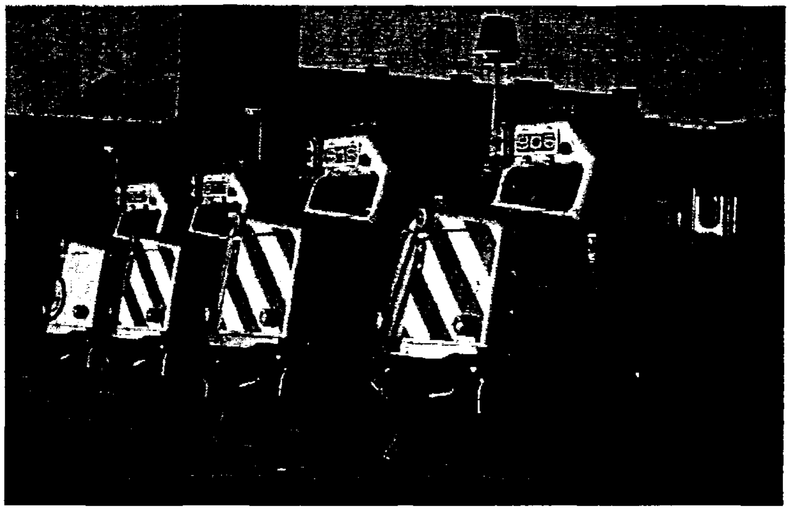
Draft

Caltrain Rapid Rail Study

Peninsula Corridor Joint Powers Board
October 1, 1998

A Collaboration of Caltrain and STV Incorporated

1 Executive summary



Rapid Rail Study key findings and recommendations

The purpose of the Caltrain Rapid Rail Study is to develop a comprehensive approach for improving and expanding the railroad's physical infrastructure. The intent was to focus on how capital improvements to the physical infrastructure could improve Caltrain travel times and therefore attract more riders to the system.

The Rapid Rail Study is the first comprehensive analysis of Caltrain's rehabilitation needs to bring the railroad's infrastructure to a state of good repair and coordinate long-term expansion projects within this context. Most importantly, it is the first study that specifically addresses the trade-offs between programming critical rehabilitation improvements and expansion projects. Comparing these types of projects is a critical step in guiding Caltrain to a future that optimizes capital spending and benefits to its customers.

The Rapid Rail Study focused on evaluating proposed improvements in four key categories:

1. Reducing travel times.
2. Increasing frequency and capacity.
3. Improving reliability.
4. Being a better neighbor.

Important findings in these categories are outlined below.

Travel time and ridership

The Rapid Rail Study evaluated several projects that could reduce travel time and/or increase ridership. Table 1-1 summarizes the results of that analysis.

Travel time and ridership improvements
Table 1-1

Improvement	Travel time savings (minutes)	Travel time savings (percent)	Ridership increase (trips)	Ridership increase (percent)	Notes
Rehabilitation	4:26	5.50%	1,450	5.40%	Improve track to 79 mph.
Enhancement	5:28	7%	1,900	7%	Improve track to 90 mph.
Consolidate 3 stations	10:28	13.20%	3,500	13%	90 mph track
Electrification – existing track	5:00	6%	1,600	6%	
Electrification – rehabilitated track	11:50	15%	4,000	15%	79 mph track
Electrification – enhanced track, consolidate 3 stations	16:50	21%	5,600	21%	90 mph track
Parking program	na	na	1,800	7%	

Table 1-1 illustrates a very important principle, namely, improving Caltrain will be an incremental process made-up of several building blocks designed to work in concert. Only by implementing the building blocks in a structured and well planned manner can Caltrain achieve its true potential for serving the Peninsula's growing transportation needs.

For example, electrifying the existing railroad would improve run times by about 6%, but, with the recommended rehabilitation and enhancement program, electrification could improve run times by approximately 21%.

Train frequency and capacity

A second important point is that once Caltrain completes the rehabilitation and enhancement program and acquires additional railcars, the system will be able to carry significantly increased numbers of passengers by increasing the frequency of trains. For example, during peak periods train frequencies could be increased as shown in Table 1-2.

Train frequency and capacity
Table 1-2

Description	Existing	Rehabilitation	Enhancements	Increase
Peak direction: San Jose to San Francisco in the morning				
Local trains	5	7	7	+40%
Express trains	9	9	16	+78%
Capacity	7,800	9,200	18,200	+134%
Reverse peak: San Francisco to San Jose in the morning				
Local trains	7	7	7	–
Express trains	2	4	10	+500%
Capacity	5,000	6,300	13,400	+169%

The rehabilitation and enhancement program includes sections of third track and improvements to the train control system that will enable Caltrain to operate significantly increased peak period service. As shown in Table 1-2, following the rehabilitation and enhancement program, Caltrain's existing peak period capacity could more than double to 18,200 in the peak direction and could increase by almost 170% to 13,400 in the reverse peak direction. The timing for increasing train service will depend upon operating subsidies provided by the JPB member agencies and acquisition of additional railcars.

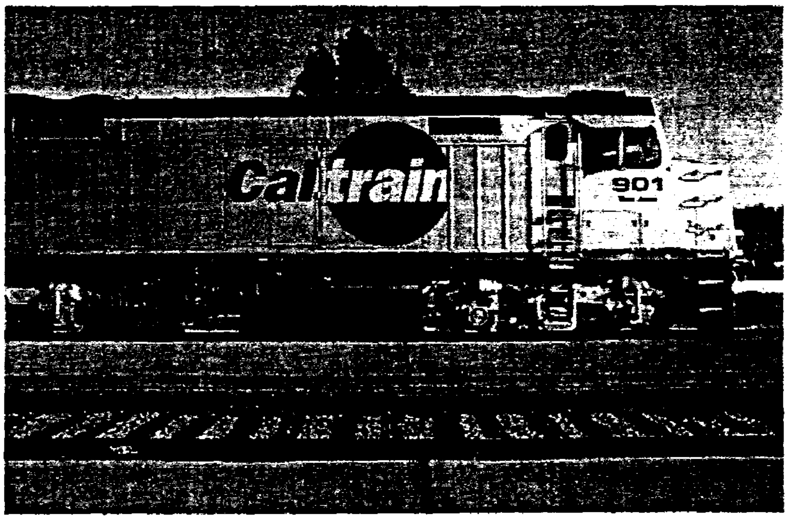
A better neighbor

In addition to carrying more customers, upon completion of the Rapid Rail Study improvements, Caltrain would be a better neighbor. Electrification will reduce air pollution and noise generated by Caltrain locomotives. As part of the rehabilitation and enhancements programs, Caltrain will work closely with cities to improve stations and grade crossings. Stations would be made safer and more attractive. Grade crossings would be made safer and easier to use by pedestrians, bicyclists and motorists.

Service reliability

While reducing travel times, increasing capacity and being a better neighbor are very important objectives, one quality most desired by Caltrain customers is reliability. If Caltrain can not get you where you are going when you need to be there– consistently– then you will think twice about using it.

Caltrain currently provides a very high degree of reliability of over 90% on time performance. Caltrain's significant increase in ridership can be partly attributed to that performance. However, Caltrain operates on a system whose tracks, structures and signaling systems will require significant rehabilitation in the near term to maintain that high level of reliability. If Caltrain does not aggressively rehabilitate these critical parts of the system, then reliability and other measures of customer satisfaction will decrease.



Key recommendations

The following chapters of the Rapid Rail Study contain many important recommendations for improving Caltrain service. However, there are three key recommendations which summarize the main findings of the study. These recommendations are:

- Caltrain should aggressively complete a comprehensive rehabilitation and upgrade of the existing railroad infrastructure. The proposed rehabilitation and enhancement projects will enhance safety, improve train speeds, increase train frequency and capacity, improve customer service and reduce operating costs. Engineering and construction should be started immediately; this rehabilitation will cost approximately $543,000,000.

- Electrification has many benefits including reduced travel times, less noise and lower levels of air pollution. Therefore, Caltrain should begin work immediately on engineering and planning for electrification. The cost for electrifying Caltrain to Gilroy is approximately $376,000,000.

  Consideration should be given to electrifying Caltrain using a design/build/procure approach similar to that being used for several major railroad projects now underway, including Amtrak's Northeast Corridor electrification project. Under this approach, several teams of private engineering, construction and railcar manufacturers would develop detailed plans and cost estimates (bids) for completing the entire electrification project, including new railcars. This approach has very significant advantages in that the infrastructure can be fully integrated with the railcars.

  An example is that one team might propose replacing Caltrain's existing passenger cars with electric multiple unit (EMU) railcars. Performance wise, compared to electric locomotives hauling push/pull railcars, EMUs would reduce travel times by approximately 3%; however, EMUs also cost more to purchase and maintain.

  The JPB will be able to evaluate the trade-offs between the different approaches proposed by each team and select the best possible electrification plan to implement. The bids would contain a cost and schedule, so once the JPB selects a team, work could start immediately. This approach could lead to a better electrification project than would otherwise be possible and would significantly reduce the time necessary to electrify Caltrain. Furthermore, the teams could assist with financing the project.

- Once the rehabilitation, enhancements and electrification programs are underway, Caltrain should focus on expansion projects, which could include the Dumbarton Rail Corridor and a direct connection with San Francisco International Airport's new AirTrain system, now under construction.

In order to successfully implement these recommendations, Caltrain must significantly improve its ability to construct improvement projects and must seek additional funding. However, by aggressively moving forward with these recommendations Caltrain can achieve its goals of increasing ridership, improving customer service and becoming a better neighbor more quickly, cost-effectively and with less disruption than would otherwise be possible.

One logical question to ask at this point is whether it makes sense to spend approximately half a billion dollars to rehabilitate and enhance Caltrain and an additional approximately $376,000,000 to electrify the railroad. Findings of the Rapid Rail Study answer that question with an unqualified

YES. Caltrain has many advantages over other solutions for increasing transportation capacity in the corridor. These include:

- **Cost.** Improving Caltrain is less expensive in terms of capital and operating costs than constructing a new light or heavy rail system within the same corridor.

- **Flexibility.** The enhancement program will enable Caltrain to operate additional express trains specifically tailored to serve particular markets, an ability rapid transit and light rail systems lack.

- **Capacity.** The enhancement program will enable Caltrain to provide capacity similar to rapid rail systems by increasing frequency.

- **Inter-operability.** Caltrain is compatible with other standard gauge railroads. Improving Caltrain and retaining standard gauge tracks provides the flexibility to easily expand service to new areas such as the Dumbarton Corridor, through Altamont Pass, and onto Monterey. It also enables other operators— such as Amtrak, Altamont Commuter Express (ACE), Capitol Corridor trains— to share Caltrain tracks for through service.

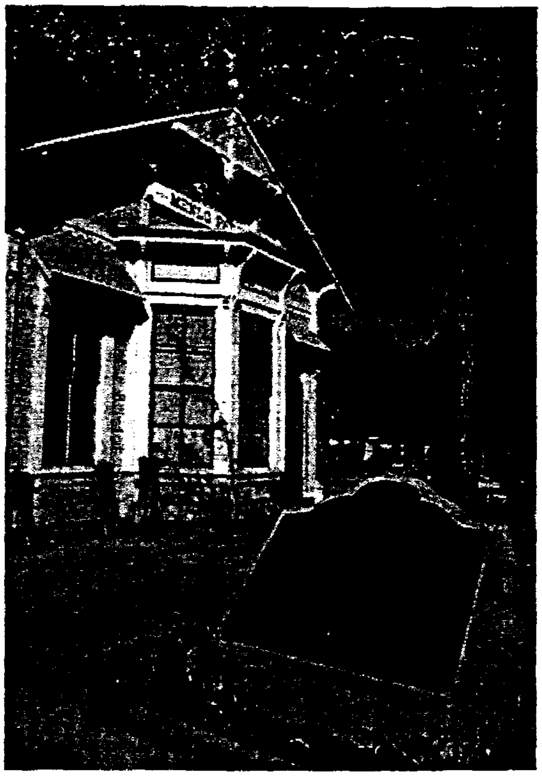
- **Maintenance of service.** Replacing Caltrain with another completely new rail system might require curtailing service on Caltrain while the new system is constructed. In contrast, Caltrain can implement its improvement program without shutting down service.

Because of its cost effectiveness, flexibility and relative ease of implementation, commuter rail systems have become a popular antidote to increasing traffic congestion. Without the benefit of a concerted marketing campaign, the new Altamont Commuter Express service has taken orders for over 600 monthly tickets for its two daily trains and it isn't even operating yet. The Bay Area Rapid Transit District has decided to embrace commuter rail technology on the Capitol Corridor (Bay Area to Sacramento area corridor). European cities are focusing on improving their regional rail operations by increasing speeds, improving access to stations and introducing new generations of railcars. This is exactly the approach recommended in the Rapid Rail Study.

Finally, it is important to emphasize that the Rapid Rail Study simply presents a long-term strategic plan for improving Caltrain. A significant amount of work remains to be done in order to implement the recommendations, including service planning, engineering, and fund programming. As with any strategic plan, the Rapid Rail Study will need to be revisited on a regular basis in the future to refine and revise plans based on changes to Caltrain's markets and operating environment.

1.1 Background

Caltrain provides commuter rail service along a 77 mile corridor between San Francisco and Gilroy in Santa Clara County. Caltrain is managed by the Peninsula Corridor Joint Powers Board (JPB), a public agency formed by San Francisco, San Mateo and Santa Clara counties to operate rail service along this corridor. There are 34 Caltrain stations along this route, serving three counties and 19 communities.

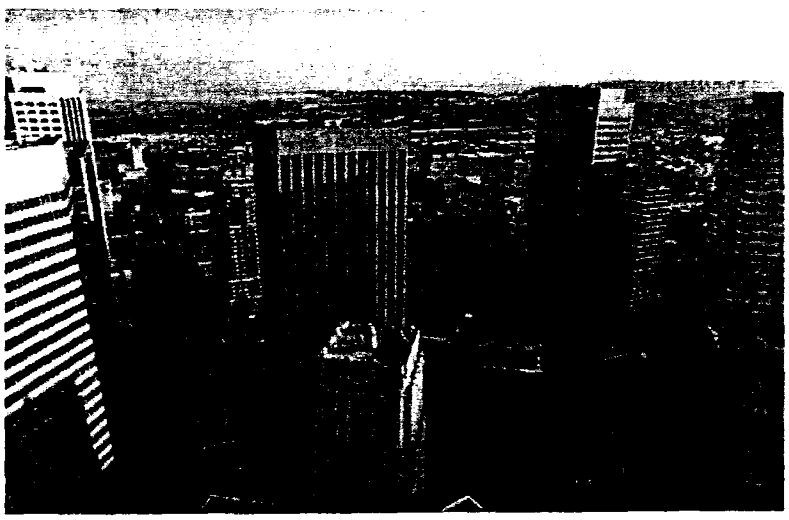


In 1991, the JPB purchased the rail line between San Francisco and San Jose from the Southern Pacific Railroad (SP). Prior to that, the SP had owned and operated railroad service along the Peninsula for over a hundred years. At the turn of the century the SP made considerable investments in improving its passenger rail service. Such improvements included building tunnels through the southeast portion of San Francisco to provide a direct route into the city, and procuring right-of-way for a four-track, high-speed service. Unfortunately, by the time the JPB purchased the line, its infrastructure had deteriorated to the point that it was in need of significant repair.

While the railroad requires significant investment to reverse decades of deferred maintenance, it does own a priceless asset— an excellent railroad corridor along a relatively densely developed urban setting. Caltrain's exclusive right-of-way has the ability to provide a fast, reliable and convenient way to travel along the Peninsula.

In addition to its valuable route, Caltrain's as a commuter rail service, is ideally suited to meeting today's transportation needs. Commuter rail is an inherently simple and flexible technology. This enables Caltrain to serve niche markets relatively easily. For example, Caltrain has the ability to operate express trains– trains that can be customized to meet specific market niches. Caltrain's extremely popular "reverse" commute express service is another example of serving an emerging market niche. These trains operate from San Francisco during the morning peak period to various Silicon Valley employment sites, and in the opposite direction during the afternoon peak period.

Caltrain's ridership has grown significantly since the JPB assumed operation of the railroad. While Caltrain has been able to add additional service (expanding from 54 to 66 daily trains) to accommodate growing demand and new markets, its aging physical infrastructure and rolling stock is placing limits on the ability to further increase service and to better serve customers. The Rapid Rail Study's objective is to develop a capital improvement plan that will enable Caltrain to most effectively serve existing and new markets and thereby improve mobility along the Peninsula.



1.2 Planning context

The main impetus for this study was the rejection by the City of San Francisco of a long planned Caltrain extension from the existing terminal (at Forth and Townsend Streets) to a new multi-modal transportation terminal near Market Street. This decision left the JPB without one of the major organizing principles for its improvement program and left it with financial resources that could be redirected for other projects. In this context, the Rapid Rail Study sets forth a new strategy and recommended set of capital improvements for Caltrain.

Caltrain has completed several studies since the JPB began operating service in 1992. The Rapid Rail Study is based upon information from some of these previous studies including:

- *Caltrain's Market Demand Study* (1997).
- *Caltrain's 20-Year Strategic Plan* (1997).
- *Caltrain's Fleet Plan.*
- *Caltrain Simulation Study* (1998).

The *Market Demand Study* used a computerized transportation demand model to evaluate the impact of various types of improvements upon Caltrain ridership. Ridership increases presented in this study are largely based upon data from the *Market Demand Study*.

The *Strategic Plan* describes goals and objectives for improving Caltrain service. The *Strategic Plan's* five goals are:

1. Improve customer service by putting passenger needs and desires first, and by maintaining a quality rail system.

2. Attain ridership growth by expanding service, infrastructure and facilities.

3. Achieve financial stability and member agency commitment to the future.

4. Develop regional partnerships to establish multi-modal linkages throughout the Bay Area and beyond.

5. Serve local needs and support livable communities by linking land use and transportation decisions.

The Rapid Rail Study recommendations are based on how well projects and programs meet these five goals.

In addition to the *Market Demand Study* and *Strategic Plan*, Caltrain has completed a series of planning studies that evaluate specific improvement projects. These include: additional train service (*Caltrain Simulation Study*), service on the Dumbarton Branch, a direct connection to San Francisco Airport's new AirTrain light rail system, electrification of Caltrain and extending Caltrain to Downtown San Francisco. Results from these studies were used to provide basic information and concepts for improvements in the Rapid Rail Study.

1.3 Study methodology

The goal of the Rapid Rail Study was to develop a long-range capital improvement plan for Caltrain, which is intended to increase speed, frequency and reliability, and to improve access. Simply stated, the study effort evaluated candidate capital improvement projects and prioritized them within expected funding availability. The study's main steps are outlined below (more detailed descriptions are presented in the following chapters).

Define future service strategy

This step consisted of developing a basic understanding of the type and level of Caltrain service that would be operated in the future using travel trends and demographic forecasts. One of Caltrain's key goals is to increase service. There are three factors that govern increasing service:

1) Operating support.
2) Physical infrastructure (including rolling stock).
3) Market demand.

Caltrain's operating subsidy is provided by the three JPB members, San Francisco, San Mateo and Santa Clara counties. The level of subsidy is determined during the annual budget process and is closely related to the number of trains operated. In order to increase service, the annual subsidy provided will need to increase.

The Rapid Rail Study focused on determining the structure for service increases and the physical infrastructure needed to increase service. The approach used was to analyze service using a three-tier approach to service expansion. The three tiers are summarized in Table 1-3.

Future service strategy
Table 1-3

Criteria	Tier 1	Tier 2	Tier 3
Definition	Existing service.	Service with planned fleet.	Growth in service to 2015.
Passenger cars	73	92	170
Locomotives	20	23	30
Peak period trips	14 peak/ 9 reverse	16 peak/ 11 reverse	23 peak/ 17 reverse
Midday frequency	Hourly	Hourly	30 minutes
Gilroy trips	8	Up to 16 (peak & off)	
Daily trips	66	72 – 80	86 –130
Peak capacity	7,800 peak/ 5,000 rev	9,200 peak/ 6,300 rev	18,200 peak/ 3,400 rev

Note: **Achieving these service levels depends on the level of operating subsidy provided by member agencies, rehabilitation of railroad and implementation of improvements recommended in Rapid Rail Study.**

As part of the Rapid Rail Study, the capital improvements necessary to effectively operate the proposed services were identified for each service tier. Railcar requirements were estimated based on the Caltrain Fleet Plan, but it is recommended that Caltrain develop a long range comprehensive fleet plan to address future fleet needs for increased service as soon as possible.

Tier 2 service will be possible once Caltrain completes its current railcar acquisition and rehabilitation program. Until Caltrain has its full compliment of locomotives and railcars (or leases vehicles from other operators) it is impossible to operate any *significant* increase in service.

Tier 3 service can be implemented in steps. However under all cases the railroad must first be rehabilitated and the signal system replaced with centralized traffic control. Aggressive implementation of the rehabilitation and enhancement program will reduce the time until when Tier 3 service may be implemented. The additional improvements necessary to operate increased Tier 3 service include constructing third track sections (to operate more peak service), adding new track crossovers, providing a new maintenance facility (to improve the availability of railcars for operation), acquiring additional rolling stock and installing new turnback tracks.
A key benefit of using this three-tiered approach was that future levels of service could be presented in a general way. The exact number of trains would depend upon the operating funding provided by the member agencies, but the infrastructure would be capable of accommodating increased train service.

Analyze existing infrastructure and major new initiative projects

A field survey was conducted of the existing railroad and its infrastructure and facilities. This was the first comprehensive survey of the railroad in several years. Using results of the field survey, a program of rehabilitation and enhancement projects was developed. The rehabilitation projects, also known as "state of good repair" improvements, were those necessary to maintain railroad operation and reverse years of deferred maintenance.

Enhancement projects were those which could be implemented concurrently with the rehabilitation projects and substantially contribute to improved system operations and customer service. Examples of enhancement projects include station improvements and the installation of sections of third main line tracks.

New initiative projects were defined as extensions and major upgrades to service. They included electrification, the Dumbarton Corridor extension, San Francisco International Airport AirTrain Connection, grade separation projects, and Gilroy service expansion. The purpose of this analysis was to complete a comprehensive and long-term plan for Caltrain, so that improvements could be implemented in an efficient and effective manner. For example, if the decision was made to electrify Caltrain, track could be rebuilt during the rehabilitation using a design compatible with electrification.

Project prioritization and development of Capital Improvement Plan

Following project identification and evaluation, the projects were prioritized using criteria developed from the goals, principles and policies outlined in Caltrain's Strategic Plan. These criteria were:

- Safety.
- Customer service– improved system reliability and efficiency.
- Ridership growth– more frequent service, increased speed, improved station access and parking.
- Ridership growth– new service extensions, more responsive schedule patterns.
- Financial stability– reduced operating costs.
- Multi-modal linkages– improved station access and extensions.
- Local needs and livable communities– improved station access, promotion of transit-oriented development, as well as reduced noise and pollution from Caltrain operations.

Using the results of the prioritization process, recommendations were developed and a capital improvement plan (CIP) was prepared which linked specific projects with specific funding programs.

1.4 Recommendations

The Rapid Rail Study is a comprehensive study of Caltrain's infrastructure, service and environment in 1998. Recognizing the there will be many changes in these areas during the coming years and much more information coming from more detailed studies that will be completed, these recommendations should not be considered as set in stone, but rather part of a dynamic set of principles designed to optimize transportation service along the Peninsula Corridor.

Three types of recommendations were developed: 1) a recommended capital improvement program, 2) recommendations for consolidating stations and closing grade crossings and, 3) program planning recommendations.

1.4.1 Capital Improvement Program

The Rapid Rail Study's key recommendation is that Caltrain should aggressively pursue rehabilitation and enhancement projects while beginning work on electrification. This approach will minimize the time it takes to renew Caltrain to a state of good repair and significantly improve customer amenities. It also will enable Caltrain to develop an integrated approach to electrification whereby the rolling stock, electrical systems, operations and financing can be optimized to best serve its customers and neighbors.

The Capital Improvement Plan recommendations are:

Priority 1: Rehabilitation

Consistent with Caltrain's Strategic Plan goal to improve customer service and safety, rehabilitation— comprising a set of projects to keep the railroad operating safely and reliably— was established as Caltrain's number one priority. This includes the following projects:

- **Safety priority projects.** This includes signal system replacement and systemwide annual rehabilitation projects (trackwork and structures). These projects must be completed soon in order to keep the railroad operating; together they cost approximately $40,000,000.

- **Speed and operations: track replacement.** This includes reconstructing track and grade crossings where necessary. These projects will address years of deferred maintenance on the rail infrastructure and are necessary to enable Caltrain to improve track speeds to 79 mph throughout the entire system. The increase in speed will reduce Caltrain running times by approximately 6%, which will in turn, increase daily passenger trips by approximately 1,600. The cost of these projects is approximately $128,000,000.

- **Speed and operations: structure replacement.** This Includes replacing bridges, culverts and other major structures. Similar to track replacement, these projects will address years of deferred maintenance and are necessary to keep Caltrain operating. The cost of these projects is approximately $52,000,000.

Priority 2: Enhancements

Enhancement projects meet all five goals in Caltrain's Strategic Plan. They improve customer service and safety, they enable increased service and promote ridership growth, they reduce operating costs, they help improve multi-modal connectivity and they support local efforts to improve station areas. These projects would be implemented simultaneously with the rehabilitation projects in order to reduce impact on Caltrain's customers and neighbors, as well as to reduce construction costs. The following projects are included in the enhancements category:

- **Operating flexibility.** This includes constructing new third main line track sections, improving San Francisco and San Jose terminals, and replacing the existing CTC system. These projects will enable Caltrain to increase the number of peak hour trains and improve speed to 90 mph; they also will improve service reliability and operations. Collectively, the cost of these projects totals approximately $98,000,000.

- **Station enhancement projects.** There are two types of station enhancement projects: systemwide improvements and station upgrades. The systemwide improvements consist of making comparatively minor improvements to all Caltrain stations to bring them up to a basic level of amenities and passenger facilities in conformance with the newly established *Caltrain Station Planning Concepts* document. The cost for this program is approximately $14,000,000.

  The station upgrades are more significant station reconstruction projects that include constructing outside boarding platforms and providing full ADA accessibility. These projects will improve safety, attractiveness, Caltrain operations and speed. The cost for these projects is approximately $144,000,000.

- **Parking and access.** This project category seeks to increase the supply of Caltrain parking and to improve multi-modal access to Caltrain stations. There are two major projects in this category: the first would capitalize upon low cost opportunities to improve parking and access, the second is a major parking projects subcategory that would fund property acquisition and (potentially) structured parking. These projects would address the need for improved access to Caltrain stations. The cost for these projects is estimated at approximately $60,000,000. According to forecasts provided in Caltrain's *Market Demand Study*, providing parking for Caltrain passengers is estimated to increase ridership by 1,800 daily passenger trips.

Priority 3: Electrification

Electrification has many benefits including reduced travel times, lower operating costs (once the threshold of 114 trains per day has been reached), less air pollution, less noise and a more modern image. Electrification is consistent with many of Caltrain's Strategic Plan goals, but its cost (approximately $376,000,000) means that it must be separately considered.

One important fact is that electrification, by itself, will not significantly improve Caltrain service. All of the rehabilitation projects and many of the enhancement projects must be implemented to obtain the full benefits of electrification. Specifically, electrifying the existing railroad would reduce run times by approximately 6%. However, improving the railroad to 79 mph operation and eliminating three stations would reduce run times by approximately 21%.

Given the benefits of electrification, especially as a part of a vastly improved Caltrain infrastructure, the Rapid Rail Study recommends beginning detailed planning for electrification immediately. It is recommended that Caltrain consider a design/build/procure approach (described above) to electrification.

Priority 4: Expansion

Expansion projects are consistent with Caltrain's Strategic Plan goal to increase ridership. They are projects that implement a significant new service or changes to service. The Rapid Rail Study recommends that once the rehabilitation, enhancement and electrification projects are underway, Caltrain focus on the expansion projects.

Dumbarton rail corridor. This project would cost approximately $150,000,000. Caltrain should continue to work to develop the feasibility of this project and to seek additional funding partners for this important regional project.

San Francisco International Airport Air Train connection. The project would cost approximately $70,000,000. Caltrain should ensure that nothing is done to preclude making this connection and should seek additional funding partners for this project.

Grade separation projects. The Rapid Rail Study prioritized each grade crossing project for implementation. The cost of the 14 highest priority grade separation projects is estimated at approximately $590,000,000. Given this high cost and limited available funding, it is recommended that Caltrain meet with cities to determine their interest in pursuing these grade separation projects. Depending upon their interest, preliminary planning for these long-term projects could begin. The Rapid Rail Study recommends closing 11 existing grade crossings which have low traffic volumes and leaving the remaining 23 existing grade crossings in operation. It should be noted that eliminating grade crossings is not required for improving Caltrain service but would be required for a rapid transit system such as BART.

Gilroy service. This project would increase service to Gilroy. Santa Clara County has expressed a strong desire to increase Gilroy service and has funding available in its Measure A/B sales tax. Therefore, the JPB should work closely with Santa Clara County to develop a mutually beneficial plan to increase such service. Capital costs for increasing Gilroy service were not included in the Rapid Rail Study because they are subject to negotiation with the Union Pacific Railroad.

Table 1-4 summarizes the recommended Capital Improvement Plan.

1.4.2 Consolidating stations and closing grade crossings

The Rapid Rail Study evaluated Caltrain's infrastructure from a strategic perspective. Two important findings were that grade crossings should be eliminated whenever possible and that travel times could be increased significantly by closing several stations with very low patronage. These are not recommendations that will be popular with customers directly impacted by them, but they would provide significant benefits to the Caltrain community at large.

Given the strong public feelings on these recommendations Caltrain would perform a thorough analysis of any specific crossing closing or station consolidation project before it is implemented. This analysis will include the pros and cons of closure on costs, ridership and safety. This analysis would involve extensive public participation. The objective would be to develop a win-win situation by considering innovative solutions.

The specific recommendations presented below should be considered as a starting point. The next step in the planning process would be to meet with affected communities and groups to begin the planning process for these long-term projects.

Closing grade crossings

In order to improve safety, pedestrian and vehicle grade crossings should be eliminated whenever possible through either grade separation projects or by permanently closing the crossing. Another important reason for eliminating grade crossings is that this will reduce the cost of electrification and reduce Caltrain's operating and maintenance costs.

Grade separation projects and closing grade crossings will both have impacts on communities. Caltrain will work closely with cities, the FRA, the PUC and local agencies to develop mutually acceptable plans for addressing grade crossing safety.

The following highway grade crossings have been recommended for closure:

- Scott Street (South San Francisco).
- North Lane (Burlingame).
- South Lane (Burlingame).
- Villa Terrace (San Mateo).
- 2^{nd} Avenue (San Mateo).
- Maple Street (Redwood City).
- Watkins Avenue (Atherton).
- Glenwood Avenue (Menlo Park).
- Stockton Avenue (San Jose).
- Lenzen Avenue (San Jose).

In addition to these highway grade crossings it is recommended that Caltrain provide grade-separated pedestrian crossings at stations whenever adjacent highway grade crossings are grade separated.

Consolidating stations

Several Caltrain stations serve fewer than one hundred customers each day. Each station stop adds approximately a minute and a half to a train's running time, considering the time it takes a train to brake, board passengers and then accelerate. This is a significant amount of time, especially given the amount of money Caltrain would need to spend on other improvements to achieve the same travel time savings.

One of the most effective ways of reducing Caltrain's running speed is to reduce the number of stops– this is why Caltrain's express trains are so popular. Therefore, in order to improve travel speed, underutilized stations should be consolidated with other stations, especially when there are alternate stations nearby. Travel time simulations indicate that eliminating three station stops would reduce run times by about 6% leading to an increase of approximately 1,600 trips per day.

Another benefit of consolidating stations is reducing station maintenance and capital costs. An average Caltrain station costs approximately $25,000 per year to maintain and bringing a typical Caltrain station up to the current Station Planning Concept standards costs on the order of $2,000,000 to $3,000,000. Furthermore, reducing the number of stations will enable Caltrain to better focus improvements on the remaining stations.

Clearly this is a case where the community's needs must be carefully balanced against Caltrain's objectives, but consolidating stations with low boardings will improve service for the majority of Caltrain passengers and significantly reduce capital and operating costs.

The following stations are candidates for consolidation:

- Paul Avenue (20 average weekday boardings).
- Broadway– consolidate with Burlingame Station.
- Bay Meadows– consolidate with Hillsdale Station.
- Atherton (206 average weekday boardings).
- Castro– replace with new San Antonio Station.
- College Park (197 average weekday boardings when school is in session).

1.4.3 Program planning recommendations

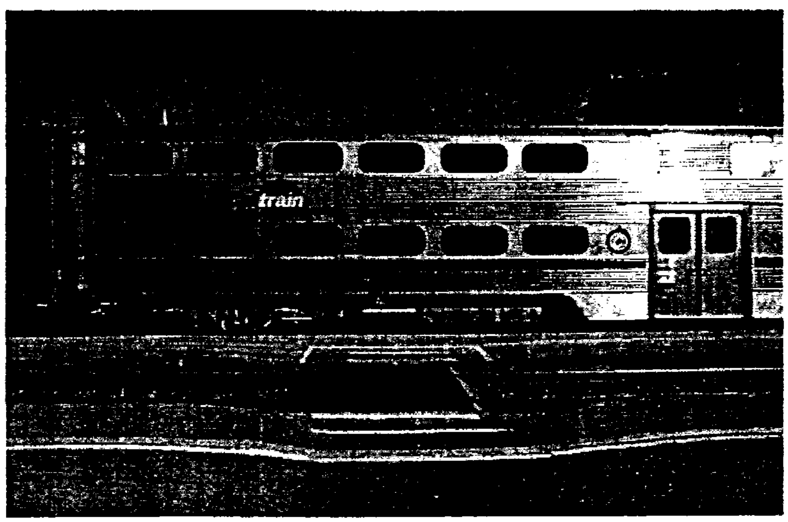
It is recommended that Caltrain take the following actions to improve planning and project implementation.

Safety

Caltrain's first priority is safety for our customers, employees and all others who interact with the system.

Consistency with long-term planning

All Caltrain capital improvements should be consistent with long-term plans, to the maximum extent feasible.



Update Fleet Management Plan

Lead times for procuring new rolling stock can take several years; therefore, Caltrain should immediately develop a long-term fleet strategy and management plan. This plan should be closely coordinated with the electrification proposal. Even if electrification is not pursued, Caltrain still needs to begin planning for a new fleet to replace the existing fleet.

Minimize impacts on customers and communities

Caltrain should implement all construction projects in a manner that will minimize the impacts on customers and neighboring communities. One way of accomplishing this policy is to package improvements so that all the projects in a given area are completed simultaneously. For example, station enhancement projects and grade crossing improvements should be undertaken at the same time as track in the area is being rehabilitated. In addition to reducing customer disruption, this will reduce overall costs and reduce the time needed to complete the program. This approach was followed in the recommended capital improvement plan.

Project delivery

In order to construct the rehabilitation and enhancement projects needed to restore Caltrain to a state of good repair, Caltrain will need to expand its ability to deliver capital projects. Implementing an improvement program of nearly $900,000,000 will require a well thought-out approach that could include combining projects into large single programs similar to the approach used for the Ponderosa Project. Another idea is to explore is using a single contractor to complete both the design and actual project construction (design/build). Should a design/build contractor approach be selected, the electrification project could be included in the rehabilitation and enhancement package. Caltrain must develop a detailed approach to project delivery within the next year.

Project categorization Table 2-1		
Rehabilitation		
Safety	$40	
Track rehabilitation	$128	
Structure rehabilitation	$52	
Subtotal		**$220**
Enhancements		
Operating flexibility	$98	
Station enhancements	$130.5	
Parking and access	$60	
Subtotal		**$288.5**
Electrification		
Electrification		**$376**
Expansion		
Dumbarton rail corridor	$150	
Caltrain -- SF Airport connection	$70	
Rolling stock	NA	
Gilroy service	NA	
Grade-separations	$590	
Subtotal		**$810**
Grand Total		**$1694.5**
Note: All costs in millions of 1998 dollars.		

Rehabilitation

Safety priority projects. This category includes signal system replacement (funding for shortfall in CTC Phase 1) and systemwide annual rehabilitation projects (trackwork and structures). These projects must be completed soon to keep the railroad operating. They cost approximately $40,000,000.

Speed and operations: track replacement. This includes reconstructing track and grade crossings where necessary (see chapters 4 and 6 for a complete description of the work to be performed). These projects will address years of deferred maintenance on the rail infrastructure and are necessary to enable Caltrain to improve speed and reliability. The cost of these projects is approximately $128,000,000.

Speed and operations: structure replacement. This category includes replacing bridges, culverts and other major structures (see chapter 9 for a complete description of the work to be performed). Similar to the track replacement, these projects will address years of deferred maintenance and are necessary to keep Caltrain operating. Collectively, the cost of these projects is approximately $52,000,000.

Enhancements

Operating flexibility. This includes constructing new third main line track sections, improving the San Francisco and San Jose terminals, and replacing the existing CTC system. These projects will enable Caltrain to increase the number of peak hour trains and improve speed; they also will improve service reliability and operations. Altogether, the cost of these projects is approximately $98,000,000.

Station enhancement projects. There are two types of station enhancement projects: systemwide improvements and station upgrades. The systemwide improvements consist of making comparatively minor changes to all Caltrain stations to bring them up to a basic level of amenities and passenger facilities in conformance with the newly established Caltrain Station Planning Concepts document. The cost for this program is approximately $14,000,000.

Station upgrades are significant station reconstruction projects that include constructing outside boarding platforms and providing full ADA accessibility. These projects will improve safety, attractiveness, Caltrain operations and speed. The cost for these projects is approximately $144,000,000.

Parking and access. This project category seeks to increase the supply of Caltrain parking and to improve multi-modal access to Caltrain stations. There are two major projects in this category: the first would capitalize upon low cost opportunities to improve parking and access, the second is a major parking projects subcategory that would fund property acquisition and (potentially) structured parking. These projects would address the need for improved access to Caltrain stations. The cost for these projects is estimated at approximately $60,000,000. According to forecasts provided in Caltrain's Market Demand Study, providing parking for Caltrain passengers is estimated to increase ridership by 1,800 daily passenger trips.

Electrification

Electrification. This project would electrify the railroad between San Francisco and Gilroy. It includes electrification of the line (with a single track electrified between Tamien and Gilroy) and assumes that new electric locomotives would be purchased for push/pull service. The cost of electrification could be quite different if, for example, electric multiple unit railcars were purchased instead. This project would improve service by increasing train speeds and reducing operating costs (once Caltrain service reaches a breakeven threshold of about 114 trains per day). It would also reduce air pollution and noise generated by the existing fleet of diesel locomotives. The cost for electrification is approximately $376,000,000.

Expansion

Dumbarton corridor service. This project would rehabilitate the existing Dumbarton Railroad Bridge and operate commuter rail service between the East Bay and the Peninsula. The project includes track and bridge rehabilitation, as well as acquisition of new rolling stock to operate the service. Several different proposals are under evaluation for serving this corridor. The cost of this project is approximately $150,000,000.

San Francisco International Airport AirTrain connection. This project would extend the San Francisco International Airport's AirTrain system (under construction within the airport) to the Caltrain station in San Bruno. It would provide a convenient transfer between Caltrain and the airport and is estimated to cost approximately $70,000,000.

Rolling stock. A detailed analysis of future rolling stock needs was not completed as part of the Rapid Rail Study since Caltrain's fleet will be increased by three new locomotives and 19 new passenger cars by the year 2002. (By 2002 the new vehicles will have arrived and the existing railcars will have been rehabilitated.) However, it is clear that with additional growth in passenger ridership, additional rolling stock will be soon needed. It is recommended that the procurement of rolling stock be closely coordinated with electrification.

Gilroy service. This project would increase Caltrain service to Gilroy. The Rapid Rail Study included an analysis of this project, but did not develop detailed cost estimates since the level of capital improvements necessary is dependent on negotiations with the Union Pacific Railroad.

Grade separations. Grade separation projects were analyzed as part of the Rapid Rail Study. These projects improve traffic conditions and safety, but are not required to operate train service. A dedicated portion of San Mateo County's transportation sales tax provides funding for these large-scale and very expensive projects. Funding for projects in other counties is unidentified. The total cost of the recommended grade separation projects is $590,000,000.

2.3 Project prioritization

Once the projects were placed into categories, the categories were then prioritized using criteria developed from the goals, principles and policies outlined in Caltrain's Strategic Plan. The criteria were:

- Safety (Strategic Plan Goal 1).
- Customer service– system reliability and efficiency (Strategic Plan Goal 1).
- Ridership growth– more frequent service, increased operating speeds, improved station access (Strategic Plan Goal 2).
- Ridership growth– new service extensions (Strategic Plan Goal 2).
- Financial stability– reduced operating costs (Strategic Plan Goal 3).
- Multi modal linkages– improved station access, promotion of transit-oriented developments and service extensions (Strategic Plan Goal 4).
- Local needs and livable communities– improved station access, as well as reduced noise and pollution (Strategic Plan Goal 5).

The projects that were included in each of the categories were evaluated as part of the prioritization process. Table 2-2 presents the results of this process. This table is organized with the evaluation criteria listed across the top of the page and the project categories down the side. A full circle indicates that a project fully meets the evaluation criteria, a half filled circle indicates that the project partially meets the criteria, and an empty circle indicates that the project does not meet the criteria at all.

Using the results presented in Table 2-2, and an analysis of the different categories of projects, the following prioritization of the four general categories of project was developed:

Project evaluation matrix
Table 2-2

Project/Category	Safety	Customer service	Ridership growth speed	Ridership growth extension	O&M costs	Multi-Modal linkages access, extensions	Livable communities access, pollution
REHABILITATION							
Safety priority	●	○	○	○	●	○	○
Track replacement	◒	◒	○	○	●	○	○
Structure replacement	◒	◒	◒	○	●	○	○
ENHANCEMENTS							
Operating flexibility	○	◒	●	○	◒	○	◒
Systemwide station	◒	●	○	○	◒	◒	◒
Station upgrades	◒	●	○	○	◒	◒	◒
Parking and access	○	○	○	●	○	●	●
ELECTRIFICATION	○	○	●	NA	○	○	●
EXPANSION							
Dumbarton corridor	○	○	NA	●	○	●	○
SF Airport Connection	○	○	NA	◒	○	●	○
Rolling stock	○	◒	NA	●	○	○	○
Gilroy service	○	○	NA	●	○	●	○
Grade-separations	◒	○	NA	○	○	○	●

Key:
- ● Fully meets criteria
- ◒ Partially meets criteria
- ○ Does not meet criteria
- NA Not Applicable
- LO Local Option

Priority 1: rehabilitation

Consistent with Caltrain's Strategic Plan goal to improve customer service and safety, rehabilitation-- comprising a set of projects to keep the railroad operating safely and reliably-- was established as Caltrain's number one priority. This includes replacement of rail, ties and subsurface, the signaling system, bridges and major structures.

Priority 2: enhancements

Enhancement projects meet all five goals in Caltrain's Strategic Plan. They improve customer service and safety, they enable increased service and promote ridership growth, they reduce operating costs, they help improve multi-modal connectivity and they support local efforts to improve station areas. This category of project was given second priority following the required basic rehabilitation and safety projects.

Priority 3: electrification

Electrification will meet many of Caltrain's Strategic Plan goals, but its sheer magnitude (approximately $376,000,000) means that it must be separately considered. Furthermore, electrification, without the requisite rehabilitation and enhancement projects, will not significantly improve Caltrain service. All the proposed rehabilitation projects and many of the enhancement projects must be implemented to obtain the full benefits of electrification. Therefore, this project was given third priority in the Rapid Rail Study.

Priority 4: expansion

Expansion projects are consistent with Caltrain's Strategic Plan goal to increase ridership. They are projects that implement a significant new service or changes to service. This category of project was ranked fourth since the existing railroad should be rehabilitated and upgraded before new extensions are pursued.

2.4 Funding programs and assumptions

A fundamental part of the Rapid Rail Study was developing a capital improvement program that was financially constrained within the expected funds available to Caltrain. The JPB used MTC's financial projections from the 1998 Regional Transportation Plan to determine available funding and then prioritized projects within the funding limits. This section outlines the major funding programs assumed available for the Rapid Rail Study and the assumptions made regarding local funding for the program.

It should be emphasized that the Rapid Rail Study is a strategic plan for guiding Caltrain's capital investments over the next ten to twenty years. As such the funding assumptions presented below are subject to a significant amount of change over the years as Caltrain completes certain projects and new priorities are identified. One critical JPB assumption is that Caltrain will aggressively seek to increase the federal and state funding available for the program– in order to reduce the amount of local and discretionary funding required. The assumptions for funding presented below should be considered conservative.

Federal and state funding programs

The following Federal and State funding programs were considered in developing Caltrain's CIP (all figures are presented in 1998 dollars):

- **Federal Section 5309– Transit Capital Replacement Program.** Approximately $108,000,000 is available for completing rehabilitation projects during the next ten years from two separate projects: 1) Track Rehabilitation and, 2) North/South Terminal Rehabilitation. The region has recognized Caltrain's extensive deferred maintenance needs and is prepared to make an investment in these improvements, provided Caltrain can develop a complete plan and demonstrate that it is able to implement its plan effectively.

- **Federal Section 5307– Rail Modernization Program.** Approximately $130,000,000 of funding originally dedicated to the Caltrain's Downtown San Francisco extension project in MTC Resolution 1876 has been reallocated to fund projects from the Rapid Rail Study (MTC Resolution 3021). These funds will be available following completion of the BART A/B car rehabilitation project and the Muni light rail vehicle purchase.

- **State Transportation Improvement Program (STIP).** These funds can be used for either highway or rail projects. Caltrain would have to compete with other projects from the three member counties to obtain funds from these programs, and there is fierce competition for these funds. Thus, it is difficult to identify exactly how much would be available for Caltrain improvements in the next several years. For purposes of this analysis, it is assumed that Caltrain could receive $15,000,000 from this program to fund Phase 2 of the Centralized Traffic Control (CTC) program.

- **State Public Utilities Commission Section 130 Program.** This is a program funded by the California Public Utilities Commission to improve the safety of railroad grade crossings. Approximately $20,000,000 is allocated each year throughout the state based on a set of criteria which includes traffic volumes and accident data. The funds can be used for grade separation, warning systems and/or traffic engineering. For purposes of this analysis, it is assumed that Caltrain will receive $10,500,000 over seven years from this program.

- **State Inter-regional Program.** The Inter-regional Program is a new funding program developed as part of the recent reorganization of the STIP process. Caltrain could qualify for funding under this program-- especially projects could be used by multiple rail operators (e.g. the Santa Clara to Gilroy segment). In order to be conservative, no funding is assumed to come from this category as part of this analysis. However, Caltrain will apply for funds and the JPB believes that especially the Santa Clara–Tamien route section should rank highly in the program.

- **State Bridge Program.** The State Bridge Program is another new funding source that could be used to pay for bridge and structure replacements. This program will be administered as part of the recent reorganization of the STIP process. In order to be conservative, no funding is assumed to come from this category; nonetheless, Caltrain will still apply for funds for bridge and structure replacement.

- **Regional Transportation Fund For Clean Air.** The Transportation Fund for Clean Air program has been suggested for use in helping to electrify Caltrain (since replacing Caltrain's existing diesel locomotives would improve air quality). The TFCA funds are distributed by the Bay Area Air Quality Management District based on the amount of air pollution removed by the project. Unfortunately, this program would only fund about $16,000,000 to $20,000,000 annually throughout the region. Therefore, it is unlikely that any significant funding would be available for Caltrain capital improvements of the magnitude contemplated in this study.

Local funding programs

Local funding will be needed to complete the Rapid Rail Study. This funding will be needed for two reasons. First to meet the matching fund requirements of most Federal and State funding programs. In past years the local match requirements have been met by using Proposition 116 funds; however, these funds are now exhausted.

The second need for local funds will be to meet the shortfall between Federal and State funds available for Rapid Rail Study projects and the cost of these projects. The following local programs are available:

- **San Mateo County Transportation Authority.** The SMCTA is a local sales tax authority for San Mateo County, approved by the voters in 1987. Currently, approximately $160,000,000 remains in the program designated for Caltrain improvements, and another $90,000,000 remains in the grade separation category.

- **Santa Clara County Sales Tax.** Funding for Caltrain was included in Santa Clara County's Measure A/B program. Funds are identified for both the San Jose–Gilroy and San Jose–Palo Alto segments. Funding is provided in the measures for both capital and operating improvements. Approximately $50,000,000 is assigned to the San Jose–Palo Alto segment, with additional funding assigned to the San Jose–Gilroy segment.

- **San Francisco County Transportation Authority.** San Francisco County has a local transportation sales tax that is administered by the SFCTA; however there are no funds specifically identified for Caltrain improvements in that authority's enabling legislation.

In addition to county sales tax programs there are other possible sources of funds that are allocated under local prerogative. Two examples are STIP funds and bridge toll revenues. These sources could be potentially used to meet both local match as well as program shortfalls.

Rapid Rail Program Funding summary

Table 2-3 summarizes all Federal, State and local funding assumed to be available for Rapid Rail Study projects. Again, this is a conservative program in the sense that Caltrain will seek additional funding from Federal and State programs to preserve local and other discretionary programs.

Funding program summary
Table 2-3

Description	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Funding requirements												
Rehabilitation	40.5	42.5	34.5	33.5	29.5	20.5	4.0	5.0	5.0	5.0		**220.0**
Enhancements	19.0	40.0	39.0	53.0	44.0	36.0	21.0	36.0	20.0	15.0		**323.0**
Total Required	**59.5**	**82.5**	**73.5**	**86.5**	**73.5**	**56.5**	**25.0**	**41.0**	**25.0**	**20.0**		**543.0**
Funding programs												
FTA 5309	14.0	14.0	14.0	14.0	14.0	7.5	7.5	7.5	7.5	7.5		**107.5**
FTA 5307 - Reso 1876	18.8	20.4	25.6	32.8	29.2	3.2	0.0	0.0	0.0	0.0		**130.0**
Tea-21	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		**28.0**
Local match requirement	8.7	9.1	10.7	12.5	11.6	3.4	2.6	2.6	2.6	2.6		**66.4**
STIP	0.0	0.0	7.5	7.5	0.0	0.0	0.0	0.0	0.0	0.0		**15.0**
PUC 130	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0.0	0.0	0.0		**10.5**
Other local sources	14.5	35.5	11.3	15.3	14.3	37.9	10.4	27.9	11.9	6.9		**185.9**
Total Funding	**59.5**	**82.5**	**73.6**	**86.6**	**73.6**	**56.5**	**25.0**	**41.0**	**25.0**	**20.0**		**543.3**

All figures in millions of 1998 dollars.

The local funding requirements for the JPB over the 10-year implementation period is as follows:

- Local funding to match federal funds: $66,400,000.
- Local funding to make-up shortfall: $185,600,000.

The Joint Powers Agreement between San Francisco, San Mateo and Santa Clara counties for operating Caltrain service includes formulas for allocating operating subsidies and capital costs between the three member counties. The formula for allocating capital costs is that each county is obligated to fund one-third of capital costs between San Francisco and Tamien.

The purpose of the Rapid Rail Study is not to open policy issues regarding the Joint Powers Agreement between the three member counties. However, it is clear from this analysis that the member counties will need to come to an agreement on capital project funding in order to implement any long-term capital improvement program. This is especially true for major improvement projects such as electrification.

2.5 Rapid Rail Study Capital Improvement Program recommendations

Once the project prioritization process was complete, the next step was to develop an implementation program for the projects that linked projects with funding programs and an implementation schedule. Table 2-4 summarizes the recommended funding program.

Recommended capital improvement program
Table 2-4

Description	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Rehabilitation												
Safety	16.5	6.5	6.5	3.5	3.5	3.5						40
Track rebuild	24	32	18	19	22	13						128
Structure rebuild		4	10	11	4	4	4	5	5	5		52
Subtotal	41	43	35	34	30	21	4	5	5	5		220
Enhancements												
Operating flexibility	3	4	21	26	15	13	8	8				98
Enhancements - Parking	2	7	7	7	8	13	13	3				60
Enhancements - Station	14	29	11	20	21	10		15	20	15		155
Subtotal	19	40	39	53	44	36	21	26	20	15		313
Electrification												
Phase 1: Engineering	2	4	4	6								16
Phase 2: Construction					50	80	80	80	70			360
Subtotal	2	4	4	6	50	80	80	80	70	0		376
Expansion												
Dumbarton Rail Corridor	Timing to be determined											150
SF Airport connection	Timing to be determined											70
New vehicles	Costs to be identified in Fleet Plan											
Gilroy service increase	Costs to be identified by Santa Clara County in negotiations with UP											
Grade separations	Exact program to be developed working with impacted cities											590
Subtotal												810
Annual Total (without Expansion)	62	87	78	93	124	137	105	111	95	20		
Grand Total												1,719

The following recommendations were followed in developing the implementation program:

- **Aggressive implementation.** Caltrain's infrastructure is well overdue for rehabilitation; without an aggressive program to replace its tracks, signal system, structures and facilities, customer service will decline, operating costs will increase and Caltrain could be at greater risk for catastrophic failures. Furthermore, Caltrain cannot effectively improve service until its basic system is rehabilitated.

  Therefore, the objective of the Rapid Rail Study is to complete the rehabilitation and enhancement projects as quickly as possible, with a goal of completing them by 2006. This objective has the impact of utilizing slightly more local funding for rehabilitation, but results in an upgraded railroad substantially sooner than slower implementation programs. (Under a program that utilized only Federal transit rehabilitation funds for track rehabilitation projects, the program would not be complete until 2013, and only $36,000,000 would be saved-- although this would be significantly decreased by the impact of inflation.)

- **Focus on rehabilitation and enhancements.** With the tremendous backlog of critical rehabilitation and replacement needs that must be initiated immediately and in the very near-term, electrification and new service area expansion projects are recommended for later implementation. The relevance or importance of these types of projects has not been overlooked; rather, they have been placed in a sequence that first ensures safe and reliable operation and then later provides the means for improving both the quality and quantity of service provided to Caltrain customers.

- **Minimize customer interference.** Projects will be implemented to minimize the impacts on Caltrain customers. The objective of the Rapid Rail Study will be to implement enhancement projects (station upgrades and operating flexibility projects) when track and structure rehabilitation projects are being undertaken in the same area. This will minimize construction costs, as well as reduce disruption to customers and neighbors.

- **Begin preparations for electrification immediately.** The process of electrifying Caltrain will require significant policy input, public involvement, engineering analysis and financial commitment. If Caltrain starts this process immediately, upon completion of the requisite rehabilitation and enhancement projects, construction of electrification can then continue without delay.

- **Consider design/build/procure electrification programs.** During the last several years many major railroad projects have been completed using a design/build/procure approach, whereby a single consortium of companies completes the engineering, construction and provides vehicles. Two good examples are Amtrak's Northeast Corridor High Speed Rail project and the Oslo Airport Express train. The JPB should consider implementing electrification through a design/build/procure program. This would enable Caltrain to optimize vehicles, trackwork and electrification systems to function as a single integrated package. Furthermore, the selected consortium might even be able to assist in financing the project.

The design/build/procure program would consist of the following steps. First, the JPB would develop a series of performance-based specifications for service (capacity, number of trains per day, operating costs, operating parameters, environmental impacts, capital costs, etc.). Next, consortiums comprised of vehicle manufacturers, construction companies and engineering firms would be invited to develop proposals that would fully implement electrification in a single package. That package would include vehicles and all related facilities required for electrification, as well as a funding strategy.

Major funding for this program would need to be provided through the update of the Bay Area's Regional Rail agreement. With a funding commitment, project construction could begin while the rehabilitation and enhancement projects were being completed, and this could be finished by 2008 or 2009. In this manner the line would be completely rebuilt to take full advantage of the benefits of electrification.

- **Delay implementation of Dumbarton extension and San Francisco International Airport AirTrain connection.** Given Caltrain's extensive rehabilitation and enhancement needs, it is recommended that both these extension projects be delayed. Both of these projects have high costs, relatively low ridership and most importantly-- they should be partially funded by other agencies that have not yet agreed to participate.

  Once Caltrain is operating a rehabilitated and electrified system with increased and faster service, it will be more likely that others might be willing to participate in funding these service extensions. Another reason for delaying the Dumbarton project is that a new rail bridge would be built in the Dumbarton Corridor if California proceeds with the proposed high-speed rail system. Such a new bridge could also be used by Dumbarton corridor commuter service, thereby saving Caltrain the cost of rehabilitating the existing Dumbarton bridge.

- **Increase Gilroy service.** Santa Clara County has expressed a strong desire to increase Gilroy service and has funding available in its Measure A/B sales tax. Therefore, the JPB should work closely with Santa Clara County to develop a mutually beneficial plan to increase service to Gilroy.

- **Grade separation projects.** The San Mateo County Transportation Authority has a limited amount of funding for grade separation projects in the county. These projects should be closely coordinated with Caltrain rehabilitation and enhancement projects as well as with the local community. In order to improve the efficiency and effectiveness of these grade crossing separation projects-- from a railroad standpoint-- Caltrain should retain responsibility for planning and constructing these projects.

CHAPTER 12

ELECTRIFICATION

12 Electrification

Summary

Electrification is recommended as a long-term service enhancement project, in conjunction with the implementation of a new rolling stock fleet strategy and completion of other infrastructure improvements discussed elsewhere in this report. This approach maximizes the benefits of electrification, such as improved air quality and reduced travel time, with operations on railroad infrastructure that has been brought to a state of good repair. Implementation of electrification thus follows a strategic progression of capital investments.

The JPB recommends that Caltrain pursue a design/build/procure contract for completion of the electrification project. This process would consist of several consortiums that include engineering firms, construction contractors and railcar manufacturers prepare bids for completing a turnkey electrification project. The major benefit of this approach is that Caltrain would have a totally integrated project where the railcars are optimized to the electrification system. Furthermore the consortium could assist in providing financing for the project. This same approach has been used successfully with Amtrak's Northeast Corridor High Speed Rail project, on the Hudson Bergen LRT line in New Jersey and with Oslo's Airport Express train.

The total electrification cost is estimated at $324,000,000 for a double track railway from San Francisco to Tamien, and an incremental cost of $52,000,000 for electrifying a single track railway from Tamien to Gilroy, excluding the real estate cost for substations. This cost estimate assumes that Caltrain's existing locomotives would be replaced with electric locomotives.

This chapter discusses significant issues that are associated with electrification of the Caltrain rail line. The costs of major electrification-related elements are estimated and summarized in this chapter, as are the benefits of electrification.

12.1 Introduction

Electrification of Caltrain has many benefits, including the potential for improved travel times due to the higher performance of electric powered locomotives or vehicles. It will reduce the operating costs associated with fuel and locomotive operations and maintenance. Other benefits include a reduction in air pollution and lower average noise along the corridor. Electrification can also reduce overall highway vehicle-miles traveled if it can attract more riders to Caltrain; this in turn could further reduce air pollution, noise and energy consumption in the corridor.

On the other hand it must be emphasized that electrification is not a prerequisite for higher operating speeds; such speeds can also be attained using diesel technology. Further, increased operating speeds can only be obtained once Caltrain's signal system, track and grade crossings are in a state of good repair. Finally, advances in diesel engine technology are reducing pollution and noise from locomotives.

Electrification of the Caltrain system is a concept that has been under consideration for several years. In 1992 Morrison Knudsen Corporation (MK) conducted a feasibility study of electrification. In 1996, ICF Kaiser Engineers updated parts of the study as part of the Downtown San Francisco extension project.

This chapter summarizes earlier electrification concepts and addresses various concerns raised about the previous reports in an attempt to provide useful information for decision-makers in evaluating the costs and benefits of electrification. It augments the previous reports with supplementary information gathered from recent projects around the country. It should be noted that much of this information is still conceptual in nature, since no engineering has been conducted under the Rapid Rail Study to address this issue.

The Caltrain electrification project consists of two major components: a power distribution system (including substations) and vehicles. The two components are generally considered together in deciding what type of electrification to complete. Vehicle technology is described in *Chapter 13-Vehicle Technology Analysis*. This chapter describes the power distribution elements of electrification.

12.2 System description

An electrified Caltrain system would consist of traction power substations that receive power at high voltages from utility companies, and then step down to lower voltage for use by electric locomotives or cars. The questions that need to be addressed are the type of voltage that would be used and how it would be distributed to vehicles.

In electrifying a railroad, there are several voltages that can be considered using direct current (DC) and alternate current (AC) applications. The most common voltages for DC electrification are 650 V, 750 V, and 1500 V, and those for AC are 25 kV 60 Hz and 50 kV 60 Hz. The selection of a particular voltage depends on a number of factors such as the method of power distribution (third rail or overhead), size of conductors, overhead clearance restrictions along the right-of-way, the availability of power supply, and most importantly— direct and indirect costs.

For example, if there are many grade crossings, a third rail system would not be practical or safe to operate. The high cost for fencing in a third rail system is another factor in selecting an alternative means of distributing power. Also, if there are severe overhead restrictions such as that of a tunnel with a low roof or overhead bridges with many low clearances, the cost to modify them for an overhead contact system would become economically impractical. Further, the signaling system and the railroad and telephone communication circuits must be compatible with whichever type of electrification selected.

The MK study considered different types of electrification and it recommended that Caltrain be electrified with a 25,000-volt alternating current (25 kV AC) system. This system is compatible with most long distance electrified railroads in operation today (including high-speed systems operating in Europe and on the East Coast) and is the most cost-effective electrification voltage for Caltrain operations.

Electricity would be provided to trains via an overhead contact system (OCS) also known as a catenary system. This system requires the fewest number of substations, uses reasonably small catenary wires and requires the least amount of equipment. It also has less energy loss in its transmission and would therefore result in less energy cost. This system is also most common for commuter rail operations, has standard equipment with off-the-shelf design, and is readily available in this country.

12.3 Similar projects

While electric railroads are not common in the United States there are some examples of electrification projects that, while not analogous to Caltrain, nevertheless provide interesting background information for the Caltrain project. These examples are outlined below.

Amtrak Northeast Corridor (NEC) Electrification Project. As part of a larger project to improve service on Amtrak's high speed corridor, the line from New Haven to Boston is being electrified.

This includes installing approximately 160-route miles (double-tracked) of catenary system, installation of 25 substations to transform and regulate electrical power for railroad use, and modification of seven overhead bridges to provide necessary clearances. The construction schedule calls for all work to be completed in slightly over three years, a very short duration considering the total distance involved.

To facilitate such a schedule, the contractor is working practically around-the-clock, including weekends. During the daytime, construction work is being performed utilizing single-track operations, while complete outages of track sections are implemented at night.

The capital cost for this project is $1.2 billion (or $7.5 million per double-track mile), including all infrastructure improvements to bridges, elimination of most grade crossings, trackwork, traction substations, catenary system, signals and communications.

New Jersey Transit North Jersey Coast Line. In the late 1980s the 21-mile long North Jersey Coast Line was electrified from South Amboy to Long Branch. This line provides direct access to New York City via the Northeast Corridor. The project included construction of a large terminal in Matawan. The capital cost of this electrification was $220 million, over 40% of which was spent on railroad modernization including signals, communications, bridges, stations and track work. It took approximately 5½ years to complete, and single tracking was used to expedite this construction.

Before electrification, a mixture of electric and diesel-powered trains was operated on this line. Following electrification, electric train service was extended further south, enabling greater numbers of customers to enjoy a one seat ride into New York City without the time consuming locomotive change at South Amboy. In addition to electrification, new high level platforms were constructed and track and signal improvements were made to improve service.

Following implementation of these improvements and an extensive marketing program, ridership on this line increased by approximately 15%. The ridership gain can be attributable to several factors:

1) New, non-stop peak hour train from Matawan to Newark and New York.
2) More peak and off-peak service.
3) Faster and direct trains to Midtown Manhattan by eliminating the practice of changing electric and diesel engines at South Amboy.

Other factors such as station improvements and better station access also helped in the ridership gain.

New Jersey Transit Morris and Essex Lines. Another set of New Jersey commuter rail lines that was modernized in the early 1980's was the three branches (Montclair, Gladstone and Morristown lines) comprising the 67-mile long Morris and Essex Lines. This commuter line was electrified at 3000 VDC in 1931, but faced with increasing equipment obsolescence, it was re-electrified to 25 kV AC.

Construction and modification of the catenary system required contractors to work on or near the tracks, working among wires that were normally energized. In order to provide safe occupancy of track areas by contractors, train operations were modified due to de-energization of wires in selected sections during selected hours. Normal peak period schedules were maintained during construction, except when in some cases express runs were converted to local-express. Off-peak changes in service and operational timetables were based on one or more of the three methods: 1) single-tracking by using train orders and flagging, 2) substituting buses for a portion of the trip (usually a station to station distance of five to ten miles) and, 3) operating diesel-powered trains to enable extensive catenary de-energization.

There are two important points that should be taken from these examples: 1) that construction on an operating railroad is difficult, 2) and that it will impact the service that can be provided.

12.4 Environmental issues

Caltrain electrification raises a number of environmental issues including air quality, noise, EMF, visual and power. There has been considerable debate on both the positive and negative environmental effects attributed to electrification. Each of these issues is outlined below.

As a matter of interest, the FRA received approximately 500 letters and 117 oral comments on Amtrak's Draft Environmental Impact Statement/Report (DEIS/R) for the NEC Electrification Project. The majority of comments were on alternative routes, alternative technologies, impacts to freight service, impacts to moveable bridges, impacts on marine traffic, potential effects of electromagnetic fields generated by overhead wires, noise and vibration, visual and aesthetic impacts, elimination of grade crossings, and the basis for ridership projections.

Noise

There are two potential sources of long-term noise emissions from an electrified rail line: noise from train operations and noise emanating from fixed electrical facilities such as transformer hum at substations. Both are outlined below.

Trains. Electric trains are normally quieter than any diesel train based on current technology. The example given in the MK report indicated a very substantial difference in noise level, 87 +/- 2 dBA for a diesel locomotive (F40PH) versus 69 dBA for an electric locomotive (AEM-7) measured at 100 feet from the locomotive, as obtained from the General Motors Corporation. By way of comparison, a substation is said to emanate 40-50 dBA at 100 feet without a sound walls, and the inside of an average automobile is measured at 45 dBA with all its windows closed.

Noise is also a function of train frequency, with the noise levels growing as train frequency increases. However, this factor would affect both diesel and electric operations. Similarly, the noise generated by the constant warning signal system at grade crossings and the whistles or bells sounded off by approaching trains would affect both diesel and electric operations. The cumulative noise level of electric operation would likely be less than that for diesel.

According to Amtrak's noise models and actual measurements used to predict the noise impact to sensitive residential receptors on Amtrak's NEC service, electrified operations are several times quieter than diesel operations at the same level of service.

Substations. There are potentially 5 traction power substations required in the Caltrain electrification. Noise from substations emanates from transformers and ventilation fans. Potential mitigating measures may include sound-absorptive barrier walls around the transformers, and quiet fans and/or fan silencers in the case of ventilation equipment. In any case, this is only necessary when there is the potential to affect residences in close proximity to the substation sites, say within 100 feet or so. Thus, another mitigation measure is to locate the substations as far away from sensitive receptors as possible. Noise from substations should be easy to mitigate.

Air quality

The San Francisco Bay Area presently does not meet several federal and state standards for air quality. There are two aspects of air quality impacted by electrification, the reduction in emissions from Caltrain locomotives and any reductions in automobile travel caused by increased transit patronage. Both are outlined below.

Diesel locomotive replacement. Replacing Caltrain's existing diesel locomotives with electric locomotives or electric multiple unit vehicles will reduce diesel emissions. Pollutants such as carbon monoxide, nitrogen oxide, sulfur dioxide, hydrocarbon emission and Particulate Matter of a size less than 10 microns in diameter (PM 10) will be reduced. According to the ICF Kaiser/ DeLeuw Cather Downtown Extension Environmental Impact Study, the present Caltrain operation exceeds the existing and future 2010 Bay Area Air Quality Management District threshold limits in each of the above pollutant categories with the exception of PM 10.

With full electrification from Gilroy to San Francisco, up to an 86 train service level, the above mentioned pollutants would fall to a fraction of the threshold limits except for nitrogen oxide, which would come just below the limit.

Increased transit patronage. As indicated in the MK Feasibility report, electrification of Caltrain would help to attract additional riders shifting from automobiles to transit (see Section 12.8 on ridership impacts). This would result in less vehicle miles traveled when compared to diesel operation. This decrease would contribute to regional reductions in the projected daily local emission burden of some pollutants.

High voltage lines near public areas and EMF

Public safety concerns associated with the introduction of a "high voltage" transmission line (the Caltrain catenary system) would be present in the electrification of a rail system. The catenary system proposed for Caltrain would be energized at 25 kV, 60 Hz alternating current. This represents a medium voltage level transmission line.

Although electric shocks from the catenary system can be eliminated by design, Caltrain electrification will generate electromagnetic fields along the rail line and near fixed electrical facilities such as substations. Thus there may be concerns over the potential health effects of EMF exposure. This is an area where there is no clear scientific consensus.

A 1993 Finnish study of children living within 500 meters (approximately 1,639 feet) of a transmission line discerned no statistically significant rise in susceptibility to leukemia and lymphoma, although it did report a slight excess of nervous system tumors in boys exposed to magnetic fields above 0.2 micro-Tesla. A 1992 Swedish study, published after the Finnish one, added evidence to the link. A 1993 Danish study noted a significant association between the sum total of all major types of childhood cancer and the children's exposure to magnetic fields higher than 0.4 micro-Tesla.

On the other hand, in 1990, the IEEE Spectrum published a special report, "*Electromagnetic Fields: The Jury's Still Out,*" indicating inconclusive evidence. The Chair of IEEE's Committee on Man and Radiation, Eleanor Adair, stated in 1994, "As studies become better controlled, and study larger populations, the risk ratios are getting smaller. I would be ready to draw a conclusion right now — that there is no link there."

In view of all the controversy on the topic, the Council of American Scientists announced in 1996 that it had found no evidence of a connection between EMF and cancerous illnesses in humans. As a result of the lack of scientific consensus, there are no Federal regulations or clearly defined indicators of EMF impact.

In Amtrak's FEIS/R for the NEC Electrification Project, an overhead catenary system and power transfer facilities design was developed to minimize environmental EMF along the right-of-way. A similar catenary system is used by the TGV electric high-speed rail service that has been operating in France for over a decade. In this system, the out of phase currents in the catenary and return feeder provide a partial magnetic field cancellation (except for the passengers in the current loop). At 30 feet from the track, the EMF due to this design is estimated to be about half of that produced by each overhead wire's current. In addition to EMF field reduction, this design also minimizes electromagnetic interference (EMI) at the source. The design also minimizes the number of substations and utility tie-ins required for rail line, thus limiting the number of potential EMF generators. This traction power distribution system is very similar to that proposed for the Caltrain Corridor.

The analyses performed for the NEC Electrification Project estimated the likely EMF levels and resulting levels of exposure that would be experienced by various population groups potentially affected by the electrification. For the residential and commercial areas surrounding the right of way, the estimated level of exposure were one one-hundredth (0.01) to one one-thousandth (0.001) of the most relevant exposure guideline (using a number of national and international groups or agencies interim exposure guidelines). The population segment with the greatest exposure would be passengers and employees on the trains. Their maximum level of exposure would be four one hundredths (0.04) of the most relevant exposure guideline.

Visual appearance

Concerns over the visual impact of electrification facilities typically deal with the overhead catenary system. The overhead catenary system in most places consists of 8-inch (and some 12-inch) wide flange poles, 30 feet high on both sides of the tracks from which a 12-foot cross arm is attached.

Attached to the arms will be three wires (a messenger wire, a contact wire and a return conductor). The signal cable is assumed to be buried to mitigate electromagnetic field effects in the proposed system.

The poles are spaced approximately 200-feet apart on tangent track, and closer together on curves. The net overall impact on visual appearance in most locations should be minor as indicated by MK (see Appendix A).

With reference to Amtrak's NEC Electrification Project, although most of the 156-mile corridor did not pass through scenic areas, many valuable vistas exist. In the project's FEIS over 200 potential visually sensitive receptors were identified. These receptors include residences, restaurants, parks, and other public locations with either a direct line of sight to the waterfront or other scenic view, or located within 1,500 feet of the right-of-way. This was the distance which it was estimated that poles similar to those proposed for use to support the catenary were no longer significant in the view. The analysis concluded that the net overall impact of the project on visual resources in most locations would be relatively minor.

Construction impacts

As with any construction project, Caltrain electrification would create construction impacts. There would be higher levels of dust, noise and traffic around construction areas. However, there are cost-effective and easily implemented mitigation measures to reduce these impacts. One of the major mitigation measures is public awareness of the construction work. This should be carried out well ahead of time to prepare the public for it, with emphasis on the promise of better facilities to come. If traffic is impacted, traffic diversion plans should be well planned and publicized. If construction work is close to residential areas, work should be carefully controlled and performed during reasonable hours without causing a nuisance greater than necessary.

12.5 Construction issues

Electrifying the Caltrain railroad would be a major construction project. It would impact the entire Caltrain right-of-way from San Francisco to San Jose and potentially as far as Gilroy. This construction project will impact both adjoining property and as outlined in the description of similar projects presented above, it would affect Caltrain service. Thus it would be necessary to carefully design the system to reduce impacts and to enable the system to be constructed efficiently and cost-effectively.

This section summarizes some of the most important issues surrounding construction that must be taken into account if Caltrain was electrified.

Construction time

Construction of Caltrain electrification from San Francisco to Tamien could take approximately two years to complete, assuming sections of single-track operation during construction. Single-tracking would be possible following installation of centralized traffic control (CTC) as outlined in *Chapter 5- Signal System* and crossovers located strategically on the right-of-way. Even with single-tracking there would likely be some service delays and potential shutdowns of service during the construction period.

The capital cost estimate provided at the end of this chapter represents the cost for supply and installation only. Allowance for lower productivity due to single-tracking and other possible delays would be included in the contingency.

Substations are wayside facilities that can be built close to the tracks or a short distance from it, while the overhead system is an installation activity within the track right-of-way. Therefore, the construction of a substation will not interfere with rail traffic, while the installation of an overhead catenary system will require occupying the tracks unless an access road is available along both sides of the entire right-of-way.

Provision for future third track operations

The Rapid Rail Study identifies two locations where third tracks will be required in the near future (see *Chapter 10- Rail Expansion Improvements*). In these areas the catenary system would be designed with a third track in mind. In this way, all pole foundations can be installed at the same time when work for the two existing mainline tracks is being performed, while poles with cross arms for the future third track would be installed as needed at the appropriate time in the future.

Overhead bridges

Vertical clearance requirements for roadway overpasses, signal bridges, railroad overpasses and tunnels, were identified and evaluated for electrification, based upon overhead clearances identified by MK, from prior Southern Pacific Railroad information, and from STV's database. The ideal minimum contact wire height of 20'-10" (for track sections south of Bayshore) was determined by MK in their previous study.

Using this criterion the Wolfe Road Overpass is identified as being "close" to possibly needing minor lowering of tracks. This overpass requires additional headroom of 3 inches.

There are five other overpasses at Mariposa Street, 22nd Street, 23rd Street, Oakdale Avenue and Paul Avenue that will require about 18 inches of track lowering.

In addition, there are three overhead bridges at San Bruno Drive, Millbrae Avenue and 5th Avenue, which have no clearance information. Thus, we cannot assume that these bridges were designed for catenary clearances.

The track lowering operation would take about 6 hours for one track and therefore is best carried out over weekends starting right after the last train on Friday and Saturday nights. Assuming one weekend per overpass, this will take about nine weekends for the nine overpasses. The existing mainline tracks through these nine areas are not in a condition that permits high-speed operations at 80 or 90 mph. Therefore any track lowering should be incorporated into the rehabilitation program for these track segments. This action will minimize the cost for getting sufficient clearance in track-related work.

Tunnel clearances

There are four tunnels along the Caltrain route and each tunnel has a maximum crown height of 23 feet. However, the clearance gauge for rail cars is only 19'-3". Thus, within tunnels, it is necessary to deviate from the "ideal" contact wire height of 20' 10" mentioned above. With a contact wire height of 18 feet, the clearance gauge for cars will be at 17 feet.

This height is fine for Tunnels 1 and 2 as Caltrain's cab control car clearance requirement is 16'-6", but it would be too low if double-stack containers were to be used in Tunnels 3 and 4. In this case, a gauntlet track between the existing tracks in tunnels 3 and 4 seems to be a solution that would not require major track lowering. If a gauntlet track is found to be unsuitable, the tracks would have to be lowered by over 3 feet in order to accommodate the double-stack container cars, a potential fatal flaw due to subsurface conditions.

Catenary protection on overpasses

In order to protect public safety and the catenary system from vandalism at overhead bridges and overpasses accessible to the public, barriers in the form of 8-feet high steel wire fabric screens, would need to be installed on parapets. These screens span the entire right-of-way in order to prevent wires or ropes from being thrown onto the catenary system, and resemble barrier fences installed on freeway overpasses.

There are eleven signal bridges along the Caltrain Corridor; each of these signal bridges would probably need anti-climbing devices bolted onto its structure to prevent the miscreants from climbing and reaching the catenary wires.

Utility relocation

The installation of catenary pole foundations could impact nearby underground utilities and the catenary wires themselves could impact utility wires crossing overhead. In order to estimate the cost of utilities relocation a detailed survey of all utilities (including telephone lines, fiber optic cables, petroleum lines, water pipes, gas lines, electrical transmission lines etc.) crossing or running parallel to the Caltrain right of way would need to be completed.

If the exact location of underground utilities can be determined, the catenary pole foundations could, in many instances, be moved to accommodate an obstruction. This would clearly be less costly than relocating a utility. However, this is not always possible and a certain amount of utility relocation would usually be required.
With overhead electric wires, raising the wires on existing supporting structures is sometimes sufficient; if not, new utility towers may be required and could be costly.

Even with a detailed utility survey, it may not be possible to accurately determine relocation costs until at least a 60% catenary design is completed. The more information available about utilities at the beginning of design, the better the chance for reducing the amount of utility relocation.

Utility relocation costs for projects vary significantly and a high contingency is required to estimate these costs early in the project planning process. Since the Caltrain right-of-way is already well established the cost would not be expected in the high range for utility relocation. However, the cost could only be estimated after a detailed utility survey is conducted.

Protection of cars in storage areas

With an electrified system it is more important than usual to keep the public out of car storage areas and off the right-of-way in general. The issue here is to protect trespassers or miscreants from climbing atop the rolling stock and touching the overhead contact system and becoming hurt or electrocuted, as well as protecting the railcars and locomotives from vandalism.

Vandalism in storage yards occurs whether or not the rail service is electrified, and so electrification should not make the cars more vulnerable to vandalism. However, when rail cars are stored and the pantographs are lowered, the concern is to prevent trespassers from climbing on top of the railcars or locomotives and touching the overhead wires, resulting in electrocution or injury. Many warning signs should be strategically posted in yard areas alerting to high voltage overhead wires, as well as posted on the catenary poles and catenary messenger wires. Educating the public about the dangers of high voltage wires is the only effective means of avoiding accidents.

Intersections crossing trolley bus lines

At intersections where the Caltrain alignment crosses trolley bus lines, it would be necessary to connect the Caltrain contact wire of the catenary system to the trolley wire of the trolley bus system by use of a trolley wire cross clamp. This is required in order to maintain continuity of the contact path for the Caltrain current collecting pantograph and that for the trolley bus shoe. The arrangement would be similar to what is normally made for two trolley bus lines crossing each other, except that the cross clamps would have to be especially made to accept trolley wire and contact wire of different sizes. The messenger wire of the Caltrain catenary could directly pass over the support span wires of the trolley bus system since it is normally 4 feet above the contact wire.

However, it would be necessary to make the sections of catenary and trolley wire where they are joined electrically dead, so that neither the shoe on the trolley pole nor the pantograph would collect any current over this section of wires. The Caltrain train and the trolley bus would rely on their own momentum to cross over these intersections. This arrangement is commonly used in other cities where a railroad crosses a trolley bus line. A minimum 18 feet trolleybus wire height is required when trolleybuses cross Caltrain tracks.

12.6 Operating and maintenance costs

One of the main benefits of an electrified system is that in general the operating and maintenance costs for electric vehicles are lower than for diesel vehicles. However, this is balanced against a higher cost for operating and maintaining the fixed facilities (power distribution system) required for an electrified system.

Basically, the cost differences between diesel and electric rail operations fall in three cost centers: Catenary and Subsystem Maintenance, Maintenance of Equipment and Power Consumption. These were addressed in both the MK Feasibility study and ICF Kaiser Downtown Extension study and are summarized in this section for reference purposes.

- **Catenary and subsystem maintenance** consists of the labor (resources) and non-labor (materials and service vehicles) costs in maintaining the overhead catenary system and substations in good operating order. This cost is not incurred with diesel service.

- **Maintenance of equipment** consists of labor and non-labor costs of maintaining locomotives. According to ICF Kaiser, labor costs for electric locomotive repair are said to be 40% lower compared to diesel locomotives. (A 1977 report by General Motors Electro-Motive Division advised that the cost per mile of a 6000 hp electric locomotive was 60% of that for a 3000 hp diesel locomotive based on 150,000 miles of service per year.) Thus, there is a savings in locomotive servicing costs on an electric line.

- **Power consumption** is the cost of electric power used to drive electric locomotives to provide the required level of rail service, or the cost of diesel fuel in the case of diesel locomotives. In both the MK and ICF Kaiser studies, it was concluded that electric power costs are higher than diesel fuel costs below the 114 train schedule service level, based upon Pacific Gas & Electric Rate Schedule E-20.

To illustrate the potential O&M cost savings, the ICF Kaiser Operating and Maintenance (O&M) Cost Results Report indicated that the cost of operating full electric service from Gilroy to the proposed new Downtown San Francisco Terminal would be nearly $55.6 million (1995 dollars). This is compared to an annual O&M cost of $49 million for the no-build diesel operations, based upon a 60 train per weekday schedule. It should be noted that the referenced O&M costs do not include any annualized capital costs for electrification, or any revenue income.

To continue with the ICF cost savings illustration, Table 12-1 summarizes the O&M costs for No-Build diesel and full electrification from Gilroy to San Francisco with the proposed Caltrain extension to the Transbay Terminal downtown. The cost estimates in this table were developed by ICF Kaiser in the aforementioned report, and were then inflated to 1998 dollars using a factor of 3.5% per year.

Comparative O&M cost factors
Table 12-1

	No-Build diesel		Full electrification	
O&M cost estimate	**60 Trains**	**86 Trains**	**60 Trains**	**86 Trains**
Annual O&M cost	$54,217,413	$67,221,565	$61,665,780	$75,051,330
Incremental O&M cost	N/A	N/A	$7,448,367	$7,829,765
Annual cost/passenger trip	$6.59	$7.50	$5.50	$6.22
Annual cost/train-hour	$1,950	$1,724	$2,141	$2,141
Annual cost/car-mile	$12.24	$10.82	$11.61	$8.30

The rest of this section describes the operating and maintenance costs expected for a potential electrified Caltrain system.

Catenary and substation maintenance assumptions

Operating and maintenance costs for an overhead catenary system depend upon the type of equipment in use and the speed of train operations. A more rigorous maintenance program is required for a 90 mph system compared to a 60 mph system, and more frequent maintenance is required for a fixed termination Overhead Catenary System (OCS) than for an auto tension OCS. For example, Metro-North Railroad operates three types of OCS design with some sections dating back to 1907. The newer type of OCS is auto tensioned similar to the system proposed for Caltrain requiring inspection only once every three years, while the older OCS sections are inspected annually.

Routine maintenance of OCS usually includes inspection of the wire positions along the track to ensure that the wire will not go off the pantograph, with special attention around curves, and checking if all nuts and bolts on supports are tightened. Sometimes a camera train is used for inspection. Special vehicles are generally required including high-rail bucket trucks, scissors lifts and rail wiring trucks.

Substation maintenance normally includes blowing dust off equipment, checking the breaker operations, settings of protective relays, battery charging conditions, grounding connections, and other auxiliary equipment such as alarms, lights, and fans and so on and performing housekeeping tasks such as cleaning and painting. Test equipment consists of oscilloscopes, meters and other hand tools.

As a matter for comparison, Table 12-2 presents data collected from several electric railroad operators on the number of maintenance personnel employed relative to the size of the electrified rail system:

Electrification data
Table 12-2

Description	Amtrak	SEPTA	NJ Transit	Metro-North + New Haven Line
Total AC catenary track miles	1,210	262	228	240
Number of substations	53	19	35	20
Catenary & substation maintenance employees	210[A]	64[A]	45[A]	54 (plus 11 Power Directors)

Note A: Headcount does not include Power Directors.

Further information received from Metro-North indicates that out of the 54 maintenance employees, 31 people are in the catenary department and 20 are in the substation department. The total annual payroll for the catenary department is $1,500,000 and $781,000 for the substation department. The annual materials budget for catenary is $217,000 and that for substations is $560,000. In addition, Metro-North has 11 power directors for 24-hours/7 days per week operation with a total annual payroll of $560,000.

For the Caltrain electrification with approximately 100 track miles, it is not envisioned that power directors would be required, rather, the dispatchers would be monitoring conditions of the power system. It is estimated that approximately 13 workers would be required.

It is important to recognize that the catenary and substation maintenance personnel would only be required if Caltrain were electrified. It represents an additional line item in the maintenance of rail line cost center. However, this increase would be offset somewhat by the lower labor costs for electric locomotive repair compared to diesel locomotives.

In the power consumption cost center, diesel fuel costs would be replaced with electric traction power costs. Electric traction power costs were based on projected energy consumption rates derived for electric locomotives.

12.7 Capital costs

A preliminary cost estimate for electrifying Caltrain from San Francisco to Tamien is shown in Table 12-3 at $324,000,000; the estimate from Tamien to Gilroy is shown in Table 12-4 at an incremental cost of approximately $52,000,000.

The estimates do not include the upgrade costs of the existing Caltrain signal system and highway crossings addressed in Chapters 5 and 6 respectively. These upgrades are necessary whether or not the railroad is electrified. However, the cost estimate in Table 12-3 does include the incremental cost of making modifications to these systems, to accommodate electrification.

The following sections describe costs in more detail.

Caltrain electrification cost estimate
Table 12-3

Description	25 kV AC overhead catenary electrification system from San Francisco to Tamien		
	Unit price	*Quantity*	*Total*
PG&E connection	$1,800,000	lump sum	$1,800,000
Traction substation	$2,300,000/ea.	4	$9,200,000
Overhead catenary - mainline	$492,000/track mile	100*	$49,200,000
Palo Alto siding	$492,000/track mile	0.19	$94,000
Third track at two locations	$492,000/track mile	4.8	$2,362,000
San Francisco Terminal storage tracks	$403,000/track mile	1.14	$460,000
San Jose Maintenance Facility	$403,000/track mile	4.3	$1,735,000
Tie-breaker station	$482,000/ea.	4	$1,928,000
Environmental impact study	$5,000,000	lump sum	$5,000,000
Track lowering allowance	$500,000	9 locations	$4,500,000
Overpass fencing	$10,000	42	$420,000
Catenary shields at signal bridges	$1,000	13	$13,000
Utility relocation allowance	$7,500,000	lump sum	$7,500,000
Signal and grade crossing constant warning system improvements for electrification (1)	$38,890,000	lump sum	$39,000,000
SCADA modifications	$300,000	lump sum	$300,000
Fencing	$20/ft.	assume 5000 ft.	$100,000
Subtotal			***$123,612,000***
Contingency @ 40%			$49,444,800
Amtrak support @ 12%			$14,833,440
Design / CPS @ 10%			$12,361,200
Construction mgt. @ 10%			$12,361,200
JPB mgt. supervision @ 3%			$3,708,360
Vehicle:			
New electric locomotives (2)	$5,000,000	23	$115,000,000
Resale of F40PH diesel locomotives	($500,000)	15 (3)	($7,500,000)
TOTAL			**$323,821,000**

* The distance between San Francisco and Tamien is approximately 50 route-miles.

(1) The cost indicated is for the Phase 4 improvements on the already upgraded signal and grade crossing constant warning system for electrification, as described in Chapter 5. Note that this cost is based on existing technology and could be expected to decrease significantly as alternate technology become available in the future.

(2) In the event that bi-level EMU technology is ultimately selected, the cost per vehicle would be $4,000,000 or $372,000,000 to replace the existing fleet of 93 push/pull railcars.

(3) Diesel locomotives are retained in order to provide service from Tamien to Gilroy.

Caltrain electrification cost estimate
Table 12-4

Description	25 kV AC overhead catenary electrification system from Tamien to Gilroy		
	Unit price	*Quantity*	*Total*
PG&E connection	$250,000	lump sum	$2,50,000
Traction substation	$2,300,000/ea.	1	$2,300,000
Overhead catenary - mainline	$492,000/track mile	26.8*	$13,190,000
Tie-breaker station	$480,000/ea.	1	$480,000
Environmental impact study	$1,340,000	lump sum	$1,340,000
Track lowering allowance	$500,000	0	$0
Overpass fencing	$10,000	0	$0
Catenary shields at signal bridges	$1,000	0	$0
Utility relocation allowance	$2,500,000	lump sum	$2,500,000
Signal and grade crossing constant warning system improvements for electrification (1)	$10,500,000	lump sum	$10,500,000
SCADA (substation controls)	$150,000	lump sum	$150,000
Fencing	$20/ft.	0	$0
Subtotal			***$30,710,000***
Contingency @ 40%			$12,284,000
Amtrak support @ 12%			$3,685,200
Design / CPS @ 10%			$3,071,000
Construction mgt. @ 10%			$3,071,000
JPB mgt. supervision @ 3%			$921,300
Vehicle:			
New electric locomotives (2)		Not required	
Resale of F40PH diesel locomotives	($500,000)	5	($2,500,000)
TOTAL			**$51,242,500**

* From Tamien to Gilroy is approximately 27 miles of single-track.

(1) The cost indicated is the projected (based on Chapter 5) Phase 4 improvements on the existing signal and grade crossing constant warning system for electrification. Note that this estimate is based on existing technology and could be expected to decrease significantly as alternate technology become available in the future.

(2) Number of locomotives is based upon MK's simulation of electric train operation from San Francisco to Gilroy.

This section outlines the major assumptions incorporated into the development of those cost estimates.

12.7.1 Rehabilitation assumptions

A number of assumptions have been made relative to the condition of the Caltrain infrastructure at the time that electrification would be implemented. They are described below.

Track rehabilitation

Caltrain has significant track rehabilitation needs to bring the tracks into a state of good repair for safe railroad operation with or without electrification. They include replacement of rail, ties and subsurface track structure components (see *Chapter 4- Rail Infrastructure*). These improvements are needed to better reap the benefit of higher speeds as a result of electrification. The improvements include better grading of tracks and, if necessary, reducing track curvatures. Owing to clearance requirements for freight operations and the lack of space in the Caltrain corridor, catenary poles between tracks are not recommended.

All track rehabilitation will be planned to enhance electrification.

Additionally, Caltrain also has a number of other capital programs underway, such as a third track installation program, a station rehabilitation program, bridge and structures repairs, etc. These program elements require coordination as well. This is of particular concern when other agencies or organizations sponsor those improvements (e.g., a county-managed overpass replacement project) and they might be unfamiliar with the design and construction requirements needed to support electrification. Coordination is required with any electrification program to ensure staging efficiency, to eliminate duplicative efforts (such as retrenching the same tracks repeatedly), and to prevent design and construction conflicts.

Signal system

Chapter 5 described the signal improvements that need to be implemented in order to reach a state of good repair. The signal system design will be compatible with future electrification. For example, the signal block design for the CTC upgrade should provide for headways to account for both the proposed increase in train frequency utilizing the existing tractive power and for electric tractive power, which has an increased deceleration rate requiring shorter braking distances. The design would permit maximum allowable operating speed accounting for both tractive power efforts and the maximum allowable speed for freight operation.

The interlocking processor and track circuit design should also be fully compatible with present tractive power and future electrification. These systems should allow for a seamless implementation of cab signal/speed control system and 90 mph operation technology.

All signal field component locations such as wayside signals, signal bridges, switch machines, signal houses, highway crossing systems etc., will account for the possibility of future electrified clearance envelopes and for the possibility of future catenary and electromagnetic interference. All signal houses will contain adequate room to conveniently add specific components to implement electrification and cab/speed control.

Grade crossings warning devices

The present highway grade crossing warning system has outlived its useful life. The new grade crossing warning system that is recommended in Chapter 5 will be able to detect traffic in both directions; this will make it possible to efficiently operate under reverse running. This is essential to rail operation during construction of electrification; otherwise sections of the railroad would have to be shut down completely as work is being performed. The cost for this rehabilitation and upgrade work is part of the Phase 1 CTC program cost in Chapter 5.

The recommended highway grade crossing design provides state-of-the-art constant warning time (CWT) devices compatible with the present diesel operation. Since this type of constant warning time device technology is currently not available for electrified railroads, the CWT devices may have to be refined, or even retired, when the railroad is electrified.

The alternative to this approach is to utilize "simulated" constant warning components in an attempt to mitigate all operating scenarios. However, a "simulated" system can lead to excessive warning time when a crossing is near a passenger station, causing vehicle congestion and eventual operating problems. The apparent savings must be weighed against the potential problems of the simulated approach.

As outlined in Chapter 5, it is recommended that a constant warning time system be provided as part of the CTC project with the expectation that developments in the technology will allow this system to be easily modified for electrification. The worst case scenario is that the constant warning system will need to be replaced by a state-of-the-art constant warning system which will be available at the time electrification commences. The cost of having to completely replace the grade crossing warning device system is $39 million as identified in Chapter 5. This cost is included in the cost estimate for electrification and represents a conservative scenario.

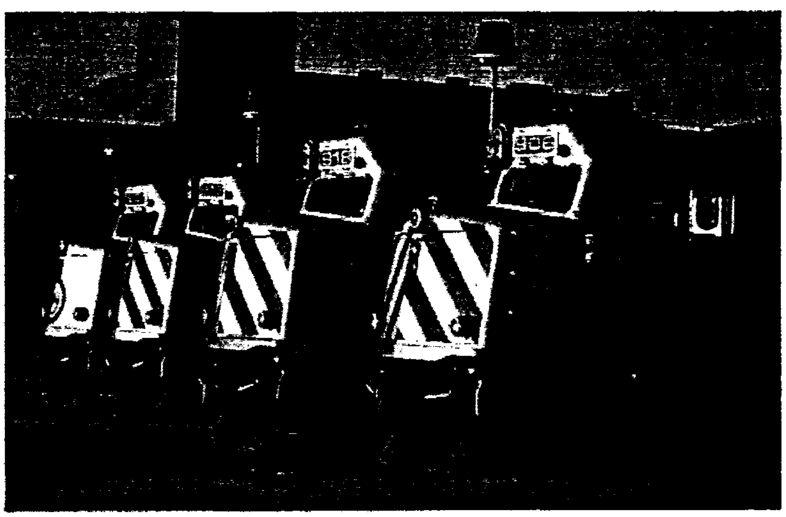
12.7.2 Line costs and substations

The construction of a 25kV AC overhead catenary electrification system includes line improvements such as the installation of catenary poles and wire, utility relocation, track lowering where required, catenary protection at overpasses and signal bridges and fencing for both main line and yard facilities. The construction cost for these elements is estimated to be $66,400,000 from San Francisco to Tamien and another $15,700,000 from Tamien to Gilroy.

The construction of the four traction substations that will be required and the tie-breaker stations and SCADA allowance are estimated to cost $13,000,000 from San Francisco to Tamien and another $3,000,000 from Tamien to Gilroy.

12.7.3 Vehicles

Chapter 13 discusses vehicles in more detail. For purposes of developing a cost estimate for electrification, it was assumed (consistent with the analysis presented in the MK report) that electric locomotives would replace diesel locomotives on a one-for-one basis. The cost of a new 6,000 horsepower electric locomotives was estimated at $5 million. The total cost for 23 locomotives is $115 million.



12.7.4 Salvage value for diesel locomotives

As with everything else, the sale of locomotives is dependent on market demand and the age of the locomotives when Caltrain is electrified. At the present time, since new locomotives cannot be built as cost-effectively as rebuilding old ones, the market for selling used locomotives has been fairly favorable. Given current market conditions, and assuming an expected remaining life of seven years (after mid-life overhaul and after electrification commences), it is estimated that the F-40PH diesel locomotives would each be worth approximately $400,000.

12.7.5 Utility power connection

In order to confirm the availability of the utility distribution network for traction power substations, and a connection charge estimate, Pacific Gas and Electric Company (PG&E) was contacted. PG&E has indicated that the situation has changed since deregulation of the industry and would now charge a connection fee for each of the five proposed substations, as opposed to only charging a fee for one substation when they were initially contracted by ICF Kaiser about two years ago. The reason is that PG&E is now only renting out distribution and transmission lines and is no longer in the business of generating and selling power to customers. PG&E therefore will not be able to recover new connection fees from profits previously realized by selling generated power.

PG&E will perform a preliminary evaluation of the connection charges later in 1998. However, the fees are expected in the $2,000,000 range for the five proposed substations. PG&E will provide a letter providing the revised estimate at that time.

12.7.7 Electrification to Gilroy

From an operating standpoint, extending electrification to Gilroy would eliminate the need to change from diesel to electric locomotives at either Tamien or San Jose. This would reduce the running time for riders south of Tamien, potentially attracting more riders. Another benefit of extending the electrification is that there would be no need (except to keep one or two for yard duties) to maintain the diesel locomotive fleet. These benefits must be balanced against the cost for electrifying the San Jose to Gilroy segment which would be approximately $52 million.

A number of issues for electrifying the Gilroy segment need to be considered. First, the track segment to Gilroy is not owned by Caltrain and would require agreements with Union Pacific to electrify the line, since this route is used by freight trains. The catenary system would thus need to be designed with the clearance envelope for freight cars operating on this segment. The signal design for this segment would also have to be compatible with freight train operations.

Finally, the cost for electrifying any additional track required on this segment to operate additional trains has not been estimated since the amount of additional track required is subject to negotiations with the Union Pacific.

12.7.6 Operations Control Center (OCC)

The replacement of the signal system with Centralized Traffic Control (CTC) and electrification would create the need to monitor and control the various functions of these systems. The most efficient way to operate Caltrain is to centralize all the control and monitoring functions at one location. The centralized facility for dispatching train operations should be designed to have sufficient space for an overhead screen or required CRT display necessary to monitor and control traction power substations.

The operations control center (OCC) monitors and controls the movement of trains, controls tunnel ventilation if installed, generates alarms advising of abnormal events, stores data for future retrieval through computers, fare collection, and performs a host of other functions. The OCC receives information from a remote terminal unit (RTU) installed in the field, which obtains the status of variables through out the rail network. The data transmission media between the RTU and the OCC may be telephone lines, metallic conductors, fiber optic cables, or even data radio.

The lowest cost capital investment for data transmission would be to use telephone lines, however, in the long run it may not be the most economical way since it does not provide any residual return. In many cases, fiber optics are the more cost-effective means, since the "owner" can usually lease out any surplus fibers to other users. Many transit agencies are leasing fibers out to communication companies.

As described in *Chapter 8- Major facilities*, it is recommended that a central OCC be installed at the planned Newhall Yard Maintenance Facility. Space should be provided for the OCC as part of that project and individual subsystems would be installed as they are needed.

12.8 Ridership impacts

The door-to-door journey time is usually a major factor in determining ridership for passenger rail service. In addition, other factors such as frequency and speed of service, destinations served, availability of transfers to other modes of service, station access, fare structures etc. help influence ridership demand.

The MK Feasibility study identified a travel time savings from San Francisco to San Jose ranging from 9.2 minutes (electric locomotive pulled trains) to 13.1 minutes (electric multiple unit vehicles) for a six car consist due to electrification. According to MK, this would result in an increase of ridership in the range of 7-14% using electric locomotives, and an increase of 10-20% using electrical multiple unit rail cars. It is important to know that in the simulation of the Caltrain operation, MK assumed the same conditions for tracks and signal, and used the same higher operating speed of 79 MPH. The savings can be seen as a direct comparison between diesel and electric operations, with everything else being equal. Their simulation results only reflected the performance difference between diesel locomotives and electric locomotives.

Simulations prepared for the Rapid Rail Study were not quite as optimistic, but they still yielded times savings. These simulations indicated that with an assumed 70 mph top speed, the time savings between today's diesel locomotive push-pull operation and an electric locomotive push-pull operation is 6%; the time savings between diesel push-pull operation and electric multiple unit operation is 7.4%. Under an assumed top speed of 79 mph, the respective time savings are 15% for electric locomotives and 15.4% for electric multiple unit trains.

The ridership increases from electrification would come from increasing the speed of service. Caltrain's Market Demand Study showed that decreasing run times would increase ridership. Electrification is only one element in a comprehensive program of improvements that Caltrain should implement (including rehabilitating track for higher speeds and reducing station stops) in order to provide higher speed service.

As an example of taking this comprehensive approach to improving passenger service, after electrification in 1982, the New Jersey Transit North Jersey Coast Line Matawan Extension claimed a ridership gain of 30%. According to surveys about half of the increase were diversions from other rail stations and rail lines, and half of the increase was from bus and automobile passengers and newly induced travel. The ridership increase was credited to several factors; most importantly being improved service in terms of reduced travel time and increased frequency of service. Additionally, aggressive marketing aimed at attracting people to try the Matawan service was extremely effective. However, this line cannot be viewed as comparable with Caltrain, as elimination of the need to change electric and diesel engines at South Amboy was an important attribution in reducing travel time for Matawan passengers, as well as faster service with electric trains.

Faster services brought about by electrification can help increase ridership.

12.9 Recommendations

Electrification of Caltrain services has been a long sought objective of various stakeholders along the Peninsula. But why electrify? Why not use existing locomotives or new alternative fueled locomotives?

There are a number of attributes that are associated with an electrified Caltrain service, and for this reason we recommend, as a long term goal, electrification. These attributes supporting electrification include:

- **Electric trains are quieter.** Compared to existing diesel push-pull trains, electric push-pull or multiple unit railcars are considerably quieter, both for the riding customers, as well as neighbors. A quieter operation enables Caltrain to be a better neighbor.

- **Electric trains are not dependent upon fossil fuels.** Though not fashionable these days to discuss fossil fuel conservation or development of alternate energy sources, unlike diesel locomotives, electricity may be generated from any number of alternate sources. In the event of a diesel fuel shortage or price increase, such flexibility with electrification will be appreciated.

- **Electric trains do not emit "tailpipe" exhaust.** While Caltrain's diesel locomotives are not a significant source of Bay Area emissions, with a fleet of electric locomotives or railcars, there is no "tailpipe" exhaust. Again, this is another neighbor-friendly benefit. While there theoretically could be "tailpipe" emissions at a central, oil burning electrical generating facility, historically the Bay Area has not depended upon such methods of electricity generation.

- **Electric trains have higher performance.** While diesel push-pull trainsets can operate at high speeds (up to 90 mph elsewhere in this country; at 125 mph in Great Britain), given Caltrain's physical characteristics which comprises many closely spaced stations, the real need is not so much for sustained high speed running, but more for high performance trains. This is where electric trains can help.

  Electric trains can accelerate and stop faster than comparable diesel trains. With close set station stops, much of the running time between stations is spent either accelerating or decelerating. For local trains, particularly all stop locals, the time savings can be significant. Electrification of the Caltrain corridor would result in travel time savings for most major station to station trips. The magnitude of time savings depends on the length of the trip and the number of station stops made. The decrease in travel times would be a benefit and attract new riders to the Caltrain service.

  Both the MK Feasibility study and train simulations prepared by Booz Allen for the Rapid Rail Study found considerable time savings under electrification, although of varying ranges. The time savings becomes even greater as the train consist length increases; this is attributable to the higher performance of the electric locomotives.

- **With electrification, faster running times would be possible.** It would be more competitive with automobile trip times. It would provide a more attractive product to market to customers and potential customers.

- **Lower operating costs.** In their analysis, both MK and ICF Kaiser concluded that the break-even point for electrification is an operating schedule of about 114 trains per weekday. At this service level, the operations and maintenance costs for electrified service is about the same as for diesel service. In the longer term, should oil become more expensive relative to electricity costs, the break-even point would come down and make electrification even more attractive.

A cost/benefit summary comparing existing diesel operation with electrified operation is shown in Table 12-5 below.

Cost/benefit summary – San Francisco to Tamien
Table 12-5

Element description	Cost	Diesel operation	Electric operation
		Benefit	
Electrification - includes all line items on Table 12-4 except electric locomotive cost	$210,035,000	None	Electric train service with a modern image and clean environment
Track	Same improvements for both operators	79 mph operation	79 mph operation
Locomotive - 20 new diesel locomotives (1) 18 electric locomotives (2) Acceleration rate (3) Service brake rate (3) Life expectancy	 $50,000,000 ($2,500,000 ea.) $90,000,000 ($5,000,000 ea.)	 Replace existing loco which were purchased in mid-80's. None 1.6 mphps 2.1 mphps 25 years	 None Traction motive power 2.2 mphps 2.1 mphps 35 years
Trip time from San Francisco to Tamien (3)		1:14:38 A 6% reduction compared to existing Caltrain operation.	1:07:12 A 9% reduction compared to existing Caltrain operation.
O&M Cost (4)		$54,217,000	$61,666,000
Environment - Noise Air quality Visual effect EMF Leakage of fuel/oil	 Not quantifiable Not quantifiable Not quantifiable Not quantifiable Not quantifiable	 Comparably noisier Pollution along corridor No change from existing None outside the trains Leakage of diesel fuel and lubricating oil along the right-of-way	 Quieter than diesel No pollution along corridor Yes, but impact is minor Yes, but can be mitigated by design None
Ridership	Not quantifiable	May increase from existing operation due to shorter trip time with higher operating speed.	May increase more compared to diesel due to shorter trip time and the additional "sparks effect" of image of modernity, cleanliness and performance from electrification.

(1) Locomotives required to replace the same number of existing locomotives.
(2) Number of electric locomotives is less to account for lower maintenance requirements.
(3) Source: Chapter 13 on Vehicle Technology Analysis by Booz-Allen & Hamilton.
(4) Source: ICF Kaiser Preliminary Operating & Maintenance Cost Estimates, Feb. 1997, with escalation adjustment.

Planning and funding for electrification requires long lead times, as evidenced by Amtrak's Northeast Corridor electrification project and NJ Transit's North Jersey Coast Line electrification, both of which took decades to fund and implement. It is the type of project that requires working with communities and the private sector to make it possible. Electrification should therefore be part of the equation for all future capital improvements so that suitable building blocks would be in place when funding becomes available in the future.

The proposed Caltrain electrification, as discussed in this chapter, would significantly impact overall fleet planning and rolling stock acquisition (e.g., procurement of different locomotive types with a totally different power source). Caltrain's rolling stock needs are discussed in the next chapter which also provides recommendations to meet these needs.