Sacramento Regional Transit's Light Rail: Approaching Middle Age

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Sacramento Regional Transit's light rail system opened in March 1987. Planning for the system started in the late 1970s and construction began in 1983. The 18.3-mi (29.2-km) line has exceeded all expectations in terms of ridership and community acceptance. As the system approaches its ninth anniversary, it is starting to show signs of "middle age." Actions necessary to keep a system operating at peak efficiency as it enters its second decade of service are described; they include general inspections of vehicles, wayside equipment rehabilitation programs, and changes in staffing levels. In addition, external pressures on today's light rail transit systems in the form of the Americans with Disabilities Act, the Clean Water Act, and the Clean Air Act are discussed. Included is Regional Transit's plan for light rail in the 21st century.

The start-up of Sacramento Regional Transit's (RT's) light rail system on March 12, 1987, heralded the return of electric railway operation to California's capital city. Until January 4, 1947, streetcars and interurbans of the Pacific Gas & Electric Company (PG&E), Central California Traction Company, Sacramento Northern, and their successor Sacramento City Lines plied the streets of Sacramento and the surrounding area. The 40-year hiatus watched Sacramento grow from a sleepy California valley town of 100,000 to a metropolitan area of more than 1 million people.

Sacramento has been the capital of California since the mid-1800s. Unlike other capital cities, however, Sacramento was always the "stepchild" of the state compared with San Francisco, Los Angeles, and San Diego. Into the early 1960s, Sacramento was often thought of as nothing more than a rest stop for travelers between the San Francisco Bay Area and the Reno/Lake Tahoe area of Nevada.

During the California real estate boom of the 1970s, Sacramento remained a bastion of lower-priced residential housing. As homes became less and less affordable in Southern California and the San Francisco area, people began migrating to the Sacramento Valley. During the late 1970s and early 1980s, population continued to grow at a rapid rate. This growth brought the usual urban problems to Sacramento: congestion and air pollution. Freeway and road construction attempted to keep up with the phenomenal growth, but the people who had moved to Sacramento feared that this uncontrolled growth would end up duplicating the communities that they had left.

In 1983 it was decided to pursue the construction of an 18.3-mi (29.2-km) light rail transit (LRT) line serving the eastern and northeastern suburbs of Sacramento. Federal Interstate transfer moneys were used to help fund construction of a "no-frills" light rail system, patterned after the very successful San Diego Trolley. Design and construction of a no-frills system involved evaluating every aspect of the system on the basis of

what was absolutely necessary rather than what would be nice to have. The initial line was built for less than $10 million/mi, making it the lowest-cost federally funded transit project in the United States.

Service commenced in March 1987; the full line was opened by September of that year. Initial service levels were constrained by a severe lack of operating funds in the first few years of operation. Trains ran no later than 10:00 p.m. during the week and 7:00 p.m. on Saturday and Sunday. In addition, weekend headways were 30 min, compared with the 15-min weekday frequency.

In November 1988, citizens of Sacramento passed Measure A, which dedicated a half-cent sales tax to transportation projects in the Sacramento area, "transportation" being the key word. Two-thirds of this money is to go toward road construction and maintenance, and the remaining third is to be dedicated to operating and capital projects for the transit district. This influx of money, which has amounted to about $20 million a year, allowed RT to replace some aging diesel buses, add some connecting bus service to the rail line, and—most important—bring the rail line service levels up to the 1987 expectations. Trains now could operate on a 15-min headway 7 days a week. Service began at 4:30 a.m. and continued until 1:30 a.m. the following morning. Half-hour headways were operated after the evening rush hour. Timed-transfer connections were made from bus routes at key transfer stations. To handle the increased traffic, 10 additional light rail vehicles (LRVs) were ordered from the builder of the original fleet and placed in service during 1990, bringing the fleet to a total of 36 cars. Four-car trains are operated in the morning and evening rush hours on eight trains, and 32 cars are required for both the morning and evening rush hours.

As originally designed, 60 percent of the system was single-tracked. Double tracking was provided only in areas where train meets occurred and in the downtown area. This constraint kept capital costs to a minimum. It also required precision dispatching and train operation to maintain the 15-min headway. Any delay to a train quickly caused the entire system to suffer late schedules. Fortunately, this did not happen very often.

Starting in 1988, various double-track projects were implemented on both the Northeast (N) and Folsom (F) lines. These projects have changed the lines' configuration such that today's system is 60 percent double track and only 40 percent single track. This addition has provided much more flexibility in operating trains.

Besides the double-track projects, "tail tracks" were installed at both of the terminal stations located at Watt Avenue/I-80 and at Butterfield. This feature allows a disabled vehicle to be removed from the mainline and stored without disrupting regular service. In addition, a "scissors" crossover was installed on the K Street Mall, allowing trains to be turned back in the downtown area.

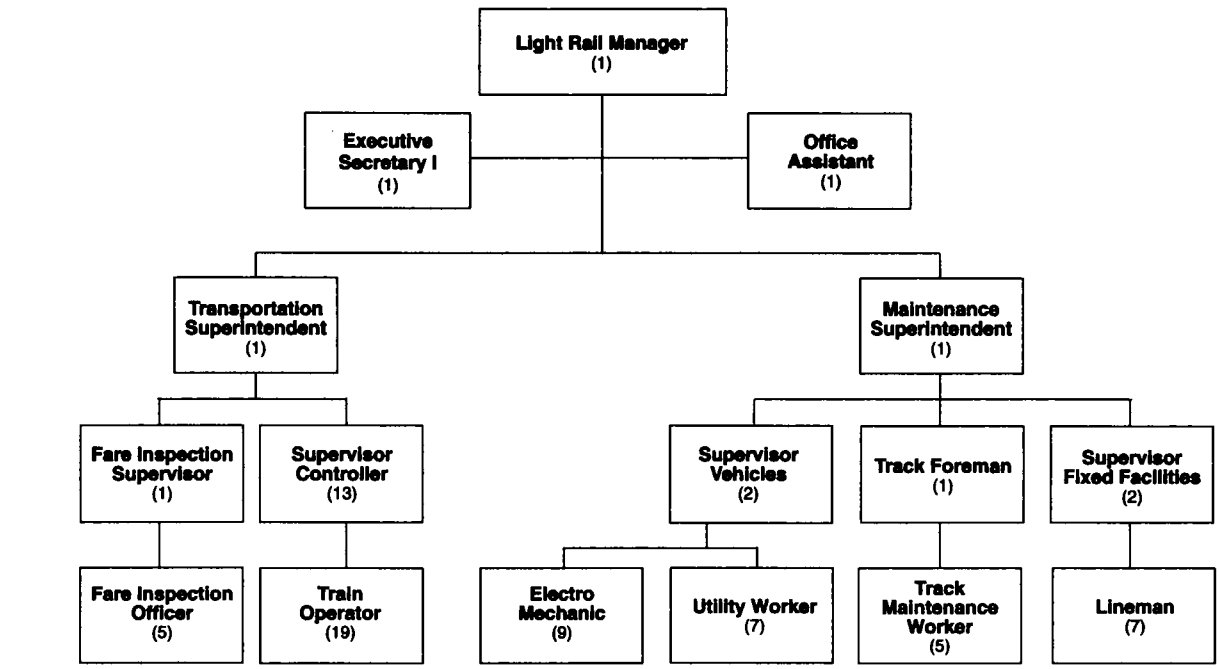
The double tracking of some station locations required the construction of a second platform. On the basis of early experience, newly constructed platforms had several additional amenities for passengers including lighted kiosks, additional shelter space, and mini-high platform shelters and benches.

With the full line in operation on September 5, 1987, the staffing of RT's light rail department was approximately 90 people. This included all of the transportation, vehicle maintenance, and wayside maintenance functions associated with running a rail transit system. The original staffing levels were based on an operating plan with limited or nonexistent night and weekend service, and the assumption that all new equipment and facilities were relatively trouble-free and under warranty. The original staffing plan was adequate for the start up of revenue service. It took into consideration the needs of a new system with the knowledge that expanded service hours and aging equipment and facilities would require more people.

Today, the staffing level is at 112, reflecting the much higher level of service provided and the age of the system. Figure 1 shows the organization charts from September 1987 and today. The increases are primarily in the operator and mechanic ranks. The additional operators were required to accommodate the substantially higher level of service; the additional maintenance staff were brought on board in a phased pattern that reflected the aging of the system and its components.

Starting in 1993, the system's original 26 LRVs, built by Siemens Duewag, came due for their general inspection. On Sacramento's LRVs, this generally equated to 310,000 mi (500 000 km). The general inspection calls for disassembly of major components, including the trucks, traction motors, motor/alternator set, couplers, and suspension components. In addition, the cam controller is to be removed from the car and inspected and repaired as necessary. The general inspection has produced some interesting results. Even though these cars accumulated more than 500 000 km in less than 8 years, only a minimal amount of work has been necessary during the inspection process. The following items were rebuilt or repaired:

1. Traction motors were disassembled, new bearings installed, commutators were resurfaced, and brushes were replaced. No other maintenance has been necessary to the motors.
2. Gear boxes on the monomotor trucks were removed and disassembled. Approximately a third of the fleet's gear boxes have experienced what RT would describe as excessive wear; they are being rebuilt in the San Francisco Bay Area with parts supplied by the orig-



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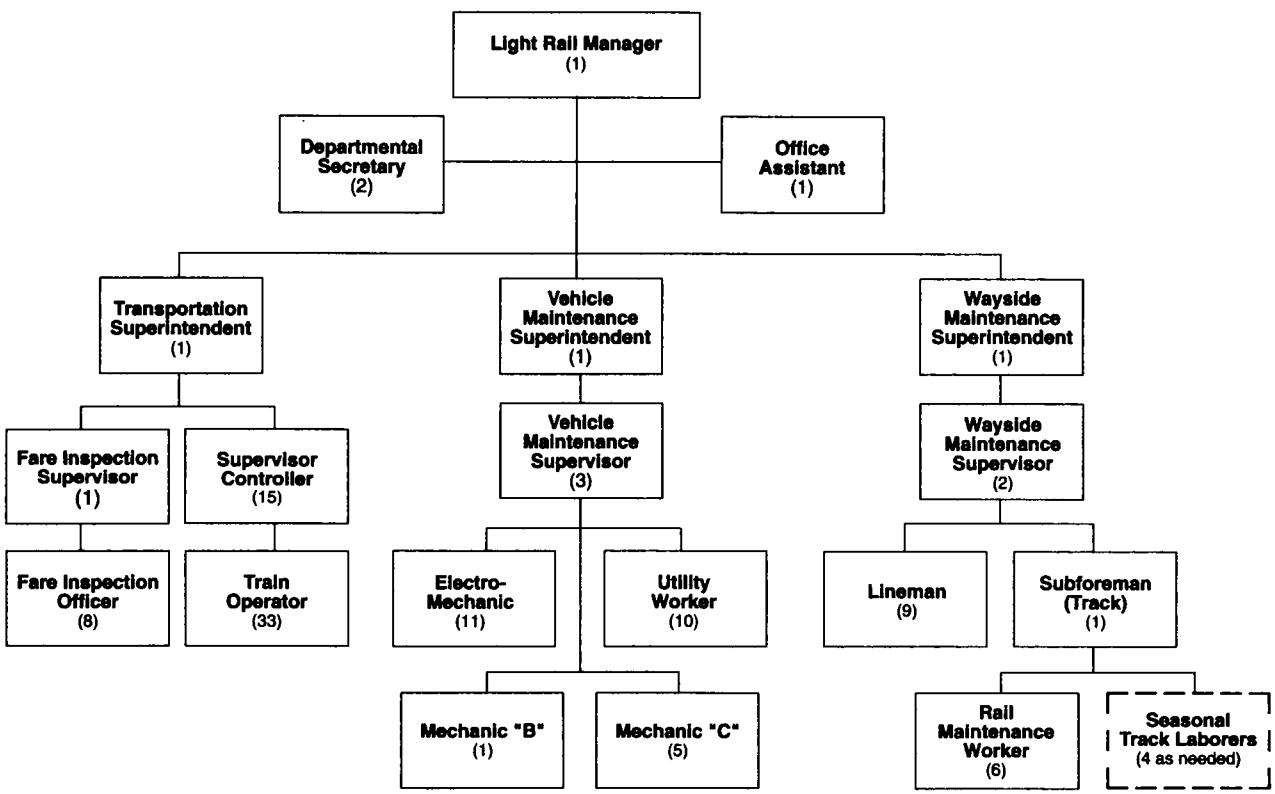

Total: 112

FIGURE 1 Sacramento Regional Transit light rail department organization, 1987 (*top*) and 1995 (*bottom*).

inal car builder. It is important to note that unlike other LRT systems with monomotor trucks, Sacramento has never suffered a catastrophic failure of an LRV gear box. RT is meticulous about wheel maintenance, especially the regular reprofiling of wheelsets. This effort has resulted in its spectacular record of no gear box failures.

3. The electrically operated seven-step brake actuator was removed and rebuilt. RT's experience has shown that it is much more economical to rebuild these components in house. Training for this task was provided by the manufacturer. Shipping the actuators back to the original supplier had resulted in long delays and substantially higher costs.

4. The cam controllers have been disassembled, inspected, and put back together with very minimal parts replacement. Although this technology is "outdated," it continues to work well in RT's application under extremely severe service conditions.

5. Couplers, which have been a problem for several other LRT operations, have required minimal efforts to rebuild during the inspection process. RT couples and uncouples train consists regularly throughout the day. It appears that this frequent operation has contributed to, rather than detracted from, coupler reliability.

In summary, these cars have seen heavy service during the first 8 years of their existence. Regular performance of preventive maintenance has allowed the vehicles to continue to provide extremely reliable service to the citizens of Sacramento.

Wayside equipment is also beginning to suffer a "midlife crisis." Electric switch machines are removed from service, torn down, and rebuilt to original equipment manufacturer standards. It is important to note that switch machines on Sacramento's light rail system throw as often as 140 times a day. This is substantially more often than similar equipment used on many light rail and most mainline railroads. Again, preventive maintenance has enabled this equipment to function almost flawlessly.

Signal relays are removed and recalibrated by wayside staff in the field. RT has been fortunate to have been able to recruit and hire railroad signal maintainers with many years of both field and shop experience. This hands-on experience has allowed RT to develop unique preventive maintenance inspections and rebuild programs tailored to its specific needs. This in turn has greatly increased the reliability of wayside equipment.

In 1993 RT contracted with an outside firm to grind the rail on the entire 18.3-mi (29.2-km) line. Corrugation had begun to develop on portions of the light rail system, resulting in higher noise levels and in some cases deteriorated ride quality. RT does not foresee having to regrind the system for another 3 to 4 years. In addition to the grinding program, several tight-radius curves have required rail transposition or change-out during the past few years. When possible, RT replaces its 115-lb T-rail with a head-hardened version in these tight-radius curves. Restraining rails are used in all curves under a 300-ft (91-m) radius. In some cases, the restraining rails have been extended farther into the spiral to minimize high-wear points.

Virtually all of the grade crossings in private rights of way were constructed of rubber panels installed during original construction. In some cases, these panels have failed over time, especially on streets with extremely high traffic. As the panels wear out, RT is replacing them with either poured concrete or prefabricated concrete panels. Stray current has not been a problem with the concrete panels because of Sacramento's very dry climate.

The original starter line budget did not provide for separate offices for wayside personnel or for storage of track, signal, and overhead contact system materials. A new wayside maintenance building was constructed and placed into service in 1994. This building provides expanded shop space for wayside activities including electronic and welding shops. In addition, there is inside storage of high-value materials, locker rooms, and additional office and training space for the wayside staff.

The starter line budget also did not include a paint and body shop. A single-track metal building addition was grafted onto the east side of the existing facility during 1994. This facility provides for a paint and body preparation area as well as an environmentally compliant paint booth. Before the construction of this facility, minor paint and body work was performed outside the facility. Fortunately, the only major painting required was the result of an accident in 1990 involving Car 105. This vehicle was transported to the builder's plant in Sacramento after the accident, where it was repaired and painted.

To comply with the long-term aspects of the Americans with Disabilities Act, RT is studying various low-floor options for both existing and new LRVs. RT is exploring the idea of constructing a low-floor center section to be spliced into its existing equipment. Doing this would make each of the cars an eight-axle vehicle approximately 120 ft (36 m) long. Remaining questions about this modification address

1. The ability of the existing traction power package (both on the car and the wayside distribution system) to support the performance requirements, and
2. The ability of the modified vehicle to meet the 2-*g* buff strength requirement imposed by the California Public Utilities Commission (CPUC).

New low-floor LRVs are also being considered by RT for future purchases. The performance issue would not

be a major problem with new cars, but the 2-*g* buff strength requirement imposed by the CPUC remains an issue. At this time, there is no way to construct a low-floor LRV that would provide this level of compression strength. Adding structural members to increase body strength also adds weight, which exacerbates the problem. In addition, either retrofit or new purchase of low-floor technology will require some form of platform modifications. As stated previously, RT passengers board from both top of rail height as well as from 8-in. (20-cm) curbs. For low-floor vehicles to function effectively, a 8- to 10-in. (20- to 25-cm) platform may be necessary. There are two issues with this:

1. More than 5/8 mi (1 km) of the line is on a pedestrian mall. Creating curbs where they do not exist today would present an additional barrier to free movement on the mall.
2. Four-car trains are operated by RT in the a.m. and p.m. peak hours. At several downtown locations, these trains extend into intersectons. It would not be possible to place platforms in the middle of these intersections.

In recent years, environmental legislation has been passed at both the state and federal levels. Even though transit is obviously supportive of environmental concerns, the new laws have a substantial impact on a transit system's daily operation. For example, the Clean Water Act has very specific language regarding the use and monitoring of underground storage tanks. This is a relatively minor problem for the rail system (which has one small underground storage tank for waste oil), but RT's bus facility is located where the various predecessor companies ran horsecars, streetcars, and gasoline-powered buses for more than 100 years. Faced with a massive clean-up effort at the bus facility, RT has also had to reevaluate its underground storage tank procedures at the rail facility, resulting in equipment modifications and increased monitoring efforts. In addition, stormwater runoff from the bus and rail facilities must undergo substantial treatment before entering the city's storm drain system. This represents both an additional capital and operating cost to the district that is not directly related to providing service to its riders.

Passage of the 1990 Clean Air Act had a profound impact on RT's operations. Sacramento is considered a nonattainment area for oxides of nitrogen (NOx). Even though almost a third of the daily ridership rides zero-emission electrically powered rail vehicles, the local air quality management district lobbied very heavily for replacement buses that were powered by alternative fuels. This resulted in RT's purchasing 95 compressed natural gas (CNG) buses and building a "fast fill" CNG fueling station at a cost of more than $4 million. These increased capital expenditures cut deeply into the limited moneys available for bus and rail capital improvements.

RT has adopted a master plan for transit in the Sacramento metropolitan area for the next 20 years. The plan calls for substantial increases in bus service and both extensions of the existing rail line and new rail lines to areas currently not served. The master plan envisions a tripling of bus service in the metropolitan area. In addition, it includes an extension from the N Line terminal at Watt Avenue/I-80 to Antelope Road and ultimately into the city of Roseville. The Antelope Road extension would be approximately 6 mi (10 km). An additional 4 mi (7 km) would continue into the city of Roseville and Placer County. The F Line would be extended to Sunrise Boulevard and the community of Gold River approximately 6 mi (10 km). A further extension of this line would continue into the city of Folsom, a rapidly growing suburban community east of the downtown area. The Folsom extension would add an additional 6 mi (10 km) to the easterly extension.

RT has just completed an extensive alternatives analysis/draft environmental impact statement (AA/DEIS) for a 10-mi (14-km) line to the south area of Sacramento. This area provides the heaviest ridership to RT's existing bus system. Included in this study was the selection of a corridor. The two corridors studied were the Union Pacific (former Western Pacific) mainline, which envisions joint use of right of way for both light rail and mainline freight trains. The other corridor is a former Southern Pacific branch line that is currently abandoned but owned by the district. Part of this right of way is currently used by the California State Railroad Museum for steam excursion trains. After a 3-year effort, the RT Board of Directors selected the Union Pacific alignment as its preferred alternative in January 1995.

A short, 1.2-mi (2-km) extension to a new multimodal transportation terminal is also being studied closely. Current plans call for the existing Amtrak and Greyhound terminals to be consolidated in an area northwest of downtown Sacramento that has been used for over 100 years as the main shops of the Southern Pacific. Sacramento has a unique opportunity to redevelop this area, effectively creating a "new" downtown.

Also being studied is the operation of historic streetcars in a downtown circular system. To this end, a citizens support group known as Friends of Light Rail has acquired two old Sacramento streetcar bodies in the hope of restoring them to operation. This idea was fueled by RT's operation of PG&E Car 35, on special occasions, which has been restored by the San Jose Trolley Corporation for operation on Santa Clara's light rail system.

No one doubts that the extensions and increased bus service are needed badly in the area, but there is no

current source of operating funding available to make these things happen. RT is in the awkward position of passing up both federal and state capital dollars for worthwhile projects because of the lack of a dedicated source of operating revenue. The board of directors has commissioned a blue ribbon committee to look at long-term funding for the transit system. Until a source of revenue is found, RT's only extension plans will consist of a 2½-mi (4-km) extension from the east end of the F Line at Butterfield to a new station at Folsom Boulevard and Mather Field Road. Plans call for this extension to be under construction in late 1995 and to open in 1996. RT will not be procuring any additional equipment for this extension. The current scheduled recovery time at Butterfield (10 min) will be used to enable trains to continue to Mather Field Road and return. Recovery time at the Mather Field Road station will be minimal; an additional fall-back operator will be necessary at this end of the line to ensure reliable on-time performance.

RT is justifiably proud of its light rail system and the impact that it has had on the community. The efforts made during construction to keep the system simple have paid off in reduced operating and maintenance costs. As RT approaches its second decade of service, it looks forward to resolving its funding issues and expanding clean, low-cost LRT service throughout a rapidly growing metropolitan area.