Bicycle Racks 1973	Bicycle Racks 1975	Bicycle Lockers 1973	Bicycle Lockers 1975
Fremont	700	700	64	100%	21	149	12	60
Union City	485	810	63	100	18	66	12	36
South Hayward	507	507	31	100	20	38	12	52
Hayward	696	861	65	100	20	86	18	38
Bay Fair	1,408	1,407	114	82	20	64	18	54
San Leandro	1,106	1,106	78	44	31	50	12	32
Coliseum	923	923	77	19	19	50	12	32
Fruitvale	730	730	121	82	24	42	12	32
Lake Merritt	233	233	20	100	40	40	12	20
12th Street Oakland	--	--	--	--	--	--	--	--
19th Street Oakland	--	--	--	--	--	--	--	--
MacArthur	450	487	46	94%	20	20	12	12
Ashby	560	560	19	35	52	12	12	24
Berkeley	--	--	--	--	--	--	--	--
North Berkeley	500	500	95	72	20	50	12	28
El Cerrito	509	509	48	78	36	40	12	32
El Cerrito del Norte	985	985	117	83	36	40	12	32
Richmond	784	784	36	35	24	30	12	36
Concord	1,059	1,059	76	100%	20	114	12	32
Pleasant Hill	1,337	1,337	101	100	20	158	12	28
Walnut Creek	1,114	1,114	116	100	18	82	18	42
Lafayette	669	669	88	100	18	60	12	24
Orinda	939	939	59	93	18	32	12	24
Rockridge	776	776	26	79	20	20	12	12
Oakland West	391	391	--	53%	20	20	12	12
Embarcardero	--	--	--	--	--	--	--	--
Montgomery	--	--	--	--	--	--	--	--
Powell	--	--	--	--	--	--	--	--
Civic Center	--	--	--	--	--	--	--	--
16th Street Mission	--	--	--	--	20	20	--	--
24th Street Mission	--	--	--	--	20	20	--	--
Glen Park	--	--	--	--	20	12	18	18
Balboa Park	--	--	--	--	20	20	--	8
Daly City	785	888	94	100%	20	51	12	24
Total	17,646	18,275	1,554	81%	635	1,386	312	744

Source: BARTD Transportation Department.

BART's Energy Consumption

This section briefly discusses BART's historical energy consumption to date and its projected energy consumption for full-system operation. Reference 4 provides a more complete discussion.

Historical Energy Consumption. Figure 10 presents BART's energy consumption since the start of operations. The three principal categories of energy consumption are:

- Maintenance energy--All energy consumed in the Concord, Richmond, and South Hayward shops and yards (except traction energy from the third rail).
- Station energy--All energy consumed by BART stations, parking lots, ventilation facilities for the Transbay Tube and the Berkeley Hills Tunnel, and the operation of the BART administration building at Lake Merritt Station.
- Traction energy--Energy used to propel the cars and power their auxiliary functions (air conditioners, heaters, lights, etc.) as provided by the 1,000-volt d-c. third rail.

While station energy and maintenance energy consumption has remained relatively constant since full-system operation began, traction energy consumption has increased significantly in accordance with the increase in the scale of System operations.

BART's historical energy consumption on a per-car-mile basis is presented in Figure 11. The figures show that:

- As BART's service has increased, energy consumption per car-mile has decreased to about 25% of the original level, largely because fixed station and maintenance energy consumption is allocated among a greater volume of car-miles.
- As BART's service and patronage have increased, traction energy has assumed a greater proportion of total energy consumption. During early operations, traction energy comprised about 25% of total energy consumption, whereas presently it comprises 70%.

Forecast of BART's Energy Consumption for Full-System Operations. Analysis of BART's historical energy consumption for maintenance and station operations suggests that the energy for these purposes is

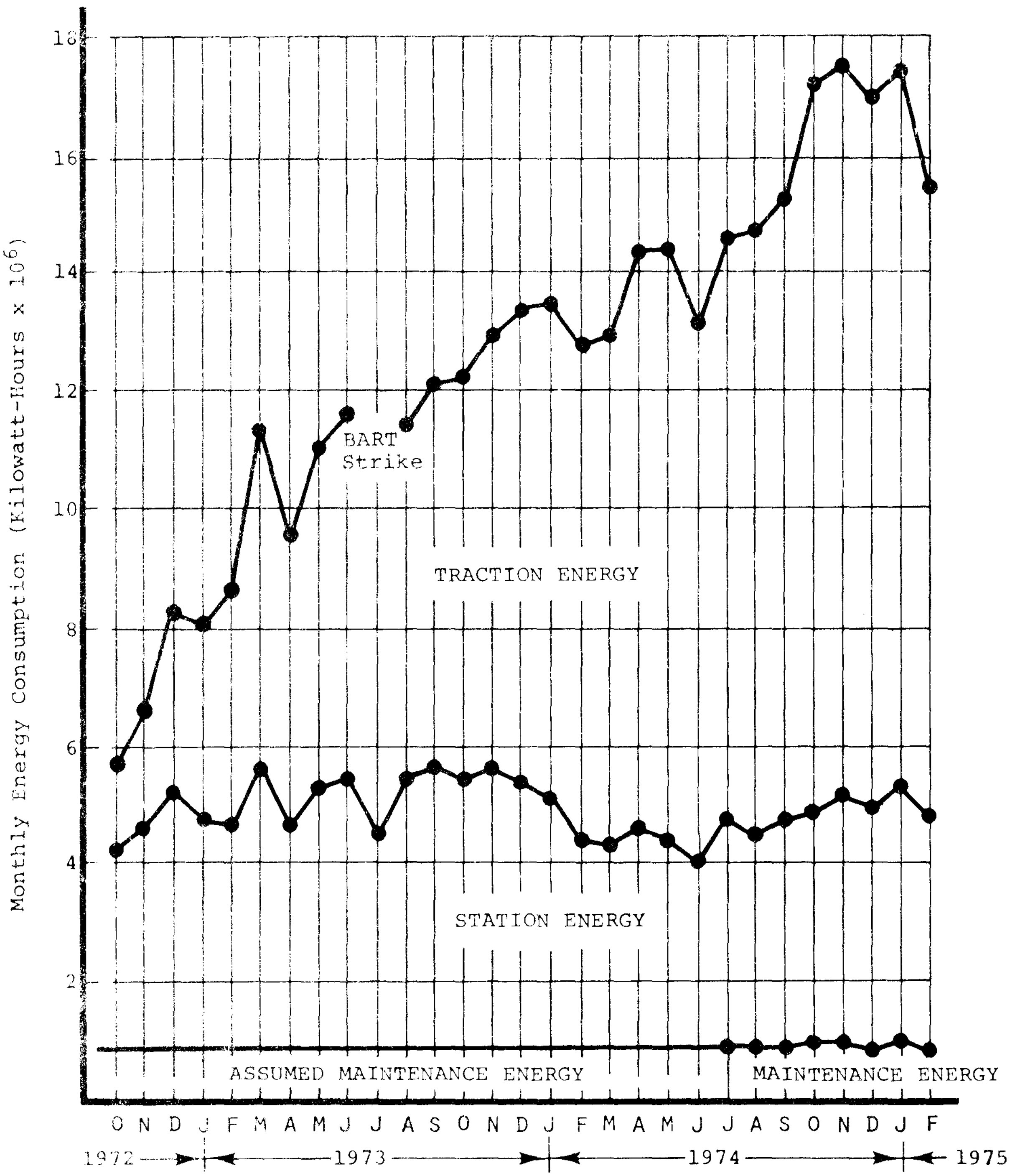


FIGURE 10

HISTORICAL BART MONTHLY ENERGY CONSUMPTION

Source: * Peat, Marwick, Mitchell & Co. Analysis of Data Provided by BARTD Engineering Department.

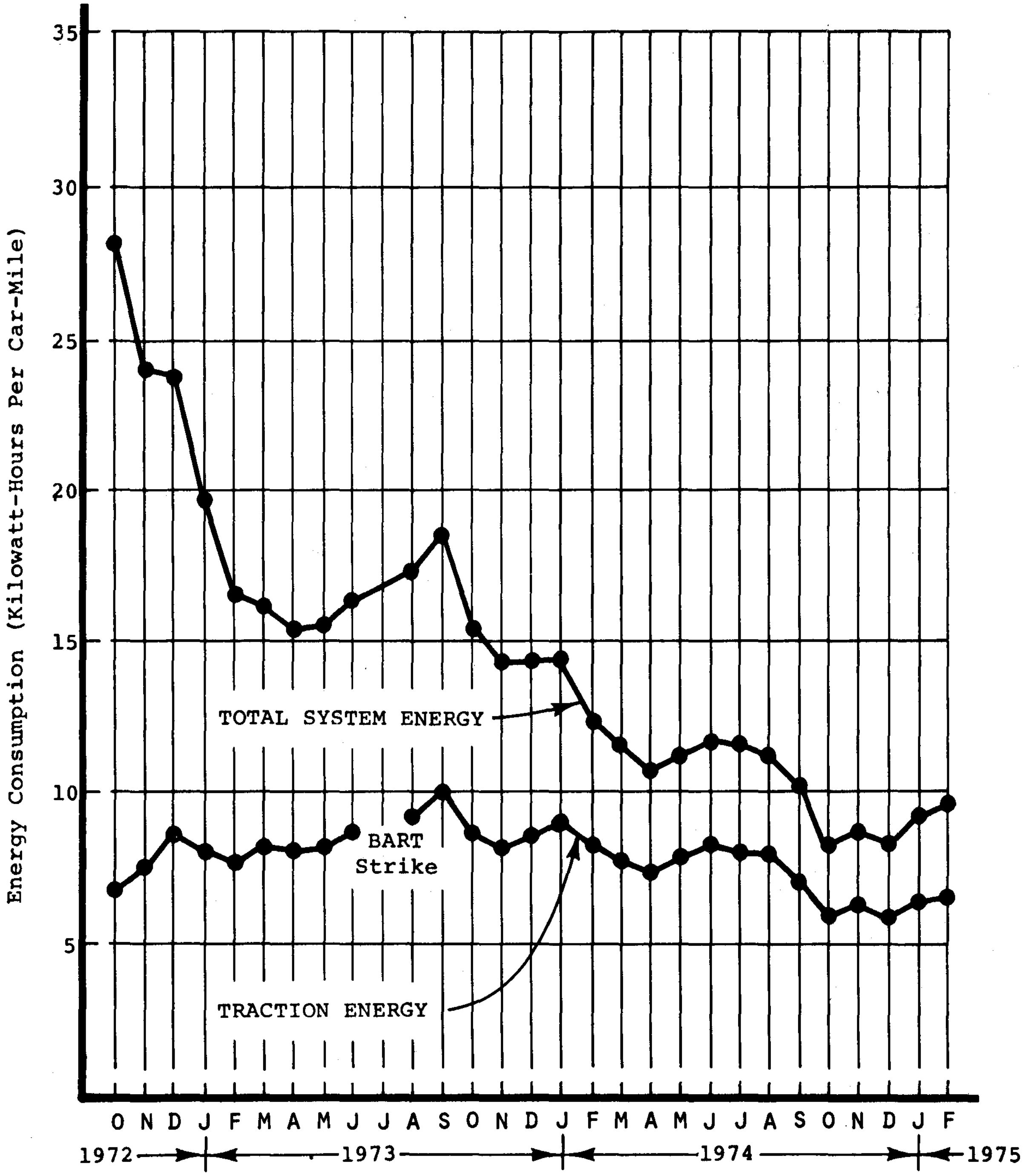


FIGURE 11

BART ENERGY CONSUMPTION PER CAR-MILE

Source: • Peat, Marwick, Mitchell & Co. Analysis of Data Provided by BARTD Engineering Department.

largely independent of the scale of System operations. Energy consumption for station operations will, however, increase when BART's hours of operation are extended from the current 70 hours a week to full-system operation of 140 hours a week. Considering these factors, maintenance energy consumption of 1.0×10^6 kilowatt-hours (kwh) per month and station energy consumption of 4.6×10^6 kwh per month are estimated for full-system operations.

Projections of traction energy consumption were made using a regression equation estimated from historical data for the period shown in Figure 10.* The number of BART cars in use and the car-miles run per month were the explanatory variables in the equation. Using this equation and assuming a full-system operation of 600 cars and 4,300,000 car-miles per month gives a projected ultimate traction energy consumption of 21.9×10^6 kwh per month.

BART's monthly energy consumption in the period following transbay BART service (October 1974 to February 1975) is compared in Table 8 to corresponding projections for full BART service (defined as about twice the current operating levels). The results suggest the following:

- Total monthly energy consumption will increase about 64% from current operations to assumed full-system operations, although the corresponding energy consumption per car-mile will decrease by about 25% and the corresponding energy consumption per passenger-mile will decrease by about 19%.

- The proportion of total energy consumption devoted to traction will increase from 70% under current operations to about 80% at full-system operations.

Comparison of BART's Energy Consumption to That of Other Rail Transit Systems and Other Modes. Table 9 presents a comparison of BART's energy consumption to that of other rail transit services and other modes. (It should be emphasized that the energy consumptions shown for the other modes are for traction energy only.) Compared to other rail rapid transit services, BART's traction energy consumption is currently about 10% above the national average, probably because of BART's shorter operating hours, the relatively high proportion of cars which are out of revenue service, and the fact that auxiliary power (to run lights, air conditioners, heaters, etc.) is consumed by BART vehicles 100% of the time. As BART's operations expand from 24,000,000 to 52,000,000 annual car-miles and from 70 to 140 weekly operating hours, its traction energy consumption (on a per car-mile basis) is estimated to decline to 5.1 kwh per car-mile or 10% below the national average.

---

*Details of the estimation equation are given in Reference 4.

Table 8

FORECAST OF BART ENERGY CONSUMPTION
FOR FULL-SYSTEM OPERATIONS

Post Transbay BART (October 1974-February 1975)[a]	BART Energy Consumption: Total Per Month (kwh x 10^6)	Per Car-Mile (kwh)	Per Passenger-Mile (kwh)
Traction Energy	11.9	6.0	0.30
Station Energy	4.0	2.0	0.10
Maintenance Energy	0.9	0.5	0.02
Total	16.8	8.5	0.42
Projected Ultimate System[b]			
Traction Energy	21.9	5.1	0.27
Station Energy	4.6	1.1	0.06
Maintenance Energy	1.0	0.2	0.01
Total	27.5	6.4	0.34

a. Based on 350 cars, 2,000,000 car-miles per month, and 40,000,000 passenger-miles per month.
b. Assumes 600 cars, 4,300,000 car-miles per month, and 80,000,000 passenger-miles per month.

Source: PMM&Co. analysis of data provided by BARTD Engineering Department.

Table 9

COMPARISON OF BART TRACTION ENERGY CONSUMPTION WITH OTHER MODES

Mode	Energy Consumption	Weight (lbs)	Seats	Weight Per Seat (lbs)	Btu/sm[a]	Btu/pm[b] Load Factor 25%	50%	100%
Auto (average urban)[c]	11.5 mpg	4,000	6	670	1,810	7,240	3,620	1,810
Auto (subcompact)[c]	25.0 mpg	2,000	4	500	1,250	5,000	2,500	1,250
Jitney[c]	8.0 mpg	8,000	8	1,000	1,950	7,800	3,900	1,950
Demand Responsive Bus[c]	4.2 mpg	n.a.	19	n.a.	1,570	6,280	3,140	1,570
Fixed Route Bus[c]	3.6 mpg	20,000	50	400	690	2,760	1,380	690
Express Bus[c]	4.8 mpg	20,000	50	400	520	2,080	1,040	520
Commuter Rail[c,d]	1,030 Btu/sm	Locomotive: 300,000 Cars: 180,000	500	1,800[e]	1,030	4,120	2,060	1,030
Trolley Coach[f]	3.62 kwh/cm	n.a.	50	n.a.	830	3,320	1,660	830
Street Car[f]	4.49 kwh/cm	n.a.	55	n.a.	930	3,720	1,860	930
Heavy Rail Transit[f,g,h] (national average)	5.50 kwh/cm	85,000	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
BART[i]		57,000	72	790				
Present System								
Traction	6.0 kwh/cm				950	3,390[j]	1,900	950
Station and Maintenance	2.5 kwh/cm				400	1,430	800	400
Total	8.5 kwh/cm				1,350	4,820	2,700	1,350
Ultimate System								
Traction[k]	5.1 kwh/cm				810	3,240	1,620	810
Station and Maintenance	1.3 kwh/cm				200	800	400	200
Total	6.4 kwh/cm				1,010	4,040	2,020	1,010

n.a. = not available
mpg = miles per gallon
Btu = British thermal unit
kwh = kilowatt-hour
sm = seat-mile
cm = car-mile

See continuing page for footnotes.

Table 9 (cont.)
COMPARISON OF BART ENERGY CONSUMPTION WITH OTHER MODES

Footnotes

a. British thermal units per seat-mile. Assumes 125,000 Btu per gallon of gasoline. For electrical energy, the direct conversion is 3,412 Btu/kwh.

b. British thermal units per passenger-mile.

c. Energy consumption, vehicle weight, and seating capacity as reported in Reference 5.

d. Reference 5 reported the energy consumed by the Southern Pacific commuter service operating between San Francisco and San Jose. These trains consist mostly of double-deck cars with 150-seat capacities; however, there are several single-level cars with approximately half the capacity. The energy consumption and capacity as reported in this table are for an "average" train. The specific energy (Btu/sm) decreases significantly for peak-hour trains that have up to 1,300 seats and increases for off-peak trains that may have only one car.

e. Weight calculated as follows:

Car weight	= (180,000 lbs/car) ÷ (150 seats/car) = 1,200 lbs/seat)
Locomotive weight	= 300,000 lbs ÷ 500 seats = 600 lbs/seat
Train weight	= 1,200 lbs/seat + 600 lbs/seat = 1,800 lbs/seat

f. Energy consumption from Reference 6. Seating capacity is assumed.

g. Since New York City represents the majority of heavy rail rapid transit use in the United States, the weight of a New York City transit car is used for this category.

h. Energy consumed per seat-mile is not applicable for this mode as many rail transit cars, New York City's rail rapid transit in particular, are designed for standees as much as they are for seated passengers.

i. Energy consumption from BARTD records and PMM&Co. forecasts as presented in Reference 4.

j. Specific energy consumptions for the present System reflect the 28% load factor that was experienced by BART in February 1975.

k. This does not include the benefits of regenerative braking, which may decrease net traction energy requirements by as much as 0.8 kwh/cm (Reference 7).

Source: Reference 4 lists sources.

Table 9 uses the energy consumption unit of British thermal units (Btu) per production unit (seat-miles or passenger-miles) to compare BART's energy consumption with that of other modes. An efficiency factor of 30% for generating and transmitting electrical power is assumed. Presently, BART experiences a total system consumption of 1,350 Btu per seat-mile (Btu/sm) which includes 950 Btu/sm for traction energy and 400 Btu/sm for station and maintenance energy. Projections indicate that BART's energy consumption for full-system operations will decrease to 1,010 Btu/sm; this includes 810 Btu/sm for traction energy.

The traction energy consumption for other modes ranges from 520 Btu/sm for an express bus to 1,950 Btu/sm for an eight-passenger jitney. Thus, the fixed-route and express buses are the most energy efficient modes; this is in contrast to the commonly held belief that a steel-wheel on steel-rail technology has the greatest energy efficiency. The following factors contribute to BART having a higher energy consumption per seat-mile than buses:

- BART has almost twice the weight-to-seat ratio.
- It employs a much higher rate of acceleration.
- It travels at speeds up to 80 mph as opposed to a maximum speed of 55 mph for an express bus and 30 mph or less for a regular fixed-route bus.
- BART's climate control system operates 24 hours a day, although BART is in operation only 14 hours a day and the average car is not in full service during that entire period.

IV. CHARACTERISTICS OF INTERIM BART SERVICE

This chapter discusses the characteristics of BART service from the perspective of the traveler. The first section presents selected data describing BART's service in terms of travel times, fares, reliability, security, and seat availability. BART's service is then compared to that of bus and automobile on the basis of travel times and costs. Finally, some of BART's impacts on accessibility, again defined in terms of travel times and costs, are discussed.

BART Service Levels

Travel Time. Figure 12 presents interstation travel times, as published by BART. This schedule is based on a statistical sample of actual train travel times compiled by BART. The single longest travel time between any two stations on the System is given as 65 minutes between Concord and Fremont.

Fares. Figure 12 also lists station-to-station fares. BART's fare schedule, adopted on December 20, 1971, has remained unchanged since revenue service began in September 1972.* Fares are computed as two components. The basic fare is based on distance traveled (mileage component). This is then modified to reflect differential service levels on different parts of the System (speed component), as follows:

Mileage Component

Trips up to 6 miles	$0.30
Trips 6 to 25 miles	$0.35 plus $0.03 per mile
Trips over 25 miles	$0.92 plus $0.01 per mile
Transbay surcharge	$0.15

Speed Component

Trips faster than System average scheduled speed--premium charge per minute saved	+$0.02
Trips slower than System average scheduled speed--discount per extra minute	-$0.02

All fares are rounded to the nearest $0.05. The schedule yields a maximum fare of $1.25.

---

*A new fare schedule was introduced in November 1975, as described in Chapter I.

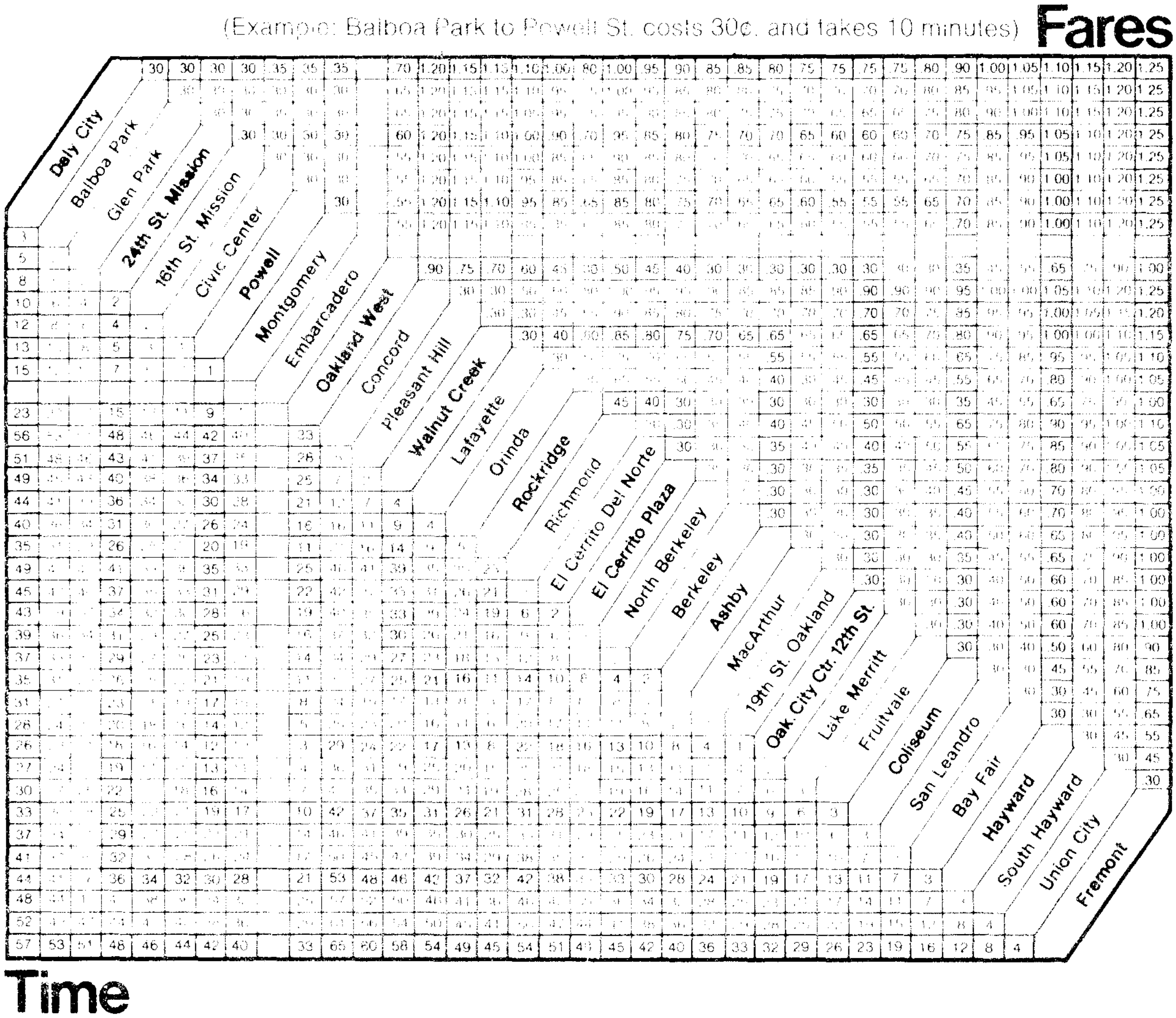


FIGURE 12

BART FARE AND TRAVEL TIME MATRIX

Source: • BARTD Information Booklet "All About BART," February 1975.

Before adopting this fare structure, BART analyzed four different fare structures (labeled flat-fare, distance-related, auto-competitive, and "multipurpose") and assessed the sensitivity of forecast patronage and revenues to fare levels for each of these structures.[8] The distance-related fare structure was recommended by the BART staff and ultimately adopted in modified form by the BART District Board as the fare structure which offered the best potential for generating sufficient revenue to cover the District's operating expenses--a requirement specified in the legislation that established the BART District. A discussion of the historical background of the BART fare structure is given in References 2 and 9.

Persons 65 years of age and older receive a 90% fare discount; children under five ride free; and children five to twelve receive a 75% discount; and physically handicapped persons receive a 75% discount.

BART provides an excursion fare which allows up to three hours of travel anywhere on the System. The excursion ticket costs $1.00 (up from $0.60 in 1974), and requires the user to exit the System at the same station he entered.

Reliability of BART Service. Figure 13 gives the standard deviation of the mean headway between trains as one measure of BART's reliability as perceived by travelers (the larger the standard deviation, the lower the reliability).

The measurements for Lake Merritt Station indicate service reliability on the Fremont Line; measurements at Rockridge indicate reliability on the Concord Line; measurements at MacArthur measure reliability on the Richmond and Concord Lines; and measurements at Oakland West estimate reliability for transbay services. These data provide a very limited basis for drawing conclusions about the reliability of BART service in general, but allow the following observations.

Reliability at the Lake Merritt Station was relatively poor immediately after BART service began in September 1972 but improved until May 1973. Service reliability at Lake Merritt Station then deteriorated in June 1973 (immediately after the start of service on the Concord Line). As shown by comparing the Rockridge and Lake Merritt Station measurements, reliability on the Concord Line was better than on the Fremont Line. This reliability did not deteriorate much between May and June of 1973.

The variation in headways at MacArthur Station increased substantially between September 1974 and December 1974. This increase is difficult to explain, since both measurements apply to the period following the start of transbay service. Measurements at Oakland West Station show no substantial change from September 1974 to February 1975.

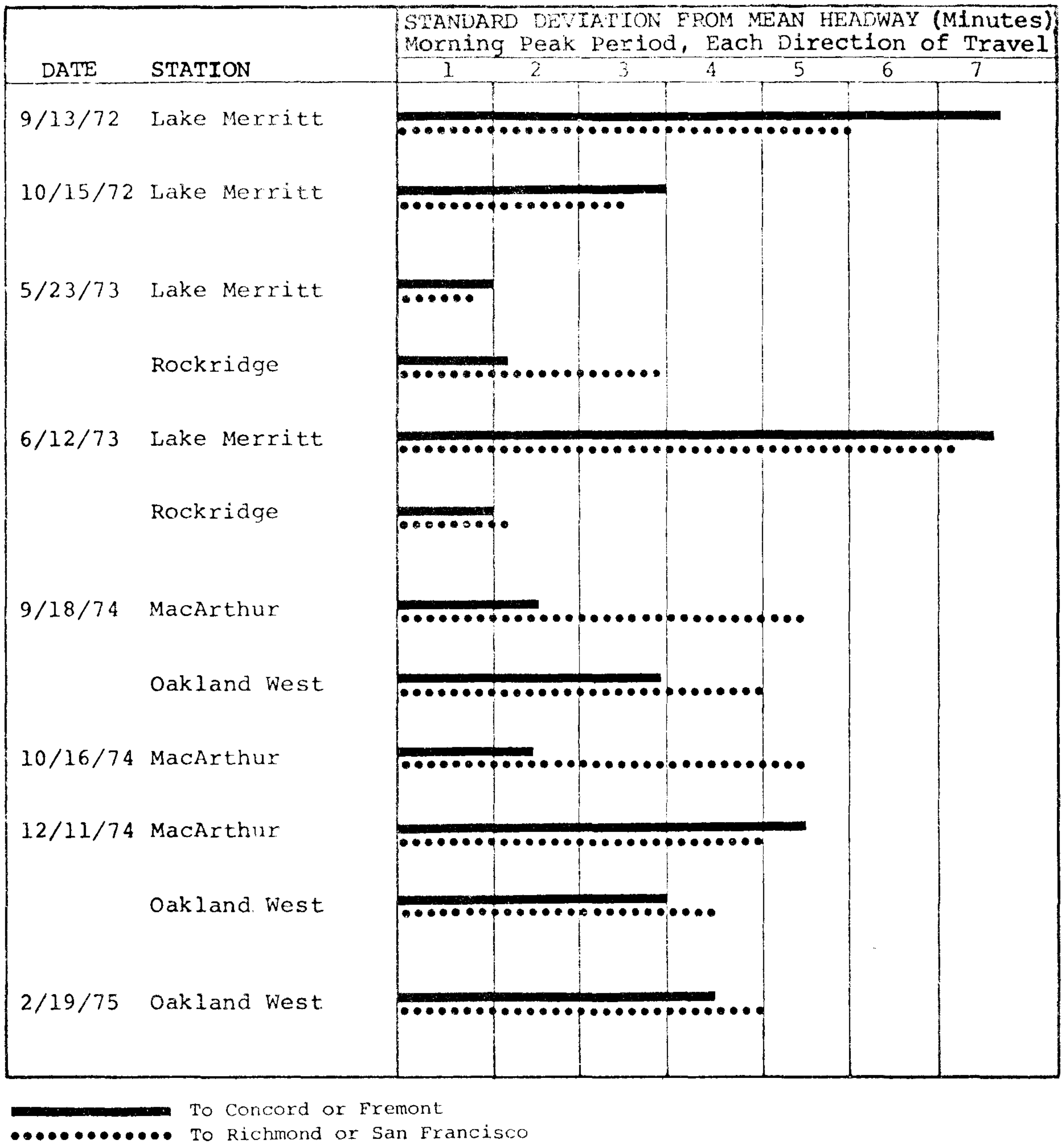


FIGURE 13

BART TRAIN HEADWAY VARIATION

Source: • JHK & Associates Compilation of Data Provided by BARTD Transportation Department.

Security. The fear of being the victim of a crime deters transit riding in many cities. Table 10 gives crime incidents on the BART System in May 1973, May 1974, and February 1975. In February 1975, the following crimes made up 75% of those reported: petty theft (25%), fare evasion (15%), vandalism (13%), automobile theft (12%), and automobile burglarly (10%). It is noteworthy that violent crimes against persons are very few. But Table 10 covers a period when BART was not operating at night; BART's security problems may become more serious when evening service starts. It is also interesting to note that, excluding vandalism and rock-throwing incidents, reported crime did not increase from May 1974 to February 1975, although average daily ridership increased 73% over the same period with the start of transbay BART service.

BART operates its own police force of 100 men. This force was equipped with police dogs in 1973 to patrol station areas and ride the trains, but the practice was discontinued in 1974 because of public objections.

Seat Availability. Table 11 shows load factors on BART trains during the morning and evening peak hours in October 1974, January 1975, and February 1975 (all after transbay service began). Load factors are defined as the ratio of the total number of passengers on all trains during the peak hour divided by the total number of available seats on all trains during the peak hour. Load factors on individual trains during the peak period may, of course, be much higher than the numbers given. Load factors are measured close to the most heavily traveled section of the line.

Except for Richmond-Fremont service, peak period load factors in the dominant direction of flow are well in excess of one on all services. Services on the Concord Line are the most crowded. As discussed further in Chapter V, these crowding levels may be a significant factor in constraining ridership. However, it should be acknowledged that peak period crowding on BART is probably much less severe than is endured by rapid transit commuters in most large cities of the world.

Comparison of BART's Travel Times and Costs to Those of Bus Transit

Comparison of BART and Bus Service to San Francisco and Oakland. Many origin-destination interchanges served by BART are also effectively served by bus. This section compares travel times and fares on BART and parallel bus services, for selected journeys to and from central Oakland and San Francisco, as summarized in Table 12. Certain facts should be borne in mind when interpreting the table:

- Interchanges are not intended to be a representative sample of all journeys that could, conceivably, use bus or BART, but are simply a selection of the more obvious.

Table 10

BART SYSTEM REPORTED CRIME INCIDENTS BY TYPE AND BART LINE

Classification	May 1973					May 1974					February 1975				
	Fremont	Concord	Richmond	San Francisco	Total	Fremont	Concord	Richmond	San Francisco	Total	Fremont	Concord	Richmond	San Francisco	Total
Aggravated Assault	1	--	--	--	1	1	--	1	--	2	--	--	--	--	--
Automobile Theft	6	2	6	--	14	7	1	1	4	13	16	4	3	--	23
Battery	1	--	--	--	1	3	--	1	1	5	--	--	--	1	1
Burglary	3	--	--	--	3	1	--	--	--	1	1	--	--	1	2
Burglary (Automobile)	--	--	--	--	--	6	2	1	3	12	14	1	4	--	19
Disorderly Conduct	5	2	2	--	9	7	--	--	1	8	1	--	--	--	1
Drunkenness	2	--	1	--	3	4	--	--	--	4	2	1	--	1	4
Fare Evasion	4	2	4	--	10	15	1	9	4	29	10	7	--	11	28
Grand Theft	1	--	--	--	1	--	--	--	1	1	1	--	--	--	1
Narcotic Drug Laws	1	--	3	--	4	4	--	2	2	8	1	2	--	1	4
Petty Theft	10	2	18	--	30	18	15	15	3	51	22	14	7	5	48
Robbery	1	--	--	--	1	--	--	--	--	--	1	--	2	1	4
Rock Throwing	29	4	13	--	46	15	1	10	1	27	5	--	2	1	8
Indecent Exposure	--	--	2	--	2	1	--	1	--	2	--	--	--	2	2
Trespassing	--	--	--	--	--	3	--	1	--	4	--	--	--	--	--
Vandalism	17	1	5	--	23	23	5	17	7	52	14	3	6	2	25
Weapons Offenses	--	--	--	--	--	2	--	--	--	2	1	--	--	--	1
All Other Offenses	5	--	3	--	8	7	3	--	3	13	10	3	3	2	18
Total Crime Reports	86	13	57	--	156	117	28	59	30	234	99	35	27	29	190
Total Excluding Vandalism and Rock Throwing	40	8	39	--	87	79	22	32	22	155	80	32	19	26	157

Source: BARTD Police Services Department.

Table 11

PEAK-HOUR BART TRAIN LOAD FACTORS BY LINE

BART Service	October 1974		January 1975		February 1975	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Concord-Daly City	1.77	.30	1.66	n.a.	1.61	n.a.
Daly City-Concord	.39	1.48	n.a.	1.62	n.a.	2.04
Fremont-Daly City	1.20	.19	1.27	n.a.	1.34	n.a.
Daly City-Fremont	.19	1.30	n.a.	1.23	n.a.	1.25
Richmond-Fremont	n.a.	n.a.	.94	n.a.	.84	n.a.
Fremont-Richmond	n.a.	n.a.	n.a.	1.25	n.a.	1.23

n.a. = not available.

Source: BARTD Transportation Department.

Table 12

COMPARISONS OF BART AND COMPETING BUS SERVICES

BART Route	Competing Bus Route	Peak-Hour Travel Time[a] (minutes) BART	Bus	One-Way Fare (dollars) BART[c]	Bus	Peak-Hour Headway[b] (minutes) BART	Bus	Midday Headway (minutes) BART	Bus
Richmond-Oakland	AC-31	22	37	$0.50	$0.35	12	30	12	No Service
	AC-33R	22	60	0.50	0.35	12	15	12	No Service
	AC-72	22	55	0.50	0.35	12	8	12	10
Richmond-San Francisco	AC-L	33	42	0.85	0.70	12	10	12	30
	AC-LX	33	35	0.85	0.70	12	10	12	No Service
Berkeley-Oakland	AC-15	10	27	0.30	0.25	12	10	12	15
	AC-33 Berkeley	10	22	0.30	0.25	12	15	12	30
	AC-40	10	30	0.30	0.25	12	12	12	15
	AC-43	10	30	0.30	0.25	12	12	12	15
	AC-51/58	10	40	0.30	0.25	12	8	12	8
Berkeley-San Francisco	AC-F	21	31	0.65	0.60	12	9	12	15
	AC-FX	21	27	0.65	0.60	12	7	12	No Service
	AC-FXX	21	24	0.65	0.60	12	6	12	No Service
San Francisco-Oakland	AC-A	10	19	0.55	0.60	6	20	6	20
San Leandro-Oakland	AC-80	12	40	0.40	0.35	12	20	12	30
	AC-81	12	40	0.40	0.35	12	20	12	30
	AC-82	12	40	0.40	0.35	12	15	12	30
San Leandro-San Francisco	AC-N	21	48	0.85	0.70	12	10	12	30
	AC-R	21	36	0.85	0.70	12	10	12	30
Hayward-Oakland	AC-32	19	38	0.60	0.40	12	20	12	No Service
	AC-81	19	67	0.60	0.40	12	20	12	30
	AC-82	19	60	0.60	0.40	12	15	12	30
Hayward-San Francisco	AC-R	28	35	1.00	0.75	12	10	12	30
Fremont-Oakland	Peerless Stages	32	75	1.00	1.45	12	60	12	120
Concord-San Francisco	Greyhound-Y	40	60	1.20	1.41	12	12	12	No Service
Walnut Creek-San Francisco	Greyhound-R	33	57	1.10	1.24	12	8	12	No Service
	Greyhound-T	33	57	1.10	1.24	12	12	12	No Service
	Greyhound-X	33	57	1.10	1.24	12	20	12	No Service
Daly City-San Francisco	Greyhound-M	15	25	0.35	0.55	6	20	6	20
	Greyhound-N/O	15	30	0.35	0.55	6	15	6	60
	Greyhound-S	15	30	0.35	0.55	6	20	6	No Service
	Mission St. Jitney	15	25	0.35	0.35	6	1	6	4
24th Street Mission-San Francisco	MUNI-9	7	20	0.30	0.25	6	8	6	14
	MUNI-11	7	20	0.30	0.25	6	8	6	16
	MUNI-12	7	20	0.30	0.25	6	6	6	7
	MUNI-14	7	20	0.30	0.25	6	6	6	7
	Mission Jitney	7	14	0.30	0.25	6	1	6	4

a. BART or bus access time is not included.
b. Average of a.m. and p.m. peak hour headways.
c. Cost of transfer between BART and bus is not included.

Source: JHK & Associates analysis of operator timetables.

- Travel times were estimated from timetables published by the operators and are not actual observed journey travel times.

- Travel times by bus were computed by selecting the bus stops nearest to the BART stations at the origin and destination of the trip.

Thus, the table does not consider the time required to get to and from the bus stop or BART station and, therefore, tends to overstate BART's total journey time advantage.

Although travel time on BART is generally lower than travel time on bus for the journeys shown, in some situations the difference in the travel times between BART and bus is small. These are generally situations in which express bus service is provided--for example, the AC Transit LX route between Richmond and San Francisco and R route between Hayward and San Francisco. In most instances shown in Table 12, the one-way bus fare is less than the one-way BART fare. Thus, BART may offer a faster (but more expensive) journey relative to bus for many travelers. However, as noted above, BART's travel time advantage over bus will be reduced and may be reversed if the traveler must use a bus to get to the BART station. On those journeys served by Greyhound and Peerless Stages, BART provides a shorter travel time as well as a lower travel cost.

In many cases, bus headways during the peak periods for a given route are similar to BART. If several bus routes provide service between a given origin and destination, the bus may offer a more frequent service than BART. During midday periods, bus headways are generally longer than BART's.

Comparison of Travel Times and Costs of Transbay BART and Bus Trips. Table 13 compares the travel times and costs of transbay bus and BART trips for those bus travelers who have diverted to BART and those bus travelers who continue to use bus. The analysis is based on the results of on-route surveys of transbay BART, bus, and automobile travelers conducted by the TSTB Project in October 1974.[10,11] Times are as reported by survey respondents.

For those transbay BART travelers who previously used the bus, the average BART trip took slightly less time (58 minutes compared to 62 minutes) but cost slightly more ($1.30 compared to $1.25). Thus, bus travelers who diverted to BART, on the average, made a small time-for-money tradeoff. For those transbay trips made by bus after transbay BART service began, travelers reported BART as both taking significantly more time (59 minutes compared to 48 minutes) and costing more ($1.10 compared to $.90). Most of the difference between BART and bus travel times is accounted for by the access trip.

Table 13

TRAVEL TIMES AND COSTS OF TRANSBAY BART AND BUS TRIPS[a]
October 1974

	For Transbay BART Trips Previously Made by Bus	
	Previous Bus Trip	Current BART Trip
Door-to-Door Travel Time (minutes)	62	58
Access Time[b] (minutes)	n.a.	14
Transit Cost	$0.95	$1.00
Automobile Cost[c]	0.30	0.30
Total Trip Cost	$1.25	$1.30

	For Transbay Trips Currently Made by Bus	
	Actual Bus Trip	Hypothetical BART Trip
Door-to-Door Travel Time (minutes)	48	59
Access Time[b] (minutes)	12	19
Total Trip Cost	$0.90	$1.10

n.a. = not available.

a. Average times and costs (to nearest $0.05) for one-way trips as reported by survey respondents.
b. Access time to bus or BART (San Francisco) plus access time from bus or BART (East Bay).
c. Toll, parking, and other automobile operating costs as perceived by survey respondents.

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

Comparison of BART and Automobile Travel Times and Costs. Comprehensive data on relative times and costs for BART and automobile are currently available only for transbay journeys, as derived from the October 1974 transbay travel surveys.

Table 14 compares travel times and costs for those transbay BART travelers who diverted from automobile and those transbay travelers who continue to use automobile. Again, the table is based on travel times and costs reported by survey respondents. For those transbay BART travelers who diverted from automobile, BART took substantially more time for the door-to-door journey (57 minutes compared to 44 minutes previously) but was perceived by these travelers as being very much less expensive ($1.50 compared to $3.00). Thus, in contrast to those BART travelers who diverted from bus, BART travelers who diverted from automobile on the average made a money-for-time trade-off in taking BART.

Those transbay automobile travelers who continue to use automobile perceive that their trip cost would be significantly lower if they used BART ($1.95 as compared to $3.05), but this cost savings is not sufficient to offset the greatly increased travel time (61 minutes compared to 35 minutes). About 20 minutes of the BART journey time would be spent in getting to or from the BART station.

BART's Impact on Accessibility to Central San Francisco and Oakland

This section describes some exploratory analyses of BART's impacts on accessibility to central San Francisco and Oakland, based on network representations of the transportation system before and after the start of BART service. The analyses are described more fully in Reference 12. Further, more comprehensive analyses of areawide accessibilities are planned for the next phase of the TSTB Project.

Two types of accessibility measures were employed in the Phase I analyses. The first was based on network estimates of zone-to-zone travel times and the second on estimated interzonal transit fares. In each case, the measures were expressed in the form of simple "accessibility indices," weighted by the size and characteristics of the resident population in the origin zone. The analysis covered all residential origin zones in a "BART impact area" defined by Alameda, San Francisco, and Contra Costa Counties, plus the northern portion of San Mateo County.

The comparisons were made for the ethnic minority (nonwhite) population and the low-income population (the number of families below the poverty level as defined by the 1970 Census) in each zone, as well as the general population.

Travel time data were derived from "pre-BART" and "post-BART" highway and transit networks developed for the years 1971 and 1976, respectively, with 440 traffic zones defining the area. Transit fare data were based

Table 14

TRAVEL TIMES AND COSTS OF TRANSBAY BART AND AUTOMOBILE TRIPS[a]
October 1974

	For Transbay BART Trips Previously Made by Automobile	
	Previous Automobile Trip	Current BART Trip
Door-to-Door Travel Time (minutes)	44	57
Access Time[b] (minutes)	--	14
Transit Cost	$ --	$1.00
Automobile Cost[c]	3.00	0.50
Total Trip Cost	$3.00	$1.50
	For Transbay Trips Currently Made by Automobile	
	Actual Automobile Trip	Hypothetical BART Trip
Door-to-Door Travel Time (minutes)	35	61
Access Time[b] (minutes)	--	20
Total Trip Cost	$3.05	$1.95

a. Average times and costs (to nearest $0.05) for one-way trips as reported by survey respondents.
b. Access time to bus or BART (San Francisco) plus access time from bus or BART (East Bay).
c. Tolls, parking, and other automobile operating costs as perceived by survey respondents.

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

on interzonal transit fare matrices constructed for the same two years.* All demographic information was based on updated estimates of 1970 U.S. Census information.

It should be emphasized that accessibility is defined here in "potential" terms, i.e., irrespective of the demand for travel between the zones in question. The travel times and costs are computed for paths through the network which assume BART will be used, if at all reasonable. These paths need not represent the transit modes that would actually be used by travelers after considering relative travel times, fares, and other travel impedances. Caution should therefore be exercised in interpreting the results. Travel times and fares are also computed between zone centroids--effectively assuming that all zone households are located at the zone centroid. The estimates cannot, therefore, accurately account for differences in access times within zones.

BART's Impact on Peak Period Accessibility. Figures 14 and 15 summarize BART's impact on peak period travel times by transit to the central business district (CBD) of San Francisco. Figures 16 and 17 show the same information for travel times to Oakland's CBD. These figures illustrate BART's impacts on accessibility to the two major employment centers of the area. However, it should be stressed that the BART System was specifically designed to serve these two centers, so BART's impacts on accessibility overall will be much less than implied by the following discussion.

For the study population as a whole, BART reduced peak period transit travel times to the San Francisco and Oakland CBDs by approximately 11 minutes (21%) and 18 minutes (29%), respectively. In general, the greatest reduction in travel times resulting from BART service occurred for those residents living farthest from the CBDs.

Although substantial, average peak period savings in transit travel times for low-income and minority residents to the CBDs were lower than for the population as a whole. Average transit travel times for low-income residents to the central areas of San Francisco and Oakland decreased by about 9 and 15 minutes, respectively, equivalent to savings of 18% and 27% compared to pre-BART levels. For ethnic minorities, the equivalent average savings were 6 and 12 minutes, representing reductions of roughly 15% and 24%, respectively.

Two factors account for the differences between the results for the general population and those for the low-income and minority populations. First, time savings by BART accrue mainly for long trips. A high proportion of low-income and minority residents in the three BART counties

---

*As described in Chapter I, effective November 1975, BART's fares increased over those used in this analysis.

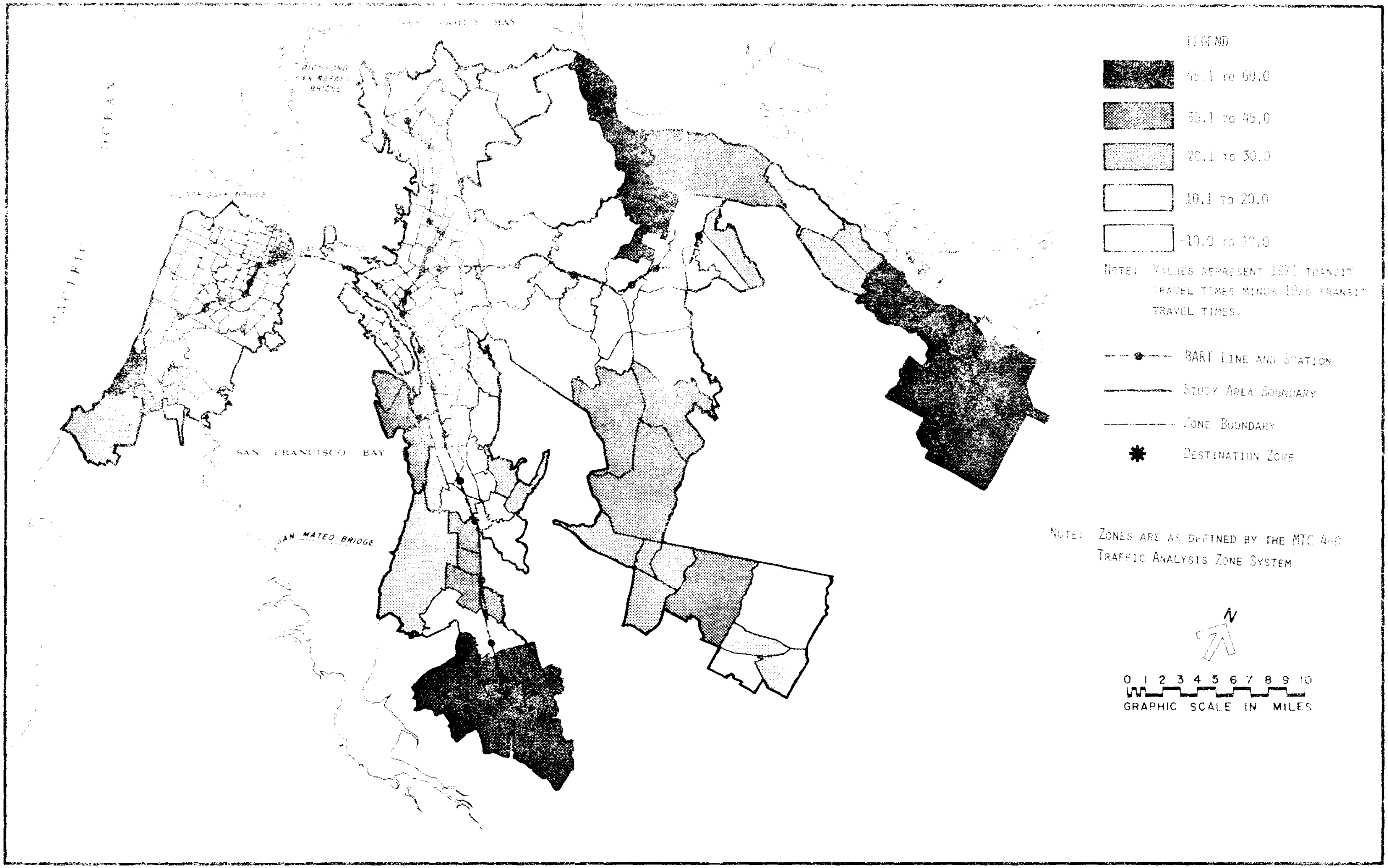


FIGURE 14

CHANGES IN PEAK PERIOD ACCESSIBILITY TO SAN FRANCISCO CBD

(CHANGES IN PEAK PERIOD ZONE-TO-ZONE TRAVEL TIMES, 1976 (POST-BART) TRANSIT SYSTEM COMPARED TO 1971 (PRE-BART) TRANSIT SYSTEM)

Source: • Peat, Marwick, Mitchell & Co. Analysis of Regional Transit Network Travel Time Matrices.

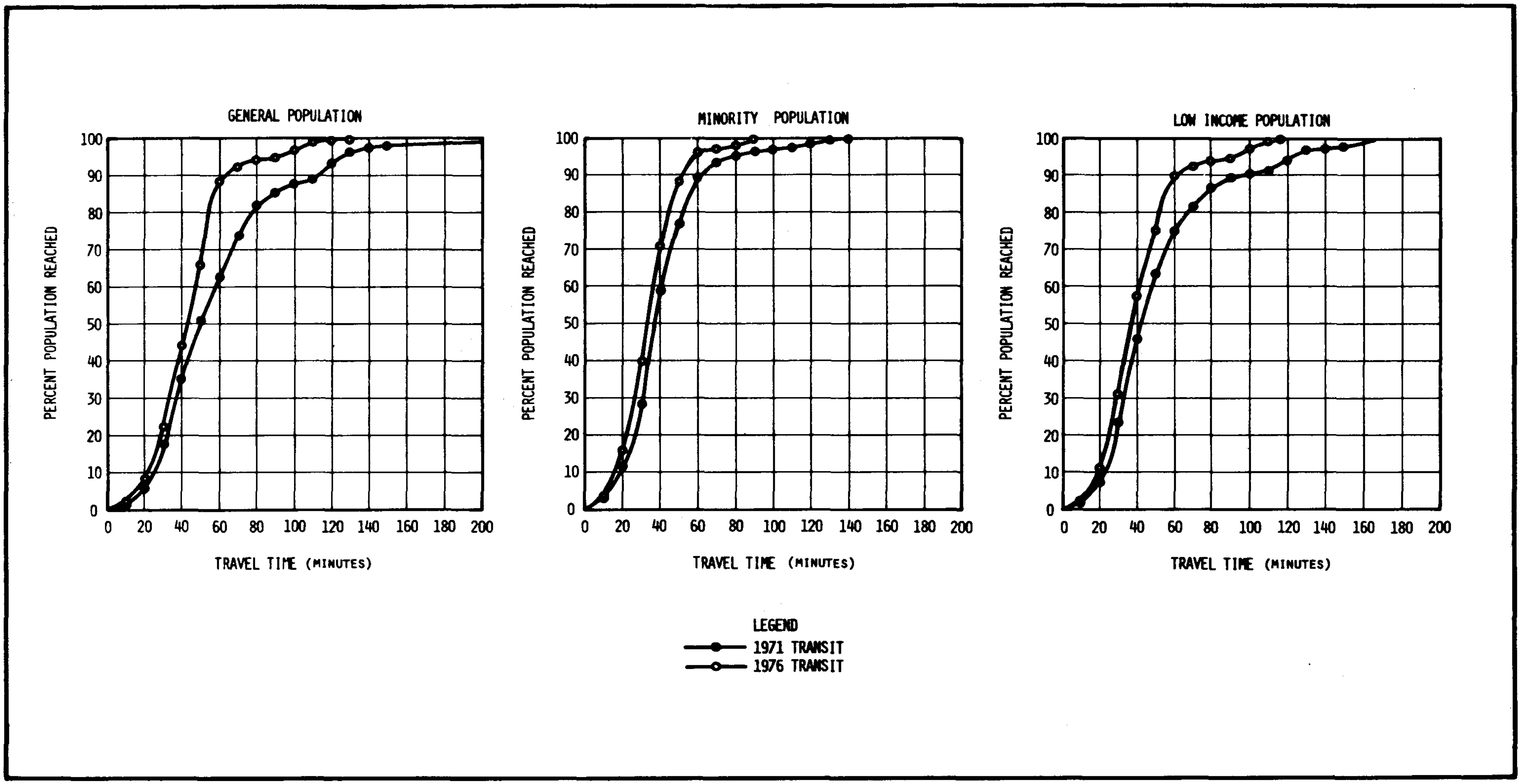


FIGURE 15

CHANGES IN PEAK PERIOD ACCESSIBILITY TO SAN FRANCISCO CBD FOR DIFFERENT POPULATION GROUPS

(CHANGES IN PERCENTAGE OF POPULATION REACHED FOR PEAK PERIOD ZONE-TO-ZONE TRAVEL TIMES, 1976 (POST-BART) TRANSIT SYSTEM AND 1971 (PRE-BART) TRANSIT SYSTEM)

Source: • Peat, Marwick, Mitchell & Co. Analysis of Regional Transit Network Travel Time Matrices and 1970 U. S. Census Data.

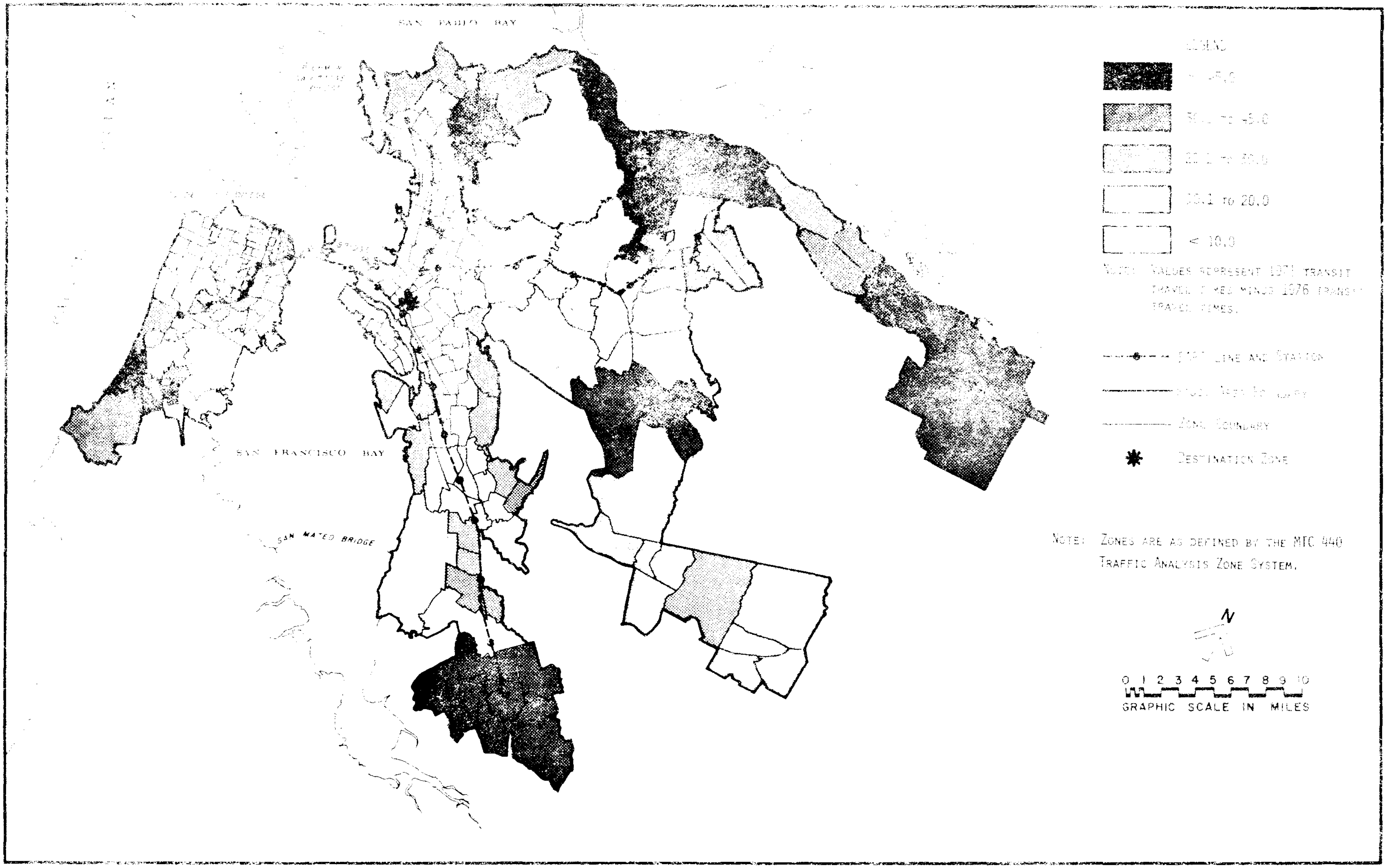


FIGURE 16

CHANGES IN PEAK PERIOD ACCESSIBILITY TO OAKLAND CBD

(CHANGES IN PEAK PERIOD ZONE-TO-ZONE TRAVEL TIMES, 1976 (POST-BART) TRANSIT SYSTEM COMPARED TO 1971 (PRE-BART) TRANSIT SYSTEM)

Source: • Peat, Marwick, Mitchell & Co. Analysis of Regional Transit Network Travel Time Matrices.

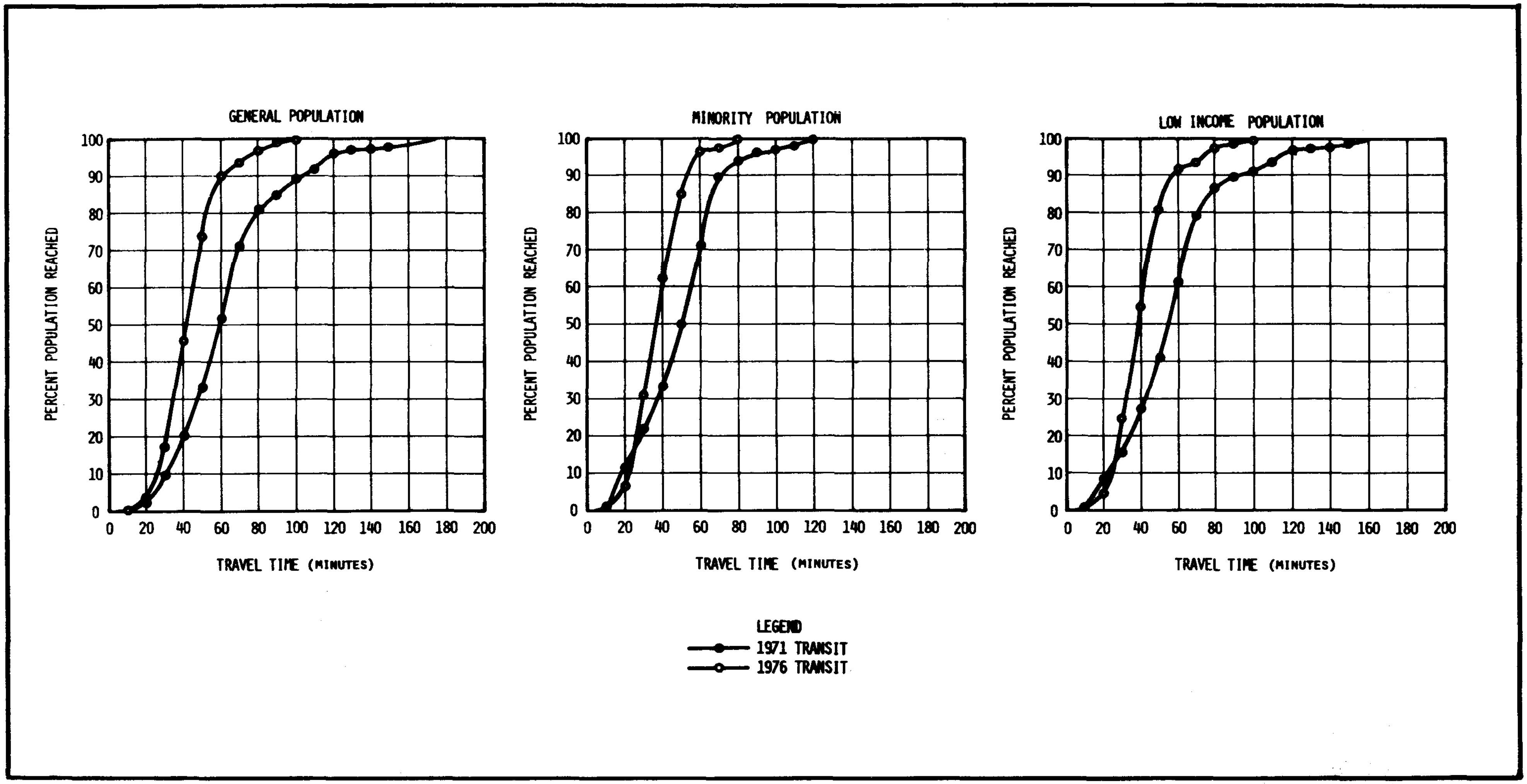


FIGURE 17

CHANGES IN PEAK PERIOD ACCESSIBILITY TO OAKLAND CBD FOR DIFFERENT POPULATION GROUPS

(CHANGES IN PERCENTAGE OF POPULATION REACHED FOR PEAK PERIOD ZONE-TO-ZONE TRAVEL TIMES, 1976 (POST-BART) TRANSIT SYSTEM AND 1971 (PRE-BART) TRANSIT SYSTEM)

Source: • Peat, Marwick, Mitchell & Co. Analysis of Regional Transit Network Travel Time Matrices and 1970 U. S. Census Data.

live close to the centers of San Francisco and Oakland. Hence, their potential time savings resulting from BART are relatively low. Second, the level of pre-BART transit service in many of these close-in communities was already high relative to the outlying suburbs now served by BART.

Analysis of interzonal transit fares shows that, from 1971 to 1976, the average transit fare to the San Francisco CBD increased by $0.21 (32%) for "potential" travel by the population as a whole. Correspondingly, the average transit fare to the Oakland CBD increased by $0.13 (19%) for the general population. Fare increases for the minority and low-income populations do not differ significantly. In interpreting these results, it should be borne in mind that MUNI and AC Transit bus fares remained essentially constant over the period in question. Thus, the increased fares result from adding BART to the transit system (assuming that BART will always be used when it is "reasonable" to do so).

<u>BART's Impact on Off-Peak Transit Travel Times</u>. Comparing pre-BART and post-BART off-peak travel times by transit yields conclusions similar to those reached in the analysis of peak period accessibility. BART decreased average transit travel times for the overall population to the San Francisco and Oakland CBDs by 16 and 18 minutes (26% and 29%), respectively. The minority population experienced reductions in average travel times of 8 minutes (17%) to the San Francisco CBD and 11 minutes (22%) to the Oakland CBD. Travel times decreased more in the off-peak period than in the peak period. This is largely due to the improved frequency of transbay service provided by BART in the off-peak period.

Introduction of BART service increased average off-peak fares to the CBDs of San Francisco and Oakland by $0.15 and $0.09 (21% and 12%), respectively, for the general population; and by $0.4 and $0.07 cents (28% and 12%), respectively, for the minority population. These fare changes differ from the peak fare changes discussed above because some bus services included in the 1971 networks operated only at peak periods. Since transit fares were compared only for zones which had transit service in both 1971 and 1976, a different (smaller) set of zones was included in the off-peak analysis.

V. BART RIDERSHIP

Historical BART Ridership

Figure 18 shows average daily ridership on the System since the start of service on the Fremont Line in September 1972. In October 1973, when only the three East Bay lines were in operation, average daily ridership was about 36,000 trips. This increased to 68,000 with the start of service on the line between San Francisco and Daly City. Following the start of transbay service in September 1974, average daily ridership on the System increased to about 120,000 trips.

Distribution of BART Ridership on the System. In the first nine months of transbay service, ridership did not increase significantly. In June 1975, average daily ridership was about 121,000 trips.* Of these, 39,000 trips (32%) were made entirely on East Bay lines of the System, and 28,000 trips (23%) were made entirely on the San Francisco Line. The remaining 54,000 average daily trips, (45% of the total), were made between East Bay and San Francisco stations.

The gasoline shortage of early 1974 had a significant effect on ridership, increasing average daily trips from 66,000 in January to 80,000 in March. The AC Transit strike in July and August of 1974 also increased East Bay ridership slightly.** However, apparently neither of these events gave rise to a permanent increase in BART ridership. In December 1974, average daily ridership on lines other than the transbay link was about 70,000 trips, the same number as in December 1973.

The graphs plotted in Figure 18 show that none of the three sections of the System have experienced sustained growth in ridership. Combined average daily ridership on the three East Bay lines was 37,000 in June 1973, the month following the start of service on the Concord Line. At the height of the gasoline shortage, East Bay ridership rose to 50,000 average daily trips; however, by June 1975, East Bay ridership had declined to 39,000, only slightly higher than when service first started. Ridership on the San Francisco Line in December 1973, the month following its opening, was 33,000 trips per day on average; in June 1975 ridership on the San Francisco Line had declined to 28,000. In October 1974, immediately after transbay service began, BART's average daily transbay ridership was 52,000; in June 1975 it was 54,000. Some of the differences between these numbers may be due to purely seasonal effects, but it is unlikely that seasonal effects would change the conclusion; no sustained growth in ridership has occurred on the East Bay, San Francisco, and transbay sections of the System.

---

*As noted in Chapter I, net ridership increased to 127,000 trips per day by December 1975.

**Reference 13 analyzes the impacts of the AC Transit strike on BART.

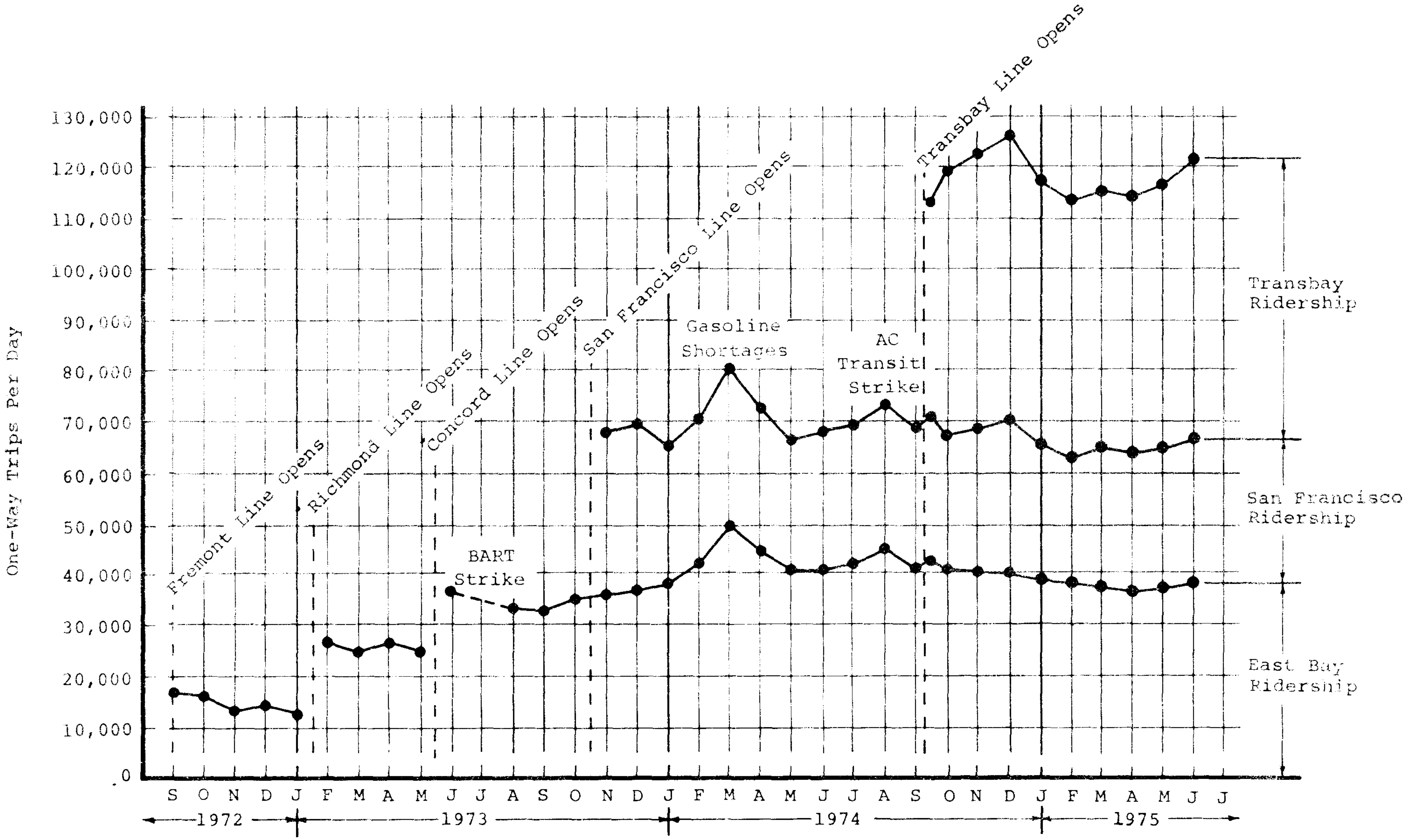


FIGURE 18

AVERAGE DAILY BART RIDERSHIP, SEPTEMBER 1972 - JUNE 1975

Source: ● BARTD Office of Research, Monthly BART Patronage Reports.

BART's Ridership Relative to Bay Area Transit in Total. BART's unchanged ridership is especially noteworthy when viewed in the context of growth in public transit ridership in the Bay Area as a whole. As shown in Figure 19, since BART opened full East Bay service (i.e., since May 1973), the total combined ridership on MUNI, AC Transit, Golden Gate Transit, Greyhound, and BART has increased significantly.

Much of the combined increase can be attributed to automobile travelers diverting to BART when service began on the San Francisco Line in November 1973 and when transbay BART service began in September 1974. However, in spite of the considerable diversion of ridership from bus to BART when the San Francisco Line and Transbay Tube opened,* as shown in Figure 20, since early 1973, ridership on non-BART transit has increased overall. (In May 1973, the combined ridership of MUNI, AC Transit, Greyhound, and Golden Gate Transit averaged 517,000 trips per weekday. In May 1975, the average was 594,000.)**

This analysis of ridership is complicated by increases in ridership resulting from the introduction of new bus services, many of which act as feeder services to BART, and the reduction or elimination of some bus services on routes parallel to BART. However, these complications do not alter the conclusion that transit ridership on systems other than BART is increasing in the area as a whole. Transit ridership has increased as a result of increased gas prices and favorable changes in attitudes towards transit generally, among other factors. BART's failure to increase its ridership above the initial level following the start of service on each of its lines is especially noteworthy when viewed in this context.

BART's Ridership Relative to Predictions

The various predictions of ridership published before the start of service provide further benchmarks to compare with actual BART ridership. These comparisons are useful to the extent that the forecasts represent the expectations which, in large part, justified the System's construction. Over the years of BART's planning, construction, and implementation, several forecasts and revised forecasts have been prepared. These

---

*The October 1974 survey of transbay BART travel, conducted six weeks after the start of transbay service, showed that about 54% of BART riders had previously used bus transit. (See Reference 10.)

**It is true that most of the increase in bus ridership shown in Figure 19 occurred over the period May 1973 to October 1973; since October 1973, there has been no net increase in non-BART transit ridership. However, if the residual effects of the AC Transit strike in mid-1974 are taken into account, a continuing upward trend in total bus ridership is still apparent.

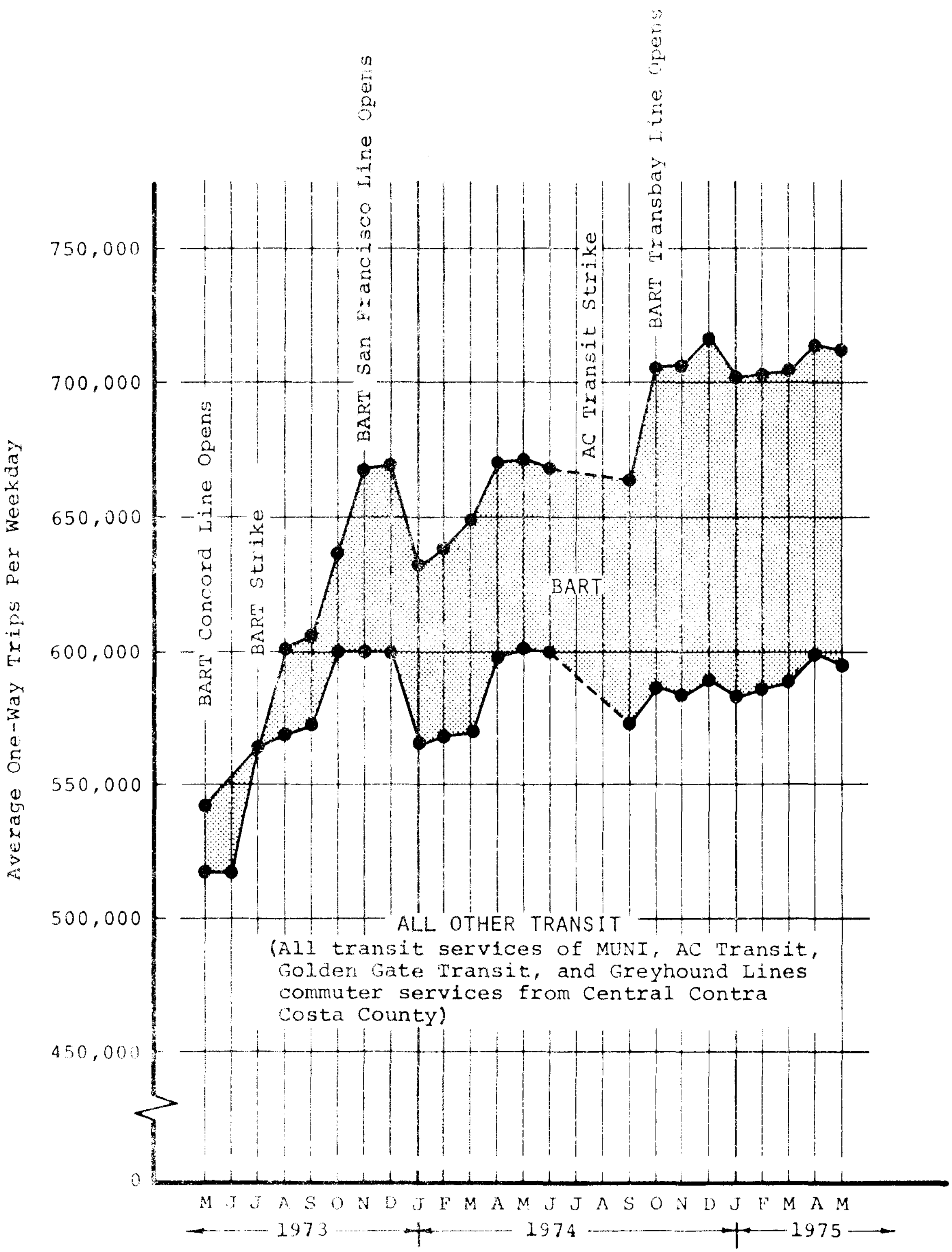


FIGURE 19

BART AND TOTAL BAY AREA TRANSIT RIDERSHIP, MAY 1973-MAY 1975

Note: Ridership on AC Transit and MUNI includes trips to and from BART.

Sources:
- BARTD Office of Research, Monthly BART Patronage Reports.
- AC Transit District, Daily Passenger Counts.
- San Francisco MUNI, Quarterly Patronage Reports.
- Golden Gate Transit District, Monthly Patronage Counts.
- Greyhound Lines, Inc., Contra Costa Service Passenger Counts.

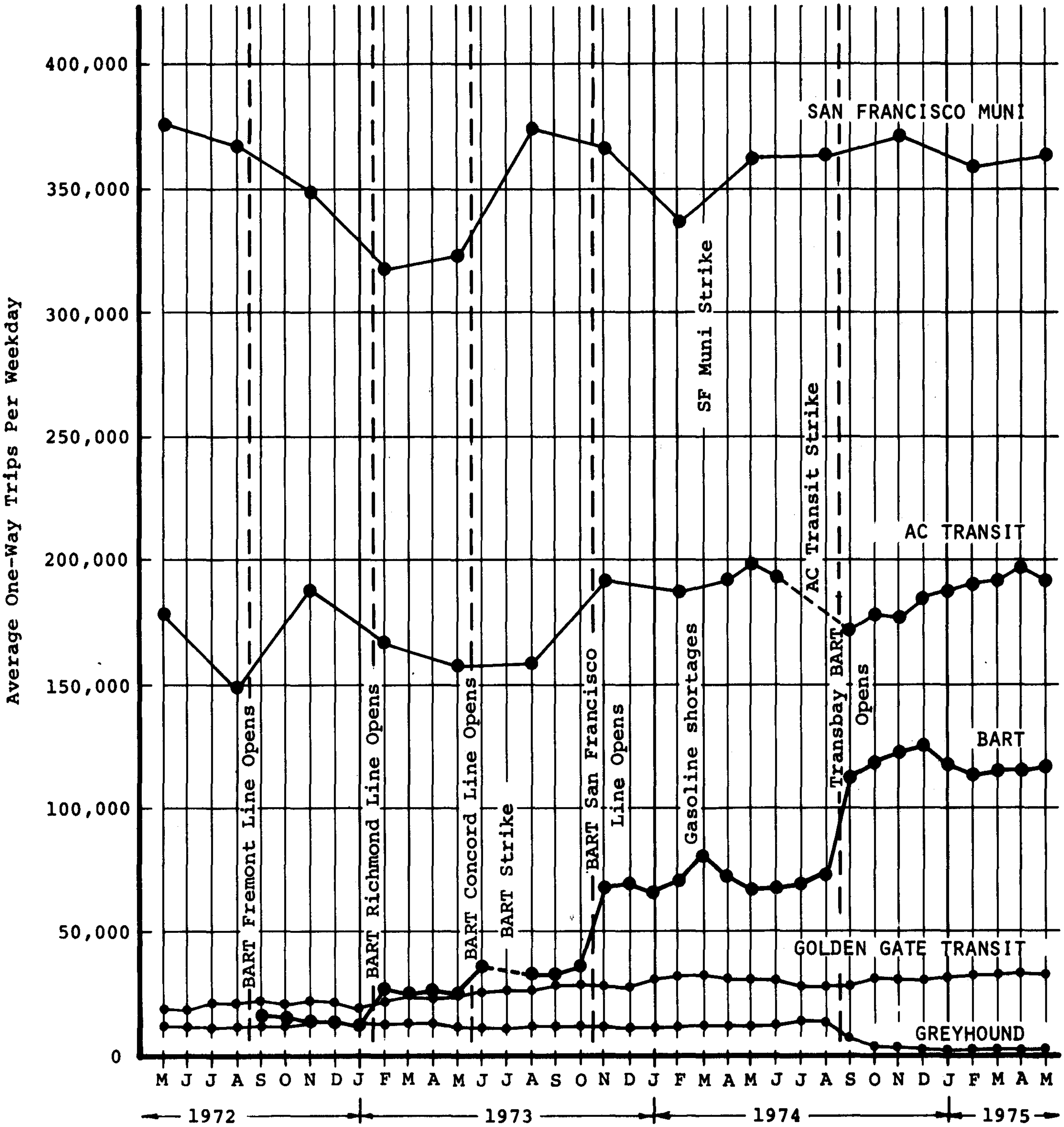


FIGURE 20

RIDERSHIP ON BART, MUNI, AC TRANSIT, GOLDEN GATE TRANSIT, AND GREYHOUND

MAY 1972 - MAY 1975

Note: Ridership on AC Transit and MUNI includes trips to and from BART.

Sources:
- BARTD Office of Research, Monthly BART Patrongage Reports.
- AC Transit District, Daily Passenger Counts.
- San Francisco MUNI, Quarterly Patronage Reports.
- Golden Gate Transit District, Monthly Patronage Counts.
- Greyhound Lines, Inc., Contra Costa Service Passenger Counts.

have generally taken 1975 as the principal forecast year on the assumption that BART's 71-mile System would be in full operation then. Each successive forecast has tended to reduce earlier ridership estimates.

Forecasts of BART Ridership. The Composite Report[3] contains the earliest forecast of BART ridership. This was based primarily on a 1954 travel survey conducted for the San Francisco Bay Area Rapid Transit Commission. Total passenger trips in 1975 were estimated at 77.8 million, or 259,000 trips per weekday. In the 1967 final report of the Northern California Transit Demonstration Project,[14] BART patronage for 1975 was estimated at as many as 253,000 trips per weekday.*

In 1970, Wilbur Smith and Associates developed a transit ridership estimation model as part of their work for the State of California Division of Bay Toll Crossings. In 1971, the BARTD Office of Research used this model to produce a Revised Patronage Estimate of 59.3 million annual trips or 201,000 trips per weekday.[8] School trips are excluded from this estimate. The Revised Estimate remains BART's basic patronage forecast for full, stabilized operations.[16] Table 15 shows the distribution of the Revised Estimate's forecast trips among the lines of the System and the actual trip interchanges observed in November 1974.

Comparison of Actual and Forecast BART Ridership. Table 15 shows that in total, current daily ridership on BART is about 60% of that forecast. However, there are wide variations among the ratios between actual and forecast trips. For example, travel to and from stations on the Concord Line is actually slightly higher than forecast (15,700 actual trips per day compared with 14,900 forecast), while travel among the five central Oakland stations is only 5% of that forecast (500 actual trips per day compared to 8,700 forecast). In general, BART's ridership is lowest, relative to the forecast, for those trip interchanges relatively well-served by bus transit. These tend to be the shorter trips.

Levels of BART Service Underlying Actual and Forecast Ridership. The comparisons of actual and forecast patronage shown in Table 15 reflect the accuracy of the forecasting procedure as well as BART's passenger-carrying performance. The comparison is also influenced to the extent that BART's Revised Estimate for 1975 assumed "full stabilized operations," i.e., 20-hour weekday service with trains running at 6-minute headways during the peak periods, and direct transbay service

*Several lower estimates were also made in this study, as a function of alternative fare policies. A low estimate of 185,000 adult trips per day (corresponding to about 194,000 total trips per day) was associated with a fare schedule "designed to reflect the maximum fares feasible under present circumstances."[15]

Table 15

ACTUAL AND FORECAST AVERAGE WEEKDAY BART RIDERSHIP BETWEEN BART LINES

	Concord Line Stations[a]		Richmond Line Stations[b]		Fremont Line Stations[c]		Oakland Stations[d]		San Francisco Line Stations[e]		Total[f]	
	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast
Concord Line Stations[a]	1,900	600									15,700	14,900
Richmond Line Stations[b]	2,000	1,100	2,600	3,200							14,400	17,900
Fremont Line Stations[c]	1,500	800	4,700	2,400	6,300	6,200					20,700	27,900
Oakland Stations[d]	5,100	7,900	6,700	12,300	8,900	16,200	500	8,700			15,400	42,500
San Francisco Stations[e]	19,100	18,800	10,400	13,600	13,700	24,000	9,300	31,400	28,700	53,800	55,000	97,600
Total All Stations											121,200	200,800

a. Concord through Rockridge BART Stations.
b. Richmond through Ashby.
c. Fremont through Fruitvale.
d. MacArthur through Lake Merritt plus Oakland West.
e. Daly City through Montgomery Street.
f. Totals are one-half the sum of origin plus destination trips. Thus, the total for each line is given by one-half the sum of all entries in its row plus all entries in the corresponding column. For example, for Fremont Line stations: (1,500 + 4,700 + 6,300) + (6,300 + 8,900 + 13,700) ÷ 2 = 20,700.

Sources: Actual ridership: BARTD Office of Research, "BART Station-to-Station Trips, Typical Day, Early November 1974," January 1975.
Forecast ridership: BARTD Office of Research, "BART Patronage: Background, Forecasts and Initial Results," December 1972. Forecast is BARTD's "Revised Patronage Estimate." School trips are excluded.

to San Francisco from all three East Bay lines. Current BART service (corresponding closely to the actual patronage figures given in Table 15) is 14-hour weekday service with trains running at 12-minute peak-period headways and providing direct transbay service only Concord-Daly City and Fremont-Daly City.* Nevertheless, comparisons of the actual and predicted patronage figures on a line-by-line basis do provide some useful insights into BART's passenger-carrying performance relative to that expected of it.

Given the operating factors currently constraining BART's service below full-system operation levels, it is not surprising that actual total patronage is less than forecast. However, the differences between current and full-system operating levels do not convincingly explain the difference between BART's current daily ridership of 120,000 and the original Composite Report forecast of 260,000 (or even BART's Revised Estimate of 200,000). The conclusion remains that BART's ridership is much less than originally predicted.

BART Fare Schedules Associated with Actual and Forecast Ridership. The station-to-station fare schedule assumed in developing the Revised Estimate forecast is the same as the fare schedule currently in effect (August 1975).** But in the four years since the forecasts were made, there have been significant (and unanticipated) increases in prices, particularly the price of gasoline.*** Given this price inflation, BART's current fares are much lower in real terms--relative, say, to the cost of traveling by automobile--than was the case at the time of the forecast. If the patronage forecast had been adjusted to reflect this relative decrease in BART fares, the Revised Estimate would presumably be higher than 200,000 trips per day. Correspondingly, actual current ridership would represent an even smaller percentage of the forecast.

Characteristics of BART Travelers

The previous section discussed BART ridership in terms of the total number of trips made on the System. This section describes the characteristics of the people making the trips.

---

*See Chapter I for changes in BART service since the time of writing.

**This fare schedule is described on page 53. Typical fares from downtown San Francisco (Montgomery Street) are to: Daly City $0.35, Oakland City Center $0.55, Berkeley $0.65, and Concord $1.20. See Chapter I for changes in the fare schedule since August 1975.

***From 1971 to 1975, the Consumer Price Index for the San Francisco area increased about 30%. Over the same period the price of gasoline increased about 60%.

Table 16 summarizes five characteristics (age, sex, race, education level, and income) of BART travelers for three major groups of trips: (1) trips between BART stations in the East Bay, (2) trips between stations on the San Francisco Line, and (3) transbay trips between East Bay and San Francisco stations. Table 16 also shows the distributions of the five characteristics for the total population aged 16 and over as surveyed in the BART Impact Program May 1975 Areawide Travel Survey.*

The characteristics of East Bay and San Francisco Line BART travelers were obtained from a Passenger Profile Survey conducted by BART in May 1974,* when all lines were open except the transbay link. The characteristics of transbay BART travelers were obtained from the BART Impact Program October 1974 Survey of Transbay BART Travel,* conducted shortly after the start of transbay service.

Comparison Among BART Travelers. The characteristics of BART travelers making trips in the East Bay were generally similar to those traveling in San Francisco, but the characteristics of the two groups differ significantly from those of transbay BART travelers. Relative to nontransbay BART riders, a higher proportion of transbay BART travelers were white, male, well-educated, and upper income. For example, 35% of transbay BART travelers had more than four years of college compared to 12% of East Bay travelers and 16% of San Francisco travelers. Transbay BART travelers also had significantly higher income levels: 25% having annual incomes of over $25,000 compared to 13% for East Bay BART travelers and 10% for San Francisco travelers.

Comparison of BART Travelers and Areawide Population. The characteristics of BART travelers and the characteristics of the areawide population differ significantly, as shown in Table 16. The differences are especially marked in comparing the transbay BART travelers with the total population.

BART carries proportionately fewer old people than there are in the general population and significantly more men than women; 69% of transbay BART travelers are male, compared to 48% of the adult population. BART's patronage--especially transbay--also contains a higher proportion of white, well-educated, and upper-income persons than occur in the population as a whole. Among transbay BART riders, 89% are white, 58% have attended four or more years of college, and 62% have an annual family income of $15,000 or more. These differences reflect the predominance of work trips, especially in transbay BART ridership (68% of transbay BART trips are to or from work), and the emphasis on journeys to male-dominated, white-collar employment in downtown San Francisco, especially from the affluent East Bay suburbs. The distributions of nontransbay

*See footnotes to Table 16 for descriptions of the survey.

Table 16

CHARACTERISTICS OF BART TRAVELERS COMPARED TO AREAWIDE TRAVELER POPULATION
(Percent)

Characteristics	BART Travelers, 1974 East Bay[a]	San Francisco[a]	Transbay[b]	Areawide Population Aged 16 and Over (1975)[c]
Age				
Under 18	3%	3%	1%	3%
18-24	28	25	17	20
25-34	30	36	35	19
35-44	16	16	19	16
45-54	13	12	17	16
55-64	7	6	8	13
65 or over	3	2	3	13
Sex				
Male	52%	47%	69%	48%
Female	48	53	31	52
Race[d]				
White	81%	69%	89%	82%
Spanish-American	4	8	3	3
Black	8	8	3	10
Oriental	4	11	4	3
Other	3	4	1	2
Education				
Less than high school graduate	7%	5%	2%	19%
Graduated from high school	25	21	11	31
Some college or junior college	40	39	29	26
Four-year college graduate	16	19	23	13
More than four years of college	12	16	35	11
Annual Family Income[e]				
Less than $5,000	11%	8%	7%	15%
$5,000-$9,999	20	26	13	26
$10,000-$14,999	25	27	18	29
$15,000-$25,000	31	29	37	23
$25,000 or over	13	10	25	7
Total[f]	100%	100%	100%	100%
(Number of trips)	(40,700)	(25,400)	(51,500)	

See footnotes on following page.

Table 16 (cont.)
CHARACTERISTICS OF BART TRAVELERS COMPARED TO AREAWIDE TRAVELER POPULATION

Footnotes

a. Source: BARTD, May 1974 Passenger Profile Survey. BARTD conducted this survey on Wednesday, May 22, 1974, when all BART System lines were in operation except the transbay link. The survey sampling design was a 100% questionnaire handout at all stations on the System between 6:00 a.m. and 2:00 p.m. (half the BART operating day). About 17,200 questionnaires were returned, a 50% response rate overall. However, the response rate for questionnaires handed out over the morning peak period was higher than for those handed out later in the day. The survey results summarized here have not been weighted to reflect differential response rates either by time of day or by location. The results are consequently biased toward the characteristics of early morning riders, and may be biased in other (unknown) ways.

b. Source: BART Impact Program, October 1974 Survey of Transbay BART Travel. The data on transbay travel patterns presented in the table and the report were derived from a series of surveys of travel by BART, bus, and private automobile in the San Francisco-Oakland Bay Bridge corridor. The surveys were conducted by the TSTB Project in October 1974 and consisted of an on-route distribution of questionnaires to transbay BART, bus, and automobile travelers together with various ancillary control surveys and counts. A sample of 2,000 responses to the on-route transbay BART travel survey was analyzed. Results given in the table are from this analysis, weighted to reflect different response rates by time of day and location of questionnaire handout.

   The methodologies of the surveys are detailed in Surveys of Transbay Travel, October 1974: Data Collection Methodology, BART Impact Program Document No. DD 4-3-75, May 1975. The findings of the surveys are given in Immediate Travel Impacts of Transbay BART, BART Impact Program Document No. TM 15-3-75, May 1975.

c. Source: BART Impact Program, May 1975 Areawide Travel Survey. The data presented in the table and the report on current total travel in the BART impact area were derived from preliminary tabulations of an areawide survey of travel conducted between April 25 and May 18, 1975, by the TSTB Project. The survey is referred to as the "BART Impact Program May 1975 Areawide Travel Survey" or simply as the "areawide travel survey." The survey was conducted by telephone interviews with a sample of 1,002 respondents drawn from the adult population of the BART impact area defined by Alameda, Contra Costa, and San Francisco Counties and the northern part of San Mateo County. The area of San Mateo County covered comprised the following cities: Daly City, Colma, Brisbane, Pacifica, South San Francisco, San Bruno, and Millbrae. Details of the survey sampling plan and survey methodology will be given in a separate report of the TSTB Project. Before tabulation, the data were weighted to conform to the distributions of sex, age, and family income given by the 1970 Census for the area. However, this weighting does not necessarily account for all sampling imperfections, and sampling and nonresponse biases could be present in these preliminary results. In the future, the TSTB Project will refine the analysis to account for any such biases.

Table 16 (cont.)
CHARACTERISTICS OF BART TRAVELERS COMPARED TO AREAWIDE TRAVELER POPULATION

Footnotes

d. Racial/ethnic categories are as included in the questionnaires of all three passenger profile and transbay BART surveys and the areawide survey.

e. Total annual family income before taxes.

f. Percentages for BART travel are based on total daily trips. The totals used for East Bay and San Francisco Line trips (40,700 and 25,400, respectively) are average daily BART patronages for May 1974. The total for transbay BART travel (51,500 trips) is the total for the October 30, 1974 survey date. The sum of the three, 118,000, is about the same as average daily BART ridership in May 1975.

Percentages for areawide traveler characteristics are based on the total adult population of the area. The total 1975 population of the BART impact area surveyed in the May 1975 Areawide Travel Survey is estimated at 2,579,000 persons. Of these, 1,869,000 are aged 16 years or older. This "adult" population was taken as the total traveler population for the survey and is used as the basis for all data and analyses presented in this report.

traveler characteristics are much closet to those of the general population, especially for sex, race, and income.*

Comparison of BART Travelers with Bus and Automobile Travelers. Table 17 compares the demographics of transbay BART travelers with bus and automobile travelers (both drivers and passengers).

Travelers making transbay BART trips in October 1974 were, relative to bus riders, more likely to be male (69% compared to 54%) and white (89% compared to 80%). Family income and automobile ownership were also higher for BART travelers than bus travelers: 25% of BART travelers reported incomes of $25,000 or over, compared to 20% for bus; household automobile ownership was 1.72 for BART travelers and 1.50 for bus travelers. To some extent, these comparisons reflect the ability and willingness of higher income travelers to pay the higher cost of traveling by BART. These are largely the long-distance commuters from the high- and middle-income (and mainly white) suburbs of the East Bay to the employment centers of downtown San Francisco.

The distributions of traveler characteristics for BART and automobile travelers were remarkably similar in almost all respects. The only significant difference between the two is for household automobile ownership, which was higher for automobile trip-makers (1.93) than for BART trip-makers (1.72). This is a reflection of the "transit captive" component of BART ridership.

Purpose of BART Travel

Table 18 shows the distribution of purposes among BART trips, comparing transbay and non-transbay travel. The predominance of work travel is apparent; 78% of transbay and 70% of non-transbay BART trips were made for travel to or from work and other work-related purposes. Trips made to or from school or college made up the next largest purpose category (10% of transbay trips and 16% of non-transbay trips). The remainder of BART trips were approximately evenly split among the shopping, visiting, touring, and "other" categories (about 3% of BART ridership in each case).

---

*Preliminary results from a BART passenger profile survey conducted in May 1975 (weighted to reflect differential response rates by survey station, but not time of day), give the following racial composition of BART's ridership: White 77%, Spanish-American 5%, Black 7%, Asian 8%, Others 3%. These more recent figures show a somewhat different picture of ridership from that given by Table 16, and suggest that BART's ridership in total actually contains a higher proportion of nonwhites than are present in the general population.

Table 17

CHARACTERISTICS OF TRANSBAY BART TRAVELERS
COMPARED TO BUS AND AUTOMOBILE TRAVELERS

Characteristics	Transbay Trips, October 1974			
	BART Trips	Bus Trips	Automobile Trips	Total Transbay Trips
Age				
Under 18	1%	1%	1%	1%
18-24	17	14	9	11
25-34	35	35	37	36
35-44	19	19	22	21
45-54	17	18	18	18
55-64	8	11	10	10
65 or over	3	2	3	3
Sex				
Male	69%	54%	72%	69%
Female	31	46	28	31
Race[a]				
White	89%	80%	87%	87%
Spanish-American	3	2	2	3
Black	3	7	5	5
Oriental	4	10	4	5
Other	1	1	1	1
Education				
Less than high school graduate	2%	2%	2%	2%
Graduate from high school	11	13	10	11
Some college or junior college	29	27	30	29
Four-year college graduate	23	24	21	22
More than four years of college	35	34	37	36
Annual Family Income[b]				
Less than $5,000	7%	4%	5%	5%
$5,000-$9,999	13	21	12	14
$10,000-$14,999	18	21	22	21
$15,000-$19,999	19	17	18	18
$20,000-$24,999	18	17	17	17
$25,000 or over	25	20	26	25
Category of Income and Race				
White				
Under $10,000	16%	18%	13%	14%
$10,000-$19,999	33	29	34	33
$20,000 or over	40	34	39	39
Nonwhite[c]				
Under $10,000	4	6	3	4
$10,000-$19,999	4	9	5	6
$20,000 or over	3	4	6	4
Household Size[d]	2.32	2.23	2.28	2.28
Household Automobile Ownership[e]	1.72	1.50	1.93	1.84
Total Transbay Trips[f]	26,100 (100%)	17,100 (100%)	92,400 (100%)	135,600 (100%)

a. Racial/ethnic categories as included in the survey questionnaires.
b. Total annual family income before taxes.
c. Spanish-American, Black, Oriental, and Other.
d. Mean number of people aged 16 or over living in the household.
e. Mean number of automobiles and pick-up trucks in the household.
f. Daily trips in one (eastbound) direction, October 1974.

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

Table 18

PURPOSES OF BART TRAVEL

Purpose of Travel	Nontransbay BART Travel May 1974[a]	Transbay BART Travel October 1974[b]
Work	66%	70%[c]
Business Call	4	8
School or College	16	10
Shopping	4	3
Visiting Friends or Relatives	3	3
Recreation or Touring	3[d]	3[e]
Other Purposes	4[f]	3
Total[g]	100%	100%

a. Source: BARTD, May 1974 BART Passenger Profile Survey. Data were weighted to account for differential sampling rates by time of day and location.

b. Source: BART Impact Program, October 1974 Survey of Transbay BART Travel. Data were weighted to account for differential sampling rates by time of day and location.

c. Of which 68% are home-based work trips.

d. "Visiting a recreation area of facility" and "BART Excursion ride".

e. "Visiting a recreation area or facility", "BART Excursion ride", and "Touring".

f. Includes "Visiting a Doctor or Dentist".

g. Total for nontransbay travel represents 66,100 average daily trips in May 1974. Total for transbay travel represents 51,500 daily trips in October 1974.

Distribution of BART Travel by Time of Day

Consistent with the mainly work-oriented nature of BART travel, most of BART's ridership is concentrated in the peak periods. In May 1975, BART ridership in the peak 4-hour period (morning and evening combined) averaged 69,000, about 59% of the 14-hour daily total of 118,000 trips.

Transbay BART travel is even more heavily concentrated in the peak periods. In October 1974, BART's eastbound transbay ridership was about 26,000 trips during the 14 hours of operation. About 53% of this ridership occurred in the 3 hours from 3:00 p.m. to 6:00 p.m. By contrast, only 6% of all daily eastbound ridership occurred in the morning 3-hour period from 6:00 a.m. to 9:00 a.m. This reflects the predominant pattern of journeys to work in San Francisco from the residential suburbs on the East Bay, returning to the East Bay in the evening. Relatively few transbay BART riders were making the reverse journey from residences in San Francisco to workplaces in the East Bay. Over the whole day, about 15,600 trips were made to the East Bay from work in San Francisco (87% of trips between work and home); only about 2,300 trips (13% were made from San Francisco to work in the East Bay.)

Origin-Destination Patterns of BART Travel

Table 15 on page 77 shows the origin-destination distribution of BART ridership by line. The orientation of travel to downtown San Francisco and, to a lesser extent, downtown Oakland and Berkeley is also shown in Table 19, which summarizes the average number of daily trips made to and from specific stations on the System.

The station pairs between which the most trips are made are Montgomery Street-Daly City (3,700 average daily trips per day in both directions in November 1974); Montgomery Street-Pleasant Hill (1,800 trips); Powell Street-Daly City (1,400 trips); Montgomery Street-Walnut Creek (1,300 trips); Montgomery Street-Balboa Park (1,000 trips); and Montgomery Street-Lafayette (1,000 trips).

Modes of Access to and from BART

Table 20 shows the distribution of (October 1974) transbay BART trips according to the mode used to access the System. Access modes for the San Francisco (origin) ends of the journeys and the East Bay (destination) ends of the journeys are shown.* The table shows both the actual

---

*"Origin" and "destination" are defined here consistent with the (eastbound) direction of transbay BART travel surveyed in October 1974. However, in the remainder of this discussion it is assumed that the mode used to get to BART on the first half of a round trip is the same as the mode used to get from BART on the second half, and vice versa.

Table 19

BART STATION USAGE
May 1975

Station	Average Daily Passengers[a]
Montgomery Street	20,600
Powell Street	9,800
Daly City	7,200
Berkeley	6,000
Civic Center	5,900
19th Street Oakland	5,800
12th Street Oakland	4,300
Concord	3,700
Fremont	3,400
Hayward	3,200
Walnut Creek	3,200
Pleasant Hill	3,000
Lake Merritt	2,900
Glen Park	2,900
Balboa Park	2,800
Fruitvale	2,800
Bay Fair	2,600
24th Street Mission	2,300
San Leandro	2,200
Coliseum	2,200
Lafayette	2,000
MacArthur	1,900
El Cerrito del Norte	1,900
Rockridge	1,800
Union City	1,800
Orinda	1,700
16th Street Mission	1,600
El Cerrito Plaza	1,600
South Hayward	1,500
North Berkeley	1,500
Richmond	1,200
Ashby	1,100
Oakland West	1,100
Total	117,500

a. Sum of average daily station entries and exits divided by two.

Source: BARTD Office of Research, BART Patronage Report for May 1975.

Table 20

BART ACCESS MODES
(Transbay Travel, October 1974)

Modes	East Bay BART Access[a]		
		Hypothetical BART Access Mode[b]	
	Actual BART Access Mode	Current Bus Trips	Current Automobile Trips
Walk	22%	26%	18%
Bus	16	34	20
Drive Car[c]	47	28	51
Car Drop-Off/Pick-Up	13	11	8
Other Modes[d]	2	1	3
Total	100%	100%	100%
Actual Number of Trips[e]	26,100	17,100	92,400
Median Access Time (minutes)	8	11	9

Modes	San Francisco BART Access[f]		
		Hypothetical BART Access Mode[b]	
	Actual BART Access Mode	Current Bus Trips	Current Automobile Trips
Walk	77%	75%	42%
Bus	10	20	36
Streetcar	3	1	3
Drive Car[c]	5	2	8
Car Drop-Off/Pick-Up	4	1	3
Other Modes[d]	1	1	8
Total	100%	100%	100%
Actual Number of Trips[e]	26,100	17,100	92,400
Median Access Time (minutes)	6	8	11

a. Access from East Bay BART stations (for eastbound transbay journeys).
b. Mode which would be used by current bus and automobile travelers if they were to use BART for their transbay trip.
c. "Drove car alone" or "Car pool (either driver or passenger)".
d. Includes taxi, motorcycle, and bicycle.
e. Midweek daily transbay person-trips made eastbound between 6:00 a.m. and 8:00 p.m. (the hours of BART operation).
f. Access to San Francisco Line BART stations (for eastbound transbay journeys).

Source: BART Impact Program, October 1974 Survey of Transbay BART Travel.

distribution among modes for current transbay BART travelers and the hypothetical modes which current bus and automobile travelers said they would use if they were to ride BART.

San Francisco Access Modes. Table 20 illustrates the small extent to which vehicular modes were used to access BART in San Francisco; walking was the method of access for 77% of all transbay trips made. The percentage is higher (84%) for journeys to or from work, and if only trips made from workplaces in San Francisco to residences in the East Bay are considered, the figure is 94%. But for trips made for purposes other than traveling between home and work, about 2,100 transbay trips (19%) used MUNI bus or streetcar to get to BART. For all trips, the median access time was six minutes.

For those travelers who continued to use transbay bus, the hypothetical distribution among access modes to BART was similar to the actual distribution for BART riders, although the percentage of those who would use bus or streetcar is somewhat higher, 21%, compared to 13% for current BART trips. For those travelers who continue to drive, the hypothetical BART trip would involve much longer access journeys; 30% requiring a bus or streetcar journey and a further 19% some other vehicular mode. However, 42% of trips (38,600 trips) were made by people who considered they could walk to BART at the San Francisco end of their trip. This, on the face of it, implies a considerable market segment of potential BART riders.

East Bay Access Modes. Table 20 shows the importance of the automobile as the mode of access to BART in the East Bay--60% of all transbay trips used automobiles to get to BART stations. (For journeys to and from work the figure was 69%, and for journeys to work in San Francisco from home in the East Bay, 78%.) The distribution among access modes for the hypothetical BART trips of transbay bus and automobile travelers was similar to the distribution for BART trips. The most significant difference among the three is that bus riders could use bus to get to and from BART more readily than transbay BART and automobile travelers.

The BART access mode distribution shown in Table 20, conceals the large variation among the different stations in the East Bay. This is illustrated in Table 21. Automobile was the predominant mode of access at the extremities of the East Bay BART lines, especially on the Concord Line. Bus was a more important feeder mode in the more densely urbanized areas, and walking was the most important access mode in the central cities of Oakland and Berkeley.

Table 21

BART ACCESS MODES FOR EAST BAY BART STATIONS
(Transbay Travel, October 1974)

BART Station	Mode of Access From BART: Walk	Bus	Automobile[a]	Total Actual Number of Trips[b]
Concord	5%	1%	94%	2,340
Pleasant Hill	13	--	87	2,360
Walnut Creek	6	2	92	2,080
Lafayette	13	--	87	1,690
Orinda	4	--	96	1,610
Rockridge	35	15	50	1,380
Richmond	39	13	48	150
El Cerrito del Norte	10	12	78	610
El Cerrito Plaza	26	18	56	440
North Berkeley	31	8	61	470
Berkeley	53	45	2	2,660
Ashby	36	12	52	330
Fremont	5	--	95	910
Union City	2	2	96	630
South Hayward	3	14	83	330
Hayward	13	29	58	840
Bay Fair	3	11	86	620
San Leandro	5	29	66	750
Coliseum	9	47	44	520
Fruitvale	9	47	44	870
Lake Merritt	59	3	38	730
MacArthur	10	28	62	920
19th Street Oakland	72	23	5	1,100
12th Street Oakland	47	41	12	1,390
Oakland West	52	7	41	370
Total All Stations	22%	16%	62%	26,100 (100%)

a. Automobile mode includes: drove car alone, car pool (either driver or passenger), car drop-off or pick-up, taxi, motorcycle, and bicycle.

b. Midweek daily transbay person trips made eastbound between 6:00 a.m. and 8:00 p.m. (the hours of BART operation).

Source: BART Impact Program, October 1974 Survey of Transbay BART Travel.

BART's Share of Areawide Travel

The 1975 population of the area covered in the BART Impact Program May 1975 Areawide Travel Survey* is estimated to be 2,579,000 persons. Of these, 1,869,000 are aged 16 years or older. This estimated adult population was taken as the total traveler population for the areawide travel survey and is used as the basis for the data and analyses presented in the remainder of this chapter.

According to the areawide travel survey, the traveler population of the BART impact area makes about 33.4 million trips per week by transit, private automobile, or other vehicles. Some 24.7 million (74%) of these are made on the five weekdays combined and 8.7 million (26%) on Saturday and Sunday. (These figures represent trip-making rates of 2.64 trips per person per day on weekdays and 2.33 trips per person per day on weekends.) The proportion of these trips made on BART is clearly of interest.

<u>BART's Share of Total Weekly Trips</u>. Table 22 shows total weekly vehicle trips made in the BART impact area, distributed by mode (BART, bus, car driver, and car passenger) and by purpose of travel (work, business, school, shopping, and other purposes). Both weekend and evening travel are included in the trip estimates.**

Overall, BART's share of total areawide trips is small. About 590,000 trips per week are made by BART, or something under 2% of the 33,400,000 trips made by all vehicle modes. About 11% are made by other forms of transit and the remaining 87% by automobile and other modes. But BART's share of travel to and from work is much greater; about 400,000 trips, or over 6% of all weekly work trips are made by BART.

BART's share of total travel for nonwork purposes is negligible. (The one exception is travel to and from school and college; the 80,000 trips made on BART represent about 3% of areawide trips.) For example, the

---

*See notes following Table 16 on page 81 for a description of the survey.

**Table 22 was developed from the results of the May 1975 Areawide Travel Survey and the two on-route surveys of BART conducted in 1974: the May 1974 BART Passenger Profile Survey conducted by BARTD and the BART Impact Program October 1974 Survey of Transbay BART Travel conducted by the TSTB Project. These two on-route BART surveys were used to establish the distribution of purpose for BART trips more reliably than is possible using the relatively small number of BART trips (28 round trips) surveyed in the areawide survey. The total number of BART trips shown in the table equals BART's average weekly ridership for May 1975. The results of the May 1975 Areawide Travel Survey were used to establish the total number of trips and the distribution by purpose for bus and automobile travel.

Table 22

MODE AND PURPOSE OF TRAVEL IN THE BART IMPACT AREA
(Total Trips Made in Vehicles Per Seven-Day Week, May 1975)

	Mode of Travel				
Purpose of Travel	BART	Bus or Streetcar	Car Driver	Car Passenger	Total All Modes
To or From Work	397,000 6.2%	1,220,000 18.9%	4,388,000 68.0%	445,000 6.9%	6,450,000 100.0%
Business	36,000 1.6%	153,000 6.7%	1,815,000 79.6%	276,000 12.1%	2,280,000 100.0%
School or College	78,000 3.2%	330,000 13.7%	1,742,000 72.0%	269,000 11.1%	2,419,000 100.0%
Shopping	21,000 0.3%	499,000 5.9%	6,670,000 79.5%	1,205,000 14.3%	8,395,000 100.0%
Other Purposes[b]	56,000 0.4%	1,335,000 9.6%	9,297,000 67.1%	3,170,000 22.9%	13,858,000 100.0%
Total--All Purposes	588,000 1.8%	3,537,000 10.6%	23,912,000 71.5%	5,365,000 16.1%	33,402,000 100.0%

a. Includes "other" modes, largely pickup trucks and other commercial vehicles. A total of 1,036,000 weekly trips are made by these modes.
b. Includes travel for recreation (4,576,000), trips to visit friends or relatives (3,574,000 trips), and for personal business (3,173,000 trips).

Sources: BART Impact Program May 1975 Areawide Travel Survey.
BART Impact Program October 1974 Survey of Transbay BART Travel.
BARTD May 1974 BART Passenger Profile Survey.

20,000 shopping trips made on BART each week represent only 0.3% of all shopping trips made areawide. The 60,000 trips made on BART for recreation, to visit friends or relatives, for personal business, and "other" purposes represent less than 0.5% of all trips for these purposes.

BART's Share of Weekday Daytime Trips. BART's particularly small share of nonwork trips is partially explained by its interim hours of service. BART is currently operating only from 6:00 a.m. to 8:00 p.m., Monday through Friday.* If only weekday daytime travel between these hours is considered as the base, BART's share of the areawide travel market is higher than Table 22 suggests. Of all trips made on weekdays (about 4.9 million per day on the average), approximately 85% or 4.2 million are started between 5:00 a.m. and 7:00 p.m. The 118,000 average daily trips on BART represent about 3% of this weekday daytime travel market. About 990,000 work trips are made on an average weekday in the area as a whole during the hours of BART operation. BART's 80,000 daily trips represent about an 8% share of these trips.

BART's Share of Trips As a Function of Distance from BART. The total urbanized area of Alameda, Contra Costa, San Francisco, and San Mateo Counties covered in the May 1975 Areawide Travel Survey is about 330 square miles. Although the BART System serves parts of all the major cities in this area, less than one-third of the area is within a mile of any of the 33 BART stations, currently in use. (The areawide travel survey showed that 32% of all weekly vehicle trips in the BART impact area are made by people who reside within a mile of a BART station.) Of all vehicle trips by travelers who reside in the area, nearly 3% are made on BART (compared to under 2% for trips made in the area as a whole). Of those trips by people who reside within half a mile of a BART station (14% of areawide trips), well over 4% are made on BART.

These figures imply that the closer people live to BART the more likely they are to use it. However, caution should be exercised in drawing the conclusion that distance of residence from BART is a determinant of people's propensity to use BART. Many other variables--some of which may be correlated with distance (income level, for example)--influence the decision.

BART's Share of Potential Trips. Another way of assessing BART's effective share of the travel market is to express BART trips as a percentage of the trips that travelers themselves consider they could make

---

*Since the time of writing (August 1975), BART has begun regular evening service (see Chapter I).

by BART.* Of total weekly trips made areawide, 2% (588,000 trips) are made by BART, and 7% (2,470,000 trips) are made by other modes, but could have been made by BART. The remaining 91% (30,344,000 trips) are not, and could not be made by BART.

The total of those trips that are either made, or travelers perceive could be made, on BART is 3,058,000 trips per week, or 611,000 trips per weekday. Taking this total as the "potential travel market," BART's current daily ridership of 118,000 trips represents a 19% share. Following the same logic, BART's potential work-trip market is 276,000 trips per weekday. BART's actual work-trip ridership of 70,000 trips per day represents a 29% share. These estimates of BART's potential travel market share present a more generous picture than the estimates of BART's share of total areawide trips presented previously. However, it must be emphasized that the total potential travel market is defined here by travelers' perceptions of the feasibility of using BART for particular trips. These perceptions probably vary greatly among travelers so that the resulting defintion of the travel market is largely arbitrary. Therefore, the estimates of potential market share can be viewed only as general indicators of BART's share of travel.

BART's Share of Transbay Travel. One of the key links of the BART System is the Transbay Tube connecting the downtown employment and commercial centers of San Francisco with the residential areas of the East Bay. Of all the people who work in San Francisco, about 18% live in the East Bay. Shortly after transbay BART service began in September 1974, these workers made some 85,000 daily weekday person-trips in each direction in the San Francisco-Oakland Bay Bridge corridor. Total travel for all purposes and by all modes in the corridor was about 136,000 trips daily between 8:00 a.m. and 6:00 p.m.

BART's share of trips in this heavily traveled corridor varied somewhat with the purpose of travel. Overall, some 19% of transbay trips were made by BART (with bus carrying 13% of the trips and automobile the remaining 68%). For transbay travel to and from work, transit usage was higher: BART carried 21% of trips, bus 17%, and automobiles 62%.

Factors Constraining BART Ridership

The data presented in earlier sections of this chapter suggest that BART's ridership is, in many cases, lower than has been expected or predicted. The TSTB Project has not yet undertaken a comprehensive

*In the May 1975 Areawide Travel Survey respondents were asked to describe all vehicle trips they made on the day before the survey. For trips not made by BART, they were simply asked "Could you have taken BART?" (Yes or No).

analysis of the reasons for people's use or nonuse of BART. However, available evidence points to a number of factors currently constraining BART's ridership.

The results of the May 1975 areawide travel survey suggest some of the factors. According to the survey results, a majority (57%) of the traveler population of the BART impact area has tried BART at least once since its opening. However, only a fairly small proportion of those who have tried BART continue to use the System regularly: only 16% of people who have tried BART continue to use it for three or more trips per week.

Reasons for Reduced Use of BART. A large portion of the remaining people (who have tried BART but do not now use it regularly) are people who have tried BART out of curiosity rather than because it represents a viable alternative mode for the trips they usually make. Of those who have tried BART, but have not continued as regular users, about two-thirds said they do not continue to use it regularly for reasons on the theme of "It doesn't go where I want to go."

Among specific BART characteristics mentioned by respondents to the areawide travel survey, unreliability was mentioned most often as the reason for not using BART more frequently. The expense of riding BART, travel time, the shortage of automobile parking spaces at stations, and difficulties in transferring to and from BART were other reasons specified.

The fact that BART does not provide service in the evenings or on weekends was also mentioned by a significant number of travelers as a deterrent to their using the System more.* Respondents to the areawide travel survey were asked if they would "use BART on a more regular basis if it operated on weekends." About two-thirds of all those who have used BART at least once said they would. About one-half of those who have tried BART said they would use BART more regularly if it operated during the evenings.

Many of the factors constraining current BART ridership are also suggested by the data on BART service levels presented in Chapter IV, which provide much of the explanation for why BART is not used as fully as has been predicted in terms of the costs and times of travel by BART relative to bus or automobile.

---

*As noted in Chapter I, BART started weekday evening service in November 1975.

Factors Constraining BART's Transbay Ridership. Further evidence is provided by the results of the October 1974 transbay travel surveys. Table 23 shows the distribution of transbay travel to the "catchment areas" of the 25 East Bay BART stations. Transbay trips by bus and automobile have been assigned to individual BART stations based on the station the travelers said they would use if they were to use BART. Tabulation of the data in this way allows an assessment of the share of the transbay travel market which BART, bus, and automobile carry to each BART station catchment area.

BART's Share of Transbay Journeys for Concord Line Stations. Among the Concord Line stations, BART had the highest share of trips for Concord itself (32%), followed by Pleasant Hill (31%), Orinda (28%), and Lafayette (26%). The percentages for Walnut Creek (19%) and Rockridge (16%) reflected a higher usage of bus--Greyhound in the case of Walnut Creek and AC Transit in the case of Rockridge. Driving from east of the Berkeley Hills to San Francisco involves a long trip through the Caldecott Tunnel and over the Bay Bridge, which is especially trying during rush hours. It might be expected, therefore, that BART would attract a higher proportion of Concord Line travelers from their cars than the 25% share shown in Table 23. For work travel, BART's share was appreciably higher, but nevertheless, large numbers of commuters continued to drive.

In the first place, the figures reflect the fact that BART is operating near the passenger-carrying capacity which can be provided by its currently available stock of cars during peak periods. At the time of the October 1974 transbay surveys, the System's total car availability was about 85 "A" cars and 130 "B" cars. Over the two-hour period 7:00 a.m. to 9:00 a.m., load factors on trains from Concord to San Francisco, measured at MacArthur Station, typically averaged between 1.5 and 2.0 (i.e., as many standing passengers as seated), with occasional trains approaching load factors of 3.0.* Bearing in mind that these are averages over a train which may be as long as nine cars, they represent considerably higher loading levels than many travelers may find acceptable--especially for a journey as long as 40 minutes, the scheduled BART journey time from Concord to Montgomery Street. It is noteworthy that BART's share of travel is appreciably higher from Concord (where seats are available on originating trains) than at stations closer to San Francisco.

A second "capacity constraint" on BART ridership on the Concord Line was imposed by the availability of access to the stations. In October 1974, the automobile provided essentially the only means of access for those beyond walking distance of Concord Line BART stations in Contra Costa County. However, the capacity of BART station parking lots currently

---

*As shown in Table 11 on page 59, load factors have decreased since October 1974.

Table 23

DISTRIBUTION OF TRANSBAY TRAVEL BY MODE
BY EAST BAY BART STATION

East Bay BART Stations	Daily Transbay Trips 6:00 a.m.-8:00 p.m. Percentage Distribution By BART	Bus[a]	Automobile[a]	Total Trips[b]
Concord	32%	3%	65%	7,400
Pleasant Hill	31	11	58	7,500
Walnut Creek	19	13	68	10,800
Lafayette	26	7	67	6,400
Orinda	28	4	68	5,700
Rockridge	16	17	67	8,600
Subtotal--Concord Line Stations	25%	10%	65%	46,400
Richmond	4	8	88	4,200
El Cerrito del Norte	17	27	56	3,600
El Cerrito Plaza	8	19	73	5,700
North Berkeley	8	17	75	5,900
Berkeley	19	16	65	13,900
Ashby	12	9	79	2,700
Subtotal--Richmond Line Stations	13%	16%	71%	36,000
Fremont	46	1	53	2,000
Union City	48	4	48	1,300
South Hayward	45	26	29	700
Hayward	24	7	69	3,400
Bay Fair	24	14	62	2,600
San Leandro	20	18	62	3,800
Coliseum	13	11	76	4,000
Fruitvale	10	16	74	8,300
Subtotal--Fremont Line Stations	21%	13%	66%	26,100
Lake Merritt	15	8	77	4,700
MacArthur	11	18	71	8,700
19th Street Oakland	21	12	67	5,200
12th Street Oakland	20	8	72	7,000
Oakland West	26	4	70	1,400
Subtotal--Oakland Stations	17%	12%	71%	27,100
Total--All Stations	19%	13%	68%	135,600

a. Numbers are total midweek daily transbay person trips made eastbound between 6:00 a.m. and 8:00 p.m. (the hours of BART operation).

b. The distribution of bus and automobile trips among BART stations is made on the basis of the station which survey respondents said they would use if they were to travel by BART (whether or not BART is actually regarded by them as a feasible alternative).

Source: BART Impact Program, October 1974 Survey of Transbay BART Travel.

limits the number of people who can "park-and-ride." As shown in Table 24, the five Concord Line stations east of the Berkeley Hills had parking spaces for 5,400 vehicles, virtually all of which were taken by 9:00 a.m. (and generally much earlier).

BART's Share of Transbay Journeys for Fremont Line Stations. Table 23 shows that BART's share of trips from the station catchment areas at the southern area of the Fremont Line was high (Fremont 46% and Union City 48%), albeit the total number of transbay trips was fairly small. Among other factors, this reflects the fact that AC Transit buses did not serve the area south of the South Hayward BART Station at the time of the survey.

Table 24 shows that the automobile parking lots at all five southernmost stations on the Fremont Line (with a combined parking capacity of 3,800 spaces) were essentially full by 9:00 a.m. As with the Concord Line, this suggests a capacity constraint on BART use by potential park-and-ride trip-makers. As shown in Table 11, peak-period load factors on the Fremont Line are typically well over 1.0, but considerably lower than those on the Concord Line, suggesting that crowding on the trains is a less important factor in deterring ridership on the Fremont Line.

BART's Share of Transbay Journeys for Richmond Line Stations. Relative to either the Concord or Fremont Lines, BART's share of transbay trips from the catchment areas of Richmond Line stations was low, averaging 9% for the Richmond, El Cerrito del Norte, El Cerrito Plaza, and North Berkeley Stations combined. The corresponding bus share of trips from these station areas was 18%, with automobile accounting for the remaining 73%. For the Berkeley and Ashby Station areas, BART's share was slightly higher (18%) than bus (15%), with automobile accounting for 67%.

Table 24 shows that parking lot use at Richmond Line stations was relatively low, especially at Richmond itself; plenty of spaces were generally still available at the end of the morning peak period. Train load factors for Richmond to Fremont trains also indicated relatively little passenger crowding on the trains (see Table 11). However, BART is not operating trains directly from the Richmond Line to San Francisco, requiring transbay passengers to change trains either at the MacArthur Station onto Concord Line trains or at the Lake Merritt Station onto Fremont Line trains. In either case, a transfer onto an already-crowded train is involved. It is likely that this presents a significant deterrent to BART ridership for transbay travelers from the Richmond Line.

Table 24

UTILIZATION OF BART STATION AUTOMOBILE PARKING LOTS AT 9:00 A.M.

BART Station	Parking Capacity	Utilization Before Transbay BART[a]	Utilization After Transbay BART[b]
Concord	1,350	66%	100%
Pleasant Hill	1,337	58	100
Walnut Creek	1,114	94	100
Lafayette	650	95	100
Orinda	939	64	90
Rockridge	776	16	82
Richmond	784	25%	35%
El Cerrito del Norte	985	60	83
El Cerrito Plaza	509	20	83
North Berkeley	500	24	48
Ashby	560	17	28
Fremont	700	99%	100%
Union City	477	92	100
South Hayward	504	82	100
Hayward	696	69	90
Bay Fair	1,408	34	80
San Leandro	1,106	24	39
Coliseum	923	7	10
Fruitvale	730	41	70
Lake Merritt	339	65%	88%
MacArthur	487	20	48
Oakland West	391	--[c]	20
Daly City	820	100%	100%
Total	18,085		

---

a. Before transbay BART utilizations are derived from the average of counts taken on Wednesday, September 4, 1974 and Wednesday, September 11, 1974.

b. After transbay BART utilizations are derived from the average of counts taken on Wednesday, October 30, 1974 and Wednesday, November 6, 1974.

c. Station not open.

Attitudes Toward BART

Further insights into the reasons for use or nonuse of BART are provided by data on traveler attitudes concerning the characteristics of BART, bus and automobile for transbay travel.*

Conceptually, travelers can be considered to choose between BART and other modes on the basis of two kinds of "attitudes" toward the characteristics of the travel alternatives. These are (1) the importance they attach to different travel factors and (2) their relative satisfaction with the levels of the factors for the alternative modes. Thus, the typical traveler chooses BART rather than bus as a function of (among other things) how much more satisfied he is with the comfort of BART relative to bus and how important comfort is to him relative to cost, time, and other factors.

Relative Importance of Factors in Travel Choice. Table 25 presents various factors ranked in the order of their importance in travel choices, (as reported directly by survey respondents).**

Attitudes on factor importance did not noticeably differ between those who had tried BART and those who had not tried BART. This was true for both bus and automobile travelers, except that those who had tried BART and returned to using their automobiles considered seat availability rather more important than either those who had not tried BART or those who had previously driven and changed to BART. This is also true regarding the satisfaction of non-BART travelers with BART characteristics; those who had tried BART had very similar attitudes to those who had not. This suggests that people who do not ride BART are reasonably aware and well-informed about BART as an alternative mode.

---

*The data presented here are derived from the October 1974 Surveys of Transbay Travel, conducted about six weeks after the start of transbay BART service.[10,11] Clearly the attitudes of travelers regarding non-transbay travel may be different. Attitudes may also have changed since the time of the surveys.

**The validity of importance measures obtained by direct questionnaire approaches has been widely questioned. However, it is felt that the results given here are meaningful within the limited context of the present discussion. The rankings shown in Table 25 (and Tables 26 and 27) are derived from mean scale ratings for groups of travelers. Accordingly, there are fairly large variances about the mean estimates for some factors, reflecting differences in the attitudes of individuals in the groups. Moreover, the difference between means is in many cases small. In combination, these influences mean that the relative position of factors within a given ranking is not an exact indicator of the relative strength of attitudes; nor are differences between rankings of less than about three positions in the scale likely to be significant.

Table 25

IMPORTANCE OF TRAVEL FACTORS (IMPEDANCES) IN TRANSBAY TRAVEL CHOICE
(Factors Ranked in Order of Importance)
October 1974

	Current Transbay BART Travelers		Current Transbay Bus Travelers		Current Transbay Automobile Travelers			
	Previously Drove Automobile	Previously Rode Bus	Have Tried BART	Have Not Tried BART	Automobile Drivers	Automobile Passengers	Have Tried BART	Have Not Tried BART
Most Important:	Cost	Total time	Total time	Total time	Flexibility	Total time	Total time	Flexibility
	Comfort	Comfort	Dependability	Dependability	Total time	Flexibility	Flexibility	Total Time
	Total time	Dependability	Seat availability	Seat availability	Multipurpose	Dependability	Dependability	Multipurpose
	Safety	Cost	Waiting time	Cost	Dependability	Waiting time	Multipurpose	Dependability
	Activity en route	Flexibility	Cost	Waiting time	Waiting time	Cost	Waiting time	Waiting time
	Parking space	Waiting time	Walking time	Walking time	Cost	Multipurpose	Cost	Cost
	Dependability	Seat availability	Flexibility	Safety	Activity en route	Security	Activity en route	Activity en route
	Flexibility	Walking time	Comfort	Flexibility	Security	Activity en route	Seat availability	Security
	Walking time	Security	Activity en route	Comfort	Privacy	Waling time	Privacy	Privacy
	Waiting time	Safety	Safety	Security	Walking time	Seat availability	Security	Walking time
	Security	Privacy	Security	Activity en route	Parking space	Parking space	Walking time	Parking space
	Seat availability	Parking space	Parking space	Parking space	Safety	Comfort	Comfort	Safety
	Multipurpose	Multipurpose	Multipurpose	Multipurpose	Seat availability	Privacy	Parking space	Seat availability
Least Important:	Privacy	Activity en route	Privacy	Privacy	Comfort	Safety	Safety	Comfort

Note: The rankings of factor importance are based on the aggregate of the times each factor was mentioned by survey respondents as being either the first, second, third, or fourth most important reason in their choice of mode.

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

The basic factors considered important by travelers do not vary radically as a function of the mode used. Thus, although there are some significant and interesting differences, travel time, cost, and dependability appear at or near the top of the importance rankings for all groups. This lends credibility to the data set as a whole.

BART travelers who previously rode bus were generally very similar in attitude to those who continued to use bus. The two noticeable exceptions were the rankings for comfort, which was considered more important by those who had switched to BART, and seat availability, which was considered more important by those who had not switched. This suggests that the decision of bus travelers to switch to BART is largely dependent on whether or not they obtain a seat on BART.

The differences between the importance ratings for BART travelers who previously drove across the Bay Bridge and those who continued to drive were much more pronounced. Those who had switched to BART considered cost, comfort, safety, and ease of parking relatively important; those who continued to drive emphasized the obvious advantages of the automobile as being important--the flexibility of being able to travel when they want, the ability to combine trip purposes, and not having to spend time waiting.

Comparing the importance rankings of BART travelers according to their previous mode shows the following differences between those who rode the bus and those who drove. Previous automobile travelers considered safety from accidents, the ability to do what they want while traveling, and ease of parking more important. Previous bus travelers, who had become accustomed to these advantages of transit, considered dependability, the time they have to spend waiting, and the chances of obtaining a seat significantly more important than those who previously drove. This is an interesting reflection on the way in which travelers' attitudes are modified by their travel experience.

Finally, it is noteworthy that "security from crime and unpleasant behavior of other people" was listed as relatively unimportant by all transbay traveler groups, along with "feeling of privacy" (even among automobile drivers). Attitudes regarding security may, of course, change when BART begins night service.*

Satisfaction of Travelers with BART. Table 26 shows that satisfaction with BART's comfort, safety, and security was high for all traveler groups, both those who use BART and those who do not. Attitudes among automobile drivers and passengers were also very similar. Apart from these commonalities, a number of differences are noteworthy.

*As noted in Chapter 1, effective November 1975, BART extended service to midnight.

Table 26

SATISFACTION OF TRANSBAY TRAVELERS WITH BART
(Factors Ranked in Order of Satisfaction with BART)
October 1974

	Current Transbay BART Travelers			Current Transbay Automobile Travelers	
	Previously Drove Automobile	Previously Rode Bus	Current Transbay Bus Travelers	Automobile Drivers	Automobile Passengers
Most Satisfied:	Comfort	Comfort	Comfort	Comfort	Comfort
	Safety	Security	Security	Safety	Safety
	Security	Safety	Safety	Parking space	Parking space
	Walking time	Walking time	Walking time	Seat availability	Security
	Cost	Activity en route	Activity en route	Activity en route	Seat availability
	Activity en route	Flexibility	Parking space	Security	Activity en route
	Seat availability	Parking space	Privacy	Cost	Walking time
	Parking space	Cost	Flexibility	Walking time	Cost
	Total time	Total time	Multipurpose	Privacy	Dependability
	Dependability	Multipurpose	Cost	Dependability	Privacy
	Privacy	Privacy	Seat availability	Total time	Flexibility
	Flexibility	Dependability	Dependability	Flexibility	Total time
	Multipurpose	Waiting time	Total time	Waiting time	Waiting time
Least Satisfied:	Waiting time	Seat availability	Waiting time	Multipurpose	Multipurpose

Note: The rankings of satisfaction with BART's factors are based on the mean of satisfaction ratings given by respondents for each factor. (Ratings were recorded on a 7-point linear semantic scale from "very satisfied" to "very dissatisfied".) Thus, for example, BART travelers who previously rode the bus gave on average the lowest (least satisfied) rating to the seat availability factor in their BART trip.

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

BART travelers who previously rode the bus and current bus travelers had basically similar attitudes towards BART's characteristics. The only significant difference is that current bus travelers were less satisfied with BART's travel time than those who changed to BART; but this should come as no surprise given that the bus trips would, on the average, take 11 minutes (23%) longer by BART. Among the characteristics of BART with which both of these groups were the least satisfied are the chances of obtaining a seat on BART, its dependability, and associated with this, the time spent waiting.

Automobile travelers and those who diverted from automobile to BART also had very similar attitudes toward BART, with one noticeable difference: Those who rode BART (and used their automobile to travel to the BART station) were much less satisfied with the ease of finding a place to park than were those who did not use BART. As might be expected, both previous and current automobile travelers rated "travel time flexibility" and "ability to combine trip purposes" poorly for BART. They were also dissatisfied with the dependability of BART and the associating waiting time.

<u>Travelers' Satisfaction with BART Relative to Alternative Modes.</u> The satisfaction ratings given in Table 27 show the attitudes of travelers towards BART relative to their alternative mode—either used now or previously. These rankings show some significantly different patterns from the corresponding rankings shown in Table 26.

For those who either previously rode or currently ride the bus, BART was perceived as being significantly more comfortable. Safety, security, flexibility to travel when you want, and the ability to combine different trip purposes were also rated highly (although BART's security and safety were rated higher by bus travelers than by those who actually rode BART). BART was perceived as considerably less attractive than bus with regard to seat availability, dependability, and the waiting time required. Those who rode the bus were much less satisfied with trip travel time on BART relative to bus than were those who rode BART. But the cost of the BART trip relative to bus was not perceived as being significantly different by either group.*

For both travelers who drove or used BART and drove previously, BART was perceived as being more attractive than automobile primarily with regard to cost, safety from accidents, comfort, the ability to find a place to park, and the opportunity to do what you want while traveling. BART was viewed in relative terms as being least attractive in the freedom it allowed for travel when one wants to combine trips, privacy, waiting time, and dependability. Satisfaction with total travel time, the time spent walking, and security were not perceived very differently.

*The recent BART fare increase (see Chapter [illegible]) may, however, have changed this perception.

Table 27

SATISFACTION OF TRANSBAY TRAVELERS WITH BART RELATIVE TO ALTERNATIVE MODES
(Factors Ranked in Order of Relative Satisfaction with BART)
October 1974

	Current Transbay BART Travelers			Current Transbay Automobile Travelers	
	Previously Drove Automobile	Previously Rode Bus	Current Transbay Bus Travelers	Automobile Drivers	Automobile Passengers
Most Satisfied:	Cost	Comfort	Comfort	Safety	Safety
	Safety	Flexibility	Security	Cost	Parking space
	Activity en route	Multipurpose	Safety	Comfort	Comfort
	Parking space	Walking time	Multipurpose	Parking space	Cost
	Comfort	Total time	Flexibility	Security	Activity en route
	Total time	Security	Privacy	Activity en route	Security
	Walking time	Safety	Parking space	Walking time	Total time
	Security	Cost	Activity en route	Total time	Dependability
	Dependability	Activity en route	Cost	Seat availability	Walking time
	Waiting time	Parking space	Walking time	Dependability	Seat availability
	Seat availability	Waiting time	Waiting time	Privacy	Flexibility
	Privacy	Privacy	Total time	Waiting time	Waiting time
	Multipurpose	Dependability	Dependability	Flexibility	Privacy
Least Satisfied:	Flexibility	Seat availability	Seat availability	Multipurpose	Multipurpose

Note: The rankings are based on relative factor satisfaction ratings obtained by subtracting the mean of the satisfaction ratings for the bus or automobile mode (either current or previous) from the mean ratings used in Table 26. Thus, for example, for those BART travelers who previously drove, the difference of the average rating for the cost of travel on BART minus the average rating for the cost of travel for automobile was the largest (most favorable to BART) of 14 factors.

Source: BART Impact Program, October 1974 Surveys of Transbay Travel.

VI. BART IMPACTS ON BUS AND AUTOMOBILE TRAVEL

Previous Mode of BART Travelers

Table 28 shows the previous mode of travel for BART travelers surveyed in the May 1973 BART Passenger Profile Survey, the May 1974 BART Passenger Profile Survey, and the October 1974 BART Impact Program Survey of Transbay BART Travel.* The first of these surveys (May 1973) was conducted when only the Fremont-Richmond service was in operation. The May 1974 survey was conducted when all lines were in operation with the exception of the transbay link. (Table 28 shows the previous mode for May 1974 East Bay and San Francisco Line travel separately.) The October 1974 survey covered only transbay travel.

As shown by the 1973 survey, the distribution of prior mode for BART travel in the East Bay was 56% automobile, 27% bus, 14% "did not make trip before", and 3% other. As shown by the 1974 survey, the prior mode for East Bay BART trips was 50% automobile, 24% bus, 24% "did not make trip before", and 2% other. Changes in home and work locations account for some proportion of trips reported as not having been made before the start of BART service. Of course, changes in home and work location continued in the year between the two surveys, accounting for the increased percentage of trips reported as not made previously. Taking this into account, the results of these two surveys are consistent. Comparing them with the transbay results shows that transbay BART ridership has been diverted from bus to a much greater extent than has been the case for East Bay BART trips. This reflects (1) the higher proportion of total trips previously being made by transit in the transbay corridor than in the East Bay; (2) the longer trips being made across the often-congested Bay Bridge--which make transfer to, and the higher cost of, BART more acceptable to travelers; and (3) the generally good bus service already provided by AC Transit in most of the central areas of the East Bay served by BART.

Comparing the previous modes of transbay BART travelers with the previous modes of BART travelers within San Francisco (as indicated by the May 1974 passenger profile survey) shows very close distributions. These results indicate the way in which both transbay BART and the San Francisco Line provide transit service in corridors where use of existing transit services was already high.

---

*See notes following Table 16 for description of these surveys. The sampling design of the May 1973 Passenger Profile Survey is similar to that of the May 1974 survey.

Table 28

PREVIOUS MODE FOR BART TRAVEL

Mode	East Bay BART Travel[a] May 1973	East Bay BART Travel[a] May 1974	San Francisco BART Travel May 1974	Transbay BART Travel[b] October 1974
Bus or Streetcar	27%	24%	55%	54%
Automobile[c]	56	50	30	35
Other Modes	3	2	4	--
Did Not Make Trip Before	14	24	11	11
Total	100%	100%	100%	100%
(Actual number of trips)[d]	(24,900)	(40,700)	(25,400)	(51,500)

a. Source: BARTD Office of Research, May 1973 and May 1974 BART Passenger Profile Surveys. Data were not weighted to account for differential response rates by time of day or location.

b. Source: BART Impact Program, October 1974 Survey of Transbay BART Travel. Data were weighted to account for differential response rates by time of day and location.

c. Includes motorbike or motorcycle.

d. Average daily one-way BART trips at the time of the surveys.

Comparisons of Previous Transbay Travel Mode by Trip Purpose. Comparison of the previous mode for the two trip-purpose categories shown in Table 29 indicates that the diversion of travel from bus was much higher for trips between work and home than for other purposes. Thus, 63% of all trips made on BART between work and home were previously made by bus. Only 34% of BART trips made for other purposes were previously made by bus. Correspondingly, the percentage of BART trips previously made by automobile was much lower for travel between work and home (29%) than for other purposes (49%).

Comparisons of Previous Transbay Travel Mode Among BART Lines. In October 1974, a large part of transbay BART ridership (about 44%) was to or from the Concord corridor. Of these trips, about 62% were previously made by bus, and of these most were made by Greyhound to or from Contra Costa County. The fact that the diversion from bus in the Concord corridor was proportionately greater than for the other lines reflects the way in which BART's Concord Line closely parallels the previous Greyhound services. Like BART, Greyhound generally provided service only to and from central stations, necessitating the use of a separate access mode and a transfer for most travelers. However, because of the congestion encountered by buses in the Caldecott Tunnel and on the Bay Bridge, BART offered an appreciably faster line-haul journey. The generally higher-income travelers residing in the Concord corridor were also probably more willing to pay the additional cost of the higher quality BART service.

BART's Impacts on Transit Travel

Total Travel by Transit in the BART Impact Area. Figure 20 shows total ridership on five of the major transit properties in the San Francisco Bay Area over the three years from May 1972 until May 1975. San Francisco Municipal Railway (MUNI), Alameda-Contra Costa County Transit District (AC Transit), and Greyhound bus services are described in Chapter II. Golden Gate Transit provides bus service within Marin County and from Marin County via the Golden Gate Bridge to downtown San Francisco. Although Golden Gate Transit's ridership is drawn entirely from outside the BART impact area, it is shown here for comparison.

In May 1975, average weekday ridership on all services of MUNI was about 364,000 trips (51% of the total carried by all the services shown in Figure 20). Ridership on all of AC Transit's services was about 192,000 trips per weekday (27% of the total); Golden Gate Transit carried about 34,000 trips per weekday (5%); and Greyhound carried about 3,000 (1%). BART's average daily ridership in May 1975 was about 118,000 (16% of the total transit ridership).

Table 29

PREVIOUS TRAVEL MODE OF TRANSBAY BART TRIPS[a]

Transbay Trips Made Before BART by	Destination of Travel[b]				Total	Purpose of Travel	
	Concord Line BART Stations (6 stations)	Richmond Line BART Stations (6 stations)	Fremont Line BART Stations (8 stations)	Oakland BART Stations (5 stations)		Trips between Work and Home	Trips for All Other Purposes
Bus	7,100 62%	2,400 51%	2,500 47%	2,000 44%	14,000 54%	11,300 63%	2,700 34%
Drove Car Alone	2,200 19%	1,300 28%	1,900 34%	1,700 40%	7,100 27%	3,700 21%	3,400 42%
Traveled by Car with Others	1,000 9%	300 5%	600 10%	200 5%	2,100 8%	1,500 8%	600 7%
Did Not Make Trip Before	1,100 10%	700 16%	500 9%	600 11%	2,900 11%	1,500 8%	1,400 17%
Total	11,400 100%	4,700 100%	5,500 100%	4,500 100%	26,100 100%	17,900 100%	8,200 100%

a. Midweek daily transbay person-trips made eastbound between 6:00 a.m. and 8:00 p.m. (the hours of BART operation).
b. Stations are grouped as shown in Table 24.

Source: BART Impact Program, October 1974 Survey of Transbay BART Travel.

Figure 20 confirms that BART has, since the start of operations in September 1972, captured a large portion of transit ridership in the Bay Area. Figure 20 also shows that over the past three years, despite the diversion of large numbers of riders to BART, ridership on other transit services has generally been increasing; at least the downward trend in ridership of the past two decades has been halted. In large part, this increase in ridership reflects the steadily increasing subsidy of transit which has allowed fares to remain low over the period when other prices--particularly the price of gasoline--have risen sharply. These trends have served to give transit a significantly increased price advantage relative to the cost of driving. The changes in bus ridership over the past three years also reflect changes in the services provided.

BART's Impacts on Transbay Bus Ridership. BART's greatest impacts on bus ridership have been in the transbay travel corridor between San Francisco and Oakland, where well over half the BART riders diverted from bus. In June 1974 (before the AC Transit strike), average weekday transbay ridership on AC Transit was about 63,000 trips per day. In October 1974, transbay ridership fell to about 43,000 trips per day, and in June 1975, weekday ridership averaged only 36,000 trips.*

A sharp drop in ridership on Greyhound's commuter bus services from central Contra Costa County to San Francisco also took place when BART started transbay service. In June 1974, Greyhound's average daily ridership on their transbay commuter routes was over 12,000 trips per day. Ridership on these services, which very closely parallel BART service on the Concord Line, fell to under 3,000 by June 1975.

BART's Impact on East Bay Bus Ridership. In the East Bay, AC Transit bus services both parallel and act as feeder services to the Fremont and Richmond BART Lines. Therefore, changes in aggregate bus ridership on all services can only give an imprecise indication of BART's impacts. In April 1972, before BART was operating, the East Bay bus routes of AC Transit carried 126,000 trips per weekday. In April 1973, after the Fremont and Richmond BART Lines started service, ridership fell to 108,000 trips per weekday, suggesting that diversion from bus to BART more than offset new trips using AC Transit as a feeder service to BART. In April 1974, shortly after the gasoline shortages associated with the Arab oil embargo, East Bay AC Transit ridership rose to 125,000 trips per weekday, and in April 1975 to 146,000. The latter figure includes an average

---

*A more complete analysis of BART's impacts on transbay travel by all modes is given later in this chapter.

weekday ridership of over 2,000 trips on the "BART Express" services operated by AC Transit to BART stations from the far northern and eastern areas of Alameda and Contra Costa Counties.

Growth in AC Transit ridership over the year, April 1974 to April 1975, occurred on many lines of the network--some of them remote from BART, some paralleling BART lines, and some acting as connecting services to BART. Only on a few lines can changes in bus ridership be attributed to the start of BART service.

Ridership on AC Transit Routes 31 and 33, which parallel the Richmond BART Line from Richmond to Oakland, was reduced from 3,900 trips per weekday on average in April 1972 (before the start of service on the Richmond Line) to 2,200 trips per weekday on average in April 1973 (after the start of Richmond Line service). The combined ridership on AC Transit Routes 40, 41, and 43, which also parallel the Richmond Line between Berkeley and Oakland, averaged 16,200 trips per weekday in April 1972. In April 1973, ridership had decreased to 15,000 trips per day. However, in April 1974 ridership had again risen to 17,200 trips per day and in April 1975 it was 18,700 trips per day. These figures confirm that large numbers of riders diverted from bus to BART when the Richmond Line opened. However, they also suggest that the reduction in bus ridership caused by BART was small relative to the subsequent increases in ridership caused by other influences.

Experience on AC Transit's routes paralleling the Fremont BART Line has been similar. The combined ridership on Routes 80, 81, 82, and 83, connecting Hayward and Oakland, was 17,200 trips per weekday in April 1972 (before the start of service on the Fremont Line). In April 1973, after the start of Fremont Line service, ridership had fallen to 15,100 trips per weekday on average. However, in April 1974, ridership on the four routes had risen to 17,700 trips, and in April 1975, it was 18,400 trips per weekday. Again, over the period since BART's opening, diversion of ridership to BART from parallel bus services appears to have been more than offset by increases in bus ridership due to other causes.

<u>BART's Impacts on San Francisco Bus Ridership</u>. As shown in Figure 20, total ridership on San Francisco MUNI has exhibited a generally upward trend over the period shown--which includes the start of service on the San Francisco BART Line in November 1973.

In the first quarter of 1973, MUNI ridership averaged about 317,000 trips per weekday. In the first quarter of 1974 (following the start of San Francisco Line service), MUNI ridership had increased to 336,000 trips per weekday in total. In the first quarter of 1975, ridership had again risen to about 35[illegible],000 trips per weekday. About 55% of San Francisco BART travelers surveyed in the May 1974 Passenger Profile Survey had diverted to BART from bus or streetcar. However, this diversion from parallel routes has clearly been offset by the use of MUNI as a feeder to BART and, more significantly, by increased bus usage because of other reasons.

In short, BART's impacts on total bus ridership are not detectable in the context of the trend towards generally increasing bus ridership. Indeed, available data show a significant drop in MUNI ridership on only three lines paralleling the San Francisco BART Line: Route 26 (both local and express services) which parallels BART for its whole length in San Francisco; Route 14 which runs the length of Mission Street; and the Route 17 express services to downtown San Francisco on Interstate 280. Ridership on the first two lines dropped by about 50% when BART started service; ridership on Route 17 dropped by about 25%.

BART's Impacts on Automobile Travel

Factors Changing Travel Patterns. BART's impacts on travel by all modes, and especially travel by automobile, must be considered in the context of other influences affecting travel patterns over the period since September 1972 when BART service started. Long-term changes in highway traffic have been brought about by the growth of the urban area, its population, economy, and automobile ownership. The past trend in traffic growth caused by these influences has been recently modified by the gasoline shortages of early 1974 and associated increases in gasoline prices. The start of service on the lines of the BART System has changed highway traffic volumes, as have other events, including transit strikes and the opening of new highway facilities. Variations about the trend have also occurred as a function of the month of the year, reflecting vacation patterns and seasonal business cycles. Finally day-to-day variations in travel have occurred as a function of the day of the week, the weather, public holidays, and so on.

Gasoline Price and Availability. The gasoline shortage in 1974 and the associated rise in gasoline prices are among the most important influences on automobile travel. Figure 21 shows two time series of (regular) gasoline prices: one estimated for a sample of gas stations in San Francisco County and published by Oil and Gas Journal; the other published by the U.S. Department of Commerce for the five-county San Francisco-Oakland Standard Metropolitan Statistical Area (SMSA). These time series show that the price of gasoline in San Francisco in September 1972, when the first BART line opened, was about $0.37 per gallon. The price remained at about this level until the summer of 1973, but in the six months from September 1973 to March 1974, it rose from $0.38 per gallon $0.51 per gallon according to San Francisco County estimates, an increase of about 35%. The SMSA figures show a similar percentage increase in prices to $0.54 per gallon in March 1974. By May 1975, the SMSA price had risen to $0.58 per gallon--an increase of over 50% on the price two years earlier.

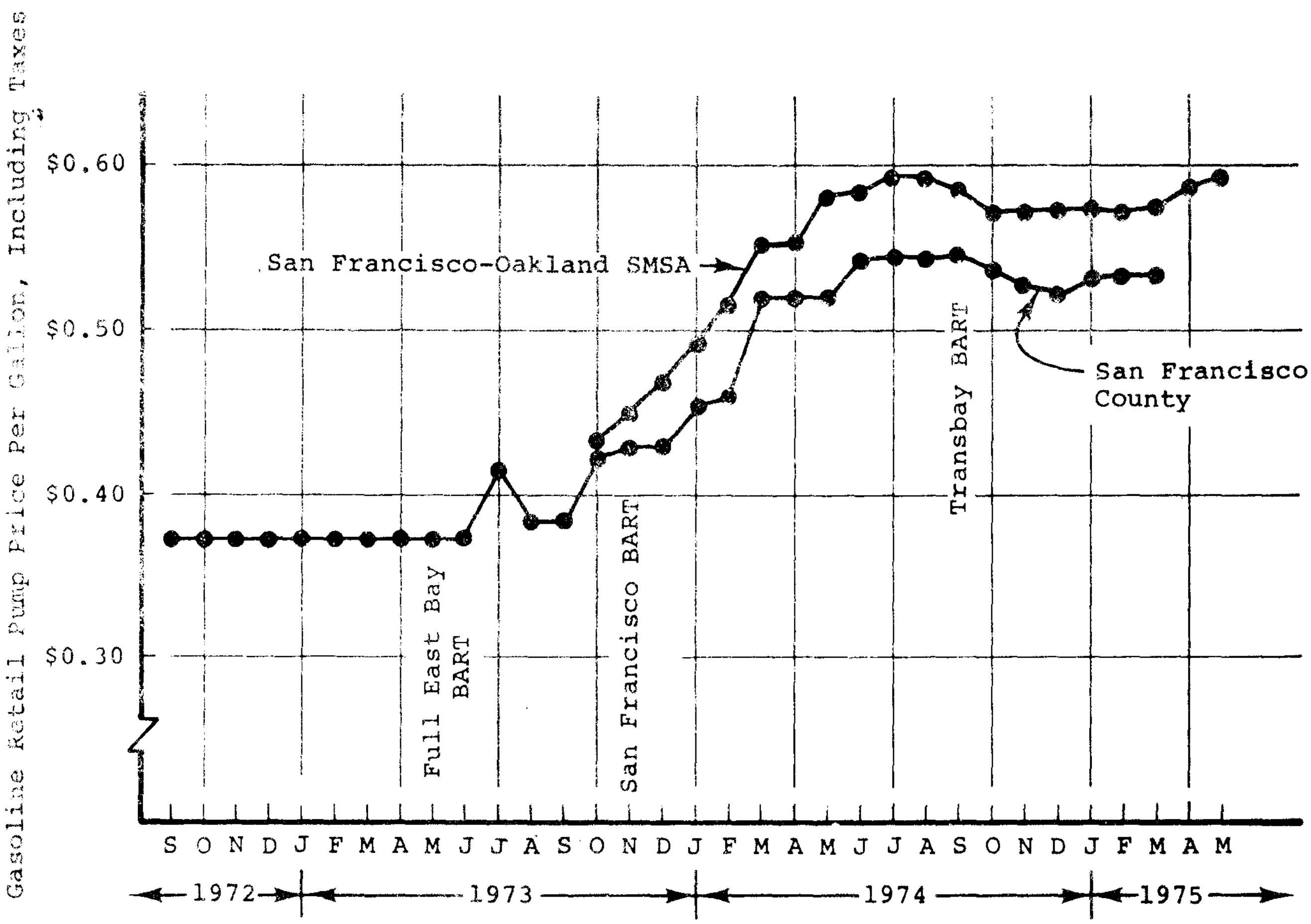


FIGURE 21

CHANGES IN GASOLINE PRICES, SAN FRANCISCO COUNTY AND
SAN FRANCISCO-OAKLAND METROPOLITAN AREA, SEPTEMBER 1972 - MAY 1975

Sources: * Oil and Gas Journal (San Francisco County).
* U.S. Department of Commerce (San Francisco-Oakland SMSA).

Vehicle Registrations. As discussed in Chapter II, the population of the Bay Area as a whole increased over the period 1970 through 1974, as did per capita income. These increases are reflected in increased vehicle registrations over the year 1970 to 1973. (Over this period, automobile registrations increased at an appreciably greater rate than did population.) In Alameda, Contra Costa, and San Francisco Counties, automobiles registered in 1970 totaled 1,082,000; in 1971 the figure was 1,112,000, an increase of 3% over 1970. In 1972, automobile registrations in the three counties totaled 1,140,000, an increase of 3% over 1971; and in 1973, they totaled 1,163,000, an increase of 2% over 1972.

However, although population in the three counties overall continued to increase, automobile registrations in 1974 dropped to 1,154,000, a 1% reduction from 1973. This reduction reflects both the effects of increased gasoline prices and a general economic recession. As is shown later in this chapter, the increase in automobile registrations between 1970 and 1973 correlates with an upward trend in highway traffic over that period, and the drop in automobile registrations in 1974 correlates with reduced highway traffic volumes.

Vehicle Traffic on the San Francisco Bay Bridges

In an attempt to isolate BART's impacts on highway traffic levels from the influences of other factors, traffic volumes on the four major bridges across San Francisco Bay were analyzed. The four bridges, whose locations are shown in Figure 22, are the San Francisco-Oakland Bay Bridge, the San Mateo-Hayward Bridge, the Richmond-San Rafael Bridge, and the Golden Gate Bridge.

The most important is the San Francisco-Oakland Bay Bridge (generally referred to as the Bay Bridge). Typically, over 90,000 vehicles per day travel on the five lanes of the bridge in each direction. BART service through the Transbay Tube parallel to the Bay Bridge was expected to have major impacts on this traffic volume.

The Golden Gate Bridge connects San Francisco to the residential areas of Marin County, and like the Bay Bridge, it carries high volumes of commuter traffic to and from the City. Typically, over 50,000 vehicles per day cross the bridge in each direction. Since there is no reason to suppose that BART has affected traffic volumes on the Golden Gate Bridge, it forms a logical control site with which to compare Bay Bridge traffic volumes.

The San Mateo-Hayward Bridge and the Richmond-San Rafael Bridge carry about 15,000 and 10,000 vehicles per day in each direction, respectively--much lower traffic volumes than the San Francisco-Oakland and Golden Gate Bridges. Nevertheless. comparing them with the Bay Bridge is useful since (1) the BART Fremont Line is a possible alternative to the San Mateo-Hayward Bridge for some travel from southern Alameda County

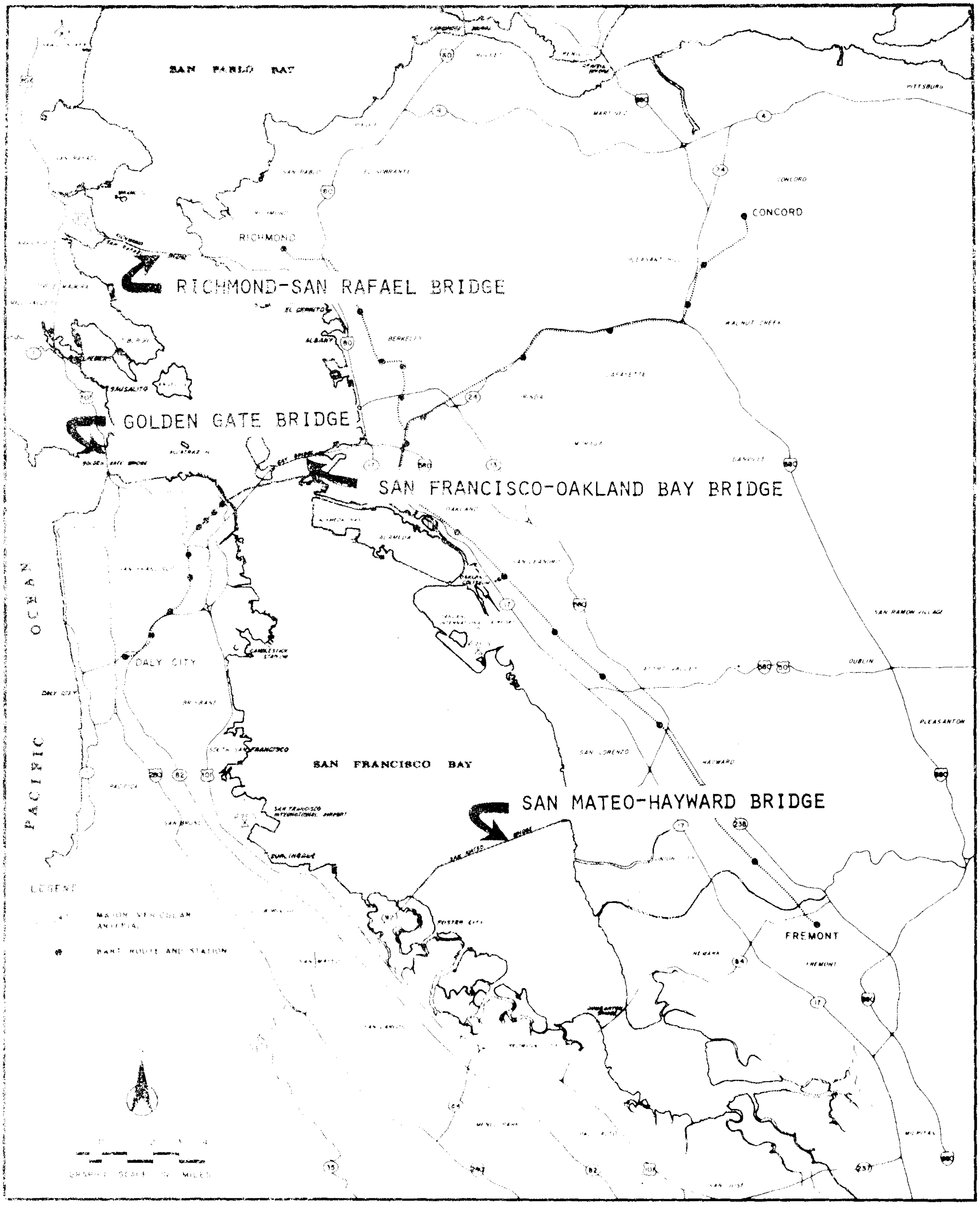


FIGURE 22

HIGHWAY BRIDGES ACROSS THE SAN FRANCISCO BAY to San Francisco; and (2) traffic on the Richmond-San Rafael Bridge is essentially unaffected by BART, making it another "control site."

Traffic volumes on the four bridges are particularly amenable to analysis since they are toll bridges and keep continuous and consistent records of traffic volumes on a day-to-day basis. Therefore, a much more precise time-series analysis of traffic volumes was possible than for other highway facilities where only infrequent counts have been taken.

Long-Term Trends in Traffic Volumes. As is illustrated by Figures 23 and 24, until the fall of 1973, when the "gasoline crisis" first became apparent, traffic on the San Francisco-Oakland Bay Bridge and the Golden Gate Bridge had increased steadily for several years.* For the Bay Bridge, the linear trend line for the four years from October 1969 to September 1973 (just before the first major gasoline price increases) shows a rate of increase of 1,800 vehicles per midweek day each year. This is an annual increase of 2.0% of the mean traffic volume for the whole period (88,300 vehicles per day). On the Golden Gate Bridge, the corresponding annual rate of increase over the four years to September 1973 was 1,100 vehicles per day, an annual increase of 2.4% of the mean midweek traffic volume over the period (46,800 vehicles per day).

Traffic on the San Mateo-Hayward and Richmond-San Rafael Bridges also increased steadily over the four-year period to September 1973, but at much higher percentage rates. On the San Mateo-Hayward Bridge, the annual increase in midweek traffic was about 900 vehicles per day (6.0% of the four-year mean). On the Richmond-San Rafael Bridge, the rate of increase was about 800 vehicles per day (8.4% of the four-year mean).

Seasonal Variations in Traffic Volumes. Figures 23 and 24 also show the marked variations in bridge traffic volumes above and below the trend that occur as a function of the month of the year. The Golden Gate Bridge shows a particularly consistent recurrent seasonal pattern, with traffic volumes typically varying between a maximum in August (at about 4,300 vehicles per day above the trend line) and a minimum in

*The data shown in Figures 23 and 24 are averages of midweek (Tuesday, Wednesday, and Thursday) traffic volumes. These data were selected for analysis because traffic volumes on these days generally show very much smaller day-to-day fluctuations than do data for Mondays and Fridays. Data for public holidays (where they fell on a Tuesday, Wednesday, or Thursday) and for Tuesdays or Thursdays adjacent to long holiday weekends were also excluded so as to minimize extraneous influences.

SAN FRANCISCO-OAKLAND BAY BRIDGE

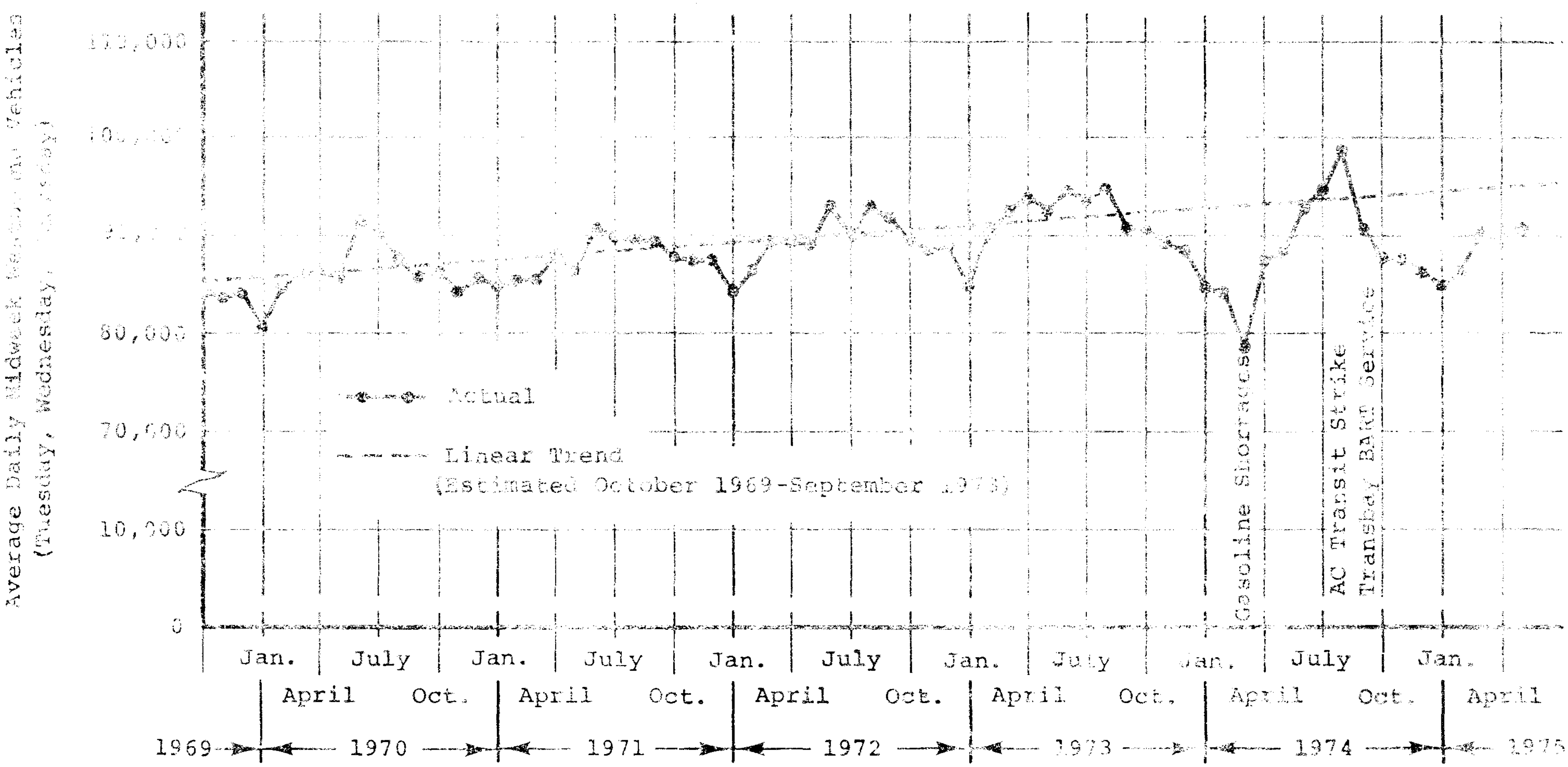


FIGURE 23

AVERAGE DAILY MIDWEEK TRAFFIC ON THE SAN FRANCISCO-OAKLAND BAY BRIDGE, OCTOBER 1969-MAY 1975

Source: • CALTRANS Toll Bridge Administration, Daily Totalizer Volume Counts.

January (at about 3,900 vehicles per day below the trend). The other three bridges all show similar patterns of variation. Traffic levels are high in the summer, low in winter, and close to the mean in the spring and fall months of April, May, September, and October.

Projections of Traffic on the Basis of Trend and Seasonal Components

Separate estimates of linear trend and monthly seasonal components of traffic volume were made for each of the four bridges using a multiple linear regression model. The models were estimated using data for the 48 months from October 1969 to September 1973.* As a means of taking the underlying trend and seasonal components of traffic variation into account and so allowing the impacts of BART and other factors on bridge traffic volumes to be assessed, these "trend plus seasonal" regression functions were used to "project" traffic volumes for the period from October 1973 to May 1975. These projections represent the traffic volumes which would have arisen if the trend and seasonal patterns of the previous four years had continued unchanged. In other words, the projections represent "what might have been" had factors such as BART and the gasoline crisis not disrupted travel patterns. Differences between the actual traffic volumes and the values projected by the regression model represent traffic volumes which must be explained by factors other than trend and seasonal influences.

Figures 25, 26, 27, and 28 show the actual and projected traffic volumes for, respectively, the San Francisco-Oakland Bay Bridge, the Golden Gate Bridge, the San Mateo-Hayward Bridge, and the Richmond-San Rafael Bridge. In each case, traffic volumes are shown from January 1972 through May 1975.** The difference between the actual and projected traffic volumes from October 1973 onward is emphasized as a shaded area.

---

*Details of the model formulation and estimations will be reported in a forthcoming report of the TSTB Project.

**It is noteworthy that for all four bridges, the estimated traffic volumes shown from January 1972 through September 1973 (the latter part of the period used in estimating the regression function) conform very closely to the actual data throughout the period. This confirms that, before October 1973, the "trend plus seasonal" model provides a very good explanation of aggregate traffic volumes. It thereby lends credibility to the underlying assumption of the analysis that projection of the function forward provides a meaningful "baseline" with which to compare actual traffic levels.

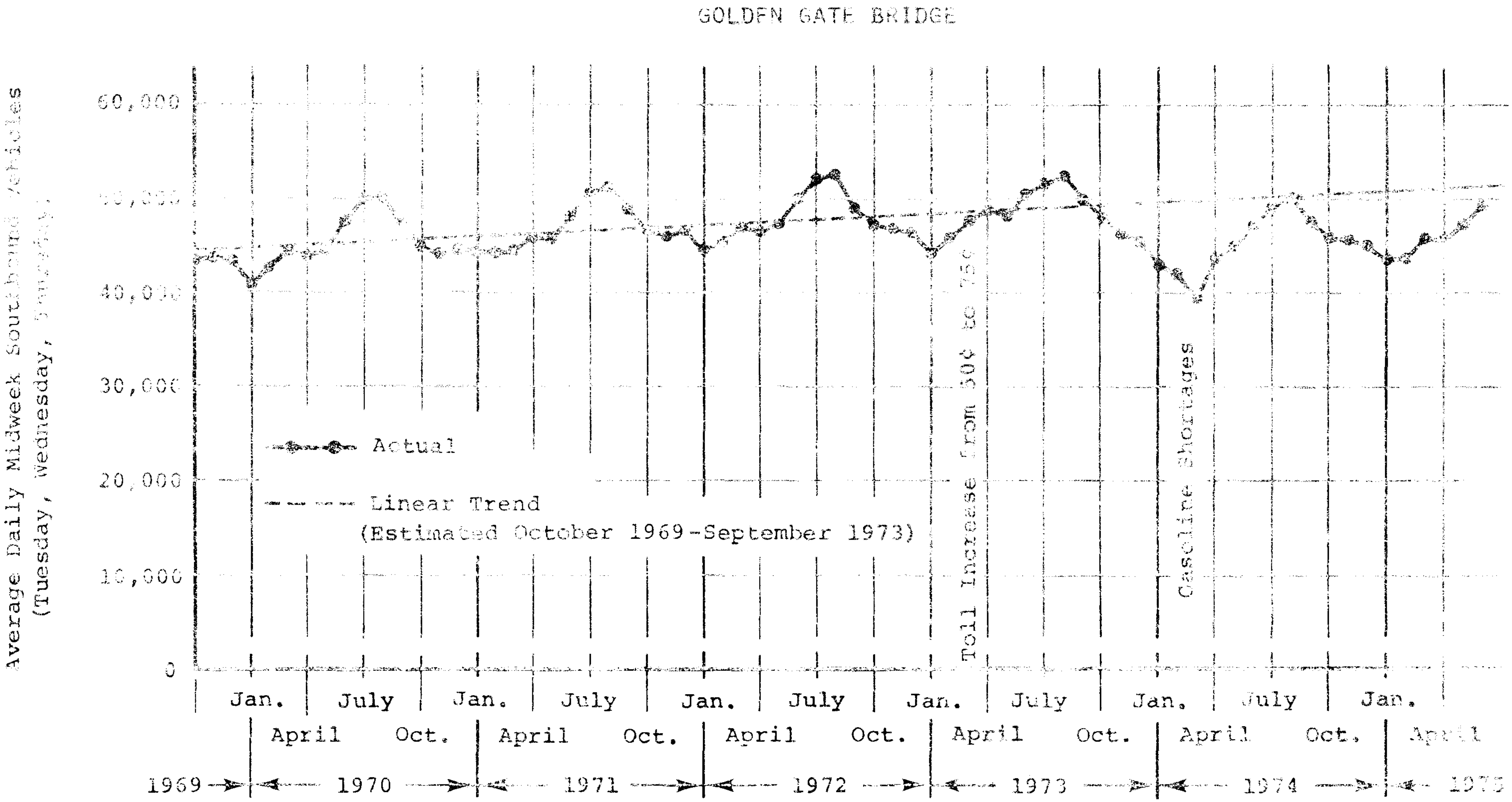


FIGURE 24

AVERAGE DAILY MIDWEEK TRAFFIC ON THE GOLDEN GATE BRIDGE, OCTOBER 1969 - MAY 1975

Source: ● Golden Gate Bridge Highway and Transportation District, Summary Vehicle Counts.

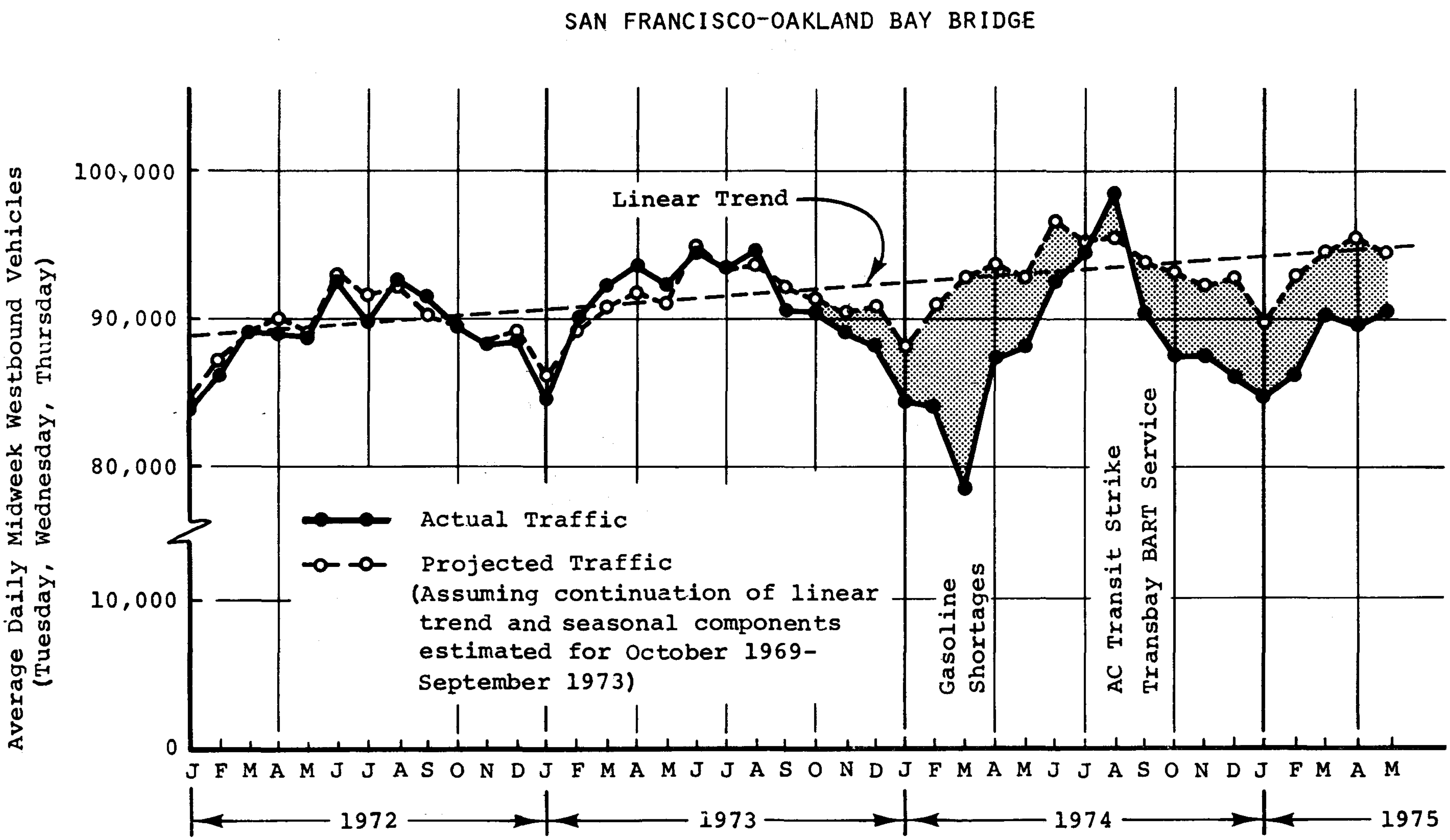


FIGURE 25

ACTUAL AND PROJECTED MIDWEEK TRAFFIC ON THE SAN FRANCISCO-OAKLAND BAY BRIDGE, JANUARY 1972-MAY 1975

Sources:
- CALTRANS Toll Bridge Administration, Daily Totalizer Volume Counts.
- Peat, Marwick, Mitchell & Co. Analysis.

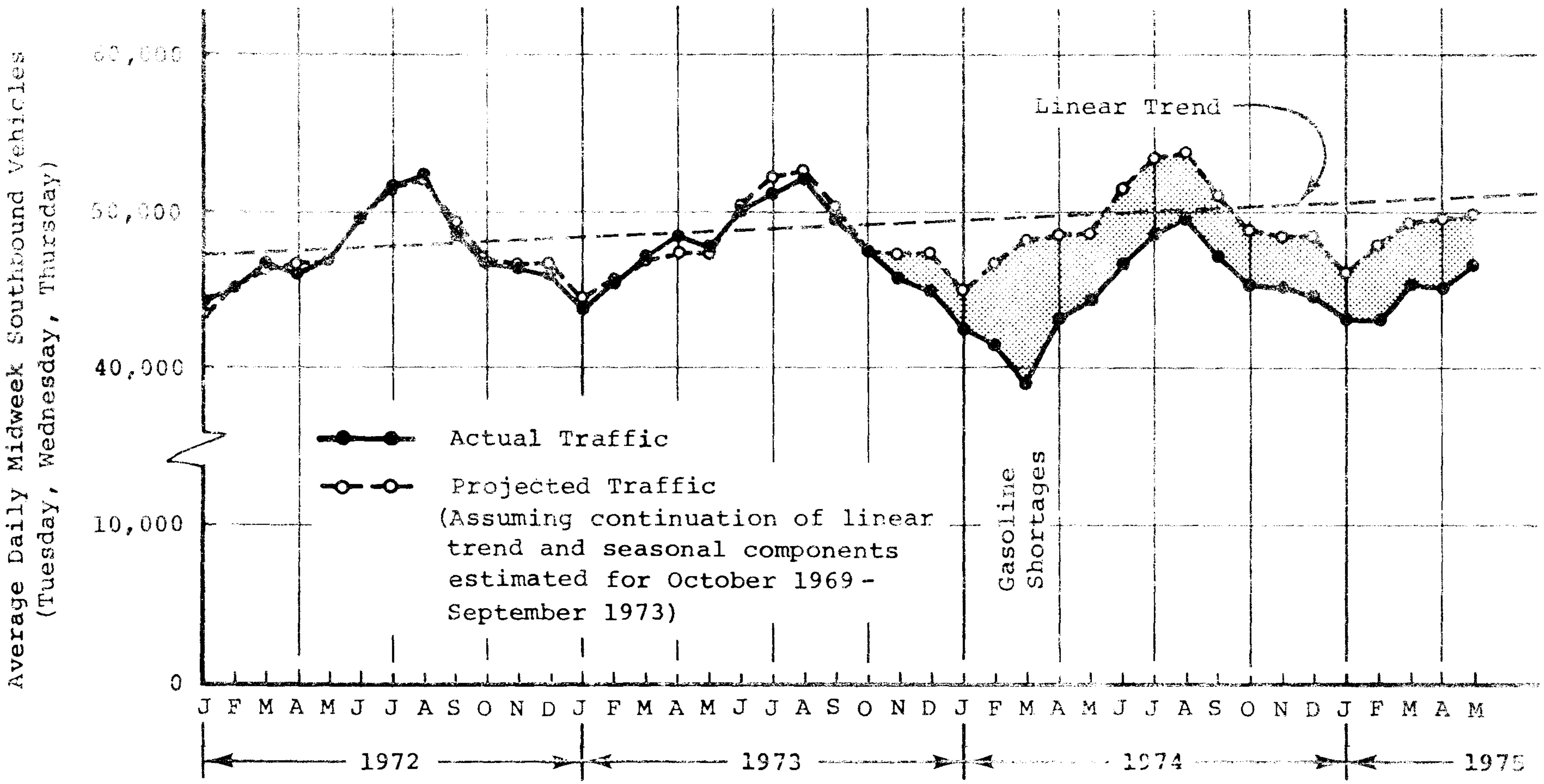


FIGURE 26

ACTUAL AND PROJECTED MIDWEEK TRAFFIC ON THE GOLDEN GATE BRIDGE, JANUARY 1972 - MAY 1975

Sources:
- Golden Gate Bridge Highway and Transportation District, Summary Vehicle Counts.
- Peat, Marwick, Mitchell & Co. Analysis.

SAN MATEO-HAYWARD BRIDGE

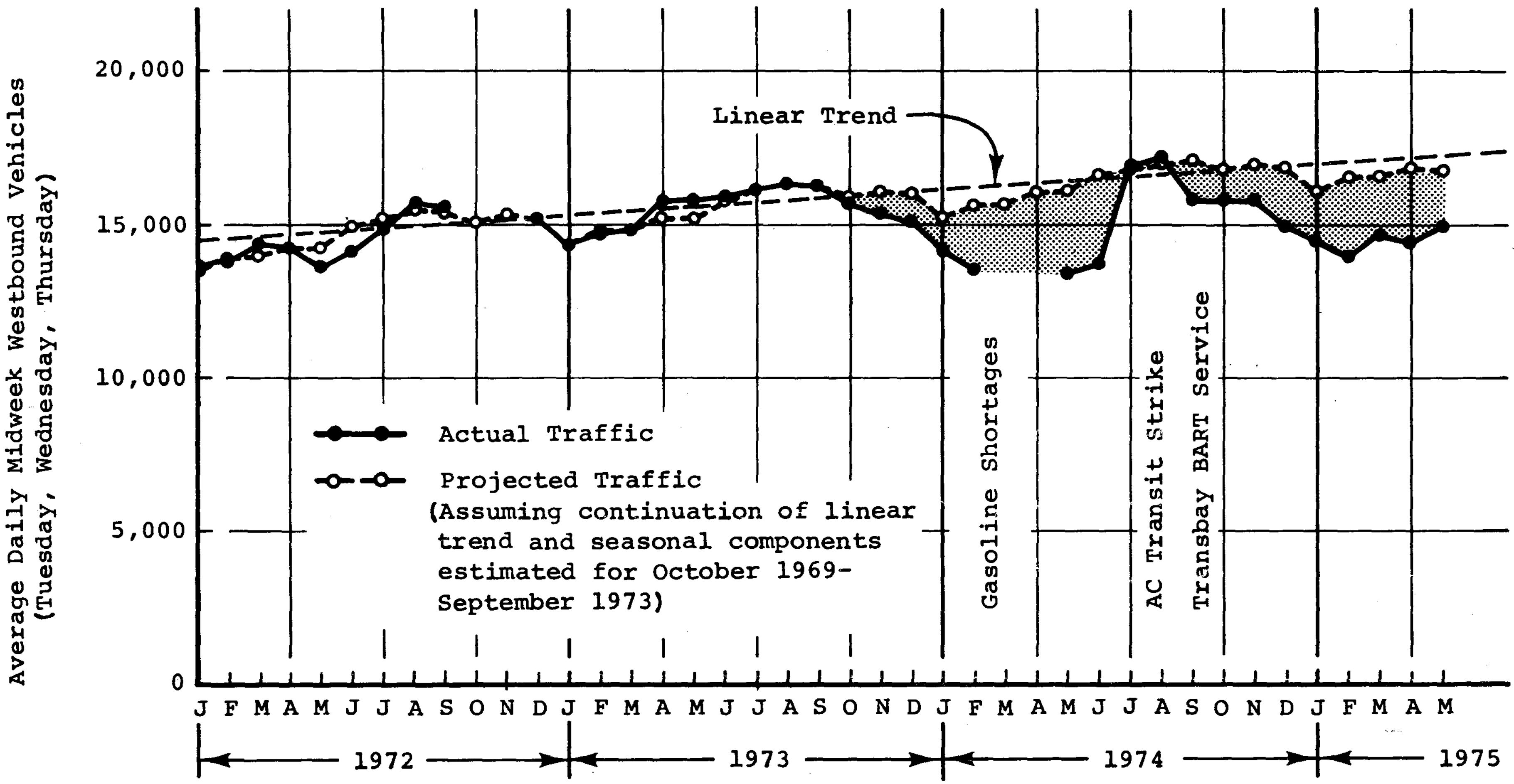


FIGURE 27

ACTUAL AND PROJECTED MIDWEEK TRAFFIC ON THE SAN MATEO-HAYWARD BRIDGE, JANUARY 1972-MAY 1975

Sources:
- CALTRANS Toll Bridge Administration, Daily Totalizer Volume Counts.
- Peat, Marwick, Mitchell & Co. Analysis.

RICHMOND-SAN RAFAEL BRIDGE

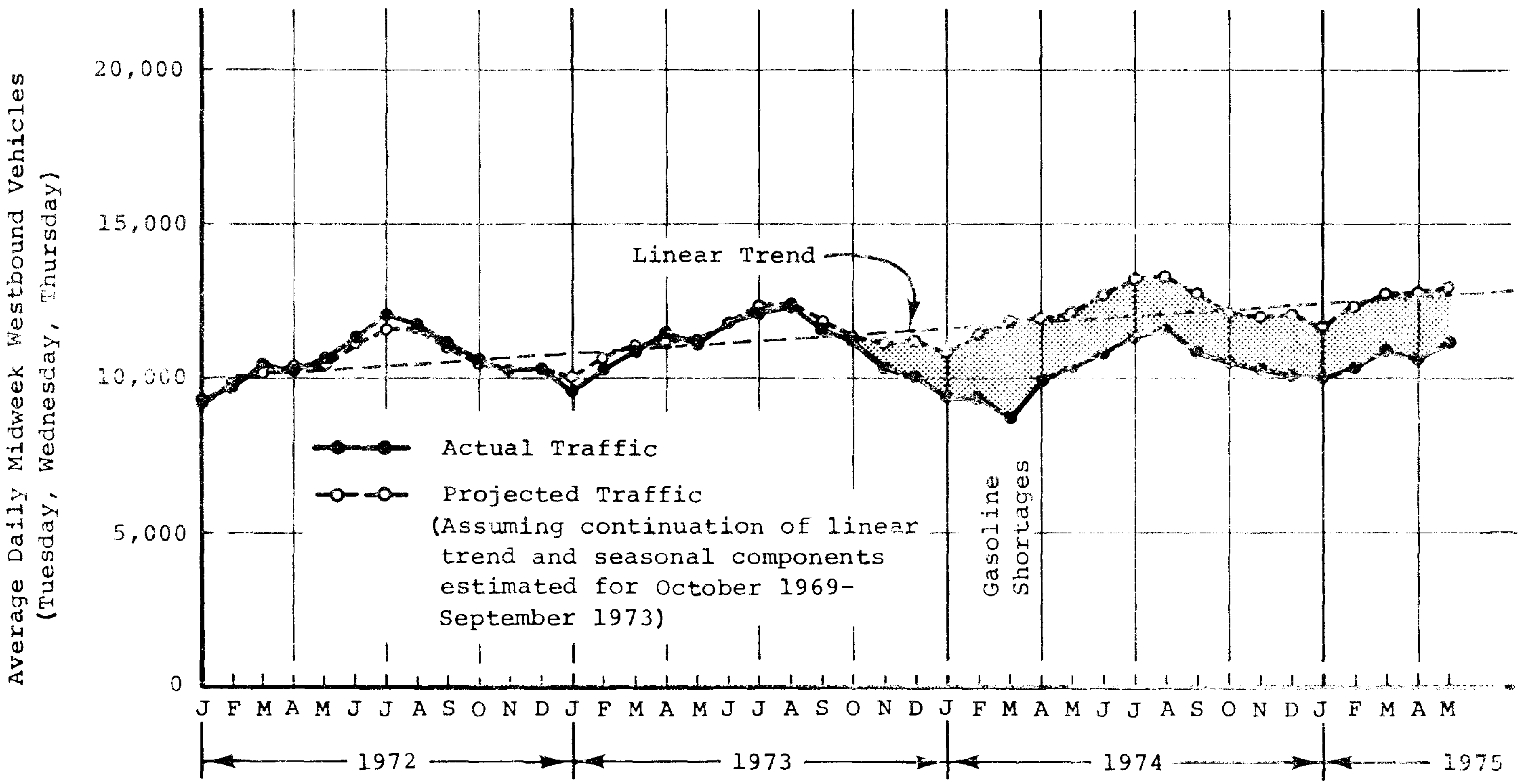


FIGURE 28

ACTUAL AND PROJECTED MIDWEEK TRAFFIC ON THE RICHMOND-SAN RAFAEL BRIDGE, JANUARY 1972-MAY 1975

Sources:
- CALTRANS Toll Bridge Administration, Daily Totalizer Volume Counts.
- Peat, Marwick, Mitchell & Co. Analysis.

San Francisco-Oakland Bay Bridge Traffic. The shaded area of Figure 25 shows clearly the effects of increasing gasoline prices from October 1973 onward. In early spring of 1974 when gasoline was in shortest supply, actual traffic levels fell far below those projected. Traffic levels recovered when gasoline again became available in the early summer of 1974, but the cumulative effects of increased gasoline prices continued to depress actual traffic volumes below projected volumes in May and June. In July and August of 1974, the AC Transit strike caused Bay Bridge traffic to increase above the projected line. The difference between the projected and actual traffic volumes for September 1974 onward represents the combined effects of the transbay BART line's opening in mid-September and further increases in gasoline prices. It is interesting that the differences between the actual and projected points are fairly constant over the last eight months shown in Figure 25, suggesting that actual traffic volumes are indeed continuing to follow the trend and seasonal patterns of previous years, but are displaced downwards--presumably by the effects of BART and the rise in gasoline prices. The average displacement over the eight months from October 1974 (the first full month of transbay BART service) through May 1975 is a reduction of 5,300 vehicles daily.

Golden Gate Bridge Traffic. Figure 26 shows a similar pattern to Figure 25, except that traffic volumes on the Golden Gate Bridge were unaffected by the AC Transit strike and have not been influenced by BART. The differences between the projected and actual traffic level therefore show a much more regular pattern, reflecting primarily the effects of the gasoline shortage and associated price increases. From May 1974 to May 1975, the actual traffic levels follow those predicted very closely, with the actual points displaced below the projected points by an average of 3,800 vehicles per midweek day.

San Mateo-Hayward Bridge Traffic. Figure 27 shows the difference between projected and actual traffic levels on the San Mateo-Hayward Bridge. A pattern very similar to the Bay Bridge is apparent. Unfortunately, data for March and April 1974 are not available, so the effects of the most severe gasoline shortages are not shown in the figure. But the figure clearly shows (1) the effects of the AC Transit strike in diverting traffic from the Bay Bridge to the San Mateo Bridge; and (2) the continuing effects of increased gasoline prices and possibly BART-related traffic reductions over the last eight months shown in the figure. Over this period, actual midweek traffic levels averaged 1,900 vehicles per day below those projected.

Richmond-San Rafael Bridge Traffic. Figure 28 compares projected and actual traffic levels for the Richmond-San Rafael Bridge, showing a pattern very close to the Golden Gate Bridge. Again, neither the AC Transit strike nor BART has affected traffic levels; the difference between projected and actual levels represents only the effects of gasoline availability and price. On average, actual daily midweek traffic levels were 1,800 vehicles lower than projected over the 13-month period May 1974 to May 1975.

Explanation of Reductions in Bridge Traffic Volumes

Table 30 summarizes the analysis of average daily midweek traffic on the four bridges across San Francisco Bay. The table shows the average difference between the traffic volumes projected from the "trend plus seasonal" model, and actual traffic volumes for the eight-month period from October 1974 (immediately after the start of transbay BART service) to May 1975. The "trend plus seasonal" model was estimated from data for the four years, October 1969 to September 1973 (immediately before the gasoline crisis). The differences between the projected and actual traffic volumes--shown as the shaded areas of Figures 25, 26, 27, and 28--represent the reductions in traffic which must be explained by factors other than past growth trends and seasonal influences.

Table 30 also shows (1) the average daily midweek traffic volume for the eight months from October 1974 to May 1975; (2) the average "projected minus actual" difference in traffic volumes, expressed as a percentage of the average daily volume; and (3) the slope of the long-run trend in traffic growth (i.e., the growth rate estimated in the "trend plus seasonal" model). This slope was estimated as a percentage of the average traffic over the 48 months from October 1969 September 1973. Finally, the table gives the number of traffic lanes in each direction on the bridges, and the average daily volumes divided by the number of lanes. The latter figures form crude measures of the volume-to-capacity characteristics of the bridges.

Comparison of Traffic Reductions Among Bridges. Of the four bridges, BART was expected to have major traffic-reducing impacts on only the San Francisco-Oakland Bay Bridge. But while the total reduction* in average daily traffic (5,300 vehicles per day) has indeed been greatest for the Bay Bridge, the percentage reduction in traffic (6%) is the smallest of the four bridges. This reduction represents the sum of several influences--not just BART. On the Bay Bridge and the three other bridges, the differences between projected and actual traffic volumes shown on Table 30 could result from:

---

*The word "reduction" is used here to describe the difference between predicted and actual traffic volumes for the same period. More strictly, this is a "deficit" or "shortfall."

Table 30

SUMMARY OF ACTUAL AND PROJECTED AVERAGE DAILY MIDWEEK BRIDGE TRAFFIC[a]

	San Francisco-Oakland Bay Bridge	Golden Gate Bridge	San Mateo-Hayward Bridge	Richmond-San Rafael Bridge
Average Difference (Projected-Actual) Traffic October 1974-May 1975	5,300	3,600	1,900	1,900
Average Daily Traffic October 1974-May 1975	87,900	44,900	14,800	10,500
Difference as Percentage of Average Daily Traffic	6.0%	8.0%	12.6%	17.7%
Slope of Long-Run Trend in Traffic Growth	2.0%	2.4%	6.0%	8.4%
Number of Traffic Lanes in Each Direction	5	3[b] (or 4)	2[c] (or 3)	3
Average Daily Traffic per Lane	17,600	15,000 (or 11,200)	7,400 (or 4,900)	3,500

a. See accompanying text for explanation of traffic projections.
b. The six lanes of the Golden Gate Bridge can either carry three lanes in each direction, or four lanes in one direction and two in the other.
c. The San Mateo-Hayward Bridge has two lanes in each direction on the approach causeways and three in each direction on the main span.

Source: Peat, Marwick, Mitchell & Co. analysis of traffic counts compiled by CALTRANS, Toll Bridge Administration, and Golden Gate Highway and Transportation District.

1. Reductions in highway traffic caused by a diversion of automobile travel to BART.

2. Reductions in highway traffic caused by increases in the cost of owning and operating an automobile.

3. Increases in traffic volumes that have been "induced" by these reductions in traffic volumes and associated congestion levels.

4. Natural growth in traffic above or below the trend line used in the projections.

5. Seasonal traffic variations different from the pattern used in projecting traffic.

Items 4 and 5 are probably negligible, since the figures show that the graph of actual traffic volumes on the bridges from October 1974 until May 1975 closely parallels the projected line for both underlying trend and month-to-month variation. Assuming that BART has had a significant impact only on Bay Bridge traffic volumes (and possibly on San Mateo-Hayward Bridge volumes) leaves items 2 and 3 to explain the differences shown in Table 30 especially for the Golden Gate and Richmond-San Rafael Bridges.

Effects of Gasoline Shortages. The analyses presented earlier in this chapter show that a marked decrease in highway traffic has coincided with increasing gasoline prices, and it seems reasonable to assume a direct cause-and-effect relationship between the two. However, the form of this relationship is not obvious. The elasticity of highway travel with respect to gasoline price is probably a function of the purpose of travel--with "essential" travel such as work trips being less elastic than "nonessential" trips such as recreational trips. This may explain, in part, why the percentage reductions of traffic on the San Mateo-Hayward and Richmond-San Rafael Bridges are larger than for the Bay Bridge and the Golden Gate Bridge, since the former two carry a smaller proportion of commuter traffic than the latter two bridges. It is also likely that travel by high-income travelers is less elastic than travel by low-income travelers. Gasoline prices also vary slightly among different parts of the BART impact area. These factors may all contribute to differential effects of gasoline price on traffic volumes on the four bridges.

Effects of Induced Traffic. The data presented in Table 30 do not allow any definite conclusion to be drawn with regard to item 3; however, a large part of the differences between the percentage traffic reductions for the four bridges might be explained by the effects of induced traffic. Table 30 shows (1) a positive correlation between the percentage reduction of actual traffic below projected traffic and the slope of the trend line, and (2) an inverse correlation between the percentage reduction in traffic and the average daily traffic per lane.

Both these relationships point to the fact that the reduction in traffic has been proportionately smallest for those bridges on which the daily traffic volume is closest to capacity (and on which, therefore, the growth rate may have been slowed by capacity constraints). The data are also consistent with the hypothesis that the reductions in traffic caused by BART and gasoline price increases (or gasoline price increases alone) have given rise to reductions in traffic congestion--which, in turn, have relaxed the capacity constraints and induced previously suppressed trips to be made more frequently.

For example, on the Richmond-San Rafael Bridge where traffic volumes were well below capacity, congestion levels on the bridge probably suppressed traffic very little. The 18% reduction in traffic levels, therefore, represents only the traffic-reducing effects of the rise in gasoline prices. In contrast, on the Bay Bridge where traffic volumes were previously very heavy over long periods of the day, the net reduction of 6% in traffic volumes may reflect a reduction due to increased gasoline prices offset by an increase due to induced travel. The corresponding percentage reductions of 8% and 13% on the Golden Gate Bridge and the San Mateo-San Rafael Bridge, respectively, are also consistent with the respective volume-to-capacity characteristics of these two bridges.

Clearly, many uncertainties are associated with this "induced traffic" argument. Analysis of aggregate highway traffic volumes, alone, does not allow the effects of BART, gasoline price increases, and induced traffic on the Bay Bridge to be separated. However, when taken together with an analysis of changes in travel by bus and BART, some rather stronger conclusions can be reached.

Impacts of BART on Total Travel in the San Francisco-Oakland Corridor

The previous section considered only aggregate 24-hour vehicle traffic volumes. More meaningful analyses of the impacts of transbay BART on travel in the San Francisco-Oakland Bay Bridge corridor must (1) concentrate on the 14-hour period when BART operates, and (2) consider total travel by bus, BART, and private automobile.

Figure 29 shows midweek daily westbound passenger travel in the San Francisco-Oakland Bay Bridge corridor in the 14 hours from 6:00 a.m. to 8:00 p.m. (the hours of BART operation). Included in these data are trips by persons in private automobiles, AC Transit, and Greyhound buses across the San Francisco-Oakland Bay Bridge, and by transbay BART.

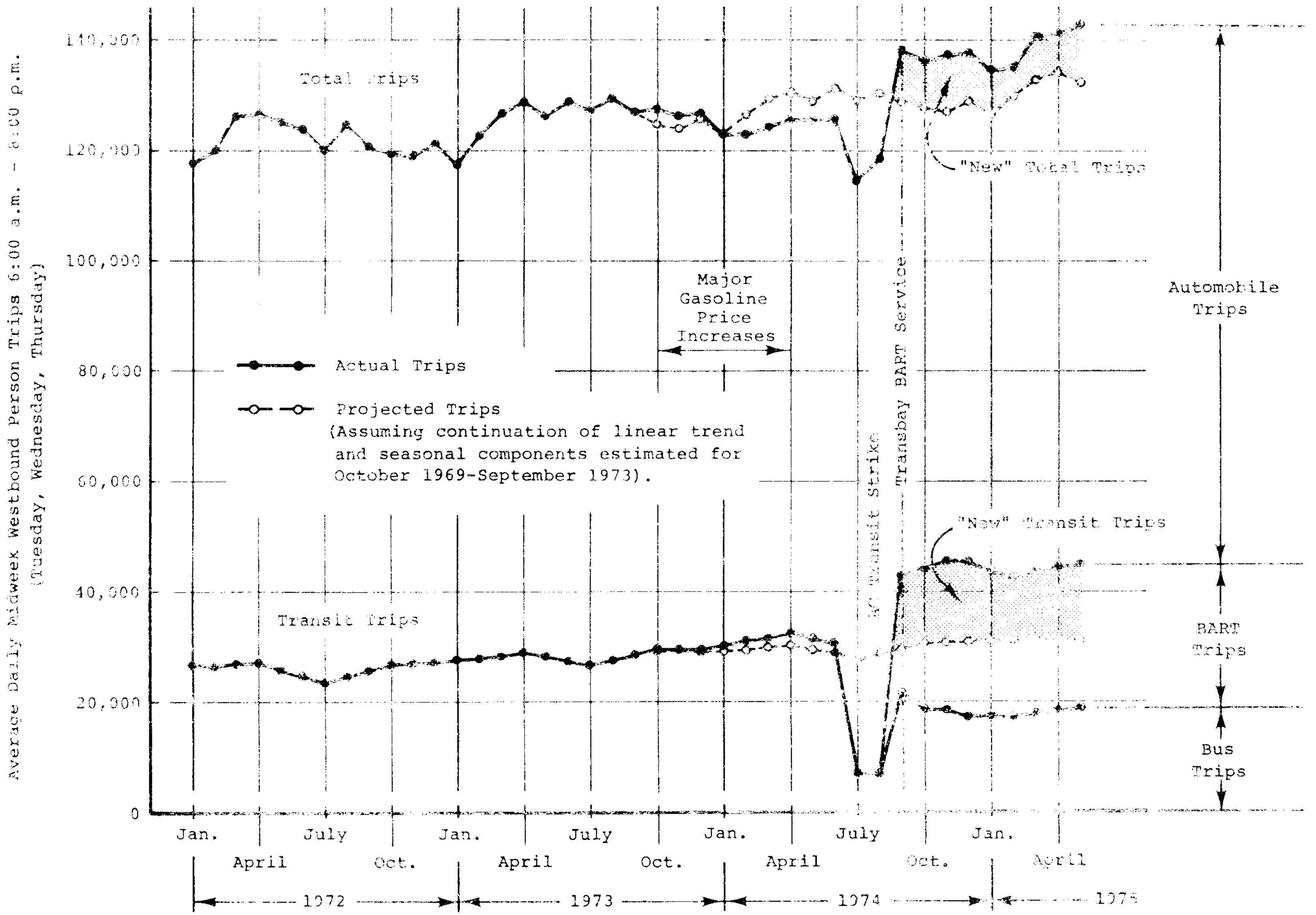


FIGURE 29

AVERAGE DAILY MIDWEEK TRIPS BY AUTOMOBILE, BUS, AND BART IN THE SAN FRANCISCO-OAKLAND BAY BRIDGE CORRIDOR, JANUARY 1972-MAY 1975

Source: Peat, Marwick, Mitchell & Co. Analysis of Traffic and Patronage Counts Compiled by • CALTRANS Toll Bridge Administration • University of California, ITTE • BARTD • AC Transit • Greyhound Lines.

Long-run trend and seasonal components of travel are apparent from the graphs of total trips and transit trips across the Bay Bridge. Regression analyses were made to estimate these trend and seasonal components in the same way as was done for the vehicle traffic analyses of the previous section. Over the three-year period from January 1971 to December 1973, the slope of the trend line for bus travel was an annual increase of 1,500 trips per day. This represents an average increase of 5.5% per year (as a percentage of the mean number of daily trips over the period January 1971 to December 1973). For travel by all modes, the slope of the trend line was an annual increase of 3,200 trips per day, or an average increase of 2.7% per year.

Figure 29 also shows projections of the "trend plus seasonal" model for both total trips and bus trips. These projections assume as before that the trend and seasonal travel patterns of previous years continue unchanged through 1974 and 1975, and projected volumes are taken as a baseline against which actual traffic levels can be considered to have increased or decreased.

The figure shows the effects of the gasoline crisis in early 1974, with total travel reduced well below projected levels and bus ridership increased significantly. The effects of the AC Transit strike in July and August are also clear, with both transit and total travel drastically reduced. Only Greyhound provided significant transbay transit service in the period.

Effects on Transit Travel. Compared to projections of bus travel, transbay BART service increased transit ridership by over 40%. Over the nine months after transbay BART opened, BART's ridership averaged 25,800 trips per day in each direction, and bus ridership averaged 18,400 trips per day. These trips per day total 44,200, compared to an average of 31,000 trips projected by the "trend plus seasonal" model of bus travel. The difference between the two, 13,200 trips per day, constitutes "new" transit ridership attracted at the start of transbay BART service. These "new" trips are shown as a shaded area in Figure 29.

Effects on Total Travel. Comparing actual and projected trip volumes for the nine months after BART opened shows an average difference of 8,500 trips per day (138,200 actual trips compared to 129,700 projected trips). These trips represent "new" trips which, according to the assumptions [illegible] the "trend plus seasonal" analysis, would not have been made had transbay BART (and possibly other events) not occurred.*

Modal Distribution of Transbay Travel with and without BART. Table 31 summarizes the pattern of midweek daytime transbay travel. The average number of trips per day made by automobile, bus, and BART in the nine months after transbay service are compared with the trips that would have been made (hypothetically) if BART had not been operating. The bases for the "without-BART" estimates are the "trend plus seasonal" projections given earlier.

Two assumptions were made in constructing the table; (1) no significant diversion of travelers to bus resulted from BART's opening, and (2) there was no diversion from bus to automobile.** The distribution of BART trips among automobile, bus, and "no trip made" was estimated on the basis of responses to the October 1974 Transbay BART Survey question on the previous mode of travel.*** Numbers in the table are approximate, reflecting the need to "balance" the various estimating errors involved, but in all cases are close to the corresponding actual or projected figures.

---

*The traffic projections shown in Figure 29 are based only on the long-run trend and seasonal components of travel. To the extent that the rise in gasoline prices and the capacity of the Bay Bridge would have tended to constrain automobile travel below this "trend plus seasonal" estimate, the "projected trips" line shown in Figure 29 should be considered a high estimate of travel volumes had BART not started service. Accordingly, the estimate of "new" trips is low; 8,500 trips per day may be considered a "lower bound" estimate of the number of new trips attributable to the start of transbay BART service.

**The second assumption is a potential source of error since some previous bus riders may have started traveling by car as a result of cutbacks in bus service following the start of BART service. This is possible especially for travelers who used Greyhound bus services from central Contra Costa County. Unfortunately, data are not available from which to estimate the extent of this diversion, if any.

***Responses to the October 1974 survey of BART travelers indicate that 54% of transbay BART trips were trips previously made by bus, 35% were trips made by automobile, and 11% were trips not made prior to BART's opening. The latter should be considered an upper bound estimate of the trips truly "induced" by BART because factors such as changes in job and residence locations since the start of BART service may account for some part of the "did not travel before" category. Trips which were made infrequently or were being made for the first time on the days of the surveys (but which would have been made regardless of whether BART was available) are also included.

Table 31

MODE OF TRANSBAY TRAVEL WITH AND WITHOUT BART
Average Daily Midweek Westbound Person-Trips
(6:00 a.m. to 8:00 p.m.)

	Mode of Travel with BART			Total Trips Projected
	Automobile	Bus	BART	without BART
Mode of Travel without BART				
Automobile	87,000	--	11,000	98,000
Bus	--	18,000	13,000	31,000
No Trip Made	7,000	--	2,000	9,000
Total Trips Actually Made with BART	94,000	18,000	26,000	138,000

Note: Reading down each of the four columns shows, for automobile, bus, BART, and total trips respectively, the distribution of actual trips among automobile, bus, and "no trip made" on the assumption that BART is not available. For example, of the approximately 26,000 trips actually made by BART, 11,000 would be made by automobile if BART were not available; 13,000 would be made by bus; and 2,000 would not be made at all.

Source: Peat, Marwick, Mitchell & Co.
(See accompanying text for derivation.)

According to the analysis summarized in Table 31, of the average, daily transbay trips made after transbay BART began, approximately 9,000 probably would not have been made had BART service not started under the Bay. Of these, no more than about 2,000 were being made on BART itself. The remaining 7,000 trips were being made by automobile. These 7,000 trips correspond to about 5,000 vehicles, or 7% of the total vehicles typically using the Bay Bridge between 6:00 a.m. and 8:00 p.m.

Sources of New Transbay Automobile Trips. Available data do not permit a definitive explanation of the sources of these 7,000 apparently new automobile trips. However, analysis of the time-of-day distribution of traffic on the Bay Bridge before and after the start of BART service shows that the proportion of the 24-hour total occurring during the 14 hours from 6:00 a.m. to 8:00 p.m. has not significantly changed; nor has there been any perceptible change in automobile occupancy.

This leaves the conclusion that a large proportion of the new automobile trips on the Bay Bridge has been induced by the changes in travel conditions brought about by BART. Some portion of the new trips may have diverted from the San Mateo-Hayward Bridge, but the evidence summarized in Table 30 suggests that this diversion has been small. Therefore, most of the new trips probably would not have been made across the Bay Bridge (or would have been made less frequently) without BART. These may be entirely new trips or trips previously made between locations on one or the other side of the Bay.

As shown in Table 31, about 11,000 transbay person-trips by automobile have diverted to BART (the equivalent of about 8,000 vehicle-trips). Apparently, about 7,000 automobile trips have been induced (the equivalent of about 5,000 vehicle-trips). Taken together these numbers imply a net BART-related decrease of about 4,000 automobile person-trips (about 3,000 vehicle-trips) between 6:00 a.m. and 8:00 p.m.

The analyses of Bay Bridge vehicle traffic volumes given earlier in this chapter (and summarized in Table 30) show that the overall reduction in traffic (due to BART, increased gasoline prices, and all other factors) has been about 5,000 vehicles per 24-hour day. However, the "projected" data on which the latter estimate was based imply very high traffic volumes, which would probably not have been attained given the capacity constraints of the bridge and the effects of the gasoline crisis. Thus, the 5,000-vehicle reduction is almost certainly a high estimate, and given the uncertainties associated with the supporting analyses, it should not be considered inconsistent with the estimated reduction of 3,000 vehicles per day suggested by Table 31.

BART Traffic Impacts Relative to Other Variations in Traffic Levels. The foregoing analysis allows an approximate estimate of the Bay Bridge traffic-reducing effects of BART: a net reduction of between 3,000 and

5,000 vehicles per day is suggested (with the lower estimate probably being more likely). This change needs to be viewed in the context of the many other factors influencing traffic levels. As discussed in earlier sections, Bay Bridge vehicle traffic has been increasing at an average annual rate of nearly 2,000 vehicles per day for several years. Typically, average daily traffic may be as much as 4,000 vehicles per day above or below the annual mean at different times of the year due to seasonal variations. Variation among days of the week is also such that there is often a difference of 15,000 daily trips between the highest weekday (Friday) and the lowest weekday (Monday).

In the context of these sources of variation in traffic volumes, a net reduction in traffic of 3,000 to 5,000 vehicles per day is significant, statistically speaking, but nevertheless small in relation to the total volume of transbay travel. The reduction in automobile travel attributable to BART represents about two years historical growth in Bay Bridge travel and is of the same order as normal week-to-week variations in traffic.

Finally, the net traffic-reducing impacts of BART are small when viewed in the context of expectations. Both The Composite Report[3] and the 1967 Coordinated Transit[14] report predicted major traffic-reducing impacts for BART. The latter, for example, predicted that BART's effects "will be the equivalent of seven transbay lanes in the peak hour/peak direction". The above analysis clearly shows that no such dramatic reduction in traffic has taken place.

Comparison of Transbay BART Highway Traffic Impacts with Other Systems

It is instructive to compare the BART experience with other recently constructed rapid rail systems in the United States. Two of the most interesting comparisons are with the Philadelphia-Lindenwold High-Speed Line (generally referred to as the Lindenwold Line) and the South Shore Extension of the Massachusetts Bay Transportation Authority (MBTA) rapid transit system in Boston.

The Philadelphia-Lindenwold High-Speed Line. The Lindenwold Line resembles lines of the BART System in several ways. The 14-mile line runs from the suburbs of southern New Jersey to Camden and across the Delaware River into the City of Philadelphia. Six of the system's 12 stations are outside the central city areas, with an average distance of about 1.8 miles between suburban stations.* The maximum operating

*Outside central Oakland, station spacing on the three East Bay lines of the BART System is about 2.9 miles.

speed is 75 mph, and the average speed for the entire run from Lindenwold to Philadelphia is 40 mph (compared to an 80 mph maximum and 38 mph average for the BART System). Like BART, train operation is automatically controlled, as is the fare collection system. Trains run around the clock with headways as small as two minutes at rush hours. The line is in a setting similar to that of transbay BART in that highway access to central Philadelphia from the New Jersey suburbs served by the Lindenwold Line is only possible via two heavily traveled bridges over the Delaware River--the Ben Franklin Bridge (which carries the Lindenwold Line tracks) and the Walt Whitman Bridge. Close to 12,000 vehicles typically travel over these bridges in the peak hour (compared to about 9,000 on the San Francisco-Oakland Bay Bridge).

The Lindenwold Line started operation in January 1969. By the end of the first year, about 13,000 trips per weekday were being made in each direction across the Delaware River (compared to 26,000 transbay BART trips in each direction). A survey of the Lindenwold Station (the furthest station from Philadelphia) conducted by the Delaware River Port Authority in October 1969 showed that the previous travel mode of commuters from Lindenwold had been 49% by bus or train and 38% by automobile. Thirteen percent had not traveled previously.* The diversion from automobile was less for stations closer to the City. These results are very close to those obtained in the surveys of transbay BART in which 54% of BART travelers gave bus as the previous mode and 35% automobile.

The impact of the Lindenwold Line on peak period highway traffic congestion has also been similar to BART insofar as the reduction in traffic on the Ben Franklin and Walt Whitman Bridges has been rather less than the diversion of automobile travelers to the Lindenwold Line. The decrease in average weekday traffic on the Ben Franklin Bridge between 1968 and 1969 was about 3,000 vehicles, continuing the trend of the previous two years. (Weekday traffic decreased by 5,800 vehicles between 1966 and 1967; and by 3,000 vehicles between 1967 and 1968.) However, over the peak period (7:00 a.m. to 9:00 a.m.), traffic apparently <u>increased</u> significantly from 1968 to 1969. In summary, available traffic data suggest that the opening of the Lindenwold Line had no detectable effect on peak period highway traffic congestion.

<u>The South Shore Extension to the MBTA Rapid Transit System</u>. In September 1971, the "South Shore Extension" of Boston's MBTA rapid transit system began service to the cities of Quincy, Milton, Braintree, and Weymouth to the south of Boston. Although only six miles long (and serving three stations), the line forms a useful basis for comparison with BART to the extent that, like BART and the Lindenwold Line, its

---

*See Reference 17, p. 8.

construction was justified in large part by the promise it held for alleviating peak period traffic congestion. Paralleling the South Shore Line is the Southeast Expressway (Route 3) running from the South Shore suburbs to Boston. At the time of the South Shore Line's opening, this expressway and the parallel Route 3A were heavily used and congested at peak periods. At a screenline at the north end of the South Shore Extension Line, inbound traffic on the Southeast Expressway and Route 3A together averaged about 64,000 vehicles daily in 1971, of which 8,000 were in the peak hour. Surveys conducted in April 1972, eight months after the opening of service, showed that 52% of South Shore Line riders had previously used mass transit, 29% had used automobile, 16% had not made the trip before, and 3% had used some other mode.* These results are similar to both the transbay BART and Lindenwold Line findings.

By December 1971, ridership on the South Shore Line was about 10,000 passengers in each direction, implying a reduction of about 3,000 vehicles per day on the parallel highways. However, no perceptable changes in traffic congestion were recorded on these facilities. The Metropolitan Area Planning Council's report[18] concluded that the transit extension neither reduced inbound average daily traffic, nor reversed the trend of increasing peak-hour volumes.

---

*See Reference 18, p. VI-6.

VII. BART IMPACTS ON THE MOBILITY OF MINORITY GROUPS

BART and Low-Income Groups

Location of Low-Income Residents Relative to BART. On average, low-income residents of the Bay Area live closer to BART than the general population. As shown in Table 32, 24% of all households in the three BART counties had annual family incomes of less than $7,000 at the time of the 1970 Census. Of those households in census tracts within one-quarter mile of the BART lines, 31% had incomes of less than $7,000. Clearly, proximity to the BART tracks is not necessarily a meaningful indicator of accessibility to BART; however, the results of the May 1975 areawide telephone survey confirm that, on average, low-income residents live closer to BART stations than higher-income residents.*

Annual Household Income	Average Distance between Home and Most Convenient BART Station
Less than $10,000	1.4 miles
$10,000 - $20,000	1.9 miles
More than $20,000	2.7 miles

Use of BART by Low-Income Residents. A summary of population, total weekday travel, and BART travel, categorized by low, medium, and high household income is given in Table 33. The estimates of total weekday trips included in the table are from the May 1975 areawide telephone survey of BART impact area residents aged 16 years and over. The estimates of BART trips are derived from on-board surveys of all travelers conducted in May and October 1974.** Table 33 shows that low-income residents travel less in total and use BART less than is implied by their share of the areawide population.

Two factors may contribute to the proportionately low usage of BART by low-income persons: First, low-income groups tend to work in locations

*The closer proximity of low-income households to BART is a secondary consequence of one of BART's primary planning objectives. In locating the lines and stations of the System, BART planners attempted to link population centers and dense urban areas. These areas happen to be where many low-income families live.

**See notes to Table 16 on page 81 for a description of the surveys.

Table 32

FAMILY INCOME DISTRIBUTION BY DISTANCE FROM BART

Area	Median Family Income[a]							
	Low-Income Families (less than $7,000)		Medium-Income Families ($7,000 to $12,000)		High-Income Families (more than $12,000)		Total Families	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
BART Lines[b]								
Concord Line	6,776	19%	8,319	24%	19,895	57%	34,990	100%
Richmond Line	10,880	33	10,666	33	11,133	34	32,679	100
Fremont Line	21,791	32	24,225	35	22,788	33	68,804	100
San Francisco Line	14,216	38	11,874	31	11,624	31	37,714	100
Total BART System	53,663	31	55,084	32	65,440	37	174,187	100
Counties								
San Francisco County	48,615	30	48,331	29	68,396	41	165,342	100
Alameda County	64,560	24	84,158	32	117,417	44	266,135	100
Contra Costa County	27,065	19	42,517	29	76,897	52	146,479	100
Total Three-County BART Area	140,240	24	175,005	30	262,710	46	577,956	100

a. Excludes income of unrelated individuals in a household.
b. Includes census tracts within one-fourth mile of BART tracks.

Source: 1970 U.S. Census of Population and Housing at census tract level.

Table 33

USE OF BART BY LOW-, MEDIUM-, AND HIGH-INCOME HOUSEHOLDS

	Average Annual Household Income			
	Less than $10,000	$10,000 to $20,000	Greater than $20,000	Total
Total Population 16 years and over (1975)	41%	44%	15%	1,870,000 100%
Total Daily Weekday Trips by Population 16 years and over	33%	48%	19%	4,940,000 100%
Daily BART Trips (1974)	27%	43%	30%	118,000 100%

Sources: BART Impact Program, May 1975 Areawide Travel Survey.
BARTD, Passenger Profile Survey, May 1974.
BART Impact Program, October 1974 Survey of Transbay BART Travel.

that are not as well served by BART as the central-city workplaces of many high-income groups. For example, the May 1975 areawide telephone survey showed that 44% of those with annual household incomes less than $10,000 work in the cities of San Francisco and Oakland, while 72% of those with incomes above $20,000 work in Oakland and San Francisco. Second, low-income persons are probably more sensitive to the higher costs of BART relative to bus. Some limited evidence to support this hypothesis is provided in Table 16: 24% of transbay bus trips are made by travelers with family incomes under $10,000, whereas only 20% of transbay BART trips are made by travelers in this income group.

BART and Ethnic Minorities

Location of Ethnic Minorities Relative to BART. Many members of ethnic and racial minority groups are from low-income households.* As a result, the conclusions of the previous section tend also to apply to ethnic minority groups. Thus, the May 1975 areawide telephone survey showed that, on average, whites live further from BART stations than blacks or other minority groups.

Ethnic/Racial Identification	Average Distance between Home and Most Convenient BART Station
White (Including Spanish-American)	1.9 miles
Black	1.3 miles
Other (Including Oriental)	1.5 miles

Use of BART by Ethnic Minorities. Table 34 shows areawide population, total weekday vehicle trips, and trips on BART categorized by three ethnic groups: white (including Spanish-American), black, and other (mainly Chinese and Japanese). The sources and derivations of these estimates are the same as for Table 33. Table 34 shows that blacks and other minorities make fewer trips in total than would be expected

*According to the May 1975 areawide telephone survey, 60% of the black population of the BART impact area had annual family incomes of under $10,000, while 5% had family incomes over $20,000. In contrast, only 39% of the remaining (nonblack) population had family incomes under $10,000 while 16% had incomes over $20,000.

Table 34

USE OF BART BY WHITE, BLACK, AND OTHER ETHNIC/RACIAL GROUPS

	Ethnic/Racial Identification			
	White (including Spanish Surname)	Black	Other Ethnic Minority	Total
Total Population 16 years and over (1975)	82%	11%	7%	1,870,000 100%
Total Daily Weekday Trips by Population 16 years and over (1975)	86%	8%	6%	4,940,000 100%
Daily BART Trips (1974)	86%	6%	8%	118,000 100%

Sources: BART Impact Program, May 1975 Areawide Travel Survey.
BARTD, Passenger Profile Survey, May 1974.
BART Impact Program, October 1974 Survey of Transbay BART Travel.

given their representation in the areawide population; 18% of the population are nonwhite (as defined by the areawide travel survey), but they make only 14% of the trips.

Factors contributing to the lower trip-making propensity of minorities have not been fully assessed, but the generally lower incomes of the ethnic minority population are probably a major factor. Use of BART by members of black and other ethnic minority groups (taken together), while less than expected, is proportionately similar to their travel by all modes. According to the 1974 BART passenger surveys, 14% of BART trips were made by nonwhites--the same percentage as their share of all trips. Proportional use of BART by the black community does, however, appear to be lower than both their representation in the population and their proportional share of all trips.

<u>Factors Contributing to Lower Use of BART by the Black Community</u>. The lower average income of the black community may be one reason for their apparently low use of BART. Exploratory work during Phase I of the TSTB Project suggested a number of other reasons:

- Bus access services to BART are inadequate from areas in which ethnic and racial minorities live.
- Minorities may be particularly discouraged from using BART by concerns about the reliability of BART's equipment, discomfort at being underground and underwater, and fears about losing one's orientation in the BART System.
- BART does not currently provide service when many minorities travel, i.e., during evenings and on weekends.
- Some working-class black people have a resistance to using BART because they view it as an alien "white" system.

These hypotheses will be examined in the next phase of the TSTB Project.

<u>BART and the Physically Disabled</u>

This section briefly describes the response of physically disabled people to the facilities provided to help them use the BART System. Other BART Impact Program documents[19,20] describe BART's impacts on the physically disabled more completely.

Design Features Incorporated in BART To Serve the Physically Disabled. Many of BART's original design features contemplated in The Composite Report[3] made provisions for physically handicapped persons. Design features included high-level platforms so that passengers do not have to climb steps to board trains; escalators for all vertical distances of 12 feet or more; provision of a seat for every passenger; and train doors and station entry and exit gates wide enough to accommodate wheelchairs.

In 1965, the BART District adopted official design standards conforming in many respects to American Standards Association specifications for making buildings and localities more accessible and usable by physically handicapped people,[21] but the 1965 design standards excluded provision for full accessibility to BART by people confined to wheelchairs. California state laws enacted in 1968 required that BART's design standards be modified in two major areas; the legislation required that (1) elevators be included in stations, and (2) restrooms be redesigned to accommodate persons in wheelchairs. In September 1969, the BARTD Board voted to install elevators in all BART stations to allow full access to the System by persons confined to wheelchairs.* As of the date of this report, elevators are installed in all but one BART station.

Physically Disabled People in the Population. Only limited data are available on the incidence of physical disabilities which limit personal mobility. According to a 1969 survey[22] conducted by the National Center for Health Statistics, about 3% of the total U.S. population (excluding those confined to home or an institution) have a chronic condition limiting their mobility.

According the the BART Impact Program May 1975 areawide telephone survey, about 4% of households in the BART impact area have one or more members (aged 16 years or older) with a physical handicap which makes it difficult for them to travel by bus or BART. Many of those with reported handicaps were older people--about 40% were 65 or over. A survey of about 140 handicapped persons conducted for BART in 1975** showed that 7 of them (5%) could use escalators only with someone else's help or could not use escalators at all. These data are consistent with estimates given in Reference 22, in that about 31,000 residents of the three BART counties use a cane, walking stick, or crutches as a mobility aid, and about 5,000 people use a wheelchair. Relating these estimates to the total population implies that about 1 person in 100 uses a cane or crutch, and 1 person in 500 uses a wheelchair.

---

*A full account of the events leading to this decision is given in Reference 2, pp. 192-195.

**Source: Interim results of the BART Market Segments Study conducted for BART by Market Facts, Inc., Chicago, Illinois.

Use of BART by the Physically Handicapped. While the available data are extremely limited, they generally suggest that use of BART by physically handicapped people is small relative to their representation in the population as a whole. For example, as part of the BART ridership surveys conducted by the TSTB Project in October 1974, a census of physically handicapped travelers was conducted at three San Francisco BART stations.

The results of the census suggest that about 1 out of every 1,000 BART travelers walks with the aid of crutches or canes, 1 out of every 2,000 BART travelers is blind, and 1 out of every 10,000 BART travelers is confined to a wheelchair. Data on elevator use at BART stations imply low use of the System by physically disabled people. In August 1974, the elevators at all 32 stations where they were installed were together used a total of 116 times per day on average (not all of these rides were necessarily by disabled people, since the elevators are available to anyone on request). Much of the apparently low use of the BART System by physically disabled people is explained by the fact that many of them are elderly people who do not work or travel as much as the rest of the community. Some further factors which may be contributing are discussed in the following sections.

Factors Discouraging Use of BART by the Physically Handicapped. In the spring of 1975, a survey of 43 physically handicapped residents of the BART impact area was conducted as part of the TSTB Project by the Center for Independent Living, an advocacy group for the physically handicapped.[20] Of the 43 persons surveyed, 20 had used BART one or more times, and 11 were using BART regularly. Six of the regular BART users were blind persons who had access to AC Transit buses and 5 were quadraplegics involved with the Center for Independent Living who were without other transportation. In total, 28 of those surveyed had access to an alternative transportation mode--20 owned an automobile or a van and 8 had access to AC Transit. About three-quarters of these people preferred their alternative mode to BART.

The Center for Independent Living study concluded that three broad categories of factors contribute to the relatively low use of BART by the physically handicapped:

- Difficulties encountered in using BART itself
- Difficulties in getting to and from BART stations
- Lack of information about the BART System.

Difficulties in Using BART. Although BART has made significant advances in providing a barrier-free system for the physically disabled, the respondents to the Center for Independent Living survey reported a number of areas where they were experiencing problems in using the System. To use the elevators, travelers must phone the station agent who then activates and controls the elevator. Many respondents reported physical difficulty in using the telephone; many experienced delays in obtaining responses from the station agent--particularly during peak travel periods. In a number of stations (particularly those whose construction was advanced when the decision to install elevators was made), the elevators are awkwardly located some distance from the station entrance and the station agents' booths. Some respondents to the survey experienced difficulty locating the elevators, particularly because BART has no signs at the stations indicating the location of the elevators for security reasons.

Originally, BART planned a "train screen" between the tracks and the platform--a solid-wall barrier with doors that open simultaneously with the train doors. A train screen would have helped the blind use BART by providing positive insurance that they could not fall on the track. But the train screen was eliminated from the final BART System for economy reasons and to increase operational flexibility. Although the edge of the platform has a different texture to help blind persons locate it, several survey respondents indicated that the texture difference is inadequate.

Several respondents reported difficulty in traversing the approximately two-inch gap between the train and the station platform edge, particularly wheelchair travelers. Respondents to the survey also indicated that the normal 20-second dwell times do not give them sufficient time to secure their wheelchairs or to obtain a seat on the train before the train begins accelerating. Similarily, on leaving, the 20-second period does not allow them time to release their wheelchair or stand up and walk to the door before the doors close. Blind persons, in particular, experience difficulty in determining whether a given train was the one they wanted to use and whether they had reached their desired destination; they requested public announcements in stations and on-board trains.

BART's mechanical breakdowns have exacerbated the difficulties of the physically disabled in using the System. Besides the inconvenience caused by the failures, they have engendered a fear of using the BART System in some disabled people because of their concerns about being trapped or helpless in a breakdown.

Difficulties in Getting to and from BART. Many respondents to the survey reported difficulties in traveling between their final origin or destination and BART stations. Physically disabled people who are able to drive an automobile have the best access service. Parking spaces for the physically handicapped are designated in BART parking lots as close to station entrances as possible (although some difficulties have been experienced in locating these spaces and in illegal use by those who are not disabled).

Walking distances between the BART station and AC Transit or MUNI bus stops are generally short, but bus service for people who must use a wheelchair is poor--no AC Transit or MUNI buses are equipped with wheelchair lifts. Curb cuts for wheelchairs are provided in BART parking lots, but generally not on local streets adjacent to the lots, making access difficult for people confined to wheelchairs.

Lack of Information about BART. Many respondents to the survey indicated that they did not have sufficient information about BART's special facilities for the physically disabled. So, the low use of the BART System to date by the physically disabled may result from their lack of knowledge. Many disabled people may not perceive that BART could be useful to them and dismiss it from their lives without ever having tried it.

VIII. BART IMPACTS ON THE REST OF THE TRANSPORTATION SYSTEM

The previous three chapters have discussed the diversion of travel to BART and the impact of this diversion on travel patterns by bus and automobile. Accompanying these changes in travel patterns have been changes in the service provided by the bus and highway systems. Two kinds of transportation system impacts are important: (1) changes in bus service on routes parallel to BART resulting from reduced bus ridership, and (2) changes in highway traffic congestion and travel times resulting from the diversion of travel from automobile to BART.

BART's Impacts on Bus Service

BART's impacts on the frequency of service on selected parallel bus routes are summarized in Table 35. On a number of routes, service has been changed in response to changes in travel demands.

As a result of decreased transbay ridership, AC Transit has reduced scheduled services on many of its transbay routes (the routes designated by letters in Table 35). From the start of transbay BART service in September 1974 until the end of May 1975, a total of 66 buses were withdrawn from transbay service in both the morning and evening. AC Transit has also reduced service on Routes 31 and 33 (between Richmond and Oakland) and on Route 32 (between Hayward and Oakland), but not on Routes 40 and 43 (between Berkeley and Oakland) or Routes 80, 81, and 82 (between San Leandro/Hayward and Oakland).

Greyhound services paralleling the Concord Line have been severely curtailed since transbay BART service began, corresponding to a major decline in ridership. For the sample of routes in Table 35, the number of buses per hour decreased from 60 to 28 and from 58 to 33 in the morning and evening peak hours, respectively. Some areas of Contra Costa County have experienced reductions or elimination of local bus service as well as service to Oakland and San Francisco.

MUNI has not significantly modified its service on routes parallel to BART as of the date of this report, even on its No. 14 route which has experienced a major patronage decline.

BART's Impacts on Highway Traffic Congestion

Many factors have influenced traffic levels over the period of BART's introduction, making it extremely difficult to hypothesize what the hourly distribution of traffic would have been if BART were not operating. BART's impacts on reducing traffic congestion are correspondingly difficult to assess.

Table 35

EFFECT OF BART ON SELECTED PARALLEL BUS SERVICES

Bus Route	Service Provided Between	Service Frequencies Before BART: A.M. Peak-Hour	Service Frequencies Before BART: P.M. Peak-Hour	Service Frequencies Before BART: Midday	Current Service Frequencies[a]: A.M. Peak-Hour	Current Service Frequencies[a]: P.M. Peak-Hour	Current Service Frequencies[a]: Midday
AC-15	Berkeley & Oakland	4	7	4	4	7	4
AC-31	Richmond & Oakland	3	3	No Service	2	2	No Service
AC-32	Hayward & Oakland	6	6	2	3	2	No Service
AC-33 Berkeley	Berkeley & Oakland	7	8	4	4	4	2
AC-33R	Richmond & Oakland	4	8	No Service	3	4	No Service
AC-40	Berkeley & Oakland	5	5	4	5	5	4
AC-43	Berkeley & Oakland	5	5	4	5	5	4
AC-51/58	Berkeley & Oakland	8	8	8	8	8	8
AC-72	Richmond & Oakland	6	8	6	6	8	6
AC-80	San Leandro & Oakland	3	4	2	3	3	2
AC-81	San Leandro & Oakland	3	4	2	3	4	2
AC-82	San Leandro & Oakland	3	5	2	3	5	2
Peerless Stages	Fremont & Oakland	2	2	1	1	1	1
AC-A	Oakland & San Francisco	2	4	3	2	4	3
AC-F	Berkeley & San Francisco	7	8	4	5	9	4
AC-FX	Berkeley & San Francisco	8	No Service	No Service	9	No Service	No Service
AC-FXX	Berkeley & San Francisco	11	12	No Service	10	10	No Service
AC-L	Richmond & San Francisco	10	8	2	10	10	2
AC-LX	Richmond & San Francisco	6	7	No Service	6	7	No Service
AC-N	San Leandro & San Francisco	6	10	2	6	6	2
AC-R	San Leandro & San Francisco	11	12	2	6	7	2
Greyhound-M	Daly City & San Francisco	3	3	3	3	3	3
Greyhound-N/O	Daly City & San Francisco	4	3	1	4	4	1
Greyhound-S	Daly City & San Francisco	3	3	No Service	3	3	No Service
Greyhound-R	Walnut Creek & San Francisco	14	13	No Service	8	8	No Service
Greyhound-T	Walnut Creek & San Francisco	12	12	No Service	5	5	No Service
Greyhound-X	Walnut Creek & San Francisco	12	12	No Service	No Service	3	No Service
Greyhound-Y	Concord & San Francisco	12	12	No Service	5	5	No Service
Mission St. Jitney	Mission District & San Francisco	65	65	20	50	50	17
MUNI-9	Mission District & San Francisco	8	6	4	8	6	4
MUNI-11	Mission District & San Francisco	5	6	4	5	6	4
MUNI-12	Mission District & San Francisco	8	9	8	8	9	8
MUNI-14	Mission District & San Francisco	14	26	13	14	26	13

a. Number of buses per hour in the peak direction in July 1975.

Source: JHK & Associates analysis of operator timetables.

Among the few data which do allow some conclusions to be drawn on how BART has influenced traffic congestion are the records of a metering system used to control traffic flows on the Bay Bridge. Since March 14, 1974, a system of metering westbound traffic entering the five lanes of the San Francisco-Oakland Bay Bridge has been operational. The flow of traffic leaving the 17 toll-booth lanes is controlled by a red or green traffic light above each lane before the pavement merges into five lanes at the beginning of the bridge structure itself. The traffic lights are operated automatically by detectors which monitor the speed of vehicles entering the bridge. At normal speeds, all lanes show a green light. The metering system is activated (and shows periodic red lights above lanes) when traffic speeds fall below a prespecified level, indicating a build up of congestion on the bridge. Thus, the starting time and duration of metering system operation are interesting measures of congestion on the Bay Bridge for which data are available on a continuing and consistent basis. Figure 30 shows the times of system activation during the morning peak period for Tuesdays, Wednesdays, and Thursdays, day-by-day from March 1974 until May 1975. Gaps in the figure indicate days for which data are not available.

Figure 30 indicates a fairly consistent pattern of traffic congestion from March to June 1974, with day-to-day variations about the norm caused by weather, traffic accidents, and other influences. The starting time, duration, and day-to-day variations in the duration of metering all increased dramatically in July and August of 1974 giving a clear picture of the traffic congestion caused by the AC Transit strike in those two months. The period of activation then decreased in September when transbay BART service began. However, since then the period appears to have increased back to higher levels, close to those of early 1974.

Comparing the nine-week period in 1974 following the start of metering system operation with the corresponding nine-week period in 1975 shows that the period over which the metering system operated both starts later (7:09 a.m. on average in 1975 compared to 6:59 a.m. in 1974) and has a shorter duration (80 minutes in 1975 compared to 91 minutes in 1974). Both these differences are statistically significant at a 5% level. Nevertheless, they represent fairly small changes when considered relative to total travel times and are also small in the context of the expectations held for BART's impacts on congestion.

Highway Travel Times

Highway travel time surveys are the traditional method of measuring changes in traffic congestion. A considerable body of travel time data for various times before and after the start of service on BART lines

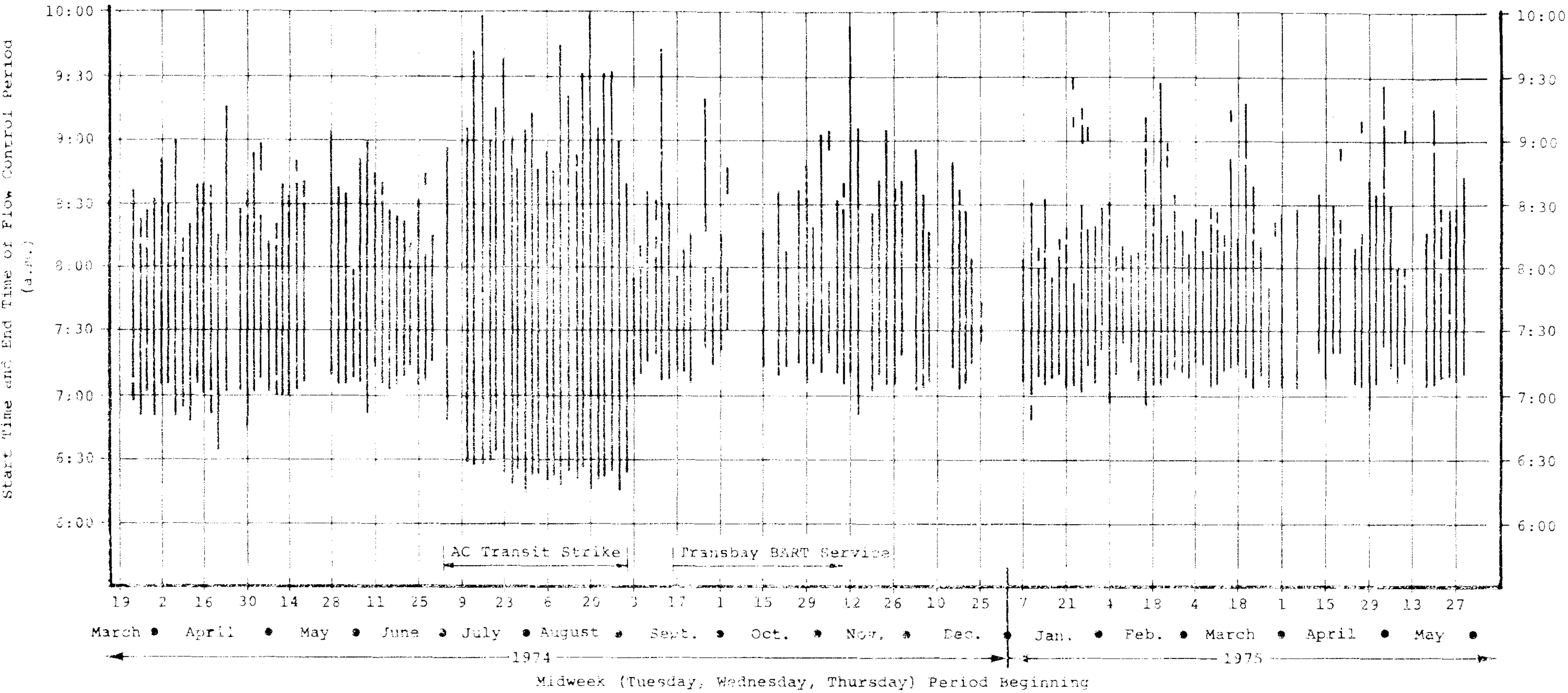


FIGURE 30

TIMES OF ACTIVATION OF THE SAN FRANCISCO-OAKLAND BAY BRIDGE TRAFFIC METERING SYSTEM
TUESDAYS, WEDNESDAYS, AND THURSDAYS, MARCH 1974 - MAY 1975

Source: • CALTRANS Toll Bridge Administration, Daily Records of Bay Bridge Metering System.

has been collected and analyzed as part of the TSTB Project.* Unfortunately, many factors have influenced traffic patterns over the period of BART's introduction. These include the 55-mph speed limit, introduced in January 1974, and several new traffic control measures (such as the metering system) on the Bay Bridge. It is consequently difficult to assess the impacts of BART on travel times from the travel time survey results. However, analyses of the data point to the same general conclusions as were suggested in the preceding section: (1) reductions in peak period travel times have occurred, but these have been small relative to total travel times; and (2) the most congested periods appear to have shifted to slightly later times of the day.

Changes in Bay Bridge Peak Period Travel Times. Figure 31 summarizes the results of two morning peak-period travel time surveys conducted over the Bay Bridge. The first (pre-BART) survey was conducted in April 1974 and the second (post-BART) survey in May 1975. Transbay BART service started in September 1974.

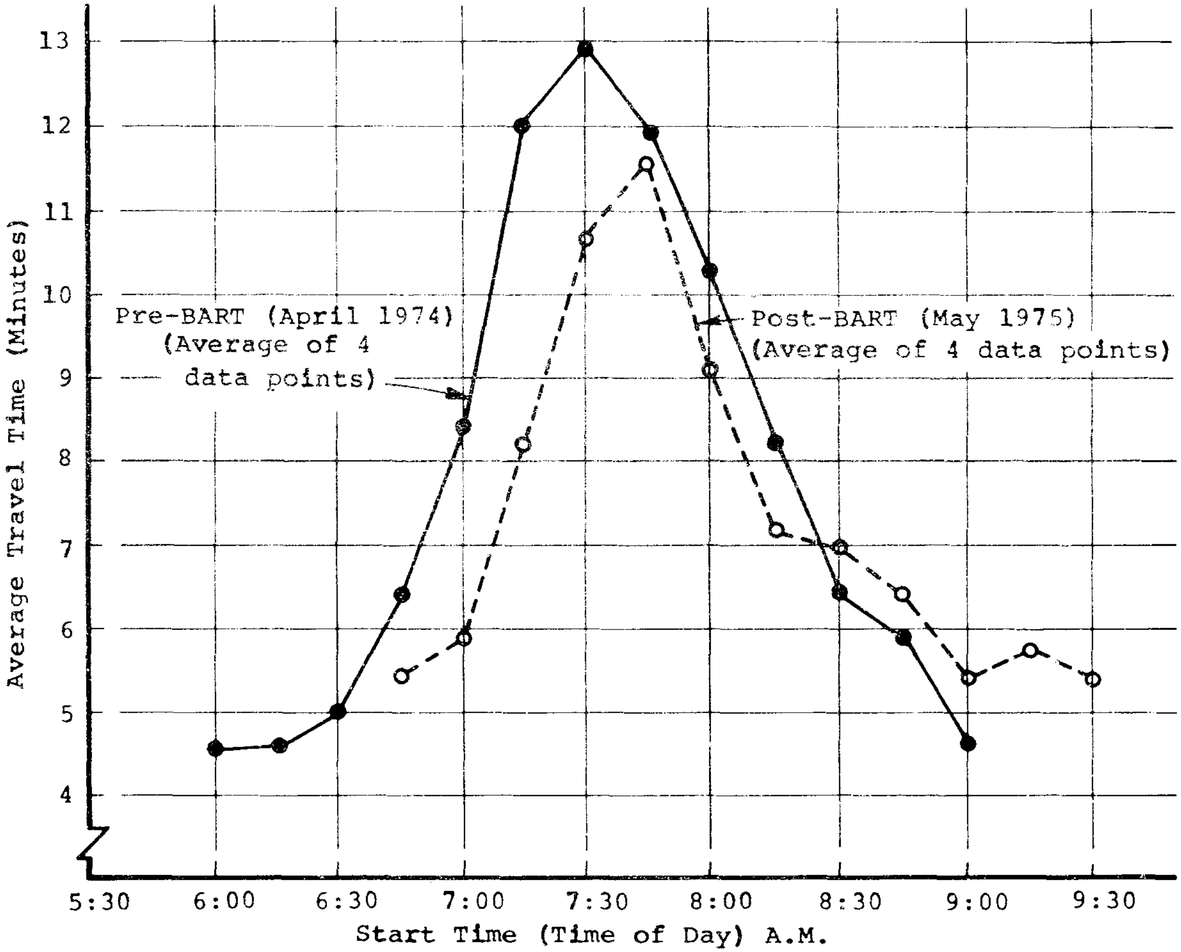
The relatively short period between the "before" and "after" data sets means that the differences between the two graphs in Figure 31 may be attributed to BART with some confidence. However, the effects of the gasoline crisis complicate the picture. In April 1974, traffic levels were probably depressed because of gasoline shortages in February and March and accompanying price increases. Average daily (24-hour) midweek traffic volumes on the Bay Bridge in April 1974 (87,400 vehicles per day) were actually lower than those in May 1975 (90,700 vehicles per day) in spite of the reductions in traffic presumably resulting from BART.

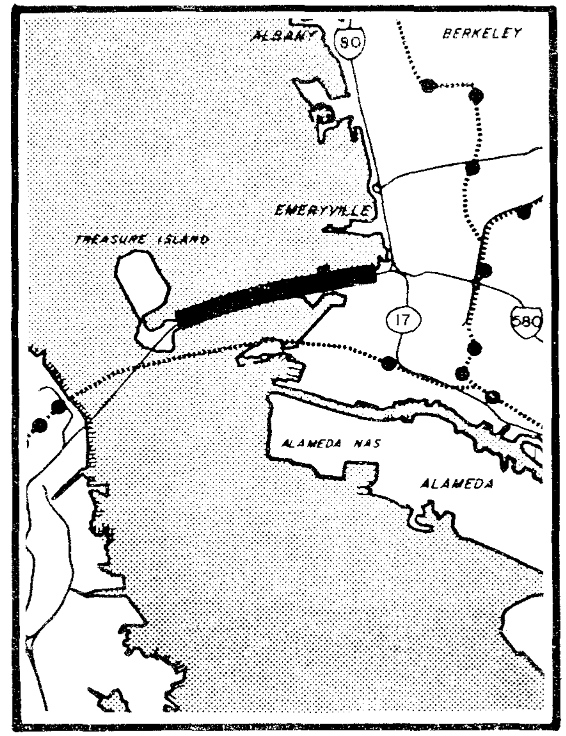
Figure 31 shows that peak period travel times in May 1975 were about 2.5 minutes shorter than in April 1974. This represents an increase in average speed from about 16 mph to 18 mph at the most congested time. The most congested part of the peak period has shortened and shifted to a slightly later time; the figure shows a shift of about 15 minutes (from 7:30 a.m. to 7:45 a.m.).

Changes in Route 24 Peak Period Travel Times. Figure 32 shows a summary of morning peak-period travel times on Route 24 before and after BART service began on the Concord Line and transbay. The section of Route 24 surveyed, as shown in the figure, parallels the BART Concord Line from Lafayette to Oakland and is a major connector to the Bay Bridge.

---

*These analyses will be reported more fully in a future technical memorandum of the TSTB Project.





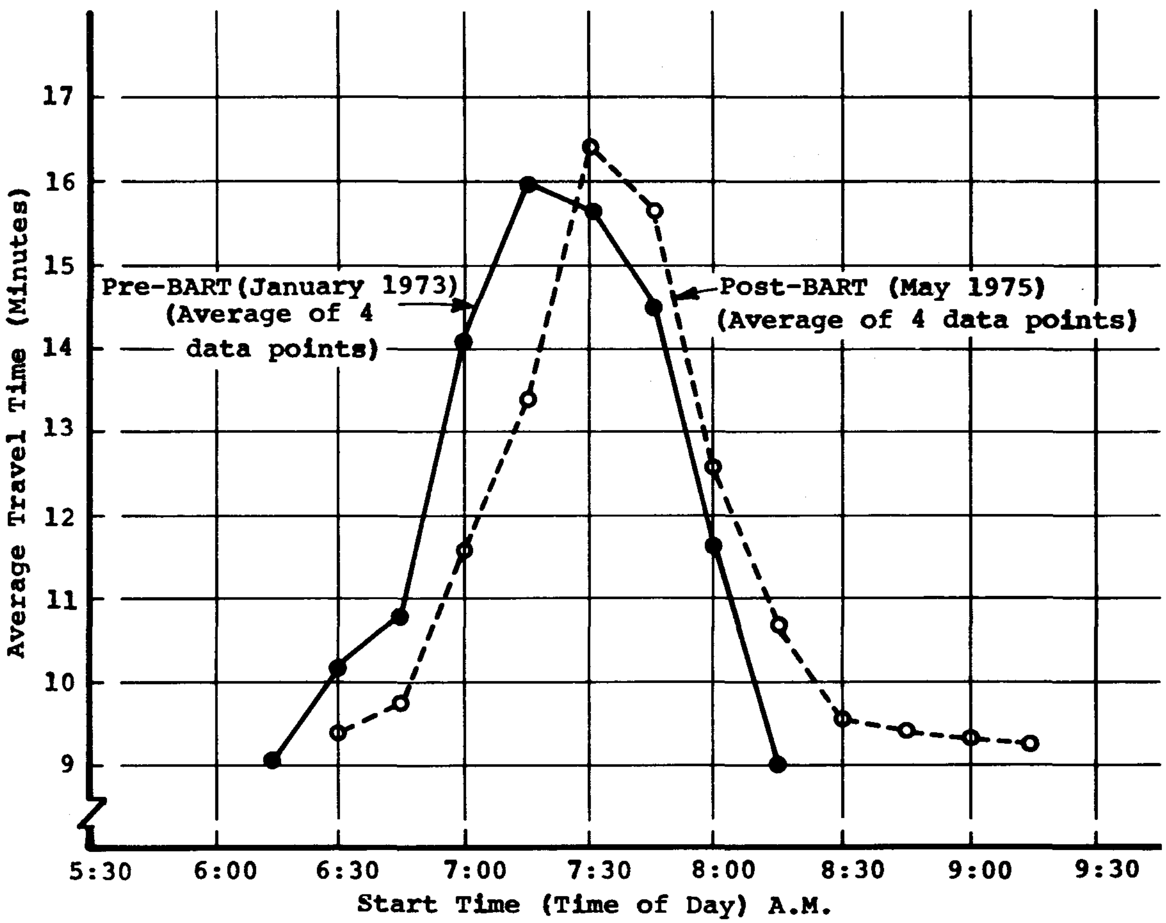
Event Between Pre-BART and Post-BART Data:

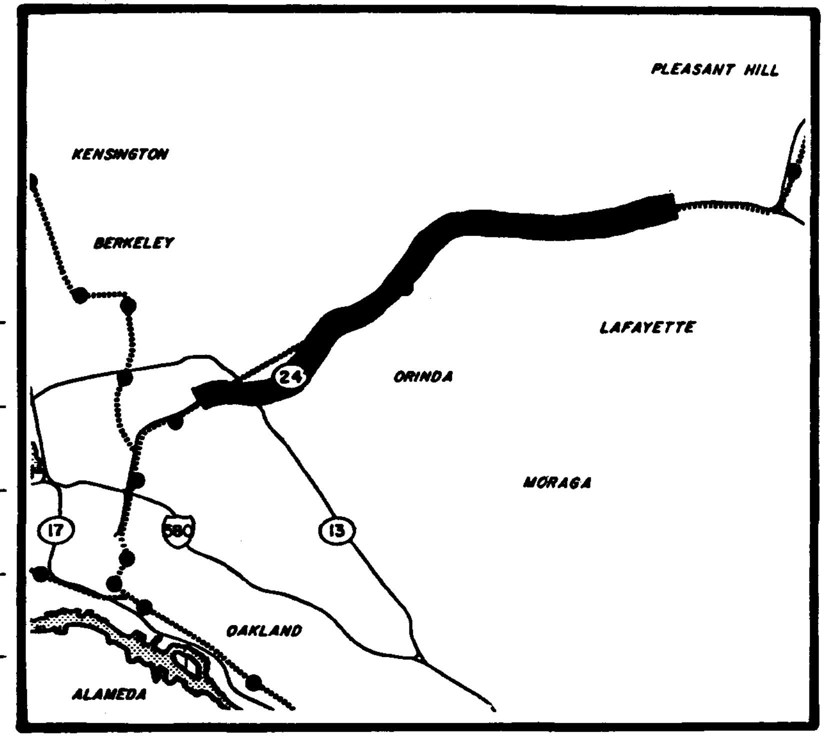
- BART Transbay Line opened September 1974

FIGURE 31

MORNING PEAK PERIOD (WESTBOUND) TRAVEL TIMES ON SAN FRANCISCO-OAKLAND BAY BRIDGE
WEST GRAND AVENUE (OAKLAND) TO TREASURE ISLAND: 3.2 MILES

Source: • CALTRANS and BART Impact Program, Moving Car Observer Travel Time Surveys.





Events Between Pre-BART and Post-BART Data:

- BART Concord Line opened May 1973
- Gasoline shortages and price increases occurred Winter 1973-1974
- 55 MPH speed limit introduced January 1974
- BART Transbay Line opened September 1974

FIGURE 32

MORNING PEAK PERIOD (WESTBOUND) TRAVEL TIMES ON ROUTE 24
OAKHILL ROAD (LAFAYETTE) TO BROADWAY (OAKLAND): 6.1 MILES

Source: • CALTRANS and BART Impact Program, Moving Car Observer Travel Time Surveys.

The figure shows no change in the travel time between the two surveys at the most congested time of day. But the peak has shifted to slightly later in the day--by about 15 minutes--with accompanying reductions in travel times early in the peak period. This is consistent with the conclusions for the Bay Bridge.

Again, a number of events--in particular the gasoline crisis--influenced traffic patterns over the period involved, and purely seasonal variations may account for some of the difference between the January and May observations. Because of these influences on traffic patterns, the changes in peak period travel times in Figure 32 cannot be attributed to BART with any confidence.

IX. BART'S COSTS AND REVENUES

This chapter describes BART's capital costs, operating costs, and revenues and compares them to the estimates in The Composite Report[3] and to those for other rail rapid transit systems. A future report of the TSTB Project will describe BART's costs more completely.

Capital Cost of BART

Estimated Final Capital Cost of BART. The most recent estimate of the total capital cost for completing BART is $1,608 million.[23] This includes the cost for constructing the entire BART System (71 system-miles, 34 stations, 450 cars, 4 shops, 3 yards, and the BART administration building).* As of the end of 1974, $1,468 million (91%) of the forecast total capital costs had been expended. The remaining $140 million is for purchasing the rest of the car fleet, testing and retrofitting cars, working on the train control and power distribution systems, completing the Embarcadero Station, and adding parking facilities at certain BART stations.

Comparison of the Estimated Final Cost to the Preconstruction Cost Estimate. Table 36 compares the preconstruction capital cost estimates for BART with the currently estimated final costs based on an analysis conducted by BART.[25] All costs are expressed in dollar prices current when the estimates were made (i.e., no adjustment is made for price inflation).

In December 1974, the estimated capital cost to complete BART was 62% more than estimated in 1962. The greatest proportional increases are for preoperational testing, the transit vehicles, and engineering and management.

- Preoperational testing costs increased from $7 million to $77 million, largely because of problems encountered with the train control system and the transit vehicles.

- The Composite Report estimated vehicle costs at $71 million for 450 cars, or $157,800 per car. Including $2 million for projected modifications, the final cost estimate is $161 million or $357,800 per car.

---

*The total also includes the cost of constructing 3.3 miles of subway route and facilities for the San Francisco MUNI streetcar system. The additional cost to BART of this construction has been estimated as no more than $155 million.[24]

Table 36

BART CAPITAL COST COMPARISON
(Millions of Dollars)

Cost Categories	Composite Report May 1962[a]	Comparative Data Report December 1974[b]	Increase[c] Amount	Percent
Basic System				
Construction	$579	$ 867[d]	$288	50%
Utility Relocation	45	32	(13)	(29)
Engineering and Management	62	134[d]	72	116
Right-of-Way	97	101	4	4
Preoperational Costs	7	77	70	1,000
Reserve for Unfunded Requirements	--	16[d]	16	--
Nonallocable	--	40	40	--
Subtotal	$790	$1,267	$477	60%
Transbay Tube and Approaches				
Construction	$116	$ 162	$ 46	40%
Utility Relocation	4	6	2	50
Engineering and Management	12	11	(1)	(8)
Right-of-Way	1	1	--	0
Subtotal	$133	$ 180	$ 47	35%
Transit Vehicles				
Vehicles	$ 71	$ 159	$ 88	124%
Modifications	--	2	2	--
Subtotal	$ 71	$ 161	$ 90	127%
Total	$994	$1,608	$614	62%

a. Source: Reference 3.
b. Source: BARTD, Reference 23.
c. Numbers shown in parenthesis are decreases.
d. Estimates made in December 1972 when total estimated costs were $1,494 million (Reference 25).

- Project engineering and management fees increased from $74 million to $145 million.

Factors Contributing to Capital Cost Increases. A thorough analysis of the factors contributing to BART's capital cost increases is extremely difficult, since it would require a detailed analysis of the working papers supporting The Composite Report as well as various BART contractual and financial documents. The following discussion attempts to identify only:

- Cost increases resulting from changes in scope
- Cost increases resulting from inflation rates higher than assumed in The Composite Report
- Cost increases resulting from delays in the construction program

Cost Increases Resulting from Changes in Scope. A number of changes were made to the scope of the BART construction program beyond that originally planned, requiring major increases in capital costs. These are documented in Reference 2, pp. 130-140, and in Reference 23. Changes included increased subway station sizes and improved finishes ($37 million additional),* construction of subway lines in Berkeley ($15 million), extension of mezzanine and plaza areas at San Francisco stations ($15 million), construction of the "box" structure to contain the Embarcadero Station ($8 million), provision of facilities for the physically disabled ($8 million), landscaping ($7 million), relocation of yards and shops ($5 million), and increased weight of rail ($5 million). Reconstruction of Highway 24 adjacent to the BART Concord Line cost an estimated $27 million additional.

These increases in scope were offset by eliminating or deferring some System elements included in the original design. Costs were saved by, among other items, reducing electrification costs ($25 million savings), using more functional finishes at some stations ($10 million), eliminating the Daly City yard ($6 million), and eliminating some station parking structures and lots ($5 million) The net effect of these and many other changes in scope is an estimated increase of $110 million over the original cost estimates, in "current" dollar prices.

---

*Figures are derived from data given in References 23 and 25 and are expressed in "current" dollars. (No adjustments were made to account for price inflation when comparing estimates.)

Cost Increases Resulting from Unanticipated Inflation Rates. The Composite Report assumed that construction costs for BART would inflate at an annual rate of 3%. This inflation rate is consistent with the actual construction cost inflation rate experienced during the 1950s and early 1960s. A review of the Engineering News Records (ENR) index of general construction costs reveals that the inflation rate for construction was much higher than this. The inflation rate varied from 3% to 5% per year between 1960 and 1967 and from 8% to 14% per year between 1967 and 1973.

Analysis of the capital cost cash flows contained in The Composite Report suggests that the higher-than-anticipated inflation rates were responsible for about $60 million (current dollars) of the increase in BART's construction costs.

Cost Increases Resulting from Construction Schedule Delays. As documented in Reference 2, many delays were encountered in BART's construction, and these occurred during a period of severe inflation. If the cash flow of BART's actual construction costs is expressed in terms of "constant" January 1960 dollar prices by deflating costs by the ENR general construction inflation index, the actual construction cost for the originally designed System plus scope changes, in constant January 1960 dollars, is about $944 million. Of this total, $66 million (1960 dollars) stems from scope changes. Hence, the actual construction cost of the originally designed BART System is about $878 million (1960 dollars).

Similarly, the estimated cash flow for the capital cost of constructing BART, as presented in The Composite Report, can be deflated to constant January 1960 dollars using the assumed 3% inflation rate. This yields an estimated capital cost for constructing BART of $827 million (1960 dollars). Thus, in terms of constant 1960 dollars, the $878 million actual construction cost of BART as contemplated in The Composite Report is only about $51 million (6%) greater than the original $827 million cost estimate (although it should be pointed out that the original estimate did include a 10% allowance for contingencies).

As noted, BART's actual construction cost (including scope change costs) is about $944 million (constant 1960 dollars). Subtracting this figure from the total System cost of $1,608 million (current dollars) yields a total inflation-related cost of $664 million. This inflation cost may be allocated as follows:

	Millions of Dollars
Inflation costs estimated in The Composite Report, assuming inflation rate of 3% per year	$167
Inflation costs resulting from inflation rates higher than 3%	60
Inflation costs associated with scope increases	44
Inflation costs associated with delays in the construction schedule	393
	$664

The preceding analysis attempts to simplify a very complex set of events, and uncertainties remain about the true costs of various elements of the BART construction program. However, the analysis does make it clear that overall BART's cost overrun is largely attributable to inflation, particularly when combined with the many delays in the construction schedule.

Comparison of BART's Capital Costs to Those of Other Rail Rapid Transit Systems. Three generally comparable rail rapid transit systems are currently being constructed or planned in:

- Washington, D.C. (METRO)
- Atlanta, Georgia (MARTA)
- Baltimore, Maryland (MTA)

Major construction has only begun on one of these systems, the Washington METRO; much of the cost data for METRO and essentially all of the cost data for the other two systems are, therefore, preconstruction estimates.

In comparing the capital costs of BART with the costs of these systems, it must be recognized that:

- Despite the fact that all four systems employ (or will employ) similar transit technologies, many factors such as variations in site conditions, location, construction techniques, and design philosophy affect costs.
- Since the construction periods of the four systems are different, inflation forms a major component of (current dollar) cost differences. Costs must be expressed in constant dollars for valid comparisons,

requiring forecasts of the capital cost cash flows and construction cost inflation rates for the three systems under construction.

Recognizing these problems, Table 37 presents an approximate comparison of the system characteristics and construction costs of BART and the three other systems.

Estimated capital costs for each of the systems are corrected for the actual and anticipated rates of inflation over the appropriate construction periods to show an average cost per system-mile expressed in terms of constant 1974 dollars.

BART is the second largest of the four systems in terms of (planned) route-mileage and the third largest in terms of stations. The estimated cost per system-mile for BART is $32.1 million (1974 dollars). The equivalent estimates for MTA and MARTA are slightly less--$27.1 million for MTA and $30.2 million for MARTA. The equivalent figure for METRO is $45.9 million, much higher than the three other systems (43% higher than BART). In interpreting the construction cost estimates for the three systems which are under development, it should be borne in mind that the estimated capital costs of METRO have risen by some $2.0 billion (80%) since it was at a stage of development comparable to the current stage of the MTA and MARTA systems.

Interim Operating Costs of BART

Historical BART Operating Costs. Table 38 shows monthly BART operating costs since September 1974, the date transbay BART service began, based on monthly statements of revenues and expenses provided by BART.

At the interim service level provided over the period shown, BART incurred $4,063,000 in operating costs per month, or about $2.12 per car-mile and $0.10 per passenger-mile. Approximately 27% of the operating costs are associated with System operation and police services, 47% are incurred in vehicle and facility maintenance, and the remaining 26% are for general and administrative services and related construction and engineering activities.

Comparison of BART's Operating Costs with Those of Other Rail Rapid Transit Systems. Table 39 shows the physical, operating, and cost characteristics of BART compared with the New York Metropolitan Transportation Authority (MTA), the Chicago Transit Authority (CTA), the Cleveland Transit System (CTS), and the New York Port Authority Trans-Hudson (PATH). Data for both pre- and post-transbay BART operations are shown in the table.

Table 37

BART'S CHARACTERISTICS AND CAPITAL CONSTRUCTION COSTS COMPARED WITH OTHER NEW RAIL RAPID TRANSIT SYSTEMS

	System			
	Baltimore MTA[a]	Atlanta MARTA[b]	Washington METRO[c]	BART[d]
System Characteristics				
System-Miles	28	53	98	71
Number of Stations	21	39	86	34
Seats per Car	80	70	81	72
Maximum Cars per Train	6	8	8	10
Top Speed (mph)	75	70	75	80
Average Speed (mph)	40	n.a.	35	42
Period of Construction				
Construction Period				
Beginning	1974	1975	1969	1964
Estimated Completion	1981	1980	1979	1974[e]
Midpoint of Construction	1978	1978	1974	1969
Estimated Total Capital Cost (millions of current dollars)	$1,000	$2,100	$4,500	$1,600[f]
Capital Cost (millions of dollars)				
Inflation Factor to Convert Costs to 1974 Dollars[g]	$0.76	$0.76	$1.00	$1.43
Total Capital Cost (constant 1974 dollars)	$760	$1,600	$4,500	$2,280
Average Capital Cost per System-Mile (constant 1974 dollars)	$27.1	$30.2	$45.9	$32.1

n.a. = not available.

a. Source: Mass Transit, Vol. 1, Number 4, October 1974, p. 28.
b. Source: MARTA Third Friday, Metropolitan Atlanta Regional Transit Authority, November 15, 1974.
c. Source: METRO Memo, Washington Metropolitan Area Transit Authority, Issue 56, December 1974.
d. Source: BARTD
e. Start of transbay service.
f. Includes up to $155 million for MUNI streetcar facilities.
g. Based on actual inflation rates for years prior to 1974 and an assumed 7% per year beyond 1974.

Table 38

POST-TRANSBAY BART OPERATING COSTS

	1974 October	1974 November	1974 December	1975 January	1975 February	1975 March	Average
Total Cost by Component (thousands of dollars)							
1. Transportation	$ 877	$ 861	$ 901	$ 946	$1,032	$ 928	$ 924
Percent of Total	24%	24%	23%	22%	23%	21%	23%
2. Police Services	164	166	162	165	176	171	167
Percent of Total	4%	5%	4%	4%	4%	4%	4%
Subtotal (1 + 2)	$1,041	$1,027	$1,063	$1,111	$1,208	$1,099	$1,091
Percent of Total	28%	29%	27%	26%	27%	25%	27%
3. Maintenance	$1,786	$1,739	$1,838	$1,918	$2,108	$1,995	$1,897
Percent of Total	48%	49%	46%	44%	47%	46%	47%
4. General and Administration	599	544	813	816	812	951	756
Percent of Total	16%	15%	21%	19%	18%	22%	18%
5. Construction and Engineering	271	239	256	486	345	314	319
Percent of Total	8%	7%	6%	11%	8%	7%	8%
Subtotal (4 + 5)	$ 870	$ 783	$1,069	$1,302	$1,157	$1,265	$2,972
Percent of Total	24%	22%	27%	30%	26%	29%	26%
Total	$3,697	$3,549	$3,970	$4,331	$4,473	$4,359	$4,063
Percent of Total	100%	100%	100%	100%	100%	100%	100%
Unit Costs (Dollars)							
Cost per Car-Mile	$1.76	$1.79	$1.96	$2.27	$2.78	$2.33	$2.12
Cost per Passenger-Mile	$0.09	$0.09	$0.09	$0.10	$0.12	$0.11	$0.10

Note: These cost estimates are based on unaudited financial data.

Source: BARTD monthly statements of operating expenses.

Table 39

RAIL RAPID TRANSIT SYSTEMS' MONTHLY OPERATING STATISTICS

	1973 Statistics[a]					BART[b]
	New York MTA	Chicago	Cleveland	New York PATH	BART	Post-Transbay 10/74-3/75
System Attributes						
System-Miles	232	107	19	14	63	71
Total Miles of Single Track[c]	842	243	43	35	150	166
Stations	481	149	17	13	32	33
Cars	6,704	1,179	116	298	220	350
Car-Miles (millions)	27.5	4.1	0.31	0.74	0.73[b]	1.92
Car-Miles per Track-Mile (thousands)	32.1	16.9	7.2	21.1	4.9	11.6
Car-Miles per Car (thousands)	4.1	3.5	2.7	2.5	3.3	5.5
Car-Hours (thousands)	1,500	--	--	39	21	--
Average Car Speed (mph)	18.3	--	--	19.0	34.8	34.8[d]
Car-Hours per Car	223.8	--	--	130.9	95.5	157.8[d]
Passengers (millions)	93.5	10.6	--	2.5	0.7	2.5
Passengers per Car-Mile	3.4	2.6	--	3.4	1.1[b]	1.3
Average Trip Length	5.8[e]	7.2[e]	--	--	13.6[b]	16.4
Passenger-Miles (millions)	542.3	76.3	--	--	9.5	41.0
Passenger-Miles per Car-Mile	19.7	18.6	--	--	13.0	21.4
Employees	32,516	--	--[f]	1,052	1,450	1,800
Employees per Million Car-Miles	1,182	--	--	1,422	1,986	938
Employees per Million Passengers	348	--	--	421	2,071	720
Employees per Million Passenger-Miles	60	--	--	--	153	44
Distribution of Monthly Operating Costs						
Transportation						
Millions of Current Dollars	$21.1	$2.6	$0.14	$0.7	$0.5	$0.8
Percent of Total	41%	43%	31%	37%	22%	20%
Maintenance						
Millions of Current Dollars	$15.1	$1.4	$0.10	$0.6	$1.0	$1.9
Percent ot Total	30%	23%	22%	32%	43%	47%
Power						
Millions of Current Dollars	$4.0	$0.4	$0.05	$0.1	$0.1	$0.3
Percent of Total	8%	7%	11%	5%	4%	7%
Administration						
Millions of Current Dollars	$10.9	$1.6[g]	$0.16[g]	$0.5	$0.7	$1.1
Percent of Total	21%	27%	36%	26%	31%	26%
Total	$51.1	$6.0	$0.45	$1.9	$2.3	$4.1
	100%	100%	100%	100%	100%	100%
Inflation Rate						
Percent Increase in Top Operator Wage Rate, 1973-1975	15.7%[h]	11.7%[h]	15.0%[h]	10.0%[i]	23.7%[b]	--
Cost per Car-Mile						
1973 Dollars	$1.86	$1.46	$1.45	$2.57	$3.15	--
1975 Dollars	2.15[j]	1.63[j]	1.67[j]	2.83[j]	3.90[j]	2.12[k]
Cost per Passenger-Mile						
1973 Dollars	$0.09	$0.08	$ --	$ --	$0.24	$ --
1975 Dollars	0.11	0.09	--	--	0.32	0.10

Note: Cost estimates are based on unaudited financial data.

See continuing page for footnotes.

Table 39 (cont.)
RAIL RAPID TRANSIT SYSTEMS' MONTHLY OPERATING STATISTICS

Footnotes

a. Source: American Transit Association, 1973 Transit Operating Report.

b. Source: BARTD.

c. Source: Institute for Defense Analysis, Economic Characteristics of the Urban Public Transportation Industry, February 1972.

d. Assuming the same average System speed as pre-transbay.

e. U.S. Department of Transportation, 1972 National Transportation Report, July 1972, p. 193. (Data for Chicago and New York regions.)

f. Included with bus system.

g. Prorated from combined bus/rapid transit administration costs based on other direct operating costs for each mode.

h. Source: John Dash & Associates, Philadelphia, Pennsylvania, and American Public Transit Association.

i. Source: New York Port Authority Trans-Hudson Corporation.

j. 1975 costs are estimated from 1973 costs using the top operator wage rate increase as the inflation indicator.

k. Actual.

Comparison of Physical and Operating Characteristics. At current operating levels, BART is smaller, in terms of car-miles, than the New York MTA or Chicago systems and larger than the Cleveland or New York PATH properties. When it achieves its planned service level of 4.3 million car-miles per month, BART will be operating about the same number of car-miles as the Chicago system.

The system attribute statistics shown in Table 39 reflect a number of differences between BART and the other systems, although the post-transbay BART statistics are much closer to those of the other systems.

- BART operates a smaller proportion of car-miles per track-mile than the other properties, (except Cleveland). This difference will probably decrease when more cars are in service and the improved train control system allows headways to be reduced.

- BART's car utilization, measured in monthly car-hours per car is lower than, say New York MTA, but monthly car-miles per car are higher. (This reflects the much higher average speed of trains on the BART System). In interpreting these figures, it should be borne in mind that BART currently operates substantially fewer hours per week than the other properties.

- BART has a lower number of passengers per car-mile than the other systems. However, the average trip length on BART (about 16 miles) is much longer than the average trip length on the other transit properties so that BART has a larger number of passenger-miles per car-mile than the other systems for which data are shown.

- Similarly, BART has a much higher number of employees per passenger compared to the other systems, but (for post-transbay operations) a lower number of employees per passenger-mile (compared to the New York MTA, the only other system for which the statistic is shown).

Comparative Analysis of Cost Components. The components of operating cost given in Table 39 show a similar distribution of cost for the four mature systems, while BART's distribution differs significantly. Whereas transportation costs (costs associated with actual system operation) are between 31% and 43% of total operating costs for the four mature systems, they comprise only 20% of BART's operating costs. In contrast, maintenance costs range from 22% to 32% for the mature systems, but make up 47% of all operating costs for BART.

At current interim service levels, BART operates only about 50% of the car-miles per month projected for full-system operation and its hours of operation are constrained. Thus, BART's transportation costs are smaller than they will be for full-system operation. On the other hand, the entire System is in operation and requires maintenance. BART's start-up and "debugging" problems have also resulted in high costs which appear as maintenance costs (although it might be argued that these start-up costs should be considered capital costs).

Comparative Analysis of Costs Per Car-Mile and Per Passenger-Mile. Table 39 also shows operating costs for BART and the other five rapid transit systems on a per car-mile and per passenger-mile basis (where data are available). The data for the other systems (and for pre-transbay BART) are shown in actual 1973 prices and in 1975 prices. The increase in the top wage rate for motormen (train operators) was used as the inflation factor in estimating the 1975 costs.

In 1975 dollars, estimates of operating costs for the five systems shown vary from $1.63 to $2.83 per car-mile. BART's cost is $2.12 per car-mile for current interim system operations, close to the $2.15 per car-mile for the New York MTA. On a passenger-mile basis BART's post-transbay cost of $0.10 is very close to the estimates of $0.11 and $0.09 for the New York and Chicago systems, respectively. Both car-mile and passenger-mile costs for BART decreased markedly between 1973 and 1975 as the scale of operations expanded.

Clearly, any comparison of BART's operating costs with those of other rail rapid transit systems must be interpreted cautiously in light of the unique physical, organizational, and accounting characteristics of the different systems. However, the data given in Table 39 show that, for current operations, BART's operating costs are in line with those of the older, established U.S. rail rapid transit systems. As the BART System matures to full-system operations, it is expected that BART's car-mile and passenger-mile costs will decrease.

Comparison of BART's Operating Costs to Those of Commuter Rail Systems. Table 40 shows BART's operating costs compared to estimates of average operating cost for about ten U.S. commuter railroads. Data for the commuter railroads were abstracted from recent reports prepared for the U.S. Department of Transportation by DeLeuw, Cather & Company[26] based on 1970 data and by the Institute for Defense Analysis[27] based on 1972 data inflated to 1973 prices. Historical commuter railroad costs have been inflated to 1975 dollars using the average railroad wage rate as the inflation factor.

Although BART has a much lower operating cost per car-mile ($2.12 for BART compared to $3.65 for commuter railroad), its cost per passenger-mile is higher ($0.10 compared to $0.08). Among factors contributing to these differences are that (1) commuter railroad cars generally have

Table 40

COMPARISON OF BART AND COMMUTER RAIL OPERATING COSTS

Distribution of Operating Costs (percent of total)	Commuter Rail	BART October 1974 to March 1975[a]
Transportation (including power)	58%[b]	27%
Maintenance	36[b]	46
Administration	6[b]	27
Total	100%[b]	100%
Cost per Car-Mile		
1973 Dollars	$3.33	n.a.
1975 Dollars	3.65[c]	$2.12
Cost Per Passenger-Mile		
1970 Dollars	$0.05[d]	n.a.
1975 Dollars	0.08[c]	0.10

n.a. = not applicable.

a. Source: BARTD.
b. Source: Institute for Defense Analyses.
c. Inflated based on national average railroad wages as reported in Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C.
d. Source: DeLeuw, Cather & Company.

more seats per car than BART, and (2) commuter railroads provide most of their service (car-miles) at peak periods when passenger load factors are high and very little service during off-peak periods. In contrast, BART provides a relatively high level of off-peak service.

Comparison of BART's Operating Costs with Those of Other Bay Area Transit Modes. Table 41 compares BART's operating costs with those of MUNI and AC Transit. Because of the wide variation in vehicle size, the comparison is based on cost per seat-mile. The most recently available operating cost data for AC Transit and MUNI were inflated to estimates of January 1975 costs based on AC Transit and MUNI operators' respective wage-rate increases.

The figures given in Table 41 show that BART's operating cost of $0.030 per seat-mile is essentially the same as AC Transit's bus operating cost of $0.029. This is somewhat surprising, since many proponents justify the large capital investments required for rail rapid transit by arguing that the operating costs will be smaller than those of less capital-intensive bus systems.

Special caution should be exercised in interpreting the data shown in Table 41, since many factors complicate the comparison between BART and other transit systems--such as the different kinds of service provided by the systems, differences in accounting methods, and the fact that the estimates of BART's operating costs are for an interim stage of operation. However, the comparisons (especially those with AC Transit) are of interest in that they provide a tentative indication of the relative operating costs of bus and rail rapid transit in general.

Comparison of BART's Operating Costs to Those Estimated in The Composite Report. In The Composite Report, BART's annual operating expenses were estimated at about $13 million for 1972 (the first year in which full BART operations were anticipated) and increased in increments to about $14 million per year in 1980. Annual operating costs of about $13.5 million were estimated for 1975. (All these estimates are in constant 1960 dollars.) BART actual costs in Fiscal Year 1975 were $49.8 million.

Not all the factors that have contributed to the difference between the projected and actual operating costs can be discussed in this limited study. However, two factors appear to have contributed significantly to the difference: (1) inflation in the costs of operating rail rapid transit systems, particularly labor costs, and (2) BART's requirement for a larger personnel complement than was originally planned.

Analysis of data for other U.S. rapid transit systems show that operating costs per car-mile increased by the following factors between 1960 and

Table 41

COMPARISON OF OPERATING COSTS FOR BART AND OTHER BAY AREA TRANSIT MODES[a]

Mode	Date of Data	Cost per Vehicle-Mile (current dollars)	Inflation Factor[b]	Cost per Vehicle-Mile (January 1975 dollars)	Seats	Cost per Seat-Mile (January 1975 dollars)
BART[c]	1975	$2.12	1.00	$ 2.12	72	$0.030
MUNI[d]	1973-1974					
Motor Coach		2.01	1.09	2.19	48	0.046
Trolley Coach		2.35	1.09	2.57	48	0.054
Streetcar		2.34	1.09	2.56	55	0.047
Cable Car		9.51	1.09	10.38	30	0.346
AC Transit[e]	1973-1974					
Motor Coach		1.21	1.15	1.39	48	0.029

Note: These cost estimates are based on unaudited financial data.

a. Costs reflect total operating costs less depreciation allowances.
b. Inflation factors based on the top operator's wage rate increase.
c. Source: BARTD.
d. Source: San Francisco Municipal Railway (MUNI).
e. Source: Alameda-Contra Costa Transit District (AC Transit).

1975: New York MTA, 3.07; New York PATH, 2.64; Cleveland CTS, 2.69; and Chicago CTA, 2.18 times.*

On average, costs per car-mile for the four systems increased by a factor of 2.65 over the period 1960 to 1975. Applying this factor to BART's original operating cost estimate of $13.5 million gives $35.8 million in 1975 dollars.

In late 1970, before the start of BART service, BART estimated its total staff requirement for (1975) stabilized full-system operation at about 1,200 personnel.[28] During Fiscal Year 1975, BART about 1,900 employees, 58% more than were estimated in 1970.

Since over two-thirds of BART's operating costs are for salaries and benefits, BART's operating costs might be expected to increase approximately in proportion to the size of the staff. Applying a 58% increase to the estimate of BART's operating costs derived above, gives an estimate of $56.6 million. This may be compared with BART's actual 1974/1975 costs of $49.8 million. Clearly, many other factors have influenced BART's costs, but the above (admittedly approximate) analysis shows that the difference between the original cost estimates and actual operating costs are largely explained by the two factors of (1) inflation, and (2) unrealistically low original estimates of staff requirements.

BART's Revenues

Table 42 shows BART's monthly patronage and revenue since service began in September 1972. Changes in patronage, revenues, and trip length are obvious when service started on each BART line. Over the nine full months shown since transbay service began, patronage has averaged 2,535,000 trips per month (equivalent to 30,422,000 trips per year), and fare revenue has averaged $1,586,000 per month (equivalent to about $19.0 million per year).

These figures compare with estimates of 77,137,000 trips and $23.8 million gross fare revenues** contained in The Composite Report for Fiscal Year 1975. Thus, current BART patronage is about 40% of the original estimate for full-service operations, but fare revenues are about 80% of those originally estimated. The difference between the two percentages is partly explained by the fact that BART fares shown in Table 42 are about 40% higher than estimated in The Composite Report.*** (The average

*Data sources are as given in the notes to Table 39.

**The Composite Report estimated $24,284,000 combined gross fare and concession revenues for the year ending June 30, 1975. Concession revenues have been assumed at 2% of the total, leaving $23,798,000 estimated gross fare revenues.

***As noted in Chapter I, BART increased its fares further effective November 1975.

Table 42

HISTORICAL MONTHLY BART PATRONAGE AND REVENUE

Month	Gross Fare Revenue[a]	Passengers	Passenger-Miles	Average Miles Per Trip	Gross Fare Per Passenger	Gross Fare Per Passenger-Mile
September 11, 1972--Fremont Line Opens						
September 1972	$ 138,863	237,020	4,197,039	17.7	$0.5859	$0.0331
October 1972	195,101	353,430	5,796,629	16.4	0.5520	0.0337
November 1972	169,970	294,360	4,827,799	16.4	0.5774	0.0352
December 1972	166,021	296,909	4,869,340	16.4	0.5592	0.0341
January 1973	170,286	308,322	5,056,481	16.4	0.5523	0.0337
January 29, 1973--Richmond Line Opens						
February 1973	272,492	536,436	8,422,045	15.7	0.5080	0.0324
March 1973	270,154	548,704	8,614,053	15.7	0.4923	0.0314
April 1973	279,255	553,611	8,691,693	15.7	0.5044	0.0321
May 1973	351,356	673,755	10,005,262	14.9	0.5215	0.0351
May 21, 1973--Concord Line Opens						
June 1973	416,232	769,754	11,430,847	14.9	0.5407	0.0364
July 1 to August 6, 1973--BART Strike						
July 1973	--	--	--	--	--	--
August 1973	369,644	675,593	10,017,719	14.8	0.5471	0.0369
September 1973	347,162	635,860	9,442,521	14.9	0.5460	0.0368
October 1973	443,529	816,936	12,131,500	14.9	0.5429	0.0366
November 5, 1973--San Francisco Line Opens						
November 1973	646,073	1,429,185	14,603,651	10.2	0.4521	0.0442
December 1973	653,220	1,465,722	15,956,162	10.9	0.4457	0.0409
January 1974	690,773	1,507,673	17,082,983	11.3	0.4582	0.0404
February 1974	650,343	1,407,161	16,150,895	11.5	0.4622	0.0403
March 1974	745,125	1,551,431	18,811,837	12.1	0.4803	0.0396
April 1974	745,144	1,591,704	18,474,039	11.6	0.4681	0.0403
May 1974	690,933	1,519,976	17,691,656	11.6	0.4546	0.0391
June 1974	617,493	1,360,439	15,670,701	11.5	0.4539	0.0394
July 1974	675,103	1,545,892	17,835,428	11.5	0.4367	0.0379
August 1974	695,696	1,619,469	18,777,351	11.6	0.4500	0.0390
September 16, 1974--Transbay Link Opens						
September 1974	1,046,458	1,894,604	26,740,000	14.1	0.5523	0.0391
October 1974	1,659,743	2,749,104	43,194,000	15.7	0.6037	0.0384
November 1974	1,537,336	2,489,474	39,622,648	15.9	0.6175	0.0388
December 1974	1,689,876	2,688,982	43,501,000	16.2	0.6284	0.0388
January 1975	1,645,721	2,633,726	42,875,000	16.3	0.6249	0.0384
February 1975	1,393,741	2,228,958	36,414,000	16.3	0.6253	0.0383
March 1975	1,541,891	2,435,903	40,218,000	16.5	0.6330	0.0383
April 1975	1,593,999	2,545,434	41,569,000	16.3	0.6262	0.0383
May 1975	1,580,454	2,497,169	41,376,000	16.6	0.6329	0.0382
June 1975	1,630,030	2,548,079	42,526,000	16.7	0.6397	0.0383

Note: Revenue estimates are based on unaudited data.

a. Total fares collected at faregates and by other administrative procedures.
b. Average trip lengths are estimates derived from data on extracted fares. Actual trip lengths may be as much as 20% lower. However, no adjustments have been made in calculations reported elsewhere in the report to reflect the lower actual average trip lengths.

Sources: BARTD, Monthly Patronage and General Manager's Reports.
BARTD, Transportation Department and Office of Research.

fare for the origin-destination trip distribution which was traveled in October 1974 was $0.63; the average fare for the same trip distribution using The Composite Report fare schedule is $0.44). The rest of the difference between the percentages is explained by the fact that current BART trips are much longer, on average, than originally projected, mainly because fewer short trips are being made than originally forecast.

BART's Operating Deficit

Table 43 presents BART's operating revenues, costs, and deficits since the start of service. Deficits per passenger (trip) and per passenger-mile have clearly decreased greatly since the early stages of operation; however, costs are still well in excess of revenues. In the first six months of 1975, the average revenue per passenger was $0.59, and the average operating cost per passenger was $1.90, leaving a deficit of $1.31 per passenger (69% of costs) to be paid for by community support.

The most recent estimates[29] of the BART District forecast that operating deficits will continue to increase in total but will decrease on a per-passenger basis to a level of about $1.07 per passenger in 1980. This forecast may be contrasted with The Composite Report forecast of an operating profit of $0.14 per passenger. Three factors may be singled out to explain the difference between these forecasts.

- BART does not expect to reach the optimistic ridership forecasts of the original report even at ultimate full-system operation. (BART currently estimates that in 1980 ridership will be 71% of The Composite Report forecast.)

- BART has incurred operating costs far higher than those originally estimated; and costs are expected to continue to rise at a greater rate than forecast. Some of the reasons for these cost increases were discussed earlier in the chapter.

- BART fares have increased at a lower rate than operating costs have increased, contrary to the explicit assumption of The Composite Report that "fares and revenues will be raised sufficiently in inflationary periods to meet rising operating expenses and still provide the proportional margin of net revenue indicated in the estimates." (As discussed earlier, the average increase in operating costs per car-mile for the New York, Chicago, and Cleveland rapid transit systems was by a factor of 2.65 between 1960 and 1975; BART's fares were increased by a factor of only 1.43 over a similar period.)

Table 43

HISTORICAL BART OPERATING DEFICITS

	Net Operating Revenues[a]	Total Operating Expenses	Operating Deficit	Net Operating Revenues Per Passenger	Operating Deficit Per Passenger	Operating Deficit Per Passenger-Mile
Fiscal 1973						
September-December 1972	$ 597,000	$ 5,491,000	$ 4,894,000	$0.49	$4.14	$0.25
January-June 1973	1,629,000	13,712,000	12,083,000	0.48	3.56	0.23
Fiscal 1974						
July-December 1973	2,309,000	13,937,000	11,628,000	0.45	2.31	0.18
January-June 1974	3,935,000	19,970,000	16,035,000	0.44	1.79	0.15
Fiscal 1975						
July-December 1974	6,844,000	21,523,000	14,679,000	0.53	1.13	0.08
January-June 1975	8,851,000	28,299,000	19,448,000	0.59	1.31	0.08

Note: Revenue and cost estimates are based on unaudited financial statements.

a. Gross fare revenues less adjustments for special fare discounts, transfer expenses, and other deductions.

Sources: BARTD, Monthly Reports.
BARTD, Transportation Department and Office of Research.

X. CONCLUSIONS

Context for Interpretation of Interim Findings

The findings and conclusions presented here are interim in several respects.

- The TSTB Project, as one of several projects of the BART Impact Program, attempts to assess only BART's impacts on the service provided by the transportation system and on travel patterns in the Bay Area. Many other impacts, such as impacts on the urban development, employment, environment, economics, and finances of the region are outside the scope of the TSTB Project.

- The conclusions summarized here result from only the first phase of the Project. Much of the Phase I work was exploratory and concerned with assembling data on different aspects of BART's impacts. The costs and benefits of the various impacts were not analyzed together in a comprehensive way, and the impacts of the fixed-route BART rail system were not compared with the possible impacts of hypothetical alternative transit systems. No travel choice modeling or network simulation of travel patterns was undertaken in the first phase of work. Further analyses and, hopefully, more definite conclusions will result from later phases of the TSTB Project.

- The findings of the report are for an early period of system operation when BART's service was much below that ultimately planned. Direct service was not yet operating on all routes of the System, no regular weekend or evening service was operating, and train frequencies were lower than ultimately planned. Since the first line opened in September 1972, the System has been plagued by problems of equipment availability and reliability which continue to affect the service provided. Attainment of full, reliable BART service will probably give rise to increased BART ridership and greater impacts.

Certain factors in BART's setting also limit the extent to which the BART experience can be usefully applied to planning or operating transit elsewhere.

- The geography and economy of the San Francisco Bay Area differ from those found in other metropolitan areas of the U.S.

- BART itself, although the forerunner of a new generation "heavy" rail rapid transit system, is unique--for example, in its line-mileage distribution among suburban and central city areas, station spacing, train speeds, and other operating characteristics.

- BART's decision history and the political and economic climate in which its development took place differ from the circumstances in which transportation decisions will be made in other locations.

Even though the findings have limitations, useful interim conclusions can be drawn from the first phase impact studies of the TSTB Project.

BART Service

Although BART's service is still affected by start-up and equipment reliability problems, the System is basically doing what it was primarily designed to do--providing high-quality, long-distance commuter service to central San Francisco and Oakland. For many of those living in remote suburbs, especially on the Concord and Fremont Lines, travel time accessibility to work locations in the downtown areas has improved (especially relative to travel by bus).

But only long-distance travelers and people who have convenient access to the BART stations are enjoying these improvements. BART offers less travel time advantage for short trips where getting to and from the station forms proportionately more of the journey time. Thus, in spite of BART's 80-mph trains, its improvements in door-to-door travel times have been significant only for a relatively small percentage of areawide residents.

Since travelers typically spend a high proportion of their total journey time in getting to and from the System, convenient access is very important to a fixed rail system such as BART. Limited parking space at BART stations is currently constraining the service offered to many travelers, and bus access services are only now being introduced to some stations (although many, especially those in the MUNI and AC Transit service areas are relatively well served by conventional bus). Unfortunately, the Phase I analyses do not allow a definite conclusion about the extent to which overall BART service might be improved by increasing access services. Enlarging parking capacity at some stations would probably make the System more attractive to many potential BART travelers, but the opportunities for increasing ridership by improving feeder bus service are less clear.

BART's fares are generally slightly higher than the bus fares for corresponding journeys. For example, for the typical transbay journey in October 1974, the total trip cost by BART (about $1.30) was between $0.05 and $0.10 more than the bus trip cost. However, BART is much less expensive than automobile. Clearly, the cost difference varies widely as a function of travelers' perceptions of the cost of driving, but the total trip cost by BART was perceived by travelers as being between $1.00 and $1.50 less than by automobile for typical transbay journeys in October 1974.

Travelers' perceptions of BART's quality of service largely reflect the equipment availability and reliability problems which continue to adversely affect some aspects of service. In general, BART's service levels are below people's expectations; nevertheless, most travelers generally perceive aspects of the System favorably. Most travelers are satisfied with BART's comfort, safety, and security (although attitudes regarding security may change when night service is introduced). But many travelers are dissatisfied with BART's reliability, seat availability, and the time they must spend waiting for trains.

The Phase I analyses do not allow firm conclusions on the extent to which the various aspects of BART service affect people's decisions to use the System. However, the interim results indicate that relative travel time and reliability are the most important factors in most peoples' decisions. There is little evidence that qualitative factors such as comfort are important in persuading travelers to ride the System, although much of the investment in the BART System was in providing comfortable and attractive trains and stations to attract ridership.

Impacts on Travel Patterns

Aggregate Ridership on BART. In total, BART's ridership is well below the original forecast. (Current ridership of about 120,000 trips per day is little more than one-half of the forecast for full-system operations.) BART's ridership is also low when compared to total travel by automobile and transit areawide. (BART's average weekly ridership of about 590,000 trips represents under 2% of all vehicle trips made by residents of the BART Impact Area.)*

---

*But there are different ways of looking at BART's share of the "trip market." If only weekday travel between 6:00 a.m. and 8:00 p.m. is considered, BART's share increases to about 3%; if only trips to and from work are included, BART's share is 8% of areawide trips. If BART's potential trip market is defined in terms of trips people consider could reasonably be made by BART, its share rises to 19% of trips for all purposes and 29% of trips to and from work.

BART's apparently low ridership is explained in part by BART's (1) restricted hours of service and passenger-carrying capacity, and (2) equipment reliability and other operating problems which affect service levels. As evening and weekend service are introduced, service frequency and reliability improved, and peak-period seat availability increased, ridership will increase. However, reasons for the apparently low usage of the System--especially at off-peak periods--must be explained primarily by analyzing the service offered by BART relative to travel by bus and automobile.

The reasons for traveler's use or nonuse of BART are complex and depend on many aspects of the service offered by BART and the alternatives--including travel time, cost, dependability of service, comfort, and so on. The Phase I analyses of the TSTB Project have not included a comprehensive analysis of the relative importance of these factors, but apparently, door-to-door journey travel time is the dominant factor in most peoples' travel choice (given the levels of all other factors currently associated with the various alternatives). As discussed earlier, BART offers a door-to-door travel time advantage to relatively few travelers (especially when compared to travel by automobile).

There may be opportunities for decreasing door-to-door travel times by improving bus service to BART stations. Waiting times will be reduced by increasing service frequencies. Introduction of direct Richmond-Daly City service will also reduce journey times for some travelers. However, these changes will probably have only small effects. Overall journey times by BART in the future will probably not be much below existing levels. BART's opportunity for increasing ridership must, therefore, be with improving the quality of service offered--in terms of peak-period seat availability, parking space at the stations, and above all, the dependability of on-time service.

The extent to which these improvements in BART's service will increase ridership is largely a matter of speculation, but presently it appears unlikely that the original forecasts will be achieved. This conclusion points to the need for careful appraisal of the reasonableness of ridership forecasts at the early stages of planning a system such as BART, (even though this may sometimes conflict with a desire to show the system's potential for success in the best possible light when voter approval of funding is being sought).

Characteristics of BART Ridership. On average, BART trips are long (16.5 miles) and mainly made between workplaces in downtown Oakland or San Francisco and the more remote residential suburbs of the area. Relatively few trips are made in the reverse-commute direction, at off-peak times, or for nonwork purposes. (The low off-peak utilization of the System is illustrated by the fact that the number of seat-miles operated by BART in the six months after transbay service began was 3.4 times greater than the number of passenger-miles--even though many travelers stand for peak-period journeys.) Clearly, much of the opportunity for increasing System ridership is for off-peak and short trips.

The demographics of BART riders reflect, in part, the high proportion of BART trips made from the more affluent suburbs to downtown San Francisco work locations--the trips the System was primarily designed to serve. (Transbay BART riders have much higher average incomes, for example than travelers on other parts of the BART System.) But, overall, the characteristics of BART riders are not very much different from the characteristics of travelers in the Bay Area as a whole. BART riders have only slightly higher average incomes than the average for the population and have a slightly lower proportion of racial minorities than are present in the areawide population. This largely reflects the fact that low-income and minority persons tend to make fewer trips by any means.

The slightly lower use of BART by low-income and minority groups may be explained by the higher average BART fares (relative to bus) and the small door-to-door travel time advantage offered by BART for many of the relatively short trips to central areas from the closer-in suburbs--the trips most likely to be made by low-income and minority persons.

Use of BART by physically disabled people is much lower than their representation in the population as a whole--in spite of BART's large investments in elevators and other facilities provided specifically to allow disabled people to use the System. This apparently low use of BART by disabled people reflects, to some extent, the difficulties they experience in getting to and from the stations and, in some cases, using BART itself. However, it is not clear whether use of BART is, in fact, particularly low or whether it simply reflects a lower trip-making rate by physically disabled people in general.

Impacts on Travel by Bus and Automobile. Overall, BART has attracted most of its ridership from bus; of transbay BART trips, 54% were previously made by bus and only 35% by automobile. Trips not made before by either means made up the remaining 11% of trips.

Study of the San Francisco-Oakland Bay Bridge corridor suggests that the reduction in the number of bus trips is similar to the number of BART trips reported as previously made by bus. However, the actual reduction in trips by automobile has been much less than the reported diversion of trips from automobile to BART, suggesting that "new" automobile trips have appeared to replace some of those removed by BART. Although about 11,000 daily person-trips were diverted to BART at the start of transbay service, the net reduction in automobile trips was only about 4,000 per day. The "new" 7,000 automobile trips may actually be trips diverted from other destinations or routes rather than truly induced trips, but in either case, their effect has been a smaller reduction in automobile vehicle traffic than anticipated.

Separating the impacts of BART from the many other factors affecting travel patterns is difficult. However, a net reduction in daily Bay Bridge traffic of between 3,000 and 5,000 vehicles per day is estimated as attributable to the start of transbay BART service. This reduction is small in relation to the dramatic reductions in traffic volumes predicted by early planning studies. Although significant, statistically speaking, it is also small in relation to the total volume of transbay travel. The reduction represents about two years historical growth in Bay Bridge traffic and is of the same order as normal week-to-week variations in traffic.

The source of the "new" automobile trips that appeared after BART began service cannot be stated with certainty. However, it seems reasonable to hypothesize that the alleviation of Bay Bridge traffic congestion brought about by the diversion of travel to BART has been a factor. Some potential transbay automobile trips may have previously been suppressed; improvements in travel conditions now allow these suppressed trips to be made. In addition, substantial numbers of new trips are being made on BART itself.

These impacts of BART in the Bay Bridge corridor are rather different from those originally anticipated, but similar impacts can be expected whenever a major increase in transportation capacity is provided--whether by rapid transit or some other form of transport--in a heavily traveled and congested corridor. The benefits of increasing transportation capacity are primarily in (1) providing faster and higher-quality service to those already traveling and (2) allowing previously suppressed trips to be made. Where automobile traffic levels are already high, reductions in traffic will generally be much less than might be predicted from a simple analysis of travel diversion. And since rapid transit systems such as BART are likely to be introduced only in a densely traveled corridor, this result will usually be the case.

The areawide impact of BART on vehicle-miles of travel (VMT) by all modes has not been assessed as part of the Phase I TSTB studies. However, the estimate given earlier--that less than 2% of all weekly trips made areawide are by BART--suggests that the VMT impacts are small, especially if the hypothesized phenomenon of induced traffic has occurred in corridors other than the Bay Bridge.

Impacts on Service Provided by Bus and Automobile. BART's impacts on the service provided by the rest of the transit system are difficult to assess since both bus services parallel to BART lines and buses acting as feeder services to BART are affected; but in general, BART's impacts on bus service have been small. Services have been cut back only where BART clearly duplicates and improves service.

BART impacts on the service provided by the highway system--in particular travel times by private automobile are also extremely difficult to assess in the context of the many other factors affecting highway traffic volumes. Only on the Bay Bridge can a reduction in travel times be attributed to BART with any degree of confidence, and this reduction is small relative to total travel times, representing an estimated increase in average speed from 16 mph to 18 mph at the most congested time.

BART's Costs and Revenues

The total capital cost of the BART System, including the transit cars, is now estimated to be $1,608 million (in current dollars). This is an average of $23 million for each mile of the System, and must be considered high by most standards.

The $1,608-million estimate compares with $994 million contained in The Composite Report[3]--an increase of 62%. However, the major part of this increase can be accounted for by inflation in the cost of constructing the System, combined with severe delays to the original construction program. If the actual cost of constructing the System (exclusive of changes in scope) is compared to The Composite Report estimate in terms of 1960 prices (by deflating costs according to the Engineering News-Record index of general construction costs), BART's actual capital cost is only 6% greater than originally estimated.

Expressing costs in terms of constant (1974) dollars, BART's capital costs ($32.1 million per mile) are similar to estimates for the proposed rapid transit systems in Baltimore ($27.1 million per mile) and in Atlanta ($30.2 million per mile). BART's costs are substantially less than the latest estimates for the Washington, D.C., METRO System ($45.9 million per mile expressed in 1974 dollars).

Conclusions about BART's operating costs must be tentative, since costs continue to reflect System start-up expenses and interim operating levels. However, analysis of costs to date suggests that the high initial capital cost of BART is not being offset by correspondingly low operating costs. Expressed on either a car-mile or passenger-mile basis, BART's costs are similar to much older and less automated rapid transit systems such as the New York MTA; and expressed on a seat-mile basis, BART's operating costs appear to be similar to the operating costs of a bus system such as AC Transit.

BART's operating costs are much higher than originally projected, but as with the capital costs, most of the increase is accounted for by inflation at much higher rates than expected--particularly in labor costs. BART's current staff is also much larger than originally estimated, largely because of unrealistic original expectations of the way in which automation of the System would allow low staffing levels.

A high percentage (47%) of BART's interim operating costs are for maintenance, including costs associated with start-up and "debugging" problems; and a relatively low percentage (20%) are for transportation. As the System approaches full operating levels, this situation is expected to reverse, and operating costs per car-mile will decrease.

In the first six months of 1975, BART's average revenue per passenger was $0.59, and the average operating cost per passenger was $1.90, leaving a deficit of $1.31 per passenger. This may be compared with the operating profit of $0.14 per passenger forecast in The Composite Report. In part, this difference is explained by the optimistic ridership forecasts of the original report and cost increases much higher than anticipated. But it is mainly accounted for by the fact that in the period since the original estimates were made, fares have increased by a much lower factor than operating costs, contrary to the assumptions of the original financial projections.

The difference between BART's operating costs and revenues is comparable with the deficits of other transit properties. In a recent report by the State of California Legislative Analyst,[30] BART's total fare revenues were estimated as 35% of total operating expenses for the 1974-1975 fiscal year. This compares with corresponding estimates of 34% for AC Transit and 30% for MUNI. The estimated ratios of fare revenues to operating expenses for the 1975-1976 fiscal year were even closer: BART's fare revenues were estimated in the Legislative Analyst's report at 32% of expenses, compared to 31% for AC Transit and 33% for MUNI. It is interesting to compare these percentages with the recommendation contained in the Legislative Analyst's report that "the percent of total operating costs defrayed by user charges should be approximately 40 percent" (Reference 30, p. 10). Fare increases on BART (and the bus systems) would clearly be necessary to reach this goal.

Like its operating costs, BART's interim energy consumption per car-mile reflects the short hours of operation and low number of car-miles operated. Traction energy per car-mile is currently about 10% higher than the average for rapid transit systems in the U.S. As full-system operations are approached, it is projected that traction energy per car-mile will decrease to about 10% below the national average, reflecting among other factors, BART's relatively lightweight cars. However, even at full operating levels, BART's traction energy consumption is likely to be substantially more than express bus service when compared on a seat-mile basis. At full-system operation, BART will consume an estimated 810 Btu per seat-mile in traction energy compared to an estimated 520 Btu per seat-mile for express bus. This conclusion contradicts the widely held assumption that steel-wheel-on-steel-rail modes of transport, are more energy-efficient than rubber-tired vehicles (although many factors, such as the higher maximum speed of BART, must be taken into account in making the comparison).

Methodology of Impact Assessment

Separating the impacts of BART--especially its impacts on travel by other modes--from the many other influences affecting travel patterns is extremely difficult. This is illustrated by the analysis of Bay Bridge traffic volumes given in Chapter VI. Unusually high-quality traffic count data on a day-by-day basis over several years were available for this analysis, together with the results of extensive questionnaire surveys of BART, bus, and automobile ridership in the corridor. BART's impacts on travel in this corridor are also probably greater than in any other corridor in the Bay Area. Even so, conclusions about BART's impacts on travel by automobile could not be drawn with certainty in the context of other influences--such as increased gasoline prices and the effects of induced travel.

In general, a great deal of data, carefully collected on a consistent time series basis is necessary to allow the travel impacts of a system such as BART to be separated from other influences. Collection of sufficiently detailed data for all areas or situations where a regional rapid transit system might be hypothesized to have affected travel patterns is prohibitively expensive. Therefore, it is necessary to concentrate data collection and analysis efforts on a small number of areas or situations where significant impacts are most likely (together with an equivalent number of control sites as appropriate). Collection of sufficiently detailed data is the key consideration, whatever the number of sites studied.

For example, with given survey resources, a series of moving-car highway travel time surveys might attempt to cover all major routes with a small sample of runs on each. But it would be preferable to use the same resources to survey only one or two routes--ensuring that a sufficiently large number of runs are conducted at different times of day, on different days, and over an extended time period.

Of course, such an approach means that it may be necessary to extrapolate the findings of a small number of detailed studies to other areas or situations where minimal data may be available and where BART's impacts may be very different. This may be difficult; nevertheless, the likelihood of useful general conclusions emerging is greater than if the same total level of research effort were to be spent attempting to collect and analyze comprehensive data on all possible impacts areawide.

REFERENCES

1. Peat, Marwick, Mitchell & Co. Transportation System and Travel Behavior Project Research Plan. BART Impact Program Document Number PD 14-3-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, May 1975.

2. McDonald & Smart, Inc. A History of the Key Decisions in the Development of Bay Area Rapid Transit. BART Impact Program Document Number FR 3-14-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, August 1975.

3. Parsons-Brinkerhoff-Tudor-Bechtel, Smith Barney & Co., Stone & Youngberg, and Van Beuren Stanbery. The Composite Report, Bay Area Rapid Transit. Prepared for the San Francisco Bay Area Rapid Transit District, Oakland, California, May 1962.

4. Peat, Marwick, Mitchell & Co. Analysis of BART's Energy Consumption for Interim System Operations. BART Impact Program Document Number WP 14-3-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, June 1975.

5. Timothy J. Healy. The Energy Use of Public Transit Systems. Prepared for the State of California Department of Transportation, Division of Mass Transportation. Santa Clara, California: University of Santa Clara, August 1974.

6. American Public Transit Association. Transit Fact Book. 1974-1975 Edition. Washington, D.C.: American Public Transit Association, March 1975.

7. Timothy J. Healy. Energy Requirements of the Bay Area Rapid Transit (BART) System. Prepared for the State of California Department of Transportation, Division on Mass Transportation. Santa Clara, California: University of Santa Clara, November 1973.

8. Office of Research, Bay Area Rapid Transit District. BART Interstation Fare Schedule Report. Oakland, California: Bay Area Rapid Transit District, May 18, 1971.

9. Randall Pozdena. Choice of An Initial Structure for the Bay Area Rapid Transit District. Working Paper Number 181. Prepared for the Metropolitan Transportation Commission. Berkeley, California: Institute of Urban and Regional Development, University of California, August 1972.

10. Peat, Marwick, Mitchell & Co. Immediate Travel Impacts of Transbay BART. BART Impact Program Document Number TM 15-3-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, May 1975.

11. Peat, Marwick, Mitchell & Co. Surveys of Transbay Travel, October 1974: Data Collection Methodology. BART Impact Program Document Number DD 4-3-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, May 1975.

12. Peat, Marwick, Mitchell & Co. Exploratory Network Analyses of BART's Impacts Upon Accessibility. BART Impact Program Document Number WP 15-3-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, July 1975.

13. Peat, Marwick, Mitchell & Co. Assessment of the Impacts of the AC Transit Strike Upon BART. BART Impact Program Document Number TM 11-3-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, February 1975.

14. Simpson and Curtin. Coordinated Transit for the San Francisco Bay Area: Now to 1975. Final report of the Northern California Transit Demonstration Project. San Francisco, California: October 1967.

15. Simpson and Curtin. Fare Plans, Passenger and Revenue Projections. Technical Memorandum Number 53, Northern California Transit Demonstration Project. San Francisco, California: November 1966.

16. Office of Research, Bay Area Rapid Transit District. BART Patronage: Background, Forecasts and Initial Results. Oakland, California: Bay Area Rapid Transit District, December 1972.

17. B. Thomas Lofft. The Lindenwold Line: A Case Study of the Newest Rail Rapid Transit. Washington, D.C.: American Automobile Association, 1971.

18. Metropolitan Area Planning Council. South Shore Rail Rapid Transit Extension: Preliminary Impact Study. Prepared for the Massachusets Bay Transportation Authority, October 1973.

19. Robert Levine, Bay Area Rapid Transit District. BART and the Handicapped. BART Impact Program Document Number 17-1-75. Prepared for the Metropolitan Transportation Commission, Berkeley, California, 1974.

20. Jefferson Associates, Inc., and The Center for Independent Living. The Impact of BART on the Physically Disabled. Prepared for the Metropolitan Transportation Commission, Berkeley, California, May 1975. (To be released as a BART Impact Program Working Paper.)

21. American Standards Association, Inc. American Standard Specifications for Making Buildings and Localities Accessible to, and Usable by the Physically Handicapped. ASA Document Number A117.1-1961. Approved October 31, 1961.

22. National Center for Health Statistics. Use of Special Aids, United States - 1969. National Health Survey, Series 10, Number 78. Rockville, Maryland: National Center for Health Statistics, Public Health Service, Health Services and Mental Health Administration, U.S. Department of Health, Education, and Welfare, December 1972.

23. Bay Area Rapid Transit District. Comparative BART Report. Oakland, California: Bay Area Rapid Transit District, December 31, 1974.

24. "Construction of Facilities for San Francisco Municipal Railway." Inter-office communication, Bay Area Rapid Transit District, Oakland, California, January 20, 1973.

25. Engineering and Construction Department, Bay Area Rapid Transit District. Comparative Analysis of the 1962 Composite Report with the 1972 Status and Forecasts, Bay Area Rapid Transit System. Oakland, California: Bay Area Rapid Transit District, December 1972.

26. DeLeuw, Cather & Company. Characteristics of Urban Transportation Systems, A Handbook for Transportation Planners. Prepared for the U.S. Department of Transportation, Urban Mass Transit Administration, May 1974.

27. Institute for Defense Analyses. Economic Characteristics of the Urban Public Transportation Industry. Prepared for the U.S. Department of Transportation, February 1972.

28. "BART 1975/76 Operating Budget Estimate." Bay Area Rapid Transit District, Oakland, California, December 31, 1970.

29. Acting General Manager, San Francisco Bay Area Transit District. "Projection of Operating Results." Inter-office communication to the Administration Committee. Oakland, California, June 3, 1975.

30. State of California Legislative Analyst. Financing Public Transportation in the San Francisco Bay Area. Sacramento, California, November 1975.

PHASE I REPORTS

BART IMPACT PROGRAM

TRANSPORTATION SYSTEM AND TRAVEL BEHAVIOR PROJECT

BART Impact Program Document Number	Date	Title
PD 3-1-74	May 1974	A Review of Some Anticipated and Observed Impacts of the Bay Area Rapid Transit System
PD 2-3-74	July 1974	Phase I Work Plan, Transportation System and Travel Behavior Project
PD 10-1-75	October 1974	Detailed Research Plan, Transportation System and Travel Behavior Project
TM 11-3-75	February 1975	Assessment of the Impacts of the AC Transit Strike upon BART
DD 1-3-75	February 1975	Description of Transportation System Inventory
DD 2-3-75	February 1975	Data Collection Methodology and Primary Data Tabulations for an Assessment of the Impacts of the AC Transit Strike upon BART
DD 3-3-75	April 1975	Development of Pre-BART (1971) Highway and Transit Networks
DD 5-3-75	April 1975	Development of Post-BART (1976) Highway and Transit Networks
DD 4-3-75	May 1975	Surveys of Transbay Travel, October 1974: Data Collection Methodology
PD 14-3-75	May 1975	Transportation System and Travel Behavior Project Research Plan
TM 15-3-75	May 1975	Immediate Travel Impacts of Transbay BART
DD 6-3-75	May 1975	Development of Transit Fare Matrices

WP 14-3-75	May 1975	Analysis of BART's Energy Consumption for Interim System Operations
WP 15-3-75	July 1975	Exploratory Network Analyses of BART's Impacts upon Accessibility
FR 6-3-75	April 1976	Transportation and Travel Impacts of BART: Interim Service Findings (TSTB Project Phase I Final Report)