BEFORE THE
FEDERAL RAILROAD ADMINISTRATION

Docket No.

PETITION OF PENINSULA JOINT POWERS BOARD / CALTRAIN

FOR APPROVAL OF MIXED USE AND

WAIVER OF CERTAIN FEDERAL RAILROAD ADMINISTRATION

REGULATIONS PURSUANT TO

49 C.F.R. Section 238.203

49 C.F.R. Section 238.205

49 C.F.R. Section 238.207

49 C.F.R. Section 238.211

49 C.F.R. Section 238.213

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Dated: December 2009

Table of Contents

List of Tables

List of Figures

Figure 2-1: Caltrain Average Weekday Ridership 1992 to 2009 12
Figure 2-2: Comparison of Vehicle Technology – No. of Station Stops Served in 70 Minutes 16
Figure 2-3: Comparison of Vehicle Technology Lifecycle Costs 17
Figure 2-4: Operating Subsidy per Passenger Over Time 18
Figure 3-1 Caltrain System Map 24
Figure 3-2 Caltrain Electrification Program Project Location 26
Figure 3-3 Passenger Train Civil Speed Limits (2009) 38
Figure 3-4 Rail Operations in the South Terminal Area in the Electrified Environment . 52
Figure 4-1: Preliminary Hazard Analysis Process 57
Figure 5-1 CFR Compliance Assessment Process Flow Chart 77

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1 EXECUTIVE SUMMARY

1.1 Introduction

The Peninsula Corridor Joint Powers Board (JPB), which owns and operates the Caltrain commuter rail service between San Francisco and Gilroy, CA, is currently considering a program that increases system capacity by removing constraints within the system. This program, referred to as Caltrain 2025, will allow Caltrain to expand service and reduce costs while providing a measurably safer transportation network. A key component of this program involves the operation of high-efficiency electric multiple unit (EMU) vehicles constructed to European safety standards. Therefore, Caltrain is requesting a waiver from the Federal Railroad Administration (FRA) to operate a mix of FRA-compliant and non-compliant passenger rail equipment on the Caltrain-owned and -controlled right-of-way (ROW) between San Francisco and San Jose (milepost (MP) 0.2 to 51.9). In this document, “EMU” refers to electric multiple units conforming to European safety standards that employ crash energy management (CEM), but do not meet the structural requirements of Title 49, Code of Federal Regulations (CFR) Part 238.

Caltrain intends to comply with all applicable FRA regulations by specifying vehicle design features to achieve compliance with virtually all of 49 CFR 238. Where Caltrain will not comply with 49 CFR 238, the combination of the systemwide improvements planned by Caltrain and the EMU vehicles designed with CEM will provide a safe operating environment for mixed traffic that does not present risks more severe than operating FRA-compliant equipment. The following are the regulations for which Caltrain is requesting waivers:

- 238.203 Static End Strength
- 238.205 Anti-Climbing Mechanism
- 238.207 Link Between Coupling Mechanism and Carbody
- 238.211 Collision Posts
- 238.213 Corner Posts

Because the JPB owns and controls ROW north of control point (CP) Lick (MP 51.9), which is primarily a self-contained corridor with limited shared use with other rail operators, the Caltrain corridor is able to reduce the risk of incidents with mixed traffic operations. The Preliminary Hazard Analysis (PHA) performed by Caltrain has demonstrated that operating a mix of compliant equipment and EMUs does not compromise the safety of passengers, crew, and motorists. Caltrain adheres to the principle that collision avoidance is the first line of defense in assuring passenger rail safety. Collision mitigation, achieved through the operation of vehicles designed with CEM, is the second line of defense that effectively reduces the severity of an incident should it occur.

This Executive Summary explains the justification for the waiver petition and summarizes the findings of our analyses. The remaining chapters of the document detail the following: Chapter 2--the business case for employing non-conventional rolling stock and other major systems improvements; Chapter 3--the Caltrain system and the operating environment in which mixed operations will occur; Chapter 4--the methodology and findings of the PHA that was conducted to demonstrate that acceptable safety levels can be achieved; and Chapter 5--explanation of sections of CFR Title 49 for which Caltrain will comply (in some cases with slight design modifications) or will not achieve compliance and therefore requests a waiver. Supporting data and technical reports are provided in the Reference Documents, included at the end of this document.

1.2 Purpose

Caltrain is currently operating at the maximum capacity available under the existing signal system, track infrastructure, station configurations, and diesel technology. Caltrain is undertaking the Caltrain 2025 program to address these system limitations. The program takes a comprehensive look at ways to remove constraints on system capacity while providing a measurably safer transportation network in a financially effective manner. Improvements included in Caltrain 2025 include a new signal system featuring positive train control (PTC), electrification of the Caltrain owned ROW, and new electric rolling stock.

The purpose of the Caltrain 2025 program is to meet growing ridership demand with the least risk and lifecycle cost to the railroad, while also delivering superior levels of service and enhanced safety. Faced with a continuous demand for more frequent service and shorter travel times, Caltrain stands to lose a significant portion of its potential future ridership if it cannot provide adequate service capacity in the peak periods. Therefore, Caltrain must implement a program that can meet the expectations of its growing customer base by minimizing risk and maximizing the productivity of its limited financial resources and current assets. These expectations have led Caltrain to optimize its throughput by investing more in systems rather than in expanding track capacity, which can be much more costly in terms of time, money, and community impact. Electrification of the mainline will enable Caltrain to operate electric-powered vehicles that can serve higher ridership demand with less equipment, better reliability, and less detriment to regional air quality than a conventional diesel-powered fleet. High-performance vehicles combined with an enhanced PTC signal system tailored to Caltrain's specific operating environment will yield enhanced safety, increased performance and reduced operating costs and a greater return on investment. Electrification, high-performance electric rollingstock, and an advanced signal system with PTC were the three primary factors Caltrain considered in its selection of equipment and systems improvements.

1.3 Operating Environment

Under the Caltrain 2025 program, Caltrain will implement three major programs: a new signal system with PTC, electrification, and fleet replacement. Collectively, these changes will result in what is termed the "electrified environment." First, Caltrain plans to complete the installation of an enhanced PTC signal system, known as Communications Based Overlay Signal System (CBOSS), which will improve the safety of operations during construction and revenue service, as well as significantly improve operations. In parallel with the signal improvements will be the implementation of the Electrification Program and replacement of a majority of the diesel-hauled fleet, as it is nearing the end of its useful life. Caltrain intends to replace the retiring vehicles with EMUs. In the electrified environment, Caltrain will continue to operate some FRA-compliant rolling stock, as will the other commuter and intercity rail operators that currently utilize the Caltrain corridor in the South Terminal Area (MP 44.6 to 51.9). Freight service will operate during non-revenue passenger service hours pursuant to a Trackage Rights Agreement (TRA) with the common carrier freight service provider and as approved by the Surface Transportation Board, except in the South Terminal Area, where freight will continue to operate throughout the day. The South Terminal Area will continue to have a higher volume of FRA-compliant traffic than the rest of the corridor because the Caltrain Gilroy service, freight and other passenger rail operators utilize the area. A combination of PTC, safety precautions added to the standard operating procedure, and reduced speeds in the South Terminal Area will allow all traffic to operate safely. Aside from the South Terminal Area, mixed traffic operations will only consist of shared track between FRA-compliant passenger haul equipment and EMU trains.

While the Caltrain corridor will be one of the first segments of the California High-Speed Rail network to be constructed, it is assumed that high-speed trains (HST) will not be operating in the corridor until 2020 at the earliest, well after a majority of the current Caltrain fleet must be replaced. The environmental document and operating plan for the San Francisco – San Jose segment of California High-Speed Rail is expected to be approved in 2012. Until then, it can be assumed that most of the existing at-grade crossings on the corridor will remain until higher speed train operations necessitate a grade-separated rail corridor. Therefore, this waiver petition is a separate, but coordinated effort, from the request for a Rule of Particular Applicability to be submitted by the California High Speed Rail Authority (CHSRA). As a joint partner with the CHSRA in planning improvements on the Caltrain corridor, Caltrain will provide solutions that are compatible with the needs of CHSRA on the Caltrain ROW.

The summary shows that operating mixed traffic is in the public interest based on an improvement in *safety, increased performance and return on investment*.

1.4 Safety

With the implementation of the improvements described in this section, Caltrain's electrified operating environment will be safer than the system is today. This conclusion has been validated by detailed vehicle analyses performed by the Caltrain team and vehicle suppliers and the PHA process. By investing in mishap prevention, primarily through PTC and grade crossing improvements, Caltrain significantly reduces the probability of incident occurrences. Furthermore, by operating vehicles incorporating CEM features, Caltrain reduces the severity of incidents (collisions) should they occur. Through this combined risk reduction strategy, which addresses both the frequency and severity of mishaps, Caltrain will achieve a higher level of safety than it achieves today. This section summarizes how the following planned systemwide improvements, which Caltrain has committed to the FRA, improve the overall safety of mixed traffic operations:

- Positive Train Control via CBOSS
- Separation from Freight
- Grade Crossing Improvements
- Crash Energy Management
- Preliminary Hazard Analysis

1.4.1 Positive Train Control via CBOSS

Caltrain has developed specifications for an enhanced PTC system, referred to as CBOSS, which incorporate the essential functions of positive train separation, overspeed enforcement, and roadway worker protection, plus other capabilities specifically designed to improve grade crossing performance. CBOSS is a vital overlay of the existing wayside signal system, allowing a graceful transition from Caltrain's Centralized Traffic Control (CTC) block signal system, which remains available to provide support for contingency operations. In addition, CBOSS will allow Caltrain to reduce the peak minimum operating headway to five minutes, greatly increasing system capacity. CBOSS is specified to be compliant with the requirements of the Rail Safety Improvement Act of 2008 and all relevant regulations provided by 49 CFR 236. Furthermore, Caltrain is participating in discussions with the interchanging railroads to achieve a PTC system solution that is interoperable with those to be utilized by freight operators.

The introduction of PTC on all major rail corridors, as mandated by the Rail Safety Improvement Act, will drastically reduce the existing low frequency of train accidents regardless of the classification or type of equipment being operated (i.e. compliant or non-conventional equipment, commuter vs. high-speed). In other words, the benefit of PTC is *completely independent* of the effectiveness of EMUs to withstand collisions. By employing both PTC and a fleet equipped with CEM, Caltrain will drastically reduce both the probability and severity of incidents. In fact, **a system which employs both PTC and CEM vehicles provides the best available combination of safety and performance**. Caltrain has been working to implement PTC on its corridor for several years because of the safety and performance benefits. Caltrain began the planning and design for CBOSS prior to the Rail Safety Improvement Act and will implement CBOSS regardless of whether it operates EMUs on the corridor.

CBOSS will prevent overspeed-related derailments and collisions between trains under normal “signaled moves”. When PTC enforcement cannot be sustained, CBOSS provides contingency operating modes that allow operations to be conducted with reduced risk by enabling the train Engineer to revert to CTC operations through the temporary use of the wayside signals. CBOSS also provides a “Restricted Manual” operating mode to enhance safety when the wayside signal system is unable to display permissive signals. While in Restricted Manual mode, CBOSS enforces the Restricted Speed to ensure that collisions at elevated speed do not occur.

1.4.2 Separation from Freight

In the electrified environment, all passenger and freight trains will be equipped with PTC, which will be an extremely effective means of preventing collisions. From San Francisco to Santa Clara (MP 0.2 to 44.6), Caltrain will temporally separate freight operations from passenger operations by limiting freight movements to the hours of midnight to 5 am. Such an arrangement is permissible under the current TRA with the Union Pacific Railroad (UPRR). This will virtually eliminate the possibility of collisions between passenger and freight trains along most of the corridor. In the South Terminal Area, between Santa Clara and San Jose (MP 44.6 to MP 51.9), freight will continue to operate during revenue hours. Freight will enter the mainline at MP 44.6 from the Coast Subdivision and remain on UPRR-owned main track (MT) 1 south to Gilroy, as it does today. Other passenger operators, Altamont Commuter Express (ACE), Amtrak Long Distance, and Capitol Corridor, also operate in the South Terminal Area on MT-1 and will continue to do so. In the South Terminal Area, Caltrain operates mainly on JPB-owned MT-2 and MT-3. All trains will travel at yard speed in the San Jose Diridon Terminal (MP 47.1 to 47.9).

While UPRR-owned MT-1 will be electrified from approximately MP 44.75 to CP Lick (MP 51.9) and can accommodate EMUs, the switches between MT-1 and MT-2 will be controlled by the signal system and enforced by CBOSS to prevent freight and EMUs from using MT-1 simultaneously. Caltrain will not operate on MT-1 unless under emergency or unexpected situations. When this is necessary, freight utilization of MT-1 will be restricted. Freight separation is described further in Chapter 3.

1.4.3 Grade Crossing Safety

Although the Caltrain corridor has a strong grade crossing safety record, Caltrain still continuously strives to improve grade crossing safety by employing a broad range of improvements. Currently, grade crossing improvements are being designed and constructed in Santa Clara County and San Mateo County under the Systemwide Grade Crossing Improvement Program. Although operating mixed traffic does not increase the probability or risk of grade crossing incidents, Caltrain has identified a number of grade crossing improvement recommendations through the PHA process. Additionally, CBOSS has been specified to incorporate a host of improvements relating to the crossing warning systems aimed to boost motorists' confidence and awareness that a train is coming when the crossing devices are activated.

The results from the PHA will be incorporated into Caltrain's ongoing Systemwide Hazard Analysis. Each crossing will be evaluated with mitigation opportunities identified and programmed, consistent with the levels of risk and available resources as part of the ongoing State of Good Repair Program. Crossings may be closed or eventually grade-separated. Grade separations are expected to be necessary in an ultimate build-out scenario for CHSRA train operations many years from now but, as the PHA has demonstrated, are not essential for Caltrain-only operations.

1.4.4 Crash Energy Management

Caltrain is proposing to operate EMUs that meet European Norms (EN) 12663 and EN 15227. By working with industry leading experts from car builders and consultant firms in coordination with the FRA and Volpe Center, Caltrain has demonstrated that the EMUs equipped with advanced CEM capabilities do not present a safety risk that is any more severe than with FRA-compliant trains in collision scenarios that were identified as possible within the Caltrain operating environment. The severity of these incidents is mitigated by the fact that the sacrificial elements designed into a CEM vehicle effectively absorb the energy from a collision at speeds up to 20 mph for train-to-train collisions and up to 70 mph for train-to-truck collisions. By managing the energy from a collision, the use of CEM reduces the likelihood of uncontrolled secondary incidents. **Thus, in a grade crossing collision, train-to-train collision, or fixed object collision on the Caltrain ROW, the train passengers and crew, motor vehicle occupants, and pedestrians are at no greater risk with European EMUs that incorporate the latest in CEM technology than with an FRA-compliant train.** It was not the intent of the analysis to prove that European EMUs are equivalent to FRA-compliant rolling stock in all ways or in all environments, nor did the analysis conclude that it would be acceptable to use the two types of equipment interchangeably on other railroads.

While the vehicle analysis that Caltrain conducted for this waiver petition involved several European carbuilders that provided data for the analysis, Caltrain does not intend to preclude other carbuilders from participating in the future procurement of its EMU rolling stock.

1.4.5 Preliminary Hazard Analysis

Caltrain conducted a PHA that evaluated the potential collision risks of operating EMUs in the same system with FRA-compliant equipment with the system improvements discussed in Section 1.3. It must be noted that the scenarios examined represent those that were deemed valid in the PHA, based on the envisioned Caltrain system as a whole, recognizing the contribution of elements such as PTC, improved grade crossing protection and temporal separation from freight.

Utilizing Caltrain accident data and, when necessary, FRA data on commuter rail incidents in the U.S., Caltrain used the Department of Defense Standard Practice for Safety (MIL-STD-882) methodology to develop risk indices for the following collision scenarios based on the frequency and severity of each incident at different speeds:

- EMU Vehicle at Grade Crossing:
    - Motor vehicles circumventing grade crossing protection devices
    - Motor vehicles fouling trackway
    - Motor vehicles entering the ROW at non-grade crossings
    - Collisions with pedestrians
- EMU Vehicle Collisions with FRA-compliant Vehicle and Locomotive
- EMU Vehicle Collisions with EMU Vehicle
- EMU Vehicles Operating in Shared Corridors with Freight Traffic
- EMU Vehicle Collision with Fixed Wayside Object (wall)

The PHA also identified available or feasible countermeasures to eliminate or control the identified hazard conditions. Of the different collision scenarios that were analyzed, grade crossing incidents are the most likely to occur due to the number of crossings that are present in the corridor. Nonetheless, the rate of grade crossing incidents on the corridor has been very low. Caltrain continues to improve grade crossing safety by installing safety devices, or closing/eliminating grade crossings when feasible through the Systemwide Grade Crossing Improvement Program. Additional mitigation measures were recommended through the PHA process for consideration in the future.

The PHA shows that risk can be mitigated to an acceptable level in all cases. The results and recommended mitigations will be incorporated into a comprehensive and ongoing Systemwide Hazard Analysis for the entire Caltrain system. Chapter 4 covers the PHA in greater detail.

1.5 Performance

The Caltrain 2025 program includes a number of projects that will dramatically improve throughput and enable Caltrain to provide a greater frequency and quality of service to its passengers in the electrified environment, which is in the public interest. Caltrain is advancing (1) the Electrification Program, which will power the new fleet of high performance EMU trains; (2) delivery of an enhanced signal system able to support a five-minute headway; and (3) improvements at the North and South Terminals, which will increase system capacity and decrease run times.

The EMU vehicle technology was chosen based on the following criteria: performance characteristics of acceleration and deceleration, lower mean time to restore service following an equipment failure or incident, and compatibility with Caltrain's existing station, shop and terminal infrastructure. Simulations of the EMU, diesel locomotive haul, and electric locomotive haul trains demonstrate that the EMU has the most competitive travel times and can provide service to Caltrain customers that is similar to a rapid transit system at a fraction of the capital investment normally required of such a system. Passenger preference for shorter travel times is evident in historic ridership growth since Caltrain introduced express service in 2004. Additionally, the ridership forecasts for the program confirm that operating EMUs with the headways afforded by CBOSS is a viable business model, predicting a ridership increase of 135 percent between 2009 and 2030.

Operating EMUs can have a positive effect on service reliability because EMUs are individually powered and have built-in redundancy to address equipment failure. If a traction power failure in one car should occur, the EMU trainset can continue to operate, whereas a similar failure affecting a diesel-powered locomotive will take an entire train consist out of service. The modular design of EMUs makes it possible to switch out a malfunctioning component and get a vehicle back into service relatively quickly.

1.6 Minimizing Risk / Maximizing Return-on-Investment

In order to minimize risks to the program, Caltrain intends to employ advanced yet proven technologies, components, and or strategies for its signal system, traction power and overhead contact system, and EMU rolling stock. The designs for the electrification and overlay signal systems are specified to ensure that off-the-shelf systems are employed where possible during product design and that the need for development of new capabilities or products is kept to a minimum. The Caltrain team concluded that a radio-based overlay solution would best suit the unique needs of Caltrain's high-capacity, electrified, mixed traffic operating environment. CBOSS also incorporates crossing activation capability into the radio-based overlay, instead of complex and costly track-based alternatives. Because an FRA-compliant EMU that meets Caltrain's operational criteria has not been developed, Caltrain researched available EMUs meeting European crashworthiness standards. Caltrain found that procuring standard off-the-shelf rolling stock with proven performance would be far less risky and costly than developing an EMU specifically for Caltrain service. There is also the risk that a new vehicle will not perform as originally intended.

One of the greatest risks to the program is the time-sensitivity for beginning the fleet procurement process. Because the majority of the fleet is due for replacement by 2015, the procurement must begin by late 2010 in order to protect funding for vehicle replacement, which would otherwise be expended on extending the life of the current fleet. In order to meet this procurement deadline, Caltrain has conducted a Request for Information process with potential car builders to verify that they understand Caltrain's requirements and can feasibly meet the specified provisions of the CFR or mitigate any risk where a waiver is to be requested. From a business standpoint, it is in Caltrain's best interest to define its safety and performance requirements in a way that supports competitive bidding process amongst multiple vendors.

Caltrain has estimated the lifecycle cost savings of procuring, operating and maintaining and eventually expanding an EMU fleet, and has demonstrated that there are significant cost efficiencies to be gained over a 30-year time horizon. Growing revenues from increased ridership will gradually offset more and more of the capital and operating costs needed to provide the improved level of safety and service. Lighter equipment will result in less wear and tear on track infrastructure. With an anticipated ridership increase of

135 percent between 2009 and 2030, the annual cost per passenger is expected to decrease over time. This is a positive trend for the JPB funding partners, as well as potential investment partners.

1.7 Waivers Requested from CFR Title 49

A compliance assessment was conducted where several candidate European double-deck EMU vehicles were compared to the FRA regulations as applied to rail vehicles (Title 49, CFR Parts 200-299) for the purpose of identifying regulations that are met by the current design, regulations that could be met with practicable design changes, and regulations where compliance is not feasible. Caltrain has confirmed with several car builders that minor design modifications will be able to address most compliance issues. However, any alterations must be closely monitored to avoid compromising CEM performance. Additional waivers may be sought during the vehicle procurement process should such discoveries be made.

Caltrain intends to comply with nearly all applicable regulations, including 229 Locomotive Safety Standards, 231 Safety Appliance Standards, 236 Signal and Train Control Systems, and most of 238 Passenger Equipment Safety Standards, with the exception of the following regulations:

- 238.203 Static End Strength
- 238.205 Anti-Climbing Mechanism
- 238.207 Link Between Coupling Mechanism and Carbody
- 238.211 Collision Posts
- 238.213 Corner Posts

The collision analyses and PHA conducted for the Caltrain 2025 program have demonstrated that the electrified environment with PTC can safely accommodate mixed operations and that risks will be reduced by employing CEM vehicle technology, temporal separation from freight, and reduced speeds where freight is present.

1.7.1 238.203 Static End Strength

The EN-compliant EMU does not satisfy the FRA requirement for 800,000 pounds of buff strength and would require a major redesign that would not be practical for a rolling stock procurement of 100 cars. Redesigning an EMU to meet this regulation would not only be costly, but would not guarantee adequate performance once the cars are built.

While the EN-compliant EMU does not satisfy the FRA buff strength requirement, the incorporation of CEM into the vehicle design effectively controls the absorption of energy resulting from a collision. Compressive end load analyses provided by prospective car builders indicate an acceptable overall occupant volume strength when considered with CEM. Compliance with EN 15227 and EN 12663 will be required, and analyses of the final design (after contract award) will be submitted by Caltrain for FRA review. Additionally, the candidate vehicle must survive a train-to-train impact with a locomotive-hauled consist that is similar to current Caltrain rolling stock.

1.7.2 238.205 Anti-Climbing Mechanism

The EN-compliant EMU most likely does not meet 49 CFR 238.205, which requires that the surrounding structure of the vehicle and any additional anti-climbing mechanisms can withstand a 100,000 pound vertical force. The same structural requirement exists for the drawbar connected intermediate units. Redesign of the vehicle to meet the anti-climbing mechanism regulation may compromise the effectiveness of the CEM design.

While the EMU may not be able to meet this regulation, the CEM design utilizes many components and features specifically designed to prevent overriding or telescoping. Inherently, CEM designs are intended to serve the function of anti-climbers, and can be much more effective than anti-climbers mounted on a compliant car. CEM design is more effective at preventing overriding because it controls the way that the energy is expended on impact in the crushing of elements specifically designed for that purpose. Railcars of a more rigid design can override or bypass each other laterally if the anti-climbers fail to engage.

1.7.3 238.207 Link Between Coupling Mechanism and Carbody

Under 49 CFR 238.202, the coupler carrier must provide override protection by withstanding a downward force of 100,000 pounds without deforming (yield). However, the CEM design requires that both the couplers and the intermediate drawbars be allowed to move longitudinally under a load that is large enough to begin activation of the energy absorbing elements. Some vertical motion of the shear-back coupler may be necessary under these conditions to allow the CEM system to be fully effective. As this CFR section does not allow yielding of the coupler carrier material, this requirement may interfere with the CEM design and is therefore not suggested as a practical design modification. Therefore, the anti-climber characteristics provided by the drawbars and CEM design (as described for 238.205) will provide an equal level of override prevention as is required by this regulation.

1.7.4 238.211 Collision Posts

49 CFR 238.211 requires collision posts at both ends of every car body and outlines the basic physical features of the posts and the static loads that they must support. Current European EMU designs do not meet this requirement, but analyses conducted by both Caltrain and the Volpe Center demonstrate that EMUs with CEM do provide an end structure that provides at least equal protection in frontal impacts, whether there is a train-to-train collision or grade crossing collision between a train and truck. A waiver for 49 CFR 238.211 (as currently written) will be requested.

The FRA is currently revising this section and it is likely that the revision will include an alternate method of providing the cab-end collision post (and corner post) compliance. If the revision to the regulation is made, the EMU specification will require compliance via this alternate method, including verification of final design, and the waiver will not be required.

In regards to the regulation requirement that requires collision posts at the rear of each car, or each end of a semi-permanently coupled multiple unit, 238.211(c) (1) states that collision posts may not be required if the articulated connection is equally capable of preventing disengagement and telescoping. It is expected that the current EMU designs, that combine anti-telescoping connections and CEM, will provide a convincing argument to the FRA. However, the specification will require the car builder to submit the final design to support that argument.

1.7.5 238.213 Corner Posts

As noted in the previous section, FRA is considering a change to its regulations that would allow an alternate method of providing cab-end collision and corner post compliance. A waiver for 49 CFR 238.213 (as currently written) will be requested. If the proposed revision to the regulation is made, the EMU specification will require compliance via an alternate method, including verification of final design, and the waiver will not be required for the cab-end corner posts. However, no relief for rear corner posts is provided for drawbar-connected cars. It is not likely that the corner post at the intermediate connection of an existing European EMU was designed to meet the regulation. Ultimately, intermediate car-to-car connections are well controlled in a collision due to the drawbar connection, the controlled crushing of CEM elements, and a rigid frame protecting the passenger compartment. Thus, a waiver for 49 CFR 238.213 will be requested for non-cab ends.

1.8 Conclusion

In the electrified environment, Caltrain will provide a safer environment for mixed traffic operations by reducing the frequency and security of mishaps through the use of:

- CBOSS / PTC
- Vehicles designed with CEM
- Temporal Freight Separation
- Grade Crossing Improvements/Mitigations
- Modified Operating and Maintenance procedures (reduced speeds)

By operating EMUs designed with CEM principles and that are compliant with EN 15227, Caltrain can provide adequate protection for train crews and passengers in a collision. It has been demonstrated that in a grade crossing collision, train-to-train collision, or fixed object collision, the train passengers and crew, motor vehicle occupants or pedestrians are at no greater risk with a non-compliant EMU than with an FRA-compliant train. CEM is effective in absorbing and managing the energy produced in a collision, reducing the severity of hazardous mishaps should they occur.

Therefore, the mixed traffic operation that Caltrain is proposing on its corridor, along with key system improvements and EMU vehicle technology, is an effective means of providing enhanced rail safety, while also meeting goals of performance and economy, all of which are in the public interest.

2 PROGRAM PURPOSE / BUSINESS CASE

As a passenger railroad and public agency, Caltrain is responsible for providing safe, efficient, reliable, and affordable rail transportation to its customers. It is also responsible to its funding partners -- the three member agencies of the JPB -- as well as State, Federal and private funding sources to make prudent business decisions that are financially sustainable. Caltrain began the Caltrain 2025 program to identify and to prioritize major capital improvement programs that increase system capacity, while also improving safety, reliability, and revenue generation potential. This chapter explains the reasons for selecting non-compliant EMU technology, and the need to operate a mix of FRA-compliant and non-compliant passenger equipment.

In order to attract and retain the maximum level of future ridership, Caltrain evaluated numerous system improvements and their potential for increasing system capacity (i.e. throughput of trains per hour), safety, and reliability, as well as cost. Several programs already on the horizon, such as electrification and fleet replacement, plus a new signal system, present an opportunity for Caltrain to accommodate service level increases as future needs dictate. The Caltrain 2025 program is founded on a capital investment strategy crafted to optimize the infrastructure to provide for maximum capacity utilization and return-on-investment while considering the risks involved in selecting new technologies.

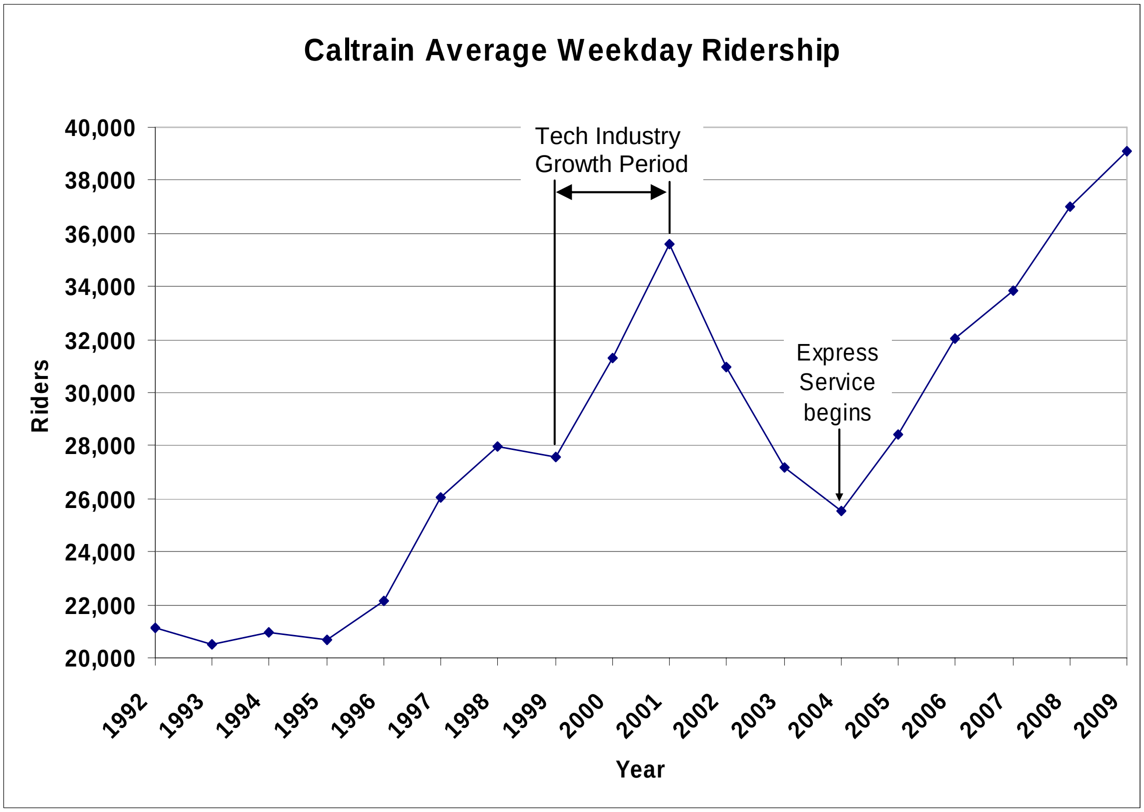
2.1 High Demand - A Good Problem to Have

Caltrain serves residential communities and major regional employment centers all along its corridor from San Francisco to the Peninsula and South Bay communities of Silicon Valley, and carries as many as 46,000 passengers on a typical weekday (fiscal year 2009). Several regional and long distance rail operators utilize parts of the corridor, and others, including the CHSRA, have plans to introduce additional service to the corridor.

In 2004, Caltrain introduced an express service that made headlines throughout the U.S. public transportation industry, earning recognition from federal agencies and national organizations such as the Federal Transit Administration (FTA) and the American Public Transportation Association (APTA). Most transit agencies at that time, including Caltrain, were facing massive deficits and declining ridership. Caltrain proposed to reduce operating costs by increasing train frequency and reducing station stops and thus, improve travel times in the commute period. For nearly 140 years, service on the Caltrain corridor operated an all-stop schedule throughout the day that served closely-spaced stations along its corridor. The “Baby Bullet” express service drastically reduced the travel time between San Jose and San Francisco from over one hour and 30 minutes on an all-stop local train to 57 minutes for a “Baby Bullet” train. Caltrain was able to implement “Baby Bullet” express service through investments in track expansion, signal upgrades, additional train consists and a revamped train schedule. The competitive trip times and more reliable operating service provided a more economical and safer transportation alternative than driving an automobile along highways serving the same corridor. Ridership increased 11 percent within one year of introducing the Baby Bullet service.

Ridership continued to grow five years after the inception of the Baby Bullet express service. Average weekday ridership increased 53 percent between 2004 and 2009, although, following the economic downturn, it has decreased slightly. It is evident that passengers are extremely sensitive to travel time and continue to choose transit, despite a slow economy, multiple fare increases, and fluctuations in gas prices. As shown in Figure 2-1, ridership recovered from the economic downturn of the early 2000's and surpassed the 2001 record achieved during the height of the technology boom in Silicon Valley.

Figure 2-1: Caltrain Average Weekday Ridership 1992 to 2009



Another result of introducing express service has been increased operating efficiencies. Since 2004, Caltrain has experienced an increase in fare revenue of 108 percent (2004-2008) by means of an increase of only 12 percent in staff and the addition of merely eight cars and six locomotives to the fleet. Caltrain has been recognized by local business organizations for optimizing the utility of existing assets and by making strategic and judicious improvements producing significant returns on investment.

Caltrain currently (2009) runs a 90 train per day schedule, with frequencies of 5 trains per hour in the peak period. In the peak direction, the maximum loads on an average weekday morning were at approximately 85 percent of seated capacity. The maximum loads for the five fullest trains in the northbound direction and five fullest trains in the southbound direction, eight of which are express trains, range from 79 to 97 percent of seated capacity [Reference 1]. When comparing ridership between express and non-express trains in the peak period, it is evident that passengers value the shorter travel times offered by express service. Trains and stations that do not offer express service are not as well-utilized, nor are the non-express station parking lots.

Since 2004, Caltrain has added additional express trains to its schedule several times and recently purchased more vehicles to provide more passenger carrying capacity. Limitations of the existing wayside signal system, locomotive-haul rolling stock, track infrastructure and platform lengths will prevent additional significant capacity increases until a new signal system overlay is installed and new EMU vehicles are procured. Should the economy rebound, highway congestion worsen, or demand for Caltrain service continue to grow, maximum capacity on many of the peak period trains will be reached. Overloaded trains could result in degraded service due to longer station dwell times, causing ridership to eventually plateau. The potential to attract and retain future ridership depends heavily on Caltrain's ability to add capacity, maintain a high quality and reliable service with short trip times, and continue to operate safely.

2.2 A Systems Solution

The Caltrain 2025 program will first focus on the most significant system enhancements to date—electrification of the mainline and a new complementary overlay signal system to provide enhanced capacity and safety. The signal system will significantly reduce headways and increase capacity from five trains per hour to six trains per hour with the existing rolling stock, or up to 12 trains per hour with EMUs. Electrification will enable Caltrain to operate higher-performing EMU rolling stock. Coinciding with these improvements is the replacement program for most of the existing diesel-hauled fleet.

Since 1995, Caltrain has focused much of its capital program on bringing the railroad to a state of good repair, and has made infrastructure investments to increase operational capacity and improve performance and reliability. While the State of Good Repair program will be ongoing, capital improvements must be prioritized to effectively support the delivery of safe, efficient, and reliable train service.

Caltrain is advancing a number of system improvement programs that add capacity both to address increased construction impacts and meet the future needs of the system. These programs are primarily designed to identify and resolve system limitations and bottlenecks and to consider their potential impact upon future service increases. Improvements at the North and South Terminals are in planning and construction is underway to remove bottlenecks that interfere with the service reliability and system capacity. These are described in Chapter 3.

Caltrain considered three strategies for increasing overall system capacity, all of which require additional rolling stock: (1) extending station platforms and train consist lengths; (2) adding additional track to allow an increase in the number of trains per hour; and (3) reducing headways with a new signal system to allow an increase in the number of trains per hour. Table 2-1 compares the benefits of each based on their effectiveness in increasing capacity, reliability and safety and compares the relative cost and the cost/benefit.

Table 2-1: Comparison of Capacity Improvement Strategies

CAPACITY IMPROVEMENT	EFFECTIVENESS / IMPROVEMENT			Relative COST	Cost / Benefit
	Capacity	Reliability	Safety		
Lengthen Station Platforms and Train Consists	LOW - Limited by number of trains per hour, and some stations cannot be modified	N/A	N/A	MEDIUM	GOOD
Increase track capacity to 3 and 4 tracks with some grade separations	MEDIUM – with the current signal system, 12 trains per hour for 2 tracks serving the same direction	HIGH	HIGH	HIGH	BETTER
Decrease headways with new signal system	HIGH - Increase from 5 to 12 trains per hour per track	HIGH	HIGH – positive train control, grade crossings	MEDIUM	BEST

The first two options require capital-intensive alterations to the railroad infrastructure, either by extending each station platform and procuring additional rolling stock to accommodate longer train consists, or by adding third and fourth tracks, and possibly constructing multiple grade separations. The third option takes a systems improvement approach by employing a new signal system to reduce the headways between trains and procure additional vehicles to increase the number of trains that can be operated within a given time period. The relative cost-to-benefit comparison of the three options shows that the signal system is the most cost-effective in terms of significantly increasing system capacity. The new signal system, referred to as CBOSS, is described in further detail in Chapter 3 and in the *CBOSS Technical Description* [Reference 3]. It provides a variety of safety benefits, particularly with regard to positive train separation, overspeed protection, roadway worker protection, and a more effective grade crossing warning system. With both electrification and CBOSS programs, Caltrain has chosen to use proven components and strategies to minimize the risk of product development cost overruns and product underperformance.

In addition, the replacement of the current fleet presents an opportunity to significantly increase capacity with higher-performing equipment. The selection of EMU technology is explained in the following section.

2.3 The EMU Solution

Currently, multiple commuter rail operators and the UPRR use the Caltrain corridor. However, JPB owns the ROW between MP 0.2 and MP 51.9, with the exception of UPRR-owned MT-1 track south of MP 44.75, and operates the majority of the service. In the electrified environment, Caltrain proposes to operate in a mixed-traffic mode, with EMUs that meet European safety standards operating alongside conventional rail vehicles. Unlike Caltrain's current trains, which consist of a diesel-powered locomotive that hauls passenger cars, EMUs are individually powered vehicles that are paired together to form longer trains. Characteristics of the Caltrain system, such as station platform length/height and seating capacity needs, dictate that Caltrain operate multi-level or double-deck passenger cars in trainsets of no more than 700 feet in length (8-car EMU consist or 6-car locomotive-haul consist).

2.3.1 Benefits of EMU Technology

The following is a sample of the many benefits provided by EMU technology:

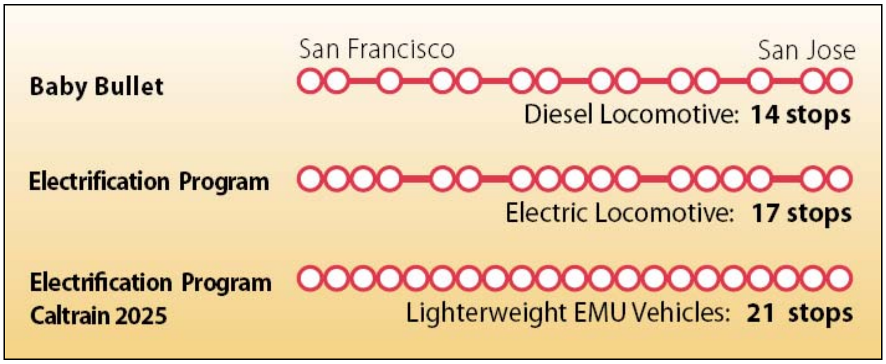
- Better performance through higher acceleration and deceleration, which yields more capacity per hour with less rolling stock
- Station platform space taken by the locomotive can now be filled by an additional passenger car, reducing passenger density on the platform;
- Distributed propulsion providing improved tolerance of propulsion failure;
- Higher reliability and lower mean-time-to-restore, resulting in better on-time-performance;
- Ability to quickly cut train lengths in half, thereby lowering energy and maintenance costs during the off-peak periods;
- Competitive lifecycle costs (capital plus operating) over a 30 year time horizon.

In addition, the benefits of operating off-the-shelf non-compliant EMUs are as follows:

- Less wear and tear on infrastructure as a result of lighter weight equipment;
- No risk associated with developing a new product, which will be costly to engineer and test. The new product may not perform as intended and could be very costly to correct;
- Several manufacturers with operations in the U.S. are already producing equipment with the characteristics needed by Caltrain, allowing for a more competitive bid process.

Performance. Caltrain anticipates that the revenue-generating potential of electric-powered vehicles, especially EMUs, is significantly higher than that of diesel-powered equipment. This is due to their higher vehicle performance, which can support service with shorter trip times <u>and</u> greater frequency of service at more stations. Simulations of vehicle performance comparing the three vehicle technologies were conducted to compare (1) the number of station stops that could be served within 70 minutes per train; (2) the total end-to-end run time for 21 stops; (3) the number of trainsets required to serve 21 stops in the peak hour; and (4) the number of station stops that the fleet could serve within 70 minutes. Figure 2-2 shows a graphical comparison of (1) the number of station stops that could be served within 70 minutes per train. It should be noted that these are idealized simulations with no recovery time built into the schedule.

Figure 2-2: Comparison of Vehicle Technology – No. of Station Stops Served in 70 Minutes



Note: Idealized simulation with no recovery time

Table 2-2: Comparison of Vehicle Technology – Idealized Performance Characteristics

	Diesel-Hauled	Electric-Hauled	EMU
Per Train:			
Stations Stops (within 70 minutes)	14	17	21
End-to-end run time (21 stops)	81 min.	74 min.	70 min
Per Peak Hour:			
Train sets	30	26	24
Station stops	169	272	366

As shown in Table 2-2, an EMU train can serve the most station stops within a given period of time or can travel end-to-end within less time given a fixed number of station stops. The shorter travel times attract and retain customers, as already witnessed with the success of "Baby Bullet" express service. Furthermore, the EMU requires fewer trainsets, and therefore, lower operating and capital costs to deliver the same level of service as locomotive-hauled trains. This is attributed to the shorter end-to-end run time for EMUs, which allows the operator to turn trains more often.

Reliability. Operating EMUs can have a positive effect on service reliability because EMUs are individually powered and have built-in redundancy to address equipment failure. If a traction power failure in one car should occur, the EMU trainset can continue to operate, whereas a similar failure affecting a diesel-powered locomotive will take an entire train consist out of service. The modular design of EMUs makes it possible to switch out a malfunctioning component and get a vehicle back into service relatively quickly.

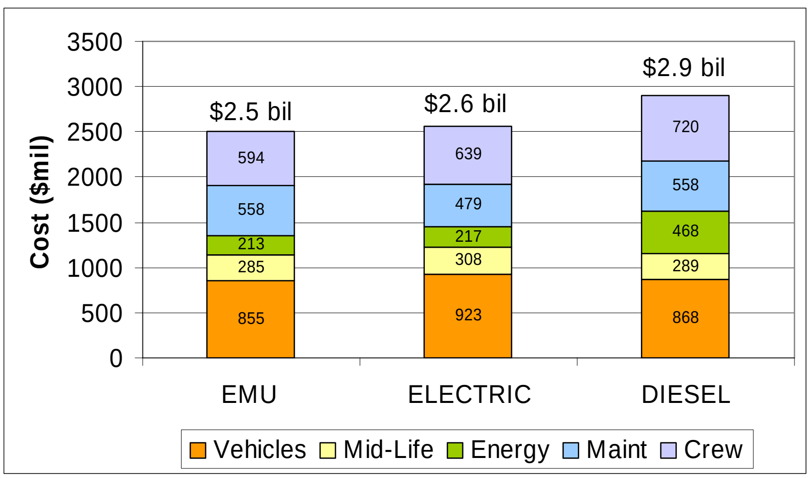
Lower Operating Costs. EMU consists can be shortened in the off-peak periods to better match ridership demand, lowering energy consumption as well as vehicle and infrastructure maintenance costs. Because of the high performance characteristics of EMUs, less equipment is needed to provide a greater level of service because EMU consists can complete more runs than locomotive-haul consists throughout the day.

A 30-year lifecycle cost analysis of different vehicle technologies conducted in 2008 showed that an all-EMU service would be less expensive than a comparative locomotive-hauled service. At this point, the electric locomotive-hauled option was dropped due to the combination of lower lifecycle cost and higher performance of the EMU service. Study parameters were:

- 8 trains per peak hour
- 23 stations served (local service only)
- Capital cost to procure entire fleet
- 146 trains per day
- 20 minute turns for locomotive-hauled, 10 minute turns for EMU
- 15% spares for locomotive-hauled, 10% spares for EMU
- Diesel fuel at $2.60 per gallon
- Electricity at $.09 per kWh

Figure 2-3 compares the lifecycle costs of diesel and EMU vehicle technologies over a 30-year period, holding the system capacity (seats per hour) constant. Even though the initial capital costs to procure EMUs are higher per vehicle, the high performance characteristics of EMU technology enable Caltrain to provide the same system capacity with less equipment than a traditional locomotive-haul fleet. As a result, lifecycle costs are lower, especially if maintenance is performed on a mileage rather than calendar basis.

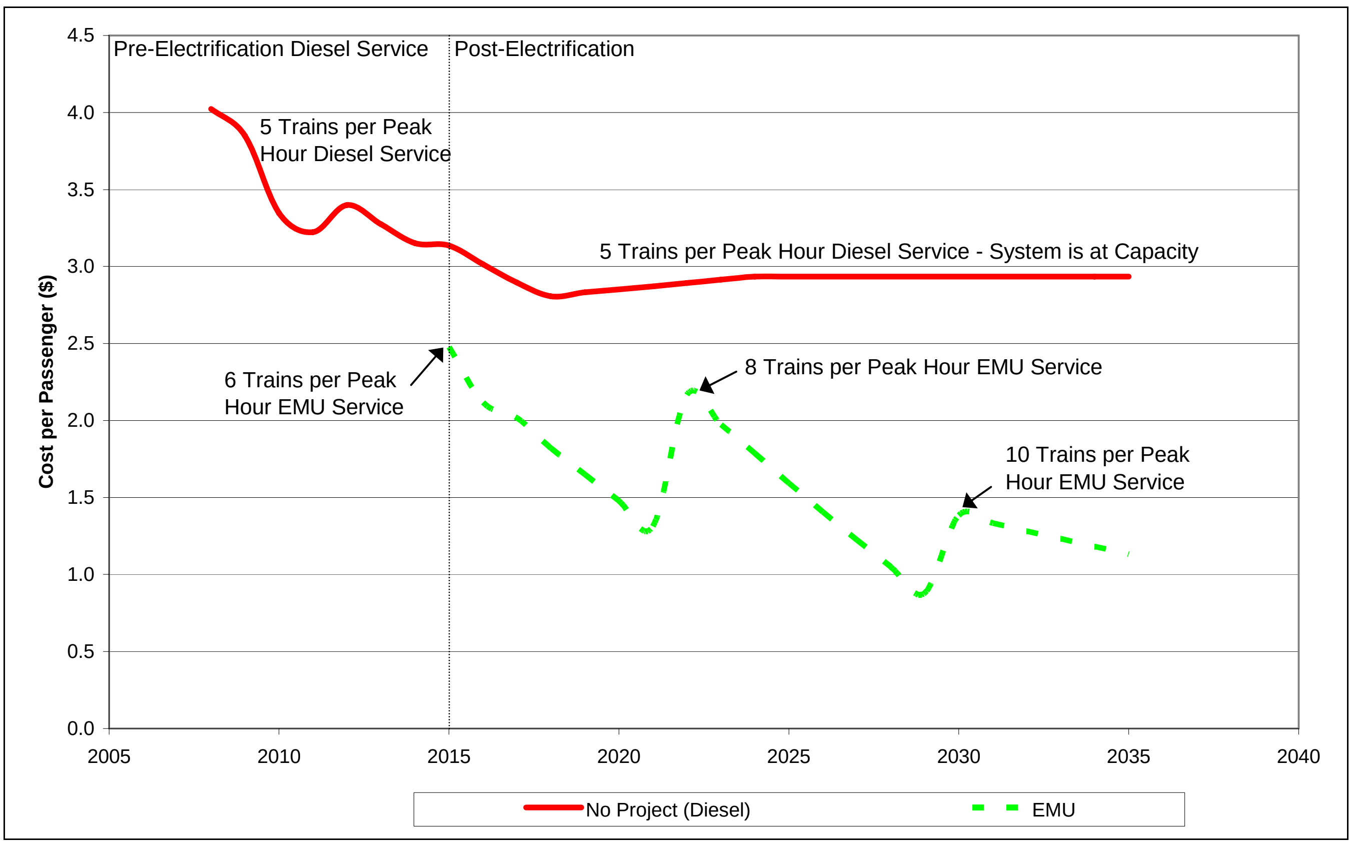
Figure 2-3: Comparison of Vehicle Technology Lifecycle Costs



Greater Return on Investment. In addition to normal population and job growth that would be experienced without an increase in rail service, Caltrain anticipates that nearly 2.35 times the number of weekday passengers that it carries in 2009 will be riding Caltrain in 2030. With greater system capacity and the ability to provide competitive (i.e. shorter) travel times, and therefore, attract more passengers, the EMU option has a significantly higher revenue generation potential.

Public transit fares typically do not offset operating costs, requiring the service to be subsidized. However, it is projected that the agency's unescalated annual operating subsidy (operating and maintenance costs minus fare revenue) per passenger will **decrease** over time as ridership increases and many operating and maintenance costs remain unchanged. Figure 2-4 compares the unescalated operating subsidy for two scenarios: No Project and EMU. The No Project scenario assumes that Caltrain will continue to operate the current diesel-hauled service with no increases in trains per hour. As Caltrain reaches the maximum capacity (in approximately 2019), the operating cost per passenger plateaus as fare revenue stagnates. The EMU scenario assumes the completion of the Caltrain 2025 program (electrification, CBOSS, and EMU technology) in the year 2015. Additions to the fleet, as ridership demand warrants, will periodically result in slight increases in operating costs, as demonstrated by the increase in cost per passenger for increases in trains per peak hour (TPPH). By 2035, the overall cost per passenger borne by JPB funding partners is projected to be reduced to just over one fourth of the current cost. While farebox revenue does not directly offset capital costs, strong revenue generation potential for EMUs improves Caltrain's ability to secure third party financing for its capital programs.

Figure 2-4: Operating Subsidy per Passenger Over Time



2.3.2 Why EMUs

Carrying Capacity. Caltrain utilizes bi-level rolling stock because of the passenger carrying capacity required by ridership demand and because its station platforms cannot accommodate trains longer than 700 feet. All of the existing FRA-compliant EMU technology is currently single-level design, with one exception which is a gallery-style EMU powered from an overhead DC system. This gallery-style EMU is incompatible with overhead AC power, which will be utilized by Caltrain's electrification project. A DC traction power system would not be cost effective as a Caltrain-only solution, nor would it accommodate high-speed trains (HST). As there are no multi-level complaint cars that use AC power, no vehicles are available off-the-shelf from any manufacturer of compliant equipment in a configuration that supports Caltrain's operating needs.

Low Risk. For Caltrain to meet its fleet replacement deadline, the vehicle procurement process must begin in 2010. However, life of the existing fleet can be extended for a limited duration to accommodate a revised electrification completion date. The cost of developing an FRA-compliant EMU would be too high to undertake for the small number of vehicles that Caltrain requires. There is also a high risk of unproven equipment not performing as intended, which would be very costly to correct. The risks to implementation schedule and cost, including life cycle costs, are lower for procuring existing EMU vehicle technology than for developing a new vehicle design.

Compatible with High-Speed Trains. The EMUs operated by Caltrain will be operationally compatible with equipment expected to be introduced by the California high-speed rail system, of which the Caltrain corridor would be one of the first segments to be constructed. This would allow Caltrain and HST to share tracks and optimize capacity in the corridor.

Safety. Caltrain has conducted a PHA (discussed in Chapter 4) and cost-benefit analysis that have concluded that EMUs, which are compliant with the latest European safety Norms, meet Caltrain's operating, performance and safety requirements. Vehicle collision analyses conducted to date have shown that EMUs designed with CEM principles do not present a safety risk that is any more severe than that of conventional equipment. They are a key component to the system safety improvements that Caltrain plans to implement on the corridor.

2.4 Mixed Traffic Operations

FRA-compliant passenger and freight equipment will continue operating on the Caltrain corridor in the foreseeable future. While most of Caltrain's fleet will reach the end of its useful life by 2015, more recently procured compliant rolling stock will not reach the end of its useful life until after 2030. Therefore, Caltrain expects to run mixed traffic operations between San Francisco and San Jose at least until 2030.

Gilroy service. Caltrain does not have plans to electrify the Gilroy segment (MP 51.9 to 77.2), and therefore, Caltrain service originating from or destined for Gilroy will continue to utilize FRA-compliant rolling stock. The CHSRA may electrify the Gilroy segment in the future, which would allow Caltrain to operate EMUs to Gilroy.

Third party operators. Third party commuter and long-distance rail service, such as ACE, Capitol Corridor, and Amtrak Long Distance, will continue to operate FRA-compliant rolling stock in the South Terminal Area, between Santa Clara and CP Lick. Amtrak Long Distance could potentially travel north on the corridor to San Francisco, but there are no known plans to operate such service. Plans to operate commuter rail over the Dumbarton Bridge from the East Bay would also add to the FRA-compliant traffic on the Caltrain mainline.

Freight. Temporal separation from freight will be instituted under this proposal. Freight trains will only operate on the Caltrain main between the hours of midnight and 5am. Freight equipment will be allowed to cross over Caltrain track in the South Terminal Area during revenue hours, with separation being assured by the PTC system, routing restrictions, and reduced operating speeds in the San Jose Diridon Terminal (MP 47.1 to 47.9). Freight operations are further described in Chapter 3.

As mandated by the Railroad Safety Improvement Act, all trains utilizing the corridor will be outfitted with some form of PTC by 2015, which will reduce the risk of train collisions. Interoperability of PTC-equipped vehicles is required for equipment operating over multiple railroads (Caltrain, UPRR, etc.)

Since all EMUS on the corridor will employ CEM and comply with European safety standards, the severity of incidents, should they occur, will be no greater than that of compliant equipment. A mixed traffic environment that employs both PTC and CEM vehicles will be much more cost-effective than creating a separate, dedicated infrastructure for non-compliant vehicles. Research has shown that shared-track operations for providing rapid transit service requires capital costs of 40 to 66 percent less than typical transit systems [Reference 2].

2.5 Conclusion

From a performance and lifecycle cost perspective, which is essential for meeting the growing ridership demand that Caltrain is facing, operating EMUs is the most logical scenario. The non-compliant EMUs meet the unique requirements of Caltrain's ridership demand and limitations of its station infrastructure. By employing CEM, EMUs become a key component of the system of safety improvements that Caltrain will implement on its corridor. They are also compatible with HST equipment that may share the corridor in the future.

A mixed traffic environment is necessitated because of the mixed fleet that Caltrain will operate through 2030, and because of the multiple operators that will continue to have access to the ROW. Dedicated tracks to separate compliant and non-compliant equipment would be cost-prohibitive.

3 CALTRAIN SYSTEM DEFINITION / OPERATING ENVIRONMENT

The JPB, the governing body for Caltrain, was formed in 1987 by the City and County of San Francisco, the San Mateo County Transit District (SamTrans) and the Santa Clara County Transit District (now the Santa Clara Valley Transportation Authority, or VTA). JPB took over Caltrain operations in July 1992 and has contracted with Amtrak for day-to-day operations and fleet maintenance for the Caltrain commuter rail service.

The Caltrain commuter rail service operates on the San Francisco Peninsula, between San Francisco and San Jose, with limited service south to Gilroy. Service is provided seven days a week, serving 19 cities with 32 stations in San Francisco, San Mateo, and Santa Clara counties. The system has a mixture of local, limited, and express trains and serves work centers in San Francisco, the Peninsula, and Silicon Valley, including limited service to developing residential areas in southern Santa Clara County. In addition to Caltrain, freight and other passenger rail operators utilize and serve a portion of the Caltrain ROW.

The JPB owns the ROW between the San Francisco Fourth & King Station at MP 0.2 to control point (CP) Lick (MP 51.9), although UPRR owns main track (MT) 1 from approximately MP 44.75 to CP Lick. Caltrain dispatches all rail traffic operating on JPB-owned ROW, including Caltrain, other passenger rail operators, and freight. The UPRR owns MT-1 from approximately MP 44.75 to CP Lick and the ROW south of CP Lick. UPRR dispatches all rail traffic, including freight and Caltrain, south of CP Lick. In addition, UPRR owns and controls industrial leads and spurs connecting with the Caltrain-owned ROW.

This chapter briefly describes the entire Caltrain system and the operating environment for both the present conditions and for the electrified environment. In the future electrified environment, Caltrain plans to operate a mixed fleet of FRA-compliant locomotive-hauled trains and EMU trainsets, for which Caltrain is submitting this waiver petition from CFR Title 49. The following are the new conditions that will apply on the corridor in the electrified environment:

- Operations
  - Caltrain Passenger Rolling Stock – Approximately 70% of the fleet will consist of multi-level EMU trainsets (8 cars long), and the remainder will consist of FRA-compliant locomotive-hauled trains (5 cars long);
  - Caltrain Inspection/Maintenance Rolling Stock – Caltrain will maintain FRA-regulated maintenance intervals and add procedures for inspection and maintenance of electric traction equipment;
  - Maximum Allowable Speed – Caltrain's maximum allowable speed (MAS) will remain at 79 mph, freight MAS will be 50;
  - Other Passenger Operations – ACE, Amtrak long distance, and Capitol Corridor will continue to operate on Caltrain's ROW in the South Terminal Area (MP 44.6 to MP 51.9) during commute periods. The CHSRA will not be operating high-speed rail service on Caltrain ROW until 2020 at the earliest.
  - Freight Operations – By 2015, it is required that freight trains operating on Caltrain ROW be equipped with PTC. In the electrified environment, freight will be temporally separated from Caltrain's passenger services, operating on

the mainline between the hours of midnight to 5 am, except in the South Terminal Area (MP 44.6 to MP 51.9). All trains will operate at reduced speeds within the San Jose Diridon Terminal (MP 47.1 to MP 47.9). See Section 3.6.2 for information on freight operations and temporal separation.
    - General Rail Operations – In the electrified environment, the trains operating on lines with passenger rail traffic are required to be fitted with PTC. This includes both the JPB-owned ROW and the UPRR-owned ROW from CP Lick to Gilroy.
- Capital Improvements
    - Power source – Electric power will be available to trains via an overhead contact system (AC 25kv) between the San Francisco Fourth & King Station (MP 0.2) and San Jose at CP Lick (MP 51.9). The Electrification Program EA/EIR will be certified in early 2010. Project completion is scheduled for 2015;
    - Signal System – A vital signal system, CBOSS, will be implemented and all Caltrain rolling stock, compliant and EMU, and will be equipped. The PTC system will satisfy the requirements of the Railroad Safety Improvement Act of 2008 as well as existing and evolving PTC regulations under development by the FRA. This project will be completed by 2015;
    - Grade Crossings – The current grade crossing improvement programs that are underway (in 2009) in two of the three counties served by Caltrain will be complete. Additional improvements may be implemented based on the Caltrain 2025 PHA (Chapter 4 of this document) and the ongoing Systemwide Hazard Analysis maintained by the Caltrain Safety Officer.
    - Grade Separations – The San Bruno Grade Separation project will be complete, eliminating grade crossings at San Mateo, San Bruno, and Angus Avenues.
    - North Terminal Area (between MP 0.2 to MP 0.5) – Platforms and tracks at and leading to the San Francisco Fourth & King Terminal will be improved to facilitate the boarding and alighting of passengers and reduce the dwell time at the station.
    - South Terminal Area (between MP 44.6 to MP 51.9) – Track, platform and signal improvements at both the Santa Clara Station and in the San Jose Diridon Terminal (MP 47.1 to MP 47.9) will facilitate throughput and reliability in the busiest section of the Caltrain corridor. The improvements will provide needed flexibility in the operations of Caltrain, the other three passenger rail operators, and freight.

The following sections more fully describe the electrified operating environment.

3.1 Caltrain Passenger Operations

The Caltrain commuter rail service operates on the San Francisco Peninsula, between San Francisco and two San Jose stations, San Jose Diridon and Tamien, with limited peak period service south to/from Gilroy.

The passenger service operates seven days a week, serving a total of 19 cities with 32 stations between the Fourth & King Station and the Gilroy Station in San Francisco, San Mateo, and Santa Clara Counties. A map of the Caltrain system is provided as Figure

3-1. The system has a mixture of local, limited, and express trains and serves work centers in San Francisco, the Peninsula, and Silicon Valley including developing residential areas in southern Santa Clara County.

Caltrain currently operates a total of 90 diesel-hauled trains per day on weekdays between San Francisco and two San Jose stations, San Jose Diridon and Tamien. Six of these trains operate south between San Jose Diridon and Gilroy. Operating hours are from 4:30 am to 1:30 am on weekdays, with the morning peak from 4:30 am to 9:00 am and the evening peak is from 3:00 pm to 7:00 pm. Up to five trains per direction are operated during the peak hours with headways ranging from five minutes to one hour. Due to budgetary restrictions, Caltrain reduced service in August 2009 from 98 to 90 trains per day through the removal of eight midday trains. Caltrain expects to re-introduce the eight midday trains once budgetary resources are available.

Four types of service are offered:

- Express service (known as Baby Bullet) provides 60-minute service between San Francisco and San Jose, serving six to eight stations, including terminal stations.
- Limited service provides skip-stop service, stopping at approximately half of the stations between San Francisco and San Jose.
- Local service stops at all stations.
- Limited/Local combination service provides local service for half of the line and limited service for the remaining half.

Figure 3-1 Caltrain System Map

In the electrified environment, Caltrain will have electrified all tracks within its ROW between the San Francisco Fourth & King Station (MP 0.2) and CP Lick (MP 51.9), including both Caltrain owned track and UPRR-owned MT-1 between approximately MP 44.75 and CP Lick. In addition, Caltrain will operate mixed traffic, comprised of EMU trainsets and FRA-compliant locomotive-hauled passenger trains. Passenger service will be expanded to 114 trains per day with six trains per peak hour between San Francisco Fourth & King and the San Jose Diridon and Tamien Stations. The 114 trains-per-day operating schedule is not finalized, though Caltrain will continue to operate a combination of Express Baby Bullet, Limited, and Local service based on passenger and capacity demands and the available fleet. Diesel-hauled 5-car trains will be operated for Express service only. EMUs will be operated for Limited and Local service. Six trains per day will also be operated as shuttle service between San Jose Diridon and Gilroy stations and will utilize existing Caltrain diesel equipment. Passenger service hours will remain approximately the same as in 2009 and peak service hours will not change. A map of the Electrification Program limits is provided in Figure 3-2.

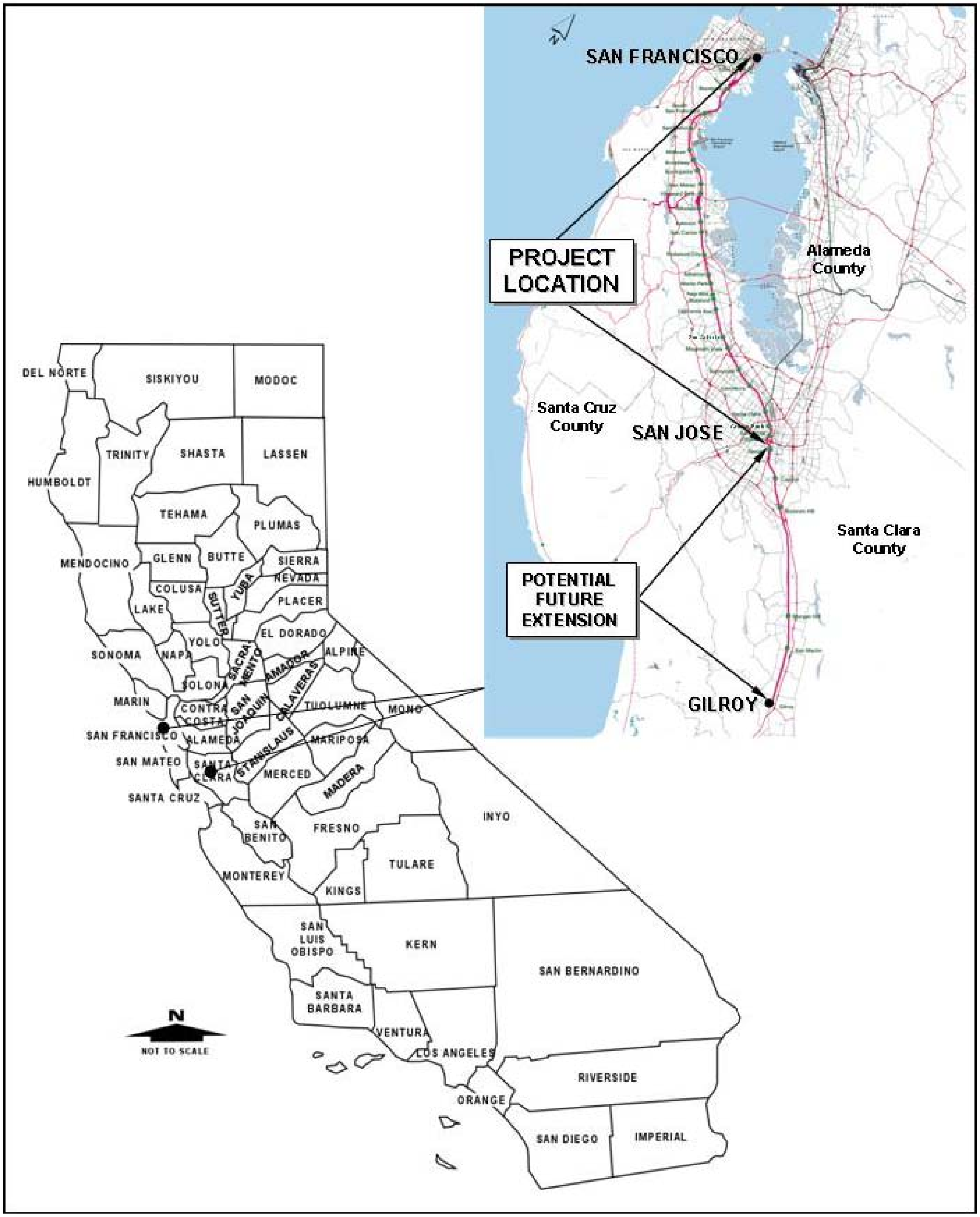
Table 3-1 provides a summary of Caltrain weekday service for 2009 and for the electrified environment, including end-to-end run times and number of trains run per type of service.

Table 3-1 Summary of Caltrain Operating Characteristics

CALTRAIN WEEKDAY OPERATING CHARACTERISTICS	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• Trains per day: 90	• Trains per day: 114
• All diesel locomotive–hauled technology	• Mixed traffic: Diesel locomotive and EMU technology
• Service Hours: 4:30 am to 1:30 am	• Service Hours: 4:30 am to 1:30 am
• Peak Hours: 4:30 am to 9:00 am, 3:00 pm to 7:00 pm	• Peak Hours: 4:30 am to 9:00 am, 3:00 pm to 7:00 pm
• Headway: o Peak Hour: 5 min to 1 hr o Non-Peak: 30 min to 1 hr 25 min	• Headway: o Peak Hour: 5 min to 30 min o Non-Peak: 30 min to 1 hr 25 min
• Service Operated o 5 trains per peak hour o Express: 22 trains o Limited: 10 trains o Limited/Local: 30 trains o Local: 28 trains	• Service Operated o 6 trains per peak hour o Service TBD
• Run Times (SF-SJD) o Baby Bullet: ~60 min o Limited: ~1 hr 10 min o Limited/Local: ~1 hr 20 min o Local: ~1 hr 30 min	• Run Times (SF-SJD) o Baby Bullet: ~60 min* o Limited: ~1 hr 10 min** o Local: ~1 hr 20 min

* Baby Bullet service to utilize existing diesel locomotive-hauled trains.
** Additional station stops added rather than reduce trip time.

Figure 3-2 Caltrain Electrification Program Project Location



Caltrain plans to expand service beyond 114 trains per day on an as-needed basis in response to passenger demand. The combination of CBOSS and the new highly efficient EMU technology allows Caltrain to substantially avoid the constraints imposed by the wayside signal system, thus achieving headway performance that approaches theoretical limits. This provides the opportunity for competitive travel times with more station stops and headways as low as five minutes. In addition, the high performance operational and safety systems available by 2015 will support the future HST service.

Caltrain also provides special service to high attendance events occurring near Caltrain stations, such as baseball games and concerts at AT&T Park and holiday parades. Longer and/or extra trains are added to the service based on system capacity and expected attendance. Caltrain will continue to provide special event service in the electrified environment.

Caltrain currently connects to, and will continue to connect to, a variety of other transportation providers within the Bay Area, including Bay Area Rapid Transit (BART), San Francisco Muni, SamTrans, VTA, ACE, Capitol Corridor, and Amtrak long distance service. Cross-platform transfers to BART are possible at the Millbrae Station, while the Mountain View Station provides access to VTA light rail. At the San Jose Diridon Station, riders are able to connect with local VTA light rail and bus services, the ACE train, Capitol Corridor, and the Amtrak long distance service. BART is also planning to extend its system from the East Bay, through San Jose, with a stop at the San Jose Diridon Station and a new terminus in Santa Clara near the existing Santa Clara Caltrain Station.

Additional information on Caltrain operations with freight and the additional passenger rail services can be found in Section 3.6 Operating Environment & Conditions.

3.1.1 Methods of Operation

Caltrain dispatches all traffic on Caltrain owned ROW between the San Francisco Fourth & King Station (MP 0.2) to CP Lick (MP 51.9), as well as on UPRR-owned MT-1 between approximately MP 44.75 and CP Lick. Caltrain operations are controlled by train dispatchers located at the Central Control Facility (CCF) in San Jose. Dispatchers control routes that display signal information to locomotive engineers. The locomotive engineers operate their trains based upon the information conveyed by the signals and in accordance with the General Code of Operating Rules and by the Peninsula Corridor Operating Timetable and Special Instructions.

Caltrain is currently operated manually and will continue to be operated manually once the corridor is electrified. However, the addition of CBOSS, Caltrain's PTC system, will provide additional safety measures for collision and derailment avoidance. PTC refers to technologies that are capable of preventing train-to-train collisions, overspeed derailments, and intrusion and collisions involving roadway workers and work equipment. By providing CBOSS, Caltrain will meet the requirement of the FRA Rail Safety Improvement Act of 2008, which requires all passenger systems to operate with PTC by December 2015. Additional information on CBOSS is provided in Section 3.4 Signal System and the *CBOSS Technical Description* [Reference 3].

A comparison of current operation methods and methods that will be operated in the electrified environment is provided in Table 3-2.

Table 3-2 Caltrain Methods of Operation

CALTRAIN METHOD OF OPERATION	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• Manual operations per General Code of Operating (CTC) Rules • Manually controlled non-enforced station stopping • Procedural enforcement of Form B	• Manual operations per General Code of Operating (CTC) Rules • CBOSS/PTC: automatic speed enforcement, positive train stop, hand operated switch protection, automatic enforcement of Mandatory Directives, including Form Bs, automatic stop/restricted speed enforcement at dysfunctional grade crossings • Automatically enforced station stopping as per the train schedule

3.2 Rolling Stock

The following is a fleet summary of the current diesel rolling stock and the proposed EMU trainsets for which Caltrain is seeking a waiver to operate on the Caltrain ROW. Additional information on the Caltrain rolling stock, as well as background on FRA and European design and crashworthiness standards, can be found in the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4].

3.2.1 Equipment

3.2.1.1 Locomotives

Caltrain currently operates 29 diesel locomotives: 23 F40 model locomotives and six MP36PH-3C model locomotives. Details for the locomotive fleet are provided in Table 3-3 below. By 2015, 20 of these locomotives will have reached the end of their useful life. Should the Electrification Program be completed after 2015, Caltrain plans to extend the life of these 20 locomotives where practicable. The remaining nine locomotives will continue to operate in 2015 and beyond until they reach the end of their useful life in the 2030 timeframe.

In the electrified environment, Caltrain will begin operating electric-powered EMU equipment. EMU cars are individually powered and therefore do not require a locomotive. Additional information on the EMU equipment can be found in Section 3.2.1.2.

Table 3-3 Caltrain Locomotive Fleet

NUMBERS	QTY	MODEL	HP	BUILDER	YEAR BUILT	30-YEAR RETIRE DATE
902-914 (b)	5	F40PH-2	3,200	EMD	1985	2015
900-919	15	F40PH-2-CAT	3,200	EMD	1985-1987	2015-2017
920-922	3	F40PH-2C	3,200	MPI	1998	2028
923-928	6	MP36PH-3C	3,600	MPI	2003	2033

3.2.1.2 Passenger Cars

Caltrain currently operates passenger cars (trailers and cab-control cars) manufactured by two different suppliers: Gallery Cars by Nippon Sharyo and Bombardier Bi-Level Cars. Combined, the total rolling stock fleet consists of 118 cars.

Nippon Sharyo manufactured all 93 Caltrain-owned Gallery cars currently in service; 73 began service in 1985 (consisting of 21 cab-control cars and 52 trailers), and 20 started service in 2000 (consisting of 6 cab-control cars and 14 trailers). As of 2015, the 73 Gallery passenger cars, which began service around 1985 will have reached the end of their useful life. Should the Electrification Program be completed after 2015, Caltrain plans to extend the life of these 73 Gallery passenger cars where practicable. The remaining 20 newest Gallery cars will continue to operate in 2015 and beyond until they reach the end of their useful life.

Bombardier Bi-Level cars were purchased in 2002 and 2008. In total, Caltrain currently owns and is operating a total of 25 Bombardier passenger cars (16 trailers and 9 cabs). All equipment will continue to operate in 2015 and beyond until they reach the end of their useful life.

Details for the current Gallery and Bombardier diesel passenger car fleet can be found below in Table 3-4.

Table 3-4 Caltrain Diesel Passenger Car Fleet

NUMBERS	QTY	MODEL	BUILDER	SEATS	YEAR BUILT	30-YEAR RETIRE DATE
4000-4020	21	Gallery Cab*	Nippon Sharyo	107	1985	2015
3800-3851	52	Gallery Trailer*	Nippon Sharyo	142-148	1985-1987	2015-2017
3852-3865	14	Gallery Trailer	Nippon Sharyo	122	1999-2000	2030
4021-4026	6	Gallery Cab	Nippon Sharyo	82	1999-2000	2030
112-118	7	Bi-level Cab	Bombardier	119	2001-2002	2031-2032
119-120	2	Bi-level Cab	Bombardier	118	2008	2038
219-230	10	Bi-level Trailer	Bombardier	148	2002	2032
231-236	6	Bi-level Trailer	Bombardier	151	2008	2038

* Not ADA accessible

In the electrified environment, Caltrain is proposing to operate multi-level EMU technology built to European EN 16223 and EN 15227 structural and crashworthiness standards that employs CEM technology. EMU vehicles are self-propelled and therefore do not require a locomotive. Caltrain's initial purchase would be a total of approximately

112 cars, configured into 28 four-car trainsets. Each four-car trainset is typically comprised of two power cars and two trailer cars. The trainsets cannot be separated and must be operated in the four-car configuration. Two trainsets can be coupled together to form an eight-car train, which would be the normal configuration for the peak hours of service. Off-peak service would be served by four-car trainsets.

3.2.1.3 Passenger Occupied Areas

Passenger occupied areas in diesel hauled trailer cars and EMUs are maximized by design. With the exception of the operator's cab, equipment lockers, lavatories, and vestibules, the vast majority of the space is fitted with seating. The only areas in the cars that would not be typically occupied are the vestibules and stairways. These would typically be occupied by standees when preparing to alight trains and less often during crush load conditions.

3.2.2 Operating Configuration

Caltrain currently operates 22 trainsets each day, two of which are protect sets, and an additional trainset rotated into a weekly maintenance cycle. Each trainset consists of one locomotive and five passenger cars, typically four trailers and one cab car. Due to the fleet configuration, some trains will operate a cab car as a trailer car. The trainsets always face the same direction, with the locomotive always leading in the southbound direction and the cab car always located on the north end of the train.

In the electrified environment, Caltrain will continue to operate six diesel trainsets for the Express Baby Bullet and Gilroy shuttle service. Each trainset will be configured in the same manner as is currently operated. Caltrain will also be operating 12 EMU trainsets, configured with eight cars per consist (i.e. two connected four-car trainsets), for the Limited and Local service. During peak hours, the entire EMU fleet will be in operation. During off-peak hours, each eight-car train can be separated to operate as four-car trainsets. This will reduce wear and tear on equipment, match ridership demands, and improve operating efficiency.

Table 3-5 Summary of Caltrain Operating Configurations

CALTRAIN OPERATING CONFIGURATION	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• Diesel: o Operated on all trains o Configuration (typical): 5-car consist (1 locomotive, 4 trailer cars, 1 cab car) o Locomotive is always leading southbound. Cab car is always located on north end of train.	• Diesel: o Operated on Express trains only o Configuration (typical): 5-car consist (1 locomotive, 4 trailer cars, 1 cab car) o Locomotive is always leading southbound. Cab car is always located on north end of train. • EMU (typical): o Operated on Limited and Local trains o Configuration (peak): 8-car consist o Configuration (off-peak): 4-car consist

3.2.3 Design Standards

3.2.3.1 FRA / APTA Requirements

All vehicles in the Caltrain fleet met all Federal structural requirements when produced, but the regulations have evolved to improve safety. The latest Gallery cars, all Bi-Level Bombardier cars, and the MP36 locomotives meet the more recent regulations (49 CFR 238). The older Gallery cars and F40 locomotives do not fully comply with the more recent regulations, but do meet the 800,000-pound buff strength requirement and are equipped with end-of-car structures that represented best practices at the time the vehicles were constructed.

49 CFR 238 is augmented by APTA Standard for the Design and Construction of Passenger Railroad Rolling Stock, APTA SS-C&S-034-99 Rev. 1. For the most part, APTA SS-C&S-034-99 Rev. 1 matches 49 CFR 238, but APTA SS-C&S-034-99 Rev. 1 adds additional requirements for corner posts, cab buffer beam strength, and seat impact performance. While it is not mandatory that APTA SS-C&S-034-99 Rev. 1 be followed during the design process, passenger cars currently under design in the United States typically comply with APTA SS-C&S-034-99 Rev. 1.

3.2.3.2 European Norms

The multi-level EMU equipment proposed for Caltrain is designed to meet structural requirements of EN 12663. Design loads are specified for compressive and tensile end loading, vertical loading, combined loading, and equipment connections. Details on EN 12663 requirements and results from the analyses performed on the proposed equipment can be found in Section 4.2, European Design Standards in the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4].

3.2.4 Crashworthiness Standards

3.2.4.1 FRA / APTA Requirements

Federal requirements for rail vehicle crashworthiness are met through compliance with the basic design requirements in 49 CFR 238, Passenger Equipment Safety Standards. For Caltrain operated Tier I equipment, there are currently no Federal requirements for energy absorption, with the exception of a soon-to-be-released requirement for cab collision and corner posts. All requirements are given in terms of strength (except for the side structure).

As noted above, 49 CFR 238 is augmented by APTA SS-C&S-034-99 Rev. 1. For the most part, APTA SS-C&S-034-99 Rev. 1 matches 49 CFR 238, but APTA SS-C&S-034-99 Rev. 1 adds additional requirements for corner posts, cab buffer beam strength, and seat impact performance. While it is not mandatory that APTA SS-C&S-034-99 Rev. 1 be followed during the design process, passenger cars currently under design in the United States typically comply with APTA SS-C&S-034-99 Rev. 1.

3.2.4.2 European Norms

The multi-level EMU equipment proposed for Caltrain is designed to meet crashworthiness requirements of EN 15227, classification CI. EN 15227 provides four specific impact scenarios that must be analyzed, with the intent that a certain degree of CEM be implemented to absorb impact energy in a controlled way. The four impact scenarios are a front end impact between two identical train units, a front end impact with a different type of railway vehicle, train unit front end impact with a large road vehicle on a level crossing, and train unit impact into a low obstacle. All equipment is expected to meet the following performance criteria:

- Reduce the risk of overriding;
- Absorb collision energy in a controlled manner;
- Maintain survival space and structural integrity of the occupied areas;
- Limit the deceleration; and
- Reduce the risk of derailment and limit the consequences of hitting a track obstruction.

European crashworthiness requirements yield designs that are less rigid than North American designs. They do not provide an ultimate strength that is quite as high, but rather dissipate the impact energy by providing crush zones, similar to modern day automotive technology. This provides a distinct advantage in that energy from the collision is dissipated in a controlled manner.

Additional details on EN 15227 requirements and results from the analyses performed on the proposed equipment can be found in Section 4.2, European Design Standards of the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4].

3.3 Track

The following sections provide an overview of the Caltrain track configuration, including information on grade crossings, operating speed limits, and locations for train storage.

3.3.1 Track Configuration

Caltrain currently operates on 77.2 route miles from the San Francisco Fourth & King Station (MP 0.2) to the Gilroy Station (MP 77.4).

The JPB owns the ROW between the San Francisco Fourth & King Station (MP 0.2) to CP Lick (MP 51.9) with the exception of MT-1, south of MP 44.75, which is owned by UPRR. All rail traffic, including Caltrain, other passenger rail operators, and freight, is dispatched by Caltrain from MP 0.2 to MP 51.9, including on UPRR-owned MT-1.

- From the San Francisco Fourth & King Station to approximately MP 44.6, the ROW is double-track with three controlled sidings and two four-track sections. There are no single-track sections between San Francisco and San Jose. The four-track sections, located near the Bayshore and Lawrence Stations, allow train overtakes to occur for trains traveling in the same direction and provide for the extra flexibility needed to operate the current five TPPH schedule. The three sidings are located on the east and west sides of the ROW, at MP 26.17 and MP 26.32, respectively, south of the Redwood City station, and on the east side south of the Millbrae station at MP 13.69. These sidings are used for special service and work trains and are only used in revenue service if necessary.
- The ROW between MP 44.6 and the San Jose Diridon Station has three tracks and one controlled siding. There are two main tracks for Caltrain and passenger rail operations and one for UPRR freight and other passenger rail operations.

The controlled siding connects to the track for UPRR freight operations at approximately MP 46.4 and continues north. This siding and the main track for UPRR freight operations are owned by the UPRR but dispatched by Caltrain.

- South of the San Jose Diridon Station, the ROW is double-track; one track for passenger rail operations and the other for freight and, if necessary, for passenger rail operations. There is one controlled siding on the west side of the Tamien station at MP 49.1.
- The San Francisco Fourth & King and San Jose Diridon Terminals each have 12 tracks to accommodate the existing capacity.
- The UPRR owns and dispatches the ROW south of CP Lick to the Gilroy Station. This section is single track with station and passing sidings. UPRR also owns and controls industrial leads and spurs connecting to the Caltrain owned ROW.

The existing infrastructure can support operations with up to six trains per peak hour. However, capacity improvements are required in the electrified environment in order to accommodate expanded Caltrain electrified service beyond six trains per peak hour and the future needs of CHSRA. In order to increase passenger capacity, track and platform redesigns are required at both the North Terminal and the San Jose Terminal areas. At the North Terminal, the tracks will need to be reconfigured and the platforms widened to increase passenger capacity and throughput. At the San Jose Diridon Terminal, seven storage tracks will be removed to add two new platforms and four new platform tracks. In addition, a new track will be constructed to directly connect the San Jose Diridon Terminal with Caltrain's Centralized Equipment Maintenance and Operations Facility (CEMOF). The construction of the new track will involve reconfiguration of the lead tracks into and out of the San Jose Diridon Terminal. A third main track south of the San Jose Diridon Terminal will be added between MP 47.7 and MP 48.1 to provide extra passenger rail capacity.

A summary of existing track configurations, and under the electrified environment is provided in Table 3-6.

Additional track reconfiguration may be required for the Caltrain ROW between San Francisco Fourth & King and San Jose Tamien Stations in order to accommodate possible HST service, Dumbarton Rail Corridor, and the Transbay Transit Center Downtown Extension projects. Further information on these projects can be found in Section 3.6.3 Future Projects Beyond Electrification.

Table 3-6 Track Configuration Summary

<table>
<tr><th colspan="2">TRACK (SAN FRANCISCO TO SAN JOSE)</th></tr>
<tr><td colspan="2">• Caltrain operates on 77.2 miles from San Francisco to Gilroy
o Caltrain owned and dispatched: 51.7 miles between San Francisco (MP 0.2) and San Jose - CP Lick (MP 51.9)
o UPRR-owned, but Caltrain dispatched: MT-1 from MP 44.75 to CP Lick (MP 51.9)
o UPRR-owned and dispatched: San Jose – CP Lick to Gilroy (MP 77.4)
• ~108 track miles used in revenue service (SF to CP Lick)

• Capacity Improvements to accommodate increased Caltrain service and future HST service:
o San Francisco: Study underway to reduce number of tracks for wider platforms that allow simultaneous boarding/alighting.
o San Jose Terminals: Projects underway to add platforms and platform tracks</td></tr>
<tr><th>CURRENT</th><th>ELECTRIFIED ENVIRONMENT</th></tr>
<tr><td>• MP 0.2 to MP 44.6: Mix of double-track, controlled sidings, and four track sections.
o Controlled Sidings
▪ Millbrae: MP 13.69
▪ Redwood City (East): MP 26.17
▪ Redwood City (West): MP 26.32
▪ Total: 4.57 miles
o 4-track sections
▪ Bayshore: MP 5.00
▪ Lawrence: MP 39.40
▪ Total: 16.35 miles</td><td>• MP 0.2 to MP 44.6: Mix of double-track, controlled sidings, and four track sections.
o No change from current.</td></tr>
<tr><td>• MP 44.6 to San Jose Diridon: Three-track
o Two tracks for Caltrain and other passenger rail operators
o One track for freight and other passenger rail operators</td><td>• MP 44.6 to San Jose Diridon: Triple-track
o No Change from current.</td></tr>
<tr><td>• San Jose Diridon to CP Lick: double-track
o One track for Caltrain and passenger rail
o One track for freight and, if necessary, Caltrain and passenger rail
o Controlled Sidings
▪ Tamien: MP 49.1, 0.35 miles</td><td>• San Jose Diridon to CP Lick
o Triple-track from MP 47.7 to 48.1
o Double-track MP 48.1 to CP Lick</td></tr>
<tr><td>• San Francisco North Terminal: 12 tracks</td><td>• San Francisco North Terminal: study ongoing</td></tr>
<tr><td>• San Jose Diridon: 12 tracks</td><td>• San Jose Diridon
o 9 tracks in the station
o New track directly to CEMOF</td></tr>
</table>

3.3.2 Grade Crossings

The following sections provide an overview of the vehicular and pedestrian grade crossings along Caltrain's ROW and the current Systemwide Grade Crossing Improvement Program currently being implemented. Additional information on the San Mateo and Santa Clara county grade crossing programs can be found in the *San Mateo County Improvement Program* [Reference 5-1] and the *Santa Clara County Improvement Program* [Reference 5-2].

3.3.2.1 Vehicular Grade Crossings

There are currently 45 vehicular grade crossings along the Caltrain corridor between San Francisco and San Jose. Each grade crossing is equipped with gates, lights, bells, signs and road markings to warn drivers and pedestrians of on-coming trains.

Although the Caltrain corridor has one of the best safety records amongst commuter rail operators, it is not without incident. Caltrain therefore continuously strives to improve grade crossing safety by employing a broad range of improvements to reduce the frequency of crossing incidents. Currently, Caltrain is implementing the Systemwide Grade Crossing Improvement Program for vehicular and pedestrian grade crossings in Santa Clara and San Mateo Counties. The program includes the review and evaluation of current pedestrian and vehicular traffic and conditions at all grade crossings to identify any opportunities for railroad safety systems and roadway safety improvements. Safety improvements are then programmed based on the existing safety infrastructure and environmental factors, such as proximity to schools. Key improvements featured in the program include:

- New roadway gate assemblies
- Median barriers
- Pavement markings
- Crossing panels
- New or modified traffic pre-emption circuitry based on traffic analysis
- New or relocation of existing roadway gate assemblies
- Replacement of incandescent light units with 12-inch LED assemblies, 24” hoods.
- Quad gates in some locations

The Caltrain 2025 PHA process identified a number of grade crossing improvement recommendations in addition to those being programmed in the current Systemwide Grade Crossing Improvement Program [Reference 5]. The grade crossing improvement recommendations from the PHA will be incorporated into the ongoing Systemwide Hazard Analysis. Each crossing will be evaluated and mitigations, as appropriate, will be applied as necessary to individual crossings in the future as part of the ongoing State of Good Repair Program. The Systemwide Hazard Analysis and State of Good Repair Program are ongoing efforts and will continue to assess the safety of all grade crossings. In addition, CBOSS has been designed to incorporate a host of improvements relating to the crossing warning systems aimed to improve the compatibility of the existing crossing signal system with CBOSS and to remove false activation of the warning system. This will relieve motorists’ doubt that a train is approaching when the crossing devices are activated, thus helping to reduce motorist disregard for crossing warning equipment.

Although operating mixed traffic does not increase the probability or risk of grade crossing incidents, the current Systemwide Grade Crossing Improvement Program and additional improvements recommended by the PHA nonetheless provide additional safety measures to increase the level of safety both for Caltrain and for the communities served.

In addition to the Systemwide Grade Crossing Improvement Program and additional mitigations to be assessed through the PHA, Caltrain is also moving forward with the San Bruno Grade Separation project. This project will separate three existing grade crossings in the 2012 timeframe. Improvements have been implemented to provide additional safety until the project is completed.

A summary of Caltrain's vehicular grade crossings and improvement programs is provided in the table below.

Table 3-7 Summary of Vehicular Grade Crossing Improvements

<table>
<tr><th colspan="2">VEHICULAR AT-GRADE CROSSINGS (SAN FRANCISCO TO SAN JOSE DIRIDON)</th></tr>
<tr><td colspan="2">• Grade crossing improvements:
o Project underway to improve safety at 25 San Mateo County and 6 Santa Clara County grade crossings (30 additional south of SJD) by adding items such as sidewalks, fencing, guardrails, pedestrian swing gates, tactile pads and readjusts of pedestrian gate.
o Additional improvements and mitigations from Caltrain 2025 program studies to be analyzed per grade crossing during the Systemwide Hazard Analysis effort.
o San Bruno Grade Separation Project will grade separate three grade crossings in the city.</td></tr>
<tr><th>CURRENT</th><th>ELECTRIFIED ENVIRONMENT</th></tr>
<tr><td>• At-Grade: 45 at-grade vehicular crossings</td><td>• At-Grade: 42 at-grade vehicular crossings</td></tr>
</table>

3.3.2.2 Pedestrian Grade Crossings

There are currently 56 pedestrian at-grade crossings along the Caltrain system between San Francisco and San Jose located at either stations or with vehicular crossings (20 of which are associated with vehicular crossings). Each grade crossing is equipped with gates, lights, bells, signs and walkway markings to warn pedestrians of on-coming trains.

As part of the Systemwide Grade Crossing Improvement Program currently being implemented, described in Section 3.3.2.1, improvements will also be made for all pedestrian grade crossings adjoining the vehicular grade crossings in San Mateo and Santa Clara counties. Key improvements featured in the program include:

- New or repositioning of existing pedestrian back gates with tip lights
- Pedestrian push gates in conjunction with pedestrian gates
- Guardrails at pedestrian crossings
- Detectable warning (tactile strips) on all sidewalk approaches
- ROW fencing to channel pedestrian traffic

Pedestrian grade crossings adjoining vehicular crossings will also be assessed in the ongoing Systemwide Hazard Analysis and State of Good Repair Program efforts until future service necessitates grade separating all or specific crossings.

In addition to the grade crossing improvement program, the redesign of the Santa Clara Station will remove a total of three at-grade pedestrian crossings and will replace them with one pedestrian underpass. The San Bruno Grade Separation Project will also remove one pedestrian grade crossing.

A summary of pedestrian grade crossings and improvement plans is provided in Table 3-8 below.

Table 3-8 Summary of Pedestrian Grade Crossings and Improvements

<table>
<tr><th colspan="2">PEDESTRIAN AND EMERGENCY CROSSINGS
(SAN FRANCISCO TO CP LICK)</th></tr>
<tr><td colspan="2">• Grade crossing improvements:
o Project underway to improve safety at San Mateo County grade crossings by adding items such as sidewalks, fencing, guardrails, pedestrian swing gates, tactile pads and readjusts of pedestrian gate.
o Additional improvements and mitigations from Caltrain 2025 PHA to be analyzed per grade crossing during the Systemwide Hazard Analysis effort.
• Station improvements and new platforms will remove grade crossings at the Santa Clara Station</td></tr>
<tr><th>CURRENT</th><th>ELECTRIFIED ENVIRONMENT</th></tr>
<tr><td>• At-Grade: 54 total
o 34 at stations
o 20 with vehicular crossings
• Overpasses
o 2 Caltrain owned
o 3 county or city owned
• Underpasses
o 9 Caltrain owned
o 1 county or city owned</td><td>• At-Grade: 51 total
o 31 at stations
o 20 with vehicular crossings
• Overpasses
o 2 Caltrain owned
o 3 county or city owned
• Underpasses
o 11 Caltrain owned
o 1 county or city owned</td></tr>
</table>

3.3.3 Civil Speed Limits

Civil speed limits are determined by the Caltrain Engineering Department to match the operating needs and vehicular speed limits and are based on the track curve geometry and locations of permanent track conditions, such as curves, switches, and crossovers. The civil speed limits define the safe and comfortable operating speeds and protect the track and supporting structures from damage. Authorized operating speeds range from 20 mph to the maximum allowed speed of 79 mph. The civil speed limits, as of 2009 and given in the Caltrain operating timetable, are provided in Figure 3-3 for the ROW from San Francisco Fourth & King Station (MP 0.2) to CP Lick (MP 51.9).

Civil speed limits will be updated for the new electric powered equipment and as track and permanent fixtures are redesigned for new construction.

Figure 3-3 Passenger Train Civil Speed Limits (2009)

San Francisco Station and Pocket Main Tracks MP 0.2 to 0.3

	Pocket and Station Main Tracks 1 through 4	**15**
	Station Main Tracks 5 through 12	**20**

Between North Limits CP 4th Street 0.3 and EQUATION 43.4/44.0

Controlled Sidings	MT-4	MT-2	MP Location	MT-1	MT-3	Controlled Sidings
	20	20	0.3 to 0.6	20	20	
		25	0.6 to 0.7	25	25	
		40	0.7 to 1.0	40	35	
			1.0 to 1.3			
		75	1.3 to 2.3	75		
		79	2.3 to 4.8	79		
		65	4.8 to 5.2	65		
	70	79	5.2 to 6.9	79	70	
			6.9 to 7.4			
		70	7.4 to 8.1	70		
		79	8.1 to 10.8	79		
		60	10.8 to 11.1	60		
		79	11.1 to 13.7	79		*Millbrae*
		75	13.7 to 14.2	75		50
West		79	14.2 to 26.0	79		*East*
30			26.0 to 27.2			30
			27.2 to 39.4			
	70		39.4 to 41.6		70	
			41.6 to 43.4/44.0			

Between EQUATION 43.4/44.0 and North Limit CP LICK

Controlled Sidings	MT-3	MT-2	MP Location	MT-1	Controlled Sidings
	79	79	43.4/44.0 to 44.6		
			44.6 to 44.9	40	*San Jose*
			44.9 to 46.3		40
	40	40	46.3 to 47.1		
	20	20	47.1 to 47.2	15	
			47.2 to 47.8		
Tamien		35	47.8 to 49.1	35	
20			49.1 to 49.4		
			49.4 to 49.7		
		79	49.7 to 51.6	79	

3.3.4 Train Yards

Trains are currently stored in three main locations: at the San Francisco Fourth & King Terminal, the San Jose Diridon Terminal and in the four storage tracks in CEMOF. In addition, storage space is available at the Tamien Yard, which is currently used to store ACE trains, and in the UPRR-owned yard in South San Francisco. Trains are not stored at any other location along the ROW.

The addition of EMU technology may require additional storage locations particularly during the commissioning stage. The size and locations of this additional storage have not yet been determined.

A summary of the location and configuration of train yards is provided in Table 3-9.

Table 3-9 Location and Configuration of Train Yards

LOCATION AND CONFIGURATION OF TRAIN YARDS	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• San Francisco 4th & King Terminal o Trains stored on terminal tracks • South San Francisco o Freight local service provided by UP • CEMOF o Trains stored in storage tracks 1 through 4 • San Jose Diridon Terminal o Trains stored on terminal tracks • Tamien Yard (used for ACE)	• San Francisco 4th & King Terminal o 4 trains stored on terminal tracks • CEMOF o Trains stored in storage tracks 1 through 4 • San Jose Diridon Terminal o Trains stored on terminal tracks • Tamien Yard • Additional storage required, location TBD

3.3.5 Track Maintenance Program

Track maintenance is performed by Amtrak, per the Caltrain Operating Agreement between Amtrak and Caltrain, dated November 1, 2001, as amended. Track maintenance responsibilities are detailed in Section 4.0 of the agreement appendix. Amtrak responsibilities include maintaining the designated passenger and freight tracks that are owned by Caltrain, the Gilroy and Tamien layover facilities, and the CEMOF facility. Amtrak is not responsible for maintaining UPRR-owned trackage south of CP Lick. All tracks are to be maintained for safe, reliable passage of trains per FRA, California Public Utilities Commission (CPUC), and Caltrain standards and regulations. In addition, all main tracks are to be inspected at least once every 72 hours and when ambient temperatures reach or exceed 95° Fahrenheit. Additional details can be found in the Operating Agreement.

The current Caltrain Operating Agreement expires June 30, 2011. However, the track maintenance program will continue to be Amtrak’s responsibility and will be part of the future renewed/renegotiated Operating Agreement.

3.4 Signal System

Caltrain’s current wayside block signal system limits operational capacity to six trains per peak hour and cannot support high-speed operations, which will be required for the future HST operations along the Caltrain ROW. In addition, the current system is not designed to distinguish between different train types (commuter, high-speed, freight) in support of temporal separation. Caltrain has developed CBOSS requirements to automatically provide train information, including train type, to the Rail Operations Control System (ROCS). This train information will allow the dispatcher to better determine and manage train movements consistent with temporal separation operating instructions It will also enable the safe operation of mixed-traffic for Caltrain, as well as future HST service.

CBOSS is a vital solution that provides safety features specifically mandated by the Railroad Safety Improvement Act of 2008 and the Code of Federal Regulations for a PTC system. CBOSS specifies additional capabilities, beyond those found in current PTC systems, to enable increased safety and operating performance for Caltrain and HST service. In addition, requirements have been developed throughout the CBOSS Systems Engineering process to consider and mitigate PTC system failure modes, particularly those relating to the human component. The requirements specify effective countermeasures as practicable.

3.4.1 System Description

CBOSS is designed to effectively serve many of Caltrain's key operating needs. PTC will provide positive train separation, continuous speed enforcement, positive enforcement of scheduled train stops, and support temporal separation of freight and passenger traffic on the Caltrain ROW. In addition, CBOSS provides a positive means of protection for roadway workers and train operations, which is critically important as high-speed/electrification construction activities are introduced to the Caltrain operating environment.

CBOSS requirements were developed in response to a thorough alternatives analysis that looked at existing system, functional, and performance requirements and current products. The reduction/elimination of failure conditions associated with operator error was a first priority and led to the development of a number of provisions to extend the safety performance of CBOSS. Results from Caltrain's PHA and Risk Management Program (including collision, systemwide, and product hazard analyses) were also included as inputs to the system design.

During CBOSS detailed design, a variety of processes will be employed to control risk. Included in these processes will be the Operations Hazard Analysis. This analysis will focus attention on the specific failure modes of CBOSS in combination with the wayside signal system and the train Operator, considering the new method of train control, so that any necessary supplemental means of risk mitigation can be identified and employed.

The final CBOSS design includes:

- Core safety functions, including, but not limited to, continuous over-speed protection, mislined hand-operated switch protection, etc;
- Extended safety functions, such as the enforcement of station stops and true constant warning time of crossings;
- Operational performance enhancements, such as schedule management functions and ideal train speed indication, to improve system operating efficiency; and

- Interoperability, which will allow trains equipped with similar PTC equipment (such as the Interoperable Train Control developed by UPRR and others) to be supported by CBOSS to ensure temporal separation requirements are met.

CBOSS is specified to recognize an unlimited number of train types. The capability to support the definition of a large number of train types ensures that operating performance and safety will not be unduly compromised for a given type of train, wherever CBOSS capabilities are implemented. Each train type can be evaluated and an appropriate model of behavior can be determined to allow optimal performance on CBOSS compatible territory.

Additional details on the CBOSS development process and final design can be found in the *CBOSS Technical Description* [Reference 3]. The following two tables provide a summary comparison of the operational communications and the signal and crossing activation systems for the current signal system and CBOSS.

Table 3-10 Summary of Caltrain Operational Communications

CALTRAIN OPERATIONAL COMMUNICATIONS	
CURRENT	**CBOSS**
• Mix of data radio ATCS and leased line links between office control system and CPs • Microwave network for key data communications (between CCF and mountaintops) to drive ATCS radio base stations and second voice channel base stations. • Leased lines used with ATT frame relay connections to link stations (Visual Message Signs, Public Address, Ticket Vending Machines) • Local CCTV at 4th and King and Diridon Stations only. • Stand alone office control system dispatching trains on Caltrain property, no external links to other dispatching systems. • Voice radio channels for Road (1 channel/simplex), Maintenance (1 channel duplex), and Yard (1 channel duplex)	• All ATCS data radio links between office and CPs for signal system monitoring and control. • Microwave network used as back up for fiber optic backbone in case of loss of redundant legs of fiber optic (for example major tree fall) • Fiber optic backbone system used to link all wayside equipment locations and station subsystems including monitoring and control of CPs , Visual Message Signs, Public Address, CCTV, and Supervisor Control and Data Acquisition (SCADA), etc. • SCADA for monitoring and control of electrifications substations, switching, facilities and OCS sectionalizing • CCTV at all stations, supervised from CCF. • Office control system linked to other railroads control systems (UPRR, HST, etc.). • Voice radio channels for Road (2 channels simplex), Auxiliary operations channels (2 channel, duplex), Maintenance (2 channels duplex), Yard (2 channels duplex)

Table 3-11 Summary of Signal and Crossing Activation Systems

CALTRAIN SIGNAL & CROSSING ACTIVATION SYSTEMS	
CURRENT	**CBOSS**
• Centralized Traffic Control • Wayside Block Speed Signaling (MP 0.2 to MP 43.2) • Wayside Block Route Signaling (south of M.P. 43.2 to MP CP Link 51.9 • Vital microprocessor interlockings (GETS HVLC) • Solid state D.C. coded vital communications and train detection (GETS Electrocode) • Incandescent color light signals • Motion sensing audio frequency train approach predictors (GETS & Safetran) • Island Circuits installed at each pedestrian crossing in stations allow the gates to recover while the train is dwelling • Train horn activated crossings after station stop • No links to grade crossings to enable office monitoring of grade crossing system status and equipment health.	• Centralized Traffic Control • In-cab speed signaling via CBOSS/PTC "primary" on all main track • Wayside Block Speed Signaling (north of M.P. 44±) "fall-back" operations • Wayside Block Route Signaling (south of M.P. 44±) "fall-back" operations • Vital microprocessor interlockings (GETS HVLC) • Solid state A.C. coded vital communications and train detection (GETS Electrocode) • Incandescent color light signals • Train approach crossing "primary" detection by CBOSS for true constant warning time • Automatic inhibit of crossings when near side train stops are automatically enforced • Train approach crossing "fall-back" detection by conventional audio frequency overlay track circuits based on maximum speed, up to 79 mph • Grade crossings system status and equipment health monitored from office (CCF)

3.4.2 Failed Mode Operations

CBOSS is specified to be vital and accordingly is required to provide a very high level of availability to perform its safety functions. The objectives are (1) to provide the specified PTC safety functions to the greatest extent possible and (2) to provide a failsafe design in to the case of lost inputs or component failure. Expectations are that the CBOSS equipment will be capable of delivering its safety functions 99.99% of the time.

A key design aspect of CBOSS is that it is an overlay on the existing wayside signal and grade crossing warning systems. The overall system safety requirements mandate that current system safety not be reduced by the introduction of CBOSS. In the event that CBOSS, or any of its parts, fails and become unavailable, the existing wayside signal and grade crossing warning systems will continue to operate as they do today and will be unimpaired by the overlay of CBOSS even during failure conditions. Procedures and rules will be implemented that will allow trains to move safely in accordance with the signal system until CBOSS can be restored. Safe operation will be maintained by a combination of the signal system, safe procedures, Caltrain's established CTC rules, and training and certification of the Engineers, Dispatchers and other operating and maintenance personnel.

CBOSS is designed to include additional modes of operation to support degraded conditions (failure modes), and limitations or failures of the wayside signal system. Failures of CBOSS do not necessarily mean that all features and functions of the overlay and enforcement system are lost. If the CBOSS system is available, train movement can continue in the case of failure of other parts of the system, including the wayside signaling system. The Dispatcher will authorize the use of Restricted Manual operation, which will be selected by the Engineer when rules permit. Restricted Manual operation will allow train movement to occur with CBOSS enforcing the maximum speed required of restricted operation. Once full CBOSS availability is restored, the CBOSS system will automatically transition to its normal operating mode (Supervision Mode) and then continue to automatically enforce stop signals, speed limits and restrictions, and other operating constraints.

Restricted manual operation, with the automatic enforcement of Restricted speed will reduce the risk of improper train movements into obstructions, over misaligned switches, or into situations in which train-to-train collisions could occur.

3.5 Infrastructure

The following is a summary of infrastructure, including bridges, tunnels, stations, and additional fixed objects along the ROW.

3.5.1 Bridges

Caltrain currently operates on a total of 54 railroad bridges, 34 of which are over local streets, and the remaining 20 are over waterways. In addition, Caltrain owns five highway bridges over the Caltrain ROW.

Caltrain is currently moving forward on four projects that will replace or rehabilitate a total of seven railroad bridges and four JPB-owned highway bridges between San Francisco and San Jose Diridon Stations. In addition, the San Bruno Grade Separation Project will replace three existing grade crossings by constructing railroad bridges over the roadways. A summary of the railroad and highway bridges is provided in Table 3-12.

Table 3-12 Summary of Railroad and JPB-owned Vehicular Bridges

<table>
<tr><th colspan="2">BRIDGES (SAN FRANCISCO TO SAN JOSE DIRIDON)</th></tr>
<tr><td colspan="2">• Bridge Replacement and Rehabilitation Programs underway for seven railroad bridges and four JPB-owned vehicular bridges
• San Bruno Grade Separation Project will replace three existing grade crossings with grade separated railroad bridges</td></tr>
<tr><th>CURRENT</th><th>ELECTRIFIED ENVIRONMENT</th></tr>
<tr><td>• Railroad Bridges
o Over local streets: 34
o Over waterways: 20
• Highway Bridges (JPB-owned): 5</td><td>• Railroad Bridges
o Over local streets: 37
o Over waterways: 20
• Highway Bridges (JPB-owned): 5</td></tr>
</table>

3.5.2 Tunnels

Caltrain currently operates through four tunnels, each serving a northbound and southbound track. Tunnels 1 and 2, located MP 1.30 and MP 2.14 are both 25 feet wide. Tunnels 3 and 4, located at MP 3.20 and MP 4.30, are each 30 feet wide.

Tunnel 2 has a parallel second 30 foot wide bore that is not seismically retrofitted and is currently not in use.

A summary of the JPB-owned tunnels is provided below in Table 3-13.

Table 3-13 Summary of JPB-owned Tunnels

TUNNELS (SAN FRANCISCO TO SAN JOSE DIRIDON)
• 4 tunnels in service: total length 8,814 ft / 1.67 miles • Tunnel 1: located at MP 1.30, length: 1,817 ft • Tunnel 2: located at MP 2.14, length: 1,806 ft • Tunnel 3: located at MP 3.20, length: 2,364 ft • Tunnel 4: located at MP 4.30, length: 3,547 ft • Tunnels 1-4 each serve both northbound and southbound traffic • 1 tunnel not in service: length 1,086 ft

3.5.3 Stations

There are currently 32 stations from San Francisco to Gilroy, 27 of which are between, and include, the San Francisco Fourth & King and the San Jose Tamien Stations.

At most stations, the platforms are configured with center- or side-boarding platforms such that two trains traveling in opposite directions are allowed to pass while passengers are boarding/alighting on the opposite track. The two four-track sections are also located at the Bayshore and Lawrence Stations. San Francisco Station currently has six 16 foot wide platforms, each serving two tracks. San Jose Diridon currently has three platforms, each approximately 22 feet wide, served by a total of five tracks.

The existing terminal infrastructure can support operations up to six trains per peak hour. However, capacity improvements will be required in the electrified environment in order to accommodate expanded Caltrain electrified and future HST service beyond six trains per peak hour. In order to increase passenger capacity, track and platform redesigns will be required at both the North Terminal and the San Jose Diridon Terminal areas. The platforms at the North Terminal will need to be widened to increase capacity and throughput. At the San Jose Diridon Terminal, two new platforms will have been constructed by removing seven storage tracks and replacing them with platforms and four new platform tracks.

A summary of Caltrain stations, both currently and in the electrified environment, is provided in Table 3-14.

Additional station reconfiguration for all stations in the Caltrain ROW between, and including, the San Francisco Fourth & King Station and Tamien Station in San Jose may be required in order to accommodate possible HST, Dumbarton Rail Corridor, and the Transbay Transit Center Downtown Extension projects. Further information on these projects can be found is Section 3.6 Operating Environment & Conditions.

Table 3-14 Summary of Caltrain Stations and Platforms

<table>
<tr><th colspan="2">STATIONS & PLATFORMS (SAN FRANCISCO TO SAN JOSE DIRIDON)</th></tr>
<tr><td colspan="2">• Stations
o 32 stations from SF to Gilroy
o 27 stations from SF to Tamien
• Capacity Improvements to accommodate increased Caltrain service and future HST service:
o San Francisco: Study underway to reduce number of tracks for wider platforms that allow simultaneous boarding/alighting.
• San Jose Terminals: Projects underway to add platforms and platform tracks</td></tr>
<tr><th>CURRENT</th><th>ELECTRIFIED ENVIRONMENT</th></tr>
<tr><td>• San Francisco Terminal
o Platforms: 6, 16 ft wide
• San Jose Terminal
o Platforms: 3, ~22 ft wide</td><td>• San Francisco Terminal
o Number of platforms to be reduced. Platforms to be re-designed and widened to accommodate Caltrain 6 train per hour service (ultimately Caltrain 10 train per hour)
• San Jose Terminal
o 2 New Platforms, each 25 ft wide</td></tr>
</table>

3.5.4 Traction Power

In the electrified environment, Caltrain will have converted from a strictly diesel-hauled railroad to one with a mixture of electrically-powered and diesel-hauled trains for service between the 4th & King Street Station in San Francisco and the Tamien Station in San Jose. This will be possible through the Electrification Program which will install 120 to 134 single-track miles of overhead contact system (OCS) for the distribution of electrical power to the electric rolling stock. The OCS would be powered from a 25 kilovolt (kV), 60 Hertz (Hz), single-phase, alternating current (AC) supply system consisting of traction power supply substations, switching stations, and paralleling stations.

Diesel-powered locomotive trainsets would continue to operate for Baby Bullet express service between Fourth & King Street Station and San Jose Tamien Station and via shuttle trains between the San Jose Diridon and Gilroy Stations. Diesel-hauled freight and other passenger railroad services will also continue.

Table 3-15 Summary of Traction Power Source

TRACTION POWER SOURCE	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• Diesel locomotive	• Diesel locomotive • Electrical overhead contact system o 120 to 134 single-track miles of overhead contact system (OCS) o 25 kV, 60 Hertz (Hz), single-phase, AC supply system consisting of traction power supply substations, switching stations, and paralleling stations.

3.5.5 Other Fixed Objects / Facilities

The Caltrain ROW is relatively free of fixed objects and facilities. In addition to items listed above in sections 3.5.1 to 3.5.4, the other main items are along the ROW are piers and abutments from overpasses and bridges. The horizontal clearance between the tracks and the piers from roadway overpasses range from 7.5 feet to over 50 feet. See the *Caltrain Infrastructure List* [Reference 6] for additional vertical and horizontal clearance information.

3.6 Operating Environment & Conditions

In addition to Caltrain, three additional passenger rail services are operated on the Caltrain ROW. ACE, Capitol Corridor, and Amtrak long distance operate passenger rail service on the Caltrain ROW between Santa Clara and the San Jose Diridon Station. Amtrak long distance continues service south of San Jose Diridon. The UPRR also operates freight between the Quint St. Lead (MP 3.05) and south beyond the Gilroy Station.

The following is a summary of rail operations on the JPB-owned ROW, both for Caltrain's current operations and its expected operations in the electrified environment. The latter summary assumes the installation of CBOSS, the completion of the Electrification Program, and the operation of EMU technology.

3.6.1 Passenger Service

The following is a detailed summary of passenger operations on the Caltrain dispatched and owned ROW under current conditions and in the electrified environment. A summary of the passenger service operations described below can be found in Table 3-16.

3.6.1.1 Present Passenger Operating Conditions

Passenger service along the Caltrain ROW is currently provided by Caltrain and three additional passenger rail operators. The three additional passenger rail operators, ACE, Capitol Corridor, and Amtrak long distance, are provided access under the terms of the TRA between the JPB and the UPRR and utilize a limited portion of the ROW in the South Terminal Area. The South Terminal Area is defined as the ROW between MP 44.6, which is just north of the Santa Clara Station, and CP Lick (MP 51.9). All operators currently utilize diesel-hauled FRA-compliant equipment. The TRA also reserves intercity passenger rights to UPRR for the entire ROW.

Caltrain typically operates diesel-hauled five-car consists along the ROW between San Francisco and MP 44.6. Service is provided northbound on the MT-1 and southbound on MT-2. Caltrain utilizes the four-track sections at Bayshore and Lawrence stations as needed. The Millbrae controlled siding and the East and West controlled sidings located in Redwood City are not used for regular service unless necessary.

Caltrain and the three passenger rail operators operate service between MP 44.6 and the San Jose Diridon Station (MP 47.5). South of MP 44.6, Caltrain operates northbound on MT-2 and southbound on MT-3. The UPRR Coast Subdivision enters the Caltrain-owned ROW from the north at milepost 44.6 and provides access to the ROW for ACE, Capitol Corridor, and Amtrak long distance. Caltrain dispatches these services to enter the Caltrain ROW and, contingent upon obstructions, construction, and train traffic, the three passenger rail services operate southbound on UPRR-owned MT-1 into the San Jose Diridon Terminal (MP 47.0 to 49.1). Within the San Jose Diridon Terminal, Caltrain and the three passenger rail operators are assigned to tracks one through five. Caltrain may also operate on MT-1 if absolutely necessary and all service will be dispatched accordingly should this occur.

South of the San Jose Diridon Terminal to CP Lick (MP 51.9), Caltrain operates bi-directionally on MT-2 and reserves the right to use MT-1 if necessary. The ROW south of CP Lick is owned and dispatched by UPRR.

3.6.1.2 Passenger Operating Conditions In The Electrified Environment

In the electrified environment, the entire ROW from San Francisco to CP Lick in San Jose will be electrified and Caltrain will be operating in a mixed-traffic mode, with EMU trains running alongside FRA-compliant locomotive-hauled passenger trains. The Electrification Program will also include the two four-track sections; the controlled sidings at Millbrae, East, West, and Tamien; and the UPRR-owned MT- 1, which runs from approximately MP 44.75 to CP Lick. MT-1 is currently used primarily for freight and non-Caltrain passenger rail operations, both of which will continue to operate FRA-compliant locomotive-hauled passenger trains. Caltrain reserves the option to operate on MT-1 if necessary.

Operations in the electrified environment for all passenger rail operators, including Caltrain, are not expected to change drastically. All operations currently in place, as described above, will still hold except for the following four changes.

- The addition of the new platform at the Santa Clara Station will allow ACE and the Capitol Corridor to stop at the Santa Clara station.
- The addition of a new dedicated lead between CEMOF and the San Jose Diridon Terminal can be used for passenger rail service and will provide additional operational flexibility.
- A third main track south of the San Jose Diridon Terminal will be added from approximately MP 47.7 to MP 48.1 and will provide extra passenger rail capacity.
- The electrification of UPRR-owned MT-1 will provide the opportunity for Caltrain to operate EMU technology on MT-1. Since MT-1 is utilized by other passenger rail operators as well as freight, the additional safety measure employed to prevent commingling of freight and non-FRA-compliant technology will also be

applied to other passenger rail operators. See Section 3.6.2.3 for information on safety measure to be in place to ensure the separation between freight and non-FRA-compliant technology and for information on temporal separation.

Table 3-16 Summary of Passenger Rail Operations

PASSENGER RAIL OPERATING CONDITIONS	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• Caltrain o Trains per day: 90 o Trains per peak hour: 5 o Diesel-hauled o 5-car consists o San Jose Diridon Terminal only – use tracks 2-5 • ACE o Trains per day: 8 o Service Hours: 6:30 am to 5:35 pm o San Jose Diridon Terminal only – use tracks 1-5 • Capitol Corridor o Trains per day: 15 o Service Hours: 6:40 am to 11:55 pm o San Jose Diridon Terminal only – use tracks 1-5 • Amtrak long distance o Trains per day: 2 o Service Hours: 9:55 am and 8:27 pm o San Jose Diridon Terminal only – use track 1 only	• Caltrain o Trains per day: 114 o Trains per peak hour: 6 o Diesel-hauled: ▪ Baby Bullet trains ▪ Gilroy shuttle trains o Electric powered service: ▪ All remaining limited and local trains o San Jose Diridon Terminal only – use tracks 2-5, possibly additional tracks • ACE, Capitol Corridor, and Amtrak long distance are assumed to still be operating in the electrified environment. Actual service to be determined. o San Jose Diridon and Santa Clara Stations – operations TBD

3.6.2 Freight Operations & Temporal Separation

In addition to Caltrain commuter rail service, the UPRR operates daily freight trains along the Caltrain ROW. Caltrain entered into a TRA with the UPRR's predecessor, Southern Pacific Transportation Company, that details the ownership and operating parameters for Caltrain, intercity passenger and common carrier freight operations. In summary, the JPB owns the ROW and trackage between the San Francisco Fourth & King Station (MP 0.2) to CP Lick (MP 51.9) with the exception of UPRR-owned MT-1 from MP 44.75 to CP Lick . All rail traffic from MP 0.2 to MP 51.9 is dispatched by Caltrain. The UPRR owns and dispatches traffic on its ROW south of CP Lick and on industrial leads and spurs, including the Coast Subdivsion north of MP 44.6. Caltrain dispatches all movement from the industrial leads and spurs onto the mainline.

The following is a summary of the current freight operating conditions, operating conditions in the electrified environment, and a description of how temporal separation will be enforced once the new EMU technology is operating on the ROW. The description is applicable to the Caltrain dispatched ROW except as noted.

3.6.2.1 Present Freight Operating Conditions

Caltrain and UPRR operate on the same tracks from San Francisco to MP 44.0. As part of the TRA with Caltrain, as long as the mid-day headway equals or exceeds 30 minutes and freight traffic can maintain commuter rail speeds, the UPRR is to be allowed, at a minimum, one 30 minute headway window on both the north and southbound tracks during 10 am and 3 pm between San Francisco and milepost 44.0 in Santa Clara. In addition, between midnight and 5 am, at least one main track between San Francisco and milepost 44.0 shall always be available for freight service.

Freight operations south of milepost 44.6 in the South Terminal Area (MP 44.6 to MP 51.9) are not restricted to specific operating hours. The UPRR connects to Caltrain's mainline through the Coast Subdivision at MP 44.6. Caltrain dispatches service and, contingent upon obstructions, construction, and train traffic, allows UPRR to operate southbound on UPRR-owned MT-1 into the San Jose Diridon Terminal (MP 47.1 to MP 47.9). In the San Jose Diridon Terminal, UPRR utilizes track 1 to travel through the station and then continues on MT-1 south to Gilroy. Currently, track 5 in the San Jose Diridon Terminal provides UPRR with an alternate route through the station should track 1 be unavailable. UPRR also services the Vasona Industrial Lead just south of the San Jose Diridon Station. Restricted speeds for all traffic within the San Jose Diridon Terminal allow freight to operate to the Vasona Industrial Lead via radio and sight. A standard operating procedure (SOP) is in place to preclude all other movement while freight is navigated through the San Jose Diridon Terminal and onto the Vasona Industrial Lead. UPRR operates northbound on UPRR-owned MT-1 to the Coast Subdivision at MP 44.6.

In addition to MT-1, UPRR owns and can operate on a controlled siding located directly east of MT-1. This controlled siding connects to MT-1 at approximately MP 46.4 and runs north of and parallel to MT-1, through the Newhall Yard, and turns east parallel to the UPRR Coast Subdivision. This siding is dispatched by Caltrain in the South Terminal Area.

A summary of all UPRR industrial leads and yard locations currently in use is presented in Table 3-17.

Table 3-17 UPRR Industrial Lead, Spur, and Yard Locations Currently In Use

UPRR INDUSTRIAL LEADS, SPURS AND YARDS
• Quint St. Lead (MP 3.05) – to Port of SF • Carrol St. Lead (MP 3.8) • Sierra Point Lumber Spur (MP 5.0) • South San Francisco East and West Yards (East: MP 8.2, West: MP 8.6) • UPRR Redwood Junction Industrial Lead (MP 26.2 and MP 26.8) • Pine Cone Lumber Spur (MP 40.0) • Calstone Lead (MP 40.9) • Butterhouse Lead (MP 41.4) • UPRR Coast Subdivision and Newhall Yard (approx MP 44.6) • UPRR Controlled siding (approx MP 46.4) • Warm Springs Subdivision (MP 46.5 and MP 47.2) • UPRR Vasona Industrial Lead (MP 47.8)

3.6.2.2 Freight Operating Conditions in the Electrified Environment

The Electrification Program will electrify the entire Caltrain corridor, from San Francisco to CP Lick, including UPRR-owned MT-1 from MP 44.75 to CP Lick. Caltrain operation of EMU technology along the electrified ROW will require a change in freight operations during Caltrain regular operating hours in order to ensure EMU vehicles and freight traffic are temporally separated.

With the implementation of electrification, UPRR freight service will be restricted to the hours of midnight to 5 am on the corridor except within the South Terminal Area. Passenger service initiated after midnight or before 5 am will be provided by FRA compliant equipment to comply with the TRA requirement for a five hour window of operations of freight traffic on the corridor. The TRA also contains a provision that permits Caltrain to seek approval from the appropriate federal authorities to abandon all freight service on the Caltrain-owned trackage if passenger service improvements prove to be incompatible with freight operations.

The following is a summary of Freight operations in the electrified environment:

- Freight operations between MP 0.2 and 44.6 will be restricted to the hours of midnight to 5 am. Passenger service initiated after midnight or before 5 am will be provided by FRA compliant equipment to comply with the TRA requirement for a five hour window of operations of freight traffic on the corridor.
- UPRR will continue to enter through the Coast Subdivision, operate southbound on MT-1 to the San Jose Diridon Terminal and through to Gilroy.
- Freight operations south of MP 44.6 in the South Terminal Area (MP 44.6 to MP 51.9) will continue to be allowed during Caltrain service hours due to the fact that MT-1 allows freight and non-FRA-compliant technology to simultaneously operate on separate tracks.
- At San Jose Diridon Terminal, freight will be restricted to track 1. When track 1 is unavailable, freight will be directed to track 2 and a through-route will be lined to direct freight to and from MT-1 without the ability to access other tracks.

- The restricted speeds and the SOP currently in place to allow UPRR to access the Vasona Industrial Lead will still be in place but will be updated with additional safety precautions. Freight access to the Vasona Lead will restrict all train movement in the San Jose Diridon Terminal (MP 47.1 to MP 47.9), will cancel all other routes within the limits of the San Jose Diridon Terminal, and will hold all trains at the San Jose Diridon Terminal limits. This will continue until the back of the freight train clears the Vasona signal. All freight trains accessing the Vasona Lead must start all movement from tracks 1 or 2 within the San Jose Diridon Terminal.
- Because the electrification of MT-1 will provide the opportunity for Caltrain to operate EMU technology on MT-1, additional safety measures are employed to prevent commingling of freight and non-FRA-compliant technology. The normal state of switches between MT-1 and MT-2 will be lined for the straight route. Position changes for these switches will be controlled by the dispatcher and requires a positive response in order to set a route that requires a position change. Caltrain will not operate on MT-1 unless under emergency or unexpected situations. When this is necessary, freight utilization of MT-1 will be restricted.
- CBOSS requirements have been developed to provide a positive indication of train information that includes train type for the ROCS.
- The UPRR-controlled siding will still be in use, thereby providing additional flexibility for ensuring the physical separation between freight and EMU technology.

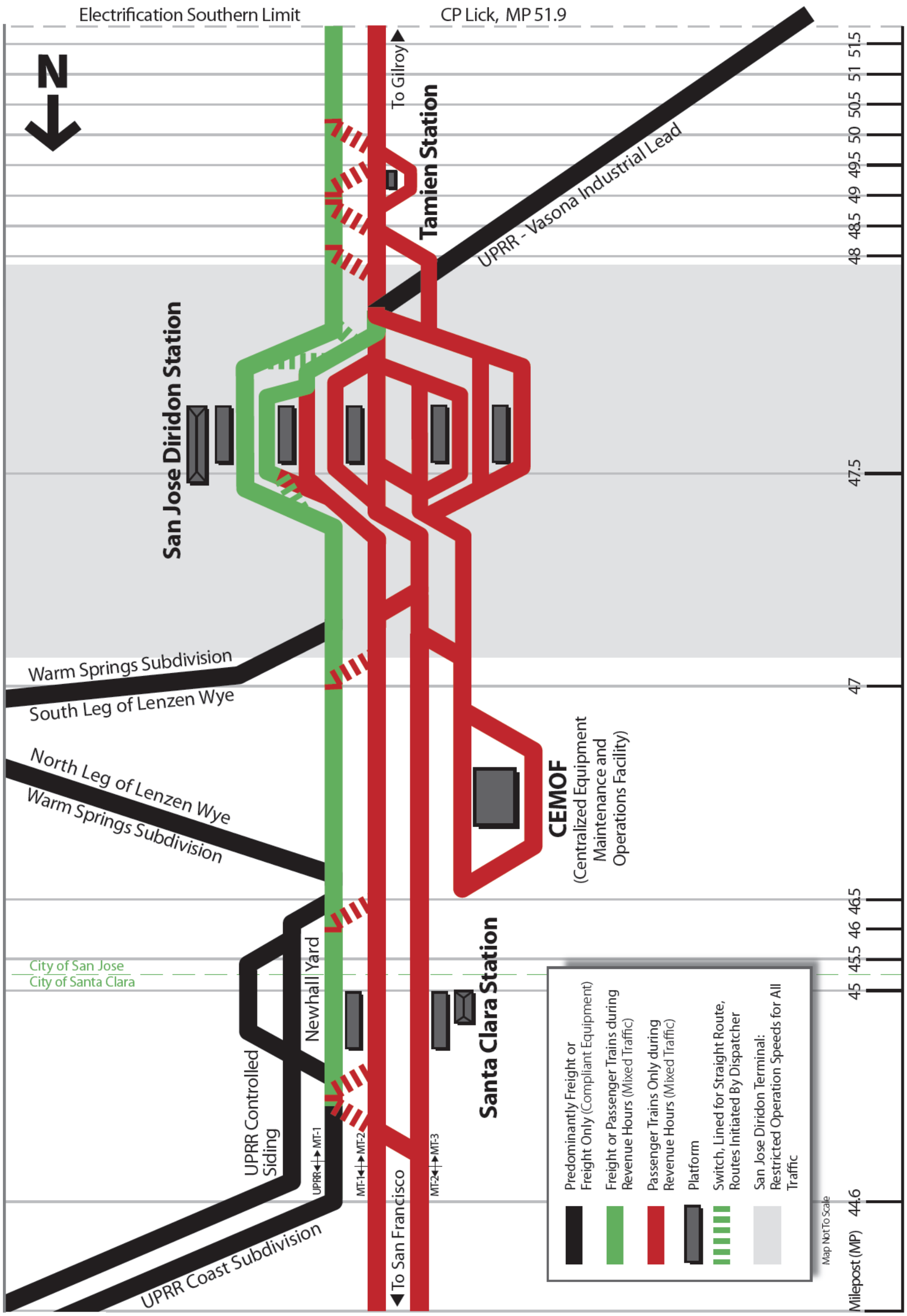
For more information how Caltrain intends to maintain temporal separation between freight and EMU, see Section 3.6.2.3.

A graphical description of freight and commuter rail operations in the segment from the UPRR Coast Subdivision to CP Lick in the electrified environment is provided in Figure 3-4.

Table 3-18 Summary of UPRR Freight Operations

UPRR FREIGHT OPERATING CONDITIONS	
CURRENT	**ELECTRIFIED ENVIRONMENT**
• Trains per day: 12 to 20 • Service Hours: 24 hrs a day, depending on passenger rail traffic • San Jose Diridon Terminal – uses track 1 with Track 5 available as a bypass if necessary. • Caltrain is required to provide windows north of MP 44.0 during midday, per the TRA	• Trains per day: TBD • Service Hours: o South Terminal Area: 24 hrs a day, depending on passenger rail traffic o MP 0.2 to 44.0: midnight to 5 am o Passenger service initiated after midnight or before 5 AM will be provided by FRA compliant equipment to comply with the TRA requirement for a five hour window of operations of freight traffic on the corridor. • San Jose Diridon Terminal – uses track 1 with track 2 available as a bypass if necessary.

Figure 3-4 Rail Operations in the South Terminal Area in the Electrified Environment



3.6.2.3 Temporal Separation

The following discussion on temporal separation applies to the Caltrain-owned and dispatched ROW in the electrified environment. However, since the TRA between JPB and UPRR permits the restriction of freight operations to 12:00 am to 5:00 am during which time Caltrain would only operate FRA compliant equipment, the location of commingled operations between freight and EMU trains occurs primarily in the South Terminal Area, where freight operations can occur 24 hours a day.

An integral function in ensuring temporal separation is the ROCS, which will be updated to receive train information, including train type, via CBOSS, which will be installed on all Caltrain locomotives, cab-end cars and EMUs. Should new regulations or interoperability efforts determine a mandate for PTC systems to provide positive indication of train type information, the ROCS and dispatcher performance can be made more efficient due to the consistent automated handling of train type information by interoperable PTC systems. The ROCS will also allow the dispatcher to “tag” non-Caltrain trains as freight, passenger, etc. if train type is not included in the information generated by the PTC system.

Together, the CBOSS train data and dispatch system inputs assist to provide safe operations and routing for EMUs and FRA-compliant passenger trains along the Caltrain dispatched ROW. However, the inclusion of freight operations in the South Terminal Area requires additional precautions due to safety concerns from possible commingling. To avoid unintentional commingling, the normal state for all switches that provide for movement between MT-1 and MT-2 will be lined for the straight route. All route requests for movement between MT-1 and MT-2 will also be initiated by the dispatcher through the ROCS. For these requests, the dispatcher is required to ensure the train ID and type, as provided by CBOSS, is correct. Upon setting a route in which movement between MT-1 and MT-2 occurs, the dispatcher will then be prompted to provide a positive response, which is a special override function that requires the dispatcher to accept/confirm that the route request is consistent with commingled route restrictions. Once the electronic route clears and the track circuit is no longer occupied, the switch will revert back to its default position, which is straight. This additional safety precaution is required for all movement between MT-1 and MT-2, including route requests from other passenger rail operators operating FRA-compliant technology.

In addition, CBOSS and its inherent PTC functions provide the ability to maintain temporal separation during mixed-traffic operations and more importantly, during commingled operations when freight trains are operating during Caltrain service hours on the Caltrain dispatched ROW. For all trains that enter, exit, and operate on the Caltrain ROW from San Francisco to CP Lick (MP 51.9), CBOSS reduces the risk of operator error though train stop enforcement, continuous speed enforcement, and the ability to maintain and enforce separation for all trains operating on the ROW. Interoperability will allow CBOSS to recognize and utilize the PTC technology to be developed for Amtrak and freight, thereby ensuring that all trains operating on the ROW will be governed by CBOSS and its PTC functions.

At locations where there are hand-operated switches, Caltrain provides protection of mainline movements by the use of electric locks that cause the wayside signal system to display a “STOP” signal indication or that result in a track occupancy whenever the switch padlock is removed. CBOSS reacts to STOP signals and track occupancies forcing any approaching train to stop before the electric lock is released that would then make movement of the hand operated switch possible. This solution provides effective mitigation reducing the risk of commingled operations. In normal circumstances the removal of the switch padlock will be coordinated with the dispatcher to avoid unintended emergency braking of approaching trains and commingling.

3.6.3 Future Projects Beyond Electrification

3.6.3.1 Caltrain

Caltrain will continue to move forward in supporting plans for future service expansions. The construction of the North Terminal reconfiguration will continue as scheduled. In addition, upgrades to station buildings may be needed at the San Francisco Fourth & King and San Jose Diridon Stations in order to adequately handle increased passenger activity within the station buildings.

Fleet expansions may be required to support future service expansions beyond the six trains per peak hour service. Additional maintenance and/or storage sites may be necessary for the expanded fleet.

3.6.3.2 Third Party

There are currently three third-party projects in the early planning stages that will connect to the Caltrain system. These projects are the Downtown Extension (DTX) to the future San Francisco Transbay Transit Center, operations on the Dumbarton Rail Corridor, and the CHSRA High Speed Rail project. These projects, should they be implemented, would substantially impact the Caltrain system and infrastructure, necessitating the addition of tracks, redesign and construction of new station platforms, and possibly grade separations. However, as they would occur after electrification is complete, their impact would not impact the purpose of this waiver. Therefore, this section is purely informational.

The Transbay Terminal Joint Powers Authority is currently in the process of replacing the existing outdated bus-only Transbay Terminal with a new intermodal Transit Center. This new Transit Center will still be served by regional bus lines, but will also include future facilities for Caltrain and HST service. Access for Caltrain and HST will be provided by a new 1.3 mile underground tunnel, referred to as the Downtown Extension (DTX), from the existing Caltrain Fourth & King Station to the new Transit Center. The DTX would require a redesign of the existing Fourth & King Caltrain Station, including track, platform, station, and operations. The construction of the temporary bus terminal and the transit center building are currently underway and are slated to be complete by 2014. The DTX project is projected to be complete by 2019.

The Dumbarton Rail Corridor project will extend rail service between Union City in the East Bay and Redwood City by reconstructing a 20.5-mile existing rail corridor next to the Dumbarton Bridge (State Route 84). A portion of the corridor is owned by the San Mateo County Transit District (between Redwood City and Newark) and a separate portion in the East Bay is owned by UPRR. The purpose of the project is to link the East Bay and the West Bay by extending rail service across southern San Francisco Bay. The extension will connect existing public transportation services such as BART, ACE, Capital Corridor, Caltrain, and regional bus service. The project is currently in the environmental review process.

The California HST system is the first high speed rail system on the West Coast and will provide service between San Francisco and Anaheim. CHSRA will use the Caltrain corridor for its Bay Area segment, at a minimum between San Francisco and San Jose (and possibly to Gilroy). The HST system would be electrified using the same traction power system proposed for Caltrain alone; thus, the two projects would be compatible. The HST system is also expected to require that the Caltrain corridor be expanded to four mainline tracks with full grade separation and a redesign of all stations in order to accommodate the four tracks and HST service. Environmental documents for the San Francisco to San Jose corridor are planned to be complete in by 2012.

3.6.4 Hazardous Material

The JPB-owned ROW is a part of the national rail network and as such, the UPRR is allowed to operate cars loaded with hazardous materials on the Caltrain ROW tracks. However, the UPRR is not allowed to place hazardous material cars on the South San Francisco yard track closest to the main track.

4 PRELIMINARY HAZARD ANALYSIS

4.1 Introduction

Caltrain performed a Preliminary Hazard Analysis to satisfy the need for an initial hazard assessment for the operation of EMU trainsets on Caltrain ROW. The purposes of the PHA are to identify, evaluate, and determine applicable systemwide countermeasures for hazard conditions that are determined to benefit the safe operation of trains at grade crossings, EMU vehicle collisions with FRA-compliant vehicles, collisions with wayside fixed objects and circumstances when train corridors are shared with freight traffic. Collision scenarios potentially resulting in serious, critical and catastrophic consequences are further evaluated in terms of applicable risk mitigation. The PHA provides a summary level analysis of conditions relevant to the introduction of EMUs into the Caltrain system. Systemwide analysis is performed once program direction is established by an acceptance of the PHA results.

The collision scenarios evaluated in the PHA include:

- Grading crossings
- Train-to-train
- Train-to-fixed object

This chapter provides a summary of the PHA effort, including a summary of the PHA process, approach, and analysis results. The PHA worksheets summarizing the analysis for each scenario can be found in the *Caltrain 2025 Preliminary Hazard Analysis Worksheets* [Reference 7].

4.2 Purpose

A PHA provides the initial hazard assessment of a proposed system or major system change and is part of the formalized process to identify, eliminate, and control hazards related to grade crossings, train-to-train collisions, operations in corridors shared with freight traffic, and collisions with fixed wayside objects. Its goals are to clarify and systematically assess conditions that could potentially affect a system's safe operation and to identify the most significant opportunities for mitigation of these hazard conditions at the system and subsystem level. A safety hazard is any real or potential set of conditions within an operating environment that can lead to or cause: injury, loss of life, or damage to equipment or property. A PHA provides the foundation for a system level basis of design thereby defining the direction that should be taken and which is supported by a variety of following hazard analysis processes that collectively provide comprehensive management of hazard conditions relating to detail design and system operation.

The PHA performed for Caltrain, coupled with the crossing-by-crossing analysis that Caltrain has performed for the Systemwide Grade Crossing Improvement Program [Reference 5], provides a comprehensive approach that focuses efforts for crossing improvements in the Caltrain corridor. The PHA also identifies countermeasures to prevent hazards resulting from freight traffic operating in the South Terminal Area. Therefore, the principal purposes of the PHA are to:

- Identify and evaluate hazard conditions existing within the Caltrain operating environment and their effects on passengers, train crews, equipment, and transit system infrastructure and the probability that a mishap may result;
- Identify and evaluate available or feasible countermeasures to eliminate or control the identified hazard conditions.

It should be noted that a PHA is not the same as a failure analysis. This distinction is important, because a hazard involves the risk of loss or harm, while a failure does not always result in loss or harm.

A summary of the PHA process is shown in Figure 4-1.

Figure 4-1: Preliminary Hazard Analysis Process

DEFINE THE SYSTEM

- Define the physical and functional characteristics, the people, procedures, facilities, equipment, and the environment

↓

IDENTIFY HAZARDS

- Identify hazardous conditions and undesired events
- Determine the causes of hazards

↓

ASSESS HAZARDS

- Determine severity
- Determine probability
- Identify and evaluate mitigation options
- Decide to accept risk or eliminate/control

↓

RESOLVE HAZARDS

- Assume risk; or
- Implement corrective action
    - Eliminate
    - Control

4.3 Methodology

The PHA effort provides results based on a range of collision scenarios. The analysis utilizes the severity of consequences for each type of collision and mishap probability. For each case that results in injury, damage, or both, causal hazard conditions and available mitigation are evaluated for situations that exist or could potentially arise within the electrified environment.

The PHA was based on the *FRA Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service* [Reference 9]. The United States Department of Defense document *Standard Practice for System Safety*, MIL-STD-882 [Reference 10] was also used in developing the criteria for determining hazard severity and probability within the Caltrain operating environment.

4.3.1 Development of PHA Scenarios

The identification of grade crossing hazards, train-to-train collisions, mixed use with freight traffic, and wayside immoveable object collision scenarios were derived from:

- Caltrain's TransitSafe Accident Database [Reference 11] – from 1992 to present
- National commuter rail operations experience
  - FRA Accident Database [Reference 12] – Accidents reports by the 18 operating railroads, as required by 49 CFR Part 225 – 2000 to 2008

A review of Caltrain and FRA data finds that the most prevalent mishap or accident type are collisions at grade crossings with automobiles, followed by collisions with pedestrians and then commercial trucks.

An effort to identify mishaps and hazard scenarios that directly relate to the Caltrain operating environment was conducted in October 2007 by an expert panel consisting of FRA representatives, commuter rail industry experts, and Caltrain senior operations staff. The panel-developed scenarios were based upon viewing a head-end video recording of the Caltrain corridor between San Francisco and San Jose (MP 0.2 to 49.2). Between February and April 2008, the Caltrain team refined the relevant hazard scenarios for the electrified environment.

The hazard scenarios selected for this analysis were derived from the refined expert panel's list of scenarios, and further expanded upon considering Caltrain's operating history and the FRA's accident database of the 18 commuter rail systems. Although Caltrain's operating history does not include train-to-train collisions, these were included due to the catastrophic nature of the event, the interface of non-compliant EMU's with FRA crashworthiness regulations, and to ensure that analysis considered opportunities to further reduce the outcome of such collisions.

The scenarios evaluated in the PHA are:

A. EMU collision with auto driving around crossing gate
B. EMU collision with highway truck driving around crossing gate
C. EMU collision with pedestrian at grade crossing
D. EMU collision with auto at non-gated maintenance of way crossing
E. EMU collision with auto fouling tracks at gated grade crossing
F. EMU collision with highway truck fouling tracks at gated grade crossing
G. EMU in shared corridor strikes freight cargo that has dislodged
H. EMU collision with FRA-compliant locomotive
I. EMU collision with flat immovable object
J. EMU collision with object (derailed train)

These scenarios are designed to address EMU non-compliance with FRA regulations as identified through a CFR compliance analysis [Reference 8].

4.3.2 Hazard Risk Index

The identified hazard scenarios are categorized in terms of hazard severity or consequence and the probability or frequency of occurrence. A Hazard Risk Index (HRI) is assigned to each hazard based on the severity and probability ratings assigned to each scenario.

4.3.2.1 Hazard Severity

The hazard severity categories listed in Table 4-1 provide a qualitative indication of the relative severity of consequences potentially resulting from the hazardous conditions. For the purposes of this PHA, the severity category assigned was based on the "typical" event involving motorists, pedestrians, and train passengers and crews. The resultant effects on the train crew and passenger occupants of the EMU were obtained from *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor*. [Reference 4].

Table 4-1: Hazard Severity Categories

Category Title	Severity Definition
Catastrophic	People – Loss of life and numerous major injuries. EMU – Cab or passenger volume is significantly compromised. EMU loss.
Critical	People – Loss of life and/or numerous major injuries. EMU – Cab or passenger volume is partially compromised. Major damage to EMU.
Serious	People – Minor injuries and limited major injuries. EMU – Major damage to exterior of EMU. Occupied volume not compromised.
Marginal	People – Minor injuries requiring medical treatment away from the scene. EMU – Minor damage to exterior of EMU. Occupied volume not compromised.
Negligible	People – No or minor injuries only requiring first aid treatment at the scene. EMU – No damage to exterior of EMU. Occupied volume not compromised.

4.3.2.2 Hazard Probability

The hazard probability levels listed in Table 4-2 represent a qualitative judgment of the relative likelihood of the development of a hazardous condition within a given period of time. The probability of a hazardous condition contributing to mishap was evaluated, rather than the frequency of mishaps alone. Mishaps within commuter railroad operating environments, and in particular that of Caltrain, are infrequent or have not yet occurred. Use of mishap data alone can lead to a conclusion that the implementation of countermeasures would not be warranted, thus potentially eliminating consideration of low cost and effective mitigation opportunities that could provide further assurance against accidents and the resulting impacts to the operation and quality of service. As the desired outcome of this PHA is to efficiently control contributing factors to mishaps, the frequency or probability of those contributing factors, coupled with mishap consequence data, was analyzed. Based upon the probability that a situation will occur, a judgment can be made as to the importance of addressing one specific concern over another, taking account of the mitigation effectiveness and cost.

Table 4-2: Hazard Probability Levels

Probability Level	Frequency of Hazardous Condition Occurring
Frequent	Daily
Probable	Weekly
Occasional	Monthly
Remote	Yearly or greater
Improbable	Highly unlikely to occur, but is possible
Design Resolved	Design characteristic provides positive assurance of safe operation and high availability, such that the hazard condition is eliminated

4.3.2.3 Assigning Hazard Risk Index

To classify each hazardous condition, the probability of the condition occurring and the severity of a mishap were combined and the hazard scenario is then assigned the corresponding Hazard Risk Index, as shown in Table 4-3. The Initial HRI is determined based on the mishap severity and probability of the hazardous condition in the electrified environment. The current means of mitigation along the ROW are assumed to still exist.[1] In addition, it is assumed that Caltrain will be meeting the requirements of the Railroad Safety Improvement Act of 2008. Additional functions provided through CBOSS that go beyond PTC, such as temporal separation and special ROCS functions, are considered as mitigation measures. Under these assumptions, each hazard was examined, qualified, addressed, and resolved based on the severity of a potential outcome, and the likelihood that such an outcome will occur when operating EMUs in the electrified environment.

Low or moderate HRI levels point to a need to evaluate opportunities to provide additional mitigation to further reduce mishap severity and/or probability. Hazard conditions with increased HRI levels are an indication of mitigation effectiveness. The indication provided by the HRI is not of a single mitigation measure but instead represents the combination of measures that collectively reduce the overall risk to the lowest level practicable within the resources available to Caltrain. Unfortunately, absolute safety will remain an elusive goal since mitigation effectiveness tends to be limited for some hazard conditions: there will always be some element of “residual risk.”

[1] Grade crossings are protected by two-quadrant gates, warning lights, audible warning bells, train whistle, signs, and pavement markings compliant with the requirements of the Federal Highway Administration’s (FHWA) Manual on Uniform Traffic Control Devices (MUTCD), as amended by the California DOT.

Improvement of the HRI (Residual HRI) reflects the implementation of available mitigation measures that reduce the probability of the hazardous condition and/or the severity of mishaps according to their degree of mitigation effectiveness.

Table 4-3: Hazard Risk Index

SEVERITY PROBABILITY	Catastrophic	Critical	Serious	Marginal	Negligible
Frequent	1	3	6	10	15
Probable	2	5	8	12	19
Occasional	4	7	11	18	23
Remote	9	13	17	21	24
Improbable	14	16	20	22	25
Design Resolved	25	25	25	25	25

Table 4-4 shows the determination for each HRI. A hazardous condition is considered eliminated if the HRI is 25, the maximum index level. HRIs of 19 or greater reflect conditions of controlled risk and are acceptable without formal review. HRIs of 12 through 18 reflect conditions of low risk and are acceptable with safety committee review. Moderate risk conditions (HRIs 7 through 11) are undesirable and must be mitigated if possible, and high levels of risk (HRIs1 through 6) are unacceptable and must be mitigated.

Table 4-4: Risk Categories and Determination

Risk Category	Hazard Risk Index	Required Disposition
High	1-6	Unacceptable (mitigate)
Moderate	7-11	Undesirable (mitigate if possible)
Low	12-18	Acceptable with safety committee review
Acceptable	19-25	Acceptable without formal review

4.3.3 Identification of Mitigation Measures

Caltrain analyzed the following three sources to determine available mitigation measures:

- Caltrain's Hazard Risk Management and Resolution
- Department of Defense Standard Practice for Safety (MIL-STD-882)
- Systemwide Grade Crossing Improvement Program

4.3.3.1 Hazard Risk Management and Resolution

Caltrain's Hazard and Risk Management process is ongoing and continuous, allowing identification and evaluation of new and changed hazardous conditions. The Hazard and Risk Management process includes participation by the engineering and management teams to review and confirm that all practicable mitigation is employed and that any residual risk that remains after mitigation is at as low a level as can be practicably achieved. Hazard and Risk Management decision-making is supported by expert panels tailored to each type of hazard condition and mitigation. The expert panel validates the hazard analysis methodology and provides input on the severity and probability of hazardous conditions, provides input to help determine the effectiveness of new mitigation alternatives, and reviews the analysis results.

A critical step in the risk management process is to assess the mitigation measures in terms of resources available to Caltrain. Those measures that would result in the greatest reduction of mishap severity and/or probability are given the highest priority. This step in the risk management process ensures that the most effective mitigation measures are selected to reduce risk to the greatest practicable extent within the available resources.

Management of risks at specific grade crossings relating to motorists and pedestrians is handled separately using the FRA and FHWA analytical tools, criteria and guidelines. It is worth noting that Caltrain's high-performance service objectives are driving the inclusion of various systems capabilities aimed at avoiding or reducing operational disruptions, some of which relate to hazardous conditions or situations beyond what is explicitly prescribed by applicable regulations.

4.3.3.2 Mitigation Measures

Overall, hazards are minimized by the application of practicable engineering and administrative mitigation measures. Hazards are controlled through the systematic application of safety precedence. The Department of Defense Standard Practice for Safety (MIL-STD-882) identifies an order of precedence in the hazard control process requiring the strongest and most effective means of mitigation for hazard conditions to be employed when feasible. This consists of eliminating or mitigating the hazard condition by design, employing safety and warning devices, and lastly introducing rules, procedures and training. Each step is briefly described as follows:

Design to Eliminate/Minimize Hazards
MIL-STD-882 emphasizes elimination of hazards through the design process. When design modifications are not possible, not practicable, or are cost-prohibitive, the use of safety devices, warning devices, and procedures and education are to be considered.

Safety Devices
Hazard conditions which cannot be eliminated by design or managed to an acceptably low risk may be controlled through the use of safety devices. Safety devices include barriers such as gated crossings.

Warning Devices
Where it is not possible to achieve sufficiently low risk through the application of design and safety devices, warning devices are used. Warnings include both visual and audible devices that alert persons of a possible hazard condition, i.e. an approaching train.

Rules, Procedures and Training
Where it is not possible to achieve sufficiently low risk through design, or adequately manage risk through the use of safety or warning devices, appropriate safety and control procedures and training (including educational campaigns) are developed and implemented to reduce the hazard to the lowest practicable level.

The Caltrain 2025 program includes a vehicle replacement program and PTC system (provided through CBOSS) which, by design, provide features that mitigate/avoid a variety of hazard conditions. The combination of the PTC system, the Systemwide Grade Crossing Improvement Program, existing mitigation measures, and the additional measures identified through the PHA, will help to reduce risks to the lowest level possible for a number of hazard conditions. The additional proposed measures identified by the PHA, include crossing photo enforcement and increased public awareness training.

4.3.3.3 Systemwide Grade Crossing Improvement Program

In addition to PTC and the mitigation measures identified through the PHA analysis, Caltrain has an active grade crossing improvement program in San Mateo [Reference 5-1] and Santa Clara [Reference 5-2] Counties. The program includes the review and evaluation of all forms of traffic, local conditions and current mitigation at Caltrain's existing at-grade crossings to demonstrate the level of safety improvements attainable at each crossing. Although requests for quiet zones are not sought by Caltrain within the operating corridor, the Quiet Zone Analysis methodology is being used to review and evaluate crossing improvements.

Key features of the program include:

- Pedestrian Improvements
  - New or repositioning of existing pedestrian back gates with tip lights
  - Pedestrian push gates in conjunction with pedestrian gates
  - Guardrails at pedestrian crossings
  - Detectable warning (tactile strips) on all sidewalk approaches
  - ROW fencing to channel pedestrian traffic
- Motor Vehicle Improvements
  - New roadway gate assemblies
  - Median barriers
  - Pavement markings
  - Crossing panels
  - New or modified traffic pre-emption circuitry based on traffic analysis
  - New or relocation of existing roadway gate assemblies
  - Replace incandescent light units with 12 inch LED assemblies, 24" hoods.
  - Quad gates

The improvements given in the Systemwide Grade Crossing Improvement Program [Reference 5] serve as mitigation measures for many of the grade crossing hazards presented in the PHA scenarios A through F. The Systemwide Grade Crossing Improvement Program will continue as two separate efforts. First, Caltrain will carry out the San Mateo and Santa Clara County programs and address any other specific grade crossing hazards that may be identified over the short term. As a long term effort, Caltrain will continue planning and advanced engineering to carry out the final grade crossing improvement program directed specifically at operating EMUs in a shared use environment. These improvements will only be feasible when funded as part of the electrification program.

4.4 Hazard Analysis Summary

The following are summaries of the hazard scenarios and the initial and residual HRIs. In addition, mitigation options for each type of scenario are provided. See Table 4-6 for a summary of residual HRIs for all hazard scenarios.

While the vehicle analysis that Caltrain conducted for this waiver petition involved several European carbuilders that provided data for the analysis, Caltrain does not intend to preclude other carbuilders from participating in the future procurement of its EMU rolling stock.

4.4.1 Grade Crossings

The PHA hazard analysis evaluated hazardous conditions for EMU and EMU occupants, as well as for the motor vehicle and motor vehicle occupant(s), for the following grade crossing scenarios:

A. EMU collision with auto driving around crossing gate
B. EMU collision with highway truck driving around crossing gate
C. EMU collision with pedestrian at grade crossing
  a) Pedestrian ignores warning devices
  b) Crossing gate or other mechanisms do not impede pedestrian travel
  c) Pedestrian stands within dynamic envelope of passing train
D. EMU collision with auto at non-gated maintenance of way crossing
  a) Gate or other barrier not provided
  b) Maintenance of way crew fails to request permission to enter right of way
E. EMU collision with auto fouling tracks at gated grade crossing
  a) Auto stops on tracks due to traffic back-up from adjacent intersection controlled by traffic signals
  b) Auto stops on tracks due to traffic back-up from adjacent intersection controlled by stop sign
  c) Auto stops on tracks due to construction activity ahead
  d) Auto fails to stop at stop bar and front end fouls tracks
  e) Auto stalls or is stuck on tracks
  f) Abandoned auto on tracks
  g) While in grade crossing, the motorist midjudges turn into parallel roadway and enters right of way
F. EMU collision with highway truck fouling tracks at gated grade crossing
  a) Truck stops on tracks due to traffic back-up from adjacent intersection controlled by traffic signals
  b) Truck stops on tracks due to traffic back-up from adjacent intersection controlled by stop sign
  c) Truck stops on tracks due to construction activity ahead
  d) Truck fails to stop at stop bar and front end fouls tracks
  e) Truck stalls or is stuck on tracks
  f) Abandoned truck on tracks
  g) While in grade crossing, the motorist midjudges turn into parallel roadway and enters right of way

A review of Caltrain's accident history shows grade crossing collisions to be the most prevalent type of accident. Table 4-5 contains mishap data that is available from the FRA Office of Safety web site [Reference 13] which illustrates the frequency of grade crossing collision occurrences at Caltrain between the time periods of 2000 to 2008. The table provides information on pedestrian and vehicular collisions, as well as collisions that occurred at grade crossings located on private property.

Table 4-5 - Caltrain Grade Crossing Collisions by Year

Collision Type	Number of Collisions by Year								
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Pedestrian	1	4	1	1	1	0	4	3	4
Vehicular	3	2	0	5	3	2	7	4	4
Private	0	0	1	0	0	0	1	0	0

The table shows that the frequency of occurrence for grade crossing vehicle collisions is significantly less than one per month though not less than one per year. If the historic mishap data is used to determine the probability of collisions occurring, the resulting mishap probability would be "remote". However, it should be recognized that the hazard could occur more often than actual mishaps occur. Therefore, "hazard probability" is used to assign more conservative probabilities to these scenarios. For grade crossings, a conservative hazard probability of at least one per month was used for the analysis which results in the probability category "occasional" for the baseline frequency.

The severities of collisions in the grade crossing hazard scenarios vary depending on whether the collision involves a pedestrian or a vehicle. However, the collision analyses performed by the Volpe Center [Reference 14], which analyzed both EMU and FRA-compliant rail passenger vehicles, showed that the outcome to the train/passengers in a collision with a highway truck were identical for both rail vehicle types. The Caltrain team analysis, described in the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4], showed that the probability and severity of an incident was found to be consistent for each type of rail vehicle and for rail passengers and train crews. The probability rating of "marginal" was given for all train speeds and grade crossing collision types.

Although the probability of grade crossing incidents and outcome severity are the same for EMUs and FRA-compliant vehicles, Caltrain is still committed to improving grade crossing safety through the Systemwide Grade Crossing Improvement Program, irrespective of whether Caltrain operates EMUs. The Systemwide Grade Crossing Improvement Program, coupled with CBOSS and the additional mitigation measures identified in the PHA, which will be implemented to the extent practicable, will further reduce the probability of a grade crossing incident and contribute to a safer environment and therefore an improvement of the HRI.

Mitigation measures for PHA Scenarios A through F:

- Systemwide Grade Crossing Improvement Program (implemented to the extent practicable determined on a crossing by crossing basis)
- Additional measures identified by PHA (implemented to the extent practicable determined on a crossing by crossing basis) include, but are not limited to, the following:
    - Increased education
    - Increased human enforcement

- o Coordination of traffic control devices

4.4.2 EMU Collision with Freight Cargo

In a mixed-traffic operating environment, Caltrain passenger trains will be temporally separated from freight trains on most of the corridor, preventing them from sharing track. This is especially important in the South Terminal Area where freight will continue to share an operating corridor (parallel tracks) with passenger trains, possibly during peak hours. (For more information on temporal separation, see Chapter 3.) Therefore, the following scenario was examined to look at collisions with freight cargo:

G. EMU in shared corridor strikes freight cargo that has dislodged
   a) Freight shifts while in transport and encroaches the dynamic envelope of EMU on adjacent track
   b) Freight shifts while in transport and falls into path of EMU on adjacent track

The initial HRI for this scenario is 21. The probability of train collisions with obstructing cargo is "remote," with intervals greater than one year between incidents in the Caltrain corridor according to data found in the TransitSafe database. Collisions of this type typically result in "marginal" consequences to a rail vehicle, as indicated by the train-auto collision outcomes, if a large enough piece of debris lands on the tracks. Additionally, vehicle side strength requirements, mandated by the FRA and met by the EMU (required in the technical specification for procurement), are intended to protect passengers from side impacts of this nature.

As a mitigation measure, the installation of oversized or shifted load sensing devices at points prior to entry into the shared corridor is an available option to mitigate this hazard condition by identifying intrusion in order to intervene to avoid the incident and service disruption costs. Upon detection of oversized or improperly fixed lading, an alarm is provided alerting the dispatcher of the possible need to intervene. This mitigation would reduce the probability of this hazard occurring from "remote" to "improbable." The residual HRI would therefore be 22.

Mitigation measures to be implemented for PHA Scenario G:

- Temporal separation between EMU and freight train operations
- Installation of presence sensing devices at strategic locations along the ROW (implemented to the extent practicable and on a case-by-case basis)

4.4.3 EMU Collision with FRA-Compliant Train

Caltrain examined the hazard scenario for an EMU collision with an FRA-compliant train operating in mixed traffic. For the hazard analysis, Caltrain performed a PHA for the following collision scenario:

H. EMU collision with FRA-compliant locomotive due to train engineer inattention

A probability rating of "improbable" was used. Although Caltrain has never experienced a train-to-train collision of any type and FRA data also indicates a low frequency for train-to-train collisions, this hazard still exists and therefore cannot be rated as "design resolved". Catastrophic outcomes result when collisions occur at elevated speed, and the recently enacted Rail Safety Improvement Act requires the implementation of PTC to eliminate many common failures that result in accidents. If CBOSS/PTC should become temporarily unavailable, alarms will be produced by the cab equipment advising each affected train operator of the condition along with an alarm for the train dispatcher. The highly reliable PTC system practically eliminates human error-related hazard conditions and dramatically reduces the already low block signal and manual operating risk by substantially limiting the time that these contingency modes of operation are used. During detailed CBOSS design, contingency operating modes will be evaluated to determine the associated levels of risk and need for any specific additional mitigation.

Since CBOSS provides automatic intervention to protect against collision occurrences at normal running speeds and limits train speed to 20 mph while in the Restricted Manual mode, this scenario was analyzed assuming a traveling speed of 20 mph. Outcome data for all EMU collisions was based on a combination of analyses performed by car builders and the Caltrain team [Reference 4]. The outcome data for the FRA-compliant collisions was extracted from analyses performed by the Volpe Center [Reference 15], and only a qualitative assessment can be made. As a comparative measure, the analysis looked at the following train-to-train collision combinations:

- 8-Car EMU to 8-Car EMU
- 8-Car EMU to 5-Car FRA-Compliant (EMU cab impacting the locomotive)
- 5-Car FRA-Compliant to 5-Car FRA-Compliant (cab car impacting the locomotive)

In general, the analyses indicate that the passenger-occupied volumes for all vehicles would remain intact following a collision at a 20 mph closing speed. In all cases but one, which was for the FRA-compliant cab car, adequate space in the cab would be maintained, protecting the operator. Differences between the cab car used in the Volpe analysis and Caltrain's cab cars would indicate that the speed at which the cab occupied volume would be compromised would be somewhere between 15 mph and 20 mph, with the bi-level cab cars in Caltrain's fleet likely being closer to 20 mph, as other Volpe tests indicate that the bi-level has a higher crush resistance than the single level car used in their train-to-train collision analysis [Reference 16]. Given these factors, an outcome of "serious" was assigned to this case, indicating major damage to the vehicles, minor and possibly a few major injuries, and preservation of occupied spaces.

The combination of an "improbable" probability and a "serious" outcome yields an initial HRI of 20. Given the results are identical for all train technologies, it can be concluded that train type is not relevant to the train-to-train collision scenario. Furthermore, no practicable mitigation measure exists for the very small percentage of time that the trains would not be under the full control of CBOSS. In addition, CBOSS provides a speed governor that caps operating speed to 20 mph when trains are operating in manual mode. The speed governor will safeguard against catastrophic consequences during most common operating scenarios, but cannot eliminate some failure conditions. Reducing the Restricted Speed would severely impact operations and only offer a negligible improvement in the outcome, i.e. the residual HRI would increase to 22. Restricted Speed will therefore remain at 20 MPH. Nevertheless, Caltrain is committed to implementing a PTC system as the primary mitigation measure, irrespective of the similarity in crashworthiness between EMU and FRA-compliant technology.

Mitigation measures to be implemented for PHA Scenario H:

- CBOSS speed governor: speed restricted to 20 mph when in manual mode.

4.4.4 Collision with Flat Immoveable Object

Caltrain examined the hazard scenario for a post-derailment collision, in which the train was considered to collide with a bridge abutment or some other immovable object. Derailments may occur as a result of:

I. EMU collision with flat immovable object
   a) Collision with another EMU or FRA-compliant vehicle
   b) Track in poor repair
   c) EMU in poor repair
   d) Rail vehicle overspeed

It should be noted that collisions with a flat immoveable object have not occurred at any time during Caltrain's operating history. The review of accident history data found that collisions with a flat immovable object were highly remote, given Caltrain's operating history. Regardless, the hazard still exists. This scenario was examined due to the potential for catastrophic outcomes and a probability rating of "improbable" was given. Caltrain currently has highly effective, robust, and aggressive track and rail vehicle inspection and maintenance programs. The introduction of CBOSS with its continuous speed enforcement, positive train stop, roadway working protection and end of track close-in enforcement capabilities will further reduce the probability of collisions, including those involving flat immoveable objects, from highly remote to a level that approaches Design Resolved.

This PHA scenario assumes an EMU collision at 10 mph. At speeds below 10 mph, the outcome would be "serious" and at speeds in the 10 to 12 mph range, the outcome would be "critical" quickly transitioning to "catastrophic" at speeds above 12 mph. As with the other impact scenarios, outcome is not a function of vehicle type. Both the EMU and the FRA-compliant trains perform similarly. Thus, the hazard exists independent of the introduction of EMUs into the Caltrain system.

While protection against collisions involving flat immoveable objects is not one of the key reasons that PTC is being employed, PTC provides positive protection against a number of hazard conditions that significantly reduce the occurrence of collisions and derailments at elevated speeds which could otherwise lead to collisions with immoveable objects.

The fixed nature of the immoveable object results in unacceptable consequences, even at lower impact speeds such that Caltrain's risk management philosophy demands that mitigation options be sought. The CBOSS technical requirements specification includes provisions that mandate enforced train movement to the end of track, i.e. bump post or track buffer, and enforcement of Restricted Speed. Experience demonstrates that train accidents are somewhat more likely to arise during non-signaled manual operating conditions. The enforcement of Restricted Speed is set to ensure that the severity of mishaps is kept to an acceptably low rating and CBOSS enforcement provides added assurance that the train cannot be operated at elevated speed. It should be noted that in any operating circumstance a train end collision with an immoveable object is a secondary event that follows the train having left the track. At Restricted Speed or below, trains can be expected to rapidly reduce speed such that an impact with an immoveable object results in impact speed that is substantially lower than the track speed.

Unfortunately, a design solution that completely avoids the risk of derailment is not possible and hazard mitigation is not available. Therefore an improvement in residual HRI is not available for this option. The continuation of existing mitigation measures currently utilized is therefore recommended.

Mitigation measures to be implemented for PHA Scenario I:

- None available to reduce severity or probability
- Continue use of existing mitigation measures

4.4.5 Collision With A Derailed Train

During the PHA, Caltrain identified a number of spontaneous failures and conditions that can occur and which cannot be completely mitigated by increased inspection or testing. Seismic events are known to occur within the Caltrain operating environment. Rail breaks and mechanical vehicle failures are also known to occur during train movement or between scheduled inspections. These can cause derailment and result in train collisions where the derailed train fouls the track of an oncoming train and be vulnerable to further damage when struck. Therefore the following hazard scenario was analyzed for the PHA:

J. EMU collision with object (derailed train)
   a) Track in poor repair
   b) EMU in poor repair
   c) Earthquake
   d) Bridge displacement (due to strike, earthquake)
   e) Adjacent railroad derailment
   f) Rail vehicle overspeed

Caltrain has instituted increased inspection and seismic sensors to identify and mitigate risks resulting from these conditions. The addition of PTC and its ability to provide continuous cab signal information will marginally reduce derailment and secondary collision risk. Therefore a probability rating of “improbable” is given.

When a derailed train fouls the track of an approaching train that is unable to stop, a “catastrophic” result is expected regardless of the types of trains that are involved in the collision. Marginal benefits may be realized in certain collision scenarios of this type by trains that incorporate CEM technology due to their superior potential for energy absorption when colliding with an irregular deformable body (derailed train).

Mitigation measures are not available to reduce the severity of collisions with a derailed train as accident consequences are expected to be “catastrophic” for EMU and FRA-compliant trains in this scenario at relatively low impact speeds. The benefits of introducing mitigation to reduce hazard probability are limited since the hazard is classified as “improbable” and the benefits gained would me minimal. However, the availability of temporal separation, which Caltrain has committed to provide, will provide some reduction in probability.

Mitigation measures to be implemented for PHA Scenario J:

- Temporal separation between EMU and freight train operations
- None available to reduce severity

4.4.6 Summary of Residual HRIs

Table 4-6 provides a summary of the Residual HRIs for each of the hazard scenarios that were analyzed. In the scenarios where an EMU collides with an automobile fouling the tracks and with a truck fouling the tracks, varying causes result in a range of residual HRIs. The lowest of these HRIs are due to the lack of practicable means to mitigate circumstances such as automobiles or trucks stalling on the tracks, or automobiles failing to stop at the stop bar.

Table 4-6 - Summary of Residual Hazard Risk Indices by Scenario

PHA #	Hazard Scenario	Probability	Severity	Residual HRI
	Grade Crossing Collisions			
A	EMU Collision with Automobile (Auto & Occupants)	Remote	Critical	13
A	EMU Collision with Automobile (Train & Occupants)	Remote	Marginal	21
B	EMU Collision with Truck (Truck & Occupants)	Remote	Critical	16
B	EMU Collision with Truck (Train & Occupants)	Remote	Serious	20
C	EMU Collision with Pedestrian (Pedestrian)	Remote	Critical	13
C	EMU Collision with Pedestrian (Train & Occupants)	Remote	Negligible	24
D	EMU Collision with Automobile at Non-Gated Crossing (Auto & Occupants)	Improbable	Critical	16
D	EMU Collision with Automobile at Non-Gated Crossing (Train & Occupants)	Improbable	Marginal	22
E	EMU Collision with Automobile Fouling Tracks (Auto & Occupants)	Varies by Cause		7-13
E	EMU Collision with Automobile Fouling Tracks (Train & Occupants)	Varies by Cause		18-21
F	EMU Collision with Truck Fouling Tracks (Truck & Occupants)	Improbable	Critical	16
F	EMU Collision with Truck Fouling Tracks (Train & Occupants)	Remote	Serious	20
	Train Collides with Freight Cargo			
G	EMU in shared corridor strikes freight cargo that has dislodged	Remote	Marginal	22
	Train-to-Train Collisions			
H	EMU Collision with FRA-Compliant Locomotive	Improbable	Marginal	22
	Train-to-Immovable Object Collisions			
I	EMU Collision with Flat Immoveable Object	Remote	Serious	20
J	EMU Collision with Object (Derailed Train)	Improbable	Catastrophic	14

In all scenarios but one, the Residual HRI is either Acceptable (19-25) and does not require formal review or is Low (12-18) and is considered acceptable with formal review. The one exception is the scenario where an EMU collides with an automobile fouling the tracks because the motorist fails to stop at the stop bar, yielding an HRI of 7 for the motorist/automobile and an HRI 18 for the EMU and its occupants. For this scenario, the result would be identical if the train were an FRA-compliant vehicle.

4.5 Conclusion

In summary, the use of the Caltrain-defined EMU in the corridor in combination with PTC, grade crossing improvements, and temporal separation from freight does not increase risk as compared to that of FRA-compliant vehicles. The analyses performed by Caltrain and the Volpe Center demonstrated that in the Caltrain electrified environment, CEM reduces the severity of the outcome to the point where the collision damage estimates are similar for the EMU and the FRA-compliant vehicle. In addition, Caltrain is committed to implementing the following mitigation measures along the ROW to the extent practicable to provide for a safer operating environment, irrespective of whether Caltrain operates EMUs.

- Continuing implementation of the Systemwide Grade Crossing Improvement Program
- Installation of CBOSS, which includes PTC and a speed governor for manual operations
- Operating with temporal separation between freight and EMU vehicles
- Proactive rolling stock and infrastructure maintenance
- Continuation of a Systemwide Hazard Analysis Program

The PHA process also identified of a number of opportunities that will further mitigate hazard conditions. Caltrain is committed to implementing the following mitigation measures to the extent practicable.

- Freight cargo intrusion detection
- Grade crossing safety improvements beyond the Systemwide Grade Crossing Improvement Program, including but not limited to:
    - Increased education on grade crossing safety
    - Human and photo enforcement at grade crossings
    - Coordinating traffic control signal upgrades with local jurisdictions
    - Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity

The combination of PTC, CEM, and the above Caltrain committed mitigations reduces risks and enhances safety by providing for a safer operating environment for all vehicle technologies.

5 REGULATORY COMPLIANCE WITH TITLE 49, CODE OF FEDERAL REGULATIONS

Caltrain is proposing to operate multi-level EMU technology, built to European Norms EN 16223 and EN 15227 structural and crashworthiness standards, in mixed-traffic with FRA-compliant locomotive-hauled commuter trains, and with temporal separation from freight trains. As the European standards differ from the FRA regulations that all U.S. rail operators must comply with, Caltrain performed a Code of Federal Regulations Compliance Assessment of Title 49, parts 38 and 200-299, pertinent to operating a non-compliant vehicle, to identify the sections of Title 49 that the EMU, as currently constructed, would not comply with [Reference 8]. The results of the CFR Compliance Assessment were then analyzed in combination with the PHA and risk management activities to identify regulations that are met by the current design, regulations that could be met with practicable design changes, and regulations where compliance is not feasible, but where risk could be satisfactorily mitigated. Based on the analysis, Caltrain intends to petition the FRA for waivers from the following regulations:

- 49 CFR 238.203 Static End Strength
- 49 CFR 238.205 Anti-Climbing Mechanism
- 49 CFR 238.207 Link Between Coupling Mechanism and Carbody
- 49 CFR 238.211 Collision Posts
- 49 CFR 238.213 Corner Posts

Table 5-1 provides a summary of which CFR Title 49 parts, sections, and paragraphs that will require design changes, which are currently deemed impracticable and will require a waiver, for which compliance will be mandated in the vehicle specifications, and which require further study by the carbuilders to determine whether design changes are feasible, and if not, how any risk associated with noncompliance might be mitigated.

The following sections provide an overview of the CFR Compliance Assessment process, summaries of the CFR Title 49 Part 238 sections for which a waiver will be requested, and the CFR Title 49 sections where compliance will be met via modifications to either the vehicle or operations. Additional details on Caltrain compliance with the CFR Title 49 parts and sections, including descriptions of parts where Caltrain is fully compliant, can be found *Caltrain 2025 European EMU CFR Compliance Assessment Report* [Reference 8]. Further justification for the five waiver items can also be found in the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4].

Table 5-1 CFR Compliance Assessment Summary

Sub-section	Title/Description	Requires Further Analysis	Intend to Request Waiver	Intend to Specify CFR Compliance	Design Change Anticipated	Comments
49CFR38	**Americans with Diasabilities Act (ADA)**					
49CFR38 Subpart E	Commuter rail cars and systems			x	x	Current design is not fully compliant but compliance will be specified.
49CFR223	**Safety Glazing Standards**					
Appendix A	Certification of glazing materials			x	x	Current side glazings do not comply, but compliance will be specified.
49CFR229	**Railroad Locomotive Safety Standards**					
229.51	Aluminum main reservoirs			x	x	Current design is not built to ASME code, but compliance will be specified.
229.125	Headlights and Auxiliary Lights			x	x	Current design may meet requirements for triangular pattern. Candlepower unknown.
229.141	Body Structure, MU Locomotives			NA		Interpereted as not applicable. Identical requirements addressed in 49 CFR 238 for EMUs and Cab Cars
49CFR231	**Railroad Safety Appliance Standards**					
231.14	Passenger-train cars without end platforms			x	x	Current design does not fully meet requirements for handbrake, sill steps, handholds, handrails, side door steps, uncoupling levers. However, compliance should be feasible.
49CFR236	**Signal and Train Control Systems**					
236	Signal and Train Control Systems			x	x	Onboard equipment must comply with the forthcoming requirements for positive train control and must be compatible with Caltrain CBOSS specification.
49CFR238	**Passenger Equipment Safety Standards**					
238.103	Fire Safety	x		x	x	LTK is preparing a comparison of standards. Caltrain intends to meet with FRA separately on this issue. Biggest challenge may be floor burn-through requirement.
238.105	Train electronic hardware and software safety			x		Specification will require FMECA
238.113	Emergency window exits			x	x	Caltrain will specify compliance with emergency exit window placement, dimension, and marking requirements.
238.114	Rescue access windows			x	x	Caltrain will specify compliance with emergency access window placement, dimension, and marking requirements.
238.115	Emergency lighting			x	x	Caltrain will specify compliance with emergency lighting requirements.
238.121	Emergency communication			x	x	Likely that current backup power system does not comply.
238.123	Emergency Roof Access			x	x	May require relocating wiring or other elements to clear away soft spot in roof.
238.201	Scope/alternative compliance			NA		This method of alternative compliance will not be used, due to CFR-mandated operational restrictions.
238.203	Static end strength		**x**			800,000 pound buff strength will not be required in specification
238.205	Anti-climbing mechanism		**x**			Current CEM design is not compatible with this requirement, but equivalent safety can be demonstrated.
238.207	Link between coupling mechanism and car body		**x**			Current CEM design is not compatible with this requirement, but equivalent safety can be demonstrated.

Caltrain current and future operation complies with all CFR parts, sub-parts, and paragraphs not listed in this summary table

Table 5-1 CFR Compliance Assessment Summary (continued)

Sub-section	Title/Description	Requires Further Analysis	Intend to Request Waiver	Intend to Specify CFR Compliance	Design Change Anticipated	Comments
238.209	Forward-facing end structure of locomotives			x	x	Current design may not have skin strength equivalent to 25,000 psi yield 1/2" steel, but design modifications should be practicable.
238.211	Collision posts		**x**			Will specify compliance via new 238 Appendix F if released in time, otherwise equivalent safety will be demonstrated. Intermediate collision post requirement met through alternative means.
238.213	Corner posts		**x**			Will specify compliance via new 238 Appendix F. Need to analyze corner post at intermediate connections.
238.215	Rollover strength	x		x		Initial analyses indicate that current designs should meet requirement without modification. Compliance will be specified. Additional analysis will be required to determine if minor design changes are needed.
238.217	Side structure	x		x		Initial analyses indicate that current designs should meet requirement without modification. Compliance will be specified. Additional analysis will be required to determine if minor design changes are needed.
238.219	Truck-to-car body attachments			x	x	Current design does not comply but minor modifications can be made to comply.
238.221	Glazing			x	x	Compliance will be specified.
238.225	Electrical system			x		Compliance with US EMI requirements will be specified.
238.229	Safety appliances - general			x	x	Current design does not comply but minor modifications can be made to comply.
238.230	Safety appliances - new equipment			x	x	Current design does not comply but minor modifications can be made to comply.
238.231	Brake system			x	x	Compliance will be specified and may be achieved through a combination of design and inspection practice (pit).
238.233	Interior fittings and surfaces			x	x	Current design will not meet strength requirements for seats, and other interior fittings, but modifications are feasible, so compliance will be specified.
238.235	Doors			x	x	Compliance will be specified, knowing that minor modifications will likely be required to meet door emergency release requirements
238.301	Scope			x		Inspection, testing and maintenace for Tier 1 Passenger Equipment
238.307	Periodic mechanical inspection of passenger cars and unpowered vehicles used in passenger trains		x			Intend to propose inspection practices based on criteria other than specified time intervals in a separate waiver petition
238.309	Periodic brake equipment maintenance		x			Intend to propose maintenance practices based on criteria other than specified time intervals in a separate waiver petition
238.311	Single car test			x		Compliance will be specified as applicable to the vehicle design
49CFR239	**Passenger Train Emergency Preparedness**					
239.107	Emergency Exits			x	x	Caltrain will specify compliance with emergency access and egress window placement, dimension, and marking requirements.

Caltrain current and future operation complies with all CFR parts, sub-parts, and paragraphs not listed in this summary table
Any waiver to 238.307 and 309 would be sought later, after proving safety of alternate maintenance and inspection standards

5.1 CFR Compliance Assessment Process

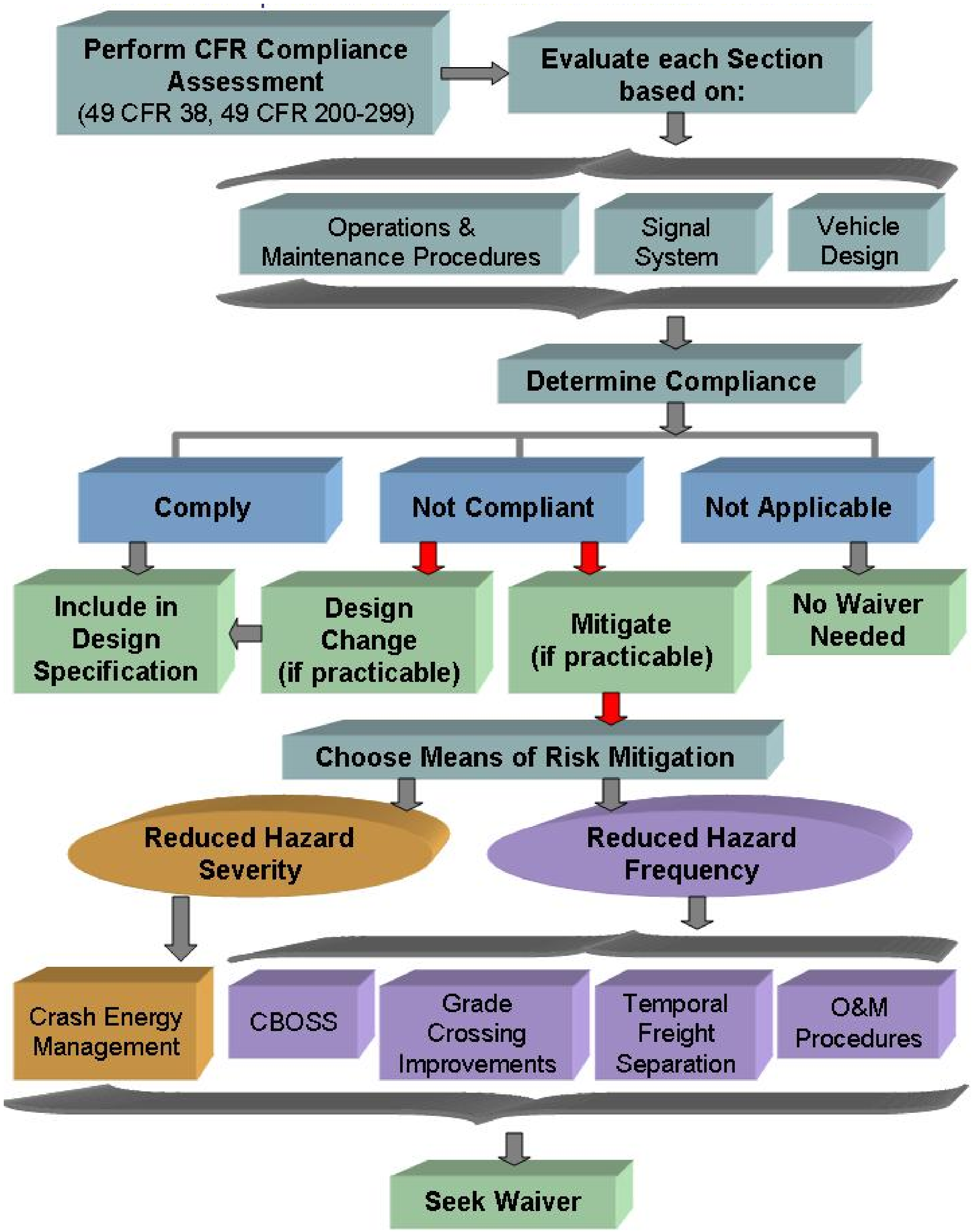
The Caltrain 2025 program proposes operation of non-FRA-compliant EMU technology in revenue service, mixed with FRA-compliant locomotive-hauled commuter trains, and temporal separation from freight trains. Since the EMUs available on the current market that meet Caltrain's operating requirements are designed to EN 15227 and EN 12663 standards, it was necessary to conduct a CFR Compliance Assessment to determine if the EMU vehicle design can comply with FRA requirements as applied to rail vehicles (49 CFR Parts 38 and 200-299).

A consistent process was utilized for analyzing the EMU vehicle for each section under Parts 38 and 200-299. A flow chart of the assessment process is provided in Figure 5-1. Each section was evaluated based on the vehicle design for several candidate European double deck EMUs (designed to EN 15227 and EN 12663), the operations for the electrified environment and maintenance procedures, and the CBOSS signal system. For parts and sections for which the EMU vehicle or operation is fully compliant without design modifications, a waiver is not required and the regulation requirements will be included in the final vehicle design specification. Waivers are also not required for those regulations that are not applicable to or affected by operating non-FRA-compliant technology.

For those sections where the EMU is not compliant as originally designed, additional analyses were performed to determine the extent and practicability of changes to the vehicle to achieve compliance. If the regulations could be met with practicable design changes, compliance with these sections will be mandated in the final vehicle design specification.

If design modifications to meet a given regulation were deemed not practicable, the system-level PHA was examined to determine if options were available to mitigate any risk associated with noncompliance through the reduction of severity and/or frequency of hazards. If adequate mitigation was available, then a waiver was requested.

Figure 5-1 CFR Compliance Assessment Process Flow Chart



5.2 Compliance via Modifications

As part of the CFR Compliance Assessment process, EMU manufacturers analyzed the CFR requirements to determine whether design modifications were a practicable means of meeting the regulations. For a majority of the applicable regulations, design modifications were deemed practicable. The final vehicle design specification will therefore require that the EMU manufacturers meet these regulations. See Table 5-1 for a list of these regulations by subsection. Additional descriptions for each subsection are provided in the *Caltrain 2025 European EMU CFR Compliance Assessment Report* [Reference 8].

5.3 Waivers Requested – 49 CFR Part 238 Only

Upon completing the CFR Compliance Assessment, it was determined that compliance with only five sections, all from 49 CFR Part 238, cannot be met due to impracticability of design modifications. Therefore, Caltrain is petitioning the FRA for waivers for the following five regulations:

- 49 CFR 238.203 Static End Strength
- 49 CFR 238.205 Anti-Climbing Mechanism
- 49 CFR 238.207 Link Between Coupling Mechanism and Carbody
- 49 CFR 238.211 Collision Posts
- 49 CFR 238.213 Corner Posts

Requesting waivers of these regulations is justified through demonstration that overall safety is not compromised through operation of this equipment on the Caltrain system. Safety is maintained, and even enhanced, via mitigation strategies integrated with equipment and operations that reduce the severity and frequency of possible hazardous situations. These mitigation strategies include CEM built into the EMU designs, grade crossing improvements, PTC provided by CBOSS, temporal separation of freight, and revised operating and maintenance procedures.

The following sections provide a brief summary of the mitigation strategies for each regulation for which a waiver is being requested.

5.3.1 49 CFR 238.203 Static End Strength

49 CFR 238.203 requires the car frame to resist an 800,000-pound compressive (buff) load on the line of draft, without permanent deformation. This requirement is directed mainly towards train-to-train crashworthiness. European EMUs are designed with CEM to specifically address collision scenarios that would otherwise result in a loss of occupied space. This level of design change would not be feasible for a small order, and to require compliance would result in no bids being received. Thus, it is necessary to mitigate any risk through other means.

Analyses performed by both the Caltrain team and the FRA/Volpe Center, as detailed in the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4], indicate that at speeds at or below 20 mph, the EN 15227-compliant EMU performs at least as well as an FRA-compliant cab car or coach in train-to-train collision scenarios. Above 20 mph, both designs suffer damage to the occupied space that would be unacceptable, making collision avoidance is very important. The use of a PTC system should greatly reduce the probability of higher speed collisions in which neither the EMU trains nor compliant equipment can prevent the loss of occupied space. These analyses demonstrate that the combination of EN 15227 compliance with CEM and a PTC system provided by CBOSS will reduce the probability of an impact and the severity of the outcome to the degree necessary to provide an improved level of safety over the current Caltrain operation.

The Caltrain EMU specification will require the vehicle manufacturer to prove the following to address the 800,000-pound buff strength requirement:

- EN12663 PII Compliance
- EN15227 CI Compliance with following specifics:
  - Train-to-train collision scenario with 8-car like trains (22.5 mph)
  - Truck impact speed 110 km/hr (69 mph)
- Additional train-to-train impact scenario
  - 8-car EMU at 20 mph impacts locomotive at the head of a stationary 5-car train
    - EN 15227 performance criteria for train-to-train collision apply with one exception. Strains in excess of 10 percent would be reviewed on a case-by-case basis.
- Minimum car body ultimate buff (buckling) strength of 1.3 million pounds
  - Maximum load resisted while buckling or crushing

5.3.2 49 CFR 238.205 Anti-Climbing Mechanism

49 CFR 238.205 requires the car to be equipped with an anti-climbing mechanism that can withstand a 100,000-pound uplift. This requirement is directed towards preventing override in a train-to-train impact. The CEM design utilizes many components and features specifically designed to prevent overriding or telescoping. Inherently, CEM designs are intended to serve the function of anti-climbers, and can be much more effective than anti-climbers mounted on a compliant car. This is because CEM is meant to control the way that the energy is absorbed on impact. Railcars of a more rigid design can override or bypass each other laterally if the anti-climbers fail to engage. However, it is likely that these individual CEM elements are not designed to withstand a 100,000-pound vertical force as required by this CFR section, and re-design may substantially complicate CEM implementation.

The Caltrain EMU specification will include the following requirements to address the 100,000-pound anti-climbing strength requirement:

- Show that during the train-to-train impact scenarios specified under waiver Section 5.3.1 above do not result in overriding or bypass at the impact interface (cab end) as well as at the intermediate connections within the train
- Provide calculations showing the vertical and horizontal strength of all elements acting to restrain the vehicles during such impacts

5.3.3 49 CFR 238.207 Link Between Coupling Mechanism and Carbody

49 CFR 238.207 requires the coupler carrier to withstand a 100,000-pound down force without yield. This requirement is also directed towards preventing override in a train-to-train impact. However, the CEM design requires that both the couplers and the intermediate drawbars be allowed to move longitudinally under a load that is large enough to begin activation of the energy absorbing elements. Some vertical motion of the shear-back coupler may be necessary under these conditions to allow the CEM system to be fully effective. As this CFR section does not allow yielding of the coupler carrier material, this requirement may interfere with the CEM design and is therefore not suggested as a practical design modification. In addition, the anti-climber characteristics demonstrated for 238.205 will provide an equal level of override prevention required by this regulation.

5.3.4 49 CFR 238.211 Collision Posts

Collision posts are required at both ends of every car body, per 49 CFR 238.211. This section is very prescriptive in that it provides the basic physical features of the posts and the static loads that it must react. Current European EMU designs do not meet this requirement, but analyses show that EN15227 compliant EMUs are equipped with an end structure that provides at least equal protection in frontal impacts, whether it is train-to-train or grade crossing train-to-truck.

The FRA is currently revising this section of the CFR and it is likely that the revision will include an alternate method of proving the cab-end collision post (and corner post) compliance. If the revision to the regulation is made, the EMU specification will require compliance via the alternate method, including verification of final design, and the waiver will not be required.

In the event that the expected revision to 49 CFR 238 is not released and a waiver is required, the Caltrain EMU specification will include the following requirements to address the cab-end collision post requirement:

- All items listed under Sections 5.3.1 – 5.3.3 of this document (49 CFR 238 sections 203, 205, and 207)
- Compliance with the FRA collision post “proxy object cart” impact requirement currently proposed for 49 CFR 238.205 Appendix F

49 CFR 238.211 requires collision posts at the rear of each car, or each end of a semi-permanently coupled multiple unit. However, paragraph 238.211(c) (1) states that collision posts may not be required if the articulated connection is equally capable of preventing disengagement and telescoping, and the FRA finds the argument persuasive. It is expected that the current EMU designs that combined anti-telescoping connections and CEM provide a convincing argument to the FRA. However, the specification will require the carbuilder to submit the final design to support that argument, showing:

- Compliance with all items listed under Section 5.3.1 – 5.3.3 of this document (49 CFR 238 sections 203, 205, and 207)
- Precisely how the drawbar and energy absorbing anticlimbers work to keep the two bodies at the intermediate connection safely connected as they come into contact with each other

5.3.5 49 CFR 238.213 Corner Posts

Corner posts are required at both ends of every car body, per 49 CFR 238.213. The same issues as noted for collision posts in Section 5.3.4 are applicable for corner posts. If the proposed revision to the regulation is made, the EMU specification will require compliance via this proxy object impact analysis, including verification of final design, and the waiver will not be required for the cab-end corner posts.

In the event a waiver is required, the Caltrain EMU specification will include the following requirements to address the cab-end corner post requirement:

- All items listed under Section 5.3.1 – 5.3.4 of this document (49 CFR 238 sections 203, 205, 207, and 211)
- Compliance with the FRA corner post “proxy object cart” impact requirement currently proposed for 49 CFR 238.205 Appendix F

No relief for rear corner posts is provided for drawbar-connected, partially articulated cars. It is not likely that the corner post at the intermediate connection of an existing European EMU is designed to meet the regulation, as EN12663 requires reaction of loads that are lower than 49 CFR 238.213 and only oriented in the longitudinal direction. As previously discussed, the intermediate car-to-car connections for EMUs are well controlled in a collision due to the drawbar connection and the controlled crushing of CEM elements, including those equipped with anti-climbing ribs. The ultimate result during a collision is a rigid frame protecting the passenger compartment, which is the objective of this requirement.

EN 12663 requires a corner post that can resist loads that do not equal 29 CFR 238.213 loads in location, orientation, or magnitude. The objective is the same: first, to provide resistance to raking loads above the vehicle floor, and second to provide some protection against overriding. The EMU relies on the drawbar connection and anti-climber/energy absorbers to provide the primary resistance to overriding, which justifies the lower design load for the corner post base, as discussed further in the *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor* [Reference 4]. Raking, caused by striking a piece of lading that might have gotten loose on a freight car on an adjacent track, is addressed via placement of over-dimensioned lading detectors at strategic locations.

Since a waiver for rear/intermediate corner posts is required, the Caltrain EMU specification will include the following requirements as mitigation:

- All items listed under Section 5.3.1 – 5.3.4 of this document (49 CFR 238 sections 203, 205, 207, and 211)
- Calculations showing the amount of deformation of the corner structure of the rail car when the static loads prescribed by 49 CFR 238.213 are applied does not compromise the occupied space

5.4 Recap of Caltrain Mitigations to Support Waiver Petition

Caltrain is petitioning the FRA for waivers for up to five regulations, depending on the outcome of proposed rulemaking. The following measures, as described in the sections above, are proposed to mitigate any risk of operating equipment under waiver:

Systemwide Measures

- PTC meeting FRA regulations currently under development
- Temporal separation of freight and passenger trains
- Continuous improvement of grade crossing protection systems
- Over-dimensioned lading detection in strategic locations

Rolling Stock Measures (by procurement specification)

- EN12663 PII Compliance
- EN15227 CI Compliance with following specifics:
  - Train-to-train collision scenario with 8-car like trains (22.5 mph)
  - Truck impact speed 110 km/hr (69 mph)
- Additional train-to-train impact scenario
  - 8-car EMU at 20 mph impacts locomotive at the head of a stationary 5-car train
    - EN 15227 performance criteria for train-to-train collision apply with one exception. Strains in excess of 10 percent would be reviewed on a case-by-case basis.
- Minimum car body ultimate buff (buckling) strength of 1.3 million pounds
  - Maximum load resisted while buckling or crushing
- Show that during the train-to-train impact scenarios specified under waiver Section 5.3.1 do not result in overriding or bypass at the impact interface (cab end) as well as at the intermediate connections within the train
- Provide calculations showing the vertical and horizontal strength of all elements acting to restrain the vehicles during such impacts
- Compliance with the FRA collision post “proxy object cart” impact requirement currently proposed for 49 CFR 238.205 Appendix F
- Calculations showing the amount of deformation of the corner structure of the rail car when the static loads prescribed by 49 CFR 238.213 are applied does not compromise the occupied space

LIST OF ABBREVIATIONS

ACE	Altamont Commuter Express
APTA	American Public Transportation Association
BART	Bay Area Rapid Transit
CBOSS	Communications Based Overlay Signal System
CCF	Central Control Facility
CEM	Crash energy management
CEMOF	Centralized Equipment Maintenance and Operations Facility
CFR	Code of Federal Regulations
CHSRA	California High Speed Rail Authority
CP	Control point
CPUC	California Public Utilities Commission
CTC	Centralized Traffic Control
DTX	Downtown Extension
EMU	Electric multiple unit
EN	European Norms
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HRI	Hazard risk index
HST	High-speed train
JPB	Joint Powers Board
MAS	Maximum allowable speed
MP	Milepost
MT	Main track
OCS	Overhead contact system
PHA	Preliminary Hazard Analysis
PTC	Positive train control
ROCS	Rail Operations Control System
ROW	Right of way
SamTrans	San Mateo County Transit District
SJD	San Jose Diridon
SOP	Standard operating procedure
TPPH	Trains per peak hour
TRA	Trackage Rights Agreement
UPRR	Union Pacific Railroad
VTA	Santa Clara Valley Transportation Authority

LIST OF REFERENCES

The following is a list of documents referenced in the Caltrain Waiver Petition to FRA to Operate Mixed Traffic on the Caltrain Corridor. All listed documents, except noted, are provided in full and are located after this List of References.

Those documents in bold font are provided in full and are located after this List of References.

[1] **Caltrain; *February 2009 Caltrain Annual Passenger Counts*; May 12, 2009**

[2] TRCP Report 130, *Shared Use of Railroad Infrastructure with Noncompliant Public Transit Rail Vehicles: A Practitioner's Guide*, Transportation Research Board, Washington, D.C., 2009, p. 76.

[3] **Caltrain; *CBOSS Technical Description*; May 1, 2009**

[4] **Caltrain; *Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor; December 1*, 2009**

[5] **Caltrain Systemwide Grade Crossing Improvement Program**

- [5-1] **San Mateo County Grade Crossings Improvement Program**
- [5-2] **Consolidated Safety Study for Caltrain in Santa Clara County (VTA)**

[6] **Caltrain Infrastructure List**

- [6-1] **Summary of Caltrain Infrastructure Assets**
- [6-2] **Vertical and Horizontal Clearances at Overpasses, Tunnels, RR through Truss Bridges, and Passenger Sheds/Canopies**

[7] **Caltrain; *Caltrain 2025 Preliminary Hazard Analysis Worksheets*; September 2009**

[8] **Caltrain; *Caltrain 2025 European EMU CFR Compliance Assessment Report*; December 1, 2009**

[9] FRA; *Collision Hazard Analysis Guide: Commuter and Intercity Passenger Rail Service*; October 2007

[10] United States Department of Defense; *Standard Practice for System Safety, MIL-STD-882*

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[16] Priante, Michelle; Single Car of Multi-level Equipment into Crash Wall, Volpe, October 23, 2007