

# Light Rail Transit in San Diego: The Past as Prelude to the Future

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In San Diego a bare-bones and simple light rail transit (LRT) system has grown into a maturing, expanding rail system. Key decisions made in the development of a growing LRT network in San Diego have guided the operating performance of the system over the past 10 years and are shaping its future. The maturation of the system, together with ridership growth, has influenced a change in design criteria and operating features.

The San Diego metropolitan area, with a population of about 1.8 million people, includes 10 cities of which the largest is the city of San Diego. The area has grown considerably since World War II, and population forecasts for the year 2010 project a metropolitan area population in excess of 2.2 million residents.

The San Diego Metropolitan Transit Development Board (MTDB) is responsible for setting transit policy and developing public transit facilities within this metropolitan area. MTDB was created in 1975 by state legislation authored by Senator James R. Mills, chairman of MTDB since 1985. Legislated provisions provided MTDB with broad-based and important powers with regard to public transit coordination, planning, and capital project programming for the metropolitan area (1,2). These transit responsibilities provided MTDB with the powers of implementation and financing that "put teeth" into the guideway development functions. A retrospective look shows that, along with the successful growth of light rail transit (LRT) in the San Diego metropolitan area, a parallel, positive, and gradual expansion of MTDB's role outside the individual project development area has occurred.

## DEVELOPMENT OF THE SAN DIEGO LRT SYSTEM

Overall LRT project development had roots in studies carried out by the San Diego Comprehensive Planning Organization (MTDB's long-range planning partner, now called the San Diego Association of Governments, or SANDAG) in the early 1970s. Substantive MTDB technical guideway planning work began in late 1976 and culminated in opening the first increment of service in July 1981 (3-5). Generally based on UMTA's decision not to provide financial assistance for a proposed rail system in the Denver metropolitan area, MTDB early on decided to build a system using only local and state financial resources (6). In retrospect this funding decision

became a significant advantage in that, to a very large degree, it placed decision making almost totally at the local level. In turn responsibility and accountability were centralized with MTDB members and management. This centralized control not only aided efficient decision making but, with an MTDB policy that linked individual pay raises with adherence to project budget and schedule objectives, also created a significant incentive for management to produce.

MTDB has become the planner and developer of public transit services and facilities in the San Diego metropolitan area and functions as an umbrella agency. It owns the assets of San Diego Transit Corporation (SDTC) and San Diego Trolley, Inc. (SDTI), both of which were formed under California law as nonprofit public corporations. In addition, MTDB owns the San Diego & Arizona Eastern Railway Company (SD&AE), a Nevada railroad corporation that covers 108 mi and 2,000 acres of property. The operations and maintenance of the two transit services and of the freight railroad are all handled through specific agreements with each of the three separate operating organizations. All day-to-day functions, labor matters, and maintenance are managed by the individual operating corporations.

The MTS (Metropolitan Transit System) is also under policy control of MTDB and not only includes SDTC and SDTI, but also several other municipal operators. Under MTDB, unified policies exist to foster high-quality transit services in the areas of fares and passes (7), telephone information, regional marketing, and route numbering.

## Design Criteria

In late 1976 MTDB adopted principles for low-cost implementation of guideway transit in San Diego. These principles formed the basis for the eventual initial LRT starter line and primarily called for the following:

1. A corridor that extends a relatively long distance and provides opportunity for high-speed operation;
2. A line with low capital cost;
3. A line primarily at grade and primarily in exclusive right-of-way; and
4. A system with low operating costs and high probability of meeting operating costs with farebox revenues.

These principles eventually led to Board Policy No. 1, which provided the foundation for the system-design criteria applied to the initial South Line LRT Project. The next step in the process was the evolution of site-specific design criteria after

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the planning work was completed. In preparation for engineering activities these criteria, adopted by MTDB in three workshop meetings in late 1978 and early 1979, provided the basis for design of the South Line LRT Project (8–10). These early criteria were general and performance-oriented, but proved workable at the time. They were effective in the sense that they provided the necessary direction for management to carry out the project. They have, however, proved to be too general as the system has matured and new extensions have come on line (11–17).

The original criteria have been brought up to date, made more comprehensive, and made more explicit. Examples of several significant changes in the design criteria over the past 12 years, and adopted by MTDB in 1991 (18,19), include

- Use of concrete ties instead of wood ties;
- Use of standardized rail size (115 lb);
- Widened passenger station platforms;
- Use of rubber crossing material instead of cast-in-place concrete;
- Installation of additional track crossover switches, providing more flexibility for train operations;
- Predominant use of single-pole (center), steel traction power supports;
- Strategic placement of pocket (turn-back) and passing tracks;
- Higher performance vehicles and addition of total climate control (heat, ventilation, and air-conditioning system);
- Gradual introduction of train-to-wayside signaling; and
- Smaller but more powerful traction power substations.

### Light Rail Transit Selection

Using MTDB's principles and comparing them with the modal options available led to selection of LRT technology as the most practical guideway alternative in 1977. After a tour of North American and European systems and an evaluation of options, LRT was judged to be suitable to the environmental, density, and transportation demands of the San Diego region (20). Further LRT's flexibility in allowing construction to fit within existing transportation rights-of-way, built-up communities, and undeveloped areas seemed to make it a logical choice. On the other hand MTDB was faced with numerous skeptics. Some pointed to the problems that Bay Area Rapid Transit (BART) was having in achieving its objectives (this project, too, was initiating service in California during the 1970s). Others brought up such things as the past problems with streetcars, the flexible and low-capital cost advantages of buses, and the public being enamored with people movers and monorails. But, in the end, MTDB made a unanimous decision to go with LRT (21).

### Fare Collection System

MTDB's examination of successful European transit systems revealed the need for simple station facilities and a fare collection system with minimal personnel requirements. In another key decision, risky at the time, MTDB opted for the barrier-free proof-of-payment (POP) or self-service fare col-

lection approach becoming prevalent in Europe (21–23). At the time, skepticism seemed to be widespread concerning the practicality of the POP system. The perception seemed to be that people in the United States were less honest than people overseas. As it turned out, POP fare collection has worked well and has not resulted in unacceptable fare evasion rates. Results with San Diego trolley continue to show evasion rates hovering around 1 percent with inspection rates of roughly 25 percent. Further, initial capital and longer-term operating cost savings are significant (24–29).

### Coordination

Perhaps because of MTDB's broad role in public transportation development and planning, the organization recognized that to ensure success any rail transit line had to be an integral part of the overall regional transit network. In parallel with design and construction efforts, MTDB decided a coordinated bus feeder plan for the South Line LRT Project rail would be implemented when rail service began (30). In addition fare and transfer policies were established that would permit passenger transfers among all MTS rail and bus operators (of which there are now seven) and implementation of an MTS regional pass system (7). This coordination has not only made the regional system healthier but also has been instrumental in helping ridership and fare revenues grow for each of the MTS operators. In 1978 total MTS operating revenues (i.e., fares) were 30 percent of operating costs, whereas projections for 1992 indicate that the figure may exceed 52 percent. This positive economic trend would seem to demonstrate the mutual dependence of bus and rail services and how their coordination ends up making the entire system operate more productively.

### Incremental Expansion

In accordance with the functional spirit of LRT and legislative directives, the San Diego trolley system has continued to expand. The first, basically single-tracked South Line opened in July 1981. Double-tracking was completed in early 1983. In 1986 the first increment to the east opened service; it was 4.5 mi (7.2 km) long and added four new stations through southeast San Diego. Two more extensions were added: one in 1989, further extending the East Line to the city of El Cajon; and another in 1990, along the Bayside corridor in Centre City San Diego.

The current San Diego trolley system, shown in Figure 1, consists of two routes:

- *South Line*—15.9 mi (25.6 km) from the Santa Fe Depot in Centre City to San Ysidro at the international border with Mexico. About 1.7 mi (2.7 km) are on city streets and the remainder on the existing, rebuilt railroad right-of-way. Eighteen stations are on the line.

- *East Line*—19 mi (30.4 km) with some of the Centre City portion shared with the South Line. This line heads east to a terminal at the El Cajon Transit Center. The line has 6 common stations with the South Line (all in Centre City) and 15 additional stations (including 3 in the Centre City Bayside corridor).

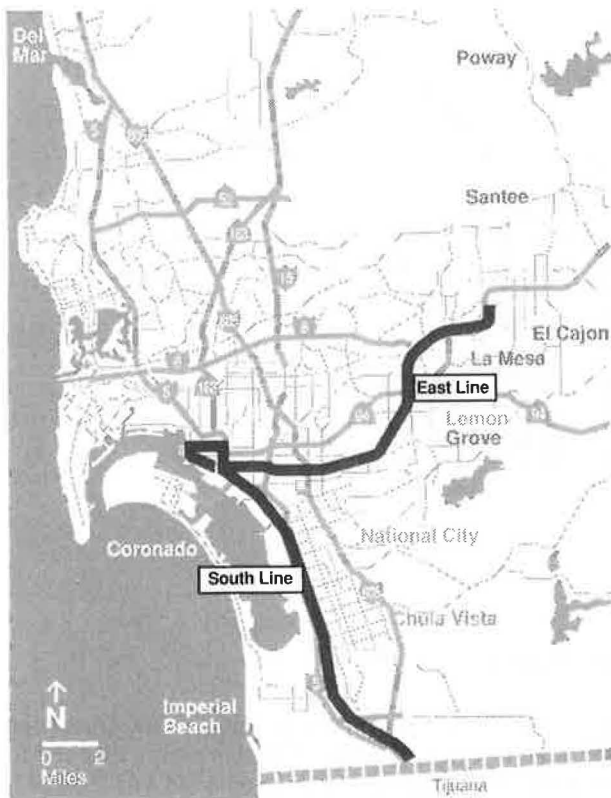


FIGURE 1 San Diego rail plan: existing service.

The initial 14-car fleet has grown to 71 (with 75 on order), all manufactured by Siemens-Duewag. The cars are double-ended, articulated, and have six axles. They are furnished with 64 seats and are 80 ft (24.3 m) long. Maximum speed is 50 mph (80 km/hr) with an average running speed, including stops, of 30 mph (48 km/hr) outside Centre City and 9 mph (14.4 km/hr) in Centre City. Each of the 71 cars has a single on-board wheelchair lift in one of the doorways next to the operator cab. This door is not available for regular passenger use.

In response to the need to enhance the system, several improvements to plant facilities and the rail fleet have been accomplished. The light rail vehicle is currently manufactured with heat, ventilation, and air-conditioning (HVAC) and a handicap lift as standard equipment. The HVAC units are modular and if they fail they can be replaced within approximately 2 hrs.

In all, including the various enhancements, the capital investment for San Diego's LRT network now stands at about \$320 million or roughly four times the initial investment in the South Line that opened in 1981.

#### SAN DIEGO TROLLEY, INC.

Consistent with the desire to concentrate on transit development and policy setting, MTDB created San Diego Trolley, Inc. (SDTI) in August 1980 as a wholly owned subsidiary to operate and maintain the light rail transit system then under construction. SDTI is a nonprofit, public-benefit corporation,

governed by a seven-member board of directors appointed by MTDB. The SDTI board includes an ex-officio, nonvoting member of MTDB.

#### Prerevenue Operations

Public rail transit services were terminated in San Diego during the late 1940s. Thus, no local reservoir of electric rail transit experience existed, and little was available nationally. MTDB and SDTI used consultant services to assist in the development of rail start-up procedures and standard operating procedures for operations and maintenance (31). A staffing plan for prerevenue service was developed in late 1980 and recruitment initiated. In September 1980 the general manager of SDTI was hired and took over the final development of an initial LRT staffing plan for the organization and eventual management of the system.

#### Service Expansion

As a result of continuous ridership growth and improvements to the system, the operating plan for the trolley has been modified several times. In February 1983 SDTI adopted a 15-min headway interval between 5 a.m. and 8 p.m., and service hours were extended with 30-min headways to 10 p.m. In July 1983 train service hours were further extended to 1 a.m. with 60-min frequencies initially during these late hours, going to 30 min in 1988. In March 1991 7.5-min morning and evening peak period headways were inaugurated on the South Line.

The first segment of the East Line, ending at Euclid Avenue, opened in March 1986, with the second and third segments to the cities of La Mesa and El Cajon opening in May and June 1989, respectively. The East Line added approximately 16 mi (25.6 km) to system route mileage. Service frequencies began with 30 min in 1986 and in 1989 went to 15 min. In 1990 another extension was added to the East Line, this one in the Bayside corridor of Centre City.

As indicated in Table 1, annual train miles and train hours have more than tripled since the first year of operation. First-year miles were 517,503 whereas in the 10th year, FY 1991, train miles increased to nearly 1.8 million. Likewise, train hours went from 29,653 in FY 1982 to 93,520 in FY 1991.

#### Staffing and Training

As service levels have increased, the SDTI staff has grown slowly but steadily. SDTI initiated revenue service operations in 1981 with 57 full- and part-time employees. As indicated in Table 1, by late 1991 SDTI employed a total of 280 full-time equivalent employees. To maintain efficiency and economy in operations from "day one," SDTI has required flexibility in job assignments and, therefore, routinely cross-trains both full-time and part-time employees to perform several tasks within their respective departments. In the early years, whenever an emergency occurred, all management personnel, regardless of discipline, participated in resolving the incident. In fact this practice has continued and, without their help

TABLE 1 San Diego Trolley Performance Trends

Fiscal Year	Total Train Miles*	Total Train Hours*	Full-Time Equivalent Employee	Operating Cost*	Boarding Passengers*	Fare Revenue*	Accidents
82	518	30	62	\$ 3,531	3,886	\$ 2,747	91
83	522	31	79	4,258	4,138	3,037	31
84	774	36	82	4,955	5,437	3,976	40
85	772	36	85	5,530	5,943	4,760	19
86	842	42	94	6,271	7,003	5,561	16
87	994	56	118	7,309	7,974	6,337	19
88	1,054	58	126	7,927	9,281	7,317	27
89	1,143	63	148	9,159	11,217	8,729	32
90	1,713	86	232	13,550	16,005	12,411	38
91	1,794	94	280	16,840	18,030	13,453	25

\*These numbers are in 1,000's.

being requested, a majority of personnel volunteer to resolve emergency situations.

### Operating Budget

SDTI's operating budget has some unique characteristics. Consistent with the commitment to control costs, SDTI does not perform all associated operating tasks with in-house personnel. Around 12 percent of the FY 1992 budget represents private- and public-sector contracts for services such as fare inspection, security, office janitorial, light rail vehicle interior cleaning, maintenance of communication equipment, legal and consulting services, and claims administration services. The purpose and philosophy for contracting out certain tasks is to reduce operating and overhead expenses, reduce liabilities, and encourage local business community participation.

Table 1 gives a comparison of the total operating budgets for FY 1982 and FY 1991. In FY 1982 the total operating budget was \$3.5 million, which included approximately 45 percent designated for personnel. For FY 1991, about 51 percent of the total \$16.84 million operating budget was dedicated to personnel.

A common question is how the relationship between MTDB and SDTI is handled in regards to MTDB services. Included in SDTI's operating budget are all direct costs associated with printing timetables, for example. However, items such as regional public information and fare media are handled by MTDB for bus and trolley services as a regional MTS obligation. Also, all planning and engineering related to LRT projects are an MTDB cost and do not show up in SDTI's budget. Fare inspection (MTDB employees) and any MTDB service related to SDTI operations (certain marketing activities) are billed accordingly, along with an appropriate overhead rate that covers legal services provided to SDTI. The composition of this rate is based upon work completed in 1982 (32) and is subject to verification by the annual audits. MTDB's services are provided for SDTI, SDTC, and MTDB contract bus services in a similar manner.

### Fare Structure

Initially the South Line began operations charging most patrons a flat fare of \$1.00; the fare within Centre City and for senior and disabled patrons was 15 cents. In July 1984 MTS fares were changed to reflect the distance traveled. This zone fare system increased revenues and ridership increased appreciably. The new fares ranged from 50 cents to \$1.50. In 1989, upon completion of the East Line, the range was extended to \$2.00. A July 1991 fare increase modified the zone system slightly and pushed up the highest fare to \$2.25.

Single-trip tickets may be purchased from self-service fare vendomats at each station. Multitrip tickets (2- and 10-ride) and monthly passes, generally offering discounts, may be purchased at outlets throughout the community.

Consistent with the POP fare collection system, patrons must have a valid ticket, transfer, or pass before boarding. Fares are inspected on a random basis, and patrons are required to show proof of fare payment on the request of the code compliance officer. The barrier-free collection system has been successful and is generally liked and respected by patrons.

### Ridership and Fare Revenues

With regard to ridership, planning projections for the first year were for approximately 9,500 riders per weekday. At the onset of revenue service, weekday ridership exceeded projections by approximately 2,000 riders per day and was in the range of 11,000 to 12,000. By early 1992 average weekday ridership has stabilized between 48,000 and 53,000 (summer being the peak period of the year). On Saturdays ridership has been between 43,000 to 48,000 and on Sundays, between 35,000 and 40,000. In addition SDTI currently handles approximately 700 wheelchair trips per month. Roughly 60 to 65 percent of SDTI's ridership is on the South Line; but both lines seem to be increasing at generally consistent growth rates. As shown in Table 1, on an annual basis, rides have

increased from 3.9 million in FY 1982 to slightly over 18 million in FY 1991—an increase of 4.6 times.

Farebox revenues have tracked well with operating cost increases, rising from \$2.7 million in FY 1982 to \$13.5 million in FY 1991 (see Table 1). As a result, the farebox recovery rate over the years has remained impressive, ranging from a low of 71 percent in FY 1983, the second year of operation, to a high of 95 percent in FY 1989. Since then the rate has decreased to slightly under 80 percent, reflecting the impact of additional service and some extraordinary cost increases.

### Performance Trends

Wahl and Humiston, in a paper in this Record, note that common with an expanding LRT network are ridership and operating cost increases. In general SDTI has managed to have farebox revenues keep pace with operating costs.

Some key performance indicators listed in Table 2 for the 10-year period show the following:

- *Effectiveness*—Operating cost per passenger was about the same in FY 1991 as in FY 1982, 93 and 91 cents, respectively. Given inflation over this 10-year period, the actual cost per passenger in constant dollars has decreased.
- *Efficiency*—Operating cost per train mile has increased 38 percent, from \$6.82 to \$9.38 in the 10 years.
- *Productivity*—Train hours per full-time equivalent employee have fluctuated over the 10 years; the figure was down 30 percent in FY 1991 from FY 1982. On the other hand average system speed has increased from a low of 16.7 mph (26.7 km/hr) in FY 1983 to 19.2 mph (30.7 km/hr) in FY 1991.
- *Service utilization*—Passengers per train hour have increased about 47 percent (193 in FY 1991 versus 131 in FY 1982), with a general upward trend, whereas the figure for passengers per full-time equivalent employee has tended to hover around the FY 1982 level (63,000 then and 64,000 in FY 1991).
- *Accidents*—After a rough start, seemingly typical of new LRT systems, accidents involving light rail vehicles have not

exhibited any significant trend. However, train miles per accident have increased in recent years, with the FY 1991 figure (71,779) being significantly improved over the early years of operation.

### SDTI as Part of MTS

A significant aspect of the San Diego trolley operation relates to its function as part of the MTS network of services. If LRT works well, and as the productive foundation of the transit network, then it should make MTS work better and vice versa.

Since its inauguration in 1981, SDTI train miles have increased to represent about 10 percent of total annual MTS service miles (bus miles plus train miles) in FY 1991. To compare this with service delivered, ridership trends are shown in Figure 2. In FY 1991 LRT ridership made up 30 percent of total annual MTS ridership. Even more significantly, SDTI's farebox revenue was 35 percent of the MTS total, as shown in Figure 3. And the SDTI share of MTS operating assistance has been relatively minimal—only 9 percent in FY 1991.

### WHAT LIES AHEAD?

The aim of MTDB's short-range transit plan is to lay out a program of improvements to the MTS network to combat the congestion and air quality problems that result from the San Diego region's high growth (33,34). Therefore the primary goal emphasizes service and facility improvements that increase ridership by attracting more "choice" riders.

The 10-year history of SDTI has demonstrated that travelers who have a choice of transportation modes can be attracted to mass transit—even in automobile-dependent Southern California. Thus the short-range transit plan focuses on improvements that not only continue development of the LRT network as a foundation of ridership growth, but also target corridors that have high potential demand for high-quality bus service improvements.

TABLE 2 San Diego Trolley Performance Indicators

Fiscal Year	Operating Cost/ Passenger	Operating Cost/ Train-Mile	Train Hours/ F-T Eq. Employee	Train Miles/ Train-Hour	Passengers/ Train-Hour	Passengers/ F-T Eq. Employee*	Train Miles/ Accident*
82	\$0.91	\$6.82	478	17.5	131	62.7	5.7
83	1.03	8.16	395	16.7	133	52.4	16.8
84	0.91	6.40	437	21.6	152	66.3	19.3
85	0.93	7.16	426	21.3	164	69.9	40.6
86	0.90	7.45	443	20.2	168	74.5	52.6
87	0.92	7.35	477	17.7	142	67.6	52.3
88	0.85	7.52	460	18.2	160	73.7	39.0
89	0.82	8.01	423	18.3	179	75.8	35.7
90	0.85	7.91	372	19.8	185	69.0	45.1
91	0.93	9.38	334	19.2	193	64.4	71.8

\*These numbers are in 1,000's.

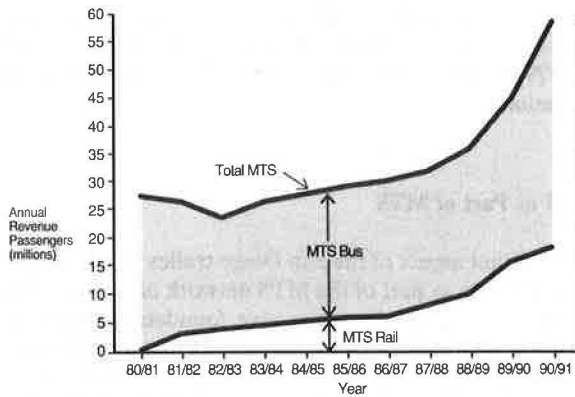


FIGURE 2 MTS ridership.

In July 1992 MTDB opened a short, two-station increment to the north and is into the early stages of construction on two short extensions of the system (see Figure 4). One extension is a continuation of the East Line from El Cajon to the neighboring community of Santee. The other is the second segment of the northerly extension of the LRT system from downtown San Diego to the historic district of San Diego called Old Town. Each of these extensions is approximately 3 mi long; they are scheduled to be in revenue service in 1995.

By the year 2005 MTDB should have three more segments of the San Diego trolley system in operation (see Figure 4). MTDB is in the initial stages of final engineering for a line segment that would extend east from Old Town through Mission Valley, terminating just east of San Diego Jack Murphy Stadium (Mission Valley West Segment). Other segments are also displayed on Figure 4 that reflect projects in various stages of planning that would bring about a post-2005 rail plan for San Diego.

**Joint Development Beginnings**

To show the way to local developers, MTDB and SDTI provided the first significant display of joint transit-land use development in San Diego by locating their offices above the Imperial and 12th Transfer Station (35,36). This project was a joint effort with the county of San Diego and includes ground floor retail uses and an adjacent multilevel parking garage.

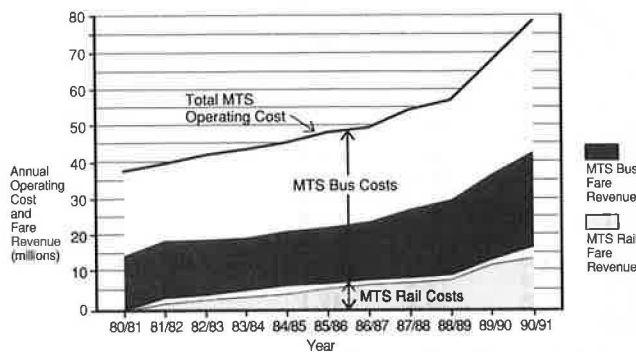


FIGURE 3 MTS operating cost and fare revenue.

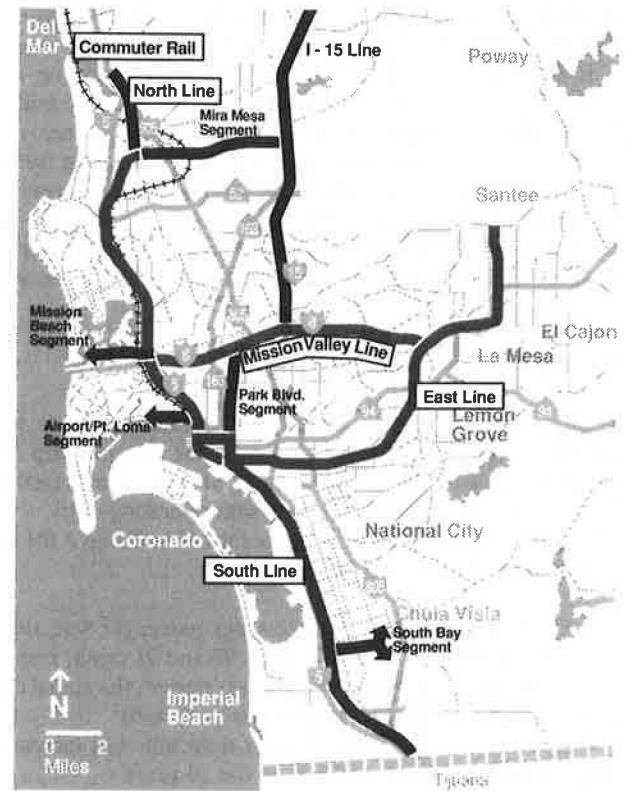


FIGURE 4 San Diego rail plan: service beyond 2005.

Now even larger joint development projects are under way at other stations, including the area's tallest office building. Smaller, yet compatible, joint projects have been implemented and more are being planned, including child care facilities (37). One such facility has been in operation for nearly 2 years at the 47th Street Station.

**Varied and Creative Financing**

Ways of financing transportation projects are changing, and in San Diego the situation is no different. The initial South Line was financed primarily through state gas tax (87 percent) and state sales tax (Transportation Development Act) revenues. No federal monies or local dedicated funds were available. However, since then a wide variety of sources have been tapped:

- Federal discretionary (Section 3) and formula grant (Section 9) monies for the East Line extension and some enhancement projects;
- A local half-cent transportation sales tax (passed in November 1987 by San Diego voters), one-third of which is dedicated for transit purposes;
- City of San Diego hotel room tax revenues for the Bayside extension and other extensions in the city;
- Revenues from sale or lease-back of light rail vehicles (under terms of now-defunct provisions of the 1982 Economic Recovery Act) provided local funds toward matching state

and federal grants for the East Line (38); "offshore" sale and lease-back of another group of light rail vehicles is providing funds for enhancement projects;

- State grade separation improvement funds permitted three at-grade crossings to be separated;
- Financial contribution from the Port of San Diego for the Bayside extension and a grade separation project on the Old Town Line; and
- Revenue from California's transportation bonds passed in June 1990.

Another important financing decision by MTDB in 1981, coincident with South Line implementation, was to fund a capital depreciation account (39). This account has already proven useful for annual SDTI capital replacement needs and will become increasingly valuable as the system and its equipment age.

## CONCLUSIONS

In looking back at the San Diego program, certainly the benefits of using light rail technology in a large, metropolitan, medium-density area are evident. However, another clear realization is that the incremental approach to system development further produces tangible benefits:

- It forces management (development and operations) to keep up with the state of the art, establishing a local "think tank" atmosphere.
- It produces enthusiasm among the operating personnel by giving them new challenges to look forward to and in-house promotional opportunities.
- It provides ongoing "free" publicity to the transit system through routine news coverage and, in so doing, stimulates the public's enthusiasm, too.
- It allows for the system to grow intelligently with personnel and other operating budget needs justified by intimate knowledge and requirements of the existing operation and the capabilities of the existing labor force.
- It provides a learning atmosphere in which mistakes and failures are relatively small as a result of the system being rather short and services simple, and so corrective actions can be taken based on the lessons learned in actual operating experience.

On the other hand, incremental development has drawbacks:

- A 1979 design "mind set" had to be converted to 1992 standards and requirements that go beyond minimal designs and related longer-term capacity and system requirements.
- An initial low-cost project is difficult (if not impossible) to duplicate as the system expands—the system becomes necessarily a more complex operation. (The low-cost beginning led to a continued expectation that future extensions could be developed for under \$10 million a mile, for example—clearly no longer possible in San Diego.)
- Higher levels of service drive requirements for more grade separations, larger stations, pocket tracks, and more complex systems.

- At times, relatively new projects or enhancements must be torn up and replaced, creating public perceptions of waste. In such instances, however, the early improvements were useful on an interim basis.

All in all, San Diego residents can look forward to a greatly improved public transit network with LRT at its foundation. The tradition founded in the mid-1970s—that of a no-frills, functional approach to public transit—has worked well in San Diego and will continue to be the cornerstone of future LRT extensions. However, now that the San Diego LRT is a "mature" rail system, the standards for incremental LRT development are necessarily being upgraded. Yet, there is the need—if not a local political mandate—to keep the farebox recovery rate at its historical high level, an indication that the past can be nothing more than the foundation for the future.

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