THE DECISION PROCESS FOR IMPLEMENTING FIXED-GUIDEWAY SYSTEMS

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DISCLAIMER

This report reflects the views and research findings of the authors, who are responsible for the contents, facts, and the accuracy of the data presented herein. The contents do not necessarily reflect the official views of the institutions represented. This report does not constitute a standard, specification, or regulation.

Preface

The principle objective of this study is to provide insight into the decision-making process of cities electing to implement or not implement a fixed-guideway system. Information was gathered on fixed-guideway system performance in four light rail cities (Portland, Sacramento, San Diego, and San Jose) and two cities with transitways (Houston and Los Angeles). The fixed-guideway decision process for each of the six cities, as well as for two "no-build" cities (Columbus and Milwaukee), was examined. Where possible, key findings and conclusions of the fixed-guideway decision process of each city were compared with data and information observed subsequent to actual system operation. From the case study analysis, the authors were able to generalize a model of the fixed-guideway decision process.

A considerable amount of information was gathered through interviews, correspondence, and informal conversations with more than fifty key individuals and officials involved with the fixed-guideway decision-making processes of the various cities. The authors are greatly indebted to each of these persons. Special consideration and thanks is also extended to George Naylor, Celia Goldstucker, and Marty Minkoff of Capital Metro for their assistance and guidance in the preparation of this report.

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INTRODUCTION

Study Objectives and Methodology

Capital Metro began the Transitway Corridor Analysis Project (TCAP) in 1986 to study alternatives for improving public transportation in the Austin service area. As a supplement to TCAP, Capital Metro contracted with the Center for Transportation Research (CTR) at the University of Texas at Austin to study decision evaluation criteria for fixed guideway alternatives. The objectives of this research effort are:

1. To gather data on fixed guideway system performance from transit agencies in the U.S. with special emphasis placed on recently implemented systems in Sunbelt and West Coast cities.
2. To compare, where possible, projected costs for construction and operation with actual costs incurred; and projected versus actual ridership by trip purpose.
3. To identify key factors and guidelines for evaluating fixed-guideway systems.

The research project is divided into three phases: Phase I - Define Project Scope, Phase II - Data Collection, and Phase III - Data Analysis and Summary. Phase I begins with identification of cities for study. Based on the objectives is was determined that three categories of cities should be selected -- light rail transit systems, transitways, and "no-build" cities. No-build cities refer to areas that were considering fixed-guideway systems and concluded that no action was warranted. Following consultation with Urban Mass Transportation Administration (UMTA) officials, transit experts, and Capital Metro staff the following cities were selected for study:

Light Rail Transit	Transitway	No-Build
Portland, OR	Los Angeles, CA	Milwaukee, WI
Sacramento, CA	Houston, TX	Columbus, OH
San Diego, CA		
San Jose, CA		

In addition to these primary sites, several other cities were contacted during the course of the study, including Denver, CO and Seattle, WA.

The second part of Phase I involved developing and refining research questions for data collection. An essential component of this task is an assessment of the capacity of existing information to address particular

research questions and decisions about collection of new information. Research questions were categorized according to four basic elements -- economic, political, social, and operational. The economic element focuses on the cost-effectiveness of the proposed fixed guideway alternative. Undoubtedly, economy in the use of resources is a principal criterion for selecting among alternative systems. The political culture and environment of an area, also, has important implications in selecting transit alternatives. Perceptions of transit operators, politicians, and the public on appropriate service levels and transit allocations is often critical to the success of transit alternatives. The benefits of a good transit system extend beyond the transit riders to merchants, developers, cultural institutions, and non-riders. These other social benefits, although often undefined, are important in developing criteria for evaluating transit alternatives. Finally, operational elements relate to the administrative feasibility and the integration of the alternative system into the total network.

Information for the Phase II of the study was collected, primarily, from two sources -- published and un-published source data and interviews. Source data includes information from census reports, transit system annual reports, etc. Interviews were conducted with key persons involved in the evaluation of fixed guideway systems.

Initial data collection focused on the overall urban environment, including population and trends, service area population, development densities and other important demographic data. This set the stage for evaluating the context in which the transit authority operated. Data also was collected on the transit authority, including the number of buses and fixed guideway vehicles in operation, number and type of routes, total operating costs and ridership. Finally, data was collected on the fixed guideway system and the decision process.

The case study methodology used in this study facilitated the analysis of data completed in Phase III of the project. The analysis focuses on identifying key factors and criteria used by transit system authorities in selecting among fixed-guideway alternatives. A second important element of the analysis is to compare the criteria identified by officials as central to

the selection of an alternative with source data. Does the identified criteria reflect the actual situation or circumstances?

Outline of Case Studies and Summary

The next three sections of the report are organized as follows: Section II - Light-Rail Cities, Section III - Transitway Cities, and Section IV - No-Build Cities. The discussion of light-rail rail transit covers the cities of Portland, Sacramento, San Diego, and San Jose (Santa Clara County. The experiences of Houston and Los Angeles are reviewed in the section on transitways. No-build cities are jurisdictions that opted not to construct a fixed-guideway system, although they may have expanded their bus service as a result of alternative analyses. This section includes Milwaukee and Columbus.

The final section summarizes the major findings of the report. It presents traditional evaluation criteria and presents a model of the decision process used by the cities in this study.

SECTION II

LIGHT-RAIL TRANSIT CITIES

PORTLAND

Overview

The city of Portland, Oregon has a population of 387,866 persons (1980 census). The Portland Standard Metropolitan Statistical Area, which extends into Multnomah, Washington, and Clackamas counties, has an estimated population of 1.25 million persons (1980 census) under the jurisdiction of more than 40 governmental entities. The Tri-County Metropolitan Transportation District (Tri-Met) is responsible for providing public transportation in the tri-county area. The District currently operates the regional bus system and Portland's light rail system, the Metropolitan Area Express (MAX), which operates between downtown Portland and the City of Gresham to the east.

Formed on October 1, 1969, Tri-Met is a publicly-owned, municipal corporation created to serve the transportation needs of 725 square miles of the urban portions of Multnomah, Washington, and Clackamas counties. Operating 26 light rail transit vehicles over one 15.1 mile LRT route and 546 buses (459 standard diesel and 87 articulated diesel buses) over 71 bus routes totalling 770 miles, the District is currently accommodating 162,700 average weekday boarding riders and 48,240,000 annual boarding riders.

Total revenue for the District in fiscal year 1988 is $86.4 million. Local support in the form of a payroll tax of six-tenths of one percent, paid by employers and independently employed persons, accounts for 60.2 percent of the total revenue for FY88. The remaining portions of total revenue are operating revenue (27.2 percent), federal operating assistance (4.8 percent), and other forms of revenue (7.8 percent). Total passenger revenue and system cost for FY88 are $21.2 million and $77.3 million respectively, resulting in a fare recovery ratio of 27.4 percent. Additional Tri-Met information is presented in Table A1 of the Appendix.

Metropolitan Area Express

Following construction of Oregon's largest public works endeavor the Metropolitan Area Express (MAX) opened for service September 8, 1986. The entire $321.3 million project involved the construction of a 15.1 mile LRT

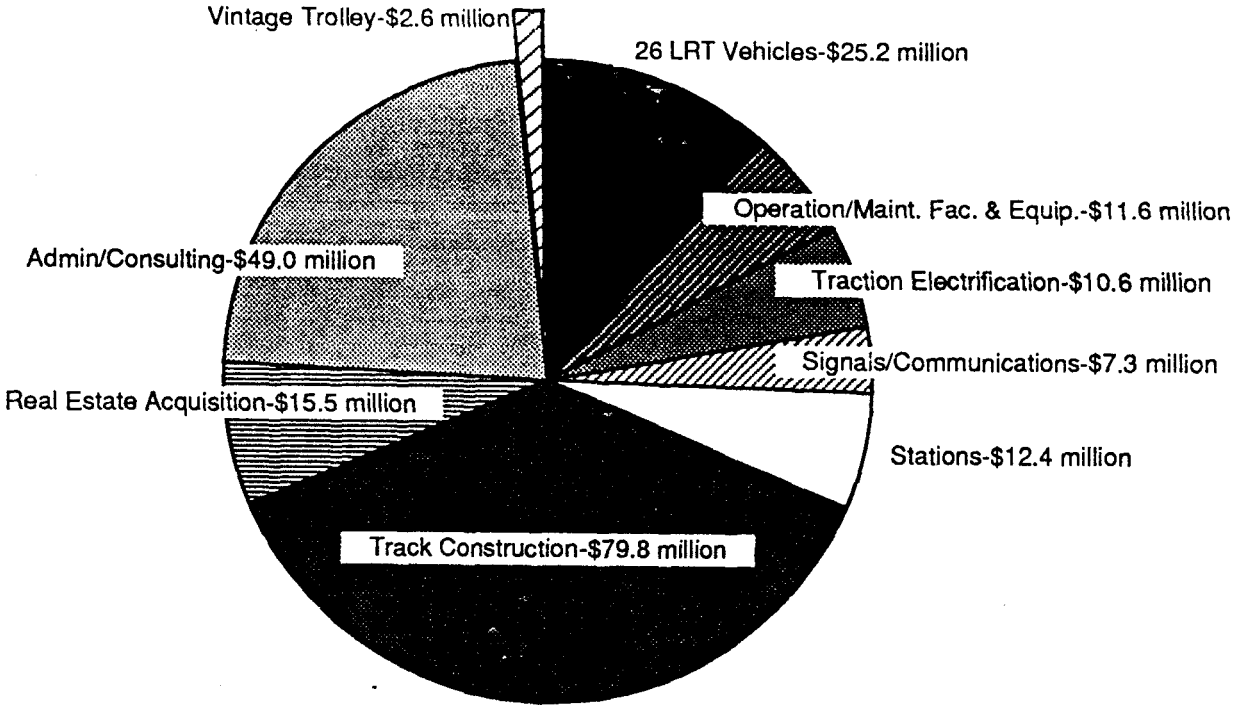
line and the reconstruction of a 4.3 mile section of the Banfield Freeway (I-84) that parallels the MAX. The light rail portion of the project totalled $214.1 million and included the cost of 26 LRT vehicles, an operations facility, maintenance equipment, track construction and electrification, station construction and amenities, real estate acquisition, and administration/consulting fees (see Figure 1). The U.S. Department of Transportation provided $176.3 million (83 percent) of the necessary funds for the LRT. The remaining 17 percent came from the following funding sources: State of Oregon ($25,800,000), Tri-Met ($9,000,000), local governments ($900,000), and private corporations and individuals ($2,000,000) (see Figure 1). Additional MAX information is presented in Table A2 of the Appendix.

The Route

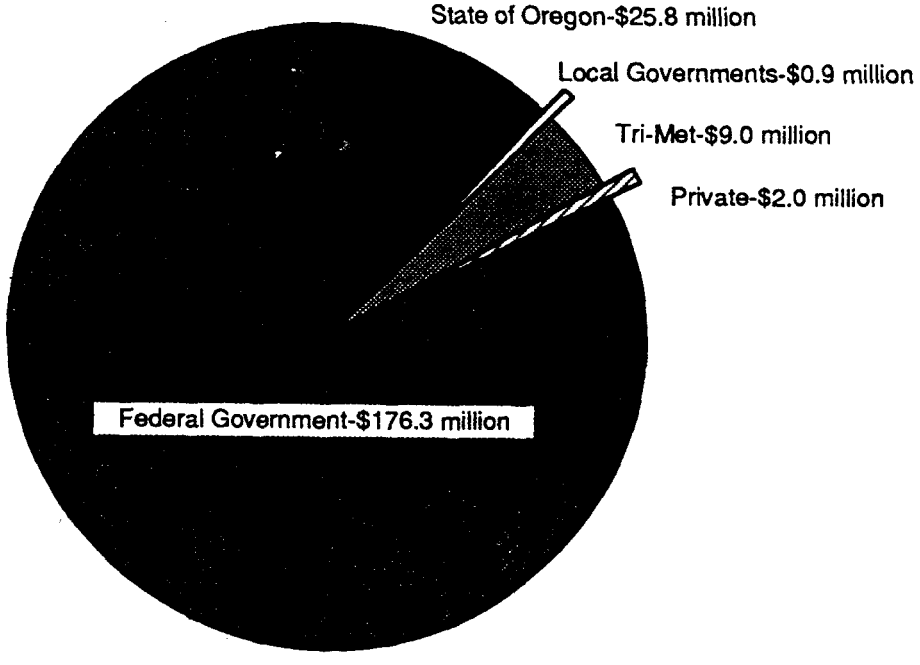
The 15.1 mile line, connecting downtown Portland with the suburban community of Gresham (see Figure 2) runs entirely at-grade with approximately 63 percent of the line surface reserved, 36 percent grade separated, and 1 percent in mixed traffic (Ref 7). The entire line is double tracked except along a downtown loop-turn.

Beginning in downtown Portland, the line forms a 10 block long, 1 block wide loop-turn intersecting the Portland Transit Mall. The MAX then passes through the Yamhill and Skidmore Historic Districts, while paralleling the Willamette River. Crossing the Willamette River, MAX exits the downtown area and descends into Sullivan's Gulch and paralleling I-84 travels east for approximately 4 miles. The line then turns south and parallels I-204 for approximately 2 miles. Upon intersecting Burnside Street, the line again turns east along Burnside Street for several miles until reaching 197th Street where MAX enters the Portland Traction Company line. MAX then travels east within the old railroad right-of-way to the community of Gresham.

In the downtown area, sidewalks were modified and different building materials were used to delineate the transit line from pedestrian and auto traffic. Also, for safety reasons, operating speeds in the downtown are between 15 mph and 25 mph. Cobblestone was placed between the rail tracks to preserve the historic character of the two downtown historic districts. Along



Project Expenditures (Total $214 million as of project completion in 1986)



Project Funding (Total $214 million as of project completion in 1986)

Figure 1: Banfield Light Rail Project Expenditures and Funding

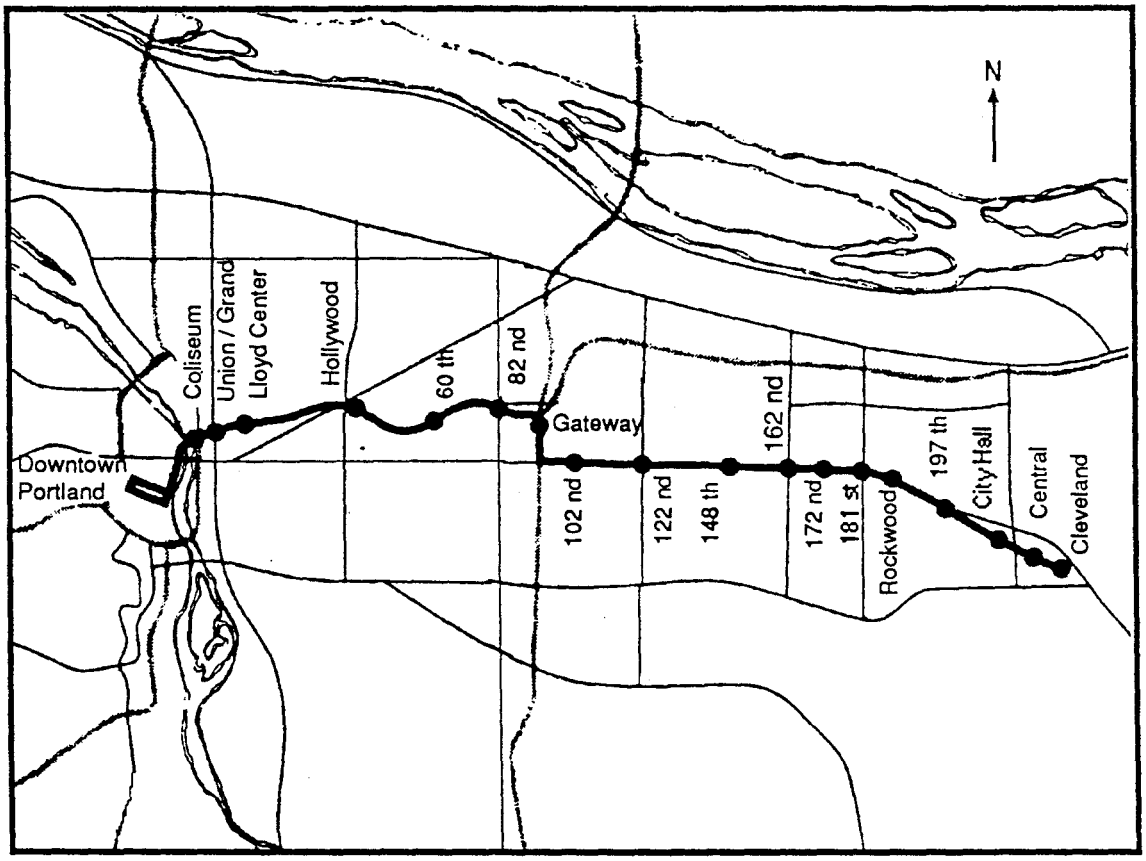


Figure 2: Alignment of Portland's MAX (Source: Tri-Met)

the freeway section of the route, MAX vehicles operate on a completely grade separated trackway, travelling at a maximum speed of 55 mph; however, upon entering Burnside Street, the rail line becomes curb-separated from auto and pedestrian traffic and the operating speed is reduced to 35 mph. During the last three miles into Gresham, the rail vehicle enters an abandoned freight rail alignment where operating speeds range from 35 mph to 55 mph.

Facilities and Vehicles

Ground-breaking for the Ruby Junction Operations and Maintenance Center located near the community of Gresham occurred on March 26, 1982 symbolically marking the beginning of the construction phase. Eventually, twenty-seven stations were constructed along the transit line at a total cost of $12,433,000. Each of the brick, metal, and glass stations is equipped with automatic ticket machines that validate and sell tickets, route and schedule information and maps, telephones with free 911 access, and wayside wheelchair lifts. Tri-Met is the first transit agency in the country to install wayside lifts instead of on-board lifts citing such advantages as assured access, improved reliability, ease of maintenance, and reduction of capital costs since fewer wayside lifts are needed. The downtown stations are simple curbside stops while the other stations feature contract vendors and concessionaires offering such services as film developing, dry cleaning, shoe repair, newsstands, and boxed lunches.

Five of the MAX stations, which serve as transit centers to the Gateway Transit Center and Gresham Transit Center, provide timed-transfer service with Tri-Met's bus system. The Gateway Transit Center is a major facility operating 12 bus lines and 330 free park-and-ride spaces. Five of the stations, including Gateway, are combined with park-and-ride lots providing 1700 parking spaces.

Tri-Met began procuring LRT vehicles in January 1980 to take advantage of potential cost savings that would result from inflation. Also, since the vehicles were to be tested and stored at the Ruby Junction facility, Tri-Met wanted to be certain that the vehicles arrived within a reasonable period of time after the completion of the facility. The first LRT vehicle arrived in

April of 1984, approximately 8 months after the completion of the Ruby Junction facility.

Today, Tri-Met operates 26 LRT vehicles. The vehicles were purchased from the Canadian transit manufacturer Bombardier for $25,232,000 ($969,000 per LRT with an expected life of 30 years). The bi-directional, six-axled, articulated vehicles, generally operating in two-car trains, are 88 feet in length, 8 feet 8 inches wide and can carry a maximum of 160 passengers (76 seated passengers).

Ridership

The DEIS ridership forecasts were initially done in 1978 using, basically, the Urban Transportation Planning System (UTPS) generic model. The model forecasted light rail ridership in the range of 40-45,000 riders per day for 1990. In 1980, the FEIS reported ridership for the preferred alternative at 42,500 riders per day in 1990. It is interesting to note that an additional 10 percent increment of ridership was included in the LRT ridership estimate to account for the "elusive mystique" of rail transit's ridership generating qualities, a factor that was later disallowed in the Sacramento Alternatives Analysis process (Ref 14). As of 1987-88, the LRT system was averaging 19,600 riders per day -- only 46 percent of the 1980 estimate.

Tri-Met originally performed the forecasts to get the project moving. In 1985, the regional metropolitan planning organization (MPO), METRO, re-ran the model and forecasted between 17-20,000 riders per day. According to one METRO official, Tri-Met published these figures and then met with their operations, planning, and public relations people to come up with what could be termed a "low-ball" ridership estimate of 12,000 riders per day. When the system opened with a ridership of 20,000 riders per day they were, therefore, a "success story".

The model seemed to work satisfactorily since METRO's ridership estimate and the actual ridership were the same. The problem with Tri-Met's original estimates seems to stem from several areawide economic changes that affected the base assumptions of the model. For example, gasoline prices, which were originally estimated at 4 percent above CPI, were down from the forecasted

levels (with prices now at a 20 year low). Another factor influencing the model was an unexpected recession between 1980-85. Because of this recession, population estimates were down from forecasted levels affecting estimates of traffic volumes and the numbers of households and workers.

During the alternatives analysis process, LRT was compared with HOV lanes as well as separated busways. Following UMTA guidelines, little bias towards LRT was shown in the UTPS generic model (although an increment of 10 percent additional ridership was eventually added to the modelling results to account for the "elusive mystique" of rail transit). Using the generic model, there were only two factors that varied between the LRT and busway alternatives. For example, buses allow a higher frequency for the same volume, which as a result, produces a higher bus ridership. It was assumed, however, that people would walk farther to reach an LRT station (1/2 mile compared to 1/4 mile for bus). Higher LRT ridership estimates would result from this assumption. As a result of these two factors, the model produced very similar ridership estimates for the two modes.

The lower operating costs per passenger of the light rail alternative compared to any of the bus alternatives was the most important factor in Tri-Met's decision to support the rail alternative (Ref 8). This number, however, is obviously influenced by the ridership estimate of the alternative. High ridership estimates favor light rail in terms of operating costs because fewer drivers are needed to handle the high demand. In Portland, predicted LRT ridership of 42,500 in 1990, which was over-estimated by more than 50 percent, favored the LRT alternative in terms of estimated operating costs. Reasons for the over-estimation of ridership include: 1) an unexpected recession which severely lowered the number of downtown workers, 2) gasoline prices did not continue to rise as expected, and 3) the additional 10 percent ridership increment allowed to account for the "elusive mystique" of rail transit.

Before operations began in September 1986, the number of average weekday boarding riders was projected to be 17,000 riders per day with the number of total boarding riders projected at 3,000,000 riders per year. After one year of operation, the number of boarding riders was 19,900 riders per day and 7,230,000 riders per year yielding a respective increase of 17 percent and 141

percent. At the close of fiscal year 1988, MAX's average weekday ridership was 19,600 boarding (unlinked trips)) rides per day with 15,600 originating (linked trips) rides per day. Total boarding riders for FY88 was 6,600,000 riders per year.

Historical Background*

Portland's LRT system has a very interesting and complex history (see Figure 3 for project chronology). The Portland light rail system began as a project to stop the construction of the proposed Mt. Hood Freeway that, if constructed, would have required the removal of approximately one percent of Portland's housing stock. As a result of strong public sentiments, Portland's newly elected mayor, Neil Goldschmidt, assembled an in-house technical staff to review transportation alternatives to meet the transportation needs of the city and region. While procedural difficulties and legal entanglements stalled the completion of the Final Environmental Impact Statement (FEIS) for the Mt. Hood Freeway, Goldschmidt assembled a coalition of state and local officials willing to examine various transportation alternatives. A Governor's Task Force (GTF), appointed by Governor Tom McCall and chaired by Goldschmidt, was created for the purpose of examining the feasibility of transit as an option to more freeways in the region. Major products of the GTF were a technical report justifying transit improvements within the region and a recommendation to strengthen the technical capability of the Columbia Region Association of Governments (CRAG), the regional Council of Governments.

In 1972 every local government within the Portland metropolitan area was required by state law to participate in CRAG. Upon formation in 1969, CRAG assumed the responsibility for the regional transportation plan and increased its technical capabilities. As a result of GTF recommendation and the strong technical expertise of the city's Planning Bureau (a result of Goldschmidt's commitment to a regional transit system and the preservation of

* This section summarizes some of the information contained in the research reports: "Urban Decision Making for Transportation Investments: Portland's Light Rail Transit System" and "Urban Intergovernmental Transportation Decision-Making Systems: Portland's Investment in Light Rail Transit".

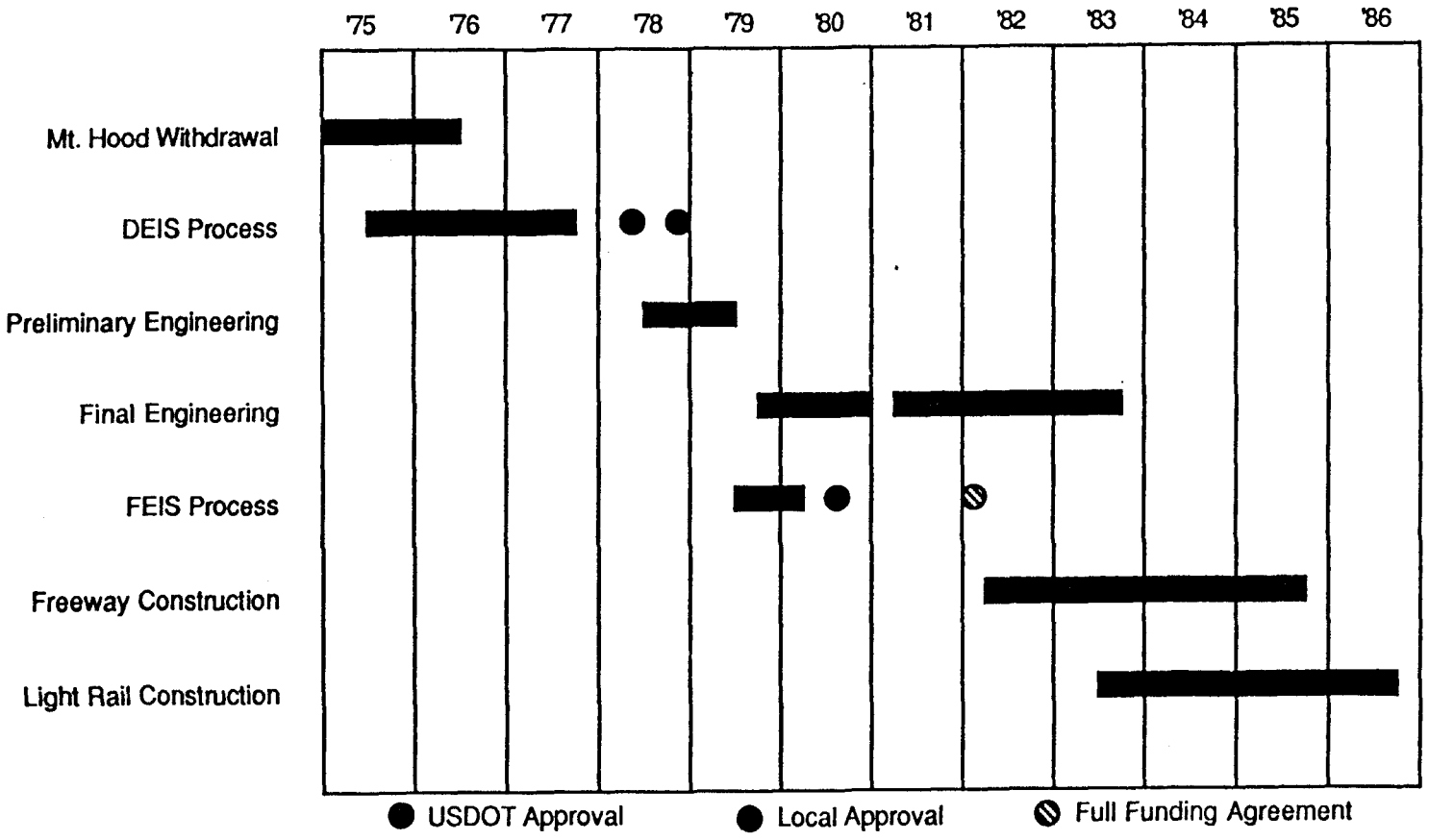


Figure 3: Chronology of the Banfield LRT Project (Source: Tri-Met)

neighborhoods), CRAG and Portland city planners assumed the responsibility for evaluating regional transit alternatives.

After exploring alternatives, the county and city governments voted to withdraw the Mt. Hood Freeway project under provisions of the Federal-Aid Highway Act of 1973. The withdrawal process allowed an urban area, with the consent of the local governments, governor, FHWA and UMTA, substitute mass transit projects for withdrawn eligible segments of planned urban Interstate. The trade-in process was modified by the Federal Highway Act of 1976 to allow for the substitution of alternate highway, transit, or a combination of highway/transit projects. At that time, the technical resources required to justify the withdrawal of the Mt. Hood Freeway existed; however, the necessary political consensus were lacking.

Building consensus for the Mt. Hood withdrawal required two steps. First, at the insistence of Goldschmidt, Governor McCall replaced the entire Tri-Met Board of Directors with a Board that did not embrace a bus-only philosophy. Secondly, Goldschmidt had to mollify Governor McCall's uneasiness over withdrawing the freeway project. Up to this point, few areas had participated in the trade-in process. As a result, the governor was wary of potential political embarrassments resulting from the loss of construction jobs and problems resulting from the lack of a substitute transit plan. Also, the Governor wanted the support of the Oregon Department of Transportation (ODOT), an agency that was clearly against the withdrawal. The support of ODOT depended on Glenn Jackson, Chairman of the Oregon Transportation Commission and "father" of the state's highway system and the support of Jackson depended on the construction of an outerbelt freeway, I-205, opposed by the county commissioners. After some political negotiations on the part of Goldschmidt, the county commissioners withdrew their opposition to the I-205 segment. The resulting deal involved the states inclusion of some form of fixed-guideway within the I-205 alignment and the relocation of an existing jail with FHWA highway funds. The county then agreed to rebuild the existing east-west Banfield Freeway. With all political parties satisfied and the support of ODOT, Governor McCall agreed to support the withdrawal in October 1974. However, McCall left office in January 1975 and was succeeded by Robert

Straub, a close personal friend of Goldschmidt. With the persuasion of Goldschmidt and Gerry Drummond, Chairman of the Board for Tri-Met, Straub agreed to support the withdrawal. The formal request for withdrawal was signed by Straub and submitted to the Secretary of Transportation in June 1975.

At this time, the region did not have a transit substitution project and, subsequently, needed flexibility in the trade-in process to aid in building a regional consensus. In June 1976, after much lobbying on the part of Portland, Congress amended the Federal Aid Highway Act to allow for an elimination of the June 1981 deadline to begin construction, increased availability of funding based on the latest estimates of the cost to complete the Interstate system, and the extension of withdrawal funds to be used on localized highway projects. These three provisions provided the necessary flexibility to negotiate a workable transportation solution for the region.

The Mt. Hood withdrawal was approved by the Secretary of Transportation in June 1976. The state and Portland metropolitan area were now authorized to use the withdrawn funds, amounting to $191.2 million, for alternative highway and transit projects. A total of 140 transit and highway projects were funded throughout the region with the bulk of the money being spent in three major transit corridors.

After studying the three corridors in more detail, the Banfield corridor was identified as the region's top priority corridor to replace the withdrawn Mt. Hood Freeway project. The reasons included the meeting of a political obligation to Glenn Jackson, the availability of an established eastside freeway corridor, and political pressure to build in the vicinity of the withdrawn project.

The next step involved an alternatives analysis and the preparation of the draft environmental impact statement (DEIS) for the Banfield corridor. In 1975, an LRT option had been included in initial DEIS work, but in 1976, the concept was abandoned on the grounds of technical infeasibility. However, in 1977, LRT was included in the DEIS process after the completion of an LRT feasibility study by Tri-Met followed by over 100 meetings with citizens groups and local jurisdictions for the purpose of promoting LRT as a viable

would not be adequate to cover the local matching funds requirement. Duncan was persuaded to support the state's funding of $16 million when Tri-Met agreed to provide an additional $10-million necessary to meet the new estimate of required local funds.

With the approval of the local funding agreement, the FEIS was begun in September 1979, completed in June 1980, and approved by U.S. DOT in July 1980. A letter of intent was signed by Goldschmidt, the newly appointed U.S. Secretary of Transportation, on December 20, 1980 after Congressional funding approval was obtained. However, upon entering office in 1981, President Ronald Reagan brought the project to a standstill with his ban on new rail starts. A new federal funding agreement was needed.

As a solution, Tri-Met proposed the reallocation of $76 million in Interstate transfer funds, which were earmarked for the Westside corridor, to the Banfield corridor. In return, Portland would accept the reallocated funds on a cash-flow basis, thereby minimizing the initial capital demands. The U.S. DOT would then issue a Letter of Intent promising $76 million in non-rail transit improvements to the Westside corridor. Senator Mark Hatfield, Chairman of the Senate Appropriations Committee, was instrumental in negotiating this final funding agreement.

A full funding agreement was received from UMTA Administrator Arthur Teele on March 26, 1982 at the ground-breaking ceremony for the Ruby Junction Maintenance Facility. Construction was completed during the summer of 1986 with revenue service beginning on September 8, 1986. The LRT portion of the Banfield project was completed within the $214.1 million final budget (although initial planning in 1977 indicated the project would cost approximately $143 million).

Economics was a critical factor in the selection of light rail but not in the expected way. Economics was critical in that supporters of light rail had to weave through a variety of funding mechanisms and alternatives as well as mobilize political support to free up otherwise unavailable funds. The light rail system could not have been built without federal and state funding. The principal supporters of light rail worked vigorously to identify and develop alternative methods for funding the project.

In addition to project cost and funding, economic issues include impacts on development, the regional economy, etc. For example, during the decision process, Portland was experiencing unprecedented growth; however, during the construction phase the area was experiencing a major slump (1980-85). Thus, this large, capital intensive project was critical to the area.

The LRT also impacted local development. A Transit Station Area Planning Program (TSAP) was begun to promote joint development opportunities emerging from a LRT line. The major results of the TSAP program were the evaluation and planning of the station area development potential, promotion of public/private development, and reinforcement of the LRT line through public sector investments within the vicinity of the LRT stations (Ref 1). This resulted in the relocation of a planned station to coincide with the location of Lloyd Center, a major mixed-use development located approximately three miles from the Portland CBD.

When LRT line began revenue service in September 1986, private development within the corridor totaled over $214 million. Today, $300 million is presently scheduled for or under construction. According to Tri-Met, the key to the positive developmental impacts was the location of the transit line. Instead of locating the line along the fringes of development areas as was done in other cities, the MAX line was located in the middle of key transit areas (Ref 4).

In terms of cost, real estate acquisition was not a major issue because the MAX line runs predominantly on-street, along public property. The only portion of the line that is unique to rail is the five-mile portion of the line paralleling the Banfield Freeway. The widening of Burnside Street, however, created some problems with residents along the section. The construction of the MAX line required the development of county-owned land that for years had been used by approximately 500 of the residents residents along Burnside.

Further, energy issues were also important factor in the decision process. Due to the abundance of hydropower in the Northwest, electricity is relatively cheap form of energy making the electrically powered LRT line an attractive

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SACRAMENTO

Overview

The city of Sacramento, the capital of California and the fourth largest metropolitan area in the state, is located approximately 90 miles to the northeast of San Francisco. Contained within Sacramento County, the Sacramento central business district (CBD) lies to the southeast of the intersection of the Sacramento and American Rivers and west of the Sierra Nevada foothills. The 1986 population of Sacramento is estimated at 324,000 persons while the population of the Sacramento metropolitan area is approximately 905,500 persons (Ref 1).

The Sacramento Regional Transit District (RT) operates two light rail transit lines in corridors extending to the northeast (I-80 Corridor) and east (Folsom Corridor) from the CBD. The combined area of the two corridors was the study area for Sacramento's alternatives analysis process which was conducted during the early 1980's.

Since World War II, suburban development has occurred in and between these two corridors primarily because of crash and noise impact zones established by two local Air Force bases as well as the need to retain prime agricultural land. More recent development, however, has been occurring outside this wedge with development spreading to the agricultural lands south and north of the CBD. By the year 2000, the area should be more evenly developed around the CBD (Ref 2).

In 1979, the population of the two corridors was approximately 500,000 persons which comprised about two-thirds of the population of the entire Sacramento Urbanized Area (743,000 persons) (Ref 3). Population density in the combined area is low. A 1982 UMTA estimate forecasts density at less than 3,000 persons per square mile by the year 2000 (Ref 2).

During the alternatives analysis process of the late 1970's, the Sacramento CBD provided jobs for 78,000 people with State government accounting for approximately 25 percent of the work force. The CBD nonresidential floorspace totaled approximately 12 million square feet.

The Sacramento Regional Transit District began operations on April 1, 1973 as the primary provider of fixed-route public transit service in the

Sacramento metropolitan area. The RT Board of Directors consists of seven appointed members, four from the city and three from the county. The RT service area covers 340 square miles and contains approximately 905,500 persons. RT operates 200 buses over 76 bus routes totaling 843 one-way route miles. The district also owns 26 LRT vehicles operating over two nine-mile LRT lines. In FY88, the district boarded over 15 million total riders and 57,000 riders per weekday.

Total FY88 revenue and expenses for the district were $36.1 million and $34.6 million, respectively. With passenger revenues amounting to $8.7 million, approximately 25 percent of the total expenses incurred by RT was paid through the farebox.

In June 1988, RT adopted their current short-range transit plan, "FY 1989 Update: Transit Plan 1986-1990"(Ref 4). According to the plan, the financial outlook for the district during the period 1989 - 1993 is not encouraging because of reductions in state and federal funding and the lack of secure local funding sources; however, in November 1988 Sacramento voters approved a 1/2 percent sales tax of which RT will receive 35 percent. Until this time, RT has been able to avoid reductions in service through various cost-containment methods.

The FY89 RT operating budget is $34.5 million with 53 percent of that total going to wages. Total operating revenue for FY89 is expected to comprise approximately 26.8 percent of the $34.5 million with passenger fares accounting for 97 percent of the operating revenue. Total non-operating revenue accounts for the remaining 73.2 percent of the FY89 budget with federal and state sources supplying 9.3 percent and 63.3 percent of the budget, respectively, and the remaining 0.6 percent scheduled to come from other sources. Additional RT data is presented in Table A1 of the Appendix.

RT Metro*

The Sacramento Light Rail Starter Line Project, a six year project from design to completion, brought an 18.3 mile LRT system to the Sacramento metropolitan area with the September 5, 1987 opening of the nine-mile Folsom Line in the Folsom (or U.S. 50) Corridor. The Northeast Line, which is

* All material from Ref 1 unless otherwise noted.

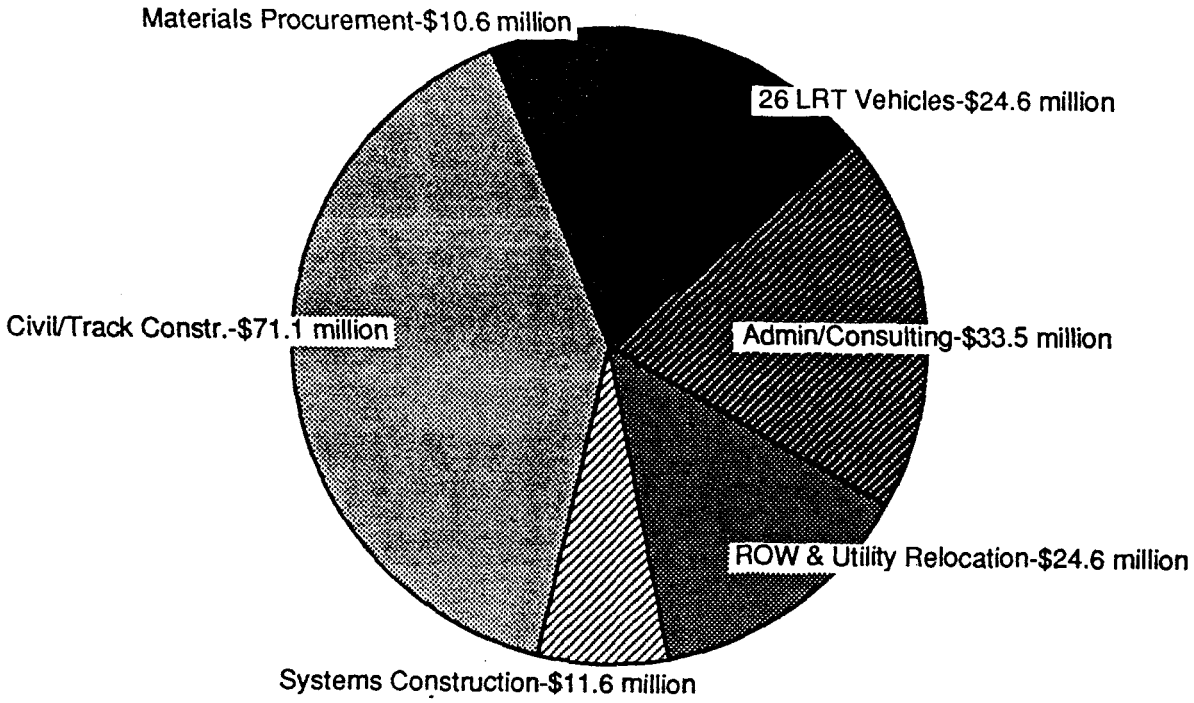
located in the I-80 Corridor, began revenue service on March 12, 1987. At project end in 1987, the primarily single-track facility cost $176 million or $9.6 million per mile. The total cost, detailed in Figure 4, includes the cost of 26 light rail vehicles, equipment, land, administration, construction, and an operations and maintenance facility. The primary funding source for the $176 million Light Rail Starter Line Project was the federal government which supplied 57 percent of the project capital. Additional funding sources were: State (18 percent), City and County (16.5 percent), RT (6 percent), and "other" sources (2.5 percent). Funding sources are illustrated in Figure 4. Additional RT Metro information is presented in Table A2 of the Appendix.

The Route

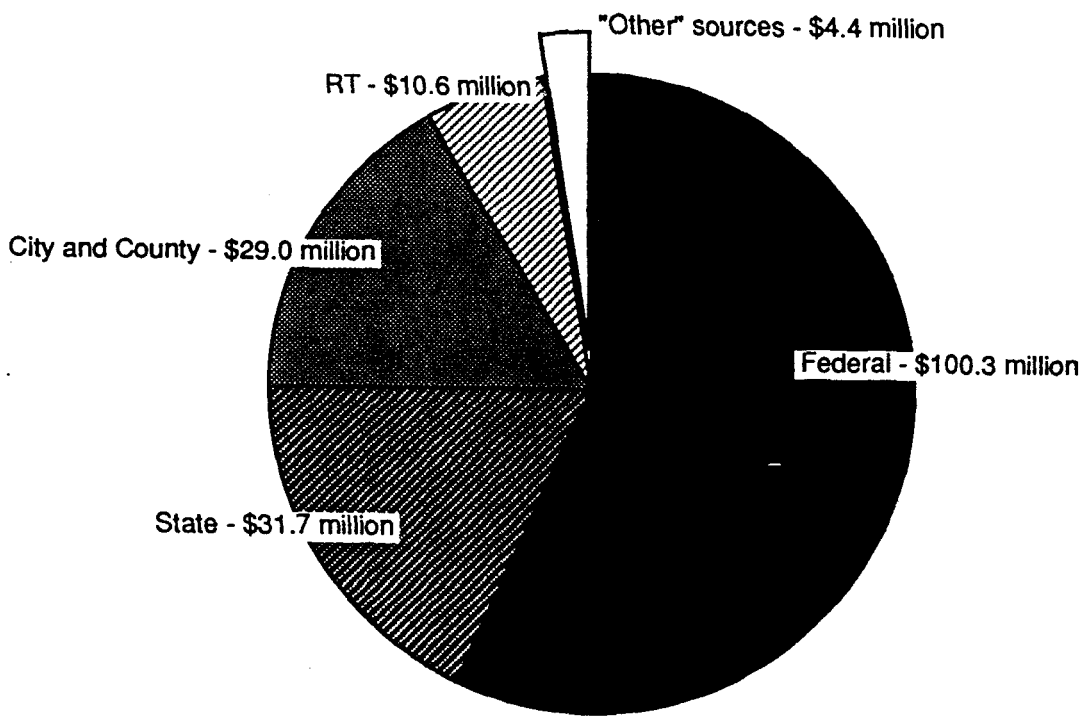
The Northeast and Folsom Lines both begin in Central City (downtown Sacramento) with each line extending approximately nine miles into Sacramento's suburbs (see Figure 5). The line is predominantly single-track with 40 percent of the route double-tracked to provide for maintenance of scheduled headways. The routes use unused railroad and/or unused freeway right-of-way except in the downtown portion where the vehicles operate on city streets. The line is characterized as 32 percent grade separated, 58 percent surface reserved, and 10 percent mixed-traffic (Ref 5).

In downtown Sacramento, or Central City, both lines share sections of track forming a "loop" of four blocks in length and one block in width. The northern and southern one-block portions of this "loop" intersect the five-block long "K" Street and "O" Street Malls, respectively.

The five-block long "K" Street Mall, initially constructed in the early 1970's, was reconstructed as part of the LRT project at a cost of approximately $2 million. The reconstruction, which included improvements such as new trees, brick pavement, new lighting, benches, and outdoor eating areas, is seen as a positive improvement to a controversial pedestrian mall that was perceived as a disappointment to many citizens and downtown merchants. The five-block long "O" Street Mall was planned in 1977; however, no work was subsequently started. The construction of the LRT line in downtown Sacramento, provided the impetus in completing this $1.6 million mall.



Project Expenditures (Total $176 million at project end / 1987)



Project Funding (Total $176 million at project end / 1987)

Figure 4: Sacramento LRT Expenditures and Funding (Source: RT)

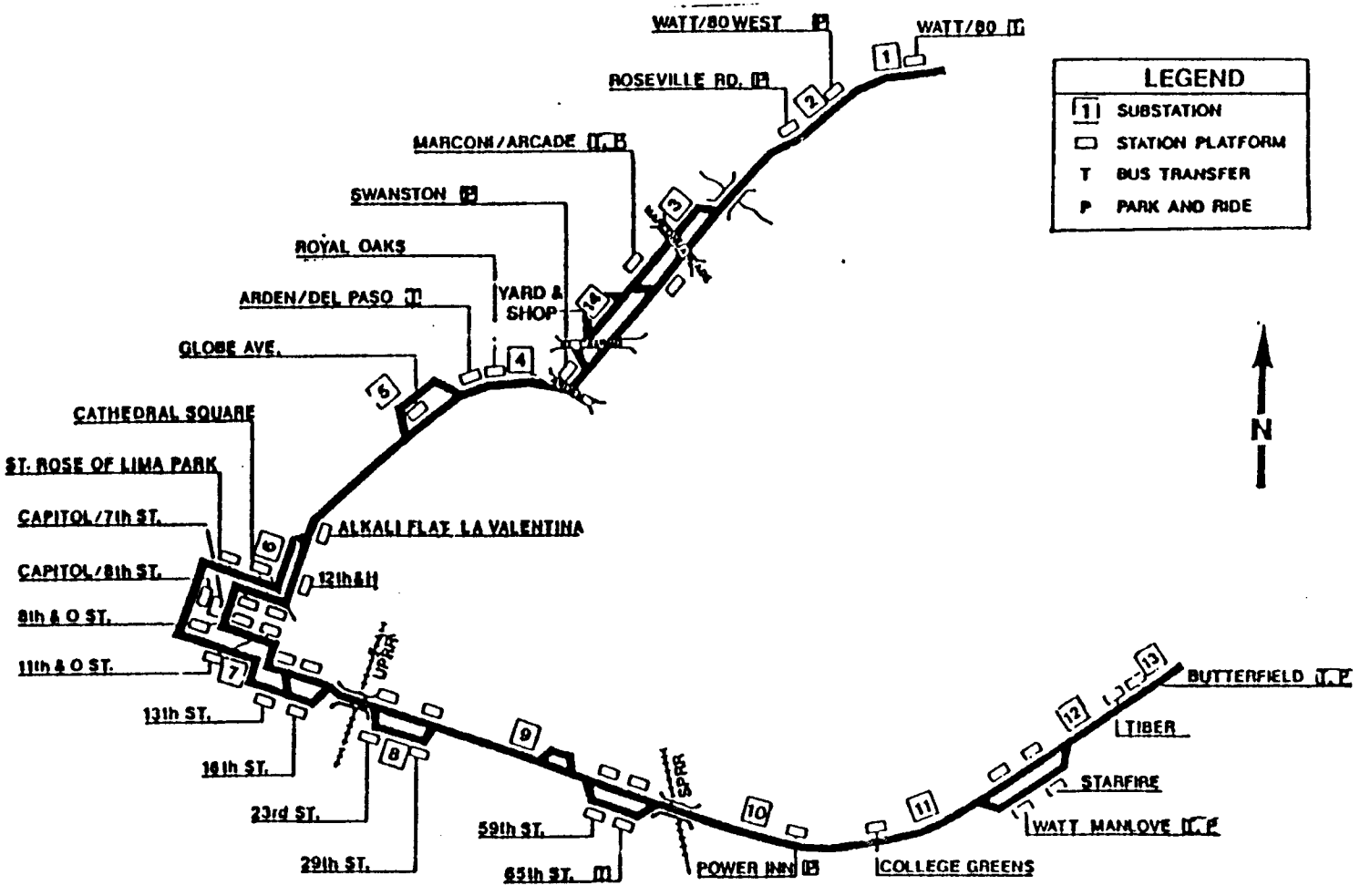


Figure 5: Sacramento Light Rail System (Source: RT)

Beginning at the Watt/I-80 Station at the outermost point of the Northeast Line, the RT Metro travels primarily along abandoned I-80 Bypass Freeway right-of-way and abandoned Sacramento Northern Swanston Branch railroad right-of-way. The RT Metro crosses the American River on the Route 160 bridge and enters downtown via 12th Street where the route intersects the "K" Street Mall. The RT Metro travels through the downtown area which includes both the "K" Street and "O" Street malls. Upon exiting the downtown area, light rail vehicles can be either uncoupled and stored in the downtown area or additional vehicles can be added to the trains depending on demand. The RT Metro then continues through the Folsom (U.S. 50) Corridor. The Folsom line operates primarily in excess Southern Pacific Railroad right-of-way located immediately north of the Placerville Line.

Civil and trackwork construction accounted for 40.4 percent of the entire $176 million budget. Additional cost components of construction can be found in Figure 4.

Facilities and Vehicles

Twenty-eight stations serve the Sacramento LRT system. When designing the stations, San Diego's "no frills" concept of station design was followed resulting in low-cost, functional stations. Each downtown station, which is basically a ramp extension of the sidewalk, provides the transit rider with ticket vending machines, money changers, telephones, and transit system information. The suburban stations offer the same amenities and also provide a covered station structure and bicycle lockers. Six of the stations provide access to the bus system and eight of the suburban stations offer 3,850 free parking spaces with land area available for expansion to 6,200 spaces. A number of artists were commissioned by RT to design artwork for display at the various stations.

RT operates a 52,000 square foot operations and maintenance facility which can store and service 50 LRT vehicles and operate and maintain 18.3 miles of trackway. The cost components of the $7.9 million facility, built on abandoned freeway right-of-way, are $3.5 million for the building, $3.2 million for the storage yard, and $1.2 million for equipment.

RT currently operates a fleet of 26 Siemens/Duwag U2A light rail vehicles and has plans to order six additional vehicles during FY89. The double-ended, six-axled, articulated vehicles have a seating capacity of 64 persons. The 26 vehicles cost approximately $24.6 million in 1984 ($945,000 per vehicle). The first vehicle was unveiled November 25, 1986.

Ridership

According to the DEIS projection, HOV daily ridership (115,000 systemwide daily transit trips and 67,000 daily busway person trips) was superior to LRT daily ridership (112,000 systemwide daily transit trips and 50,000 daily LRT person trips). UMTA, however, objected to the projected LRT ridership estimates as being unrealistically high. The Sacramento Transit Development Agency (STDA) disagreed with UMTA's assertion, however, the expected LRT daily ridership was reduced to 20,500 in the FEIS.

It was, however, the perception of many local officials that the "elusive mystique" of rail transit's ability to attract patronage was ignored and disallowed during the technical evaluation. UMTA disallowed the use of an arbitrary 10 percent increment of ridership to account for the intangible ridership attracting quality of LRT -- a factor that was allowed in the Portland modelling process (Ref 2).

In FY88, RT Metro boarded over 3.1 million riders. The average number of weekday boarding riders on the LRT system was approximately 12,900 riders. On a typical Saturday, RT Metro boarded an average of 3,200 riders, about 25 percent of the number of average weekday boarding riders. Current daily ridership, however, is below the levels forecasted in the Sacramento Light Rail Project Final Environmental Impact Report which predicted daily 1988 ridership at 20,500 riders.

Historical Background*

Interest in developing a light rail system in Sacramento arose partly as a result of the actions of several citizens groups with a common desire to

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* Information in this section is primarily drawn from Refs 2 and 6 unless otherwise noted.

eliminate proposed construction of several state freeway routes. These anti-freeway community groups, who later formed the nucleus of the Modern Transit Society (MTS), an extremely active, pro-transit (especially rail) organization, effectively pressured the Sacramento County Board of Supervisors into dropping the freeway projects.

In May 1975, the County Board of Supervisors appointed the North-East Transportation Task Force (NETTF) to advise the Supervisors on the disposal of the abandoned freeway right-of-way. The NETTF conducted a study of the transportation needs of northeast Sacramento and released a report of their findings, The Northeast Area Transportation Study, in August 1976. Among their recommendations was the withdrawal of a proposed section of Interstate Highway, the 5.2 mile I-80 Bypass, and the investigation of the feasibility of constructing light rail transit using withdrawn Interstate funds. MTS members were very active on the NETTF.

In 1976, the City of Sacramento began to voice support for the construction of light rail. The support stemmed from an MTS paper presenting the development of a no-frills historic trolley loop in downtown Sacramento. As a result of the MTS effort, the City Council agreed to fund, in conjunction with the Sacramento Regional Area Planning Commission (SRAPC), a more detailed study of the trolley concept. The 1977 "Historic Trolley - Sacramento: Feasibility Study" concluded that the trolley concept was feasible and warranted further study. The trolley was gaining a wide range of support when the passage of Proposition 13 in June 1978 caused the project to be suspended.

In August 1978, the issue of light rail was revived when Adriana Gianturco, as Director of the California Department of Transportation (Caltrans), offered to fund a portion of a light rail feasibility study of the U.S. 50 (Folsom) Corridor. Caltran's decision to support LRT was undoubtedly influenced by Governor Jerry Brown and key state representatives who were basically pro-transit and anti-highway. Because of growing local support for LRT, the City of Sacramento agreed to accept the Caltrans proposal. RT also approved of the study and was designated lead agency. Completed in April 1980, the "Folsom Corridor Rail Transit Feasibility Study" concluded that light rail transit would be feasible and more easily implemented than other options studied including HOV facilities. The study was endorsed by the city and county in

May 1980.

Also in 1978, Caltrans, with the assistance of various pro-transit groups, convinced Sacramento Area Council of Governmentments (SACOG) and the City of Sacramento to study the potential for the withdrawal of the I-80 Bypass segment and the feasibility for transit alternatives in the I-80 Corridor. The "I-80 Multi-Modal Corridor Study", completed in July 1979, recommended the bypass segment be withdrawn and suggested the need for major transportation improvements; however, no specific alternatives were specified.

On August 28, 1979, the Sacramento City Council voted to drop plans for construction of the I-80 Bypass after much lobbying by MTS, Caltrans, and other pro-transit groups and individuals. On January 11, 1980, Governor Jerry Brown and the mayor of Sacramento, Phil Isenberg, requested from UMTA and FHWA a transfer of funds from the I-80 Bypass to an unspecified transit project. UMTA and FHWA approved the transfer of funds in May 1980. Upon learning of the transfer approval, the preparation of the Draft Environmental Impact Statement (DEIS) for the I-80 corridor study was initiated.

Coinciding with the commencement of the I-80 corridor DEIS preparation was the endorsement of the state-supported U.S. 50 (Folsom) corridor study. Upon recommendation by Gianturco, the Sacramento City Council included the U.S. 50 corridor in the alternatives analysis process for the I-80 corridor.

Completed in April 1981, the DEIS analyzed a total of 10 alternatives in the I-80 and Folsom corridors. The alternatives ranged from a "no-build" alternative to either TSM (transportation systems management), HOV, or LRT in either corridor or both corridors. In June 1981, SACOG produced the UMTA required "Preferred Alternative Report" in which LRT in both the I-80 and Folsom corridors was the selected alternative. On June 16, 1981, the city council endorsed the report as did the county supervisors and RT Board of Directors.

According to the DEIS, funding sources were intended to be federal Interstate transfer monies ($98.5 million) and State monies ($25.9 million). The remaining $6.6 million of the $131 million budget would be borne by local means (Ref 2). In July 1984, an $18 million cost overrun was disclosed resulting in RT assuming project responsibility from the Sacramento Transit Development Agency (STDA), the local agency created in March 1981 to implement

the LRT system.

During the preparation of the FEIS and negotiation of funding commitments from UMTA and the California Transportation Commission (CTC), a number of objections to the preferred alternative were voiced by staff members of SACOG, UMTA, and CTC. Staff members questioned the need for such a high dollar fixed-guideway system in Sacramento, discovered deficiencies in the design of the fixed-guideway, and criticized the DEIS process and results. The public, however, continued to overwhelmingly support LRT.

Although UMTA and CTC objected to the project, funding was not withheld. UMTA could not withhold Interstate transfer funds because the local area from which Interstate funds are withdrawn is entitled to the funding. The only recourse available to UMTA was to refuse to provide Sacramento with any additional capital beyond the $100 million that Sacramento was to receive from the Interstate transfer. State funding was approved by CTC because the State's portion was much smaller in proportion to the federal funding. (The CTC did not want to be responsible for losing such a large federal grant by withholding such a relatively low investment.) It was, however, stated that additional state money would not be made available by CTC. According to R. A. Johnston *et al.* (Ref 2): "The issue of concern here is not federal funding allocation procedures, however, but rather the overwhelming local political support which was at odds with the CTC and UMTA technical evaluations."

The Final Environmental Impact Statement (FEIS) was approved in August 1983. There was little change between the DEIS and the FEIS with respect to the comments and objections that were noted previously. A complete project chronology is shown in Figure 6.

According to the DEIS, the LRT project would cost $87.7 million (1980 dollars). This figure was modified to $112.7 million (1981 dollars) in the June 1981 "Preferred Alternatives Report." In September 1983, the CTC approved the LRT project for $131 million. A number of cost overruns encountered during the engineering design and construction phases eventually brought the project total to $176 million (1987 dollars). Local sources were intended to supply approximately five percent of the $131 million project. Because of the cost overruns, however, the local share increased to 25 percent of the project total at completion in 1987 (see Figure 4).

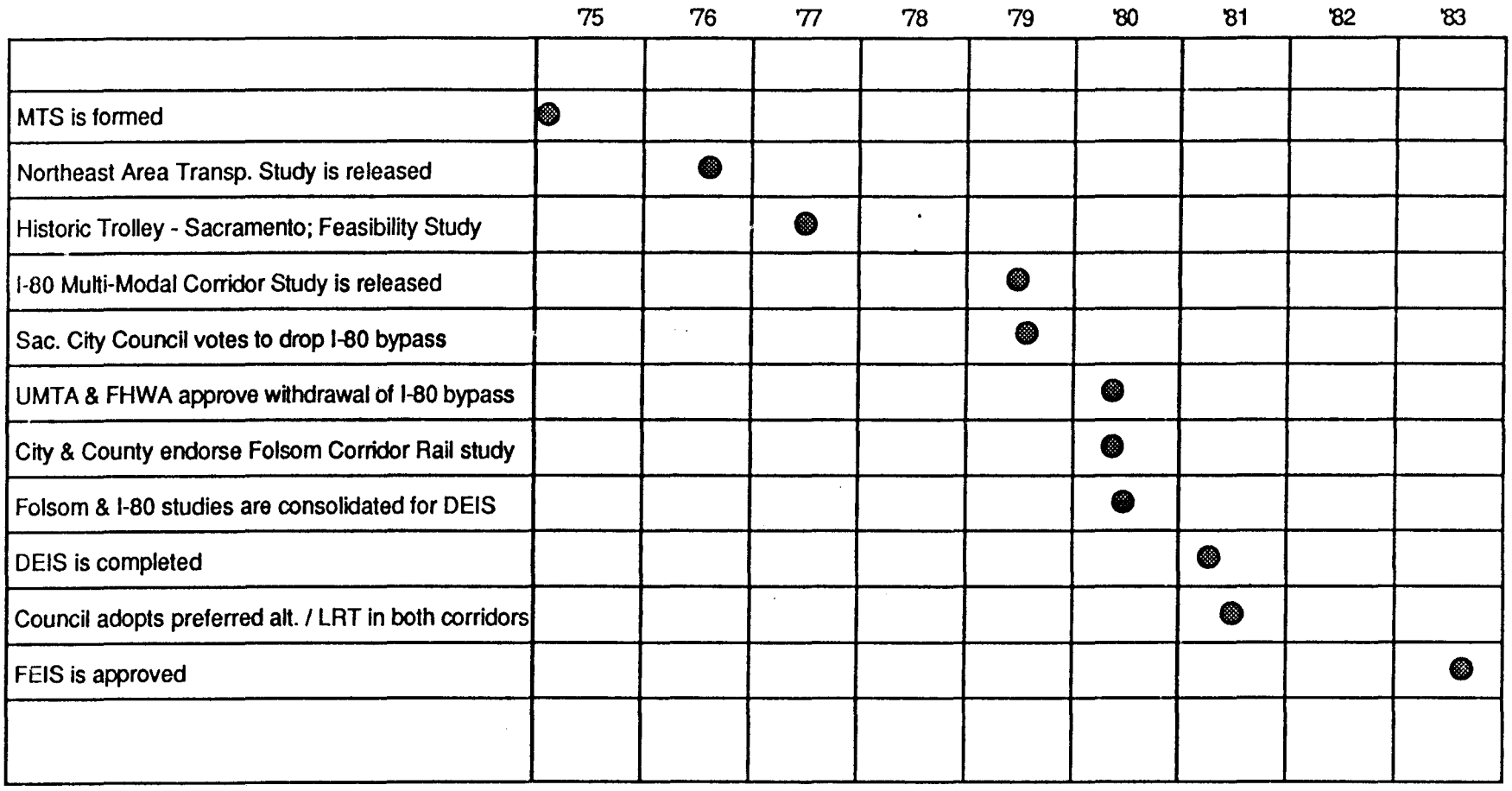

Figure 6: Chronology of the Sacramento LRT Project

Conclusion

According to the DEIS, year 2000 Operation and Maintenance costs were the only major criteria in which the LRT alternative was superior. The LRT alternative was inferior to the HOV alternative in almost every technical criteria. Interestingly, lower operations and maintenance costs are given as the primary reason for supporting LRT by local officials. LRT would have fared even worse in the evaluation if the study had not been biased in favor of LRT. For example, the factor used to annualize HOV operating costs was too high. HOV's annualizing factor of 322 would be acceptable for local bus service but not for express bus service operating only during weekdays. If the factor is changed to 290, the same factor used for LRT, the operating and maintenance cost of the HOV alternative become lower than the cost for the LRT alternative (Ref 2).

The CTC also asserted that the estimated LRT 1986 operating cost of $4.74 million was too low because San Diego, with fewer vehicles, a shorter line, actual ridership 55 percent of that estimated for Sacramento, and a frugal reputation, had a 1983 operating budget of only $4.5 million. LRT administration costs were also considered too low. The projected FY86 LRT operating budget attributed only 6.75 percent of the budget to administration; however, the average administration portion of the budget for all LRT operators running between 25 and 49 vehicles is 20.2 percent. The CTC also noted an understatement of labor costs for the LRT option (Ref 2).

As shown below, ten year capital costs for the projects also favored projects other than LRT (Ref 3). Based on these factors, it become fairly obvious that local decision makers were determined to bring light rail to Sacramento either with or without a favorable technical analysis.

Alternative	Capital Costs (millions 1980$)
LRT	$232
HOV	$182
TSM	$136.5

The line-haul portions of the system were primarily constructed on abandoned Interstate and railroad right-of-way. In the downtown, the LRT

lines were built within public right-of-way. While the right-of-way was relatively inexpensive, the routes are inefficiently located along the periphery of the dense population between I-80 and U.S. 50.

According to R.A. Johnston *et al.* (Ref 2), the use of this right-of-way was another indication of cost cutting that threatened the design of the entire project. An additional indication of skimping is in the decision to construct a primarily single-tracked LRT system. (Sacramento was forced to design the LRT system with the knowledge that all funding beyond the federal and state contributions would be provided by local means.) Operation on the single-tracked facility could be adversely affected or completely halted if a train fails to operate strictly to schedule (i.e. excessive dwell time at a station, train malfunction, conflict with motor vehicles). Also, the minimum attainable headway of 15 minutes also provides a fairly low level of service.

A primary factor behind Sacramento's selection of LRT is the broad public support that LRT enjoyed throughout the entire decision process. The local community, including public officials, believed that the ability of rail transit to focus and guide urban development is an important characteristic of rail transit which is not considered in the technical evaluation. Local officials argue that because of the permanence of rail, LRT has a tendency to attract developers and potential employers to the LRT line and station locations. HOV and buses, which are not necessarily a fixed-service, do not have the same attractive quality as LRT. Additionally, since the system was primarily constructed within abandoned Interstate and railroad rights-of-way, the effects of construction on businesses and housing were minimal -- only eight residential dwellings and three business were removed (Ref 2).

Especially instrumental in bringing LRT to Sacramento was the Modern Transit Society (MTS) which conducted planning studies, remained active on various committees and study teams, and lobbied individual decision makers and groups. Before the DEIS was released, the MTS along with an RT sponsored Community Task Force for LRT launched a major campaign to build broad community support for LRT. The community was nearly unanimous that LRT should be built in both corridors. The RT Board and SACOG unanimously supported the LRT alternative as did 10 of 11 members of the study's policy committee and eight of nine City Council members. Indicative of the broad support was

support from the 80,000 member Central Labor Council, 46 community organizations, and a comment by the president of the Sacramento Board of Realtors that support for the LRT option was probably the first issue that his organization and the Sierra Club ever agreed upon (Ref 6).

The availability of state and federal funding is perceived as an important factor in the local decision to select LRT. If HOV was selected, the area would forego approximately $25 million in state funding reserved for construction of rail transit. Local players also believed that Sacramento should opt for LRT because future funding probably would not be available for LRT and that HOV could, and probably would, be built in the future on an incremental basis (Ref 2).

Sacramento wanted LRT from the beginning and continued its support throughout the decision process. It was a uniform belief among all local decision makers interviewed by R.A. Johnston *et al.* (Ref 2) that LRT was technically comparable to HOV. Key local decision makers, however, believed that the UMTA technical evaluation process and state and federal transportation agency staffs were biased against LRT.* It was also generally perceived at the local level that the technical evaluation did not give enough weight to the less quantifiable positive effects of rail transit such as improved environmental quality (reduction in noise and diesel exhaust), superior ridership-generating qualities of LRT, and the ability of LRT to focus and guide urban growth (Ref 2). The perceived lower operating costs of LRT were cited by local officials as an important reason to select LRT.

In conclusion, Sacramento desired a light rail system throughout the entire study process. The technical analyses did not generally support LRT as the best alternative, however, the LRT alternative was selected as the preferred alternative because of a strong political and public preference for LRT.

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* Every local official and planner interviewed by R.A. Johnston *et al.* (Ref 2) believed that the technical process was inherently biased against rail because not enough weight is given to LRT's superior environmental effects such as reduced freeway noise and diesel exhaust. Also, it was believed the staffs of the federal and state transportation agency's were biased against rail.

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SAN DIEGO

Overview

San Diego County lies in the southwestern-most corner of the United States. In 1980, the population of the 4,200 square mile county, bounded on the south by the Republic of Mexico and on the west by the Pacific ocean, was approximately 1.86 million persons with an average county-wide population density of 450 persons per square mile. Between 1970 and 1980, San Diego County experienced a 3.2 percent per year growth rate, the fifth fastest growing metropolitan area in the country. (Growth rates for California and the nation were 1.7 percent per year and 1.1 percent per year, respectively.) (Ref 3)

The urbanized area lies within the western one-third of the county while the remaining two-thirds, which consists primarily of desert and mountains, is relatively less populated. The most densely populated portion of the county, which includes the City of San Diego, lies within the southern portion of the urbanized area. In 1980, the average population density of the southern portion of the county was 1,350 persons per square mile. Bordering the southern boundary of the urbanized area is the Republic of Mexico and, more specifically, Tijuana with a 1980 population of over 700,000 persons (Ref 3). Contained within the southern portion of the urbanized area is the jurisdictional area of the Metropolitan Transit Development Board (MTDB), the policy setting and coordinating agency for public transportation in the metropolitan area (see Figure 7). In 1980, the population of the MTDB area was approximately 1.46 million persons. By 1988, however, the MTDB area covered 570 square miles and attained an estimated population of 1.56 million persons or approximately 75 percent of the total population of San Diego County.

In 1975, with the passage of California Senate Bill 101, the MTDB was created for the purpose of studying the feasibility and implemention of a fixed-guideway transit system within the San Diego metropolitan area. Operationalized in January, 1976 MTDB began the Guideway Planning Study in December 1976, the beginning of the planning process for the San Diego Trolley.

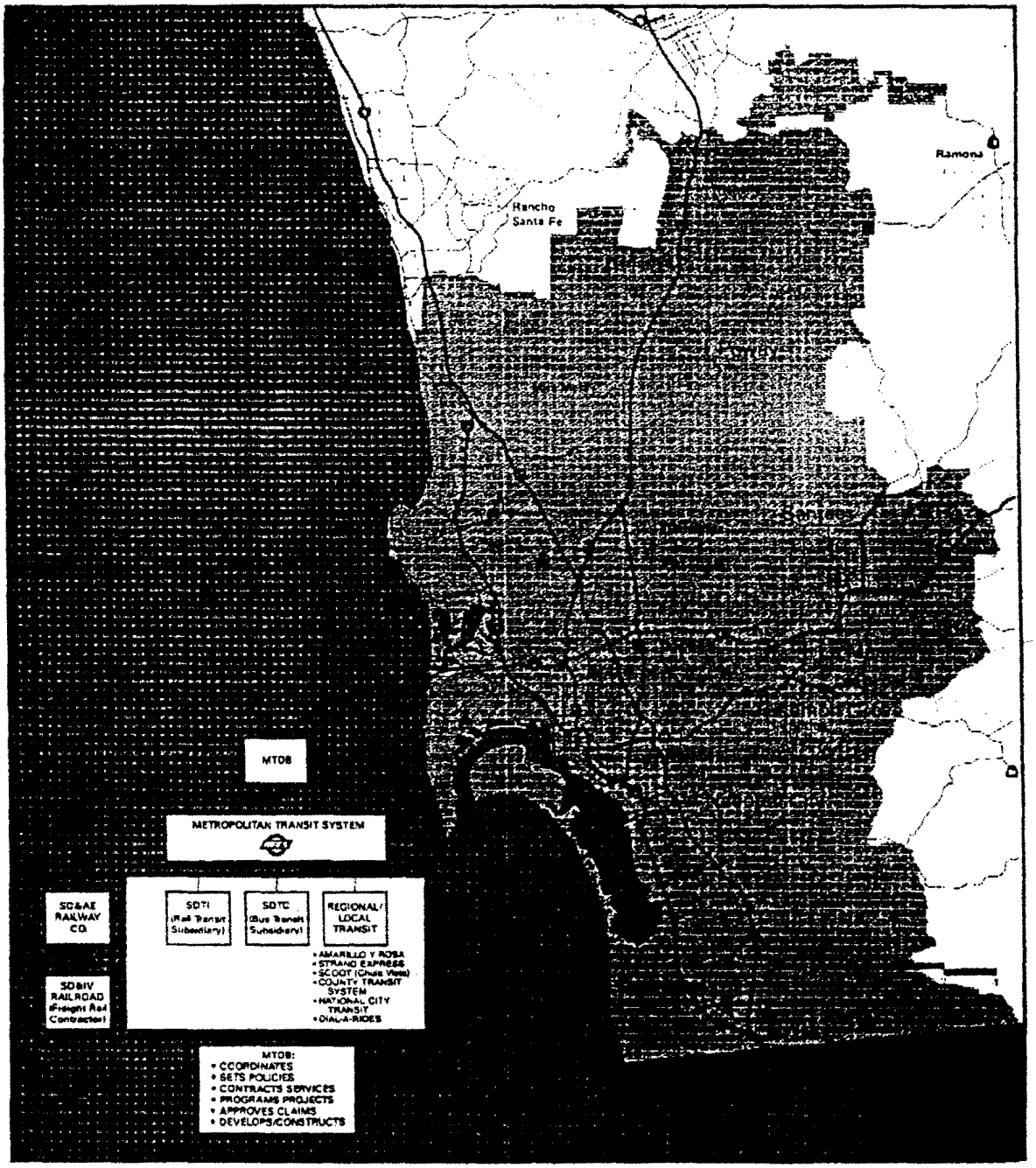

Figure 7: San Diego's MTDB Jurisdiction (Source: MTDB)

The MTD Board of Directors, originally containing 8 members, expanded to 15 members in 1984. Membership consists of 4 members appointed from the San Diego City Council, ome member appointed from each of the area city councils (Chula Vista, Coronado, El Cajon, Imperial Beach, La Mesa, Lemon Grove, National City, Poway, and Santee), one member appointed by the San Diego County Board of Supervisors, and one member appointed by the Governor of California representing the state and serving as Board Chairman.

The MTDB area currently serves 1.56 million persons in a 570 square mile region. Responsibilities include:

- light rail transit development, 1
- updating the Short Range Transit Plan,
- preparation and updating the area's Transportation Improvement Program (TIP) which details upcoming MTDB area transit services and capital projects,
- administration of Transit Development Act (TDA) and State Transit Assistance (STA) funds to transit operators,
- provision of transit service,
- and coordination of the various transit operators.

As mentioned previously, one responsibility of MTDB is provision of transit service and coordination for the MTDB area. The area is currently served by seven fixed-route operators and ten dial-a-ride operators (by contract) with five of the seven fixed route operators and all the dial-a-ride operators independently owned transit service providers. MTDB owns the assets of San Diego Trolley, Inc. (SDTI), the San Diego Transit Corporation (SDTC), and the San Diego & Arizona Eastern Railway Co. (SD&AE) -- a railroad with 108 miles of track right-of-way.

In an effort to create a unified transit system, the Metropolitan Transit System (MTS) was created by MTDB in July 1985. MTS is a symbolic federation of transit providers created to enhance the public's perception of a unified transit system. Each MTS provider is identified by an MTS logo signifying to the rider that the transit system is fully coordinated (i.e. coordinated schedules, fares, transfers, etc.).

In FY88, MTS fixed-route providers operated 363 buses and 30 LRT vehicles over 865 miles of bus routes and 20.4 miles of LRT lines. The combined fixed-route ridership was 39.4 million boarding riders with LRT serving 9.3 million or 24 percent of the fixed-route boarding riders. The fare recovery ratio for all fixed-route riders is approximately 46 percent. The largest transit service providers, accounting for 89 percent of the total MTDB area ridership, are San Diego Transit and San Diego Trolley with annual boardings of 25.8 million and 9.3 million, respectively.

Primary funding for MTDB are from operating income (passenger fares, charter income, advertising, etc.), Transit Development Act (TDA) monies provided through a one-quarter percent statewide retail sales tax, State Transit Assistance (STA) funds generated by a state gasoline sales tax, and federal assistance. During FY88, the seven MTDB area fixed-route operators received $25.7 million in fare revenue and $28.4 million in subsidies for a total of $54.1 million in revenues. Additional MTDB data is presented in Table A1 of the Appendix.

The San Diego Trolley*

In December, 1976, the MTDB began the first phase of an 18-month Guideway Planning Project study. Phase 1 involved the evaluation of candidate corridors based on the Regional Transportation Plan while Phase 2 of the study, beginning in April 1977, involved additional screening of corridors, the selection of the preferred corridor, and the evaluation of transit alternatives within the chosen corridor. As a result of the project study, the South Bay corridor was selected.

The South Bay corridor, extending southward from Centre City San Diego to the Mexican Border, impacts approximately 38 square miles (24,000 acres). In 1980, the primary land uses in the corridor were residential (31.2 percent), agricultural (13.3 percent), and manufacturing (12.7 percent). Shopping centers and strip commercial uses comprised 9.4 percent of the corridor area. A total of 188,940 people lived in the corridor resulting in an average residential density of approximately 4970 persons per square mile. Total 1978 employment for the corridor was 155,141 with 35.5 percent and 27.7 percent of

* Primary references for this section are 1, 3, and 4.

the total employed in the northernmost areas of Centre City and Barrio Logan, respectively. Major employers were military (18.8 percent) and manufacturing (15.5 percent). Retail trade amounted to 12.1 percent of the total corridor employment.

San Diego Trolley, Inc. operates two light rail lines -- the South Line which began revenue service in July 1981 and the Euclid Line which began service in March 1986. An 11.1 mile, $103.6 million extension of the Euclid Line to the community of El Cajon is currently under construction with revenue service scheduled for July 1989. Six additional extensions to the system are in various stages of development. The existing and planned light rail system is illustrated in Figure 8.

Construction of the 15.9 mile South Line, operating between Centre City and San Ysidro, was accomplished in two phases. Phase I of the project, costing $86 million in 1981, primarily involved purchase of an existing rail line belonging to the San Diego & Eastern Railway, acquisition of 14 light rail vehicles, and construction of the single-tracked light-rail line. The first construction contract was issued in December 1979 and revenue service on the facility began in July 1981. Phase II of the project involved double-tracking the line, purchasing 10 additional vehicles, and additional traction power. Upon completion of double-tracking in February 1983, the total cost of the project was $116.6 million or $7.3 million per mile.

The Euclid Line, which also occupies SD&AE right-of-way, is 6.2 miles in length. This project, however, only involved 4.5 miles of new construction since 1.7 miles of the Centre City portion of the route are shared with the South line. The Euclid Line is actually the first segment of the East line which will eventually include the extension to El Cajon, currently under construction, and a future extension from El Cajon to the community of Santee. Construction of the Euclid Line, which began in June 1984, cost a total of $33.6 million or $7.5 million per mile.

The South and Euclid lines were funded entirely with state and local monies. Approximately 88 percent of Phase I funding was derived from State gas tax money set aside for the development of rail transit with the remaining funding provided by Transportation Development Act (TDA) monies. Phase II of the project was funded primarily with state sales and gas tax monies.

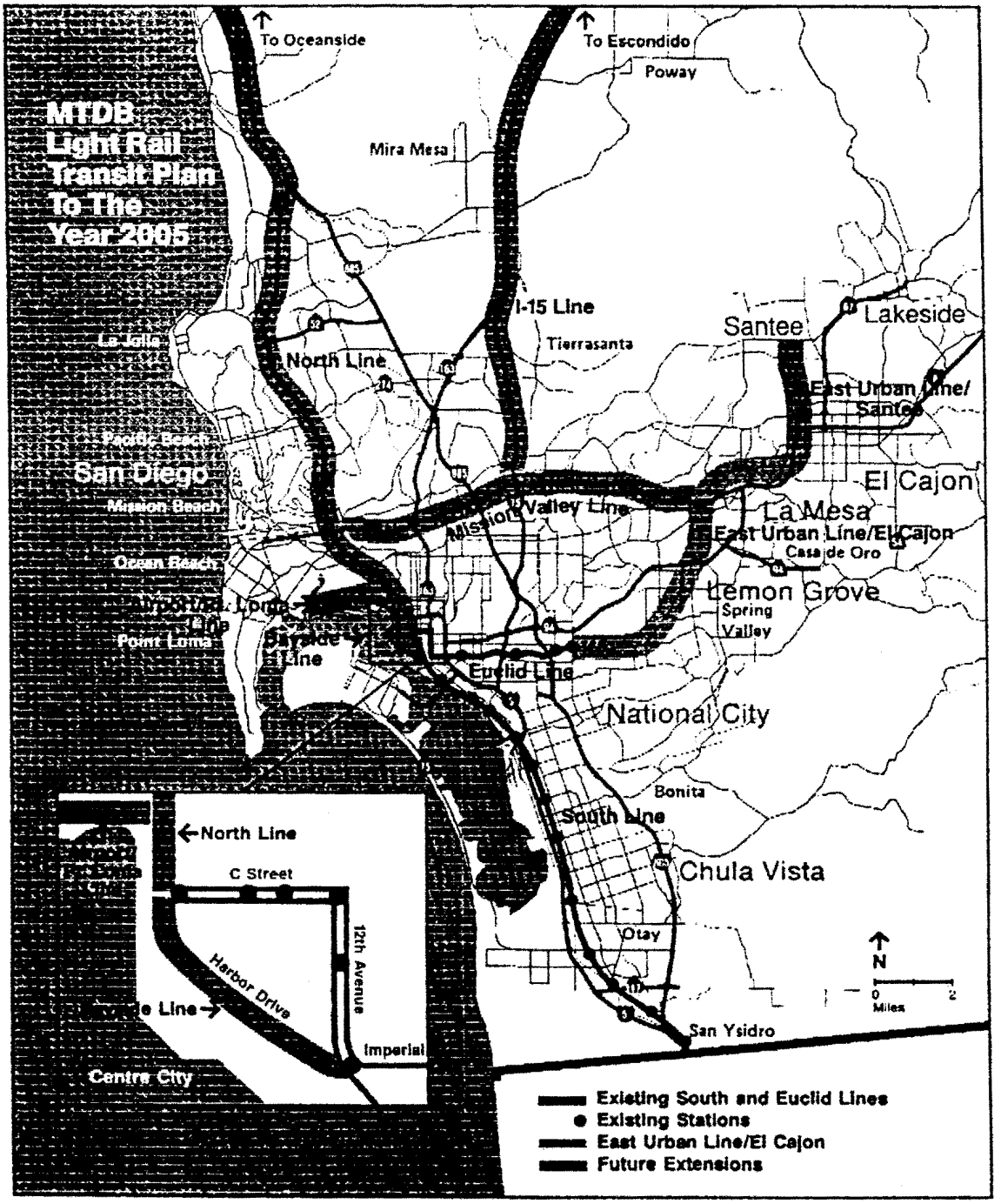

Figure 8: San Diego: Existing and Future LRT lines (Source: MTDB)

Additional San Diego Trolley information is presented in Table A2 of the Appendix.

The Route

The South and Euclid Lines consist of 20.4 miles of reserved right-of-way -- four miles on city streets and 16.4 miles on rehabilitated SD&AE railroad right-of-way. After Trolley service is ended at night, the San Diego & Imperial Valley railroad, under an operating agreement with MTDB, moves rail freight over portions of the 108 mile SD&AE rail system which was purchased by MTDB for $18.1 million in 1979.

Both rail lines begin at the Santa Fe Depot in Centre City and travel in reserved lanes on the street. Downtown automobile traffic is maintained alongside the Trolley lines except along a four block LRT/pedestrian mall on C Street. Signals and stop signs control cross-street traffic along the downtown segment. Track facilities consist of standard ballast, wood ties, and continuous welded steel rails. After travelling a common path of 1.7 miles, the lines separate at the Imperial & 12th Transfer Station.

The South Line continues south along what was previously the Mainline of the SD&AE railroad. The Mainline parallels Harbor Drive and Interstate 5 from south of Centre City San Diego to the International Border with Mexico. Grade crossings along this portion are protected by gates and flashers activated by oncoming light rail and freight trains.

The Euclid line turns east at the Imperial & 12th Transfer Station along what was previously the La Mesa branch of the SD&AE railroad ending at the intersection of Euclid Avenue.

Operating speeds vary between the different portions of the routes. In Centre City, average operating speeds are 9 mph. Along the rail portions of the routes average speeds approach 30 mph with a top speed of 50 mph. Travel time between San Diego and San Ysidro is approximately 42 minutes.

Facilities and Vehicles

Twenty-two stations serve the South and Euclid Lines. There are six stations, basically sidewalk platforms with canopies and benches that serve the 1.7 miles of Centre City trackway common to both lines. The station at

Imperial Avenue and 12th Avenue, where the two routes diverge, also serves as a transfer station.

The other sixteen stations located along the railroad right-of-way are larger shelters equipped with fare vendomat machines, telephones, and transit information as minimum amenities. Approximately 2000 parking spaces are distributed at seven of the twelve stations located along the South Line while, approximately 300 parking spaces are disributed at two of the four stations located on the Euclid Line. The station shelters, which cost approximately $300,000 per station, are relatively inexpensive due to mass production of shelters of a common design. Bus connections can be made at most stations with three South Line stations and one Euclid Line station serving as major transit centers.

The maintenance facility for the Trolley system, located in south San Diego, cost approximately $3 million during construction of the South Line. The facility is undergoing a $6 million enlargement to accomodate and maintain 41 additional vehicles on order.

A fleet of 30 Siemens/Duway U2 light rail vehicles provides service over the 20.4 miles of light rail line. The 80 foot long, six-axled articulated vehicles operate in trains of up to four vehicles; however, in order to reduce congestion caused by four car trains, the trains are uncoupled into two trains of two vehicles when entering Centre City San Diego and recoupled upon exiting the city. The design load of each vehicle is 150 persons (62 seated and 86 standing) with a crush load of 200 riders accomodated during peak hours.

The current fleet of 30 vehicles was purchased in several stages. The first 14 vehicles, purchased for approximately $8.5 million, began arriving on August 23, 1980 and serviced the single-track South Line during start-up in 1981. An additional 10 vehicles were purchased during the double-tracking, or Phase II, of the South Line project. Six additional vehicles were purchased for the Euclid project at approximately $1 million per vehicle. There are currently 41 additional vehicles on order for approximately $1.1 million per vehicle.

Ridership

According to the June 1978 "Final Report: Guideway Planning Project", 1995 ridership for the single-track facility is estimated to be 28,000 riders per day. As of FY88, the now double-tracked South Line is accommodating approximately 23,000 riders per day. When the South Line began operation in 1981 as a single-track facility, ridership estimates prepared after the June 1978 report indicated daily ridership would be approximately 9800 riders per day; however, actual first year ridership exceeded the estimate with 11,650 riders per day.

In FY88, the Trolley boarded a total of 9.3 million riders (South and Euclid lines). The average number of weekday boarding riders was approximately 29,000 boarding riders and Saturday ridership was even slightly higher with an average of 30,000 boarding riders. The increased Saturday ridership is primarily a result of tourists, comprising about 16 percent of all Trolley rides, travelling to Mexico along the South Line (Ref 6).

Total estimated 1995 ridership for the baseline bus system with and without the guideway element was lower than estimated ridership for the other alternatives; however, when the data was presented in unit-terms such as operating subsidy per passenger, passengers per vehicle-mile, operating cost per passenger, and total annualized cost per passenger, the baseline bus system with guideway alternative outperformed the other six alternatives in each case (see Table 1). Also, as indicated in Table 1, operating costs of the baseline bus system with guideway was the lowest of the alternatives. With respect to benefit/cost ratios, the only alternative outperforming the baseline bus system with guideway (benefit/cost ratio of 1.15) was the medium capital cost bus system with semi-exclusive guideway (benefit/cost ratio of 1.25).

Historical Background*

Early planning efforts and funding legislation for fixed-guideway transit set the background for the creation of MTDB and the eventual selection of light rail in the South Bay Corridor. The 1975 Regional Transportation Plan provided the technical background while two State legislative acts provided

* Primary references for this section are 2,8,and 9.

Criteria	Unit	Baseline Bus System		Low Capital Cost Bus System		Medium Capital Cost Bus System		
		Without Guideway	With Guideway	Without Guideway	With Guideway	Without Guideway	With Guideway	With Semi-Exclusive Guideway
peak hour vehicles required	No.	286	287	480	470	480	476	494
total capital cost	$000,000	54.9	116.8	102.9	164	151.3	204.9	250.6
1995 operating cost	$000,000	29.7	30.8	56.2	56.1	52.8	53.8	60.3
1995 annual passenger trips	000,000	37.9	42.6	58.2	59.8	66.4	69.8	78.6
1995 operating subsidy required	$000,000	15.7	15.1	34.1	32.8	26.3	25.9	28.9
1995 operating subsidy per pass.	$	0.41	0.36	0.59	0.55	0.4	0.37	0.37
passengers per vehicle-mile	-	2.7	2.9	1.9	2	2.3	2.4	2.5
1995 operating cost per pass.	$	0.784	0.725	0.965	0.938	0.796	0.771	0.768
total annualized cost per pass.	$	0.919	0.916	1.128	1.146	0.989	0.991	1.003
benefit-cost ratio	-	-	1.15	0.65	0.65	1.07	1.08	1.25
daily passenger trips	-	121,000	136,000	186,000	191,000	212,000	223,000	251,000
operating revenue/cost ratio	-	47%	51%	39%	42%	50%	52%	52%

Table 1: Guideway Planning Project System-wide Comparisons (Ref 11)

the financial resources necessary to seriously consider implementation of a fixed-guideway system.

Between 1970 and 1975, a number of transportation and land-use studies were conducted in the San Diego Region. Transit alternatives considered in the studies included local bus, express bus, heavy rail, light rail, and advanced technologies. In 1975, the Comprehensive Planning Organization (presently the San Diego Association of Governments (SANDAG)) adopted a Regional Transportation Plan (RTP) which included a 60-mile, intermediate capacity fixed-guideway system.

Occurring prior to the adoption of the RTP, however, were the passage of two State legislative acts providing for funding of public transportation. The Transportation Development Act (TDA), signed by Gov. Ronald Reagan in 1971, earmarked 0.25 percent of the state sales tax for funding transit in urban areas and for funding construction of local roads and streets or public transit in non-urban areas. The other important legislative action was a 1974 amendment to the State Constitution. The passage of Article 19 permitted the use of gas tax revenues, previously reserved for highway construction, for construction of rail systems. A countywide vote determines a county's participation in the program.

The development of the RTP and the availability of transit funding set the stage for creation of MTDB. MTDB was formed from legislation introduced by State Senator James Mills in early 1975. Senator Mills, President Pro Tem during this period and a strong transit advocate, was also influential in obtaining passage of the legislative acts providing for transit funding.

On January 1, 1976, MTDB came into existence for the purpose of designing and building a guideway transit system in the San Diego Region. The legislation creating MTDB dictated the Board be certain to: (1) give priority consideration to proven guideway technologies, (2) construct and begin system operations on an incremental basis so that fiscal resources may be used as they became available, and (3) keep construction costs low. MTDB was also responsible for allocation of state funds and operating subsidies within the region, development of 5-year transportation planning, and the annual Transportation Improvement Program. The complete planning and operation of

the fixed-guideway system was assigned to MTDB to assure accountability during the entire process.

In December 1976, MTDB began the Guideway Planning Project modeled after UMTA's two-step Alternatives Analysis process although federal assistance was never sought. This process was followed for two reasons: (1) the process was a rational method for determining feasibility and selecting a preferred corridor and (2) MTDB did not want to rule out the possibility of federal funding even though they were skeptical of their eligibility due to fairly low densities, uncongested highways, and undefined corridors (Ref 10).

The 18-month Guideway Planning Project was conducted in two phases. Phase 1 involved the evaluation of candidate corridors based on the 1975 Regional Transportation Plan and Phase 2, begun in April 1977, involving further evaluation of corridors, selection of a corridor for the starter segment, and technical evaluation of all alternatives in the chosen corridor.

At the onset of Phase 1 planning, the Board adopted the following policies for selection of a fixed-guideway system:

- the selected corridor should extend a long distance and allow high speed travel,
- capital cost should be low,
- operating costs should be low and attempt to cover operating costs through passenger fares,
- the system should be primarily at-grade and within exclusive right-of-way,
- and impact on residential growth should be measured.

Phase 1 planning, accomplished by MTDB staff without the assistance of consultants, was based completely on the RTP and the five policies listed above. Over 100 miles of corridor were studied in this phase with 45 miles of corridor recommended for further evaluation.

The first element of Phase 2 planning involved selection of a candidate corridor, defined as Preliminary Engineering Limits, for more detailed study. The analyses involved environmental, economic, and social impact assessments as well as station location studies. In addition, cost and patronage estimates were considered key factors in the selection. The dominant consideration, however, was the possible acquisition of the SD&AE railroad for

joint passenger and freight operations (Ref 11). In August 1977, the engineering limits, later known as the South Bay Corridor, were adopted for detailed preliminary engineering study.

In October 1977, the Board endorsed the use of light rail as the lone guideway technology to be studied in conjunction with several all-bus alternatives. The decision was based primarily on the results of a working paper and the legislative requirement that MTDB remain pragmatic in the selection of a guideway technology. The working paper presented evaluation of four guideway technologies: light rail, two categories of heavy rail, and Automated Small Vehicle Transit. MTDB staff recommended light rail based on the following results:

- light rail right-of-way is more flexible,
- light rail can offer high speed travel,
- construction costs arelower when at-grade construction is maximized,
- and light rail offers greater overall flexibility when integrating into changing local conditions.

Once light rail was selected and the corridor identified, a detailed planning analysis of the proposed transit alignment began. This process involved greater detail than usually performed at this stage for several reasons: (1) the final cost estimate needed to be as accurate as possible, (2) the study could be more detailed because the scope had been narrowed to a more simple, single-track facility, and (3) the project needed to be implemented as soon as possible to stave off the negative effects of inflation. The enabling legislation for MTDB also required rapid implementation. The need for accurate costs and a rapid implementation schedule were necessary because of the unchangeable limit of available funding.

Seven alternatives were evaluated in Phase 2 of the Guideway Planning Project. Three bus alternatives (baseline bus, low capital cost bus system, and medium capital cost bus system) were analyzed, both with and without the light rail alternative. The seventh alternative consisted of a medium cost bus network with a semi-exclusive double-track guideway alternative. It is interesting to note that a busway alternative was never considered because of the relative free-flow conditions on the South Bay freeways. The key results

of the Alternatives Analysis affecting the decision to implement light rail with baseline bus were ridership and productivity. More specifically, (1) light rail ridership was significantly higher because of lower travel time and reduced operating subsidy requirements, (2) the relative attractiveness of light rail over buses significantly increased the number of rail patrons, and (3) the number of passengers per operating dollar was significantly higher than comparable bus service (Ref 2). The system-wide results of the Guideway Planning Project can be found in Table 1.

Subsequent and very critical to the final decision to implement the LRT project was the acquisition of the SD&AE railroad. In September 1976, a tropical storm washed out a substantial portion of the SD&AE. Fiscal analyses of the damage by the railroad owner, Southern Pacific Corporation, led to a decision to petition for the abandonment of SD&AE rail service in San Diego County. The Interstate Commerce Commission denied the request prompting Southern Pacific to offer the railroad for sale to anyone willing to maintain freight operations on the line. Interested in the possibility of obtaining the existing right-of-way, MTDB went before the State Transportation Board for a ruling allowing the MTDB to purchase real estate and facilities outside of the agency's jurisdiction. The State Transportation Board ruled in favor of MTDB in November 1977. In June 1978, the MTD Board found the entire joint-use project feasible. A Memorandum of Intent to purchase the SD&AE for $18.1 million was filed with the Southern Pacific Corporation on October 30, 1978 with final acquisition occurring on November 1, 1979.

Project approval was put in motion in March 1978 when the MTD Board authorized the distribution of the draft Environmental Impact Report (EIR), a document required by state law. The Board also filed all required public notices and established a 45-day public review period. The Final EIR was certified by the MTD Board on September 11, 1978. Final approval by the City of San Diego, which is required because the Trolley would operate on 1.7 miles of city street, was obtained when MTDB negotiated the purchase of the SD&AE right-of-way for $18.1 million. The city previously had reservations in supporting the project because the passage of the California Taxpayers Initiative (Proposition 13) had cut into transit funding for the then city-owned San Diego Transit Corporation. The low cost of SD&AE and the fact that

freight service would continue between the Port of San Diego and the regions of Imperial County and Arizona prompted the City to support the project on October 25, 1978. Stating that all State environmental requirements had been met, a Notice of Determination to proceed with the LRT project was by filed by MTDB on December 18, 1978. MTDB received final project and financial plan approval from CalTrans and the California State Transportation Commission in March 1979. (Figure 9 summarizes the chronology for the San Diego Trolley Project.)

Conclusion

Between 1970 and 1975, several planning studies concluded that rail transit should be considered in the San Diego area. During this period, two legislative actions providing for funding of transit, in particular rail transit, were passed. As a result, the Metropolitan Transit Development Board (MTDB) was created by state legislation for the purpose of planning, designing, and building a guideway (rail) transit system in the San Diego metropolitan area, thereby, precluding the study of busways. MTDB's enabling legislation was initiated by the influential State Senator James Mills, a strong transit advocate, who also played a key role the development of the legislation providing for transit funding.

Funding for LRT was provided entirely through state and local sources. The availability of TDA and gas tax revenues was an important factor in the decision to create MTDB and eventually the LRT system. Federal funds were not actively sought due to the locally perceived notion that the San Diego area would not qualify for UMTA funding due to low densities, uncongested highways, and undefined corridors. Since the MTD Board decided not to compete for federal funding, the Board had a set amount of funds with which to work.

According to the June 1978 "Final Report: Guideway Planning Project", capital costs for the preferred alternative, baseline bus system with guideway, were expected to total $116.8 million between 1978 and 1995 (total includes: bus facilities and vehicles-$48.3 million, single-track rail facilities and vehicles-$45.3 million, and land-$23.2 million). Actual Phase I construction costs (single-track facility, 14 vehicles, land, etc.) totaled $85.8 million in 1981. Without consideration of inflation, the actual cost is

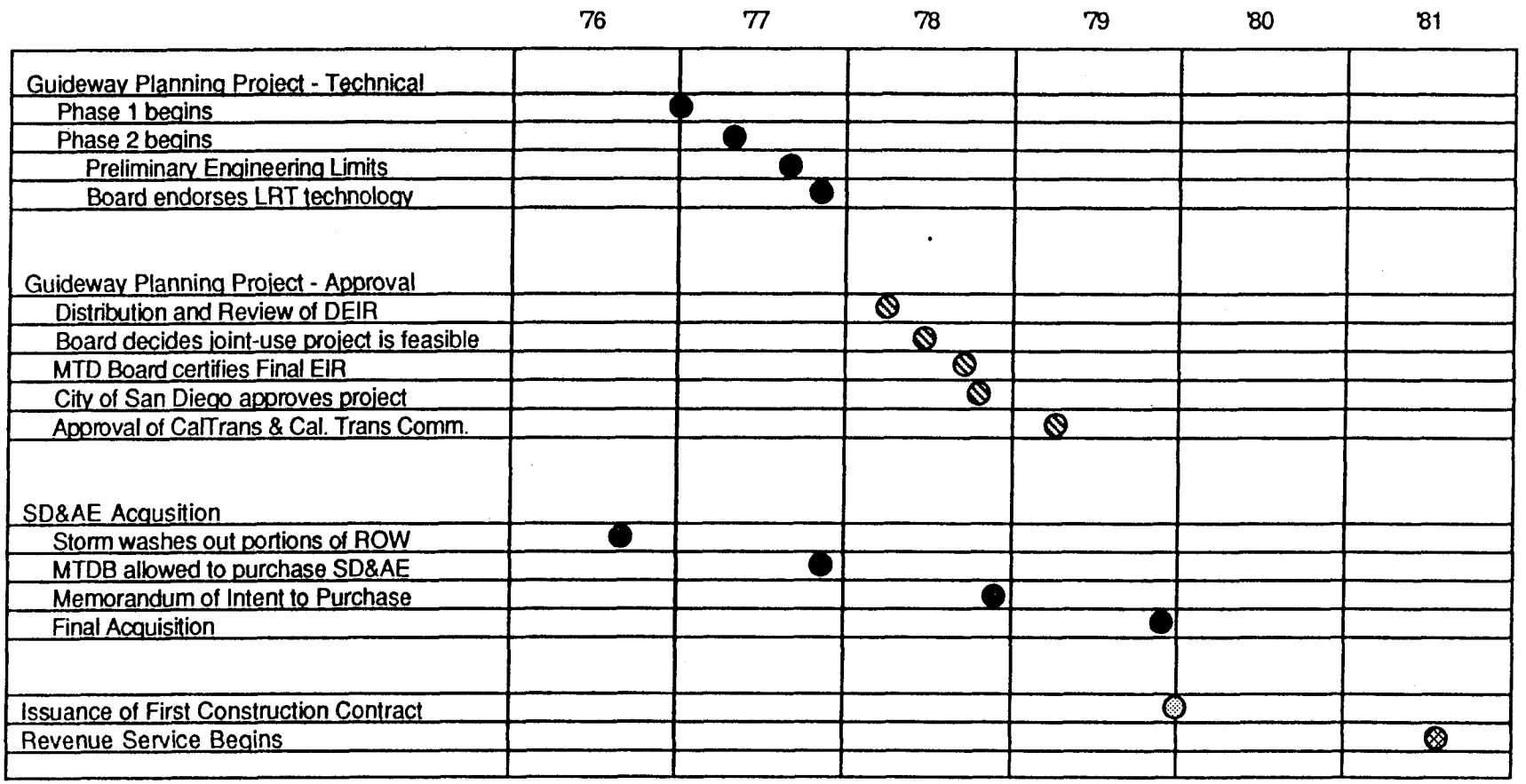

Figure 9: Chronology of the San Diego LRT Project (South Line)

approximately 25 percent more expensive than the estimated cost of $68.5 million for single-track rail facilities, vehicles, and land. After completion of Phase II construction in 1983 (double-tracking and 10 additional vehicles), the total cost of the project was $116.6 million. Although the planning estimate of $116.8 million and the final cost of $116.6 million appear very close, it should be noted that the initial planning estimate includes all capital costs for bus and rail facilities constructed between initiation of construction and 1995, while the actual total of $116.6 million is the cost of the rail facility at completion of construction in 1983.

The acquisition of the SD&AE rail line was a key factor in the decision to implement light rail and also was an important factor in the selection of the South Bay Corridor. Once the corridor was selected, rail became a highly viable alternative because the infrastructure was basically in-place in two major corridors in the region. The relatively inexpensive SD&AE acquisition (108 miles of rail line for $18.1 million (1979$) was also important because the MTDB enabling legislation and the policies later adopted by the MTD Board required the selected guideway technology to be low cost.

With the MTDB restricted to developing a rail system, the primary decisions made during the Guideway Planning Project were the type of rail transit technology to be tested (light rail, heavy rail, or automated small vehicle transit), identification of the corridor in which the alternatives (alternatives consisted of light rail in combination with various all-bus networks) would be evaluated and eventually implemented, and the selection of the preferred alternative. While the reasons cited by the MTD Board for selecting the light rail mode are given in the text, the ultimate selection of the "Baseline Bus System with Guideway" alternative was a straightforward choice based on the alternative's technical superiority over the other alternatives in almost every category (see Table 1).

Within the context of this report, the ultimate choice of a light rail system in San Diego was not a choice of light rail versus busway but a choice between light rail versus other rail technologies (as well as a choice between light rail in combination with various all-bus alternatives). The choice to implement rail was, in effect, made when the legislature created the MTDB, an agency with the primary purpose of implementing a rail system.

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SAN JOSE
(Santa Clara County)

Overview

Located at the southern tip of the San Francisco Bay, Santa Clara County has a 1988 population of approximately 1.4 million persons. The City of San Jose (pop. 637,000), 44 miles southwest of San Francisco, is located in the northern part of the county known as Silicon Valley, a major electronics and high technology area. Santa Clara County is currently constructing a 20.3 mile light rail line extending from the sprawling industrial parks of Silicon Valley, through the San Jose CBD, to the populated residential areas south of the CBD.

When transportation alternatives for the San Jose area were studied in the late 1970's and early 1980's, the area was experiencing major growth from the evolution of Silicon Valley. Experiencing the heaviest growth was the 16 mile long, five mile wide Guadalupe Corridor which will eventually accommodate San Jose's LRT system upon completion in 1991.

In 1975, population of the Guadalupe Corridor totaled 360,000. According to the Guadalupe Corridor Preferred Alternative Report (Ref 1), the population of the corridor is expected to grow to 420,000 by 1990, a 17 percent increase. During the same 15 year period, however, the number of jobs within the corridor are to increase by 105 percent from 187,000 to 383,000. As a result of the expected growth, the number of person trips within the corridor are forecasted to increase over 50 percent of the 1975 demand of 1.2 million trips. Between 1980 and 1990, 80 percent of all manufacturing jobs locating within Santa Clara County are expected to locate in the Guadalupe Corridor.

A large portion of the transportation needs of Santa Clara County are provided by the County. The Santa Clara County Transportation Agency (SCCTA) is comprised of ten divisions with responsibilities ranging from planning, operating, and maintaining the county-wide bus system to managing and operating the county's three general aviation airports. The County is also responsible for the administration and operation of the area's light rail system. The remaining Transportation Agency departments are: Administration,

Design and Construction, Fiscal Resources, Human Resources Development, Marketing, Roads Operations, and Planning and Property (Ref 2).

The SCCTA provides transit service in a 326 square mile service area populated by over 1.43 million persons. Bus service is provided by 526 buses operating over 77 routes. The total bus system consists of over 1,396 one-way miles of bus route. The agency is also operating 50 light rail vehicles over the northern one-half of the planned 20.3 mile system. The southern portion of the system is under construction and scheduled for operation in mid-1991.

As of the close of FY88, the transit system boarded over 35.2 million transit riders, an average of 118,432 weekday boarding riders. The total FY88 expenses and revenue for the bus and rail divisions of the Transportation Agency was $114.3 million and $156.5 million, respectively. Passenger revenue of $11.34 million covered approximately 10 percent of the total transit expenses. Additional SCCTA data is presented in Table A1 of the Appendix.

Primary operating revenue for the transit system is supplied through a one-half cent local transit sales tax. Additional funding is provided by state gas tax monies and federal formula monies.

The Guadalupe Corridor Light Rail System

In 1981, the Guadalupe Corridor Draft Environmental Impact Statement (DEIS) was completed resulting in the selection of light rail, expressway, and bicycle facility components as the preferred alternative. As reported in December 1981, the total capital cost of the alternative was estimated at $277 million (1980$) with the light rail, expressway, and bicycle components accounting for approximately $187 million, $89 million, and $1 million, respectively (Ref 1).

As the project progressed from preliminary engineering through final design, the anticipated costs and construction time continued to increase because of major scope changes. The initial system was planned to be relatively simple; however, as the project developed, local politicians began to ask for additional improvements. For example, costly noise abatement walls not originally included in the project were added. Also, the southern portion of the LRT line, which was expected to operate within the right-of-way of an expressway, was completely redesigned after the expressway segment was

unexpectedly upgraded to freeway standards. The conversion of the highway facility from expressway to freeway required substantial additional costs for the re-design of the LRT system in the median sections as well as the capital costs required for more elaborate station and pedestrian access facilities (i.e. crosswalks, escalators, etc.).

Several unforeseen problems also resulted in cost overruns and schedule delays. For example, the discovery of an ancient Indian burial ground in the LRT right-of-way created schedule delays and cost increases as measures were taken to exhume, catalogue, and relocate the remains. Additional construction delays were incurred by both the freeway and LRT project when a lawsuit forced the redesign of a critical highway interchange just as construction was to begin (Ref 4).

Because of major revisions in the project scope and several schedule delays, the estimated cost to complete the LRT system as of October 1988 is $556.1 million dollars for the LRT portion alone. The 1988 estimate also includes the cost of a $44.6 million downtown transit mall, not included as a component of the preferred alternative, and an additional $15 million in escrow pending litigation between the county and utility company regarding the cost of relocating utilities. By project completion, the following agencies are expected to have contributed as follows: UMTA-$257.6 million (46 percent), SCCTD-$191.1 million (34 percent), the State of California-$98.7 million (18 percent), and the City of San Jose-$8.7 million (2 percent). All local monies (i.e. $8.7 million from San Jose) and a portion of UMTA and SCCTD monies were used in the construction of the transit mall.

Upon completion in mid-1991, the agency will operate a 20.3 mile LRT system between the Silicon Valley employment area, through the San Jose CBD, to the residential areas south of the downtown (See Figure 10). A portion of the northern section linking Silicon Valley with the San Jose CBD began revenue service in mid-December 1987. It was June 1988, however, before the complete northern portion of the line extending from the transit mall located in the downtown San Jose to the Silicon Valley area north of the CBD was operational. The southern 10 mile section, eventually extending to the residential areas and major IBM employment center south of downtown, is under construction and

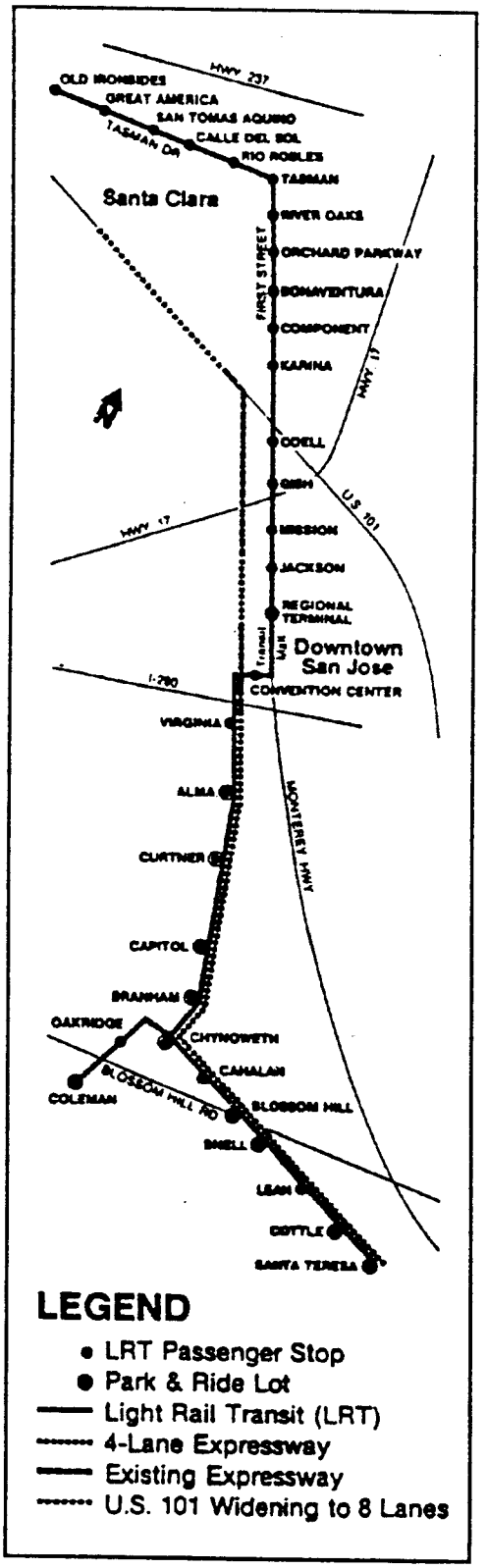

Figure 10: Guadalupe Corridor LRT Project (Source: SCCTA)

scheduled to open in mid-1991. Additional Sacramento LRT data is presented in Table A2 of the Appendix.

The Route

The LRT line, which is to extend from the Great America theme park in north Santa Clara County to the primarily residential areas south of Santa Clara, is completely at-grade. The northern portion of the system uses the median of major arterials while the southern portion, which is currently under construction, will operate primarily in the median of two state freeways being constructed as a portion of the light rail/freeway/bicycle project. Approximately 52 percent of the complete system will be surface reserved while the remaining 48 percent will be grade-separated right-of-way (Ref 3).

Beginning at the Great America theme park area, the light rail lines travel along two arterial streets to the downtown San Jose transit mall. The $44.6 million transit mall, completed in mid-1988, provides for three transit stops in each direction. Conceived as a means of increasing downtown development and providing an attractive focal point for transit activities, the following improvements were included: the planting of 500 mature sycamore trees, decorative fountains, granite pavers, stainless steel and glass transit shelters, and street furniture. The 10-block transit mall, forming a one mile loop, is designed to accommodate light rail vehicles (LRV's), antique trolleys, buses, autos, and pedestrians.

After leaving the downtown transit mall, the line will enter the freeway median of State Route 87 (under construction) and travel south to the intersection of State Route 85 (under construction) where the line will split. A portion of the line will continue to the west as a double-tracked facility in the freeway median of State Route 85 serving residential areas, Santa Teresa Hospital, and IBM's regional headquarters. The other portion, less than a mile in length, will serve residential areas as a single-track facility operating in a portion of the abandoned Lick Branch railroad right-of-way (Ref 1).

Upon system completion, travel time from end-to-end will be approximately 55 minutes. Speeds on the mall are approximately 10 mph and along city

streets the LRV's operate at about 35 mph. Maximum speeds along the freeway segments is 55 mph (Ref 4).

Facilities and Vehicles

Thirty-three stations and stops complete with wayside lifts and ticket vending machines will serve the LRT system upon completion in 1991. Passenger stops along the north segment are primarily low-level platforms with canopies; however, stations along the south segment of the freeway will be much more elaborate. These stations will be equipped with elevators and escalators to move people to the freeway median from adjacent park-and-ride lots providing over 6000 free parking spaces. Originally, station designs called for a much simpler south segment station design because transit patrons accessed median stations by crossing the expressway at signalized intersections. When the expressway was upgraded to a freeway, however, the pedestrians had to be completely removed from the freeway traffic by means of pedestrian walkways, tunnels, or overpasses. These costly pedestrian grade separations were a major factor in the LRT system's substantial cost increase over initial estimates.

A $20 million maintenance and storage facility, dedicated in October 1986, is designed to provide for the operation, storage, and maintenance of the systems 50 LRV's (Ref 4).

SCCTA operates 50 light rail vehicles manufactured by Urban Transportation Development Corporation (UTDC). These six-axled, double-ended, single-articulated vehicles are 12 ft. 5 in. high, 8 ft. 8 in. wide, and 88 ft. 6 in. long. The vehicles are designed to accommodate 165 passengers during the peak period (75 seated and 90 standing). Each vehicle is equipped to accommodate two wheelchairs. The vehicles, which began arriving in April 1986, were purchased for $940,000 per vehicle.

In addition to the 50 modern light rail vehicles, the system will operate six antique trolley cars in the downtown mall during off-peak hours. These vintage vehicles, two of which were operated on San Jose streets between 1912 and 1934, are being restored by volunteers of the private, non-profit San Jose Trolley Corporation (Ref 6).

Ridership

The Preferred Alternative Report of 1981 forecasted 45,000 average weekday riders in 1990. During preliminary engineering, however, the estimate was revised to 40,000 average weekday riders, and again in 1986, private consultants re-estimated ridership at 20,000 average weekday riders by the year 2000, 55 percent less than the original estimate. This revised estimate was a result of factors involving more plentiful and less expensive petroleum, a slow down in development especially in the Silicon Valley area, and the unanticipated funding of additional highway improvements.

As of August 1988, the completed north section of the system is accommodating over 6200 average weekday riders. Ridership on this portion has increased by over 600 percent since the north section was connected to the downtown transit mall. Current ridership is higher than the consultants estimate of 3000 to 5000 average weekday riders expected at completion of the northern half of the project.

Historical Background*

Two studies conducted in the mid-1970's provided the impetus for additional study of the Guadalupe Corridor and the eventual selection of the light rail/expressway/bicycle facility alternative. In 1974, Santa Clara County began the "Rapid Transit Development Project" where the economic and environmental impacts of large-scale transit systems were analyzed in several high demand corridors. As a means of achieving the project's high ridership goal, the staged implementation of a medium-capacity, high-performance fixed-guideway system supported by an extensive bus collection system was recommended. In another study completed in 1976, the feasibility of light rail or bus transit alternatives in several of the high demand corridors identified in the 1974 study were analyzed. The State Highway 87 right-of-way (Guadalupe Corridor) (which had been masterplanned along with the State Highway 85 right-of-way since the late 1950's but never built) and a portion of the Southern Pacific Railroad/Monterrey Highway corridor were designated as the most feasible route with the greatest ridership potential.

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* Primary reference for this section is Ref 7 unless otherwise noted.

The draft report of the Santa Clara Valley Corridor Evaluation Study (SCVCE) was completed in 1978. The SCVCE study, which was actually Phase I (system planning) of UMTA's two-phase "Alternatives Analysis" process, analyzed nine transportation alternatives and several 1990 land use scenarios. A principal recommendation of the study was a detailed evaluation of transportation alternatives in the Guadalupe Corridor.

The SCVCE 1979 final report, recommended State Route 85 and State Route 87 as primary corridors for transportation development. The report also recommended acquisition of the remaining right-of-way property and subsequent construction of a four-lane freeway spur within a portion of the right-of-way. A detailed study of transportation options for the Guadalupe Corridor was also recommended. The report recommendations were adopted by the Association of Bay Area Governments (ABAG), Metropolitan Transportation Commission, County of Santa Clara, and twelve of the fifteen cities and towns located in the county.

In 1980 and 1982, final environmental impact reports were prepared documenting the potential effects of protecting the SH 85/SH 87 corridor from future development. Additionally, the reports were intended to preserve the right-of-way property for future transportation uses.

In 1981, the Guadalupe Corridor Draft Environmental Impact Statement was completed. The report analyzed fourteen highway/transit alternatives ranging from a null (do-nothing) alternative to busway/HOV and LRT alternatives. The busway/HOV and LRT alternatives were analyzed both individually and in combination with highway projects. Commuter rail alternatives were also considered. In November 1981, the Light Rail/Expressway/Bicycle Facility alternative was endorsed as the locally preferred alternative by the City of San Jose, the City of Santa Clara, and the Santa Clara County Transit District Board of Supervisors. Subsequently, support from the Guadalupe Corridor Board of Control, the Metropolitan Transportation Commission, and the Guadalupe Corridor Technical Advisory Committee was also received. The alternative also received substantial support from the general public. Caltrans, however, endorsed an exclusive light rail alternative, but in a letter to the Guadalupe Corridor Board of Control, agreed to actively support the local decision (Ref 1).

The availability of funding played an important role in the local decision to support light rail. In 1976, county voters passed a 1/2 cent sales tax establishing a tremendous reserve of capital for the transit district. Additionally, state funding was made available for light rail because of the extremely anti-highway, pro-transit influence of Governor Brown as well as a restricted definition of fixed-guideway transit where busways were not legally interpreted as fixed-guideway facilities. With the substantial reserve of local monies, the federal portion was expected to be lower than the normal 80 percent. Initial estimates presented in the Preferred Alternative Report estimated the capital funding shares at 50-70 percent federal, 20-36 percent state, and 10-14 percent local (SCCTD) (Ref 1). Major scope changes and schedule delays substantially increased the local funding portion and resulted in the following funding breakdown (as of 10/88): 46 percent UMTA, 18 percent state, and 36 percent local.

Federal funding for the project was allocated by Congress against the wishes of UMTA.** Local officials perceived that UMTA believed the technical process was being slanted in favor of LRT. Several times UMTA questioned the capital intensiveness of the busway project. Local officials believe they adequately addressed UMTA's questions. UMTA, however, was never completely satisfied.

According to the 1981 Preferred Alternative Report (Ref 1), initial capital costs (1980$) of the busway and LRT would be approximately $100 million and $187 million, respectively, making the LRT system approximately 87 percent more capital intensive than the busway. With the inclusion of operating and maintenance costs, the annualized costs and annualized benefits become:

	Annualized Costs	Annualized Benefits	Benefits/Costs
Busway	$13.0 million	$21.9 million	1.68
LRT	$17.7 million	$23.9 million	1.35

Although LRT was more costly, local support of the LRT system was unaffected. Based on the annualized data presented above, it was stated in the Preferred

** There was strong congressional support for the project. One local source stated: "Our Congressmen went out on a limb to support (the locally preferred alternative) and felt o.k. doing so because of the universal support at the local level."

Alternative Report that "both alternatives were good investment choices."(Ref 1, p 27)

Light rail experienced strong community support throughout the process. On October 7, 1981 at a public hearing, 14 of the 21 speakers (67 percent) and 26 of 30 (87 percent) written statements received were in favor of light rail as an independent alternative or in combination with an expressway. The Modern Transit Society (MTS) was very vocal in supportive of light rail as the only alternative - no busway or freeway included in the alternative. According to a local source, the only other substantial support was for the construction of highway facilities. A strong bicycle society was also very vocal in the process. These highway and bicycle proponents were instrumental in obtaining the expressway and bicycle lane provisions in combination with the LRT alternative.

There were a number of local individuals very active in support of light rail. According to a local source, the choice of light rail was a "foregone conclusion" in the minds of many of the local politicians. These politicians perceived light rail as an investment in the future and our progeny. It was the opinion of another key local official that San Jose is "blessed with political leaders who have a clear vision of the future they would like to see happen in the county and they have remained in office for 10-15 years - a very stable and constant political base." This local official then adds: "The technical factors have been important but secondary to this vision."

Conclusion

From the mid-1970's to the early 1980's, the San Jose area was booming economically. Growth was occurring at a phenomenal rate throughout the Guadalupe corridor and, especially, north of downtown San Jose in the Silicon Valley area. The area was anticipated to continue to prosper into the 1990's; however, area growth slowed considerably. Because of the projections of high growth and the resulting mid-1980's building boom, there was a three year surplus of office space.

The anticipated high growth of the Silicon Valley played an important role in the justification of light rail. When the technical analyses were being prepared, it was assumed that the area would continue to grow substantially.

This growth assumption, along with several other assumptions that have since proven to be inaccurate, resulted in a DEIS ridership estimate of approximately 45,000 riders per day in the year 1990 for both the busway and LRT. (In 1986, a revised estimate using new assumptions resulted in a year 2000 estimate of 20,000 riders per day -- less than half of the original estimate.) Although the two fixed-guideway alternatives were comparable in terms of ridership, the fact that the ridership value was high provided local officials with an additional reason to justify light rail. It was the local opinion that, because of high ridership, the operating costs associated with light rail would be lower due to the need for fewer vehicle operators.

The transit district has received negative press because of cost increases and schedule delays; however, transportation is still perceived as the number one issue in the entire county (far above crime and housing). Polls have also shown that the community continues to desire rail transit.

The availability of land in the corridor was an important factor in the decision to implement some form of fixed-guideway. In the southern portion of the project approximately 10 miles of freeway corridor had been masterplanned since the late 1950's. This availability of undeveloped land, much of which was already state or county owned property, prompted several earlier planning studies that ultimately led to the Guadalupe Corridor study. It was a local opinion, however, that the availability of land did not present an advantage of LRT over busway since both modes required the same amount of real estate.

Key cost-effectiveness analysis information for the Expressway/Busway and Expressway/LRT alternatives as presented in the Preferred Alternative Report are as follows (discount rate of 5 percent, year 1990 estimates, 1980$):

	Busway/Expwy	LRT/Expwy	Difference
1) annualized total cost per pass.	1.38	1.45	-4.8 %
2) incremental annualized cost per incremental pass.	1.29	1.88	-31.4 %
3) operation and maintenance (O&M) subsidy per pass.	0.75	0.70	+7.1 %
4) avg. 1990 O&M cost per pass.	1.21	1.17	+3.4 %
5) incremental annualized O&M cost per incremental pas.	0.36	0.17	+112.0 %

The LRT alternative is superior to the busway alternative in only three of the ten cost effectiveness measures, all relating to operations and maintenance costs, presented in the Preferred Alternative Report -- average 1990 operations and maintenance cost per passenger, annualized operations and maintenance cost per passenger, and incremental operations and maintenance cost per incremental passenger. Additionally, according to local sources, the rising costs and uncertain future availability of petroleum was an important factor in the decision to support light rail. It was estimated at the time of the DEIS that the local electricity supplier generated approximately 40 percent of their electricity by hydroelectric means (Ref 1).

It was the local opinion that both alternatives were economically comparable. A statement taken from the Preferred Alternative Report, however, emphasized the superiority of LRT in the operations and maintenance cost per passenger category by implying future LRT operations and maintenance costs may decrease beyond the 1990 estimate because "these cost-per-passenger costs, however, are only for a single point in time, 1990, and do not consider any future growth in transit ridership and resulting operating and maintenance costs beyond 1990" (Ref 1, p. B-22).

The decision to implement a light rail system in San Jose was primarily a local political decision made, in effect, prior to the results of the technical study. It was a local perception, however, that the technical study served a secondary function -- justifying LRT over busway based on the opinion that LRT was comparable to busway, not superior. In the eyes of many local officials, the LRT investment was an investment in the future of the city.

LRT received broad local political and public support throughout the decision process. Several pro-LRT members of the County Board of Supervisors also served on the County Transit District Board of Supervisors and the Board of Control for the Guadalupe Corridor Alternatives Analysis creating a strong base of political support for LRT. Several groups such as the MTS were very vocal in support of LRT alternatives while, on the other hand, community support for busways was somewhat non-existent (although there was substantial support for the construction of highways). Because of the somewhat universal support among the local constituency, Congressional support of the project was strong and the project was funded against the wishes of UMTA staff. This

strong base of public support and the local politicians pro-rail philosophy were the instrumental factors in deciding to implement LRT.

The local pro-LRT political position was bolstered by the results of the technical analysis. Although capital costs for the LRT system were substantially higher, the total costs, which included operations and maintenance costs, indicated that both alternatives were "good investment choices". Also, ridership among the two alternatives was essentially equal; however, the fact that the estimate was "high" tended to favor LRT over busway because of potentially lower operations and maintenance costs per person. This comparability of modes tended to, in effect, support the ultimate decision for LRT because the political and community support was present.

The LRT decision would probably have been more difficult if the results of the technical report tended to overwhelmingly support busway. The ridership estimates were made under the inaccurate assumption that fuel prices would continue to increase and that growth would continue at a high rate. Also, as a result of a state appropriation, the expressway segment of the preferred alternative was later upgraded to freeway standards -- dramatically increasing the capacity of an overcrowded highway system. If these new trends and the additional capacity of the highway system were taken into consideration, anticipated LRT ridership would have been lower and, as a result, the ultimate selection of light rail transit would have been much more difficult to obtain. A statement made by a local official best sums up the San Jose light rail decision process:

> "Certainly, our decision to build a light rail system could not be justified on an immediate economic payback requirement. It was by far the most expensive alternative in terms of capital costs. It's initial ridership expectations were marginal at best. But local political leaders were convinced, rightfully or wrongfully, that only light rail would give them the kind of future quality environment and land use pattern they wanted to see happen. And there was a realization that we're probably building this system for our children and grandchildren. But future generations would look back and thank us for the foresight and vision we had."

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SECTION III

TRANSITWAY CITIES

HOUSTON

Overview

The development of the transitway system was a result of the need to improve mobility in the rapidly growing Houston area. With population increasing by 50 percent between 1970 and 1983, Houston grew more rapidly than any city in the United States. Associated with this growth and increasing mobility problem between 1970 and 1983 are a 100 percent increase in the number of dwelling units, a 107 percent increase in employment, a 348 percent increase in office space, a 104 percent increase in the number of vehicle registrations, and a 141 percent increase in freeway vehicle miles travelled (Ref 1). Generally, the transitway was perceived as a cost-effective way to increase the people carrying capacity of the congested Houston freeways.

The Houston Metropolitan Transit Authority of Harris County, or METRO, is the transportation provider for the city of Houston and 14 neighboring cities and towns. The jurisdiction covers a 1,275 square mile area including most of Harris County. METRO was created in 1978 when Harris County voters opted to fund the transit district with a one percent sales tax.

As of FY 1988, METRO is operating 1,807 buses over 105 routes; 59 local routes, 23 commuter routes, 11 circulator routes, 8 cross-town routes, and 4 express routes. METRO is also operating 36.6 miles of what will eventually be a 75.5 mile transitway system. Total FY88 ridership for the METRO system is 76.3 million boarding riders and average weekday ridership of about 264,000 boarding riders.

Total revenue for METRO in FY88 is $277.9 million and total FY88 expenses $243.1 million. METRO FY88 operating revenue is $35.1 million with passenger revenue comprising $33.4 million, or 95 percent. Approximately 14 percent of METRO's total expenses are covered by passenger revenue. Additional METRO information is presented in Table A3 of the Appendix.

The Houston Transitway System

Description

Between 1970 and the early 1980s, Houston's rapid population growth created major congestion problems along Houston's freeways. In response to the success of busways developed in Los Angeles (the El Monte busway) and Washington D.C. (Shirley Highway), the transitway was perceived as a cost-effective means of providing a substantial decrease in passenger travel time and an increase in the people carrying capacity of the freeway corridor. As of 1985, busways such as the Shirley Highway high occupancy vehicle (HOV) lane, the El Monte Busway, and the North Freeway Transitway in Houston were handling from 30 percent to slightly over 40 percent of the total freeway passenger movement in a single HOV lane.

In Houston, a 75.5 mile transitway system is being developed as a part of Houston's regional transit plan (see Figure 11). As of August 1988, 36.6 miles of the system is operational. Transitways are currently being developed or are in operation along the following Houston freeways: I-45N (North Freeway), I-10W (Katy Freeway), I-45S (Gulf Freeway), U.S. 290 (Northwest Freeway), and U.S. 59S (Southwest Freeway). Future transitway development is also being planned along the U.S. 59N (Eastex Freeway) corridor.

As of March 1988, the North and Katy Transitways are carrying approximately 45 percent and 48 percent of the total freeway passenger movement, respectively. Figure 12 demonstrates the high utilization of the transitway compared with the three main lanes of the Katy and North Freeways. It is also estimated that upon completion of the entire transitway system, those persons using the transitway will experience a per trip travel time savings of (Ref 2):

Transitway	Time Savings (minutes)
North	27
Katy	21
Gulf	30
Northwest	23
Southwest	20

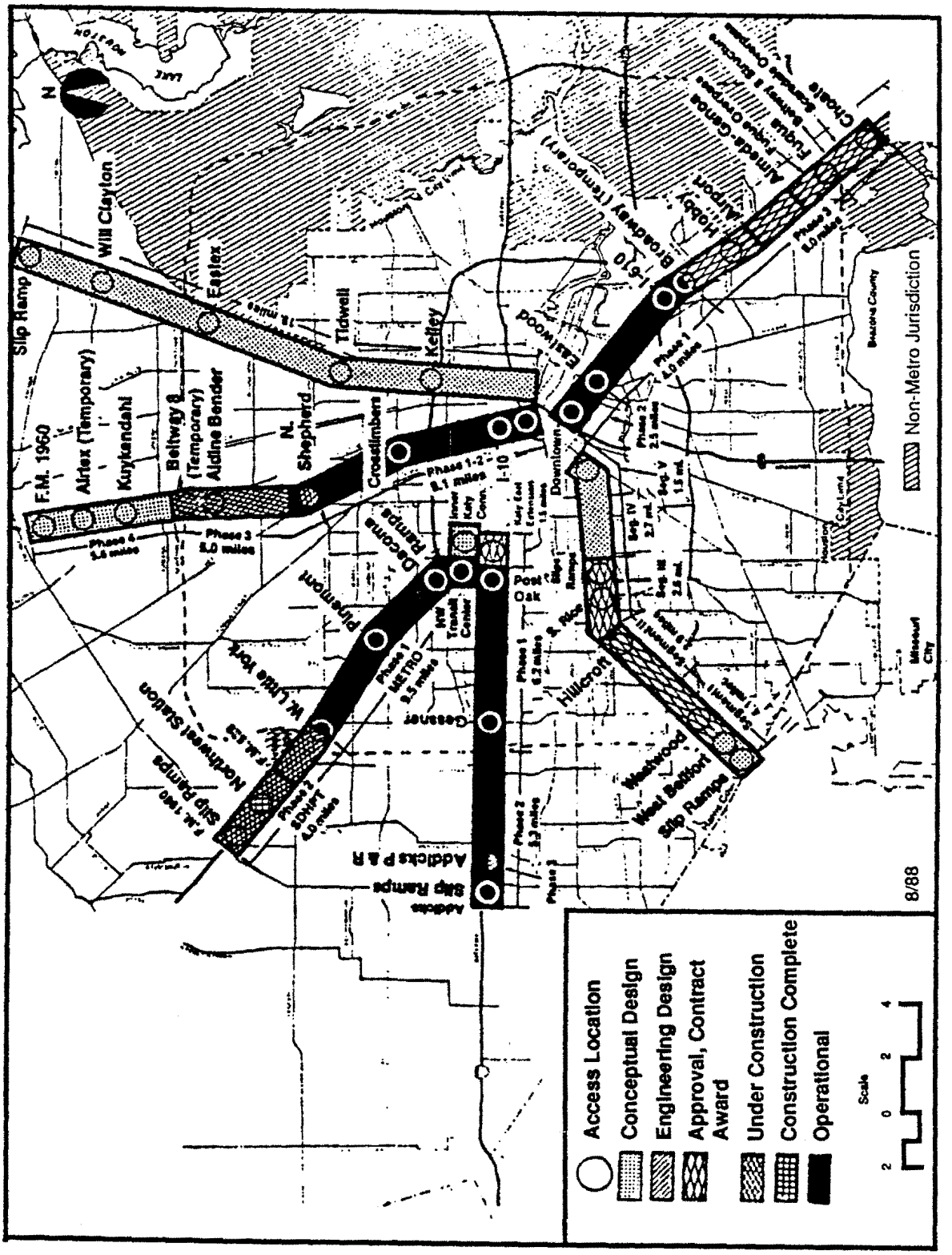

Figure 11: Houston Transitway System (Source: METRO)

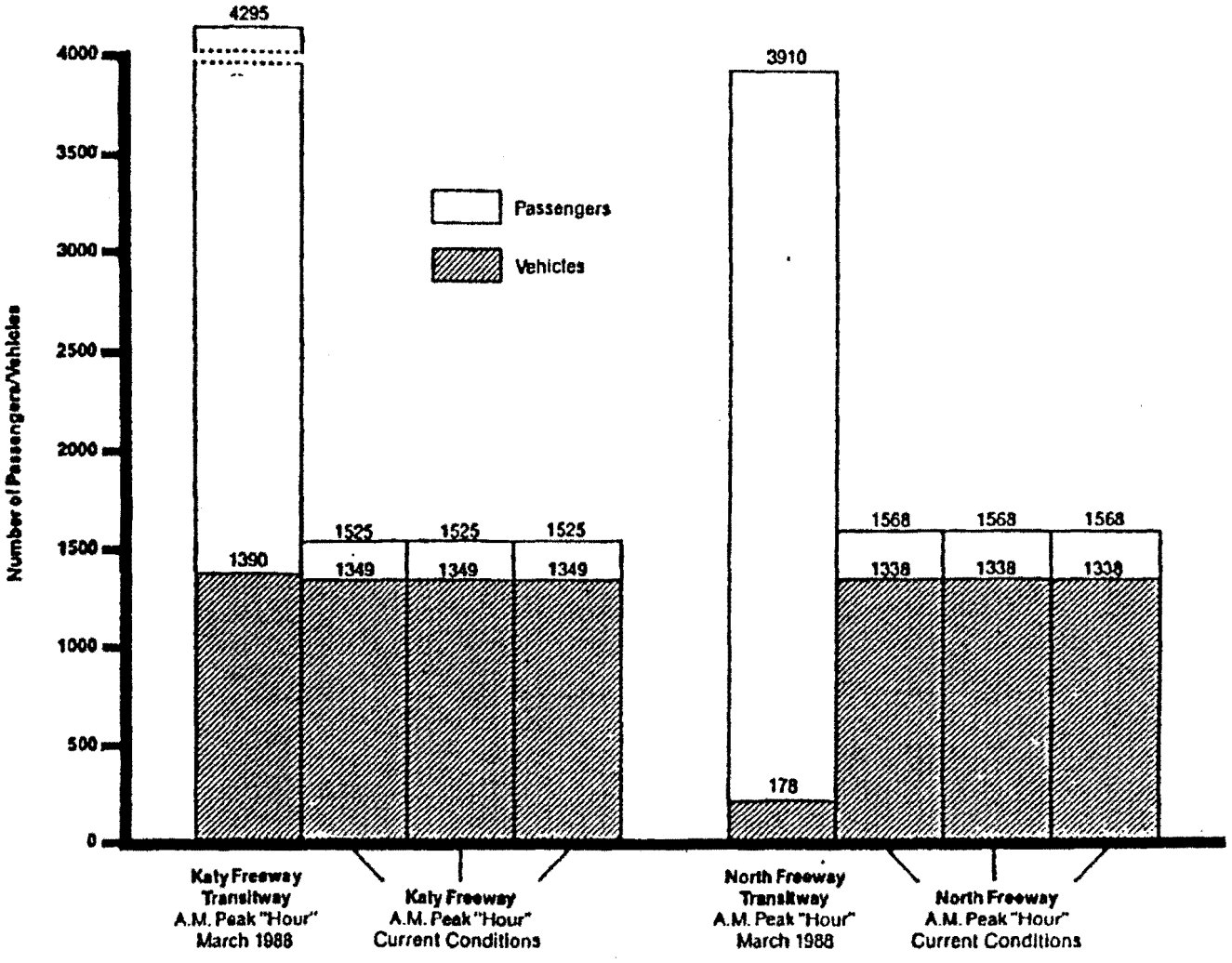

Figure 12: Transitway Lane Utilization (Source: METRO)

Each of the five Houston transitways are reversible, single-lane, barrier-protected facilities located within the median of existing freeways. Of the four operating transitways, the Katy, Gulf, and Northwest transitways allow buses, vanpools, and carpools of two or more persons. The North Freeway Transitway allows only buses and vanpools. Park-and-ride lots are connected directly to the transitways by ramps. Additional Houston transitway data is presented in Table A4 of the Appendix.

Historical Background

In the early 1970s, Houston began experiencing very high levels of congestion along the city's radial freeways. Limitations of right-of-way and the prohibitive cost of increasing freeway capacity by means of additional lanes indicated that some form of transit might help alleviate congestion and increase the capacity of the corridors. In 1969, it was envisioned by the Texas State Department of Highways and Public Transportation (SDHPT) that the construction of a barrier-separated, high-occupancy vehicle lane along the Gulf Freeway would be a quicker, more cost-effective means of achieving increased capacity rather than construction of additional freeway lanes.

Although the Gulf Freeway transitway was proposed in 1969, serious planning of the facility did not begin until the late 1970s and early 1980s. A primary factor in the eventual approval of the project, as well as the approval of an additional transitway located within the Katy Freeway corridor, was the scheduled rehabilitation of the Gulf and Katy Freeways whereby, during the reconstruction process, the freeways could be modified to accommodate transitways. Another selling point for the construction of the transitways was that additional right-of-way was not necessary.

When METRO took over operation of the transit system in 1979, METRO staff envisioned a heavy rail system as a means of reducing Houston's growing congestion problems. In June 1983, however, voters soundly rejected the building of a heavy rail line which was to be constructed along the Southwest Freeway. The citizens of Houston were unwilling to support a heavy rail system because it was perceived that few people would be served by the costly rail system. Also, the public generally had a low opinion of METRO. For

example, the agency was perceived as unwisely spending money by hiring an excessive number of consultants, and as uncaring and unresponsive in following-up on promises made in the late 1970s during the agency's formation.

Prior to the formation of METRO, UMTA agreed to fund the construction of a contraflow demonstration project in the North Freeway corridor. Project construction began in February 1978. The North Freeway contraflow lane was considered a success with bus and vanpool patrons achieving an average daily travel time savings of 15 minutes and passenger utilization growing from 1,450 person-trips to 4,600 person-trips per peak period during the first year of operation (Ref 3). Daily ridership increased from 2,900 daily passengers to 16,500 daily passengers during the period September 1979 to September 1983. The contraflow lane, however, was only an interim solution. Several studies indicated that in 1985 or earlier, off-peak travel demand would increase to the point that the contraflow lane would detrimentally affect off-peak traffic operations. Study findings offered the following options: 1) continue the contraflow lane for an indefinite period, 2) discontinue the contraflow lane without replacement, or 3) replace the contraflow lane with a transitway (Ref 3). Benefit/cost analyses indicated construction of a transitway was the best of the three alternatives.

In 1982, SDHPT and METRO agreed to develop a transitway within the median of the North Freeway as a portion of a project to rehabilitate the North Freeway. Several reasons given for the conversion of the contraflow lane to a transitway include: 1) the success of an established high occupancy vehicle lane in the form of the North Freeway contraflow lane, 2) the natural evolution of a transitway system resulting from extensive planning and development of the Gulf and Katy transitways, and 3) the failed rail referendum indicating the voters mandate against the development of a heavy rail system. Operation of Phase 1 of the transitway began in November 1984 (Ref 3).

The failure of the 1983 rail referendum had a direct effect on the development of transitways within the Northwest and Southwest freeway corridors. With the overwhelming defeat of the rail project, the agency was left without a transit project. As congestion grew worse and the agency's poor image deteriorated even further, METRO had to devise a quick solution.

In addition, a quick solution was necessary because METRO was about to lose federal discretionary funds earmarked for the rail project. The Northwest and Southwest Freeway transitways evolved as an alternative transit project rather naturally because Houston was currently heavily involved in developing transitways along the Gulf, Katy, and North freeways and had developed a strong working relationship with SDHPT. The Northwest and Southwest projects were similar to the other projects in that construction of the transitways would coincide with the rehabilitation of the freeways and additional right-of-way would not be needed.

The public's low opinion of the newly formed METRO was somewhat indirectly responsible for the eventual development of transitways in the North, Southwest, and Northwest freeway corridors. The public was dissatisfied with the fledgling agency because of unwise spending for consultants as well as studies which produced few results. It was also perceived that the agency was failing to deliver on promises made during the agency's formation. Because of the voters lack of faith in METRO, METRO's planned heavy rail system was rejected leaving transitways as the only alternative for the freeway corridors.

The North Freeway Transitway is being perceived publicly as a success because of high utilization by buses and vanpools. Initial low usage on the Katy Transitway resulted in a public outcry. In an attempt to increase transitway utilization, carpools of four or more persons were allowed to use the transitway. Utilization, however, remained insufficient so the agency allowed three or more person, followed later by two or more person, carpools. Now, the public seems more satisfied because people see the transitway being used.

Today the agency maintains a more positive image within the community. Both local service and commuter service has improved greatly since the early 1980s. For example, approximately 50 percent of the downtown destination along the North Freeway corridor arrives by way of the transitway. As a result, downtown employment has been enhanced because people feel they have a dependable trip along the transitway.

Conclusion

The potential use of a transitway along the Gulf Freeway was first envisioned in 1969. Because of the infeasibility of adding additional lanes within the restricted rights-of-way, the single-lane, barrier-separated transitway was viewed as a potential solution that would increase capacity of Houston's congested freeway corridors.

The decision to construct the Gulf, Katy, and North Freeway transitways was made during the economic boom of the late 1970s and early 1980s. The decision to develop the Northwest and Southwest transitways, however, were made during the economic downturn of 1984-85. During the boom periods, the transitways were touted as effective methods for reducing congestion problems along the freeways; however, during the economic downturn, a major selling point for transitways were their cost-effectiveness.

The development of transitways along the Gulf and Katy freeways, as well as the other transitways, was a result of the need to increase the capacity of the corridor within restricted right-of-way. An important selling point for the initial transitways approved for the Gulf and Katy freeways (as well as for the North, Northwest, and Southwest transitways) was that the transitways would be constructed in conjunction with the scheduled rehabilitation of the freeways. A lower transitway construction cost could, therefore, be realized. The support and cooperation of the Texas SDHPT has been instrumental in development of the transitways.

Federal support has been very positive. Congressional and UMTA support for the program has been excellent to the point that the Northwest and Southwest freeway transitway projects have been funded approximately 60 percent with federal discretionary grants involving congressional appropriations. Although federal support has been excellent, it is of the opinion of a key local individual that if Houston was denied federal funding, the Transit Authority or SDHPT would have found a way to continue the building program.

After the approval of the Gulf and Katy transitways, the remaining transitways evolved rather naturally because of SDHPT and METRO's new transitway philosophy. The development of a high-occupancy vehicle lane in the North Freeway corridor was natural because of the success of the North Freeway contraflow lane. Also, when Houston voters rejected METRO's proposed

heavy rail project in 1983, transitways remained the only viable alternative for increasing capacity within the remaining corridors. The decision to implement transitways within the Northwest and Southwest freeway corridors was made rather quickly so that federal discretionary funds would not be lost on the grounds that Houston no longer had a transit alternative.

Bob Lanier, Chairman of the Board for Houston METRO, has been instrumental in the development of transitways. As chairman of the Texas State Highways and Public Transportation Commission, Lanier strongly advocated the development of transitways as a cost effective means for increasing corridor capacity. Support for METRO's efforts were enhanced through the formation of an ad-hoc "Super-Group" consisting of the mayor, county judge, a member of the Texas State Highway and Public Transportation Commission, chamber of commerce, and METRO.

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LOS ANGELES

Overview

The southern California city of Los Angeles is located on the coast of the Pacific Ocean approximately 130 miles north of the Mexican border. The Los Angeles urbanized area, which covers 464.7 square miles, has a 1980 population of 3.0 million persons yielding a non-weighted population density of 6,385 persons per square mile (Ref 1). Los Angeles County, which contains the city of Los Angeles and many smaller communities, had a 1980 population of 7.5 million persons.

Transportation service to the City of Los Angeles and the 81 communities located throughout the 7.5 million persons Los Angeles County and neighboring counties is provided by the Southern California Rapid Transit District (SCRTD). SCRTD, the third largest transit authority in United States, operates a bus fleet of 2,577 buses over 240 bus routes and a 10.9 mile transitway for total route mileage of 2,630 miles (Ref 2). Total ridership for FY87 was 436.5 million boarding riders with a weekday average of 1.4 million riders.

Total FY87 revenue for the transit district was $490.1 million, less than the reported expenses of $500.5 million (excluding depreciation and loss on disposition of buses). The overall net loss when including bus depreciation and a June 29, 1986 change in the method of accounting for insurance liability claims was $42.3 million. Operating revenue of $200.9 million comprised 41 percent of the total FY87 revenue with passenger revenue ($189.3 million) accounting for 94 percent of operating revenue. Passenger revenue covered 38 percent of the total SCRTD revenue in FY87. Additional SCRTC data is presented in Table A3 of the Appendix.

The El Monte Busway

Description

The El Monte Busway is a 10.9 mile, two-way transitway operating along I-10 (San Bernardino Freeway) between the community of El Monte to east of downtown Los Angeles (see Figure 13). The $60 million facility (in 1972 dollars)

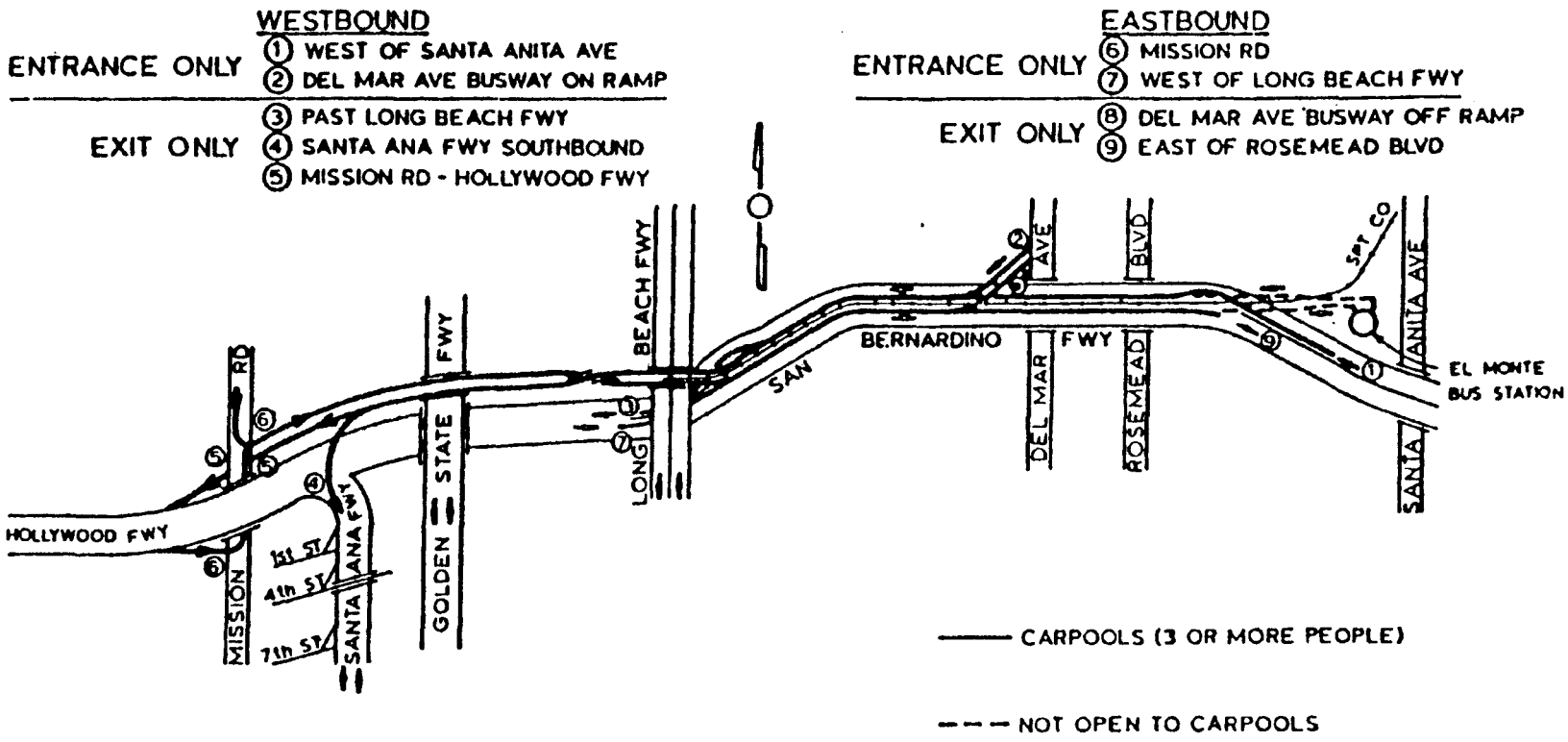

Figure 13: Los Angeles El Monte Busway (Source: CalTrans)

opened to buses in January 1973 and to carpools of three or more persons in October 1976 (Ref 3).

Beginning at the western extreme, the transitway operates along a separate alignment paralleling the westbound freeway lanes. After several miles, the westbound transitway lane crosses over the eastbound transitway lane and enters the freeway median for the remaining seven miles. While operating in the median, the 17 foot wide transitway lane and freeway are separated by a 10 foot shoulder and candlestick delineators. At the eastern extreme of the transitway, carpools enter the freeway while buses either enter the freeway or continue along a short extension ending at the El Monte Station.

Two on-line stations and one off-line station serve the El Monte Transitway. The two on-line stations are located along the westerly segment of the transitway at the Los Angeles County Hospital and at California State University at Los Angeles. A pedestrian bridge provides patron access to on-line station platforms. The El Monte off-line station, a unique 160 foot diameter circular structure, is a major transit center providing a large park-and-ride facility as well as timed transfer service to local bus lines. In 1988, the transitway accommodated approximately 22,000 transit riders per day (two-way) while total transitway passenger ridership (including carpools and vanpools) was approximately 41,000 riders per day (two-way). In comparison with total two-way passenger volumes along the transitway and freeway, approximately 38 percent of the total peak hour passenger volume and 30 percent of the peak period passenger volume operate on the transitway (Ref 1). A $21 million, one-mile extension connecting the busway with downtown Los Angeles is scheduled to be completed in early 1989. Additional El Monte Busway data is presented in Table A5 of the Appendix.

Historical Background

In the 1950s, the private transportation carriers of the Los Angeles region amalgamated into public ownership under the Metropolitan Transportation Authority (MTA) later becoming the Southern California Rapid Transit District (SCRTD). The conversion to the SCRTD in 1964 was conditioned by a mandate to develop a rapid transit system for the Los Angeles area (Ref 4).

It was not until the late 1960s that SCRTD planners and engineers considered constructing an exclusive express bus facility in the congested San Bernardino Freeway corridor (Ref 5). This corridor was selected as the busway sight primarily because of the need for a transportation improvement in the corridor and the presence of an infrequently used Southern Pacific railroad line operating just north of the freeway and in the wide freeway median. The railway right-of-way was made available after 18 months of negotiation between SCRTD, Southern Pacific, the Public Utilities Commission, and other affected governmental entities.

The project was funded by the Federal Highway Administration (FHWA), Urban Mass Transportation Administration (UMTA), California Department of Transportation (Caltrans), SCRTD, and the Southern Pacific Rail Co. The project, approximately 65 percent FHWA funded, became the first project of its kind to be granted federal highway funds. Prior to the funding agreement, FHWA Administrator Frank Turner personally visited the site. This high level involvement was instrumental in making federal Interstate funds available for transitways within a basically completed stretch of Interstate highway.

Conclusion

The decision to construct a busway in the San Bernardino corridor was based almost entirely on the availability of federal funding and adequate right-of-way rather than the result of transportation planning studies or analyses that have been required in recent years. In the words of a knowledgeable participant in the development of the El Monte Busway: "The El Monte Busway was not the result of an in depth study, addressing a broad range of policy issues. Rather, the project was a response to an opportunity created by the availability of right of way. Admittedly, the San Bernardino Freeway has long been congested during peak periods of travel and was a reasonable candidate for a busway." Also, ". . . the availa-bility of funding and real estate (right of way) were the determining factors in the implementation of the El Monte Busway."

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SECTION IV

NO-BUILD CITIES

COLUMBUS

Overview

The City of Columbus (1980 population of 564,871), the capital of Ohio, is located in Franklin County near the center of the State. The Central Ohio Transit Authority (COTA) comprises a 512 square mile service area and a service area population of approximately 895,000 persons.

At the close of FY87, COTA maintained a 342 vehicle bus fleet transporting 17.3 million boarding riders during the year. Average weekday ridership during this period totalled 67,300 boarding riders.

In FY87, total COTA revenue was $19.3 million and expenses totaled $34.8 million (excluding depreciation on assets). Passenger revenue ($6.0 million) covered approximately 17 percent of the Transit Authority's $34.8 million expenses. With depreciation ($5.4 million) included in the Transit Authority's total expenses, the district ended FY87 with a $20.9 million deficit.* Additional COTA information is presented in Table A6 of the Appendix.

Summary of the Fixed-Guideway Decision Process**

Since the mid-1970s, the Columbus metropolitan region has conducted several transportation studies examining the feasibility of a fixed-guideway transit system emphasizing transportation improvements in Columbus' North Corridor, an area experiencing rapid development and increasing congestion problems. Two such studies, A Long-Range Plan for Transit (1970) and Mid-Range Transit Development Concept for Central Ohio (1977), recommended the construction of a busway along an existing railroad right-of-way in the North Corridor. In response to the recommendations of "Mid-Range Transit Development Concept for Central Ohio", as well as additional earlier studies recommending similar

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* It should be noted that, because of striking vehicle operators and other union employees, COTA experienced a work stoppage between January 1 and February 9, 1987 .

** Information for this section was obtained from discussions with key COTA and MORPC personnel as well as the following reports: "North Corridor Transit: Solutions for the Future" and "COTA 2000 Long Range System Plan".

solutions, UMTA agreed in 1977 that additional study of the North Corridor was warranted. The report was accepted in fulfillment of the Systems Planning stage of the Alternatives Analysis process.

Four alternatives (Null or No-Action Alternative, TSM (Transportation Systems Management), Busway, and Light Rail Transit) were ultimately studied within the corridor. Early in the study process, however, UMTA disallowed continued analysis of LRT with federal monies because the alternative was not considered cost-effective (Ref 1). It was argued locally, however, that LRT should be included so that all available alternatives could be compared. As a result, MORPC and COTA, with the assistance of a consultant, continued to evaluate LRT with local funding. UMTA continued to disallow the inclusion of the LRT alternative contending that a number of incorrect and inconsistent study assumptions meant the LRT alternative could not even be accurately compared with the other alternatives. Later in the study process, the busway alternative also failed to pass UMTA's cost-effectiveness threshold criteria. Capital Costs, Operating & Maintenance Costs, and Year 2000 Daily Ridership estimates of the 1985 final planning report, "North Corridor Transit: Solutions for the Future", are presented as follows:

	Capital Costs (in 1983 millions)	Year 2000 Operations and Maintenance (in 1983 millions)	Daily Ridership (Year 2000)
Base	$22.6	$15.9	48,800
TSM	$30.3	$17.8	52,800
Busway	$76.1	$18.0	53,200
LRT	$159.2	$26.7	58,800

Neither fixed-guideway alternative was cost-effective because ridership estimates were too low in comparison to the anticipated capital expenditure. Related to high capital costs was a decision early in the study process to minimize neighborhood disruption and housing relocation. As a result, railroad alignments were considered as the most probable alignments for the fixed-guideway facilities; however, low residential densities within walking distance to the railroad alignments translated into low ridership. An additional barrier hindering ridership was created by an Interstate highway

paralleling the selected railroad alignment. The Busway Alternative (53,200 daily linked riders) generated only a one-percent increase in ridership as compared to the TSM alternative (52,800 daily linked riders). Although the LRT Alternative (58,800 daily linked riders) generated eleven percent higher ridership than the TSM Alternative, local officials felt that the capital spent on the LRT system would be disproportionately high compared to the ridership produced.

In December 1985, the Mid-Ohio Regional Planning Commission (MORPC) and the Central Ohio Transit Authority (COTA) released "North Corridor Transit: Solutions for the Future" as documentation of the results of the alternatives analysis. The report, however, did not recommend a specific alternative.

During the months before and after the December 1985 report, support for the entire project was waning. Local political support began to falter because federal funding did not appear to be forthcoming due to UMTA's dissatisfaction with both fixed-guideway alternatives. Also, unlike similar sized cities of the Northeast, citizens of Columbus do not view transit as a primary need. As a result, no official action was taken on a fixed-guideway system and applications for federal funding assistance were discontinued. In the words of one locally involved individual, the project "went out with a whimper".

Fixed-guideway alternatives were again studied in the "COTA 2000 Long Range Plan" completed in January 1988. During this study, each of the region's eight travel corridors were screened for transit compatibility. Using a generic fixed-guideway system operating under ideal conditions, each corridor was tested and evaluated against a standard set of criteria. The results of the initial screening indicated four corridors warranted additional study.

The next step of the study involved identification of fixed-guideway technologies and their applicability to the Columbus region. Using subjective judgment based on the general characteristics of the technologies and the Columbus region, the following guideway technologies were screened: rapid rail, LRT, monorail, Automated Ground Transport (AGT), Intermediate Capacity Transit, suspended rail transit, exclusive busway, and HOV freeway lanes. The guideway technology screening process indicated that LRT and AGT warranted further study.

The LRT technology was tested in two corridors where railroad right-of-way may be available. It was determined, however, that the LRT options were not feasible because of low patronage estimates. A conclusion of the report states that the existing rail lines hold little use as public transit guideways because of a lack of high density residential areas and employment centers necessary to generate sufficient ridership. Similar conclusions were found for the AGT alternative.

Conclusion

Beginning in the early 1980s, the Columbus region began planning for major fixed-guideway transportation improvements in the region's North Corridor. Study findings, however, indicated to UMTA that neither LRT or busway alternatives were, at that time, feasible in the Columbus region. Local support for the project was minimal because congestion was not extreme. It was also stated by a local individual that Columbus, which experienced substantial low-density growth following World War II, is very similar to the Sunbelt cities of the southwestern United States with respect to the difficulties of attracting transit patronage. As a result of the lack of federal and community support, local politicians did not, according to one local source, "take up the cause" and push for the implementation of the LRT or busway alternatives. The project "fizzled out" during the three months following the release of the 1985 planning report.

References

1. Mid-Ohio Regional Planning Commission and Central Ohio Transit Authority, "North Corridor Transit: Solutions for the Future", December 1985.

2. Mid-Ohio Regional Planning Commission, "COTA 2000 Long Range System Plan", January 1988.

MILWAUKEE

Overview

The City of Milwaukee, Wisconsin, which is located on the western shore of Lake Michigan approximately 87 miles north of Chicago, has a 1980 population of 636,000 persons. Approximately 66 percent of the population of Milwaukee County (1980 population of 965,000) lives in the City of Milwaukee. Transportation service for the Milwaukee metropolitan area is provided by the Milwaukee County Transit System operated and managed through contract with Milwaukee Transport Services, Inc.

As of December 1987, the Milwaukee County Transit System owned 553 buses operating over 50 routes totalling 1,329 miles. The Transit System boarded over 68.6 million riders during 1987 with total revenue and expenses amounting to $64.52 million. Operating revenue of $30.14 million accounted for 47 percent of the Transit System's total revenue. Passenger revenue ($29.41 million) accounted for 45 percent of the System's total expenses in 1987. Additional transit system data is presented in Table A6 of the Appendix.

Summary of the Fixed-Guideway Decision Process*

Beginning in March 1979, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) conducted an areawide transportation study of transportation needs in Milwaukee County and the surrounding area. The project was jointly funded by Milwaukee County, the Wisconsin Department of Transportation, and the Urban Mass Transportation Administration and guided by a 21 member Advisory Committee.

Initial work involved the development and analysis of maximum extent system plans for bus-on-freeway (express bus), exclusive busway, light rail transit (LRT), heavy rail transit, and commuter rail technologies as well as system plans for four alternative futures -- moderate growth, centralized land use

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* Information for this section was obtained from discussions with SEWRPC and UMTA personnel as well as the following documents: SEWRPC Newsletter, Vol. 21, No. 5, Sept-Oct 1981; SEWRPC Newsletter, Vol. 21, No. 6, Nov-Dec 1981; SEWRPC Newsletter, Vol. 27, No. 6, Nov-Dec 1987; and SEWRPC Community Assistance Planning Report Number 150, "A Rapid Transit Facility Plan for the Milwaukee Northwest Corridor", January 1988.

(most optimistic); moderate growth, decentralized land use; stable or declining growth, centralized land use; and stable or declining growth, decentralized land use (most pessimistic).

First stage analysis produced improved cost-effectiveness revisions to the system plans and an initial screening of transit alternatives. The initial analysis determined that a commuter rail system was only viable under the most optimistic future and also found that a heavy rail system could not be supported in the Milwaukee area because of high capital costs and under-utilization of the system's potential capacity.

Final analysis involved evaluation of the remaining technologies -- bus-on-freeway, busway, LRT, and commuter rail (analyzed under mod. growth - cent. land use only) -- using final system plans under each of the four alternative futures. The Advisory Committee concluded that, under each of the four future scenarios, the bus-on-freeway, busway, and LRT alternatives were very similar in terms of ridership (each within a range of two percent), potential levels-of-service, operating and maintenance subsidy requirements, environmental impacts, and systemwide energy consumption (LRT petroleum consumption 5 to 8 percent less than the busway plan and 8 to 11 percent less than the bus-on-freeway plan).*

It was also concluded that the only measurable difference between the three alternatives are total costs required for system implementation. Annual net public cost for the bus-on-freeway system in each future scenario, including capital costs and operation and maintenance costs, was between 14 percent and 21 percent lower than the busway plan. The LRT plan ranged between 7 and 10 percent more costly than the busway plan and 25 percent to 30 percent more costly than the bus-on-freeway plan (Ref 1).

Based on the study results, the bus-on-freeway plan was judged superior because of the lower costs associated with the plan. The Advisory Committee, however, believed that the LRT plan would dominate the bus-on-freeway plan if the intangible benefits of LRT (especially the potential to influence land development and redevelopment) were considered. Consequently, the Milwaukee County Executive and Board of Supervisors requested a study to determine how

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* Total fuel savings would amount to less than one percent of the total consumption of the Milwaukee area transportation system. (Ref 1)

express bus or LRT improvements would address transportation, land development and redevelopment needs of northern Milwaukee County.

Initiated in September 1984, the Milwaukee Northwest Corridor Rapid Transit Study evaluated six alternatives - three express bus alternatives and three LRT alternatives. Under step one of the evaluation, the three express bus alternatives and the three LRT alternatives were studied individually to determine the best alternative from each of the two technologies. Step two involved a comparative analysis of the best bus and best LRT alternatives.

An alignment utilizing an existing railroad line was selected as the best of three LRT alternatives. A primary factor in its selection as the best LRT alternative was a capital cost expected to be $3 to $4 million less expensive than an alignment along West Fond du Lac Avenue; and from $13 to $14 million less expensive than an alignment along North Sherman Boulevard (Ref 2). Although less costly and less controversial, the railway alignment is less accessible to patrons.

Public outcry against construction of an LRT line along Sherman Boulevard or West Fond du Lac Avenue was also a factor in the decision to select the North 33rd Street railway corridor as the best LRT alignment. In areas near the North Sherman Boulevard alignment, a division of the neighborhood by the light rail line prompted strong neighborhood opposition. Similarly, the business community strongly objected to the West Fond du Lac Avenue alignment primarily because of anticipated problems related to the roadway widening (i.e. construction inconveniences, loss of on-street parking, etc.).

In comparing the best LRT and express bus alternatives, express bus was determined superior with respect to direct costs and benefits. Compared with LRT, the express bus alternative was expected to provide annual operating cost savings of $2.1 million, an annual reduction in the operating deficit of $2.8 million, and a total capital cost savings of $166.7 million (Ref 2). Throughout the process, UMTA maintained that the LRT system was not cost-effective and could not be justified over the express bus option. Both alternatives, however, were similar with respect to levels of service and transit ridership.

It was determined that LRT would have a substantial effect on development along the LRT corridor. Corridor area development, however, would primarily involve relocation of existing business rather than attracting new businesses.

On October 1, 1987, the Milwaukee County Board of Supervisors, as recommended by the Advisory Committee, endorsed the planning report and the best LRT and best express bus alternatives. The Board also endorsed implementation of the express bus alternative. Key to the Board's decision to select the best express bus alternative (and not select the best LRT alternative) was federal support for a low-capital project and the non-controversial nature of the low-capital express bus alternative. The lack of a current State program to provide transit system capital assistance was also a local reason against implementation of the LRT alternative. The implementation of the best LRT alternative does remain an option for the future.

Conclusion

An areawide transportation study conducted in the early 1980s examined the feasibility of rapid transit (primarily express bus, busway, and light rail) in the Milwaukee area. The results of the study basically indicated the three transit alternatives were very similar for most of the criteria studied, except capital costs, where the express bus alternative was clearly superior. The Advisory committee recognized the express bus' financial superiority but also believed intangible benefits of LRT (primarily LRT's enhancement of land development and redevelopment) would make an LRT alternative competitive with an express bus service.

An additional study, designed to account for the intangible effects of LRT, was conducted to determine the feasibility of express bus and LRT in Milwaukee's Northwest Corridor. In choosing between three LRT alignments to be compared with the "best" of the three express bus alignments, two major factors were important -- availability of railroad right-of-way and a less controversial response from community and business factions.

In selecting the least controversial railroad alignment, the "best" LRT alignment would generate less ridership because it was not as accessible to

transit patrons; however, the capital cost of constructing a facility within railroad alignment was much less than the cost of the other two alignments.

Analyses indicated, as in the earlier study, that the express bus alternative was superior to the best LRT alternative. Also, the LRT alignment would promote business relocation rather than attract new businesses. Local support for the LRT alternative from the community and local politicians was neutral and federal support for the more capital intensive LRT project was non-existent.

References

1. Southeastern Wisconsin Regional Planning Commission, *Southeastern Wisconsin Regional Planning Commission Newsletter*, Vol. 21, No. 6, Nov-Dec 1981.

2. Southeastern Wisconsin Regional Planning Commission, *Southeastern Wisconsin Regional Planning Commission Newsletter*, Vol. 27, No. 6, Nov-Dec 1987.

3. Southeastern Wisconsin Regional Planning Commission, *Southeastern Wisconsin Regional Planning Commission Newsletter*, Vol. 21, No. 5, Sept-Oct 1981.

4. Southeastern Wisconsin Regional Planning Commission, "A Rapid Transit Facility Plan for the Milwaukee Northwest Corridor", Community Assistance Planning Report Number 150, January 1988.

SECTION V

SUMMARY AND CONCLUSIONS

Introduction

As indicated at the beginning of this report, one of the principal objectives was to identify critical evaluation criteria for selecting fixed-guideway systems. It was hoped that a series of threshold values could guide decision makers in the selection of fixed-guideway alternatives. The first part of this section reviews traditional evaluation criteria as documented by transit analysts and researchers. The second part presents findings and conclusions based on the case studies presented earlier. Generally, the CTR research team has found that cities do not use a set of criteria in making a decision to proceed or not proceed with a fixed-guideway system. Decision making is a process influenced by a variety of factors. Based on the case studies, a model of the decision process was developed. From this model, it is possible to identify factors critical to the selection of fixed-guideway alternatives.

Traditional Evaluation Criteria

In the widely referenced *Urban Rail in America: An Exploration of Criteria for Fixed-Guideway Transit* (1982, Indiana University Press) by Boris S. Pushkarev, Jeffrey M. Zupan, and Robert S. Cumella, the authors develop a set of threshold criteria at which fixed-guideway rail facilities become potentially feasible. Based on construction costs of 20 fixed-guideway facilities and associated passenger usage, a median construction cost of $1,250 (1977$) per weekday passenger-mile was determined to provide an indication of the value which public decision-makers put on fixed-guideway facilities. Assuming a $1,250 per weekday passenger-mile investment criterion, the following light rail consideration criterion were devised*:

1. Very-low capital (approx. $5 million construction cost per mile in 1977$), at-grade, minimum construction - 4,000 weekday passenger-miles per line-mile.
2. More adequate (approx. $9 million construction cost per mile in 1977$), 2/3 grade and 1/3 cut & fill - 7,200 weekday passenger-miles per line-mile.

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* It is important to note that these figures are in 1977 dollars. Accordingly, comparisons with these figures should be adjusted or qualified.

3. Substantial construction (approx. $17 million construction cost per mile in 1977$), 1/5 in tunnel with rest above ground - 13,600 weekday passenger-miles per line-mile.

After reviewing the decision histories of six cities choosing to implement fixed-guideway transit systems and two cities choosing otherwise, it has been determined that threshold values or criteria are not generally used in the fixed-guideway decision process. It has also been found that threshold values or criteria cannot be accurately contrived from the planning or operation of a facility because the decision is so heavily affected by issues other than the findings of the alternatives analysis. Also, upon preliminary engineering or after several years of facility operation, study findings are frequently found to be inaccurate. For example, Table 2 illustrates capital cost and ridership planning estimates in comparison with actual values incurred after construction or several years of operation. Without correcting for the effects of inflation, it can be seen that LRT capital costs were underestimated between 26 percent to 174 percent in each of the four cases studied. It is also seen that ridership planning estimates are quite different than actual current patronage. The San Diego South Line, with a planning estimate of 28,000 riders per day in 1995 and actual ridership of 23,000 riders per day in 1988, appears to be "on-line" in terms of ridership; however, it must be remembered that the South Line LRT facility is now a double-track line offering much higher capacity and level of service than the single-track facility that was originally planned and operated.

Model Of Decision Making

A conceptual model of decision making was derived from an analysis of the case studies. The findings indicate that evaluation of fixed-guideway systems is not a decision based on a set of criteria but rather is a complex interactive process. The basic components of the model, illustrated in Figure 14, are comprised of issues, actors, and ultimately decision. Issues are those factors affecting and influencing the actors. Actors are those persons, individually or collectively, actually making or strongly influencing the decision to implement (or not implement) a light rail system, transitway, or other transit facility improvement.

LRT System	Year Opened	Capital Cost Estimate ($ million)	Capital Cost Actual * ($ million)	Capital Cost % change**	Ridership Estimate	Ridership Actual (as of 1988)
Portland	1986	143 - (1977$)	214	50%	42,500 (in 1990)	20,000
Sacramento	1987	87.7 - (1980$)	176	101%	50,000 (in 2000)	14,000
San Diego (South Line, phase I)	1981	68.4 - (1978$)	86	26%	28,000 (in 1995)	23,000
Santa Clara / San Jose	1987	187 - (1980$)	511.5	174%	45,000 (in 1990)	6,200

Notes: * - Capital expenditures at opening of project.
** - % change in capital costs does not account for the effects of inflation

Portland - Estimates are from August 1980 FEIS

Sacramento - Estimates are from DEIS
Additional Cost Estimates - $112.7 (1981$) from Preferred Alternative Report
Additional Ridership Estimate - 20,500 riders per day in 1988 (FEIS)

San Diego - Cost Estimate represents capital expenses between 1978 and 1995 (represented in constant 1978$).
Cost Estimates taken from Preferred Alternative Report. Actual costs based on Phase I construction (includes SD&AE acquisition, single track, 14 vehicles, and construction)

Santa Clara / San Jose - Only 1/2 of system open as of June 1988.
Actual Capital Cost is actually the November 1988 estimate to complete the light rail project.
Cost Estimate from 1981 Preferred Alternative Report

Table 2: Comparison of Estimated and Actual Capital Costs and Ridership for LRT Case Studies

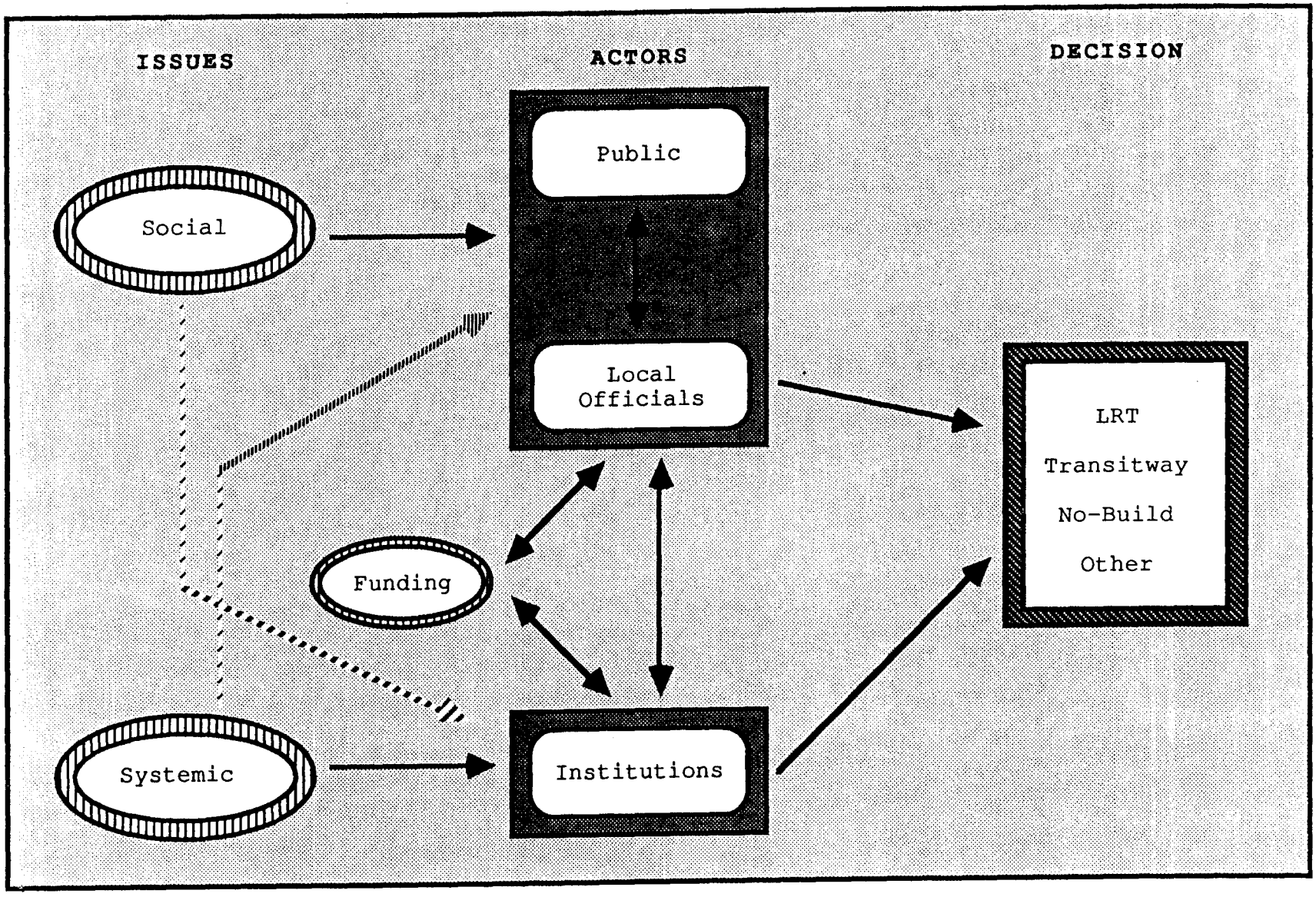

Figure 14: Fixed-Guidway Decision Model

Issues are defined as either social, systemic, or funding related. Social issues are those factors influencing the fixed-guideway decision that are primarily external to the planning and direct operation of the fixed-guideway facility. For example, the following may be considered as social issues: potential for economic development, land-use impacts (i.e. removal of housing or businesses), energy issues, and the current or anticipated state of the regional economy. On the other hand, systemic issues are the direct results of the planning study which affect decision making. Primary systemic issues are usually estimates of capital cost, ridership, and operating costs. Funding issues pertain to the availability of funding and the resulting effects on the fixed-guideway decision.

Actors are categorized as public, local officials, and institutions. The public is primarily the general population or constituency of a governmental jurisdiction as well as organizations such as special interest groups and community groups. Local officials, which are those persons primarily involved in the selection of the locally preferred alternative, are usually elected officials at the city and county level as well as transit Board members. Institutions are the federal and state funding agencies such as UMTA, FHWA, and the various state transportation departments and transportation commissions.

The various issues affect actors differently. Social issues primarily influence the desires and perceptions of the public and local officials who would directly benefit (or not benefit) from the implementation of a fixed-guideway system; however, institutions, which are seldom interested in social issues, primarily base their decision to support a project on systemic issues. For example, in each of the three federally funded LRT case study projects as well as the two "no-build" cities, UMTA did not support the construction of a fixed-guideway facility because the capital costs, operating costs, and/or ridership estimates (systemic issues), along with other factors, did not justify LRT over another alternative.

The availability of Funding affects the local level (public and local officials) as well as the institutions that control or make recommendations concerning the allotment of funds. Although the availability of funding is

important in the local decision to commit to a major investment, the local decision-makers have frequently proceeded with the decision to pursue LRT without the support of UMTA. Federal funding is later obtained through Congressional appropriations.

Interaction among actors is especially strong at the local level. Seldom have local officials made a decision to support or not support a major capital investment without the support of their constituency. On the other hand, local officials can also be effective in molding public opinion through the news media and community meetings. Interaction among institutions and local officials (and their agents or staff) is common throughout the project planning stages.

Issues

Systemic issues are those issues which generally pertain to the results of the technical study. Primary systemic issues are usually: ridership, capital costs, and operating costs.

For each LRT case study, actual light rail patronage appears to be lagging behind the ridership planning estimates which are dependent on a specified target year (See Table 2). These higher planning estimates usually justified LRT over the other alternatives primarily in one or two ways: outright superiority in terms of ridership and/or lower operating costs. In Portland, a high ridership estimate was strongly influenced by a ten percent rail "mystique" factor, anticipated high gasoline prices (which did not come about), and an unexpected recession that severely lowered anticipated population levels. Similar economic conditions in other cities resulted in a high ridership estimate for the LRT alternative.

In San Jose, the ridership estimates for both the busway and LRT alternatives were similar; however, the fact that the number was high tended to justify LRT over busway in terms of lower operating costs. Lower operating costs result from the need for fewer train operators, as compared to the number of bus operators, required to handle higher loads. Also, the LRT alternative was found to be superior to the busway alternative in only three of the ten cost-effective measures presented in the Preferred Alternative Report. All three measures were various operating and maintenance costs on a

per passenger basis. In Sacramento, operating costs were the only criteria in which LRT was judged to be superior. This factor was promoted heavily by local officials. The results, however, were based on study assumptions which, in conjunction with high ridership estimates, yielded overly optimistic values.

In each of the LRT cities, the capital costs of the completed facility was underestimated (See Table 2). Also, in both Sacramento and San Jose, the busway alternative was less expensive than the LRT alternative; however, San Jose promoted light rail by indicating that both alternatives were good investment choices. In Columbus and Milwaukee, LRT capital costs were higher than the other alternatives. The availability of right-of-way has been important in bringing down the capital costs as well as promoting the feasibility of implementing a fixed-guideway facility; however, in the cases studied, right-of-way availability did not necessarily promote the implementation of one form of fixed-guideway over the other.

Social issues are those issues which affect the fixed-guideway decision process but are primarily external to the study. These issues are commonly related to the economy, environment, or overall identity of the region.

The ability of LRT to focus and guide urban development was an issue touted by several cities including Portland and Sacramento. Also, the potential developmental impacts of LRT in Milwaukee was a primary reason for continued study of the feasibility of LRT in the Northwest Corridor even though initial studies indicated that LRT was not feasible due to excessive capital costs. UMTA did not support these local contentions.

Potential impacts on properties has been an important issue. In Portland, for example, public revolt against the construction of the Mt. Hood Freeway which would remove one-percent of the housing stock was a major impetus in mobilizing the effort to search for alternative forms of transportation. In Milwaukee, business and neighborhood group objections to two proposed LRT alignments that would either remove on-street parking or divide established neighborhoods led to the selection of a "best" LRT alignment that was inferior in terms of generating ridership.

Potential detrimental environmental impacts of buses has been an important issue in several instances. In Portland, City support for the busway began to

decline when it was determined that the downtown transit mall would be inundated by almost twice as many peak hour buses than the facility was designed to handle. Noise and air pollution would be extreme. In Sacramento, it was a local perception that not enough consideration was given to the superior environmental effects of LRT.

Energy issues have been a major consideration in the development of each of the four LRT systems. The decisions to implement the LRT systems were generally made during the late 1970s and early 1980s, a period when the availability and price of fossil fuels was questionable. Because of these uncertainties, the electrically powered LRT systems were more attractive in the eyes of the local decision makers and general public.

Freeway congestion has been a major issue that has sparked the need for transit improvements. In Houston, for example, the North Freeway contraflow lane and the transitway system was constructed as a solution to the heavy congestion resulting from rapid growth in the metropolitan area.

The intangible benefits of rail has frequently been touted as an issue that should be considered when conducting a study of transit alternatives. For example, Portland included a 10 percent increment of additional riders that would be attracted by the "mystique" of riding a rail vehicle; however, UMTA disallowed Sacramento the use of the same factor. Milwaukee cited the intangible benefits of rail such as the ability to enhance land development as the primary reason to continue studying the express bus and LRT alternatives.

The current and anticipated areawide economy has an effect on the local desire to invest in a fixed-guideway system. In San Jose, for example, Silicon Valley was growing at a high rate in the late 1970s and was expected to continue to "boom" into the 1990s. As a result of the expected growth, high ridership estimates tended to justify LRT over buses because of potential savings due to lower expected operating costs.

Funding

The model identifies funding as another important issue in the decision process. In truth, availability of funding ultimately determines whether a fixed-guideway system will be built. The funding can come from a variety of sources, but traditionally involves about 80 percent federal, 13 percent

state, and 7 percent local. However, there are many examples of local transit authorities using other funding approaches. San Diego, for example, wanting to avoid certain regulations and requirements, did not pursue UMTA funding support.

The funding issue and its interplay with the different actors is demonstrated in the Sacramento case study. During and following the evaluation process, UMTA voiced opposition to the LRT alternative, arguing the high costs and low ridership could not justify the implementation of LRT. Local officials, however, overcame UMTA objections by generating congressional support. Local and state officials lobbied Capital Hill to support funding of their LRT. Resulting legislation by-passed UMTA objections forcing UMTA to relinquish funds for the LRT project.

Actors

The second part of the model focuses on the actors involved in the decision making process. Generally speaking, the public are the citizens, individually and collectively, of a community or jurisdiction. Their importance as actors are demonstrated in a number of the case studies. In Houston, for example, propositions for heavy rail were soundly rejected by voters, forcing Houston Metro to consider other less expensive alternatives.

Included in the public category also are business, special interest and community groups. The impetus for LRT in Sacramento began with the Modern Transit Society (MTS), a pro-transit organization. This special interest group was formed from a number of community groups opposed to construction of new freeway routes in Sacramento. MTS effectively pressured the Sacramento County Board of Supervisors to abandon new freeway construction in several areas and assisted in the North-East Transportation Task Force efforts culminating in a recommendation for examining the feasibility of light-rail. At the other extreme, neighborhood groups along the North Sherman Boulevard in Milwaukee effectively voiced strong opposition to a proposed rail-line. Business groups fearing patron inconveniences due to construction and loss of on-street parking, similarly opposed a rail alignment along West Fond du Lac Avenue.

The public is a critical actor in the decision process for fixed-guideway and other transit alternatives. The case study analysis indicates that when public support was lacking, fixed-guideway systems were not developed, and where support was strong, fixed-guideway systems were implemented.

The second group of actors involved in the decision process are local officials. Local officials are the persons, boards, or other entities responsible for conducting or coordinating transit planning and alternatives studies, approving or disapproving transit plans, determining funding sources, etc. Public officials are the elected or appointed agents of the community.

The importance of local officials and the range of their influence is shown in the historical background of each of the case studies. For example, Neil Goldschmidt, first as Mayor and later as Transportation Secretary, was instrumental in the development of the MAX. Without his efforts it is unlikely that the MAX would be in operation today.

The final group of actors important in the decision model are institutions. This group consists of federal and state officials, including the UMTA, FHWA, the Congress, state transportation commissions and departments, and governors. UMTA is an important actor in that they control distribution of important financial resources for transit systems. In nearly every case study, UMTA played a role, positive or negative, in the decision to build or not build a fixed-guideway system.

Likewise, state officials influenced the decision process. California Governor Jerry Brown's pro-transit views, were instrumental in making state transit funds available for light-rail transit systems. Similarly, the support of Governor Straub of Oregon and his decision to support the withdrawal of freeway funds and their transfer to a fixed-guideway project was critical to the development of the MAX.

The model indicates that in addition to being influenced by issues, the actors also are influenced by each other. This is to say the public can influence public officials and institutions, local officials can influence institutions and the public, and institutions can likewise influence the public and local officials. None of the actors operate separately, but instead operate in a complex inter-relationship. As noted earlier, the decision to move forward with LRT in Sacramento was influenced significantly

by the MTS. Local officials were motivated by the activities of this public group and their perception of strong community support for rail transit. Likewise local officials were influenced by the Governor's office and his decision to offer funding for a light-rail feasibility study.

Summary and Conclusion

The model reveals that the activities and interaction of the actors, particularly the public and local officials, is a critical stage in the evaluation of fixed-guideway systems. The interplay of these groups is political. In fact, the interaction between the different groups is the nature of the political process. Prior to the decision of committal or non-committal to a fixed-guideway system, these groups are guided by a range of social and systemic issues, both perceived and actual.

At some point, the principal advocates of a fixed-guideway system -- one of the three actors, generally the public or local officials -- perceive significant social or community benefits to a fixed-guideway system. In some instances, the benefits are in response to immediate needs, i.e., traffic congestion, and in other instances the benefits are seen in the future. Regardless, particular actors become motivated to support a fixed-guideway system. Generally, this motivation is translated into transit studies, mobility plans, corridor impact studies, etc. During this process systemic issues assume greater importance. Capital and operating costs and projected ridership values influence to a large degree the availability of funding, especially federal funds.

Systemic issues guide primarily the institutions in their decision making. The dotted line in the model indicates that systemic issues impact local officials and the public to some degree. Local officials recognize that the systemic issues determine, in large part, the availability of funding. This is particularly true in the Portland example, where original ridership estimates were overly optimistic then after receiving funding, were re-estimated at a very low level. After the first year of operation actual ridership was reported as exceeding projections, though far below the original estimates used in the analysis of fixed-guideway alternatives. Additionally, systemic issues are important when they are related to other social benefits.

Regardless, the decision to support a fixed-guideway system is generally made prior to estimates of ridership and system costs.

Likewise social issues influence the institutions, although for UMTA, generally they are not evaluated as important decision criteria. UMTA focuses on the systemic issues.

Based on the model and the analysis of case studies, several important conclusions can be drawn:

1. The decision to commit to fixed-guideway systems is often determined by perceived social benefits that may or may not result, and is frequently not the product of an objective analysis of alternatives.
2. Public support for a fixed-guideway system is critical. This support is generally developed during the process of analyzing fixed-guideway alternatives. Lack of support or strong opposition generally results in a "no-build" situation.
3. Funding availability ultimately determines whether the fixed-guideway system is approved. In instances where local support was strong, barriers to federal support were overcome and in situations where funding was readily available, the public was inclined to support.
4. There is not a set of critical threshold values that officials use in selecting transit alternatives, including no-build scenarios. Instead, the decision process is dominated by political interaction among local, state, and federal officials guided by social benefits and systemic issues to influence funding for transit alternatives.

APPENDIX

The Appendix contains tables of additional case study information. Table A1 contains transit system information for each of the LRT case studies while Table A2 contains information specific to each LRT system. Table A3 contains information pertaining to the Houston and Los Angeles transit systems while Tables A4 and A5 contain information specific to the Houston transitways and El Monte Busway, respectively. The final table, Table A6, relays systemwide information for the "no-build" cities, Columbus and Milwaukee.

	Portland	Sacramento	San Diego	Santa Clara
GENERAL				
--transit operator	Tri-Met	SRTD	MTDB*	County Transit
--service area Population	1,245,000	905,500	1,560,000	1,432,000
--service area (sq. miles)	725	340	570	326
ROUTE INFORMATION				
--number of routes (bus / LRT)	71 / 1	76 / 2	55 / 2	77/1
--total one-way miles (bus / LRT)	770 / 15.1	843 / 18.3	865 / 20.4	1396/20.3
VEHICLES				
--number of buses	594	200	363	526
--number of rail vehicles	26	26	30	50
RIDERSHIP				
--avg. weekday boarding riders	162,700	56,957	137,261	118,432
--avg. Saturday boarding riders	76,400	21,561	not available	
--annual boarding riders	48,240,000	15,052,000	39,359,000	35,220,000
OPERATIONAL (annual data)				
--total revenue ($-million)	86.40	36.14	54.05**	156.53
--operating revenue ($-million)	23.52	9.21	not available	11.34
--passenger revenue ($-million)	21.12	8.73	25.66	11.34
--total expenses ($-million)	77.28	34.56	55.21	114.30
--pass. rev. / total expenses (%)	27	25	46	10
--total expense ($) / boarding rider	1.60	2.30	1.40	3.24
--total expense ($) / vehicle mile	3.54	4.25	3.44	4.96
--total revenue hours	1,169,460	470,520	1,069,655	1,390,000
--total vehicle hours	1,545,456	522,240	1,123,400	1,534,980
--total revenue miles	18,960,000	6,853,950	15,213,476	19,500,000
--total vehicle miles	21,840,000	8,131,800	16,071,500	23,054,441
--rev. hrs / vehicle hrs (%)	75.7	90.1	95.2	90.6
--rev. miles / vehicle miles (%)	86.8	84.3	94.7	84.6
--vehicle miles / vehicle	37,632	36,000	41,208	40,024
--vehicle hours / vehicle	2,664	2,316	2,859	2,665
--boarding riders / revenue mile	2.54	2.20	2.59	1.81

* only MTDB fixed-route operators are represented

** total fare revenue and government subsidy for all MTDB fixed-route operators

Table A1: Systemwide Statistics and Information for LRT Case Studies (FY 1988)

	Portland	Sacramento	San Diego	Santa Clara ++
GENERAL [line1 / line2 (total)]				
-name of LRT system	MAX	Metro	Trolley	Guad. Corridor LRT
LINE INFORMATION				
-number of lines	1	2	2	1
-date of revenue service	Sept. 86	Mar 87 / Sept 87	July 81 / Mar 86	1st seg. - Dec 87
-line names	MAX	N.E. / Folsom	South / Euclid	Guad. Corridor LRT
-total one-way mileage	15.1	18.3	15.9 / 6.2 (20.4)*	20.3
-project total cost ($-million)	214.0	176.0	116.6 / 33.6	511.5 ##
-cost ($-million) / mile	14.2	9.6	7.3 / 7.5	25.2 ##
-number of stations	27	28	18 / 10 (22)*	33
VEHICLES				
-number of LRT vehicles	26	26	24 / 6 (30)#	50
-cost / LRT veh. ($-million)	0.969	0.945	0.85 to 1.1	0.94
RIDERSHIP				
-avg. wkdy. boarding riders	19,600	12,876	29,000	6,200
-avg. Sat. boarding riders	19,800	3,181	30,000	
-annual boarding riders	6,600,000	3,116,000	9,280,616	360,000
OPERATIONAL (annual data)				
-fare revenue ($-million)	3.20	1.74	7.16	+
-operating cost ($-million)	5.46	6.81	8.28	11.40
-fare recovery ratio (%)	59	26	86	+
-oprtng. cost $ / brdng. rider	0.82	2.18	0.89	+
-oprtng. cost $ / psgr. car mile	3.25	7.08	3.82	+
-passenger car revenue hours	87,456	47,000	116,000	+
-total passenger car hours	110,808	53,658	119,300	+
-passenger car revenue miles	1,661,520	936,104	2,100,000	+
-total passenger car miles	1,680,000	961,523	2,170,000	+
-rev. hrs / total hrs (%)	78.9	87.6	97.2	+
-rev. miles / total miles (%)	98.9	97.4	96.8	+
-passenger car miles / vehicle	64,620	36,981	72,333	+
-passenger car hours / vehicle	4,260	2,064	3,977	+
-brdng. riders / revenue mile	3.97	3.33	4.42	+

* South and Euclid lines share 1.7 miles of common track and six stations in Centre City.
# 41 additional vehicles on order
(11/88 cost estimate) $44.6 million transit mall not included; $15 million in escrow is included.
+ Since the system is in start-up this data would be meaningless.
++ As of June 1988, only 1/2 of the system is operational.

Table A2: LRT Statistics and Information (FY 1988)

	Houston (FY 1988)	Los Angeles (FY 1987)
GENERAL		
--transit operator	Metro	SCRTD
--service area Population		
--service area (sq. miles)	1,275	2,280
ROUTE INFORMATION		
--number of transitways	4 with 1 under design	1
--total transitway mileage	36.6 in operation *	10.9
--total number of routes	105	240
--total route mileage		4,992
NUMBER OF BUSES	1,807	2,630
RIDERSHIP		
--avg. weekday boarding riders	263,785	1,395,000
--annual boarding riders	76,252,000	436,507,000
OPERATIONAL (annual data)		
--total revenue ($-million)	277.91	490.1
--operating revenue ($-million)	35.13	200.9
--passenger revenue ($-million)	33.40	189.3
--total expenses ($-million)	243.07	500.5
--pass. rev. / total expenses (%)	14	38
--total expense ($) / boarding rider	3.19	1.15
--total expense ($) / vehicle mile	6.58	4.64
--total revenue hours	1,990,000	7,256,000
--total vehicle hours	2,348,000	7,876,000
--total revenue miles	29,897,000	92,662,000
--total vehicle miles	36,955,000	107,780,000
--rev. hrs / vehicle hrs (%)	84.8	92.1
--rev. miles / vehicle miles (%)	80.9	86.0
--vehicle miles / vehicle	20,450	40,980
--vehicle hours / vehicle	1,300	2,990
--boarding riders / revenue mile	2.55	4.71

* As of Aug. 1988, the total constructed and planned system is 75.5 miles.

Table A3: Systemwide Statistics and Information for Transitway Case Studies

	North (I-45)	Katy (I-10)	Gulf (I-45)	N.W. (U.S. 290)	S.W. (U.S. 59)	Total
Transitway Length						
--in operation (mi)	9.1	11.5	6.5	9.5	-	36.6
--under const. (mi)	5.0	-	-	4.0	-	9.0
--design (mi)	5.6	1.5	9.0	-	9.6	25.7
--proposed (mi)	-	-	-	-	4.2	4.2
--total completed length (mi) **	19.7	13.0	15.5	13.5	13.8	75.5
Park-and-Ride lot capactiy	6,721	4,058	5,377	3,422	3,715	23,293
Transitway Ridership						
--passengers/day (all modes) (as of 3/88)	14,676	18,398	5,622	not available	not available	
--passengers/day (all modes) (year 2000)	35,000	22,000	21,000	25,000	31,000	134,000
Funding ($-million)						
--UMTA Section 3 & 5	65.0	0.4	-	40.5	64.5	170.4
--UMTA Section 9	13.0	7.0	-	26.5	-	46.5
--Metro	63.1	44.8	20.2	43.1	19.0	190.2
--SDHPT	-	3.0	80.0	7.2	14.8	105.0
--Total Cost	141.1	55.2	100.2	117.3	98.3 *	512.1
Transitway Cost Per Mile ($-million)	7.2	4.2	6.5	8.7	10.2 *	7.2
Opening Date of First Segment	Nov. 1984	Oct. 1984	May 1988	Aug. 1988	Summer 1992	
Opening Date of Next Segment	Fall 1989	Summer 1989	Summer 1992	Summer 1989		

*Cost for proposed 4.2 mile extension is not included.

** Total includes cost of associated park-and-ride and transit center facilities.

Table A4: Houston Transitway Information as of August 1988 (Source: Metro)

Construction Cost (1972$)	$60 million
Length	10.9 miles
Service Initiated	1973
Funding Breakdown --UMTA --FHWA --Caltrans --SCRTD --Southern Pacific Rail Co.	 17% 65% 8% 8% 2%
Cost of one-mile extension (1987$)	$21 million
Ridership at opening (passengers per day)	1,000
1988 Transit Ridership (passengers per day) 1988 Total passenger daily ridership (including carpools and vanpools)	22,000 41,000
Farebox recovery (avg of the 19 bus lines using the transitway)	31%

Table A5: El Monte Busway Information (Source: SCRTD)

	Columbus *	Milwaukee
GENERAL		
--transit operator	COTA	Mil. County Transit Syst.
--service area Population	895,000	965,000
--service area (sq. miles)	513	
ROUTE INFORMATION		
--total number of routes	63	50
--total route mileage		1,329
NUMBER OF BUSES	342	553
RIDERSHIP		
--avg. weekday boarding riders	67,300	not available
--annual boarding riders	17,357,000	68,640,000
OPERATIONAL (annual data)		
--total revenue ($-million)	19.3	64.52
--operating revenue ($-million)	6.5	30.14
--passenger revenue ($-million)	6.0	29.41
--total expenses ($-million)	34.8	64.52
--pass. rev. / total expenses (%)	17	45
--total expense ($) / boarding rider	2.00	0.94
--total expense ($) / vehicle mile	3.61	3.45
--total revenue hours	696,171	1,450,000
--total vehicle hours	704,851	1,552,000
--total revenue miles	9,548,730	16,773,000
--total vehicle miles	9,649,505	18,683,000
--rev. hrs / vehicle hrs (%)	98.8	93.4
--rev. miles / vehicle miles (%)	99.0	89.8
--vehicle miles / vehicle	28,215	33,785
--vehicle hours / vehicle	2,060	2,806
--boarding riders / revenue mile	1.82	4.09

* Work stoppage from January 1, 1987 to February 9,1987.

Table A6: Systemwide Statistics and Information for "No-Build" Case Studies (FY 1987)