BART HISTORY BY JUSTIN ROBERTS

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BART HISTORY

as written by

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of the

CONTRA COSTA TIMES

Note: *There are no dates to indicate when this document was written. According to the person, (who wants to remain anonymous) who gave this to Sy Mouber, this is supposedly written from the various news stories and editorials written by Mr. Roberts while he was actively working at the Contra Costa Times and other Lesher newspapers.*

A HISTORY OF BART

The BART story began in 1946. It began not by governmental fiat but as a concept gradually evolving at informal gatherings of business and civic leaders on both sides of the San Francisco Bay. Facing a heavy post-war migration to the area and its consequent automobile boom, these people discussed ways of easing the mounting congestion that was clogging the bridges spanning the Bay and their highway approaches.

In 1947, a joint Army-Navy review Board concluded that another connecting link between San Francisco and Oakland would be needed in the years ahead to prevent intolerable congestion on the Bay Bridge. The link? An underwater tube devoted exclusively to high-speed electric trains.

Since 1911, visionaries had periodically brought up this Jules Verne concept. But now, pressure for a traffic solution increase with the population. In 1951, the State Legislature created the 26-man San Francisco Bay Area Rapid Transit Commission, comprising representatives from each of the nine counties which touch the Bay. The Commission's charge was to study the Bay Area's long range transportation needs in the context of environmental problems and then recommend the best solution.

The Commission, advised in its final report in 1957, that any transportation plan must be coordinated with the area's total plan for future development. Since no development plan existed, the Commission prepared one itself. The result of their thoroughness is a master plan which did much to bring about coordinated planning in the Bay Area, and which was adopted a decade later by the Association for Bay Area Governments (ABAG).

BART CONCEPT IS BORN

The Commission's least-cost solution to traffic tieups was to recommend forming a five-county rapid transit district, whose mandate would be to build and operate a high-speed rapid rail network linking major commercial centers with suburban subcenters.

The Commission stated that, "If the Bay Area is to be preserved as a fine place to live and work, a regional rapid transit system is essential to prevent total dependence on automobiles and freeways."

Thus was born the environmental concept underlying BART. Acting on the Commission's recommendations, in 1957, the Legislature formed the San Francisco Bay Area Transit District, comprising the five counties of Alameda, Contra Costa, Marin, San Francisco and San Mateo. At this time the District was granted a taxing power of five cents per $100 of assessed valuation. It also had authority to levy property taxes to support a general obligation bond issue, if approved by District voters. The State Legislature lowered the requirement for voter approval from 66 percent to 60 percent.

Between 1957 and 1962, engineering plans were developed for a system that would usher in a new era in rapid transit. Electric trains would run on grade-separated right-of-ways, reaching maximum speeds of 75-80 m.p.h., averaging perhaps 45 m.p.h. including station stops. Advanced transit cars, with sophisticated suspensions, braking and propulsion systems, and luxurious interiors, would be strong competition to "King Car" in the Bay Area. Stations would be pleasant, conveniently located, and striking architectural enhancements to their respective on-line communities.

Hundreds of meetings were held in the District communities to encourage local citizen participation in the development of routes and station locations. By midsummer, 1961, the final plan was submitted to the supervisors of the five District counties for approval. San Mateo County Supervisors were cool to the plan. Citing the high costs of a new system - plus adequate existing service from Southern Pacific commuter trains - they voted to withdraw their county from the District in December, 1961.

With the District-wide tax base thus weakened by the withdrawal of San Mateo County, Marin County forced to withdraw in early 1962 because its marginal tax base could not adequately absorb its share of BART's projected cost. Another important factor in Marin's withdrawal was an engineering controversy over the feasibility of carrying trains across the Golden Gate Bridge.

BART had started with a 16-member governing Board of Directors apportioned on county population size: four from Alameda and San Francisco Counties, three from Contra Costa and San Mateo, and two from Marin. When the District was reduced to three counties, the Board was reduced to 11 members: four from San Francisco and Alameda, and three from Contra Costa. Subsequently, in 1965, the District's enabling legislation was changed to apportion the BART Board with four Directors from each county, thus giving Contra Costa its fourth member on a 12-man Board. Two Directors from each county, henceforth, were appointed by the County Board of Supervisors. The other two Directors were appointed by committees of mayors of each county (with the exception of the City and County of San Francisco, whose sole mayor made these appointments).

The five-county plan was quickly revised to a three-county plan emphasizing rapid transit between San Francisco and the East Bay cities and suburbs of Contra Costa and Alameda counties. The new plan, elaborately detailed and presented as the "BART Composite Report," was approved by supervisors of the three counties in July, 1962, and placed on the ballot for the following November general election.

The plan required approval of 60% of the District's voters. It narrowly passed with a 61.2% vote District-wide, much to the surprise of many political experts who were confident it would fail. Indeed, one influential executive was reported to have said: "If I'd known the damn thing would have passed, I'd never have supported it."

The voters approved a $792 million bond issue to finance a 71.5-mile high-speed transit system, consisting of 33 stations serving 17 communities in the three counties. The proposal also included was another needed transit project: rebuilding 3.5 miles of the San Francisco Municipal Railway. The new line would link muni streetcar lines directly with BART & Market Street stations, and four new muni stations would be built.

The additional cost of the transbay tube -- estimated at $133 million -- was to come from bonds issued by the California Toll Bridge Authority and secured by future Bay Area bridge revenues. The additional cost of rolling stock, estimated at $71 million, was to be funded primarily from bonds issued against future operating revenues. Thus, the total cost of the system, as of 1962, was projected at $996 million. It would be the largest single public works project ever undertaken in the U. S. by the local citizenry.

After the election, engineers immediately started work on the final system designs, only to be halted by a taxpayers' suit filed against the District a month later. The validity of the bond election, and the legality of the District itself, were challenged. While the court ruled in favor of the District on both counts, six months of litigation cost $12 million in construction delays. This would be the first of many delays from litigation and time-consuming negotiations involving 166 separate agreements reached with on-line cities, counties, and other special districts. The democratic processes of building a new transit system would prove to be major cost factors that, however necessary, were not foreseen.

THE PROJECT BEGINS

BART construction officially began on June 19, 1964, President Lyndon Johnson presiding over the ground-breaking ceremonies for the 4.4-mile Diablo Test Track between Concord and Walnut Creek in Contra Costa County. The test track completed 10 months later was used to develop and evaluate sophisticated new design concepts for BART's transit cars and automatic train control system.

In charge of construction management, overall design of system facilities and equipment, and monitoring of BART's major contractors were the District's General Engineering consultants, Parsons-Brinckerhoff-Tudor-Bechtel, or most commonly known as "PB-T-B." A joint venture enterprise formed to manage all technical, as well as construction aspects of the BART project, PB-T-B was comprised of three well known engineering consultant firms. Parsons-Brinckerhoff-Quade & Douglas of New York (who had done the original BART transportation plan); Tudor Engineering Company of San Francisco; and Bechtel Corporation of San Francisco.

Through this joint venture, the firms supplied (or recruited from the U. S. and abroad) the most impressive array of engineering talent ever assembled for a single public works project. The basis of the joint venture concept was that engineering specialists could be supplied as needed, moving on to other projects when their respective BART assignments were completed. This was considered less costly and more permanent than building up a large District staff.

Construction began on the Oakland subway in January, 1966. November of that year saw the first of 57 giant steel and concrete sections of the 3.8-mile transbay tube lowered to the bottom of the Bay by a small navy of construction barges and boats.

The 3.2-mile bore through the hard rock of the Berkeley hills was completed in February, 1967, after 466 work days, to become the fourth longest vehicular tunnel in the U.S.

The first major equipment contract was awarded in May 1967 for the nation's first fully automated train control system. Westinghouse Electric Corporation's low bid of $26.1 million was $3 million under the next bidder. Four other bidders were General Railway Signal Company, Philco-Ford Company, General Electric Company, and Westinghouse Air Brake Company. Although awarding of the contract to any company other than the low bidder would have been illegal, District officials were destined to face criticism and controversy as a result.

In July, 1967, work began on the Market Street subway and stations. Carried out 80-100 feet below heavy downtown traffic, against the combined pressure of mud and Bay water, the work required one of the greatest concentrations of tunneling crews and equipment in construction history. Construction of the giant five-story-high stations beneath Market Street, and the tunnels themselves, was accomplished under extremely difficult conditions imposed by the high water table in downtown San Francisco, plus an incredible maze of underground utilities installed over the last 100 years. The first tunneling in the western U. S. done entirely under compressed air conditions, the project produced a succession of "firsts" in constructing the subway and stations in a difficult mud and water environment.

Subway excavations were rich with buried ships and other memorabilia, providing a fascinating look back into Nineteenth Century San Francisco when the land-fill of lower Market Street and the Embarcadero was still open harbor. The huge construction effort reached its peak in 1969 with a contractor force of 5,000 working on the San Francisco subway and other parts of the system, the weekly payroll was more than $1 million.

The final tunnel bore was "holed through" into the west end of the Montgomery Street Station on January 27, 1971. It marked the completion of tunneling work in the huge, two-level Market Street subway and climaxed six years of tunneling underground.

Tunneling under compressed air required a special medical center with equipment specialists for close monitoring of the "sandhog" construction force. Despite the complex problems of sandhogging, the BART project was completed with one of the best safety records in heavy construction.

ENGINEER HISTORY WAS MADE

The contract for the production and delivery of BART's revolutionary electric transit cars was signed with Rohr Industries, Inc., of Chula Vista, California, in July, 1969. The initial contract called for delivery of 250 cars, with the first 10 vehicles to serve as test prototypes.

Meanwhile, a truly great chapter was written in the history of civil engineering with the completion of the transbay tube structure in August, 1969. Constructed in 57 sections, and reposing on the Bay floor as deep as 135 feet beneath the surface, the remarkable $180 million structure took six years of soil and seismic studies to design, and less than three years to construct. Before it was closed to visitors for installation of tracks and electrification, many thousands of adventurous people had walked, jogged, and bicycled through the tube. It received a dozen major engineering awards and rapidly became famous, seeming to capture the imagination of visitors from all over the world. To youngsters, especially, the transbay tube is BART.

Unhappily, the major years of BART construction in the 1960's saw seven percent average annual inflation - more than double the rate anticipated by economists and allowed for in the project cost estimates. In this climate, before substantial federal grants were available, BART's financial history was inevitably a troubled one.

While delays and inflation were sapping capital reserves, pressures from public and governmental groups resulted in the relocation of 15 miles of right-of-way and 15 stations, as well as a general upgrading of station plans. Stations were also substantially altered during construction to include elevators and other facilities for the handicapped and elderly at an added cost of $10 million. The cost of the transbay tube rose to $180 million for an original estimate of $133 million.

Prime examples of how public pressures escalated the cost of the system are the Berkeley subway and the Ashby Station. After originally approving a combination aerial and subway line through Berkeley, that city later came to oppose the plan in favor of a subway-only line, which was much more expensive. The new plan necessitated redesign of the Ashby Station from an aerial to a subway facility. Extensive controversy and hearings ensued for the next 2-1/2 years, finally to be resolved by Berkeley residents voting to tax themselves additionally to finance the changes they wanted. Next, a Berkeley City Councilman filed a successful suit to redesign the Ashby Station, yet a second time, asserting the use of skylights in the original plans was not a true subway design.

The Berkeley situation resulted in a 2-1/2 year delay in subway construction, a 17-month delay in starting Ashby Station construction, and additional costs of $18 million.

As early as 1966, it became increasingly clear that the District would fall short of funds to complete the system. The only apparent solutions were an infusion of more funds, or a drastic scaling-down of system miles to fit the original budget. Major construction contracts were rewritten and readvertised in anticipation of the threatened cutbacks.

As the crisis deepened, BART directors refused to compromise the planned 71.5-mile system until every possible alternative could be explored. Finally, in April, 1969, after three years of debate, the State Legislature granted the District's request for $150 million by authorizing the levying of a half-cent sales tax in the BART counties. The needed funds thus came from the sale of bonds pledged against the sales tax revenues.

THE PROJECT IS RESCUED

With funds to complete the system assured, construction contracts were returned to their original scope, and work quickly reached peak level in 1969. But three years of financial uncertainty had taken their toll on work schedules. The shortage of funds had also held up ordering the transit cars. When the first 250 cars were finally ordered from low bidder Rohr Industries, Inc., of Chula Vista, California, the cost was $80 million -- $8 million more than the original cost estimate for the entire 450-car fleet. (Subsequently, 200 more transit cars were ordered for another $80 million. Delivery of the total 450-car fleet would be complete by July 30, 1975.)

Meanwhile, federal monies had begun flowing into the project at an increasing rate, making possible a wide range of improvements over the original system plans. BART's widely-known "linear park," for example, was constructed under the aerial right-of-way through Albany and El Cerrito to demonstrate how function could combine with aesthetics to enhance community environments. A $7.5 million program for systemwide landscaping and right-of-way beautification was partly funded by several of the largest federal grants ever made for this purpose. Of the $160 million base cost of BART's 450-car fleet, 64 percent was funded by federal grants.

Included in the construction contract for the lower Market Street subway, awarded in the busy year of 1969, was the basic "box" structure for the Embarcadero Station. Not in the original plans, the system's 34th station was added as a result of increasing development of the lower Market Street area. Station funding was cooperative, with the San Francisco business community raising money for design, and BART spending $25 million on construction. (Of the latter figure, $16 million was raised by curtailing construction of the Muni subway at the west portal station instead of St. Francis Circle as originally planned.)

The $315 million received to date in federal capital grants was an important factor in upgrading the system from original plans, nonetheless this federal aid is only 20 percent of the total $1.6 billion investment in the system. (If BART were being built today, 80 percent of its capital costs could be federally funded under the U.S. Urban Mass Transportation Assistance Act of 1974.)

Thus, changes and improvements increased the valuation of the system considerably from the original estimates -- a cost factor that is frequently and incorrectly confused with the true project cost over-runs on specific contracts.

A NEW RAILROAD TAKES SHAPE

As the project moved into 1970, the wide range of system construction passed its peak, and contracts were being completed with increasing frequency. An amorphous collection of excavations, stacks of lumber and brick, sections of rail, and giant spools of cabling was taking on the outlines of a finished railroad. Long suffering San Francisco businessmen were even beginning to recapture Market Street from the BART construction forces.

As the system neared completion, the construction engineers so long in charge began making way for a wide range of electronic engineers and technicians, computer experts, and other specialists. Their job was to install and prove out the automatic train control system, plus three maintenance shops and train yards at Hayward, Richmond, and Concord, a staggering array of communications and wayside equipment.

The first prototype car was delivered in August, 1970. By early 1971, the 10 test prototype transit cars were being operated on the Fremont line in a round-the-clock program to prove out the new design before it went into full-scale production. Meanwhile, at its San Jose plant, IBM was readying the first group of prototype fare collection machines, which it demonstrated to District Directors in October. Since it received an initial $5 million contract in 1968, IBM had been developing a fully automatic system to collect fares on a graduated (per mile) basis, as specified by BART, to provide equity between short and long distance riders.

In December, 1971, the District Board adopted the official interstation fare schedule, ranging from 30 cents minimum to $1.25 maximum fare. Also, approved the following month were 75 percent fare discounts for patrons over 65 or under 13 years of age, with discount tickets to be sold through local bank branches instead of at BART stations.

The 1971-72 period saw the gradual phase-out of major construction work and the beginning of the transition from a construction-oriented organization to an operating railroad. New areas of emphasis included marketing, personnel training, planning feeder bus service to stations, and across-the-board preparations for revenue service. The District staff, up to 765 by mid-1972, had almost tripled in three years to build up the transportation and maintenance force for revenue service.

A study of an extension between Daly City Station and the San Francisco International Airport was concluded, and another study of an extension or shuttle access to the Oakland International Airport from the Coliseum Station was continued. Also begun were extension studies for northwest San Francisco, the Pittsburg-Antioch area, and the Livermore-Pleasanton area.

The first segment of the system to open would be 26-miles between Fremont and MacArthur stations. In mid-1972 the District Board set Monday, September 11, as the first day of revenue service. The summer of '72 did not lack for problems.

Eliminate design "bugs" from the newly-designed train control equipment. A problem they could not deal with, however, Rohr Industries, Inc., had suffered a nine-week strike, which, added to previous delays, had put the car builder one year behind in its car delivery schedules.

Another and serious problem arose on June 18 when the State imposed a hiring freeze on the District until 1,100 applicants from other local transportation lines were interviewed for BART jobs on a priority basis. The freeze was lifted June 15, but vital hiring and training time for station agents, train operators, and maintenance workers had been lost.

BART OPENS FOR REVENUE SERVICE

Opening day finally arrived...September 11, 1972: Ceremonial trains first made inaugural runs through the 12 opening stations. At exactly 12 noon the voice of BART General Manager B. R. Stokes came over the station pbulic address system from BART Central: "Ladies and gentlemen, this system is now open for revenue service." Thousands of Bay Area residents and visitors, who had been waiting in lines at all stations, surged forward to be the first riders of the first new U.S. transit system in the last 60 years.

The system opened with 26 transit cars (24-A-cars, two B-cars) which was barely sufficient to maintain eight to nine two-car trains daily. The trains ran at 10-15-minute headways, five days a week, from 6 a.m. to 8 p.m. This brave little fleet carried 100,000 people in the first week of operation -- a remarkable feat considering the limited capacity and newness of the line operation organization.

On October 2, failure of a tiny crystal in a train's on-board control circuitry caused a two-car train to enter the Fremont Station too fast. Failing to stop completely, one of the cars passed through a safety sand barrier at the end of the platform, coming to rest on a soft dirt incline. A few passengers were bruised, but none was seriously injured. Engineers judged recurrence of the accident to be extremely remote; however, circuitry was designed in all control cars (A-cars) to eliminate any possibility of a repeat failure.

Also in October, the fledgling railroad met its first test of crowd handling, moving 8,000 people per hour with only 18 cars to and from Oakland Athletic's World Series games.

Ridership was 12,000 daily on the Fremont line by the time the Richmond line opened on January 29, 1973, extending the service 11 miles northward and opening six more stations. Equipment was increased to 12 trains, each three and four cars long. Daily patronage jumped instantly from 12,000 to 27,000.

On May 21, the Concord line opened, putting 19 more miles and six more stations into service. The line, a scenic showcase of transit/freeway corridor planning and pastoral suburbia, had increased daily patronage to 37,000 by the end of June.

The system was shut down from July 1 to August 6, 1973, by a strike involving 1,100 transportation personnel of the Amalgamated Transit Union, Local 1555, and maintenance and clerical personnel of United Public Employees, Local 390. The strike developed over the issue of wage parity among employees of similar classifications.

The San Francisco line between Montgomery Street and Daly City stations was opened for revenue service on November 5, 1973. Service would remain a shuttle operation on that eight-mile, eight-station line, however, until the District could obtain State approval of its operating procedures to open the seven-and-a-half mile transbay line. Daily patronage (which had quickly recovered to 35,000 after the summer strike) doubled with San Francisco service. Four trains were operating on the line, in addition to the 18 trains on the three East Bay lines. Train lengths ranged from five to seven cars.

In technical areas, meanwhile, major programs were going forward to improve the overall reliability of the vehicle fleet and also improve margins of train safety under automatic train operation, as desired by both the District and the California Public Utilities Commission (CPUC). Equipment modifications were keyed to an analysis of the system's technical problems by a State-appointed three-man panel of electronic experts, who reported their recommendations to the State Senate Public Utilities and Corporations Committee early in 1973.

In December, Westinghouse was directed to install a new train detection system, called SOR (for Sequential Occupancy Release), as an added safety back-up to the basic ATC detection system. After careful analysis, engineers with the CPUC, the District and its engineering consultants, agreed that a back-up detection system would become desirable when train headways were reduced below five minutes (or approximately one-station separation) as they eventually would have to be to provide a high level of service.

Thus, as the District moved into 1974, its immediate goal was the start-up of transbay service - the only segment not yet in operation, but the most vital link in the 71-mile system.

Early 1974 was marked by a severe gasoline shortage in the Bay Area, which boosted daily system patronage from 70,000-plus to more than 80,000 for a two-month period. Patronage then settled back to the 70,000 level. The eight San Francisco stations were shut down March 11-15 by BART management owing to picketing by San Francisco municipal employees as part of a city-wide strike.

FINANCIAL PROBLEMS CONTINUE

But 1974 was to see more change and conflict within the District. Its continued operation threatened by a spiralling budget deficit. BART called on State legislators to provide an operating subsidy as the only means of budgeting a widening cost-revenue gap without unreasonably raising fares and lowering service levels. Although rising deficits were what the whole transit industry was experiencing, BART's unique founding legislation required it to operate strictly on fare revenue. Solvency through the fare box appeared increasingly romote. The Director of Finance warned that, without a direct subsidy, the District would be insolvent by the coming November. The system might have to be shut down as early as September to conserve funds for caretaker purposes.

General Manager B. R. Stokes and other officials called for a temporary extension of the half-cent sales tax authorized in 1969 to complete construction of the system. The tax was seen as a temporary means of meeting the unfunded deficit until the legislature could identify and enact more permanent sources of an operating subsidy.

In response, Senator James Mills (D. San Diego) introduced SB1966 extending the sales tax for two years as a temporary operating subsidy. The bill subsequently became State law in September.

On June 30, Governor Ronald Reagan signed into law AB3043, which established voting districts from which a nine-man BART Board of Directors would be popularly elected for the first time in November, 1974 supplanting the long-standing 12-man appointive Board. The nine voting districts were marked out on the criteria of equal population, community of interests, and "geographical cohesiveness."

Also on June 30, the resignation of General Manager B. R. Stokes became effective. Stokes, who had become a controversial figure among the BART Directors, was succeeded by Acting General Manager Lawrence D. Dahms until the incoming elective Board could make a permanent appointment to the post.

1974 Meanwhile, the major effort toward transbay service continued. By July, one-station separation in train operations had been accomplished system-wide. This was the vital step toward transbay operation, as the San Francisco line had to handle trains on closer headways due to the convergence of two East Bay lines through the tube.

1974 On Monday, September 16 -- to the undiluted thrill of patrons young and old -- crowded BART trains began streaking through the tube at 80 m.p.h. Opening at the same time was the Oakland West Station, at the tube's eastern end, leaving only the Embarcadero Station to open in mid-1976. The Monday opening was preceded on Saturday by appropriate ceremonies and introductory train rides through the tube for the public.

Patronage, which had been 73,000 prior to opening of the tube, jumped to 118,000 within the first week. The number of trains operating increased from 22 to 30.

Having linked its East Bay and West Bay lines, the District's next objective was to improve the reliability of both the cars and the train control system. Once this was accomplished, the District could address the question of extending service hours to nights and weekends -- an issue of increasing concern to the public.

"BART's technical and financial problems -- and certainly its limited service hours -- have thus far kept it from achieving full ridership potential. Despite this, we know from surveys that at least 52 percent of our patrons have left their automobiles to ride BART.

"Besides the quality of BART's own service," the analyst emphasized, "an important factor in its ridership will be how well feeder bus service can be improved to all BART stations."

The District has worked out BART-to-bus transfer systems with both AC Transit (which operates buses in the East Bay) and the San Francisco Municipal Railway (which operates buses in that city). The Distsict is also working to help get local bus service to all on-line communities where none yet exists.

The last major action under the appointed Board of Directors was the November 18 filing of a law suit by the District, seeking over $200 million in damages from defendants: Parsons, Brinckerhoff-Tudor-Bechtel, Westinghouse Electric Corporation, Rohr Industries, Inc., Bulova Watch Company, and their respective surety companies. The District sought relief from what it asserted was equipment faulty design and manufacture, with lost revenues and other major expenses resulting.

Also on December 2, BART activated five express feeder bus routes to outlying communities in the District which are not directly served by the train system. The bus lines are operated by AC Transit under contract to BART.

On December 2, eight men and one woman comprising the first elective Board of Directors in the history of the District were formally installed. By lot, some were installed for initial two-year terms, and others for regular four-year terms, in order to stagger subsequent four-year terms of office. Thus, BART entered 1975 with the full system in revenue operation and governed by a Board elected directly by the District residents for the first time in it's 18-year history.

A NEW DIRECTION FOR BART

In April, 1975, the new Board of Directors appointed Frank C. Herringer as District General Manager to fill the permanent post vacated by B. R. Stokes the previous June. Coming from his post as Administrator of the U. S. Urban Mass Transportation Administration in Washington, D. C. Herringer arrived at BART on July 1 during a budget and labor crisis.

Despite the administrative crisis and shift in management, the staff was able to meet a steadily increasing level of patronage. Also, it introduced the innovative "Bikes on BART" program. For the first time in the transit industry, patrons were able to bring their bicycles on the system under closely-controlled procedures to prevent interference with other patrons. This program proved so successful, it was made a permanent policy at the end of 1975.

Another industry first introduced during the summer was a program which implemented 75% fare discounts for the handicapped through a system of medical certification by physicians and agencies. Other transit lines in the Bay Area quickly adopted the BART certification program enabling them to offer discounts to the handicapped. BART discounts for senior citizens, over age 65, were increased from 75% to 90%.

After a careful financial analysis of the District's serious financial situation, BART Directors reluctantly approved an average 21% increase in fares, which took effect in November. Maximum fare increased from $1.25 to $1.45, while the 30-cent minimum fare was decreased to 25 cents in the Oakland and San Francisco downtown business areas.

The District's second key post --long vacant -- was filled with the appointment of Robert D. Gallaway as Assistant General Manager of Operations. The second member of the new management team arrived in November from his post as Executive Vice President for Operations at Texas International Airlines in Houston.

Meanwhile, the new General Manager had been conducting an intensive evaluation of the District management staff since his arrival. In late November, he announced a series of sweeping personnel changes and departmental realignments aimed at improving staff productivity and coordination.

The successful conclusion of negotiations with State Legislators and officials of the Metropolitan Transportation Commission (MTC) resulted in the funding of permanent late night service (to midnight), as of January 1, 1976. Late night service was offered during the Thanksgiving-Christmas season, but only on a temporary basis as in previous years. Providing for permanent late night service was the last major accomplishment in 1975 and it began the New Year with a major step forward.

Office of Public Information
November, 1976

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BACKGROUND INFORMATION

CHRONOLOGY

1947	- January	- Joint Army-Navy recommends action for underwater transit tube beneath San Francisco Bay.
1951	- July 25	- California Legislature creates special commission to study Bay Area transportation problems.
1957	- January 17	- Nine-county Commission recommends legislation to create Bay Area Rapid Transit District.
	- June 4	- California Legislation approves creation of five-county Bay Area Rapid Transit District.
	- November 14	- District officially activated with first Directors' meeting.
1958	- January 1	- First District offices established in Flood Building, San Francisco (later moved to 814 Mission Street).
	- July 1-30	- First property taxes collected.
1959	- May 14	- Parsons, Brinckerhoff-Tudor-Bechtel retained as Engineering consultants for system design and construction.
	- July 10	- State Legislation authorized use of Bay Bridge tolls to finance construction of transbay tube.
1960	- January 20	- State approves use of Grove-Shafter freeway median for BART transit route.
1962	- April 12	- San Mateo County officially withdraws from District program, citing high property tax and the existing Southern Pacific commuter line as reasons.
	- May 17	- Marin County officially withdraws from District, citing inability of Golden Gate Bridge to carry transit vehicles and prohibitive cost of another underwater tube as reasons.
	- May 24	- Three-county rapid transit plan adopted by Board of Directors; referred to Alameda, Contra Costa and San Francisco County Boards of Supervisors for approval.
	- November 6	- $792 million General Obligation Bond issue approved by District voters for construction of 75-mile system.

1963	- June 10	- Contra Costa County Superior Court rules in favor of District in taxpayers' suit challenging validity of Bond election.
	- July 1	- Full-scale design engineering begun by District engineering consultants, PB-T-B.
1964	- June 19	- U.S. President Lyndon B. Johnson presides at official start of construction in Concord.
1965	- April 12	- Diablo Test Track placed in operation between Walnut Creek and Concord.
1966	- January 24	- Construction begins in Oakland subway.
	- August 25	- BART receives first Federal construction grant.
1967	- July 25	- Construction begins on Market Street Subway in San Francisco.
1968	- November	- DOT grant for $28 million received for development and purchase of rolling stock.
1969	- March 28	- State Legislature approves 1/2-cent District sales tax to provide $150 million required to complete system.
	- April	- Last section of transbay tube placed; rail laying begun.
	- July 3	- BART awards transit vehicle contract to Rohr Corporation, Chula Vista, California.
	- August	- Transbay tube structure complete.
1970	- February	- BART joins with City of Oakland, Alameda County and Coliseum to study feasibility of linking Coliseum Station to Oakland Airport.
	- April	- BART joins with San Francisco and San Mateo Counties to develop plans for extending BART from Daly City to S.F. Airport.
	- June	- Southern Alameda County Line energized and lab car testing begun.
	- August	- Arrival of first prototype car and test operations begun on Southern Alameda County Line.
	- October	- Prototype of IBM fare collection equipment demonstrated.
1971	- January 27	- Final "hole-through" into Montgomery Street Station opens last subway tunnel on system.

1971 - March 25 - Another $40 million grant received from DOT for rolling stock.

- July 23 - Last rail set into place on Contra Costa Line to complete linking of all system mainline trackage.

- November 5 - Delivery of first production car for revenue service.

- December 16 - District headquarters activated in Oakland.

1972 - February - First revenue vehicles received after Rohr strike ended.

- April 27 - Directors voted first priority for revenues from State gasoline taxes to provide express bus feeder service to BART stations from areas in Contra Costa and Alameda Counties not served by public transit.

- May 22 - San Francisco Muni/BART coordination study underway.

- June 8 - BART pre-revenue train testing began on Southern Alameda Line.

- June - Livermore-Pleasanton transit extension study underway.

- July 10 - BART/AC Transit coordination study underway.

- August - Pittsburg-Antioch extension study underway.

- August - Beginning of San Mateo County Transit Development Project, a joint effort of San Mateo County and the Metropolitan Transportation Commission, with consultation from BART, to plan an extension of rapid transit beyond San Francisco International Airport to Menlo Park.

- September 11 - BART opened first 28 miles of system between Fremont MacArthur stations for revenue service at 12 noon. Ceremonies were held at the 12 opening stations before revenue service started.

- September 27 - President Nixon visited BART and rode a train from San Leandro to Lake Merritt Station.

- October 2 - A component failure caused a two-car train to run off tracks at Fremont Station. No injuries resulted from first accident since revenue service began.

- October 11 - The system was officially dedicated by U.S. Secretary of Transportation John A. Volpe, at Lake Merritt Station.

- November 28 - Northwest San Francisco BART extension project underway.

- December 12 - Millionth rider carried under revenue service.

- December 20 - Final section of rail fastened down on present system of 160 miles of mainline and yard trackage, along the Daly City Station trainway.

1973 - January 29 - Richmond-Berkeley line opened, adding 11 miles to system.

- May 21 - Concord line opened, adding 17 miles between MacArthur Station and East Contra Costa County.

- July 2 - Employee strike stopped service until August 6.

- August 10 - First train traveled through the Transbay Tube to Montgomery Street Station (S.F.), averaging 70 MPH west and 80 MPH eastward.

- September 11 - First anniversary of revenue service, with 56 miles in operation and 5 million passengers carried.

- November 3 - Ceremonial opening of BART's 7.5-mile San Francisco line serving 8 stations.

- November 5 - Service begun between Montgomery Street Station in San Francisco and Daly City Station, bringing into operation to date 63.5 miles of the 71-mile system.

1974 - September 16 - Trans-Bay revenue service opens between San Francisco and Oakland.

- November 5 - New nine member Board of Directors elected to replace previous 12 member appointed Board.

- December 2 - Start of express bus service to outlying areas as an interim extension of BART rail service.

1975 - April 24 - Board of Directors announced appointment of UMTA Administrator Frank C. Herriner as new District General Manager.

- July 1 - A 75% fare discount went into effect for the handicapped, an industry first made possible by a BART-administered plan of certification adopted by all other Bay Area transit lines. Also effective this date was a further decrease in senior citizens' fare from 75% to 90%

	- October 23	- Another key post in the District was filled with the appointment of Robert D. Gallaway as Assistant General Manager of Operations, effective November 3.
	- November 3	- The first fare increase since the system opened in 1972 went into effect, resulting in an average 21% increase in trip fares.
	- December	- "Bikes on BART," another industry first, was permanently adopted after a successful 12-month program.
1976	- January 1	- Permanent night service went into effect, extending revenue service hours from 6 a.m. to 12 midnight.
	- January 30	- BART selected as one of 200 examples of outstanding community achievement in U.S. as part of American Revolution Bicentennial Administration's "Horizons on Display" program.
	- May 27	- Embarcadero Station officially opened for revenue service, drawing thousands of San Franciscans to the colorful ceremonies at the 34th system station.
	- July 8	- District management and labor officials drew wide praise for averting a strike by signing a new three-year collective bargaining contract after extensive negotiations.
	- October 15	- Oakland officially dedicated its new City Center Plaza, the Harold Paris sculpture and BART's entrance to the plaza.

Office of Public Information
November 1976

BART
BAY AREA 'ID TRANSIT DISTRICT
800 Madison ~treet
Oakland, California 94607
Telephone 465-4100

BACKGROUND INFORMATION

BART SYSTEM FACT SHEET

BOARD OF DIRECTORS

9 elected members representing 9 election districts in the three BART counties:

Alameda, Contra Costa, and San Francisco

MILEAGE

71 total - approximately 19 subway and tunnel; 23 aerial; 25 surface; 4 of transbay tube. (4 additional miles of S. F. Municipal Railway were included in original 1962 plan.)

BART STATIONS

14 subway, 13 aerial and 7 surface stations comprise the 34 stations of the BART system. Four of these are combination BART trains and Muni Metro stations in downtown San Francisco. BART is building four additional stations for the Muni's outer Market line.

STATION FEATURES

Use of 16 architectural firms and eight landscaping firms creates diversity of design, with stations reflecting the character of BART's 19 on-line communities.

Aesthetic enhancement of stations is obtained through use of sculptures, mosiacs, graphics, earthy materials, fountains, and endless green ribbons of landscaping.

Parking is free of charge at all except Lake Merritt (25¢) stations, 23 stations have parking lots ranging from 240 to 1400 car stalls. (No parking lots within San Francisco City and County limits.) Total capacity of all lots is 18,553 cars, and will increase to 20,253 by late 1977. Special stalls for mid-day parking are available from 9 a.m. to 4 p.m.

Passengers easily learn to use the system with such aids as large wall maps, information brochures, graphics and computerized train destination signs. The destination signs automatically alert patrons to train arrivals, and display news bulletins, public service announcements, and paid advertising between train arrivals.

Special elevators, ramps and other aids enable handicapped persons -- even those in wheelchairs -- to travel the entire system. Parking lots have stalls reserved for handicapped patrons' cars.

Bicycle and motorcycle racks, plus special bicycle lockers for super security, are available at all stations except downtown Oakland, Berkeley and San Francisco stations.

TRANSBAY TUBE

3.6 miles, twin-section, concrete and steel.
24' H x 48' W, buried in trench 75' - 135' underwater.
High earthquake tolerance.

TRAINS

Third rail propulsion power is 1000-volt DC electricity.
Propulsion - one 150-HP motor per axle, four motors per car.
Features - aluminum body, 72 seats, carpeted, air-conditioned, tinted windows.
Car - 70' long, 10'6" high, 10'6" wide, headroom 6'9".
Track gauge - 5'6" wide for stability. (standard: 4'8")
Number of cars - 450 vehicles for initial full operation; built by Rohr Industries.
Speed - 80 MPH maximum, 39 MPH average, including 20-second station stops.
Acceleration and deceleration - 3 MPH per second maximum.

AUTOMATIC TRAIN CONTROL

Twin train control computers (one for back-up) - at Lake Merritt Station, Oakland; built by Westinghouse.
Car-borne equipment - console monitored by attendant who can override automatic control in emergencies to stop train, or run at 25 MPH in manual mode
Stations and wayside - network of control devices and track circuits controlling train speeds, stops, and safe spacing.

AUTOMATIC FARE COLLECTION

Station equipment - IBM change and ticket vending machines and gates - new Cubic equipment at Embarcadero Station only.
Entry gate - records time, date, station; returns ticket.
Exit gate - computes required fare, takes exact-fare ticket, instructs if additional payment needed, or deducts proper amount from multi-ride ticket.
Ticket - credit-card size, magnetically encoded or "stored" with up to $20 of fares. Machines automatically deduct trip fares from stored fare value on ticket.

BASIC FARE

Minimum 25¢ to maximum $1.45 one-way, based on trip miles.

SPECIAL FARES

All discounted tickets must be purchased at participating local bank branches only, not at BART stations.

Children 4 and under ride free.
Children 5 through 12 can purchase a red ticket worth $6.00 for $1.50.
Handicapped persons can purchase a red $6.00 ticket for $1.50.
Senior citizens 65 and over can purchase a green ticket worth $6.00 for just 60¢.

WEEKDAY TRAIN SCHEDULES 6 a.m. - approximately 12 midnight. "Last Train" schedules vary from line to line.

Trains are run between Richmond and Fremont every 12 minutes; between Fremont and Daly City every 12 minutes; and between Daly City and Concord every 12 minutes. Night "X" service at 20 minute intervals.

West Bay line (between Daly City and San Francisco, West Oakland) every 6 minutes.

Southern Alameda line (Fremont to Oakland) - every 6 minutes.

MAXIMUM MOVING CAPACITY

21,600 seated people, per hour, one way, at 2-minute headways (equal to maximum people 10 lanes of freeway traffic can move in peak hours).

ROUTES AND TRAVEL TIMES

Radiating in rough "X" shape from Oakland City Center-12th Street Station:

South to Fremont - 24 miles - 32 minutes
North to Richmond - 11 miles - 22 minutes
East to Concord - 21 miles - 29 minutes
West to Daly City - 15 miles - 26 minutes

(4 miles of streetcar line in San Francisco complete 75 miles in BART project.)

ESTIMATED COST OF SYSTEM

Total Cost of Basic System (exclusive of Transbay Tube)...$1,443,000,000

Cost of Transbay Tube.. 176,000,000

Total Cost...$1,619,000,000

Sources of Funding:

1962 General Obligation Bond Referendum..............$	792,000,000
California Toll Bridge Authority.....................	176,000,000
Proceeds of Sales Tax Revenue........................	150,000,000
Earnings from Temporary Investments..................	111,000,000
Transit Development..................................	24,000,000
Miscellaneous Income.................................	51,000,000
Federal Capital Grants...............................	315,000,000

MAJOR EQUIPMENT CONTRACTS

Rolling Stock - Rohr Industries. 450 cars at a cost of $163 million. Contract let July 1969.

ATO System - Westinghouse Corporation. Initial contract was for $26,199,959. Let March 1967. Change orders amounting to $6,461,539 brings total to $32,661,498.

AFC (FARE COLLECTION) - IBM. Initial contract was for $4,955,000. Let June 1968. Change orders bring contract total to $6,594,040.

ADDITIONAL AFC - Cubic Western Data. Pahse I, (Embarcadero Station) $5,058,860. Let March 1974. Phase II (suburban stations) Change orders, sales tax and escalation bring contract total to $7,740,190.

An additional IBM contract, let January 1975, totals $1,278,000.

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Office of Public Information
May 24, 1976

STATION DESCRIPTIONS
BAY AREA RAPID TRANSIT SYSTEM

STATION	LOCATION	TYPE	CURRENT PARKING CAPACITY	PROJECTED FULL-SERVICE PATRONAGE (Daily Arrival & Departures
	Oakland Downtown			
Oakland West	Between 5th & 7th, Center & Lewis 1451 Seventh Street, Oakland	Aerial	403	12,069
Lake Merritt	Between 8th & 9th & Madison & Oak 800 Madison Street, Oakland	Subway	225	16,322
12th Street City/Center	Broadway between 11th & 12th 1245 Broadway, Oakland	Subway	None	19,367
19th Street	Broadway between 19th & 20th 1900 Broadway, Oakland	Subway	None	17,539
	Berkeley-Richmond Line			
Ashby	Adeline between Woolsey & Emerson 3100 Adeline Street, Berkeley	Subway	560	6,347
Berkeley	Shattuck between Addison & Alston Way 2160 Shattuck Avenue, Berkeley	Subway	None	13,308
North Berkeley	Between Delaware, Sacramento, Virginia and Acton Streets 1750 Sacramento Street, Berkeley	Subway	500	4,358
El Cerrito Plaza	Between Fairmont & Central 6699 Fairmont Avenue, El Cerrito	Aerial	509	3,962
El Cerrito Del Norte	S. F. r.o.w. at Cutting Blvd. 6400 Cutting Blvd. El Cerrito	Aerial	1054	5,251
Richmond	Between 16th & 18th and MacDonald & Nevin Avenue, Richmond	Surface	754	7,798
	Central Contra Costa Line			
MacArthur	Grove-Shafter Fwy. betw'n Apgar & 40th 550 - 40th Street, Oakland	Surface	487	7,346
Rockridge	Grove-Shafter Fwy. at College 5660 College Avenue, Oakland	Surface	776	3,766

STATION	LOCATION	TYPE	CURRENT PARKING CAPACITY	PROJECTED FULL-SERVICE PATRONGE (Daily Arrivals & Departures
	Central Contra Costa Line, cont.			
Orinda	Highway 24 and Camino Pablo 11 Camino Pablo, Orinda	Surface	939	3,108
Lafayette	Hwy. 24 betw'n Happy Valley & Oak Hill Roads 3501 Deerhill Road, Lafayette	Surface	982	2,881
Walnut Creek	No. California Blvd. at Ygnacio Valley 200 Ygnacio Valley Road, Walnut Creek	Aerial	1,156	4,605
Pleasant Hill	Treat Blvd. at Wildwood Lane 1365 Treat Blvd., Pleasant Hill	Aerial	1,414	4,941
Concord	Atlantic at Oakland Blvd. 2100 Oakland Avenue, Concord	Aerial	1,074	10,477
	Southern Alameda Line			
Fruitvale	35th Avenue & East 12th 3401 E. 12th Street, Oakland	Aerial	730	16,674
Coliseum	San Leandro St., between 70th & 73rd Avenues 7200 San Leandro Street, Oakland	Aerial	923	6,203
San Leandro	Between Juana & Estudillo & Martinez & San Leandro Streets 1401 San Leandro Blvd., Oakland	Aerial	1,106	11,395
Bay Fair	Wagner & Vassar Ave., on Hesperian 15242 Hesperian Blvd., San Leandro	Aerial	1,408	5,102
Hayward	Montgomery & "B" Street 699 "B" Street, Hayward	Aerial	861	8,144
South Hayward	Tennyson Rd. & Dixon Street 28601 Dixon Street, Hayward	Surface	483	2,441
Union City	W. P. at Decoto Road 10 Union Square, Union City	Aerial	816	4,003
Fremont	2 blocks SE of Mowry at Walnut Way 2000 BART Way, Fremont	Surface	743	8,966

STATION	LOCATION	TYPE	CAPACITY	PROJECTED FULL-SERVICE PATRONAGE (Daily Arrival & Departures
	San Francisco - Market Street Line			
Embarcadero	Market between Spear & Beale 298 Market Street, San Francisco	Subway	None	36,885
Montgomery Street	Market between Post & Sutter 598 Market Street, San Francisco	Subway	None	55,327
Powell Street	Market between 4th & 5th 899 Market Street, San Francisco	Subway	None	23,254
Civic Center	Market between 7th & 8th 1150 Market Street, San Francisco	Subway	None	21,497
	San Francisco - Market Street Line			
16th Street	16th & Mission 2000 Mission Street, San Francisco	Subway	None	16,783
24th Street	24th & Mission 2800 Mission Street, San Francisco	Subway	None	13,138
Glen Park	Bosworth St., near San Jose Avenue 2901 Diamond Street, San Francisco	Subway	None	11,183
Balboa Park	Between Geneva & Ocean at Tara St. 401 Geneva Avenue, San Francisco	Subway	None	13,046
Daly City	Between Knowles & Niantic & San Diego 400 Knowles Avenue, Daly City	Surface	675	12,585
	Market Street Streetcar Stations - S. F. Muni			
Van Ness	Market between 11th & 12th 1498 Market Street, San Francisco	Subway	None	N/A
Church Street	Market between Duboce & 14th 2101 Market Street, San Francisco	Subway	None	N/A
Castro Street	Market between 16th & 17th 2400 Market Street, San Francisco	Subway	None	N/A
West Portal	West Portal at Vicente	Surface	None	N/A

Public Information Office
September 9, 1976

CURRENT COST ESTIMATE

as of 2/28/75

COSTS

Direct Construction Costs	$ 882,000,000
Design and Construction Management	123,000,000
Utility Relocation by Owners	28,000,000
Land and Land Rights	97,000,000
Rolling Equipment	162,000,000
Insurance	26,000,000
Other Construction Costs	37,000,000
Preliminary Expense, Security and Maintenance	81,000,000
Unallocated TDA Funds	3,000,000
Contingencies	4,000,000
Total Estimated Cost of Basic System (exclusive of Transbay Tube)	$1,443,000,000
Estimated Cost of Transbay Tube	176,000,000
Total Estimated Cost	$1,619,000,000

SOURCES OF FUNDS

Proceeds of Sale of General Obligation Bonds	$ 792,000,000
California Toll Bridge Authority	176,000,000
Proceeds of Sales Tax Revenue	150,000,000
Earnings from Temporary Investments	111,000,000
Transit Development	24,000,000
Miscellaneous Income	51,000,000
Federal Capital Grants	315,000,000
Total	$1,619,000,000

June 9, 1975

ATION PARKING FACILITIES

STATION	EXISTING STALLS AS OF SEPTEMBER 30, 1975	ADDITIONAL STALLS DATE TO BE ADDED	ADDITIONAL STALLS NUMBER	PROJECTED TOTAL AS OF AUG. 1977
Concord	1074			1089
Pleasant Hill	1414			1491
Walnut Creek	1156			1198
Lafayette	982			1282
Orinda	939			947
Rockridge	776			776
MacArthur	487			487
Oakland West	403			403
Richmond	754			754
El Cerrito Del Norte	1054			1071
El Cerrito Plaza	509			509
North Berkeley	500			500
Ashby	560			560
Daly City	750*	11/77	500	2000
Fremont	735	1977	361	1096
Union City	1131			1157
South Hayward	483	1977	397	1277
Hayward	926			1026
Bayfair	1408			1408
San Leandro	1106			1106
Coliseum	923			923
Fruitvale	730			730
Lake Merritt	225			225
TOTAL	19,650		758	22,388

*In addition to the BART parking lot stalls - Daly City maintains a lot at Bell & St. Charles Streets (adjacent to the BART lot) with 150 stalls for which they charge 50¢ per day.

Fares

	Balboa Park	Glen Park	24th St. Mission	16th St. Mission	Civic Center	Powell	Montgomery	Embarcadero	Oakland West	Concord	Pleasant Hill	Walnut Creek	Lafayette	Orinda	Rockridge	Richmond	El Cerrito Del Norte	El Cerrito Plaza	North Berkeley	Berkeley	Ashby	MacArthur	19th St. Oakland	Oak. City Ctr. 12th St.	Lake Merritt	Fruitvale	Coliseum	San Leandro	Bay Fair	Hayward	South Hayward	Union City	Fremont
Daly City	45	45	.45	45	.55	.55	.55		1.00	1.35	1.30	1.30	1.25	1.20	1.05	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.15	1.15	1.20	1.25	1.30	1.35	1.45
Balboa Park		30	.30	.30	30	.30	.30		.95	1.35	1.30	1.30	1.25	1.15	1.05	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
Glen Park			.30	.30	.30	30	30		.90	1.35	1.30	1.30	1.25	1.15	1.05	1.05	1.00	1.00	.95	.95	.95	.95	95	.95	95	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
24th St. Mission				30	.30	30	.30		.80	1.35	1.30	1.25	1.20	1.15	1.00	1.00	1.00	.95	.90	.90	.90	.90	.85	85	.85	1.00	1.05	1.15	1.20	1.20	1.25	1.35	1.40
16th St. Mission					25	25	.25		.75	1.35	1.30	1.25	1.20	1.15	.95	1.00	1.00	.95	90	.90	.85	.85	.85	.85	85	95	1.05	1.15	1.20	1.20	1.25	1.35	1.40
Civic Center						25	.25		.70	1.35	1.30	1.25	1.20	1.15	.90	1.00	1.00	.95	90	85	.80	.80	.75	.75	.75	90	1.05	1.10	1.15	1.20	1.25	1.35	1.40
Powell							25		.70	1.35	1.30	1.25	1.20	1.15	.90	1.00	1.00	.95	90	.85	.80	.80	.75	.75	.75	90	1.05	1.10	1.15	1.20	1.25	1.35	1.40
Montgomery									.70	1.35	1.30	1.25	1.20	1.15	.90	1.00	1.00	.95	90	.85	.80	.80	.75	.75	.75	90	1.05	1.10	1.15	1.20	1.25	1.35	1.40
Embarcadero																																	
Oakland West										1.00	.95	90	.80	.60	.30	.70	.60	50	40	.35	.30	.30	.25	.25	.25	.30	.40	.60	70	.85	90	1.00	1.05
Concord											.30	30	.30	.30	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.05	1.05	1.10	1.15	1.25	1.30
Pleasant Hill												30	30	.30	85	.95	.95	.95	.90	90	90	.90	.95	.95	95	.95	.95	1.00	1.00	1.05	1.10	1.20	1.25
Walnut Creek													.30	.30	.75	.95	.95	90	.85	.85	85	.85	.90	.90	.90	.90	90	.95	1.00	1.05	1.05	1.15	1.20
Lafayette														.30	.60	.90	85	.80	75	.75	.70	65	70	.70	.70	.80	85	.90	.95	1.00	1.00	1.10	1.15
Orinda															.30	.80	.75	.65	.55	.50	45	.30	.50	.50	.50	.60	.75	.80	85	.90	95	1.05	1.10
Rockridge																.60	.50	40	.30	.30	.30	.30	30	.30	.30	.35	.45	.60	70	85	.90	1.00	1.05
Richmond																	.30	.30	.30	.30	.30	60	65	.65	.65	.75	80	85	.90	.95	1.00	1.05	1.15
El Cerrito Del Norte																		.30	.30	.30	.30	.45	.55	55	.55	.70	75	85	.85	.90	95	1.05	1.10
El Cerrito Plaza																			.30	.30	.30	.40	.45	.45	.45	.60	.70	.80	85	.90	.95	1.05	1.10
North Berkeley																				.30	.30	.30	.30	.30	.30	.50	.60	.75	.80	.85	90	1.00	1.05
Berkeley																					.30	.30	30	30	.30	.45	.55	.70	.80	85	.90	1.00	1.05
Ashby																						30	30	30	30	.40	50	65	.80	.85	90	1.00	1.05
MacArthur																							25	.25	25	30	.45	60	70	.85	90	1.00	1.05
19th St. Oakland																								.25	.25	.30	.30	.50	65	.80	.90	1.00	1.05
Oak. City Ctr. 12th St.																									.25	.30	.30	50	.65	.80	90	1.00	1.05
Lake Merritt																										30	.30	50	65	80	90	1.00	1.05
Fruitvale																											30	30	50	65	80	95	1.05
Coliseum																												30	30	.55	70	.90	1.00
San Leandro																													30	.30	55	80	.95
Bay Fair																														.30	30	.30	.30
Hayward																															.30	.30	.30
South Hayward																																.30	.30
Union City																																	30

Time

	Daly City	Balboa Park	Glen Park	24th St. Mission	16th St. Mission	Civic Center	Powell	Montgomery	Embarcadero	Oakland West	Concord	Pleasant Hill	Walnut Creek	Lafayette	Orinda	Rockridge	Richmond	El Cerrito Del Norte	El Cerrito Plaza	North Berkeley	Berkeley	Ashby	MacArthur	19th St. Oakland	Oak. City Ctr. 12th St.	Lake Merritt	Fruitvale	Coliseum	San Leandro	Bay Fair	Hayward	South Hayward	Union City
Balboa Park	3																																
Glen Park	5	2																															
24th St. Mission	8	5	2																														
16th St. Mission	10	6	4	2																													
Civic Center	12	8	6	4	2																												
Powell	13	10	8	5	3	1																											
Montgomery	15	12	10	7	5	3	1																										
Embarcadero																																	
Oakland West	23	20	17	15	13	11	9	7																									
Concord	56	53	51	48	46	44	42	40		33																							
Pleasant Hill	51	48	46	43	41	39	37	35		28	5																						
Walnut Creek	49	45	43	40	38	36	34	33		25	7	2																					
Lafayette	44	41	39	36	34	32	30	28		21	12	7	4																				
Orinda	40	36	34	31	30	27	26	24		16	16	11	9	4																			
Rockridge	35	31	29	26	25	22	20	19		11	21	16	14	9	5																		
Richmond	49	45	43	41	39	36	35	33		25	46	41	39	35	30	25																	
El Cerrito Del Norte	45	42	40	37	35	33	31	29		22	42	37	35	31	26	21	3																
El Cerrito Plaza	43	39	37	34	32	30	28	26		19	40	35	33	29	24	19	6	2															
North Berkeley	39	36	34	31	29	27	25	23		16	37	32	30	26	21	16	9	6	3														
Berkeley	37	33	31	29	27	25	23	21		14	34	29	27	23	18	13	12	8	5	2													
Ashby	35	31	29	26	25	22	21	19		11	32	27	25	21	16	11	14	10	8	4	2												
MacArthur	31	27	25	23	21	19	17	15		8	24	19	17	13	8	3	17	13	11	8	5	3											
19th St. Oakland	28	24	22	20	18	16	14	12		5	28	23	20	16	11	6	20	17	14	11	8	6	3										
Oak. City Ctr. 12th St.	26	23	21	18	16	14	12	10		3	29	24	22	17	13	8	22	18	16	13	10	8	4	1									
Lake Merritt	27	24	22	19	17	15	13	11		4	36	31	29	25	20	15	25	21	18	15	13	11	7	4	2								
Fruitvale	30	27	25	22	20	18	16	14		7	40	35	33	29	24	19	28	25	22	19	16	14	11	7	6	3							
Coliseum	33	30	28	25	23	21	19	17		10	42	37	35	31	26	21	31	28	25	22	19	17	13	10	9	6	3						
San Leandro	37	34	31	29	27	25	23	21		14	46	41	39	35	30	25	35	31	29	25	23	21	17	14	12	10	6	3					
Bay Fair	41	37	35	32	30	28	26	24		17	50	45	43	39	34	29	38	35	32	29	26	24	21	17	16	13	10	7	3				
Hayward	44	41	38	36	34	32	30	28		21	53	48	46	42	37	32	42	38	36	33	30	28	24	21	19	17	13	11	7	3			
South Hayward	48	44	42	40	38	36	34	32		25	57	52	50	46	41	36	46	42	39	36	34	32	28	25	23	21	17	14	11	7	3		
Union City	52	49	47	44	42	40	38	36		29	61	56	54	50	45	41	50	47	44	41	38	36	32	29	28	25	22	19	15	12	8	4	
Fremont	57	53	51	48	46	44	42	40		33	65	60	58	54	49	45	54	51	48	45	42	40	36	33	32	29	26	23	19	16	12	8	4

NOTE: BART cannot assume responsibility for inconvenience, expense or damage resulting from errors in time estimates, delayed trains, failure to make connections or for changes in or shortage of equipment. The shcedules and fares shown above are subject

ADOPTED BUDGET

Estimated Fund Sources

ADOPTED BUDGET 76/77

$76.0	Million
1.5	Million Improvement Allowance
$77.5	Million

SOURCES OF FUNDING

$24.9 Million from operating revenue

$29.6 Million from 1/2 cent sales tax

$ 5.2 Million from 5 cent fund property tax

$ 8.1 Million in charges to capital programs

$ 3.3 Million from TDA & Sec. 5 funds

$ 2.4 Million balance in operating funds 6/30/76

TOTAL

$73.5 Million leaving an unfunded deficit of $4.0 Million

BART

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BACKGROUND INFORMATION

THE TRANSBAY TUBE

BART's Transbay Tube has been acknowledged the world over as one of history's outstanding civil engineering achievements.

Stretching 3.6 miles along the floor of the bay between Oakland and San Francisco, the tube represents the vital link in the nation's newest regional rail transit system. It is both the longest and--at its maximum of 135 feet below the surface--the deepest vehicular tube in the world.

Beginning in 1959, six years before the start of construction, seismic studies were conducted, and soils data obtained to aid in design and alignment decisions. Although the tube would not cross any active geologic fault, special provisions were made in the design to make the tube flexible to absorb earthquake shocks. One such provision was to cushion the tube, shore to shore, in a trench of soft soil, gravel and mud. Another was to attach the tube to its terminal buildings at either end with flexible connections, akin to giant universal joints, which allow for movement of several inches up or down, in or out, and sideways.

Design and Construction

Parsons Brinckerhoff-Tudor-Bechtel, BART's general engineering consultants, were charged with design and construction management of the total project. The plan was to build the tube in sections, 57 in all, each averaging 330 feet in length. These were to be fabricated on dry-land shipways, from which they would be launched, towed into the bay, and sunk in their proper position.

The tube sections, each the approximate size and weight of an ocean-going freighter, would resemble huge binoculars in cross-section. Twenty-four feet high and 48 feet wide, they would contain two circular trackways, to carry trains in each direction, separated by an enclosed central corridor for pedestrian access, ventilation and utilities.

By the mid-1960's construction was ready to begin. A joint venture of four large contractors--Peter Kiewit Sons' Co.; Raymond International, Inc.; Tidewater Construction Corp.; and Healy-Tibbitts Construction Co.--won the big job under the name Trans-Bay Constructors. Their low bid was $90 million for the tube's basic structure. With an additional $90 million for ventilation structures at either end, 2.8 miles of aerial and subway approaches in Oakland and San Francisco, trackage, final finish work and electrification, the full cost of the project was $180 million.

The contract called for a demanding two-and-a-half-year schedule for completion of the basic structure. This meant maintaining a pace of building and placing two tube sections per month. Sub-contracts were let and soon an army of welders set to work fabricating the steel skin of the sections at the Bethlehem shipyards in San Francisco.

First came the tube shell, constructed from 3/8-inch steel plate and reinforced with steel T-beams set six feet apart. The inside of the completed shell was then laced with steel reinforcing bars for concrete. After a section was completed and water-tight bulkheads placed at each end, it was launched from the shipways and towed to a nearby dock. Here, about 70,000 square feet, or 4,200 cubic yards, of concrete was poured to form the 2.3 foot thick interior walls, and track-bed.

The first of the 57 sections was launched in February of 1967. Barely buoyant after the addition of the concrete, it was towed gingerly out to its assigned position. There it was weighted with 500 tons of gravel ballast placed in bins on top of the section, and slowly lowered into place. Final weight of each section is approximately 10,000 tons.

Meanwhile, excavation of the trench was progressing. For this job, the contractors had assembled a small navy of specialized vessels and clamshell dredges to cut a ditch in the bay floor 70 to 100 feet deep, sloping to a 60-foot-wide bottom. In all, the contractor removed about 5.6 million cubic yards of material, a considerable earth-moving job even on land, much less 135 feet beneath the water's surface.

At the same time, surveyors worked around the clock with construction crews to keep the trench precisely aligned through two horizontal and six vertical direction changes. Using lasers from shore positions, engineers were able to pin-point the exact position required for the dredge barges.

To permit leveling of the tube to exacting specifications, the engineers specified that a two-foot layer of gravel bedding be placed along the entire length of the trench. This required some special ingenuity. To place and level the gravel, the contractor specially designed a large "screed barge" 85 feet wide, 240 feet long, and floating 44 feet high on pontoons. Installed on top was a travelling bridge which carried the machinery for funnelling gravel to the floor, and for moving a box-like leveling device called a "screed".

Tube Placement

Once the trench was ready, another specially designed rig had to be built to lower the heavy tube sections into place. It consisted of two barges, connected by means of overhead "bridges", separated just enough to nestle a floating tube section between them.

Lowering a tube section in zero-visibility deep water compounded the challenge. Engineers met this challenge by devising a sensitive system of hydraulic controls and strain gauges, permitting operators to monitor the weight on all four corner connections at once and thus keep the giant sections level during descent. This equipment was so sensitive the contractor could control the longitudinal and transverse position of the sections to within an inch.

From shore positions, surveyors were able to get an exact fix on each tube's required alignment before lowering. This was done through the use of theodolites and a specially devised optical plumb-line centered from a temporary lookout tower on the tube section itself. Divers were used to help guide the tubes into position for coupling to the preceding section. The 366-foot-long barge was furnished with two decompression chambers into which the divers could move promptly upon surfacing.

Once in place, each new section was snugged tightly against the previous one by means of four 50-ton railroad-type couplers, hydraulically operated. The procedure was to lower the new section into line about two feet away from the existing tube, engage the couplers, then activate the hydraulic rams to draw the new section tightly against the old section. Once this linkup was completed, a barge-mounted crane packed gravel and stone against the sides of the section to lock it in place. An additional five-foot layer of sand and gravel provides a top protective blanket.

Once the sections were joined and sealed by a neoprene rubber gasket around the rim, water trapped between the end bulkheads was bled off. Hydrostatic pressure then exerted enough force to keep the seal tight. Later the bulkheads were removed from inside the structure, and permanent steel connections welded into place. Concrete was added to complete the joint construction.

Ventilation Buildings

Ventilation structures on both sides of the bay act as the terminal points for the tube. Through them, air is sucked into the tube and expelled as trains pass to and fro. Also, four huge fans, each nine feet in diameter, clear the air in the tube in case of an emergency. Portions of these ventilation buildings also serve as sub-stations to feed traction power into the tube from both ends, and house train control equipment. On the San Francisco side of the bay, the massive ventilation structure is a caisson located approximately 450 feet offshore and protruding 25 feet above the surface. At this point, the Market Street subway joins the tube at a depth of about 80 feet.

Cathodic Protection System

To prevent corrosion of its steel skin from salt-water electrolysis, the tube employs a cathodic protection system. This system consists of a series of positively charged anodes placed about 250 feet off both sides of the tube. Each anode is connected to the tube by armored cable. The steel surface of the tube, being negatively charged, attracts the positive ions, thereby preventing corrosion. Calcareous deposits buildup on the tube skin, over an estimated 15-year period, will offer a protective coating and lessen the cathodic protection current requirements.

Completed and Operating

The last tube section was launched and placed just east of Yerba Buena Island in April, 1969, meeting the required schedule. Track laying, electrification and installation of train-control equipment and ventilation were completed by early 1973.

On August 10, 1973, the first powered, automatically controlled train round-trip was made through the tube. Since November, 1973, the tube has, of course, been in regular use as a testing ground and for shuttling trains back and forth for BART's San Francisco service, although passengers have not been permitted pending authorization by the California Public Utilities Commission. Now, with passage of the first transbay commuter trains on the morning of September 16, 1974, BART's underwater engineering marvel is at last complete.

* * *

November, 1976

BART

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BACKGROUND INFORMATION

CABS STORY

(SHORT HISTORY OF THE COMPUTER AUTOMATED BLOCK SYSTEM)

The Computer Automated Block System (CABS) is basically a computer enforced separation of trains over and above the primary train protection system. Using this system, BART will operate trains at 6-minute intervals on two lines through the transbay tube for an initial interim service. Full service, scheduled for early 1975, will include a third line through the transbay tube bringing the interval between trains down to about four minutes.

The story behind CABS goes back to the summer of 1972 when, prior to opening the first line of BART, a series of train detection tests were conducted. These tests were carried out to verify BART's automatic train protection sub-system and were witnessed by the California Public Utilities Commission (CPUC) staff. As a result of these tests, it was determined that on occasion the system failed to detect dead cars in various zones, or blocks on the line. Intermittent lack of detection of dead cars during normal operation was considered an extremely unlikely situation in terms of safety, but one that the CPUC staff and BART felt had to be satisfied before operation could rely totally on the automatic train control (ATC) system.

In order to open the first line at the earliest possible time (September 11, 1972) BART's operation people, together with the CPUC staff, worked out an alternative back-up plan. This plan called for a manual block procedure whereby supervisors would be assigned to every other station platform on the line and at the terminus stations. The platform supervisor's job was to phone ahead to insure that the track was clear two stations forward on the line before releasing the train at his station. This meant that trains, though operating automatically, would be kept separated by two stations at all times during normal operations (or approximately ten minutes apart). Part of this plan included maintaining daily logs of pertinent data of each train for CPUC staff and BART review. This data was eventually used as part of the yardstick for measuring the reliability of CABS against the "manual block system".

Based on this plan, the CPUC authorized BART to commence service on 28 miles of track from Fremont to MacArthur Station in Oakland, September 11, 1972; from MacArthur Station to Richmond (11 miles), January 29, 1973; from MacArthur Station to Concord (17 miles), May 21, 1973; and from Montgomery Street Station to Daly City (7.5 miles), November 5, 1973.

Meanwhile, BART engineers and technicians developed a method whereby BART's central computer could be employed to take over the function of the manual block procedure and maintain the integrity of the required two-station separation. In the spring of 1973 this concept was worked out and the CPUC staff was advised and given periodic reports on the progress of what would come to be called CABS II, literally meaning "computer automated block system, two station separation".

Though in the beginning the CABS concept was not immediately considered as a possible means for implementing transbay service, it would alleviate human error, and also release platform supervisors for other assignments. During this period, many improvements to the basic train protection sub-system were being considered to implement transbay service at the earliest possible time. However, BART engineers' work on the CABS concept continued, and on October 19, 1973, BART began operating trains on the 17-mile Concord Line under the CABS II monitor mode, while at the same time continuing with the manual block control. This was the first real operational test of the validity of the concept. Prior testing had been done through program simulation in order to validate and support the design theory of CABS.

After several months of near flawless demonstration that the central computer was doing the job, and doing it much more efficiently than the manual block system, the CPUC granted BART permission on February 20, 1974 to remove the "manual block" supervisors from the Concord Line.

Following the same procedure, the CPUC authorized removal of the supervisors on the Richmond-Fremont Line on April 23, 1974, and on the San Francisco Intra-City Line May 21, 1974, bringing the entire operating system under CABS II.

The success of CABS II during the early stages of its use on the Concord Line led BART engineers to consider a program using the same procedure on a one-station separation basis rather than two stations. It was determined that this would allow more operating flexibility, and most important, perhaps offer a means for implementing transbay operation as early as possible. Such a program would operate passenger trains through the transbay tube in sequence, with the computer maintaining train separation by one station or on approximately 6-minute intervals.

Working closely with the CPUC staff, BART designed a program for computer enforced separation of trains on a one-station basis. The task was to prove that the computer could maintain the same integrity for keeping trains separated as CABS II. The testing, done during non-revenue hours, was an unqualified success. However, based on an evaluation of CABS I by the Lawrence Berkeley Laboratory (LBL), extra safety measures were installed, mainly a zero-speed gate (or trap) past each station to overcome possible problems with station run-throughs or inadvertant train releases. BART concurred, and immediately set to work on this relatively simple circuit addition at the required locations. Its function would be to automatically stop a train that inadvertantly ran through a station, and hold the train until the next station down the line had released its train. The delay due to such a stop might only be a matter of seconds, or minutes at most.

Another feature was added to the software logic whereby a train would be held at a station platform if the previous train was not positively detected upon departing the station ahead.

After a series of further witnessed tests in which every aspect of the CABS I design (with its added safety features) was checked out and verified, the CPUC granted approval for CABS I train operation. The Richmond-Fremont Line was approved on July 2; the Concord Line on July 11; and the San Francisco Line on July 16, 1974. This phase of the CABS program was a major step toward eventual transbay service.

Further work needed to support BART's application for transbay service included the installation of pseudo-station check points at mid-point in the transbay tube, software back-up from the central computer at critical interlockings in the Oakland Wye and MacArthur Station, and a scheduling strategy which would operate two lines through the tube rather than three. Performance and integrity tests demonstrating transbay operation were successfully conducted.

On July 15, the CPUC began hearings on BART's formal application for start-up of transbay service which had been submitted on June 15 and targeted for September 16, 1974. The CPUC staff recommended approval of the application contingent on a successful full-scale, system-wide 36 train test. That test was held on August 3, covering a full 14-hour revenue day. Though BART experienced reliability problems, the test did prove the safety of the system.

In making their final report to the Commission Board, the CPUC staff recommended that five additional corrective measures be taken before commencement of transbay service. These corrective measures, three of which had already been implemented at the time the report was issued, were primarily concerned with service reliability and not safety. BART concurred in the need for the additional measures.

Now, little more than a year after the CABS program was first conceived by BART engineers, trains will carry passengers back and forth between San Francisco and East Bay communities, the result of almost five man years of concentrated effort.

Meanwhile, the installation of the Sequential Occupancy Release (SOR) modifications to the Automatic Train Protection system continues on schedule and is expected to be completed in November, 1974. BART will then have to reapply for authorization to operate under the SOR 90 days prior to start-up. This would mean that system operations will utilize the primary train protection system and, with concurrence from the CPUC, allow BART to operate a third line through the transbay tube. This is targeted for early in 1975.

BACKGROUND INFORMATION

THE BART RAPID TRANSIT VEHICLE

Rohr is building 450 vehicles for BART under a $143 million in contracts awarded since July 1969. Cars with attendant's cabs ("A" cars), each 75 feet long, are placed on each end of the BART trains. Cars 70 feet long are located in the middle of the trains ("B" cars). The trains are from two to ten cars long, depending on the passenger capacity required.

Using a systems management concept common to the aerospace industry, Rohr designed the car to meet a set of performance requirements rather than to fit existing available components. The car was initially designed at the systems engineering level to perform certain functions, i.e., to ride properly on a given track; to accelerate at a certain rate; to maintain a high degree of reliability; and perform to stringent safety requirements. The vehicle system, as a whole, was broken down into subsystems and components. The trucks had to be designed to operate on a given track. The propulsion system had to be designed to meet speed performance requirements. Systems integration became a major consideration and resulted in formal documentation, to establish just what would happen when a component is interfaced with another component.

The BART cars are being assembled by methods new to the rapid transit industry. Individual components are combined into sub-assemblies which are inspected and tested, and then incorporated into major assemblies. Each major assembly is then inspected and tested before going into final assembly. Finally, the completed vehicles are subjected to a series of tests for a step-by-step checkout of all systems.

Rohr has employed engineering and manufacturing technology in designing and building the cars to provide maximum passenger comfort and safety, as well as improved reliability and ease of maintenance. The cars have wall-to-wall carpeting, which reduces noise levels and provides a more comfortable riding atmosphere. Temperature and humidity are controlled by a multi-zone air conditioning system that provides a constant flow of fresh air without the presence of drafts. BART passengers will ride in much quieter surroundings than commuters in private automobiles.

The cars are supported on eight air cushion bellows (four per truck) which provide a smooth, comfortable ride, even at top speeds. Since the air bellows absorb more vibration than mechanical springs, roadbed irregularities go virtually unnoticed. The foam-padded seats are more comparable to living room chairs than to the ones usually found in transit cars. Not only are they more comfortable than other seats, they are cantilevered; i. e., suspended from the cars' side walls without standard pedestal supports. Elimination of the pedestal increases legroom and results in easier maintenance of car interior.

Cantilevered seats are possible because the BART cars utilize a "semi-monocoque" design in which the body is integral with the chassis and bears most of the loads. Monocoque design is used in construction of jet aircraft to achieve maximum strength at minimum weight.

The cars are built of aluminum extrusions, some of which run the full length of the vehicles. The result is a smooth, durable surface with no visible rivets or fasteners. Attendant's cabs on the "A" cars are one-piece fiberglass with no seams, similar to modern boat hulls. The windshield is made of high-impact glass similar to that used on commercial aircraft.

The BART propulsion system is the most advanced ever installed on transit vehicles in this country. It operates so smoothly that passengers have virtually no sensation of starting and stopping. The system will accelerate trains from a standstill to 50 miles-per-hour in 20 seconds and decelerate them from the 80 miles-per-hour top speed to a station stop in 27 seconds. The cars are among the lightest in the world. The light weight reduces power requirements. Even the wheels, with aluminum centers and steel rims, are light in weight.

Other improvements have been incorporated in the doors and electrical systems. A new mechanism prevents "gaps" in the doors, eliminating drafts and rattling. Shielding of the electrical systems prevents interference with television and radio reception as the cars pass. Many of the innovations in the design of the vehicles were developed by Rohr. Among these are the cantilevered seats, improvements in the door hanger system, the attendant's cab, and the extruded aluminum construction.

BART vehicles are built in two configurations identified as "A" cars and "B" cars. The two configurations are identical in all respects except that an "A" car has an Attendant's cab mounted to its front. The aft end of each configuration is referred to as the X-end and the forward end as the Y-end of the vehicle. An operational train consists of a minimum of two "A" cars mated back-to-back. Increased passenger capacity is attained by coupling from one to eight "B" cars between the two "A" cars.

Train control is accomplished through vital train lines running throughout the length of the train, and connected through the electrical portion of each car end coupler. The train is operated or controlled in one of three modes:

(1) AUTOMATIC - The train is controlled from the remote operational control center (OCC) by signals received through vehicle antennas and route relay antennas.

Train speed, braking, stopping and door operations are automatically controlled in this mode. Train speed can be varied between 0 and 80 MPH in the automatic mode.

(2) ROAD MANUAL - The train is controlled by the attendant from the cab through the operation of the attendant's control level. Train speed can be varied between 0 and 25 MPH in the road manual mode. This mode is used when a malfunction occurs in the Automatic Train Control (ATC) System to move the train on the mainline tracks.

(3) YARD MANUAL - The train is controlled by the attendant from the cab. This mode is used primarily within the District Yard Service Areas. The maximum speed obtainable is 10 MPH.

Table 1 Vehicle Dimensions

	A-Car	B-Car
Carbody Width	10'6"	10'6"
Carbody Length	75'0"	70'0"
Car Height, Top of rail to top of car, less antennas	10'6"	10'6"
Ceiling Height, center of aisle	6'9"	6'9"
Floor Height, Top of rail to top of floor	39'0"	39'0"
Maximum Dimension, Top of floor to bottom, all undercar equipment	33-1/4"	33-1/4"
Height of all door openings	6'4"	6'4"
Width of side door	4'6"	4'6"
Width of end door	46-3/4"	46-3/4"
Width of cab door	30"	-
Wheel diameter - New	30"	30"
Wheel diameter - Worn condemning	28"	28"
Truck spacing, center to center of trucks	50'0"	50'0"
Wheel Gauge, between gauging points ± 1/16"	5'5-1/4"	5'5-1/4"
Track gauge, tangent and curved ± 1/8"	5'6"	5'6"
Station platform height, from top of rail	39"	39"
Running clearance	2"	2"

Table 2. Vehicle and Component Weights

	ITEM	A-Car	B-Car
1.	Car, complete	59,000	57,000
2.	Car, without trucks	38,175	36,280
3.	Car, without Undercar Equipment and Seats *	22,615	20,655
4.	Cab, complete	1,475	----
5.	Truck, Y-end, complete	10,435	10,360
6.	Truck, X-end, complete	10,390	10,360
7.	Evaporator Box, each (6 installed)	115	115
8.	Condenser, rightside	240	240
9.	Condenser, leftside	215	215
10.	Air Receiver, 7000 cu. in., each (2 installed)	45	45
11.	Auxiliary Air Receiver, 500 cu. in., each (4 installed)	40	40
12.	Air Compressor Assembly	265	265
13.	Air Suspension Panel (2 installed)	15	15
14.	Coupler, Standard, complete (1 A-Car/ 2 B-Car)	670	670
15.	Coupler, Retractable, complete (A-car only)	365	----
16.	Hydraulic Master Control Panel	160	160
17.	Brake Control Panel, W/Accumulator (2 installed)	30	30
18.	Parking Brake Control Panel, W/Accumulator	40	40
19.	Battery Box, empty	75	75
20.	Battery Box, W/Batteries	555	555
21.	Auxiliary Electric Box, complete	1,240	1,240
22.	Semi-Conductor Box, complete	1,600	1,600
23.	MA-17 Braking Resistor Box(2 installed;LH-655LBS/RH-570 lbs)	655	655
24.	Motor Control Box	855	855
25.	Line Reactor	365	365
26.	M/A Resistor, with Line Switch Box	235	235
27.	Motor Alternator Assy, complete	2,460	2,460
28.	Motor Reactor Box	765	765
29.	Motor Blower Complete	290	290
30.	Passenger Seat, Longitudinal, each (8 installed)	80	80
31.	Passenger Seat, Transverse, each (28 installed)	80	80
32.	Attendant's Seat, complete	50	--
33.	Emergency Plank	25	25

Table 2. Vehicle and Component Weights (continued)

ITEM	A-Car	B-Car
34. Fire Extinguisher (2 installed)	17	17
35. Car Control Panel, complete	65	65
36. Attendant's Control Console, complete	45	
37. Side Door Operator Panel, complete (8 installed)	50	50
38. Door Control Relay Panel, complete	30	30

* Includes harness and ducts

Table 3. **Vehicle Voltage Requirements**

TITLE	SOURCE	VALUE
Primary	DC Contact Rail (Third Rail)	850 Minimum-1150 Maximum
Auxiliary	AC Bus	120/208,3-Phase, Regulated ±5
Low	Vehicle Battery	32 VDC Nominal

Table 4. **Hydraulic Brake** Subsystem Requirements

ITEM	VALUE
System Pressure Relief	2000 +100 psi - 50 psi
System Operating Pressure Maximum	1850 psi
Supply System Pressure	1650 to 1850 psi
Pump Stop Pressure	1850 ± 35 psi
Pump Start Pressure	1650 ± 35 psi
Control Pressure	1200 psi
Brake Caliper System Pressure	600 to 1200 psi
Parking Brake System Pressure	600 to 800 psi
Residual Brake Pressure	20 to 35 psi
Hydraulic Fluid	Brayco 776 RP oil
Reservoir Capacity	3 gallon

Table 4 Hydraulic Brake Subsystem Requirements (continued)

ITEM	VALUE
Operating Power	
Hydraulic Pump Motor	208 VAC, 3ph, 60 Hz
Starting Current	30 amp
Run Current	5.5 amp
Battery Power	32 VDC
Parking Brake (apply & release)	1.5 amp

Table 5 Air Suspension Subsystem Requirements

ITEM	VALUE
System Relief Pressure	200 psi ± 15
System Maximum Operating Pressure	175 psi
Compressor Stop Pressure	175 psi
Compressor Start Pressure	145 psi
Cut-out Switch Pressure, Decreasing, (SCS-4)	35 psi
Shut-off Switch Pressure, Decreasing, (SCS-1, 2, & 3	15 psi
Air Receiver Capacity, 2 installed per car	7,000 cu. in.
Auxiliary Air Tank Capacity, 4 installed per car	5,000 cu. in.

Table 6 Truck and Component Requirements.

ITEM	REQUIREMENT
Truck Designation	HPD-3
Truck Swivel	Sliding Air Seal and car body center pin
Suspension	Firestone #205C air bellows
Damping	Delco Hydraulic Shock
Equalization	Self-aligning ball joints
Sideframes	Cast steel ASTM A27 65-35
Suspension Adapter	Fabricated Steel USS EX-TEN 50
Wheels	30" diameter, aluminum centered, steel tire with modified cylindrical tread
Axles	AISI, 5150 Steel Tube
Journal Bearings	BRENCO 6 x 11 cylindrical bearings
Brakes	Disc type
Motors and drives	Westinghouse Electric Parallel Drive
Track Gage	5' - 6"
Truck Wheel Base	7' - 0"
Truck Width	54" journal centers, inboard journals.

Table 7 Vehicle Passenger Loading

DESIGN	LOAD CONDITION	WEIGHT (A-Car)
AW-0	Empty car (no passengers)	59,000 pounds
AW-1	72 passengers seated	73,000 pounds
AW-2	72 passengers seated - 72 passengers standing	81,000 pounds
AW-3	72 passengers seated - 144 to 216 passengers standing (crush load)	97,000 pounds

Car Body Structure

The car body is an integrated structure, reinforced in areas subject to high stress. By the use of aluminum extrusions, the car sidewalls are designed to carry the car weight throughout the span of the car. The floor beams and roof are riveted to the sidewalls, completing the integrated car body structure. To compensate for the openings of the side doors, special door frames are installed into the sidewall, thereby, insuring the continuity of sidewall strength. The Roof Panel is constructed of 3003 H14 aluminum alloy sandwiched with 300F Foam. The outer skin is a single piece running the full length of the car. Roof bows are contained within the structure. This sandwich structure is attached to four longitudinal stringers extending the full length of the car, two of which provide support for any future strap hangar applications. The roof panel is capable of supporting a 250 pound man. At the outer edge of the roof, and extending the length of the car, are three inch by two inch deep rain gutters to prevent rain run-off down the sides of the car. These rain gutters are open-ended, with lip troughs, to provide drainage over the ends. The roof has an inner liner that carries the interior car lighting and speakers. The liner is made of molded fiberglass, riveted to the roof panel, and made in five sections. The liners, by removing the rivets, can be lowered from the roof panel, but due to their size are not removable from the interior of the car, without a major end-panel removal.

The end panels are of a unitized construction, riveted to the roof panel and sidewall. The X-end panel houses the car control panel and the door relay panel.

The floor beams are interlaced with intercostal members to provide a means of suspending various undercar components, and transferring the weight of the undercar components to the sidewalls. The bolster serves to anchor the trucks to the car body, and to provide a pivot axis capable of allowing truck pivot under the car for all calculated BART rail curves. The underside of the bolster has an impregnated surface of Teflon to reduce friction between the truck and the bolster.

Another function of the bolster is to allow air to enter the air suspension bags of the trucks, by positioning the air hose into the air suspension bags for all calculated truck pivot movement. The bolster is riveted to the car sidewalls and transfers the acceleration and deceleration efforts from the truck to the car body. The bolster also serves as the anchor for the car end-sill. The end-sills are mounted to the bolsters with twelve special 5/8 inch bolts, capable of withstanding normal car buffing, that will shear under extreme buffing to reduce car telescopic damage. The end-sill also provides a firm anchor for the car coupler. The tension-compression forces created during vehicle movement are transferred through the inter-car couplers.

Completing the floor structure are six floor panels (cars up to Number 35 contain 14), riveted to the sidewall frame and the floor beams to complete the integrated circle around the car body. The floor panels are a metal sandwich structure, with the outer skins made of 6061-T6 aluminum, and a core composed of two inch thick polystyrene foam. The outer skins, and foam core are bonded together with FR8550 epoxy. With the exception of the windows, the car is completely insulated. The side wall insulation is such that it provides air passageways to direct conditioned air upward at the bottom of the side windows and act as a defroster on cold days.

The X-end of each A-car configuration and each end of the B-car configuration are provided with an intercar closure. The closure provides an enclosed passageway between vehicles. The closure section consists of buffer faceplates extended from the car end sill by elastomeric shear springs capable of both angular and longitudinal motion. An elastomeric diaphragm is located above the faceplates. The diaphragm on one vehicle contacts the diaphragm on the adjoining coupled car during train operation. A drain trough is located on the top portion of the diaphragm to divert water away from the mating surfaces of the two diaphragms.

The Y-end of an A-car is mounted with a cab riveted to the sidewalls and roof panel. The cab is made of foam sandwiched fiberglass to form an insulated compartment to house the various control components and provide the train attendant with an isolated environment. The cab side windows can be swung open to afford an external view of the train. The cab does not rest upon the end-sill, thereby eliminating any vibration that may emanate from the end-sill, or undercar structure.

Sidewall windows located within the passenger compartments of each vehicle configuration are $\frac{1}{4}$ inch green tinted safety glass and cannot be opened. The end door windows are single glazed, clear and cannot be opened. The cab side windows are similar to the sidewall windows but are contoured and can be swung inward to open. The cab windshield is made of 1 inch thick, green tinted, laminated safety glass fixed in position. The cab windshield will withstand a pressure of fifty pounds/foot force which is equal to a 175 MPH windload. All windows are installed from the exterior of the vehicle.

Four types of seats are used on the BART vehicles. The four types are differentiated only by configuration. The seat backs are of a fiberglass reinforced plastic laminate. The seats are covered with vinyl and plastic coated nylon fabric.

The double sliding end doors are constructed of aluminum with a foam core. The doors are suspended by door hangers that house rolling ball bearing races riding on the overhead rails. The bottom of the doors are retained in a threshold guide slot, and at the last inch of door closure, are cammed outward to seal the door recesses. Sealing between the sliding door mating surfaces is by two neoprene extrusions and sealing around the door edges is by typical sealing strips bonded to an aluminum strip and cap-screwed to the door frame, or to the bottom of the door. The door rails are surrounded by a 1/8" cable riding on two pulleys, mounted at the extreme of the door rails. The cable causes both sliding doors to travel in opposite directions when one, or both doors are manually opened.

The side doors are of foam core construction, reinforced internally for strength as well as providing attachments for door hardware and operating arms. The doors are constructed of aluminum alloy, with an exterior brush finish, matching the exterior car skin, and with the interior finish coated with alumilite (Alcoa 215C3) to present a smooth surface.

Vehicle Sub-Systems

The BART vehicle contains five functional interrelated subsystems that provide electrical power, propulsion, braking, suspension and air comfort. These systems are common to both A-car and B-car configurations. The A-car is controlled from the Attendant's Control Panel in the forward direction and from a Hostling Panel in the X-End of the car for travel in the opposite direction. The B-Car can be controlled, from a Hostling Panel at either end of the car, for movement in that direction.

Whether the subsystems are controlled by any one of the control inputs is contingent upon the settings of the controls within a vehicle or train of vehicles. Control of a train composed of two A-cars and a maximum of eight B-cars, is exercised by the setting of a single control unit (Attendant's Control Console) of the lead A-car which provides control signals via the trainlines to the other vehicles within the train. Diagnostic Test Equipment is provided for testing of the above subsystems.

The 1,000 VDC high current feeds from the third rail shoe to the Auxiliary Power Subsystem by way of the Auxiliary Box. 1000 V high voltage passes to the line Switch Box, Line Reactor, and into the Motor Control Box. The Motor Alternator operates in conjunction with the Aux. Box to generate the vehicle's basic 32 VDC and 3Ø 120-208 VAC power sources. The 32 volt source charges the vehicle's battery, which, in turn, assures 32 VDC is present for such vehicle electronic devices as relays, lighting indicators, and control PC board circuits. The Motor Alternator function is to generate the basic 3Ø 120/208 VAC for other vehicle electrical devices and also furnish mechanical drive for the Air Comfort Subsystem's compressor assembly. 120 VAC is available at terminals to which the 3Ø 208 VAC is routed.

Assemblies grouped within the propulsion Subsystem are: the Line Switch Box, the Line Filter, the Line Reactor, the Motor Control Box, the Semiconductor Box, the Propulsion Blower, and the Braking Resistors. Key control inputs are the ATC control or "P" signal -- an analog current signal that commands the Semiconductor box to send out subcommand signals which operate Motor Control Box interlocks that in turn control subsystem braking and motoring circuits; the BRK Signal -- a "P" signal with a limited speed range; the Yard Manual Control Signal -- a simulated "P" signal capable of commanding low speed motoring for a limited time; and the Direction Signal. Outputs from the Semiconductor box to the Friction Brake Subsystem are the Brake Command Signal; the Dynamic Brake Signal; and the Manual Parking Signal. Two additional outputs from the Semiconductor Box are contained in the 1,000 VDC Motoring and 1,000 VDC Braking circuits which pass high currents to and from the traction motors. Two groups of signal inputs (one consisting of speed signals from the Truck Subsystem speed sensors and the other load weight signals from the Air Suspension Subsystem) feedback signals to the Semiconductor Box which help it to give appropriate commands to associated vehicle

vehicle subsystems. The Propulsion Blower unit uses a motor requiring 3Ø 208 VAC input and functions to cool the Propulsion Subsystem Semiconductor Box and Braking Resistor Assemblies. The pneumatic lines to the Line Switch Box and the Motor Control Box furnish the air required to drive the electro-pneumatic switches located within these assemblies.

The Friction Brake Subsystem consists of electro-hydraulic units that control the Brake disc assemblies located in the Truck Subsystem. The two groups of signals, which are control inputs to the friction brake electro-hydraulic units, are control signals arriving via the logic tray of the Semiconductor Box Assembly and speed signals from the speed sensors which are mounted on the truck assembly gear units.

Connections between the Air Conditioning Subsystem and the remaining vehicle subsystems are of a power input nature. 1,000 VDC low current input is taken directly from the line switch box, 3Ø 120/208 VAC input is supplied by the Auxiliary Power Subsystem, and the motor drive input for the Subsystem's air compressor is taken direcily from the Motor Alternator assembly. Thermostat positions within the vehicle cause the subsystem to be of a self-regulating nature once it is energized.

There are three general links between the Air Suspension Subsystem and other vehicle subsystems. The standard power sources from the Auxiliary Power Subsystem; the group of load weight signals feeding to the Semiconductor Box; and the pneumatic connections to the Air Spring Assemblies.

Each truck of the vehicle is made up of mechanical, electrical, pneumatic and hydraulic components controlled by electronics contained in the previously discussed subsystems. The truck frame is a steel casting. A derailment detection device is provided which will break by impacting against the running rail during derailment causing an open-loop brake application as for an open door condition.

The auxiliary Electric Subsystem consists of a Motor-Alternator set with voltage and frequency regulation, circuit breakers for protection of feeder and branch circuits, contactors and motor starter for connecting loads, a battery charger to supply low voltage dc, and auxiliary relays to perform functions such as sequence control of motor starting, under frequency and under voltage trips, and power annunciation.

Most of the above circuits are contained in two units, the Auxiliary Power Box and the Motor Alternator. The Motor Alternator performs specific generating and motor drive functions whereas the Auxiliary Box performs multiple functions. It holds the auxiliary circuits for the motor alternator and numerous circuit breaking and regulating components required for such functions as air conditioning (heating, compression, exhausting and blowing of air) and operation of other vehicle subsystems requiring low level power.

Each BART vehicle is equipped with a self-contained air comfort system, capable of providing heated air, cooled air, or fresh air ventilation within the vehicle interior.

Four thermostats mounted to the Air Comfort Control Panel, located near the floor level of the car interior, dictate the type and amount of air comfort required to maintain the car interior at 72 degrees.

Each car is equipped with a self-contained pneumatic system capable of performing the following functions:

(1) Maintain the car floor level at 39 inches above the roadbed rail head, irrespective of the amount of passenger load.

(2) Continually monitor (weigh) the passenger load, and to provide an electrical factor that is blended with the car's individual acceleration and deceleration effort.

(3) Provide pneumatic means of uncoupling car.

(4) Activate the electrical line switch box.

(5) Enable reversing of the traction motors polarity.

The pneumatic system is composed of an air compressor, two air receiver tanks, three leveling valves, eight air suspension bags, load weighing system, two uncoupler valves, and provides pressure to activate the motor controller drum switch and line switches.

The air compressor is a two-stage V type assembly, and through two pressure switches, will maintain the air pressure between the 145-175 psi. When the air pressure reaches 175 psi, the compressor shuts down and the condensate pop-off valve will momentarily open to discharge accumulated moisture.

The air suspension system is controlled by three car-leveling valves, one mounted on the X-truck and two mounted on the Y-truck. The truck suspension air bags are installed between the truck suspension adapter and truck side frame, with the leveling valve installed to the truck suspension adapter and the leveling valve linkage attached to the side frame. Compression of the air bags will cause the level valve to open to pressure and expansion of the air bags will cause the level valve to vent.

The car is considered as having a three point suspension, with each point having a leveling valve. The four X-end air bags are cross connected to the single X-end leveling valve. At the Y-end, only the two left air bags are connected to the left leveling valve, while the right air bags are connected to the right leveling valve. Therefore, not only will all leveling valves maintain the car floor height at 39-inches above the rail head in the longitudinal (fore - and - aft) direction, but the two Y-truck leveling valves will maintain the car level in the traverse (sideway) direction for any placement of passenger loads.

During normal train operation braking or deceleration is accomplished through the traction motors by dynamic braking. Dynamic braking occurs within the speed range between 4 MPH and 80 MPH. At speeds under 4 MPH the dynamic field has decayed and the friction braking system assumes control. In the event of dynamic braking failure, the friction braking system will be used at any train speed. The friction braking system consists of a hydraulic power unit, mounted on the underside of each vehicle, which supplies hydraulic pressure to a brake caliper mounted on each axle. Isolation of an individual vehicle may be accomplished by a manual cutoff valve. Control of the friction braking system is accomplished through the master brake control valve. The valve responds to electrical signals received from the vehicle control systems to allow system pressure to flow to the brake calipers. The magnitude of the pressure is determined by electrical signals from the control system. The friction braking system works in connection with the wheel slip-spin detector system. If slippage of a wheel occurs, the slippage is detected by the vehicle control system which, in turn, signals the brake control valve to reduce brake pressure and reapply when slippage stops. This cycle is repeated until slippage control is obtained.

Each vehicle incorporates an electrically operated hydraulic parking brake. The system includes a manual override. The parking brake is applied to the X-end truck only.

Car Coupler is a fully automatic car coupler, having a pin with a tapered point and a funnel at each coupling face. It is necessary only to bring two cars together at speeds from $\frac{1}{4}$ to 4 MPH to accomplish complete mechanical and electrical coupling. As the cars are brought together, the main coupling pin of each coupler head enters the funnel of the opposing coupler so long as the centerlines of the couplers are not misaligned by more than 6 inches laterally and 4 inches vertically. The main pin will align the heads within +/- .012 inches and as coupling proceeds, secondary and tertiary alignment pins will engage to reduce misalignment to +/- .0 inches. When the pins have completely entered the funnels, latches in each head snap into the notches in the main coupling pins, thus locking the pins in the funnels.

The air connections from the uncoupling valve to the unlatching piston are made through the uncoupling hose and through the uncoupling air tappet on the coupler.

The electric portion includes a slide frame assembly and a removable front cover assembly. Each assembly includes 80 contacts with 30-amp capacity, and 58 contacts with 60-amp capacity.

The car coupling system provides the ability to couple cars mechanically and electrically without requiring any action on the part of the operator beyond controlling the rate of approach of the cars.

Provisions are made to eliminate differences in coupler-to-coupler alignment in the vertical and horizontal direction and to eliminate the relative skewing that may exist between the coupler heads.

Uncoupling of cars is accomplished through an Uncoupling Valve located at either end of each car. An A-car is equipped with a manually operated valve mounted under the cab at the Y-end of the car and with a solenoid/manual operated valve at the X-end of the car and mounted to the right of the coupler. A B-car is equipped with two solenoid-piloted valves, one located at each end and mounted under the right side of the car.

The draft gear is designed to permit $1\frac{1}{2}$ inches travel at 150,000 pounds buff load, with a pre-load in each direction of 6,000 pounds. The draft gear assembly includes unique tensile bolts which break at 150,000 pounds, plus or minus 10%. Once released the draft gear has $3\frac{1}{2}$ inches collapsing travel to permit the car end to engage, causing the center-sill to absorb the additional loading.

The Retractable Coupler is designed to serve as a drawbar at the Y-end of A-cars. The assembly can be rotated a full 90° and locked in place under the car when not in use. Retraction is manual and uncoupling is accomplished with the manually operated uncoupling valve. No trainline electrical connections are provided. The Retractable Coupler can withstand buff and draft loads of 100,000 pounds.

Interior car lighting consists of 48 overhead lights in the passenger area, floor level lighting at all side and end doors and one standard overhead light and two variable overhead spot lights located in the Attendant's cab. Emergency power is provided by the battery circuit, the regular power source is the motor/alternator circuitry.

The BART vehicle is equipped with a communication network that provides intercommunications between units as follows:

1. INTERCOM - between a passenger and attendant.

2. Public Address (PA) - between attendant and all passengers in the train.

3. Train Telephone (TT) - Radio telephone between attendant and:

   (a) Operating Control Center (OCC).

   (b) Yard Control Station

   (c) Mainline Relay Stations

4. Train Telephone PA (TPA) - Radio telephone to enable OCC or a Mainline Relay Station to transmit a public address announcement throughout a particular train. Each train has a separate radio frequency.

5. Attendant Signal (ATT. SIG) -- Console handset communication between personnel in cabs at both ends of the train. (Primarily maintenance checkout personnel).

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AUTOMATIC CONTROL OF RAPID TRANSIT SYSTEMS

The Bay Area Rapid Transit system is the most highly automated transit system in operation anywhere. Largely because of its reliance on automatic rather than human controls, BART also is the safest system in operation.

Because of the recognized advantages inherent in automatic operation, other cities are moving to catch up to BART technologically. All major-city transit agencies building new systems or modernizing existing ones are turning to automation. This includes cities such as New York, Washington, Boston, Montreal, Sao Paulo, Atlanta and Pittsburgh.

The reason for this trend is that automation is helping modern transit systems provide passengers with a level of service never before possible. This service is not only safer, but also faster, more convenient, more comfortable and more economical than that provided by any of the traditional manually operated transit systems. With this level of service, automated rail systems are able to do a better job of competing with the automobile and providing relief from traffic congestion on streets and highways.

To attract and keep riders, rail transit systems have had to increase speed and to reduce the headways, or intervals, between trains. But there comes a point at which it is no longer possible to assure safety and still provide sufficiently fast and frequent service with a human operator at the controls. On high-speed trains, a human operator simply cannot be sure of stopping a train within a safe distance. (It takes 1800 feet to stop a train traveling 80 miles per hour, six times the distance needed by a car.)

With automation, trains can be operated safely at substantially higher speeds and at closer headways. Electronic equipment can constantly survey the track ahead and determine far in advance how fast a train may safely travel at any given point. It can determine precisely when the train must begin slowing down. Human mistakes are the most common cause of accidents in rail transit systems. Automatic controls are not subject to the many weaknesses of human operators, i.e., mistakes in judgment, lapses of memory, inattention, fatigue, boredom, or the temptation to ignore safety rules.

Comfort and Convenience

Automation also makes it possible to provide more comfort and convenience to passengers. Computerized supervisory systems can help adjust schedules automatically to provide the best possible service for the greatest number of passengers. If a train is delayed, the computer can take steps to smooth out schedules and avoid bunching up of trains in one area or long gaps between trains in another area.

Automation spells economy. Automatic equipment can adjust service so that energy demands are kept to a minimum, reducing costs and demands on power resources. Where it is decided to have one, an attendant on a train equipped with automatic controls can make station announcements, monitor instruments that show how train equipment is performing, answer passenger questions over an intercom system, maintain contact with station and central control personnel and respond to any emergency that might arise. Compare this to the old trolley needing both a motorman and a fare collector.

Despite its recognized advantages in speed, comfort, convenience and economy, the idea of automatic train controls makes some laymen uneasy. "It's great if it works," they argue, "but what happens if something goes wrong?" The answer is that automated transit systems are designed so that if something does go wrong, the system either continues to function safely or it shuts down in a safe manner.

"Fail-Safe" Approach

This is called a "fail-safe" design approach. With this approach the designer considers all the possible ways that something can go wrong. What happens if a wire breaks? If a circuit shorts? If a component burns out? Taking all known and foreseeable possibilities into account, the designer provides safeguards so that a failure will not result in an unsafe condition.

No transit system can be absolutely safe, and fail-safety does not eliminate all possibilities of an accident. But it does provide the maximum safety attainable for the system and its users.

In a transit system, the basic role of automation is to carry out the functions that run the trains safely and efficiently. Two of these functions are detecting where trains are on the system at all times and controlling the speed of trains.

While the overall train control system is highly complex, its basic concept is not difficult to understand. Take for example, the automatic train control system for BART, the most advanced transit system operating anywhere in the world.

The Block System

The 71-mile BART system is divided into sections of track called "blocks." These blocks are from 200 to 1,000 feet long. Each block has electronic equipment that can determine whether or not the block is occupied by a train. Each block also has associated with it speed control equipment that can command a train to operate at a certain speed. For instance, a straight, level stretch of track not approaching a station may permit a maximum speed of 80 miles per hour, while another section with a curve or near a station may permit a train to operate at no more than 50 miles per hour.

Local equipment at each station can modify these maximum speeds downward if necessary because another train is ahead. When a train enters one block, the block behind it immediately receives a zero speed limit, so that a following train will stop before it catches up with the one ahead.

Detecting Trains

How are trains detected? On the BART system, train detection is accomplished by putting an electric current into the rails at one end of each block and looking for it at the other end. If no train is present, the signal will travel from the transmitter at one end to the receiver at the other end, and the block will be considered unoccupied.

When a train enters the block, the current is interrupted and does not reach the receiver. Instead, the current follows a path created by the wheels and axle and is short circuited, or "shunted," to the other rail. When the signal fails to reach the receiver, the block is reported as occupied, and speeds in preceding blocks are adjusted accordingly to make sure any following train stops before reaching the occupied block.

Train Speed Control

The train receives its speed command by "listening" to the special frequency of the signal in the rails. Different coded sequences of frequencies represent the eight possible speed commands (zero, 6, 18, 27, 36, 50, 70 or 80 miles per hour). The code used in a particular block is determined by the distance to the occupied block ahead and by the physical characteristics of the track, such as curves or grades.

Coils mounted ahead of the front wheels of the train sense the current in the rails. Electronic equipment on the train decodes the signal into a speed command. It compares this command to the actual speed of the train. If the train is going faster than the commanded speed, it slows down. If it is going slower, it speeds up. The speed command is repeated three times every second. If the train does not continue to receive a valid speed command three times a second, the propulsion power is removed and the brakes are applied.

Automatic train control equipment brings the trains to a halt at the proper position on the station platforms. The train receives a signal from a pair of wires mounted along the wayside on the approach to each station. These wires are laid out so that they cross one another at one-foot intervals. The train's equipment electronically counts the crossovers and determines the train's exact position and speed, and applies just the right amount of braking to bring the train to a smooth stop at a precise point on the platform.

Automatic Routing

As the train proceeds on its route, it continuously sends out a destination signal. This signal is received by wayside equipment on the approach to every switch, crossover or divergence point. The wayside equipment determines whether a switch should be moved to get the train to its destination. It also determines whether the switch can be moved safely before the train gets there. If not, it will stop the train to preclude the possibility of a derailment.

The safety functions of the BART automatic train control system are handled entirely by equipment at each station, along the wayside and on each train. But another feature, a central computer, performs a number of supervisory functions that provide greater efficiency in the operation of the entire transit system. And this efficiency is translated into better service for the passenger who rides the trains.

What the Computer Does

The basic function of the computer is to "optimize" the system -- to help trains get back on schedule if for some reason they are delayed, and to determine how to cope with unexpected situations that affect scheduled service. The computer cannot override local station, wayside and train carried equipment on questions of safety. It can make "suggestions" on how service can be improved. If the local equipment determines that the suggestion can be carried out safely, it will act accordingly.

The computer has a number of other major functions in the automated BART system. It dispatches trains from the yards and, working through station and wayside equipment, aligns various switches so the trains can be routed safely to their proper destinations. The computer also operates a large display board in the BART central control room. The board has a graphic representation of the various routes of the transit system. The computer lights various portions of the board to indicate the progress of all the trains in operation. The computer-operated board also displays the condition of the system's electrification equipment as well as that of auxiliary equipment such as fans and pumps. All of these functions can be carried out by computer faster, more reliably and more economically than would be possible manually.

Technological Advances

In designing the BART train control system, Westinghouse took advantage of a number of advances in technology designed to make the system operate more efficiently, at lower cost, more reliably and with a much higher level of performance than any other system in operation. The advances used by Westinghouse include:

1. Use of frequency modulation for track signaling
2. A more reliable speed-coding system
3. Multiplexing of signals
4. Use of solid-state transistorized circuitry

In prior transit systems, the train detection signal sent through the rails has been a simple on-off coding of a single frequency carrier -- essentially the same as the AM (amplitude modulation) signal used in radio broadcasting. The BART system uses a signal that switches between one frequency and another. This is the basis of the radio's FM (frequency modulation) broadcasting. This FM signal eliminates potentially disruptive outside noises and assures a clear signal.

BART also uses an advanced type of coding to represent the speed command signal. It is more reliable and more immune to outside interference than older systems. Prior systems have represented various speed commands by switching the signal on and off a certain number of times each second. In BART, a special coding arrangement eliminates the possibility that an extraneous noise -- such as that caused by a flat spot on a wheel -- might cause a misinterpreted speed command.

Another advance applied by Westinghouse to the BART train control system is the use of multiplexing of signals, a procedure widely used in modern communications systems that demand high efficiency of signal transmission. With multiplexing, as many as 30 separate signals are sent simultaneously over one pair of wires. Conventional systems would require 30 pairs of wires for these signals -- adding weight, maintenance problems and cost and making short circuits possible in the event the signal cables are damaged.

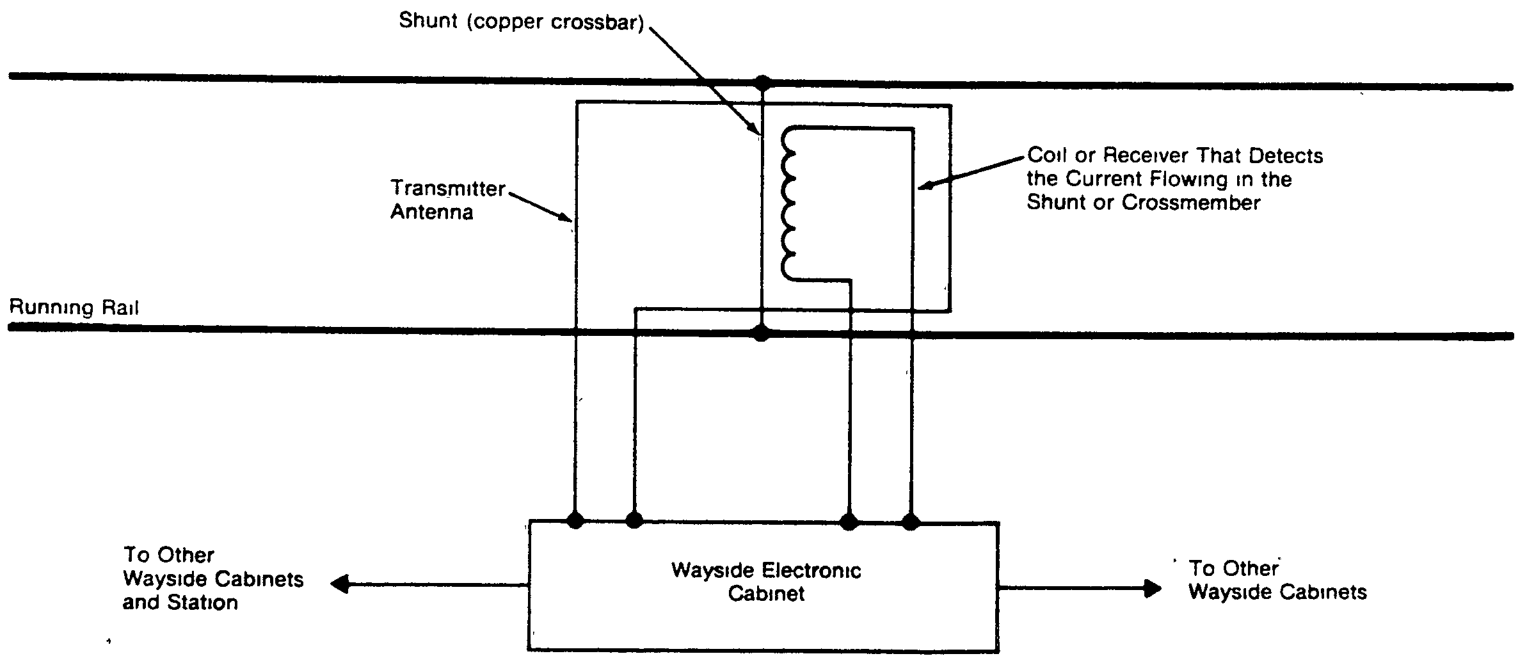
There are also technological advances in the use of very accurate and stable crystal oscillators and narrow-band crystal filters in the transmission and reception of control signals. These elements provide extremely precise communications channels for the desired signals and efficiently filter out unwanted signals.

On BART, Westinghouse has employed solid-state transistorized circuits for speed coding. Older systems use conventional electromechanical relays, which wear out. Transistorized circuitry provides savings in power and space and increases reliability to minimize the number of equipment failures.

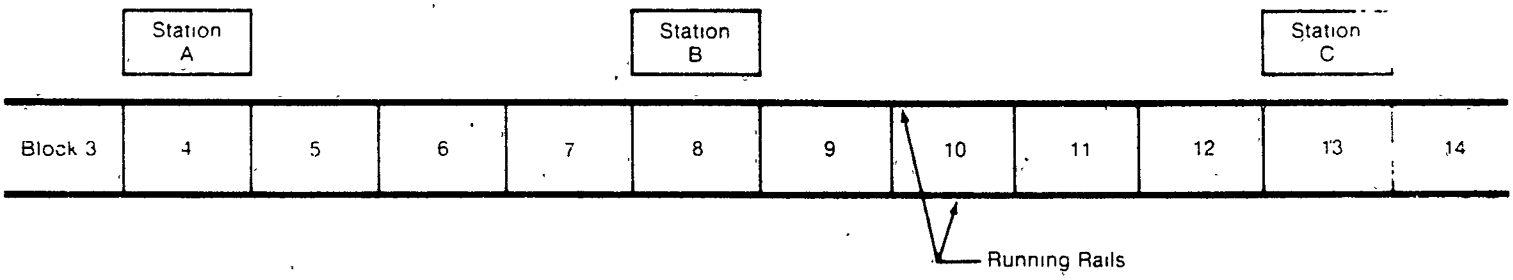
BART has pushed forward the technological frontiers of the urban transit industry. Other cities are moving to catch up. Saò Paulo, the largest city in South America, is beginning service this month with a system similar to BART. Similar automated equipment, although on a smaller scale, has been in use for more than three years at the Tampa International Airport in Florida. A system similar to this went into operation in 1973 at the Sea-Tac International Airport in Seattle, and others are planned elsewhere. Like BART, the systems in Sao Paulo, Tampa and Seattle all use Westinghouse automatic train control equipment.

##3450-24N##

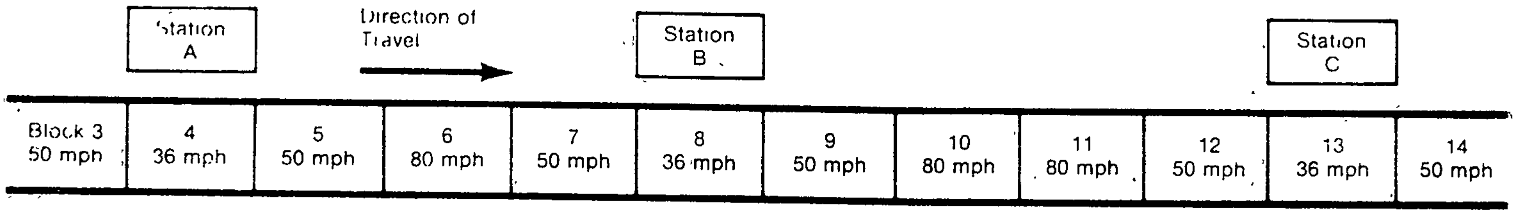
Detail of block boundary shows shunt, a copper crossbar providing a path for electric current to flow from one rail to the other; transmitter that induces current into rails, and receiver that detects current in shunt flowing from previous transmitter.



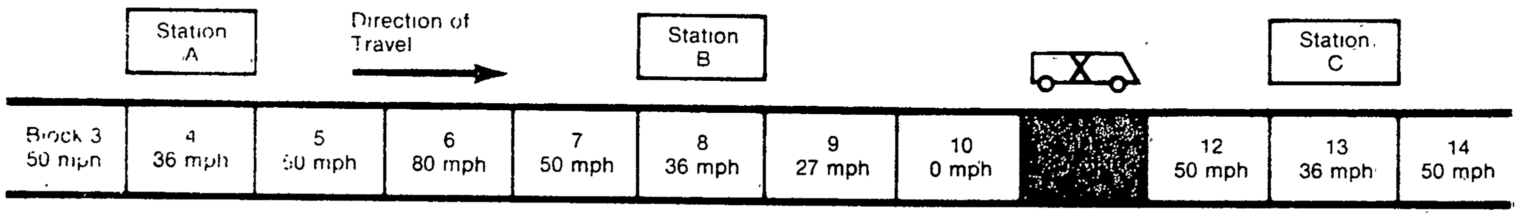
Tracks on the BART system are divided into "blocks" ranging in length from 200 to 1000 feet. Copper crossbars, or shunts, physically separate one block from the next. The block system is the basis for both train detection and speed control on the entire system.



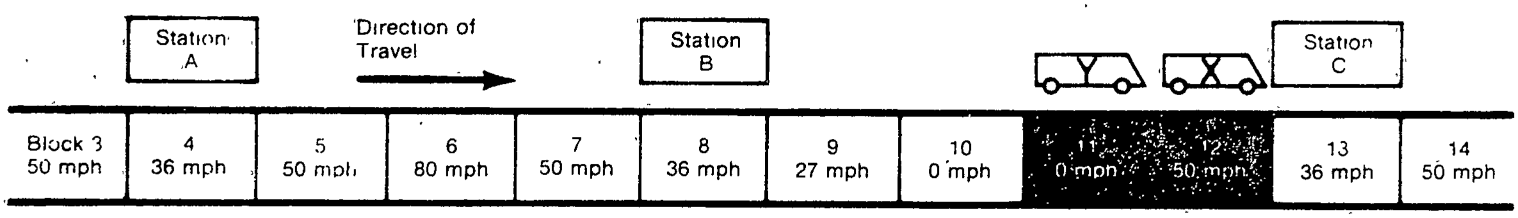
Typical speed codes on the BART system are shown here. The speeds are the maximum permitted in each block, as determined by such factors as curves, grades, and distance from a station. No trains are present in the section of track shown, so a train entering from the left would have a clear track ahead of it.



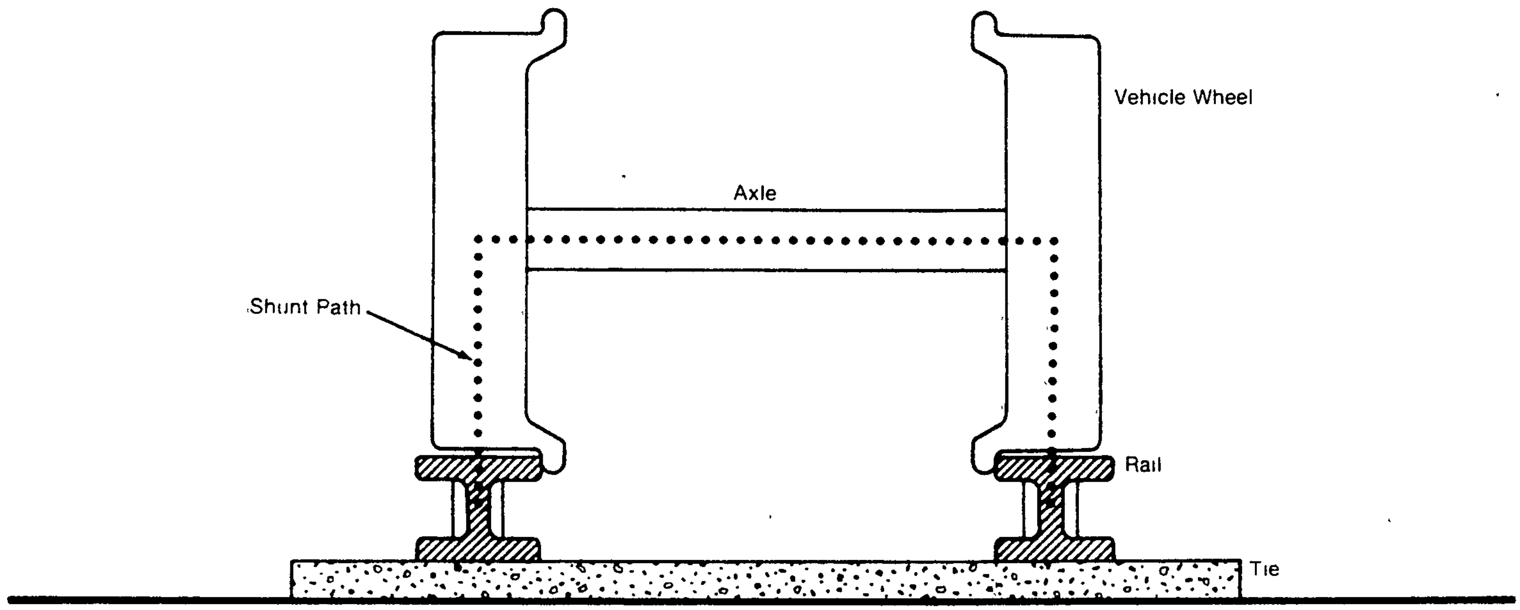
A train (X) in Block 11 can travel at 80 miles per hour because it still has a clear track ahead of it. However, its presence changes the speed limit in Block 10 to zero miles per hour (instead of 80) and in Block 9 to 27 miles per hour (instead of 50).



Here train X has advanced to Block 12, and a second train (Y) has approached it from the rear. Train Y stops because the presence of train X in Block 12 causes Block 11 to transmit a zero speed code to train Y. The presence of train Y in Block 11 changes the speed limit in Block 10 to zero miles per hour and in Block 9 to 27 miles per hour. These conditions prevail until train X moves into Block 13, and then train Y is permitted to move safely into Block 12.



Detection of a train on the BART system is established by the "shunting" of the current in the track circuit from one rail to the other by the vehicle. When shunted, the current flows from one rail through the wheels and axle of the vehicle to the opposite rail. When the receiver at the remote end of the block fails to receive the current, the block is identified as occupied.



Incen

To: Department Heads Date: August 4, 1972

From: Lawrence D. Dahms, Assistant General Manager - Planning & Public Service

Subject: Bibliography of Current Information Regarding BART

I would like to express my thanks to all the people who responded to my request of May 25, 1972, regarding the development of a bibliography of current information regarding BART.

Attached for your information is a copy of the Index and list of the materials gathered through this effort. Two copies of the Index and the materials noted as attached can be found in the Library for your further use.

Again, thank you for your assistance.

Larry Dahms
Lawrence D. Dahms

LDD:kb

cc: B. R. Stokes
D. G. Hammond
L. A. Kimball
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I. PLANNING

AC/MUNI/BART COORDINATION

(Hein)

AC Transit/BART Agreement

FEEDER BUS STUDIES

(Hein)

Coordinated Bus Study - Project CAL T-9-11, Draft Final Report, BART Office of Planning, January, 1972

SB 325

(Hein)

Status Report on SB 325, April 24, 1972, w/attachment (attached)

ROLE OF MTC

(Hein)

Letter regarding Material on MTC for UTAC Use, Lawrence D. Dahms to B. R. Stokes, April 3, 1972 (attached)

The Metropolitan Transportation Commission, April, 1971 (attached)

MISCELLANEOUS PLANNING MATERIAL

(Hein)

Background Paper on Transit Planning, BART Office of Planning and Research, July 15, 1970

San Francisco Airport Access Project Summary Report, PBTB-Wilbur Smith-Kirker, Chapman, May, 1972

Analysis of the Recommendations of the Golden Gate Bridge Highway and Transportation District for Transit Improvements in the Golden Gate Cooridor, BART Office of Planning, April 23, 1971

San Mateo County: Annexation to BART - the Legal and Financial Implications, BART Office of Planning and Research, 1971

II. PASSENGER SERVICE

ART DONOR PROGRAM

(Ferolie)

BART ART, BART Office of Passenger Service

MARKETING, ADVERTISING, FOREIGN LANGUAGE PASSENGER SERVICE

(Mattson)

Inside Track, "What to do with 50,000 Confused People, Clutching Money", June, 1972, Vol. 1, No. 5

OFF-SITE TICKETS

(Brennan)

Off-Site Ticket Sales Program (attached)

III. PERSONNEL

AFFIRMATIVE ACTION, MINORITIES

(Olsen)

Letter regarding Affirmative Action/Minorities, Director of Personnel to L. D. Dahms, June 14, 1972 (attached)

IV. OPERATIONS

AUTOMATIC FARE COLLECTION

(Davitt)

Rapid Transit Digest, August, 1971, Vol. 13, No. 2

BART's Automatic Fare Collection System, L. W. Breiner, April 13, 1971 (attached)

CENTRAL OPERATIONS

(Bratz)

BART Operations Control Center, May 2, 1972 (attached)

AUTOMATIC TRAIN CONTROL

(Wargin)

SCHEDULING

(Rausch)

Letter regarding Operations Planning, General Manager to Board of Directors and Department Heads, November 18, 1970 (attached)

13-C AGREEMENT

(Cooper)

TAX RATES

(Deliramich)

TRAINING

(McDowell)

Operations Department Training Doctrine, July, 1971

Operations Department Systems Approach to Development of Instructional Material, August, 1971

Operations Departmental Procedures #3, July, 1971

Techniques of Effective Instruction, August, 1971

BART Training System (a paper delivered by W. M. McDowell to the ATA-IRT Conference in New York, April, 1972)

Operations Department Training Unit Brochure

WRITING

Clear Technical Writing, Robert Gunning Associates, Blacklick, Ohio (attached)

V. RESEARCH

IMPACT STUDIES, ECONOMICS, FARES

(Belding)

BART Impact on Various Industries, B. R. Stokes, BART General Manager, Letter Report to C. Carroll Carter, Assistant Administrator for Public Affairs, U. S. Department of Transportation, Urban Mass Transportation Administration, May, 1971

Development Follows Toronto Subway, Toronto Transit Commission, 1968

BART Interstation Fare Schedule Report (Draft), May 18, 1971

BART Interstation Fare Schedule Report, Supplemental Memorandum, May 26, 1971

BART Interstation Fare Schedule, IBM Initial Installation, July 1, 1971

The Basis for a Comprehensive BART Fares Policy, December 7, 1971

Memorandum from the Assistant General Manager - Planning & Public Service to the General Manager, regarding Basic Interstation Fare Schedule, December 17, 1971

The BART Interstation Fare Schedule, January 24, 1972

BART Impact Study, Working papers for study design Contract DOT-05, 20093, Task Order 2, submitted to Federal Agency Technical Representatives for consideration at meeting of June 7, 1972

VI. REAL ESTATE

CONCESSIONS

(Knapp)

Summary Report Study of Excess Property Rights and Concessions, January, 1968

Policy on In-Station Customer Services adopted July, 1969

Implementation of First Stage Customer Service Program, September, 1971

Policy on mail boxes adopted July, 1971

Policy on newspaper sales at BART passenger stations adopted October, 1971

Newspaper vending rack permit and general terms and conditions, January 10, 1972

Bicycle Locker Agreement, May 12, 1972

VII. ENGINEERING

FEDERAL GRANTS

(Preston)

DHUD - Planning Requirements Guide

Bureau of the Budget Circular No. A-95

HANDICAPPED

(McCutchen)

Statement of Wilmot R. McCutchen, Chief of Design, BART, before the Special Committee of Aging, United States Senate, October 20, 1971 (attached)

LABOR RELATIONS

(Bowers)

Green

SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT

INTER-OFFICE COMMUNICATION

To: Department Heads Date: May 25, 1972

From: Lawrence D. Dahms, Assistant General Manager - Planning & Public Service

Subject: Development of a Bibliography of Current Information Regarding BART

I have long been concerned that members of my staff who must often address public groups be well-grounded in their understanding of BART. The difficulty is that the substance of BART is considerably more difficult than most people realize.

It occurs to me that we spend a great deal of time with visitors from all over the world, providing information in response to whatever interest they may have. At the same time, I do not believe we spend sufficient time properly educating our own staff. In an effort to remedy this deficiency, I am requesting your assistance.

I have developed a partial listing of key subjects of interest and have presumed the many persons to be contacted with respect to these subjects. Attached is a copy of the subjects and appropriate persons. I am requesting that each of the staff listed on the attached paper develop quickly a list of readily available material relevant to their responsibilities that should be read by any person who would hope to have a well-grounded understanding of BART. I am asking that my secretary, Kathy Bartlett, call each of these persons within a week to compile a full list of such materials.

As a follow-up, I would expect that selected persons within my part of the BART organization would take the time to read the material that has been identified and then would arrange interviews with these key source persons to enlarge upon their understanding.

I hope you will consider this effort as important as I do. Further, I would hope that some of you might be sufficiently interested to encourage some of your own staff to broaden their understanding of BART. In that interest, I will distribute the bibliography to you once it is compiled.

Thank you for your assistance.

Lawrence D Dahms

Lawrence D. Dahms

LDD:kb
Attachment

cc: Staff listed on attached paper
B. R. Stokes
D. G. Hammond
L. A. Kimball
P. O. Ormsbee
F. Chambers

District Familiarization Program

I. Background Reading and Interviews

Subject	Source
1. AC/Muni/BART Coordination Feeder Bus Studies SB 325 Role of MTC	Hein
2. Art donor program	Ferolie
3. Affirmative action, minorities	Olsen
4. Automatic fare collection	F. Davitt
5. Automatic train control	T. Bratz
6. Impact studies, economics, fares	Belding
7. Cash handling and collection	G. Graham
8. Concessions	T. Knapp
9. Extensions: Geary Livermore Pittsburg-Antioch Oakland Airport SFAAP, San Mateo	 Torrey Goode Armstrong Hein Bernard
10. Federal grants	R. Preston
11. Handicapped	McCutchen
12. Labor relations	Bowers
13. Legislation	Chambers
14. Marketing, advertising, foreign language, passenger service	Mattson
15. Off-site tickets	Brennan
16. Real estate impact	A. Gustafson
17. Scheduling	R. Rausch
18. 13-C Agreement	P. Cooper
19. Tax Rates	Deliramich
20. Training	McDowell

ABSTRACT

The electorate of the three-county core of the San Francisco Bay Area voted in November, 1962, to finance and construct the largest locally financed public works project in the history of the country.

The Bay Area Rapid Transit District, beginning in the fall of 1963, began organizing for the separate but overlapping tasks of system design, system construction and system operation.

Within four years, most of the 3600 parcels of property needed for right-of-way, approximately half of the construction contract commitment and virtually all of the basic design for the 75 miles of aerial, tunnel, subaqueous tube and freeway-median track, had been completed. Revenue operations are scheduled to begin in 1970.

A joint venture of engineering firms has had principal responsibility for design and construction supervision, subject to direction by District engineers and managers. Efforts by these consultants will gradually dwindle to the point where construction of the initial system is completed and District personnel take over the operation of the automated system.

The District and its consultants have attempted to make each phase of the system attractive and inviting. The most significant technical advancements of the art have been in the areas of automatic train operation and automated fare collection.

I. The Relationship of Topography and Rapid Transit in The Bay Area

Planning and development of the Bay Area Rapid Transit project has evolved steadily since initial land use and transportation studies were undertaken in 1953-55 by the original State-financed Bay Area Rapid Transit Commission. Commission studies were completed in 1956 with creation of a comprehensive regional plan developed by the Commission's consultants, Parsons-Brinckerhoff, Hall & Macdonald, in collaboration with professional planners. This collaboration was the prototype of arrangements, commonly entered into now in the mid-'sixties, among planners, architects and engineers in the development of metropolitan transportation systems.

This regional plan was the only regional plan available to the nine-county area until the release of a similar, but more current, document in 1966 by the Association of Bay Area Governments.

The traffic crush typical of all cities had combined in post-World War II years with the barriers of Bay Area hills and waters to create the need for solutions to transportation congestion which did not depend solely on additional freeways. The key to both the regional plan and to the transit system it spawned lies in the area's geographic uniqueness and the contrasting patterns of high downtown densities and low suburban densities--features which the topographic factors tend to encourage.

Four project objectives were identified by planners in 1955-56:

----Provide an interurban mass transportation service that is at least as fast, as comfortable, and as inexpensive to ride as the private automobile.

----Relate transit and highway systems to permit optimum utilization of both private and mass transportation.

----Encourage orderly urbanization and economic expansion of the region.

----Construct and operate at the least cost consistent with the provision of effective total transportation.

The study commission consultants pointed out in their comprehensive proposals that the topography could lend itself to a number of different patterns of community and economic development. They concluded that "the choice is between preserving the system of concentrated regional and sub-regional centers or dissipating their activities to diverse noncentral ocations."

The high-density centers and subcenters are principally the down-town areas of San Francisco, Oakland and Berkeley, central business districts close to bay waters. The suburban pockets and valleys east of the East Bay hills, together with residential communities stretched along the narrow shelf between the bay and East Bay hills, provide the bedroom support for the retail, educational, insurance, banking, light industrial, hotel and entertainment industries--activities which characterize the three high density areas.

In the strictly legal and political sense, however, the District's principal objective, according to its 1957 enabling legislation, was the construction and operation of a transit system so as to improve mobility and communication and to minimize the need for additional freeways.

II. Creation of The District

The persuasiveness of the study commission's report and the increasing need for political action led to creation in 1957 of a five-county

District with certain taxing powers to permit engineering and financial feasibility studies as a preliminary to a public referendum. The chronology of events cited in Figure I indicates the major subsequent events in the life of the District.

From 1957 to 1962, the "skeleton" District staff and its consultants refined and improved the routes and station locations of the earlier general proposal. At the request of the District, each affected city and county established a technical committee of city officials to work with District representatives, so as to create "parternships" in the local planning process. From this exchange of expertise and experience came the basic 5-county document, published in 1960, entitled "Plan of Routes, Rights-of-Way, Terminals, Stations, Yards and Related Facilities."

The subsequent withdrawal of two counties left a three-county District concerned primarily with traffic between the East Bay suburbs and the downtown areas (Figure II). We are convinced that BART's successful operation of its three-county system, commencing in 1970-71, will dramatically alter the climate of opinion in the two regionally important counties to the south of San Francisco. It is inevitable that rapid transit service will penetrate more and more communities in the 'seventies. Once exposed to the speeds, comforts, handsome qualities and relative economy of BART trains and stations, regions in the Bay Area not now served will want what Alameda, Contra Costa and San Francisco Counties enjoy.

The nine-county map (Figure III) depicts current and probable future BART construction and operations.

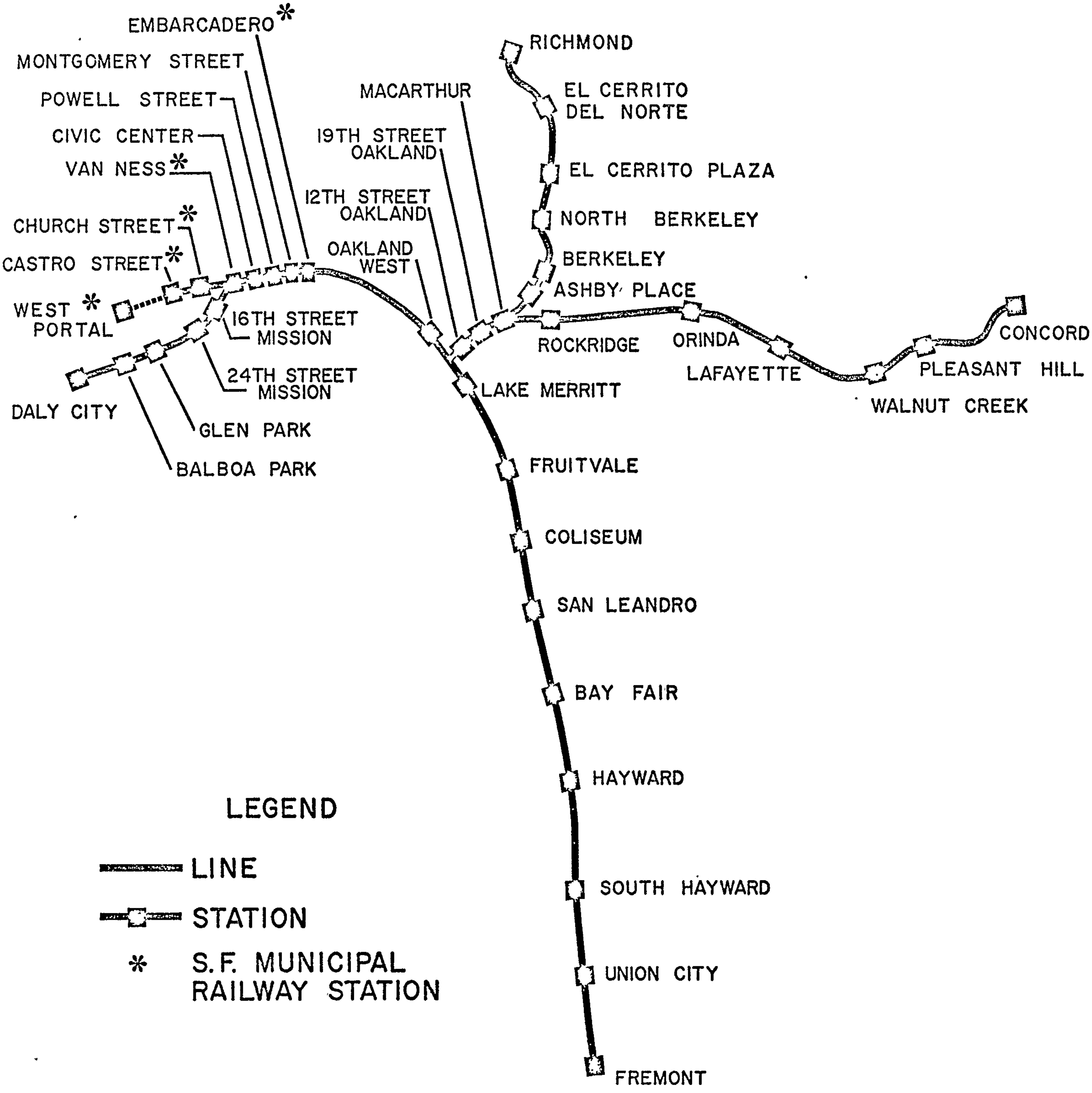
FIGURE I

CHRONOLOGY: SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT

January, 1947	Joint Army-Navy Board recommends underwater transit tube beneath San Francisco Bay.
July 25, 1951	California Legislature creates nine-county San Francisco Bay Area Rapid Transit Commission to study long-range transit problems.
January, 1953	Commission makes preliminary report to Legislature.
January, 1956	Parsons, Brinckerhoff, Hall & Macdonald recommends construction of a regional rapid transit system to solve Bay Area congestion problem.
February, 1956	Stanford Research Institute recommends creation of public district to plan, construct and operate Bay transit system.
January 17, 1957	Commission reports to Legislature and states need for rapid transit system and recommends creation of district.
June 4, 1957	Legislature approves creation of San Francisco Bay Area Rapid Transit District to plan, and if approved, to build and operate regional system.
November 14, 1957	District holds first meeting with representatives of Alameda, Contra Costa, Marin, San Francisco and San Mateo Counties.
May 14, 1959	District retains three engineering firms to develop regional transit plan: Parsons, Brinckerhoff, Hall & Macdonald; Tudor Engineering Company, and the Bechtel Corporation.
July 10, 1959	Legislature passes bill approving use of Bay Bridge tolls for construction of underwater rapid transit tube.
September 10, 1959	District retains Ebasco Services, Inc., to perform economic studies pertaining to rapid transit for the Bay Area.
October 8, 1959	District retains Smith, Barney & Company of New York to develop financial plan for Bay Transit system.

March, 1960	State Department of Public Works approves plan to route rapid transit in median strip of planned new Grove-Shafter Freeway in Oakland.
March-April, 1960	District holds public hearings on rapid transit plan in five counties.
July 1, 1960	Engineering consultants complete feasibility study of Trans-Bay Tube.
September 1, 1960	District transmits tentative physical rapid transit plan to city and county officials for comments.
February 9, 1961	District directors approve five-county transit routings.
June 6, 1961	Legislature passes bill setting 60 per cent vote requirement for authorization by electorate of transit plan.
August 1, 1961	Golden Gate Bridge directors reject rapid transit operation on Golden Gate Bridge.
December 19, 1961	San Mateo supervisors vote to reject transit plan and to withdraw county from district.
April, 1962	District engineering and financial consultants find 75-mile, three-county transit plan feasible.
May 17, 1962	Marin County withdraws from first-stage rapid transit program.
May 24, 1962	District directors adopt three-county rapid transit plan and formally transmit it to three Boards of Supervisors.
July 9 - 24, 1962	Supervisors approve rapid transit plan.
November 6, 1962	Voters of three counties approve $792,000,000 rapid transit system plan and authorize construction of the system.
November 29, 1962	District retains Parsons, Brinckerhoff, Quade & Douglas; the Bechtel Corporation; and Tudor Engineering Company to engineer and manage construction of the rapid transit system.

June 10, 1963	Contra Costa Superior Court rules in district's favor on all points raised in taxpayer's suit.
June, 1963	District receives initial $4,880,000 Federal mass transit demonstration grant to be applied to district test program.
November 27, 1963	District initiates right-of-way acquisition.
December 10, 1963	First series of general obligation bonds is sold.
June 19, 1964	President Lyndon B. Johnson officiates at Diablo Test Track groundbreaking.
January 14, 1965	San Francisco Municipal Railway, Alameda-Contra Costa Transit District and BART begin Northern California Transit Demonstration Project study of integrated feeder and transfer systems.
April 12, 1965	Test Track program inaugurated.
February 10, 1966	District rejects all bids on downtown Oakland subway; directs repackaging of contract.
August 25, 1966	District receives HUD approval of initial $13.1 million capital construction grant.
September 8, 1966	Board of Directors receives project re-estimate and adopts policy statement on long-range financing.
October 4, 1966	Berkeley voters approve special service district to finance border-to-border subway in their city.
February 24, 1967	Berkeley Hills Tunnel is holed through after 446 working days.
March 23, 1967	District awards $26 million automatic train control contract.
September 14, 1967	District reaffirms policy to obtain full financing for entire 75-mile system before any revenue operations.
December 15, 1967	Final Report of Northern California Transit Demonstration Project defines regional objectives of coordinated transportation administration.



BAY AREA RAPID TRANSIT SYSTEM SCHEMATIC MAP

DECEMBER 1965

FIGURE II

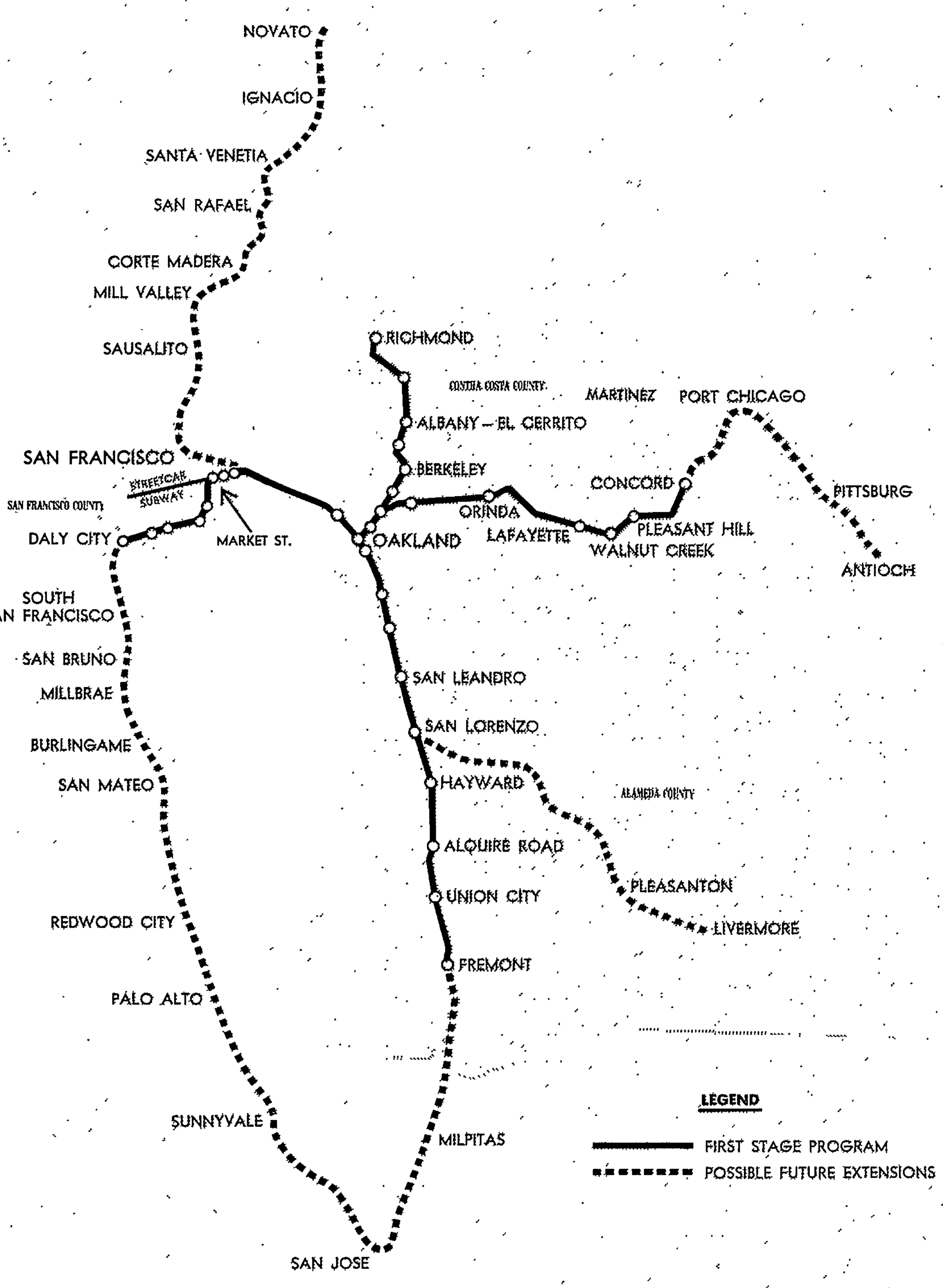

NOVATO
IGNACIO
SANTA VENETIA
SAN RAFAEL
CORTE MADERA
MILL VALLEY
SAUSALITO
RICHMOND
CONTRA COSTA COUNTY
MARTINEZ
PORT CHICAGO
ALBANY — EL CERRITO
SAN FRANCISCO
BERKELEY
CONCORD
PITTSBURG
STREETCAR SUBWAY
SAN FRANCISCO COUNTY
ORINDA
LAFAYETTE
PLEASANT HILL
DALY CITY
MARKET ST.
OAKLAND
WALNUT CREEK
ANTIOCH
SOUTH SAN FRANCISCO
SAN BRUNO
MILLBRAE
SAN LEANDRO
SAN LORENZO
BURLINGAME
HAYWARD
SAN MATEO
ALAMEDA COUNTY
ALQUIRE ROAD
UNION CITY
PLEASANTON
REDWOOD CITY
LIVERMORE
FREMONT
PALO ALTO
LEGEND
SUNNYVALE
MILPITAS
FIRST STAGE PROGRAM
POSSIBLE FUTURE EXTENSIONS
SAN JOSE

FIGURE III

III. BART Since 1962

After the successful election, the District decided to employ a single entity to manage design and construction of the complete system. A joint venture of three prominent design firms, the newly created Parsons Brinckerhoff-Tudor-Bechtel (PBTB) organization, set about to impose a huge and immensely complicated system upon the land and traditions of three counties and many communities.

The demands facing PBTB and its District "client" included:

----Study transportation needs in a three-county area which houses about 4.5 million people and generates one million person trips a day.

----Estimate passenger traffic volume and the development of financing schedules to govern expenditure of over one billion construction dollars.

----Estimate costs of design, construction, operation and maintenance.

----Precisely locate and engineer the 75 miles of routes and 37 stations.

----Design the four-mile underwater tube, as well as many miles of subway lines and subway stations.

----Acquire approximately $100 million worth of rights-of-way.

----Rebuild many streets, relocate many utilities, and negotiate for railroad rights-of-way.

----Supervise more than 150 design contracts and 100 construction contracts.

----Design high-speed trains with propulsion equipment and suspension systems able to provide safe, comfortable rides.

----Develop automated train control, electronic fare collection and other entirely unprecedented "subsystems" in the history of American transit.

By 1966-67 the joint venture's efforts and the District's total responsibility were well along the way to fruition. From a "skeleton" staff of 16 District employees in 1962, total manpower requirements in the combined District-PBTB activity climbed to almost 1500 within three short years.

With design activity still intense but less extensive, and with construction activity gradually becoming routine, District design and construction supervision activity is gradually replacing some of the Joint Venture's effort. By the time construction is completed the Joint Venture staff will be very small and the District will meet the challenge of operating the world's first high-speed automatic rapid transit system.

The recent history of the District and its consultants has been one of effective and efficient use of skilled manpower. The success of this effort has been a principal source of satisfaction to me personally. Design has been completed on the BART vehicle and specifications have been written. Engineers are evaluating results of Test Track operations, and a complex $50 million 1,000-volt D.C. electrical system is being installed. More than $300 million worth of construction has been let to contract during 1967 alone, and close to 400 individual contracts have been awarded for specialized engineering and architectural design, surveying and mapping, soils exploration, landscaping and design of station sites, fare collection systems, propulsion equipment, electrical systems, and other engineering assignments.

IV. Right-Of-Way Acquisition

Design consultants and the District's Real Estate Department have worked jointly to assemble most of the 3600 parcels ultimately needed to accommodate the 75 miles of BART tracks, stations and other facilities. Real estate acquisition costs will probably approximate $100 million.

Typically, a parcel is delineated and "certified" to District Real Estate officials by the joint venture. Independent appraisals are made, by contract, and these appraisals are reviewed by the District. Ordinarily the matter is then placed in the hands of contract acquisition agents who consummate the purchase. Relatively few cases have gone into anything but the preliminary stages of litigation, due in part to the fact that the District usually contracts for two appraisals on each property and then acquires on the basis of the highest of the two valuations.

The BART system was designed to utilize existing transportation corridors wherever possible. Thirty of the 75 miles will adjoin existing railroad tracks, using some of the private rights-of-way. About 13 miles will be in or above expanded city streets, and 17 alongside or in the median strip of freeways. This policy minimizes right-of-way costs by many hundreds of thousands of dollars. It also minimizes community disruption.

The District's real estate function will not cease with completion of the acquisition program. Property management tasks of a permanent nature must be tended to, as well as preparing for the future BART extensions into other communities. The efficient "elasticity" of the need for short-term personnel will have been provided, and that is the central issue.

V. Organizing For Development and Operations

The consultants' work in the design of structures, rolling stock and electronic equipment is increasingly shared with the more permanent District staff. By the time operations commence perhaps all of the engineering aspects of the BART system will be handled solely by BART personnel.

The adjacent Table of Organization (Figure IV) depicts the mid-1967 relationships within the District and between the District and PBTB. These organizational relationships are not static. The "elasticity" referred to above means frequent staff modifications to accommodate changing emphases.

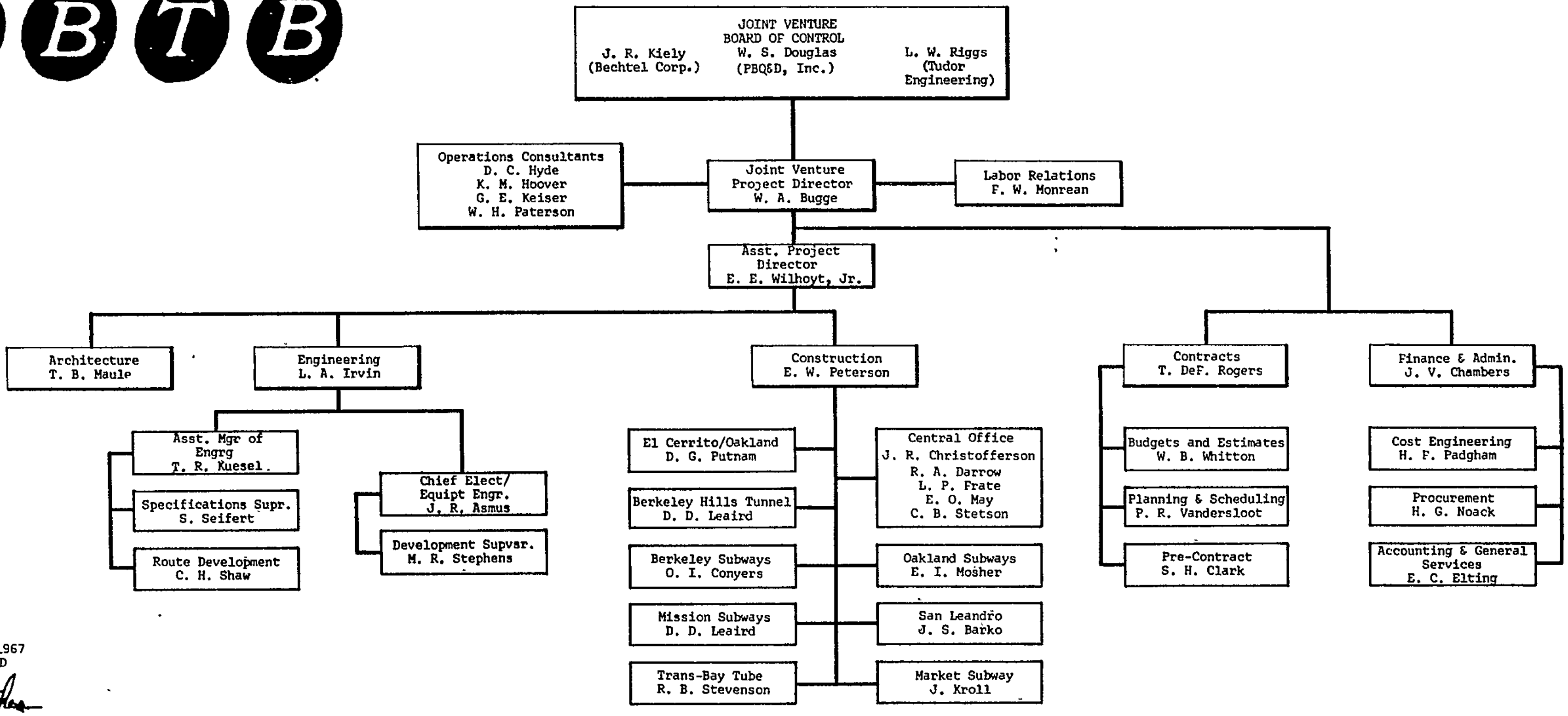
The product of the BART-PBTB organizational effort is best seen not in tables of organization but in the variety and novelty of contracts awarded in the past and contracts remaining to be awarded. Figure V lists the major contracts, past and future.

The quality of design in BART stations and line has been of great concern. The Board of Directors soon after the bond issue referendum determined that aesthetic factors would be given major weight in the BART-PBTB design project. As a result, fourteen top architectural firms are involved in design of the 33 regional stations, while major landscape architectural firms assist PBTB in its station area design efforts. The final responsibilities regarding design necessarily are vested in the Joint Venture.

Organizing for operations is of more recent origin within the District and PBTB. The District, logically enough, tends to dominate the scene inasmuch as this is its very raison d'etre. The "operations" function, in turn involves both Transportation/Traffic tasks and Maintenance (including electronic equipment maintenance) tasks. Key personnel in these two units have grown up with BART throughout its location, design and construction phases, thereby seasoning themselves in problems involving community, government and technical considerations.

PARSONS BRINCKERHOFF • TUDOR • BECHTEL

PBTB



JULY 1, 1967
APPROVED

B. R. Stokes (signature)

B. R. STOKES
GENERAL MANAGER

BAY AREA RAPID TRANSIT DISTRICT

FIGURE IV

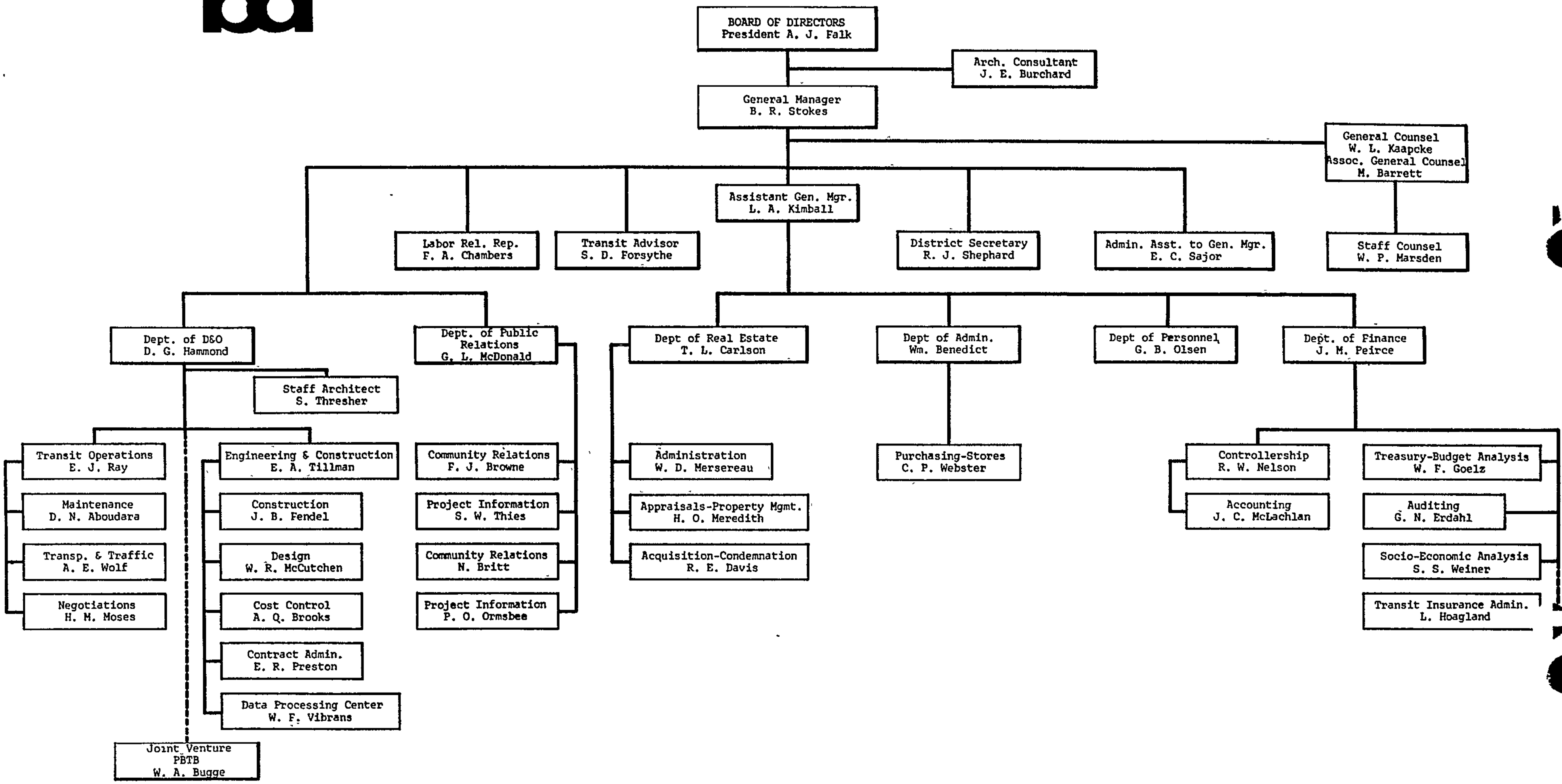


FIGURE V

BART Projects, Past and Future

Major Contracts Under Way

Project	Contractor
SAN FRANCISCO COUNTY:	
Market Street Subway Tunnels	Shea-Ball-Granite-Olsen
Montgomery Street Station	Winston-Drake-Early
Powell Street Station	Shea-Ball-Granite-Olsen
Market Street Subway Tunnels	Delaware V.M Corp.
Civic Center Station	MacLean-Grove-Shepherd
Market-to-Mission Tunnels	Morrison-Knudsen and Perini
Mission Street Stations (2)	Rothschild & Raffin and P. & Z. Co., Inc.
Mission Street Tunnel #1	Kiewit-Traylor
Mission Street Tunnel #2	Morrison-Knudsen and Perini
Tunnel under Chenery Street	S&M Constructors
ALAMEDA COUNTY:	
Aerial and grade line, South County	Stolte, Gallagher & Burk; McGuire & Hester; Holmes-Thomas; Ball-Olsen
Freeway Median	Gordon H. Ball; Guy F. Atkinson
Oakland Subway Stations	Early-Winston-Drake; Perini and Morrison-Knudsen; Rothschild, Raffin & Weirick and P. & Z. Co., Inc.
West Oakland Aerial	Fredrickson & Watson
Oakland Tunnels	MacLean-Grove; Massman; Fruin-Colnon & General
Berkeley Station	Haas & Haynie
Aerial Line, Albany-El Cerrito	Donald M. Drake
Berkeley Subway	Fruin-Colnon; Shea-Macco
CONTRA COSTA COUNTY:	
Berkeley Hills Tunnel	Shea-Kaiser-Macco
Freeway Median	Gordon H. Ball; Peter Kiewit
TRANS-BAY TUBE:	Trans-Bay Constructors, with Bethlehem Steel

VI. Design Standards

Criteria for construction design and operations have been maintained at a high level. High speed is the single most important feature which BART brings to the bay area. To attain it engineers have removed as many limitations as possible in designing fixed structures. Curve radii, both vertical and horizontal, have been increased to provide minimum curve speeds of 55 mph. The theory must be that all trains moving over a given section of track will be moving at the same speed.

The integrity of the BART design standards is well recognized by contractors, local government agencies and designers who have attempted to compromise those standards. Rolling stock criteria developed from our Test Track experience incorporated this reliance on high performance standards.

The handsome aerial structures, the subways, the Trans-Bay tube and the Berkeley Hills twin tunnels will all be clean, dry, well-lit and well-ventilated at all times. They will all safely and comfortably support speeds up to 80 mph.

The aerial structures have been designed to accommodate top operating speeds and great stress was placed by the engineers and architects on producing a highly attractive design. A simple bent consists of a uniformly cross-sectioned hexagonal column supporting a cross-sectioned horizontal member. Each horizontal member supports the ends of four post-tensioned girders of trapezoidal cross-section. These girders, averaging approximately 65 feet in length, each support one track. Between the two girders and slightly below the upper level of the girder is an inconspicuous personnel walkway. The overall appearance of the aerial structure, with its clean lines and sharp shadows, is that of a very lightweight structure as contrasted, for example, with the average highway overpass. The aerial structure and track are designed to effectively minimize the transmission of noise to adjacent areas. It is planned to landscape the area under these aerial structures so that they will become attractive lineal parks to be used by BART's neighbors adjacent to these areas and maintained by the various communities through which these aerial structures are constructed. (See Figure VI.)

The electrical engineers have made their contributions to a high scheduled speed by providing an automatic train operation with a degree of sophistication never before utilized. And they have, in addition, made very solid contributions to the vehicle propulsion and braking system.

After more than 21 months of testing, Bay Area Rapid Transit engineers have recommended a 1,000-volt DC vehicle propulsion and power supply system for the San Francisco Bay region's rapid transit network. Based on a 1,000-volt DC contact rail and solid-state, chopper-controlled traction motors, the system represents a major advance over conventional 600-volt DC systems in terms of power, controllability, and maintainability.

In addition to meeting all BART performance criteria, the recommended DC system was found to be more reliable and more economical to construct than any of the AC systems considered. Incorporating the latest advances in solid-state, power-modulating control devices, it will provide smooth and stepless changes in power application. This is a primary concern in meeting stringent performance requirements (0 to 50 mph in 20 seconds versus a typical standard of 25 to 30 mph) and ensuring passengers a smooth, comfortable ride.

The automatic train operation system will permit headways as close as 90 seconds despite the higher than normal scheduled speed. In addition to the customary train separation feature, the BART automatic train control system will be in charge of all train movements --- acceleration, running, speed control, deceleration --- at all times. Manual operation is also provided. Automated dispatching at each station is provided with the ability to run each train at, above or below normal speed to the next station. In addition, the central dispatcher has constant voice contact with every train attendant via train phones. The propulsion and braking systems, making the maximum usage of solid-state components, will provide extremely smooth accelerating and decelerating performance.

We expect the cars themselves to be the most attractive rapid transit cars available anywhere. (See Figure VII.) They will, of course, be air conditioned so that they will be capable of handling even the very abrupt temperature differentials (as high as 35 degrees) that often exist on either side of the Berkeley Hills. No smoking will be permitted in the cars, thus eliminating the stale air problem and the dirty ash tray problem. The longest ride into downtown San Francisco will be not more than 35 minutes, and we feel that we are working for the greatest good of the greatest number by prohibiting smoking during this relatively brief trip. The wide double seats (44 inches) are richly upholstered with deep foam rubber cushions covered by woven and smooth vinyl fabric. Arm rests are provided at either side of the seat. The strongly tinted safety glass windows will be much higher than we are accustomed to seeing in transit vehicles and will be unusually long, thus providing a better view of the very attractive area through which much of the BART system operates. The floors will be carpeted from wall to wall. This, we feel, will impart an air of comfort and attractiveness that will be a very distinctive feature of the BART service. This, together with many other design features, will add significantly to the quietude of the vehicle interior. (See Figure VIII.)

Attractive stations at every stop on the system have been insured by using the services of many of the leading architectural firms of the Bay Area. (See Figures IX and X) Extensive use will be made of escalators. There will always be at least one route between the street and the train platform level that can be traversed by escalators in both directions. There will be large, carefully designed, well-landscaped parking areas adjacent to all but the downtown subway stations. Careful plans have been made to insure convenient transfers between rapid transit trains and local buses. Convenient "kiss-ride" facilities have been established to encourage peak hour dropping and picking up automobile riders immediately adjacent to station entrances. These stations will be manned by BART personnel whenever they are in use. The BART personnel will be there primarily to provide an information service and to supervise the entire station operation. They will not normally be called upon to vend or collect tickets.

It is planned that trains from each of the three East Bay terminals will operate directly to Oakland and the San Francisco terminal in Daly City. It is also planned to run a service up and down the East Bay exclusively. The terminals of this service will probably be Richmond on the north and Hayward on the south. This arrangement will make possible rush hour headways on the Oakland-San Francisco line as short as 90 seconds. It will make possible headways on the East Bay lines as short as 135 seconds and headways on the Concord line as short as 270 seconds. The midday service is planned at essentially twice the headway of the rush hour service. Each of these routes will offer some unusually good views of

FIGURE IX.

BART ARCHITECTURAL ORGANIZATION

District Board of Directors
VISUAL DESIGN COMMITTEE
Special Advisor: Dean John E. Burchard

District Staff
DESIGN REVIEW GROUP

General Engineering Consultants
PARSONS BRINCKERHOFF-TUDOR-BECHTEL
Chief Architect: Tallie B. Maule

Stations	Project Architects	Landscape Architects
Test Track & Building	Gerald M. McCue & Associates	Sasaki-Walker Associates
Embarcadero	Reid & Tarics	----------
Montgomery Street	Skidmore, Owings & Merrill	----------
Powell Street	Skidmore, Owings & Merrill	----------
Civic Center	Reid & Tarics	----------
Van Ness	Reid & Tarics	Theodore Osmundson
16th Street Mission	Hertzka & Knowles	Theodore Osmundson
24th Street Mission	Hertzka & Knowles	Douglas Baylis
Glen Park	Corlett & Spackman/Ernest Born	Douglas Baylis
Balboa Park	Corlett & Spackman/Ernest Born	----------
Daly City	Gerald M. McCue & Associates	Royston, Hanamoto, Beck & Abey
Richmond	Maher & Martens	Sasaki-Walker Associates
El Cerrito Del Norte	DeMars & Wells	Royston, Hanamoto, Beck & Abey
El Cerrito Plaza	DeMars & Wells	Royston, Hanamoto, Beck & Abey
North Berkeley	Kitchen & Hunt	Royston, Hanamoto, Beck & Abey
Berkeley	Maher & Martens	Royston, Hanamoto, Beck & Abey
Ashby Place	Maher & Martens	Royston, Hanamoto, Beck & Abey
MacArthur	Maher & Martens	Anthony Guzzardo
Concord	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Pleasant Hill	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Walnut Creek	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Lafayette	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Orinda	Masten & Hurd/Joseph Esherick	Royston, Hanamoto, Beck & Abey
Rockridge	Maher & Martens	----------
19th Street Oakland	Gerald M. McCue & Associates	----------
12th Street Oakland	Gerald M. McCue & Associates	Robert Kitchen
Oakland West	Kitchen & Hunt	Jack C. Stafford
Lake Merritt	Gardner A. Dailey & Associates	Anthony Guzzardo
Fruitvale	Reynolds & Chamberlain/Neill Smith	Anthony Guzzardo
Coliseum	Reynolds & Chamberlain/Neill Smith	Anthony Guzzardo
San Leandro	Masten & Hurd/Joseph Esherick	Anthony Guzzardo
Bay Fair	Masten & Hurd/ Joseph Esherick	Ralph Jones
Hayward	Wurster, Bernardi & Emmons	Robert Kitchen
South Hayward	Kitchen & Hunt	Robert Kitchen
Union City	Kitchen & Hunt	Robert Kitchen
Fremont	Kitchen & Hunt	

Special Consultants

Car Design:	Sundberg-Ferar	Lighting:	Scott Beamer & Associates
Equipment Design:	Sundberg-Ferar	Acoustics:	Dr. Walter Soroka
Station Graphics:	Ernest Born	Maintenance:	Sanitation Systems

the Bay, the Berkeley hills, the San Francisco hills, and the many attractive residential areas served by BART.

A graduated fare system, based on approximately 2½¢ to 3¢ per mile, with the minimum fare of probably 25¢, is being planned. Prototype hardware has been undergoing extensive testing at several laboratories and manufacturing centers throughout the country. The graduated fare universally used in suburban commute service has not heretofore been used in rapid transit service. This is due in no small part to the difficulties and expense of collecting graduated fares.

The graduated fare system contemplated for BART will permit every passenger to be quickly and accurately checked into the system at point of entry and checked out of the system at point of exit. The automatic entry gates will accept either cash for a minimum ride or magnetically coded tickets, either single ride or the commute type. The exit gate will retrieve the single fare ticket and make an appropriate deduction from the commute type ticket. Automatic vending machines outside of the paid area will sell either single tickets or commute tickets between any two stations on the system. If the passenger wishes to ride farther than the purchased ticket indicates, for an appropriate additional amount of money he may purchase a new ticket at his point of departure from the system. The electrically encoded ticket will be read and returned to the ticket owner at both entrance and exit gates in less than one second.

Plans are being consummated with the two existing local public transit agencies to make the interline ride as convenient as possible, and it is intended to offer discounts on interline tickets in order to encourage additional patronage.

VII. Regional Coordination

The regional plans for coordinated interline operations have been the subject of the federally-supported Northern California Transit Demonstration Project, whose technical report was published in December, 1967.

The NCTDP report also discusses the "systems approach" to transportation planning, a technique developed and refined in recent years. The "flow chart" reflecting the systems approach is incorporated herein. It may prove helpful to metropolitan area planners elsewhere. (See Figure XI.)

Conclusions

BART is the only rapid transit system in the world created by the people it was designed to serve. The 1962 bond issue referendum was approved on the assumption that BART would create the finest rapid transit system possible.

Within a short period of time BART created the organization and the tools to create such a system. The act of creation was an evolutionary process, i.e., one which adapts the best of existing practice and makes as many obvious improvements as possible in the time permitted.

The integrity of design and performance criteria is fiercely defended. Five principal concerns are of particular significance to the successful revenue operations of BART:

----that trains operate at a high scheduled speed

----that cars be attractive and inviting

----that stations be attractive and inviting

----that service itself be attractive and inviting

----that fares and fare collection facilities must be attractive and inviting

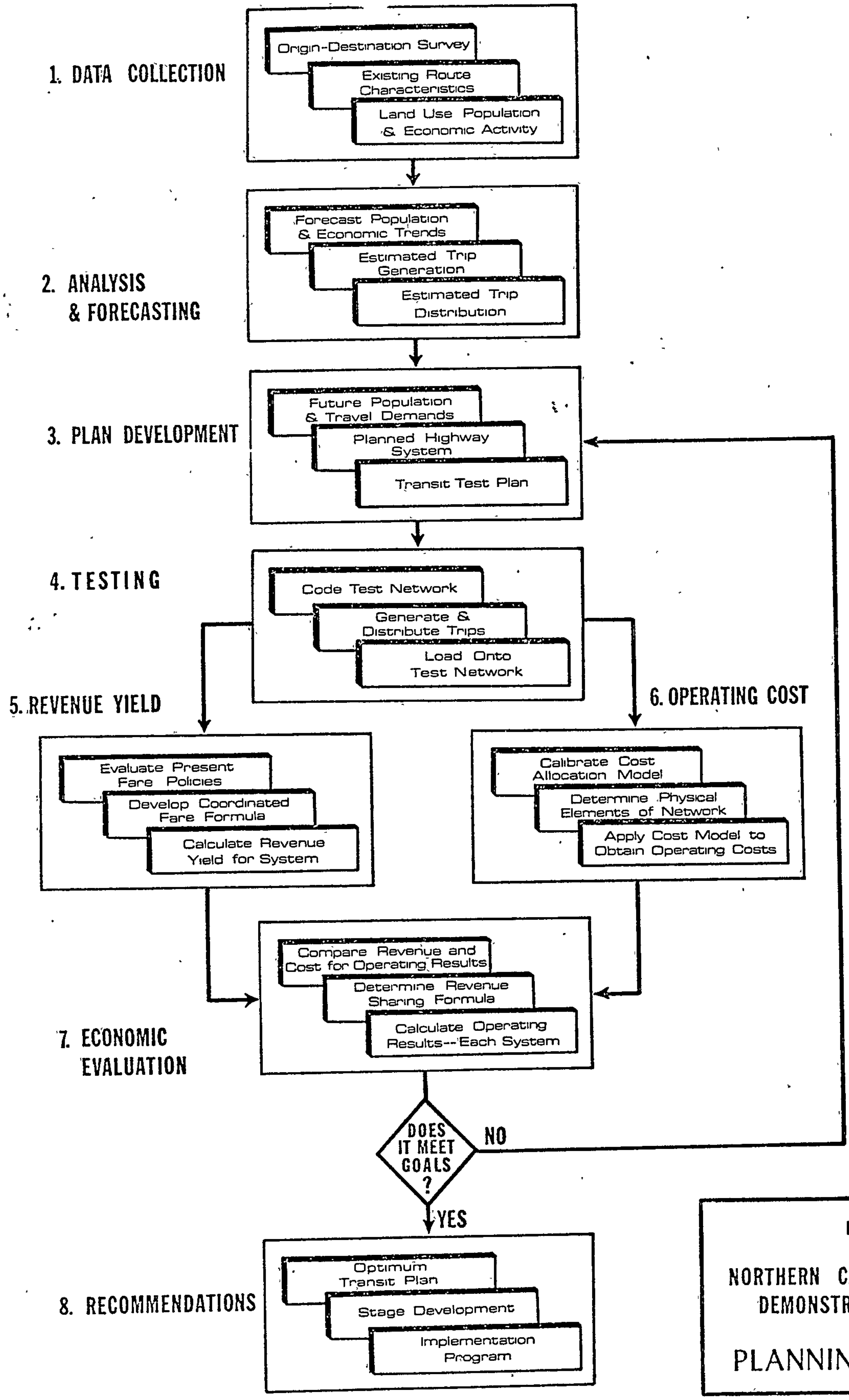


FIGURE XI

NORTHERN CALIFORNIA TRANSIT DEMONSTRATION PROJECT

PLANNING PROCESS

Automatic train control and automatic fare collection represent "advancements of the art." Equally important in attracting patronage are the design of the cars, the stations and the structures.

We believe that BART will in fact be the world's finest rapid transit system, and that it will serve to point the way to a new future for urban transportation in other metropolitan areas of the world.

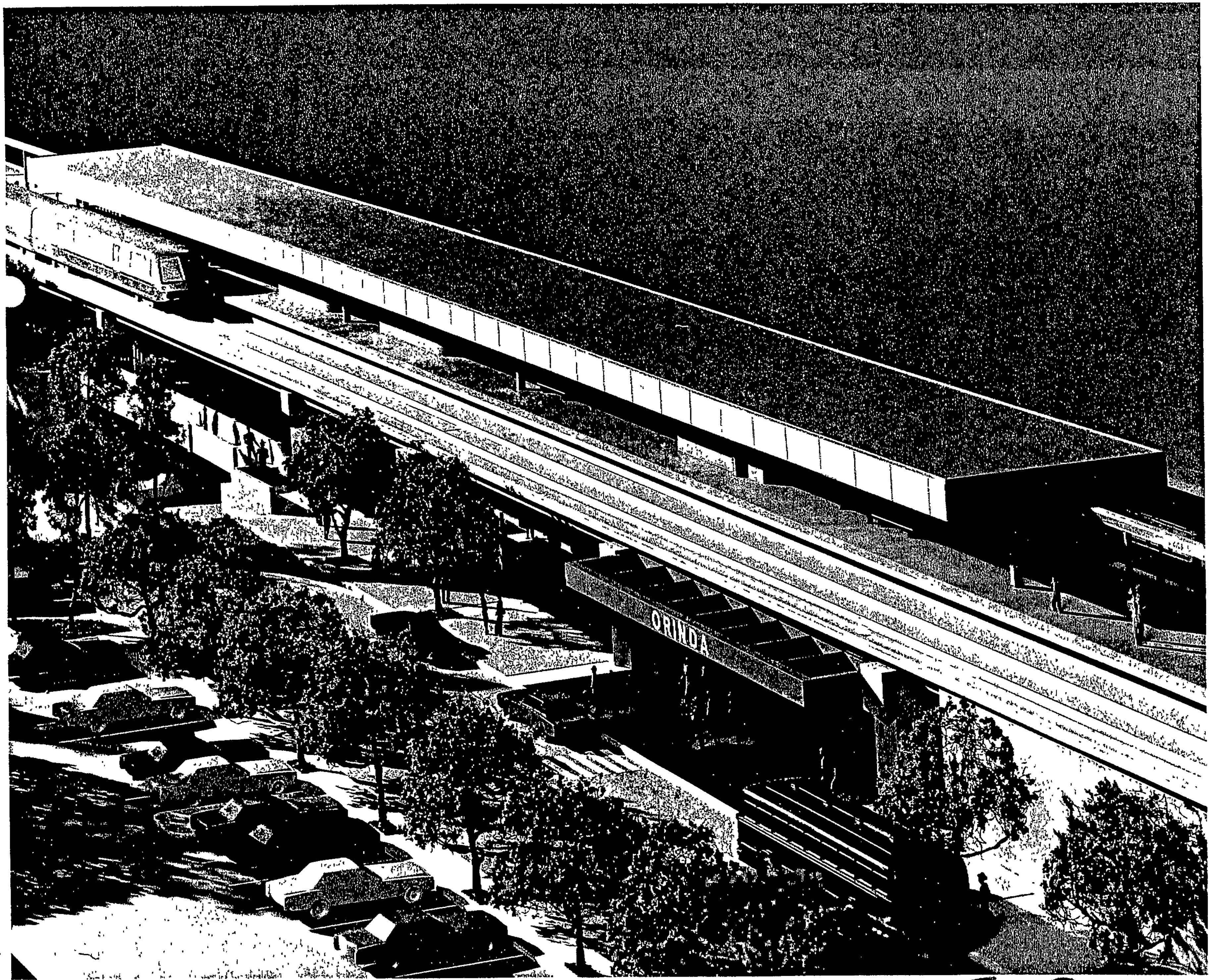


FIGURE I

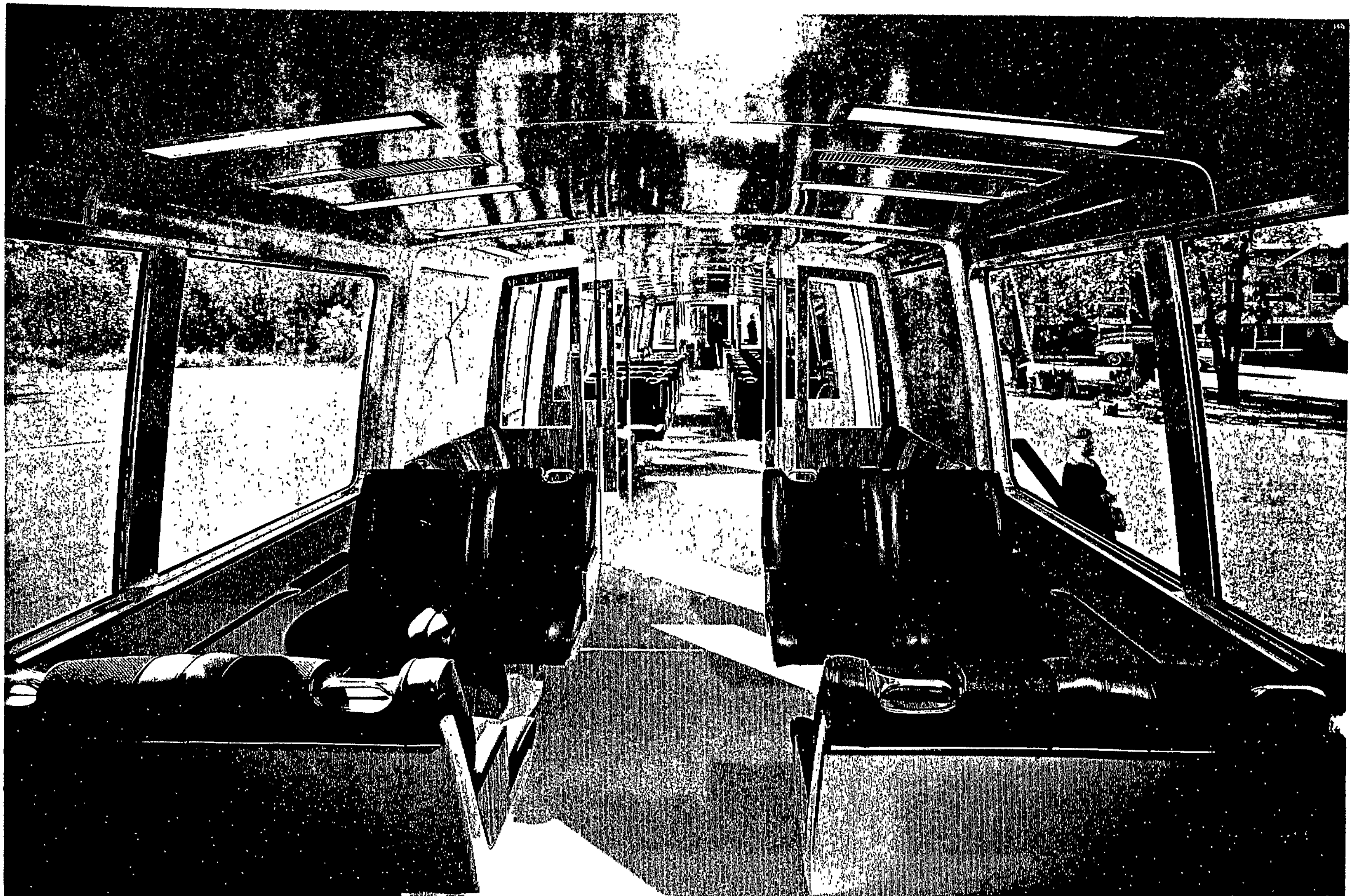


FIGURE VIII

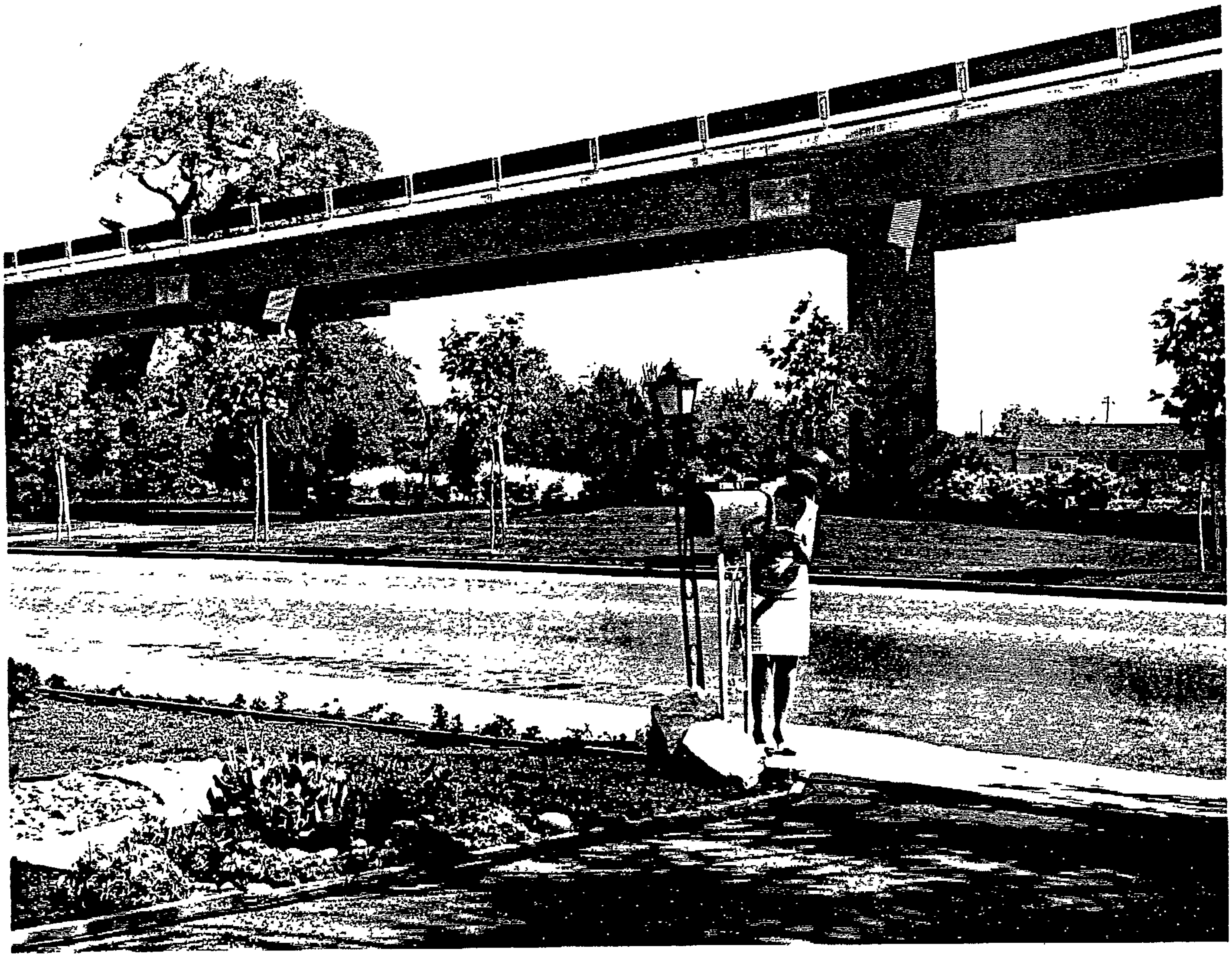


FIG. VI

FIGURE VIII