

CALTRAIN'S PTC SOLUTION FOR 2015
CBOSS
(COMMUNICATIONS BASED OVERLAY SIGNAL SYSTEM)

SYSTEM DESCRIPTION

1. INTRODUCTION

This document provides the system level description of the Communications Based Overlay Signal System (CBOSS), Caltrain's passenger railroad Positive Train Control (PTC) solution. Caltrain's PTC Systems Engineering efforts commenced more than two years ago as part of Caltrain's 2025 program to dramatically expand the commuter services and performance while anticipating the needs of California High-Speed Rail that are now confirmed for the Caltrain corridor. More recently, these efforts have been extended to develop specific interoperability requirements as relate to the Union Pacific Railroad and other interoperating railroads so as to ensure that CBOSS equipped trains can operate in UP's PTC territory and vice versa.

CBOSS is a vital solution that provides safety features specifically mandated by the Railroad Safety Improvement Act of 2008 and the CFR for a PTC system. CBOSS specifies additional capabilities, beyond those found in current product offerings, to enable increased safety and operating performance responding to the demanding needs of Caltrain and the California High-Speed Rail Authority.

2. WHY CBOSS IS NEEDED?

CBOSS is needed to meet two specific criteria; the first is the federal mandate to implement PTC by 2015. The second is increased operating capacity; Caltrain needs to increase its capacity in response to unfulfilled and increasing customer service demands. Additional capacity needs have been raised with the decision to bring high-speed passenger rail services to San Francisco via the Caltrain corridor. The response to these needs includes conversion to electrified service and the introduction of higher performance trains. Caltrain already runs a mix of through- and local-passenger services. The future addition of high-speed trains (HST) on the corridor will necessitate greater capacity. Caltrain's wayside block signal system severely limits operational capacity in that it forces train separation based on the poorest performing type of train behaving in a worst case manner. The addition of HST service consumes capacity and limits the ability to expand commuter rail services, a problem that is addressed by CBOSS. Expanded capacity and operating margin are required both in the long and short terms, as are the safety enhancements, particularly during the construction activities needed to re-build Caltrain into an electrified high-speed railroad as CBOSS adds a positive means of protection for roadway workers.

3. KEY OPERATING NEEDS OF CALTRAIN

- Automatic Movement Authority Protection – positive and continuous enforcement ensuring that trains operate at or below safe speed limits for temporary and permanent conditions and to safeguard against unintended movement into restrictive areas,
- Protection of Roadway Workers – positive enforcement of train movement to prohibit unintended entrance into a work zone
- Improved Crossing Safety / Performance - minimize the environmental impact by providing positive control over crossing warning systems
- Efficient Running of Mixed Traffic, including High-Speed Trains – minimize the separation of trains to match the safe braking needs based on specific train type(s)
- Facilitate Precise Control of Train Speed – provide the facility to enable movements that are consistent with the train schedule to improve quality of service
- Enforce Scheduled Station Stopping – positive means of keeping near side crossing gates up, avoid missed stops, improving quality of service and reduces environmental impact

4. DETERMINING CBOSS REQUIREMENTS

In developing CBOSS, Caltrain has taken a formal Systems Engineering approach. Systems Engineering aims to ensure that operating needs and risks are comprehensively identified, enabling development of a solution that is capable of fully meeting the operating need through all phases of the product life cycle. Projected service demands, future HST operations and the electrified operating environment were all instrumental in framing Caltrain's needs.

a) PTC Alternatives Analysis

To investigate and identify viable products and technologies Caltrain performed an alternatives analysis. The PTC alternatives analysis confirmed that a radio-based overlay solution is the most promising technology. Although this technology is no longer cutting edge, the analysis also showed that current products, having been primarily developed primarily for freight operations, required further development to incorporate capabilities needed by Caltrain for its high-capacity, electrified operating environment and mixed traffic challenges.

b) Crossing Activation Alternatives Analysis

Electrification renders Caltrain's grade crossing activation equipment incompatible. To identify possible alternative solutions, Caltrain performed another alternatives analysis. This analysis showed that track based alternatives exhibit worse performance than the current installed technology,

and are significantly more complex and costly. The demonstrated success of incorporating crossing activation capability into a radio-based overlay PTC solution led to the incorporation of such requirements by Caltrain into its CBOSS requirements specification.

c) Requirements Analysis / Development

As part of the requirements identification process Caltrain elicited needs from CBOSS users and stakeholders to develop a comprehensive set of functional and performance requirements. The process included participation by the supply industry that provided confirmation that the draft requirements were sound and achievable.

d) Focus on Design Elimination of Hazard Conditions

Throughout the requirements development process the Systems Engineering team focuses on potential hazard conditions, many of which are linked to human failures associated with operation and maintenance of the product. Following classic risk management philosophy to, as a first priority, eliminate hazard conditions by design, the team worked to identify mitigation opportunities that eliminated or reduced the chances of mishaps. This focus led to the development of a number of provisions that identify capabilities that CBOSS will bring to extend the safety performance of Caltrain.

5. HAZARD ANALYSIS AND RISK MANAGEMENT INPUTS

a) Preliminary Hazard Analysis

Caltrain performed a Preliminary Hazard Analysis that included the participation of railroad operators, engineers and regulators in a virtual head-end ride along the railroad. Those participating identified hazard conditions and noted existing conditions as well as those that become present as Caltrain transitions to an electrified railroad. All hazard conditions identified during this activity have been added to Caltrain's hazard database so that risk mitigation opportunities can be evaluated. Some hazard conditions were deemed to be most appropriately mitigated by defining a CBOSS capability / requirement.

b) Collision Hazard Analysis

Caltrain expanded the definition of hazard conditions from those defined in the PHA with a focus on train collisions. Train collision scenarios were considered looking at highway crossings, train-end to train-end, and train to fixed object. Efforts were focused on the various specific hazard conditions known to give rise to mishaps. Some hazard conditions were deemed to be most appropriately mitigated by defining a CBOSS capability / requirement.

c) Systemwide Hazard Analysis

Caltrain's Hazard Analysis and Risk Management Program Plan requires that all phases of work incorporate processes enabling hazard conditions to be identified so that mitigation opportunities can be identified and employed. This Program Plan requirement extends to all aspects of Caltrain work and therefore into the CBOSS product development, application, maintenance and extension processes.

d) Product Hazard Analysis

For CBOSS, product development is needed as no supplier fully incorporates the specified requirements. CBOSS must be developed upon an existing and proven product to help minimize risk. CBOSS safety requirements mandate the use of standards based hazard analysis methods to help identify and minimize failure modes and the severity of impact that they cause.

e) Operations Hazard Analysis

Operations hazard analyses and reviews are conducted throughout a product's live cycle. The analyses start with the initial needs analysis where it is often a hazard condition or mishap event that provides the impetus. During the requirements development phase, operations inputs are essential to validate that the stated requirements clearly address the operating intent. Throughout the product development phase, reviews are conducted as the design takes form to further validate that the product correctly and adequately meets the operating need. Once the product is mature and the operations and maintenance documentation is finalized, training is undertaken and logistics support mechanisms put in place to effectively integrate. Each of the phases during development and implementation employ specialized methods to ensure that the operations and maintenance aspects of the product are properly in place to minimize associated risks.

f) Whole Life Risk Management

Caltrain has implemented a hazard analysis and risk management program to continuously identify, analyze, determine mitigation, and track the implementation of required mitigation. Potential hazard conditions can be identified by anyone at any time during the system or product life cycle prompting a review of the hazard condition and need for additional mitigation.

6. SUMMARY DESCRIPTION OF CBOSS REQUIREMENTS

CBOSS requirements have been developed to enable Caltrain to meet its needs for a safe and high-performance train control solution for its passenger operating service. These requirements were developed to complement capabilities already being advanced by a number of different suppliers of radio-based PTC. CBOSS will provide an alternative control interface for the passenger train Engineer and introduces a relatively small set of additional capabilities over and above that of PTC specifically aimed at passenger rail operating needs.

a) Core Safety Functions

- Continuous Over-speed Protection – CBOSS employs tailored speed enforcement based on individual train type(s)
- Limit of Movement Authority Enforcement (prevention of overrun of red signals) – CBOSS employs an overrun safety buffer that can be tailored to each train type allowing speed reduction that is tailored for each train type
- Work Zone Incursion Protection – CBOSS employs positive intrusion enforcement and EIC authorization for train movements into and through the work zone on a train by train basis
- Mandatory Directives Enforcement – CBOSS interfaces with the Rail Operations Control System to provide positive enforcement for all form based mandatory directives
- Capitalize on existing wayside signals, rules and training for fall-back contingency operations (minimize new/changed rules) – CBOSS overlays the existing wayside signal system substantially preserving; operator training, rules and safety assurance processes for safe and efficient contingency operations

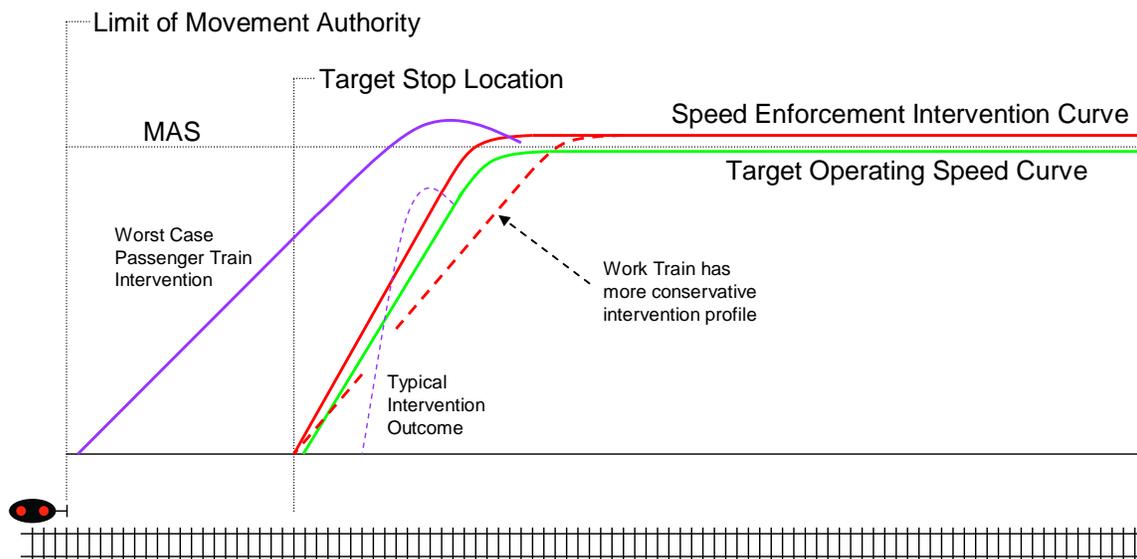


Figure 1 – Tailored Speed Control / Intervention Curves

b) Extended Safety Functions

- Enforcement of Near Side Station Stops –allows crossings to remain open for vehicular traffic longer, reducing gate violations and environmental impact
- True Constant Warning Time of Crossings – builds confidence that an active crossing warning system means the train will soon pass, reducing gate violations
- Train Specific Target Speed Enforcement & Safety Overlap – allows early intervention if expected performance is not achieved
- Detection of Train Performance-Input Data Violation or Error – monitoring of train performance during intervention provides confirmation that the conditions do not exceed those allowed for in the defined worst case train model or that system input data is valid
- Close-in Movement Enforcement – allows CBOSS trains to close-in on movement limits with supervision where a specific operating need exists (limited visibility areas, stub end terminal tracks, etc.)
- Employee In Charge Wireless Hand-held Terminal – allows the EIC in the field to exercise supervised enforcement of movement authority for trains that enter and pass through their area of responsibility
- Train Operating Mode Monitoring – provides additional assurance that the Engineer will operate in the mode that is authorized

c) Operational Performance Enhancements

- Provides Ideal Train Speed Indication – provides a tailored target speed profile to allow the Engineer to exercise precise control of train speed helping to maintain schedule and enabling the right balance between required operating performance and economy of operation.
- Performance Approaches that of an Ideal Train Control Design – since train speed profiles are continuous, optimized to the type of train and terminate at the start of a restricted speed area or target stop point, headway performance deviation from ideal is primarily linked to the time required for a train to traverse a single track circuit, about 25 seconds on Caltrain.
- Minimum Trip Time – Trip time improvements are achieved due to the use of tailored speed reduction profiles where permanent or temporary speed restrictions force trains to lower speeds, versus speed authority as conveyed by wayside signals that are engineered for the poorest performing train.

- Maximized Operating Margin (for delay absorption / recovery) – improved signaling headway provides margin to avoid or reduce the impact of delays.
- Scheduled Station Stopping is Enforced – the enforcement of scheduled train stops helps to avoid delays that result when a train has to back up to achieve proper station berthing. Quality of service is also improved for our customers by avoiding a totally missed stop.

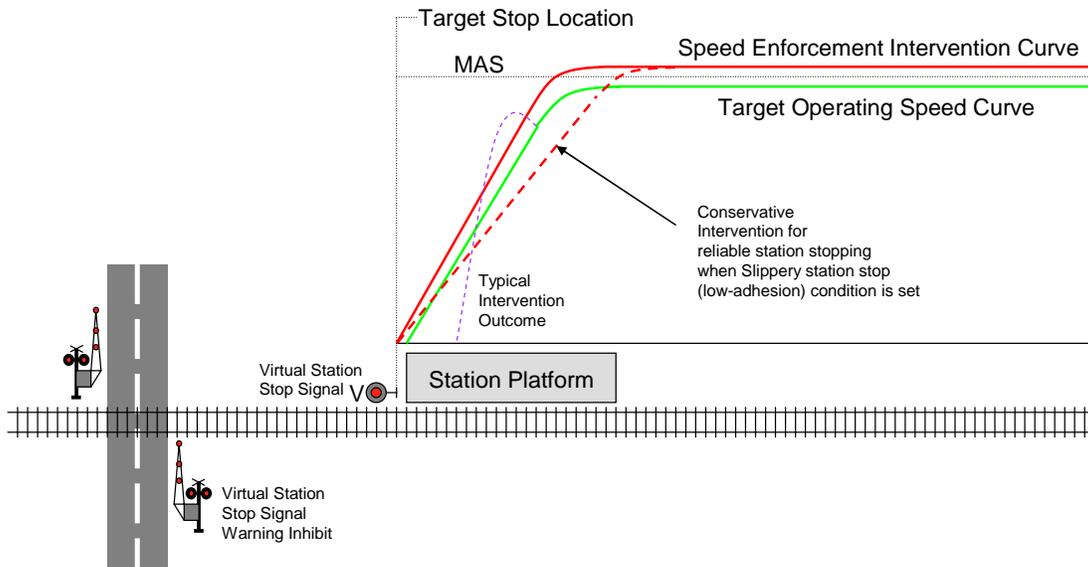


Figure 2 – Enforced Station Stop – Near Side Crossing Inhibit

- Train-Station Hold Function – this capability is tied to near side crossings such that when an extended station dwell is needed, roadway traffic will not be disrupted by the lowering of gates when the train is scheduled to depart. Access to the hold function is provided for the Engineer and the Dispatcher.
- Schedule Management Functions – train schedule data provides the basis for timely station departures helping to keep the trains on schedule and avoiding movement conflicts at junctions and terminals. As traffic levels increase in the future the capability to add real time adjustments to station departure times and permitted train speed can be introduced.

- Integrated Crossing Activation – crossing warning and gate systems are automatically activated in response to approaching trains based on actual train speed and the train’s capability to accelerate providing reliable and consistent advance warning time for all types of trains traveling at any speed including speeds that are above that for which the conventional (backup) track based detection was designed for.

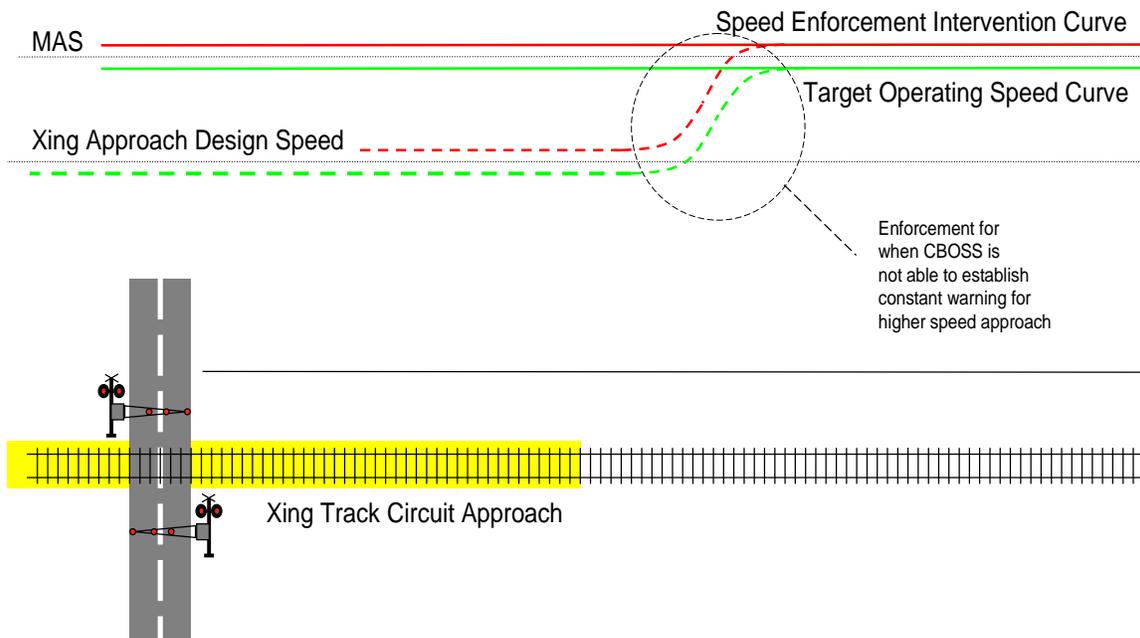


Figure 3 – Higher Speed Train Crossing Activation

d) Interoperability

- Interoperability will enable Caltrain to continue its passenger service operations using a common set of trainborne equipment over the Union Pacific PTC territory (south of CP Lick). Similarly PTC (Interoperable Train Control “ITC”, as developed by UPRR and others) equipped trains will be supported on Caltrain’s CBOSS territory. At this point, interoperating passenger railroads including ACE, Capitol Corridor, and Amtrak services have not confirmed to Caltrain their PTC Implementation Plans; Caltrain is however assuming that these interoperating passenger railroads will employ ITC or an otherwise interoperable system.
- The Railroad Safety Improvement Act of 2008 defines the required basic capabilities for all PTC systems. In situations where PTC is applied as an overlay of conventional block signaling, informational interfaces are expected to be common in terms of the particular status data that is obtained to help determine train movement authority.

- With the introduction of CBOSS, Caltrain plans to provide operator training that establishes the cab speed indication as the governing authority. The training will explain variations that arise between the information conveyed by the wayside signal and PTC systems. This training will ensure that train operators understand the continuing need for strict adherence to current rules when operating in accordance with wayside signals. Because PTC automatically intervenes to protect against violations of authorized speed or movement authority, safety is assured. Wayside intermediate signals will eventually be abandoned and a simpler form of controlled signal adopted after full fitment of trains with CBOSS/ITC and after which system availability is shown to be sufficient such that the value of retaining the current wayside signals is less than the cost of retention.
- CBOSS is specified to allow a virtually unlimited number train types – the capability to support definition of a large number of train types ensures that operating performance and safety will not be compromised for a given type of train, wherever CBOSS capabilities are implemented. Each train type can be evaluated and an appropriate model of behavior determined to allow optimal performance on CBOSS compatible territory. CBOSS equipped trains that operate on freight PTC infrastructure are expected to exhibit many of the same enhanced performance capabilities regardless of the infrastructure system without any special wayside system interfaces for basic safety functionality.

7. IMPLEMENTATION PROGRESS

Efforts to implement CBOSS are advancing though impacts are being experienced. The requirement for interoperability and the fact that CBOSS defines a number of capabilities that are not implemented in a current product challenges the supplier to develop something new and to do it in a way that involves minimal impact to the Class 1 freight railroads that are collectively working to develop their PTC solution. Interest to further develop PTC products is tempered both by the highly aggressive implementation date that has been set by congress and by, as yet, uncertain interest by the strongest stakeholders, the freight railroads.

Caltrain is essentially complete in its effort to define the system functional requirements that considered Caltrain's and the California High-Speed Rail Authority's needs to support operation in an electrified environment and enable combined diverse services with both high-speed rail and mass transit system performances and which considers the specific hazard and environmental conditions found along the Caltrain corridor. The CBOSS supplier/product developer will also need to use or be subject to the configuration management system that is employed by the interfacing freight railroad to ensure that the CBOSS basis of design is consistent with the design of the freight solution and vice versa.

The PTC system being developed by the Union Pacific Railroad, along with several other freight railroads and designated suppliers, is being engineered to meet the needs of the freight operators. Just as ITC has not been developed to meet the needs of Caltrain and the California High Speed Rail Authority, CBOSS has not been designed to address the needs of freight operators. Nevertheless, efforts are needed to explore opportunities to combine or standardize on interoperable requirements.

Caltrain has met with the Union Pacific Railroad, the tenant railroads and also with potential equipment suppliers on separate occasions to explore opportunities to participate in the development of CBOSS interoperability requirements. The Union Pacific Railroad has invited Caltrain to join in regular industry wide status reviews to facilitate a broad understanding of the issues and progress being made by the ITC group. Plans are that the successful CBOSS bidder will be given a change order to cover the work needed to coordinate an interoperable solution with the ITC group.

ITC equipped trains will eventually operate on Caltrain and will thus need to be supported by CBOSS. It is logical that the Union Pacific Railroad, as a member of the ITC development team, should avail themselves to work with Caltrain to support CBOSS and ITC co-developed to ensure systems interoperability.

8. ONGOING EFFORTS - NEXT STEPS

- The Railroad Safety Improvement Act of 2008 provides new requirements mandating the introduction of PTC to freight and passenger railroads and requires interoperability between railroads that share traffic. Caltrain is working with the member railroads who are leading the development of ITC requirements to help ensure that the mandate is achieved.
- Caltrain is continuing to meet with the other California passenger rail operators, including Amtrak and the California High-Speed Rail Authority and plans to share the final technical requirements once the bid package is finalized. Detailed technical coordination has also begun with the Union Pacific Railroad to ensure interoperability between systems as per the direction of the FRA nationally.
- It is anticipated that radio communications spectrum availability will be a critical issue, if not for Caltrain, for the general railroad network, as adequate radio spectrum and communications capacity has not been obtained to support the needs of all operators in all areas. The involvement and support by the federal regulatory agencies is vitally important to secure this critical and enabling asset for interoperability and could be of interest to Caltrain and the CBOSS supplier.

- CBOSS technical requirements are finalized and are now being packaged to enable Caltrain to commence the procurement with available funding.
- Caltrain is finalizing its initial draft of the CBOSS Systems Execution Plan (SEP). The SEP provides an integrated description of how Caltrain will safely manage the development, implementation, transition to, and operation of CBOSS for the life of the system. Caltrain intends to update and use the SEP as the program expands and to tailor the Plan to document the agreed methods and procedures brought by the various participating entities. Pending FRA requirements for the PTC planning documents, e.g. PTC Development Plan, PTC Implementation Plan and PTC Safety Plan, Caltrain intends to meet all requirements with the SEP which will also serve to show the interdependence of these key areas of interest.