California High-Speed Train Project

TECHNICAL MEMORANDUM

Rolling Stock and Vehicle Intrusion Protection for High-Speed Rail and Adjacent Transportation Systems
TM 2.1.7

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System Level Technical and Integration Reviews

The purpose of the review is to ensure:

- Technical consistency and appropriateness
- Check for integration issues and conflicts

System level reviews are required for all technical memorandums. Technical Leads for each subsystem are responsible for completing the reviews in a timely manner and identifying appropriate senior staff to perform the review. Exemption to the System Level technical and integration review by any Subsystem must be approved by the Engineering Manager.

System Level Technical Reviews by Subsystem:

Systems:	*Signed document on file*_________ Eric Scotson:	04 Aug 08 _ Date
Infrastructure:	*Signed document on file*_________ John Chirco:	_26 Jun 08 _ Date
Operations:	*Signed document on file*_________ Paul Mosier:	04 Oct 08 _ Date
Maintenance:	*Signed document on file*_________ Paul Mosier:	04 Oct 08 _ Date
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ABSTRACT

The proposed California High-Speed Train System (HST) will operate adjacent to, in close proximity, or within a shared right-of-way with other transportation systems at several locations along the high-speed rail alignment. These transportation systems include conventional passenger railroad lines, freight railroad lines, and highways. At these locations, special considerations will be made to determine the need for intrusion protection. Identifying intrusion hazards in shared rights-of-way is a key safety issue for both the CHSTP and existing transportation systems. Reducing the risk of intrusion will allow the high-speed lines to operate adjacent to existing transportation systems in a safe and acceptable manner.

The purpose of this technical memorandum is to review current practices and to provide a basis of design for the safe separation of CHSR lines from adjacent transportation systems in order to:

- Prevent errant railroad or highway vehicles from intruding into the operating space of the high-speed lines from an adjacent or overhead facility
- Prevent a derailed high-speed vehicle from intruding into the operating space of an adjacent railroad or highway
- Prevent a derailed high-speed vehicle from falling from an elevated track

Development of the basis of design for intrusion protection will include, but not be limited to, a review and assessment of the following:

- The locations where the proposed CHSR lines may be adjacent to or on a shared right-of-way with conventional passenger railroads, freight railroads, and highways in to determine the level of exposure
- Existing FRA and AREMA guidelines regarding separation and protection of adjacent transportation systems and conventional railroads
- USDOT / FRA / ORD Report entitled, "Safety of High-Speed Guided Ground Transportation Systems, Intrusion Barrier Design Study" (November 1994), for applicability to CHSR issues
- Intrusion protection measures used on high-speed rail systems in Europe and Asia
- Research for other applicable published studies regarding the safe separation and intrusion protection for high-speed trains systems and adjacent transportation systems

Issues associated with shared-use operations, where high-speed trains share the same track with conventional passenger railroads, including operational and regulatory requirements, will be addressed in separate documents.

Access control and intrusion into the HST right-of-way by pedestrians or wildlife is not addressed in this paper and will be addressed in separate documents.

1.0 INTRODUCTION

The proposed California HST system will operate adjacent to or within a shared right-of-way with other transportation systems at several locations along the alignment. These transportation systems include conventional passenger railroad lines, freight railroad lines, and state highways. At these locations, assessment will be made to determine the need for intrusion protection for the respective modes and services. Hazard analyses, risk assessment, and implementation of appropriate mitigations to reduce the potential for intrusion will allow the HST to operate adjacent to existing transportation systems in a safe and acceptable manner.

This technical memorandum introduces a discussion on potential intrusion hazards that may exist as a result of shared right-of-way, particularly as the intrusions pertain to the HST alignment and vehicles. This document is intended for use in discussion with the FRA, PUC and other relevant regulatory entities regarding requirements for track separation between high-speed vehicles and adjacent railroads and, subsequently, for use in developing the track and alignment design for the project.

1.1 PURPOSE OF THE TECHNICAL MEMORANDUM

The purpose of this technical memorandum is to describe examples of current practices for safely separating HST lines from adjacent transportation systems, including passenger and freight rail tracks and highways, and to define the HST basis of design requirements needed for the development of the preliminary design.

In this paper, intrusion protection is considered with regard to the potential for errant rail vehicles to enter into the operating space of another transportation system's right-of-way. This paper will address the basis of design being developed for the HST track, earthwork, and structures in order to reduce the potential for conventional train and HST derailment and the resulting impacts.

Subsequent reports will address the issues and design considerations associated with HST operations in proximity to automobile facilities and the potential for damage to the HST System infrastructure from errant highway vehicles. In addition, protection from intrusion by unauthorized pedestrians or wildlife will be developed in order to reduce the potential of incidence, accident, or derailment. These considerations will be the topic of a separate technical memorandum.

1.2 STATEMENT OF TECHNICAL ISSUE

HST alignments that lie adjacent to other transportation facilities pose potential intrusion hazards. If a freight vehicle intrudes into the HST operational corridor, there could be a collision and/or damage to the HST track and its operating infrastructure. There is also the potential for a collision and/or disruption to operations on another transportation system if a high-speed rail vehicle intrudes into that system's right-of-way. Additionally, there is the potential for an intrusion caused by an errant automobile or truck entering into an adjacent HST right-of-way. This memorandum considers four operating scenarios:

1. Intrusion of a derailed freight railroad car into the operating space of the HST.
2. Intrusion of a derailed freight car and damage to HST piers that support elevated HST structures.
3. Intrusion of a derailed HST vehicle into the operating space of an adjacent freight railroad line, passenger railroad line, or a highway.
4. Intrusion by an automobile or truck leaving a highway and entering the CHSTP operational corridor.

The information in this document will serve as the basis for CHSTP design criteria that will establish a minimum distance between adjacent tracks and may include the introduction of a barrier or other protection elements to reduce the risk of derailment and prevent derailed vehicles from intruding into the operating space of an adjacent transportation facility.

1.2.1 Definition of Terms

The following technical terms and acronyms are used in this document have specific connotations with regard to the HST system.

Barrier:	A device intended to contain or redirect an errant vehicle by providing a physical limitation through which a vehicle would not typically pass.
Barrier Offset Distance:	The lateral distance from the centerline of the track to the face of the barrier, trackside, or other roadside feature.
Check Rail:	The guiding rail located between the two running rails, which functions to maintain a derailed wheel in the track alignment. Check rails are installed at 14 in (36 cm) from the rail and can be placed inside one or both of the running rails.
Containment:	Engineered structure (steel, concrete or earthworks) designed to maintain a vehicle under a defined area.
Containment Curb	Low concrete structure that maintains a derailed train into a guided way by maintaining its wheels inside a defined area.
Dedicated Corridor:	A high-speed train alignment where high-speed trains operate exclusive of other railroads.
Guard Rail:	A short guidance rail in the track. When a wheel passes over a switch frog in a non-guided section, the opposite wheel is guided by the guard rail, which acts on the back of the wheel flange.
Intrusion:	An errant vehicle's exit out of its right-of-way and entry into the operating space of another transportation system's right-of-way. .
Intrusion Detection:	A device which detect entrance into a railroad protected area and which stops trains through an action on the signaling system in order to avoid a collision. This device can also raise an alarm to the control center.
Intrusion Protection:	Physical structure or space which will prevent errant vehicles, goods, objects and people from entering into a protected area.
Operating Infrastructure	HST infrastructure that, when damaged or intruded on, will require interruption of operation on one or several tracks. This area can be delineated by the zone between and including catenary posts and concerns OCS and signaling installations as well as tracks and turnouts.
Shared-Use Corridor:	A HST alignment where high-speed trains operate with other passenger railroads (e.g., Caltrain, Metrolink, and Amtrak) and share the same track.
Shared Right-of-Way:	A HST alignment where high-speed trains operate in close proximity to other transportation systems, including conventional passenger railroads and freight railroads, without sharing tracks. Also includes highways.

Acronyms

AAR	Association of American Railroads
AREMA	American Railway Engineering and Maintenance of Way Association
Authority	California High-Speed Rail Authority
CHSTP	California High-Speed Train Project
CFR-49	Code of Federal Regulations Part 49
CTRL	Channel Tunnel Rail Link (high-speed line from the Channel Tunnel to London in the U.K.)
FRA	Federal Railroad Administration
GO	General Order
HST	High-Speed Train
PUC	California Public Utilities Commission
ROW	Right-of-Way

SNCF	Société Nationale des Chemins de fer Français (French National Railway Company)
UIC	Union Internationale des Chemins de fer (International Union of Railways - The French abbreviation is also used in English)

1.2.2 Units

The California High-Speed Train Project is based on U.S. Customary Units consistent with guidelines prepared by the California Department of Transportation and defined by the National Institute of Standards and Technology (NIST). U.S. Customary Units are officially used in the United States, and are also known in the US as "English" or "Imperial" units. In order to avoid confusion, all formal references to units of measure should be made in terms of U.S. Customary Units.

Guidance for units of measure terminology, values, and conversions can be found in the Caltrans Metric Program Transitional Plan, Appendice B U.S. Customary General Primer (http://www.dot.ca.gov/hq/oppd/metric/TransitionPlan/Appendice-B-US-Customary-General-Primer.pdf). Caltrans Metric Program Transitional Plan, Appendice B can also be found as an attachment to the CHSTP Mapping and Survey Technical Memorandum.

2.0 BASIS OF DESIGN - STANDARDS AND GUIDELINES

2.1 GENERAL

Where applicable, the general basis of design will follow the standards and recommended practices described in the Manual for Railway Engineering of the American Railway Engineering and Maintenance of Way Association (AREMA). AREMA practices will be considered with regard to design standards developed specifically for the construction and operation of high-speed railways based on international best practices.

2.2 LAWS AND CODES

The development of the basis of design for intrusion protection was based on a review and assessment of available information, including the following:

- Existing FRA guidelines regarding the separation and protection of adjacent transportation systems and conventional railroads
- The Manual for Railway Engineering of the American Railway Engineering and Maintenance of Way Association (AREMA) Manual
- California Department of Transportation, Highway Design Manual
- The DOT and FRA study on intrusion protection entitled, “Safety of High-Speed Guided Ground Transportation Systems” (SHSGGTS) from November 1994
- Technical Guidebook GEFRA 2004: technical guidance from National French Railways about twinning between high-speed train and road or highway infrastructures
- UIC Code 777-2: 'Structures Built over Railway Lines – Construction in the Track Zone', this code identifies a 'danger zone' within proximity of the rail, inside which it is preferable to avoid having supports

In the case of conflicts in the various requirements for design, the standard followed shall be that which results in the highest level of conformance for all requirements or that is deemed as the most appropriate by the Authority and as required for securing regulatory approval.

2.3 APPLICABILITY TO FEDERAL REGULATIONS

To follow.

3.0 ASSESSMENT / ANALYSIS

The assessment conducted for the CHSTP will focus on four possible intrusion scenarios:

1. Intrusion of a derailed conventional freight or passenger railroad car into the operating space of the HST.
2. Intrusion of a derailed freight car and damage to HST piers that support elevated structures.
3. Intrusion of a derailed HST vehicle into the operating space of an adjacent freight railroad line, passenger railroad line, or a highway.
4. Intrusion by an automobile or truck leaving a highway and entering the HST operational corridor.

This analysis assesses the design considerations associated with intrusion protection, the intrusion protection practices of other operating HSR systems, and recommends an approach and use specific intrusion protection elements for the high-speed train, conventional rail, and adjacent highway facilities. This analysis also considers examples of potential causes and effects of derailments, and offers approaches to mitigate the risk of occurrence and the associated potential for intrusion.

3.1 BACKGROUND

3.1.1 Prior Assessment

A study on intrusion protection entitled, "Safety of High-Speed Guided Ground Transportation Systems" (SHSGGTS), was prepared for the FRA in 1994. While some of the recommendations are inconsistent with the current practices of operating international HSR systems (e.g. the use of earth berms), the report provides insight on key considerations for intrusion protection. In particular is the fact that, although travelling at lower speeds, conventional trains generate greater forces on a barrier than HSR trains. Also, a barrier placed closer to the track results in lower forces than a barrier placed further away (a closer barrier will help deflect the train car along the corridor rather than absorb the energy from a more direct impact). This study used computer analyses to evaluate three types of barrier systems: earth barriers, structural barriers, and various combinations of earth and structural barrier scenarios. A summary of the barrier systems assessed in the report follows.

Earth Barriers: Earth barriers and ditches were assessed for use as intrusion barriers in prior studies conducted for the FRA. One study concluded that the earthwork berm and ditch barrier system assessed was not a well-suited barrier for high-speed systems, primarily because of the large kinetic energy associated with a vehicle travelling at 200 mph (320 kph), which would require either high berms, long unobstructed stopping distances, or a combination of the two to effectively stop a high-speed vehicle. (Footnote – SSHGGTS – Nov 1994 - Page xvi).

Structural Barriers: Structural barriers prevent errant vehicles from leaving their protected corridor, or from entering an adjacent protected corridor, and redirect the errant vehicle back into its own corridor and/or right-of-way. Structural barriers are typically not designed to slow vehicles; rather, these barriers serve to contain a rail vehicle and rely on friction between the train and the track infrastructure within the high-speed corridor to gradually bring the high-speed vehicle to a stop.

Analyses of structural barriers under varying loads and speeds performed for the SSHGGT Study concluded that loads from conventional freight trains yield loads higher than those of high-speed trains. Higher impact loads are observed at lower derailment speeds, in the range of 75 to 100 mph (120 to 160 kph). At high speeds, train cars rebound from the barrier, continue in the original direction of travel without additional contact with the barrier, and slow to a stop. In this case, a conventional train may stop in a shallow 'zigzag' or accordion pattern. Under certain conditions with specific train set technology, a high-speed train set will remain in a straight line along the tracks. At lower speeds, impacting vehicles remain in contact with the barrier longer in a 'snagging collision' and stop in a sharper zigzag pattern. Dual barriers, installed on both sides of the corridor, experience the highest impact loads due to the tendency of train cars to get wedged between the two barriers and pushed into the barriers by following cars. (Footnote – SHSGGTS – Nov 1994 - Page xvi).

Vehicle Damage: Computer analyses demonstrated that HST vehicle damage sustained during a derailment is expected to be minor. The subject train generally remains in a straight (longitudinal) line with little lateral movement. This is consistent with the observations of actual high-speed derailments. (USDOT/FRA – See Section 5.0 reference number 3).

Passenger Safety: Passenger safety during a derailment is measured by determining the expected acceleration of the vehicles and comparing these values to the threshold limits accepted by the automobile industry. The SHSGGTS study concluded that passenger safety during HST derailment and barrier impact is at an acceptable level, except in the case of the dual barrier condition. (USDOT/FRA – See Section 5.0 reference number 3).

3.1.2 International Shared Rail Corridor Practices

This section summarizes current practices on operating HSR systems where tracks are located adjacent to freight or passenger railways. Generally, earth berms and ditches, as well as barriers, are used for intrusion protection where a hazard analysis and risk assessment have identified the need for mitigation. Containment systems such as check rails, parapets, containment curbs and physical barrier systems are used to reduce the risk of derailment.

Taiwan: Generally, HST lines and conventional freight lines in Taiwan are not located adjacent to one another. There are in total three sections where Taiwan Railway (TRA) and HSR tracks are adjacent without an intervening wall; one on each side of Taipei Station in the underground section and the third is just north of the HSR southern terminal at Tsoying Station.

- Taiwan Railway through Taipei Station: TRA train volume is approximately 290 passenger trains and possibly 10 to 20 freight trains per day. There are two sections in the Taipei Station vicinity without an intermediate wall between the high speed and the conventional railroad, one each side of the station. There is no wall through the station, but there is a row of columns between the nearest HSR track and the nearest TRA track (a freight bypass track). Approximate speed is 37 mph (60 km/h).
- The two open sections: The section west (railroad south) of the station is approximately 1000 feet (305 m) long and is located on a curve where the TRA speed limit is 40 mph (65 km/h) and the HSR speed limit is 43 mph (70 km/h). The section east (railroad north) of the station is approximately 1500 feet (457 m) long. The speed limit is 37 mph (60 km/h) for both railroads.
- In addition, there is a section at the south end in approach to Tsoying station where the tracks are parallel and close. HST count on the Taipei end is 148 on weekdays and 154 on weekends and two less each (weekday/weekend) on the Tsoying end. TRA train volume is approximately 144 passenger trains and approximately 10 freight trains per day. Track separation is about 20 to 30 feet (6 to 9 m) between track centers, with a fence between tracks. This section is about 3000 feet long (915 m) and the speed limit is 87 mph (140 km/h) on the HSR side and 68mph (110 km/h) or 75 mph (120 km/h) on the TRA side. Since this section is in approach to Tsoying Station, the speeds of many trains are lower. Approximate TRA freight train speed limit is 50 mph (80 km/h).

TRA passenger train counts are from a schedule dated June 2006.

<u>France</u>: There are several cases of parallel HST and freight operations in France, in particular on the Atlantic TGV:

- Between Auneau and Bonneval, approximately 25 miles (40 km). No specific intrusion protection measures were built. This line carries nine passenger trains and 4 freight trains per day). Line speeds for passenger and freight trains are 62 mph (100 km/h) and 50 mph (80 km/h), respectively. Safety fences were installed along the entire HST line to control access, prevent trespassing, and avoid inadvertent entry by railway staff.
- Figure 3.1-1 illustrates a segment of the Atlantic TGV, where the separation between HST and an adjacent freight track is approximately 40 ft (12 m), and can vary based on the respective elevation of the tracks. Additional consideration is warranted for tracks on embankments (when the freight track is higher than the HST track) and curves (when the freight track is inside of the HST track). Earth ditches and mounds were constructed, in conjunction with a horizontal offset to prevent a derailed freight train from reaching the high-speed tracks. This offset is about one-half

of a car length (car body lengths vary up to approximately 89 feet) and is based on the observation that freight trains often crumple in zigzags, or like an accordion, during derailment. This results in cars straddling the track, typically with half of their length on either side of the track. The two tracks on the right side of Figure 3.1-1 are HST tracks between Paris and Le Mans (under construction at the time of photo); the single track on the left is a parallel line that is used for regional passenger and heavy freight.

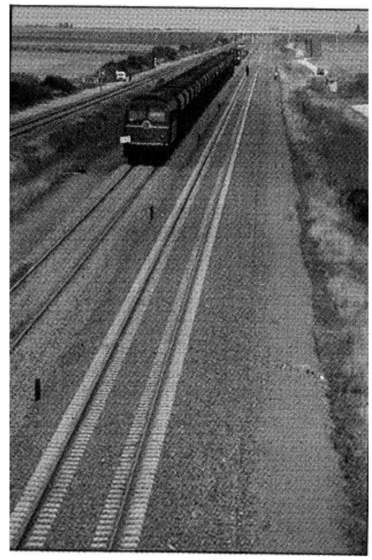


Figure 3.1-1 - HST Tracks Adjacent to Freight / Passenger Tracks

United Kingdom: The CTRL (Channel Tunnel Rail Link) runs parallel to a railway line from Ashford to the Channel Tunnel and in the Rainham area.

- The CTRL risk approach is based on the high quality of the operating infrastructure, its maintenance, and protection against vandalism. It also considers the fact that modern vehicle designs are less prone to derailment. Based on a risk analysis, the CTRL considers only specific areas for derailment containment. These include long or high bridges and structures where an incident could affect the structural integrity or cause a distortion of the track. The CTRL guidance considers three options for derailment containment: a continuous check rail, guard rails, and robust containment parapets on bridges and in tunnels.

3.2 DESIGN CONSIDERATIONS – CONVENTIONAL RAIL

3.2.1 U.S. Freight Railroad Corridors

Class 1 freight railroads in the United States require that new railroad tracks be constructed at minimum distances from existing freight tracks. This may require fully grade separated tracks. Specific requirements are described in 49 CFR 214.7 which indicates that adjacent tracks be separated by no less than 25.0 ft (7.6 m). In addition, large-scale maintenance and/or construction activities must be protected against train movements on adjacent tracks. It should be noted that this criteria is based on the requirement that all railroad freight vehicles be FRA compliant.

Prior studies have evaluated the feasibility of constructing HST lines within a freight railroad corridor and identified the following significant design issues and/or challenges:

Narrow Right-of-Way: Freight railroad corridors are generally constructed within a 100 ft (30.5 m) right-of-way with tracks centered between the property limits. The right-of-way width is usually sufficient to construct the earth embankments and fills that provide relatively flat grades through rolling terrain. The right-of-way may provide space to add additional tracks as service grows. However, in many urban areas, the original 100 ft (30.5 m) has been reduced over the years to provide for other uses.

The addition of high-speed tracks, particularly in areas with terrain variation, may require retaining walls for cuts and fills or additional property to accommodate embankment and cut slopes.

Alignments Designed for Shared Passenger and Freight Rail Service: While many railroads were originally constructed to provide shared passenger and freight service, most intercity rail passenger service has diminished to the Corridors and Lines operated by Amtrak. Except for the Northeast Corridor (between Boston MA and Washington DC) and the LOSSAN Corridor in Orange and San Diego Counties (in California) service typically operates on tracks owned and controlled by the freight railroads. The reintroduction of, or increases in, passenger service present challenges and potential liabilities for freight railroads. This is heightened by the infrastructure and operational needs of high-speed rail in freight corridors which already have service high volumes.

Rail Track Spurs and Sidings: While sufficient space may exist within a 100 ft (30.5 m) right-of-way to construct freight and passenger main line tracks, the requisite turnouts, spurs, sidings and other facilities pose additional constraints on the placement of new passenger rail tracks. The introduction of high-speed trains may require the relocation of existing freight tracks from the center of the right-of-way. Alternatively, additional right-of-way must be acquired from adjacent land owners.

Frequent Highway Grade Crossings: Grade crossings for both public and private roadways pose additional constraints. While many urban areas have constructed grade separations, the majority of suburban and rural railroads operate at-grade through the adjacent communities. The CHSTP anticipates full grade separation of high-speed rail tracks.

Case Study: In 2001, the Florida High-Speed Rail Authority (FHSRA) discussed the use of CSX-owned property for high-speed rail alignments on the corridor between Tampa and Orlando. CSX indicated that it would consider selling a portion of its property for the project, provided that the system was constructed on separate tracks, was fully grade separated, did not interfere with freight operations, and preserved a two-track freight system (with tracks realigned as necessary). It was agreed that the track center spacing between the high- speed rail and freight rail would not be less than 25 ft (7.6 m). SOURCE: *Florida High Speed Rail Authority Technical Report*, February 4, 2002, which is available on the FHSRA website, www.floridahighspeedrail.org

3.2.2 Derailment Considerations

In the case of conventional train sets (freight and passenger cars), "accordions" or “zigzags” result when an obstacle blocks the path of travel of one car and the following cars are forced to dissipate their energy. Since the trains are composed of rail cars which are structurally rigid and not designed to crush and absorb energy, cars derail and plow off of the track structure. Due to principles of physics, the cars continue straight along the track axis with one car turning one way and the following car turning the other way resulting in the accordion or zigzag pattern of derailed cars. As shown in Figure 3.2-1, the actual effect of a derailment is subject to a variety of site conditions including curvature and topography.

Figure 3.2-1: Derailment of Freight Train

Figure 3.2-1 illustrates that when the railroad track bed is higher than the adjacent ground (right), the train cars typically deflect far from the track (approximately two car-lengths here). Conversely, level ground (left) leads to a much smaller displacement (about half a car length in this case).

Separation distances or barriers can be used to minimize the risk of intrusion into the HST corridor by a derailed conventional railroad car. These protections must consider the vertical attributes of the railroad in relation to other infrastructures and the risk of derailment in the subject area.

3.2.3 At-Grade Track Separation

The separation distance between an HST line and adjacent rail infrastructure is critical in identifying the level of intrusion risk and defining appropriate mitigation measures. By providing separation of facilities, HST infrastructure can remain operational in the case of a derailment on the conventional rail line thereby maintaining high-speed train operations. The area considered as the HST Operating Infrastructure, which must remain clear in order for HST operations to continue, is shown in Figure 3.2-2.

The following sections discuss distance ranges to be applied for separating tracks and the appropriate type of intrusion protection for each location (where determined by the hazard analysis, risk assessment process). These recommendations also apply for the protection of HST viaduct piers that are located adjacent to conventional rail lines. All distances are measured between the centerlines of the closest track of each system.

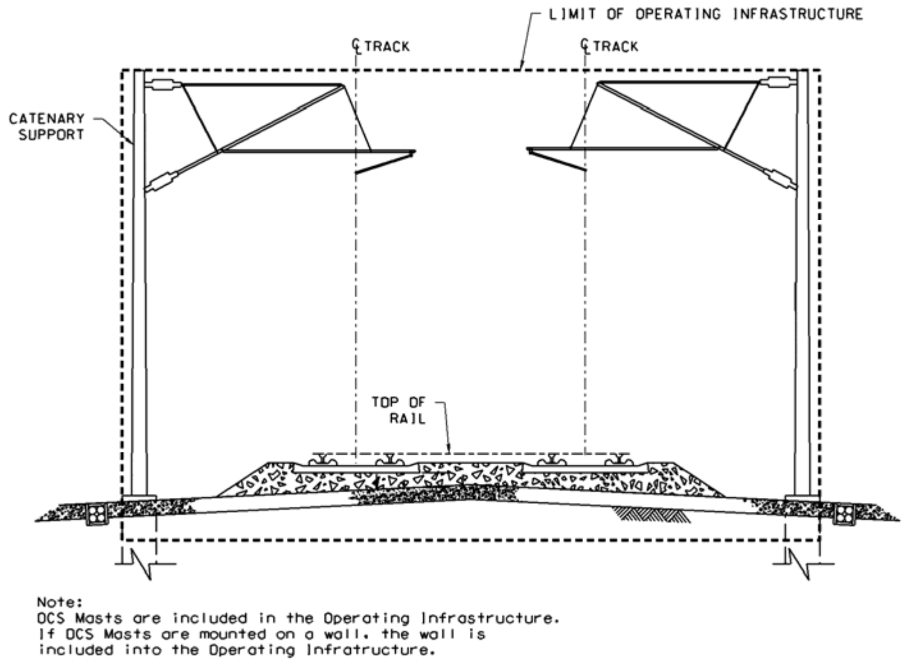


Figure 3.2-2: Limit of Operating Infrastructure

3.2.3.1 Minimum Distance between Track Infrastructures without an Intrusion Barrier

A minimum distance is established to ensure that a derailed freight train, or any contents or object falling from derailed freight cars, will not encroach into the HST operating infrastructure while traveling on level grade.

For conventional rail, Chapter 8 of the AREMA Manual part 2.1.5.1 indicates that "*research by the National Transportation Safety Board found no clear break point in the distribution of the distance traveled from the center line of the track by described equipment. It was therefore decided to retain the existing criteria of 25 ft (7.6 m) distance within which collision protection is required*."

In order to protect the HST operational infrastructure, the minimum separation distance should be increased to include the maximum practical excursion of the longest U.S. freight rail car from the center of track plus an allowance for protection of the OCS masts. Increased separation distance and intrusion protection measures should be considered based on location-specific risk analysis.

This method establishes the following separation requirements: A car body length of 89 ft (27 m) for the freight rail car displacement plus an allowance of 12.5 ft (3.8 m) offset to include an OCS mast foundation. This results in a minimum separation distance, without an intrusion protection barrier, of 101.5 ft (30.9 m), and rounded to 102 ft (31.0 m).

It is recommended that 102 ft (31.0 m) separation be considered as a minimum distance between rail systems to avoid intrusion without the need for any physical element for intrusion protection from rail cars operating on adjacent freight lines.

It is recognized that providing this separation distance may not always be practical, particularly in developed or urban corridors. In instances where it is not feasible to provide this separation distance, intrusion protection barriers should be considered.

3.2.3.2 – Minimum Distance between Tracks Using an Earthwork Barrier

Large distances between systems or concrete or steel barriers can be costly in terms of construction or right-of-way acquisition. Earthwork barriers provide an additional option for CHSTP and are used on other HST systems. Earthwork berms require additional separation distances compared to a barrier, but maintain passenger views of the surrounding environment due to their lower overall height. Maintaining a high quality passenger experience, such as favorable, attractive, visual access, has been a major consideration in the development of HST systems operating in Europe.

The earthwork berm is intended to provide 10 ft (3.05 m) high protection, which corresponds to approximately one-half the height of a plate H gauge. This height is equally divided in a berm and a ditch on the side of the freight railroad in order to maintain a passenger-friendly view. The separation can vary depending on the materials used and how the slope gradient is designed (i.e., natural slope, reinforced earthworks, gabion, etc.). With an engineered earthwork solution, a 17 ft (5.2m) berm with intrusion protection separates the two track infrastructures, and a total distance of 45 feet (rounded from 44.6 ft) (13.7 m) between centerlines of adjacent tracks is needed, as shown on Figure 3.2-3.

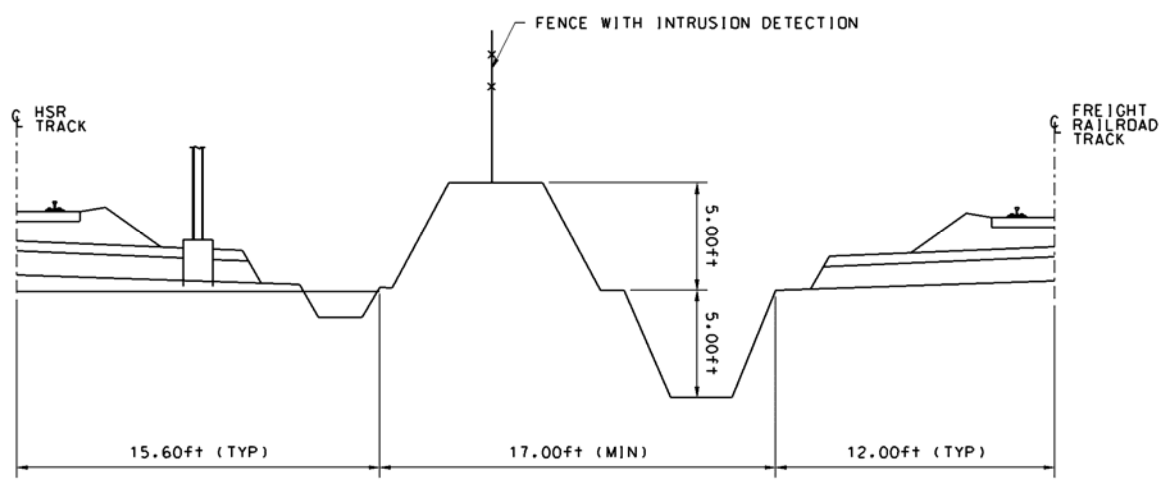


Figure 3.2-3: Separation between Tracks Using Earthwork Berms and Ditches

3.2.3.3 Minimum Distance between Tracks Using a Physical Barrier

To determine the minimum distance between track infrastructure with a physical barrier, it is necessary to take into account the minimum clearance requirements for both railways. For the HST, the minimum clearance from the track center to an obstruction is 12.5 ft (3.8 m). This allows space for catenary poles, cable trough/duct bank, drainage, and other HSR operating infrastructure, plus provision of a physical barrier. Freight railroads typically require a minimum of 9 ft (2.7 m) along a tangent alignment, but generally provide 12 ft (3.6 m) clearance to adjacent structures. A nominal minimum distance of 29 ft (rounded from 28.9 ft), (8.8 m) has been established for planning purposes. This distance is the sum of the minimum 12.5 ft (3.8 m) clearance requirements for the HST operating infrastructure plus a 3.0 ft (0.9 m) protected walkway, a 1.0 ft (0.3 m) cable tray, a 2.5 ft (0.8 m) wide intrusion barrier and a 10 ft (3.0m) offset to the centerline of the conventional railroad. The height of the barriers (concrete base plus screen on top or concrete wall) shall not be less than 10 ft (3.0 m) which is half of the height of the plate H gauge. Assessment of risk at specific locations and further development of HST standards may further reduce the minimum distance requirements for highly-constrained sections of the HST corridor.

It is recommended for planning purposes, a minimum separation of 29 ft (8.8 m), including provision for a physical barrier, is to be provided between the centerlines of adjacent HST and conventional rail lines. This distance is the sum of the minimum clearance requirements for the HST operating infrastructure (12.5 ft) plus a protected walkway (3.0 ft) and a cable tray (1.0 ft) plus an allowance of 2.5 ft for the width for an intrusion barrier plus an offset to the centerline of the conventional railroad (10 ft). A typical separation configuration is shown in Appendix 1.

3.2.3.4 Application of Track Separation and Intrusion Protection

A range of separation distances with the associated protection follows. Distances are measured from the centerline of the closest tracks of the freight line and the high-speed line.

- No intrusion protection is required for tracks with centerlines separated by 102 ft (31.0 m) or greater;
- Earthworks berms can be used as intrusion protection for tracks with centerline separation of 45 ft (13.7 m) or greater;
- A minimum 29 ft (8.8 m) separation is required between centerlines of CHST and adjacent conventional railroad track and requires a physical intrusion barrier;
- The absolute minimum offset to any obstruction is defined by each operator plus the width of the intrusion protection.

Intrusion protection, if required, is designed in conjunction with the hazard analysis and risk assessment process to verify the necessity of the physical barrier as an effective mitigation.

3.2.4 Pier Protection for Grade Separated Projects

AREMA recommends that the minimum offset between a pier and the closest track shall be 25 ft (7.6 m). If this distance can not be used, a crash wall to protect the piers shall be installed.

3.3 Design Considerations for High-Speed Rail

3.3.1 High-Speed Rail Corridors

HST systems require a high-quality track infrastructure, constantly supervised operations, and superior maintenance in order to maintain track quality. Risk of track obstruction due to vandalism is limited due to the strict control of access to the HST right-of-way. Historical data from existing HST systems in Europe and Asia indicate that the integrity of rail infrastructure and precision of the train control, which are designed in conjunction with the train sets, results in a low frequency and reduced severity for derailments. In this way, system design, maintenance, and performance of rolling stock are a fundamental component of the intrusion protection system. Intrusion protection measures could be planned at specific high-risk locations to protect other transportation facilities from HST derailment.

3.3.2 High-Speed Train Set Characteristics

This section summarizes the key design characteristics of modern high-speed trains and how the design approach reduces the risk for intrusion of HST into adjacent transportation facilities.

3.3.2.1 Vehicle Type and Speed

The specific type of rolling stock for the HST will not be selected prior to the completion of the 30% Design Level. This document's guidelines are intended to accommodate the operational needs of the HST without precluding any high-speed vehicle technology.

Design of intrusion protection will be advanced with the assumption that one of the following trainset technologies, or equivalent, will be operated on the HST since these vehicles can most likely meet the CHSTP performance requirements:

- Siemens -- Velaro E (ICE 3)
- Hitachi/Kawasaki/Nippon Sharyo -- N700
- Alstom – AGV
- Bombardier -- AVE S-102

Technical specifications for these vehicles are shown in TM 6.1 - Selected Train Technologies.

3.3.2.2 Articulated / Non Articulated Vehicles

HST technology uses two different methods to join coaches and locomotives. Train sets are either articulated or the elements are linked by couplings. TGVs and latest generation AGVs (designed by Alstom and the SNCF) are the only articulated models currently in service. ICE (designed by Siemens), Shinkansen (designed by Hitachi), ETR (designed by Fiat) and AVE (designed by Bombardier – De Patentes Talgo) are trains with couplings.

On a conventional train, the two bogies (axles and wheels) are situated beneath the cars, and thus below the seats of the passengers. The cars are linked by couplings. On an articulated train, bogies are placed between individual cars. This greatly decreases vibration and rolling noise, as the links between carriages absorb almost all of the movement between them. Moreover, interdependent cars add rigidity to the train set. In the event of a derailment, the train set stays intact and does not lose its shape. Non-articulated trains could potentially respond with the "accordion" effect. Nevertheless, the European technical specification for interoperability (TSI) requires that train sets incorporate crash energy management designs that include provisions for resisting over-riding of the coaches within the train set. These design elements will contribute to the mitigation of the "accordion effect" and will be further addressed in the hazard analysis and risk assessment process.

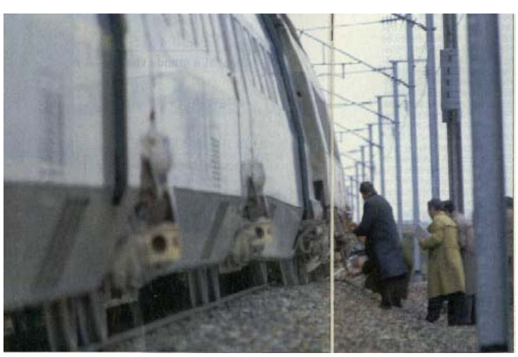
3.3.2.3 Trainset Stiffness

To follow.

3.3.3 Derailment Incidents

Four incidents of HST derailment are summarized below:

1. On 21 December 1993, a TGV train derailed at "Albaincourt Pressoir" on the northern French TGV due to a settlement of the track. The train was travelling at a speed of 183 mph (294 km/h). A bogie between two cars became derailed. Because of the stiffness of the consist, the lateral movement was very small, and no substantial damage resulted. The train came to a stop with no injuries.



2. On 5 June 2000, Eurostar 9047 from Paris to London derailed near the Croisilles Junction (Northern France, near Arras) as the train was running at 155 mph (250 km/h). Four bogies (out of 24 in the train set) left the rails due to a connecting rod breaking on a motorized bogie. Few injuries occurred among the 501 passengers.

3. On 23 October 2004, a magnitude 6.6 earthquake led to the derailment of a Shinkansen train which was running at 125mph (200 km/h). There were no serious injuries despite the fact that eight out of 10 cars derailed. The series 200 train, Toki 325, was carrying 155 passengers between Tokyo and Niigata on JR East's Joetsu Shinkansen line. The slab track maintained the train up and in line.

4. On 3 June 1998, an Inter City Express (ICE) train travelling 125 mph (200 km/h) derailed in Eschede, Germany causing the death of 98 people and injuring another 103. Several kilometers before the accident, the steel tire on the wheel of the car immediately behind the locomotive fractured. The broken wheel then jammed in a turnout, resulting in a longitudinal force that broke the coupling between this car and the locomotive. This caused the rest of the train cars to derail. The lateral movement was considerable and a bridge pier was demolished. This led to the collapse of the bridge which caused most of the casualties when the bridge fell on the train.

Incident 1 is an example of a limited derailment in which the trailing wheel of the derailed axle(s) stayed between the rails. Incidents 2, 3 and 4 are examples of a full derailment which is much rarer. In incident 2, a turnout contributed to the escalation from a limited derailment to a full derailment. In general, a major event is required to trigger such a catastrophic escalation.

3.3.4 Derailment Considerations

Derailments have been investigated by railways worldwide for many years. Examples of causes and potential solutions include:

- Flange climbing: The relation of lateral flange force to vertical wheel load has a major influence on flange climbing. Any vehicle or track property which reduces the wheel load or increases the flange force, either momentarily or permanently, could lead to flange climbing and even derailment. These factors are taken into consideration in the design and construction of the HST and when choosing the HST rolling stock.

- Gauge spread, settlement of the track, and/or other damages, such as a broken rail, can also contribute to a derailment. These conditions are mitigated by maintaining rigid standards for the HST design and maintenance.
- Mechanical failure of a component of the train's running gear could allow a wheel to jump over the rail. The accident that occurred on 3 June 1998, in Eschede, Germany, was due to the damage of the steel tire on a wheel.
- A longitudinal shock to the train can lift it clear of the rail. This could be caused by a collision with an obstruction on the track or damage to the running gear which causes a wheel to suddenly jam. Intrusion protection and a high level of maintenance can lower the risk of these occurrences.

Historical information from existing HST systems indicates that HST derailments occur as a result of infrastructure failures including, track, structure, earthworks, and/or rolling stock, or, due to objects obstructing the line (e.g., vandalism).

Maximizing safety and reliability and managing derailment risks (and other program risks) on the HST system will by achieved by:

- Developing and building infrastructure to the appropriate design standards
- Maintaining infrastructure, systems, and rolling stock at the highest appropriate level
- Monitoring track access conditions

The highest applicable standard of design for track, earthworks, drainage, and structures reduces derailment potential. The vertical clearance of bridges over roads will be sufficiently high to reduce the likelihood of bridge impact from oversized vehicles. Bridge piers and supports for other transportation systems will be located a sufficient distance from the HST running line, so that they are less likely to be affected by a HST derailment. Similarly, HST bridges over roads and other railways will be designed to withstand impacts from errant vehicle collisions. Parapets on road bridge crossings over the HST will be able to contain vehicles. Although not specifically addressed in this paper, it is noted that the HST will include an enhanced level of security barriers such as intrusion-detection fencing which will mitigate the risk of derailment due to vandalism.

3.3.5 Containment of HST

The severity of a train derailment is influenced by whether the affected train remains upright, stays within its operating envelope, and/or the derailment occurs at a low speed. The consequences of derailment escalate when a train deviates significantly from its operating envelope, causes a collision with a lineside structure (e.g., bridge overcrossing); falls from a height (e.g. bridge or viaduct); or, when there is a secondary collision with a train traveling in the opposite direction. Therefore, derailment containment devices will be designed to prevent a derailed train from deviating from within its operating envelope.

The design concept for containing a derailed HST will take into consideration the issues discussed in the prior sections of this report. Additionally, the following basic design elements are to be assumed:

- Limit lateral movement as much as possible so that the train does not attain a high lateral or rotational energy before impact with any protection device.
- Barriers are to be designed to withstand quasi-static horizontal loads that are to be transmitted with no substantial damage to the structure it protects.
- Specific intrusion protection measures are expected to be damaged during derailment but will not absorb much of the train's energy.
- The lateral or rotational energy of the train will be absorbed by the train itself, by distortion of the bogie and/or the car or locomotive structure, or by a movement between the bogie and the car or locomotive structure.

- The main kinetic energy of the train is directed along the track and is expected to be absorbed by the train's brakes as it comes to a stop. Some of this energy can be transferred to barriers or other physical structures by friction, but this is comparatively small.

Containment systems, such as check rails, parapets, and alternate barrier systems, are currently used in Europe and are described in the following sections. Implementation of containment systems will be assessed in conjunction with a hazard analysis and risk assessment process, particularly when a high level of intrusion risk is identified at a particular location.

3.3.5.1 HST Containment for At-Grade Alignments

It is preferable to contain the wheels as soon as they leave the rail due to the energy developed by a moving train according to its weight and speed. This keeps the train in line and out of the way of other trains. Check rails provide a first level of protection as shown in Figure 4.1-1.

3.3.5.2 HST Containment on an Elevated Structure

Long bridges or viaducts present potential for increased damage in the case of derailment due to increased height and/or length of the structure. Similarly, the risk of derailment can be greater on bridges where the design is considered more susceptible to the cause of train derailments (e.g. incidents which could affect the structural integrity of a bridge and cause a distortion of the track).

In these cases, HST must be contained within its operational envelope. This can be accomplished using containment curbs or parapets as shown in Figure 3.3-1, as designed for the CTRL project in the U.K.

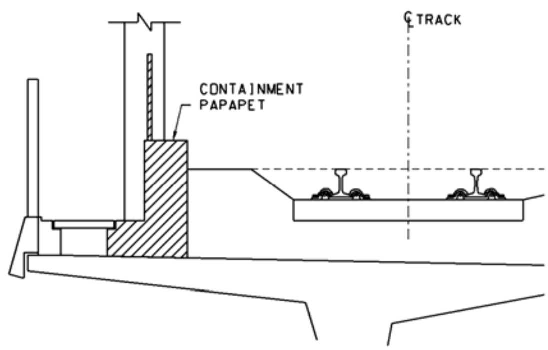


Figure 3.3-1: Containment Parapet on Elevated Structure

3.3.5.3 HST Containment in Tunnels

Special provisions to contain HST derailments in or near tunnels will be considered due to increased consequences of a derailment within a tunnel and/or on approach of a tunnel portal. The level of risk is dependant on tunnel length which affects the ease of emergency response. The severity of a derailment is also sensitive to tunnel configuration. For example, the consequences of derailment in cut and cover tunnels may be less onerous than bored tunnels. In the former case, the train is likely to remain upright and within its operating envelope due to the rectangular cross-section (e.g. vertical walls).

For twin bore, single-track tunnels, containment will be facilitated by the maintenance and evacuation walkways which function similarly to a containment curb or parapet. In the case of a single bore, twin-track tunnel, additional containment can be provided between the tracks to prevent a secondary collision following the initial HST derailment as shown in Figure 3.3-2. The operation of high-speed trains in tunnels will be consistent with the System Safety Plan and the Fire and Life-Safety Design Basis documents that will be developed during subsequent design.

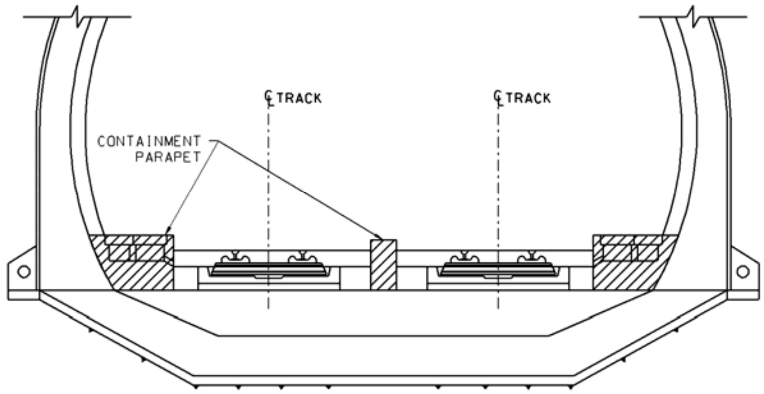


Figure 3.3-2: Containment Parapet within a Twin Track Tunnel

3.4 PROTECTION BETWEEN HSR AND HIGHWAYS

3.4.1 Background

To follow.

3.4.1.1 Prior Assessment

To follow.

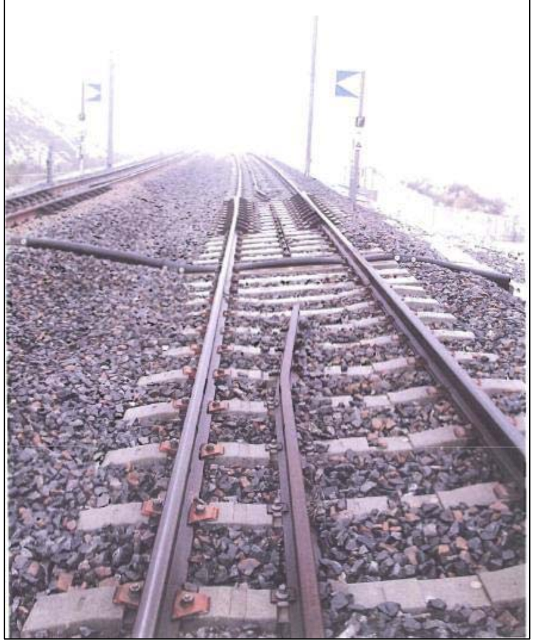
4.0 SUMMARY AND RECOMMENDATIONS

The minimum track separation and intrusion protection measures presented in this memorandum are recommended for implementation on in order to maximize the level of safety for the HST system and to ensure the safety of adjacent transportation facilities. Three intrusion scenarios have been identified for alignments along the HST right-of- way. These are summarized in the following section along with protection measures.

4.1 INTRUSION OF CONVENTIONAL RAILROAD CARS INTO HSR OPERATIONAL CORRIDOR

With respect to conventional freight and passenger railroads, design criteria should minimize or eliminate the risk of intrusion of a derailed conventional train into the HSR operational corridor. This will be accomplished with physical separation between facilities or a physical barrier where separation is not practical. Physical barriers may include earth berms or swales and reinforced concrete or steel barriers designed to withstand forces from a derailed train set. Other mitigation measures could include the use of check rails at particularly high-risk locations, such as bridge piers or switches and interlockings on elevated structures.

Figure 4.1-1 Single Check Rail within Freight Tracks



Protection Measures:

- Locate HST infrastructure at sufficient separation distances to avoid intrusion.
- Design supporting piers to mitigate impact loads.
- Place check rails on lines in high risk areas, especially before and after bridge structures, in order to maintain derailed freight cars within their operating envelope.
- Install earth ditches and berms or other physical barriers between the closest tracks of the adjacent rail infrastructure.

Note that the intent of these measures is to maintain the train within its right-of-way and not to stop the train. Supplemental protection is achieved through the use of intrusion detection technology in the fencing around HST operations. If the intrusion detection system is activated, HST operation is stopped by the signaling system.

4.2 INTRUSION OF HIGH-SPEED TRAINS INTO OTHER OPERATIONAL TRANSPORTATION CORRIDORS

The objective of the basis of design and associated guidance is to contain a HST train set within its operational corridor in order to reduce the potential for intrusion of the high-speed train into an adjacent transportation corridor. Strategies to ensure containment include operational and maintenance plan elements, which will ensure high-quality tracks and vehicle maintenance to reduce the risk of derailment. This approach is similar to HST systems around the world. In addition, physical elements, such as containment parapets, will be considered for specific areas with a high risk or high impact of derailment including, viaducts, tunnels, and approaches to conventional rail and roadway crossings.

Protection Measures for At-Grade Tracks:

- Design the HST infrastructure alignment at sufficient distances from other systems to avoid intrusion
- Use modern HST sets, which have documented performance to likely minimize the risk of the train extending beyond it operating envelope
- Ensure the highest appropriate level of maintenance of both infrastructure and rolling stock which will minimize the risk of derailment
- Use restraining parapets to contain vehicles within the HST corridor in high risk areas
- Use check rails or guard rails in high risk areas
- Install earth ditches and berms between systems

Protection Measures for an Elevated Structure/Viaduct:

- Place check rails before and after bridge structures and where switches and interlocking may have to be located on elevated structures in order to maintain the HST in-line in the event of a derailment
- Use containment parapets with appropriate structural integrity
- Consider articulated train sets, to help maintain the HST on-line on the elevated structure

Protection Measures within a Tunnel:

- Safety walkways that comply with NFPA 130 standards for emergency passenger evacuation (provides derailment containment on side that has walkway)
- In double or multi-tracked tunnels, use containment parapets between tracks to prevent a derailed train from obstructing the passage of a train on an adjacent line

4.3 INTRUSION OF HIGHWAY VEHICLES INTO HST OPERATIONAL CORRIDOR

The basis of design guidance looks to minimize the potential for highway vehicles to intrude into the HST corridor. Standard highway barriers are generally accepted to provide longitudinal intrusion protection from highway vehicles. Where highways cross over the HSR line, it must be ensured that errant highway vehicles do not enter the HST operational corridor by vaulting a protective barrier or entering from above by way of the abutment slope.

Protection Measures where High-Speed Trains Operate Adjacent to Highway Facilities:

To follow.

5.0 SOURCE INFORMATION AND REFERENCES

1. Manual for Railway Engineering of the American Railway Engineering and Maintenance of Way Association (AREMA Manual)
2. Federal Railroad Administration Code of Federal Regulations (CFR)
   - CFR Part 213, Track Safety Standards, generally and also in particular Subpart G - Train Operations at Track Classes 6 and Higher
   - CFR Part 214, Railroad Workplace Safety
3. U.S. Department of Transportation / Federal Railroad Administration: Safety of High-Speed Ground Guided Transportation Systems Intrusion Barrier Design Study (November 1994). Parsons Brinckerhoff Quade & Douglas, Inc. Boston, MA
4. California Department of Transportation, Manuals and Standards
5. USDOT/FRA/ORD Report entitled, "Safety of High-Speed Guided Ground Transportation Systems, Intrusion Barrier Study" (November 1994). for applicability to CHSR issues
6. AREMA Conference 2004, Corridor Design Issues For Florida High Speed Rail, W. Robert Moore, HNTB Corporation, Chicago, IL
7. Practices and mitigation measures used on HSR systems in Europe and Asia for intrusion protection from adjacent transportation systems
8. Research for other applicable published studies regarding the safe separation and intrusion protection for high-speed trains systems and adjacent transportation systems
9. Technical Guidebook GEFRA 2004: Technical guidance from National French Railways about twinning between high-speed train and road or highway infrastructures
10. SNCF Technical Standard For High Speed Train Line Construction (2007 Edition)
11. CTRL Technical Manuel
12. CHSTP Technical Memorandum 6.1 - Selected Train Technologies

6.0 DESIGN MANUAL CRITERIA

6.1 INTRUSION PROTECTION

The following information applies to both shared and high-speed train corridors.

6.1.1 Protection of CHSTP Operating Infrastructure from Intrusion

The main principle of these design criteria is to protect the HST operational infrastructure in order to preserve safe and reliable HST operations. The area considered as Operating Infrastructure is defined as shown on the Figure 6.1-1:

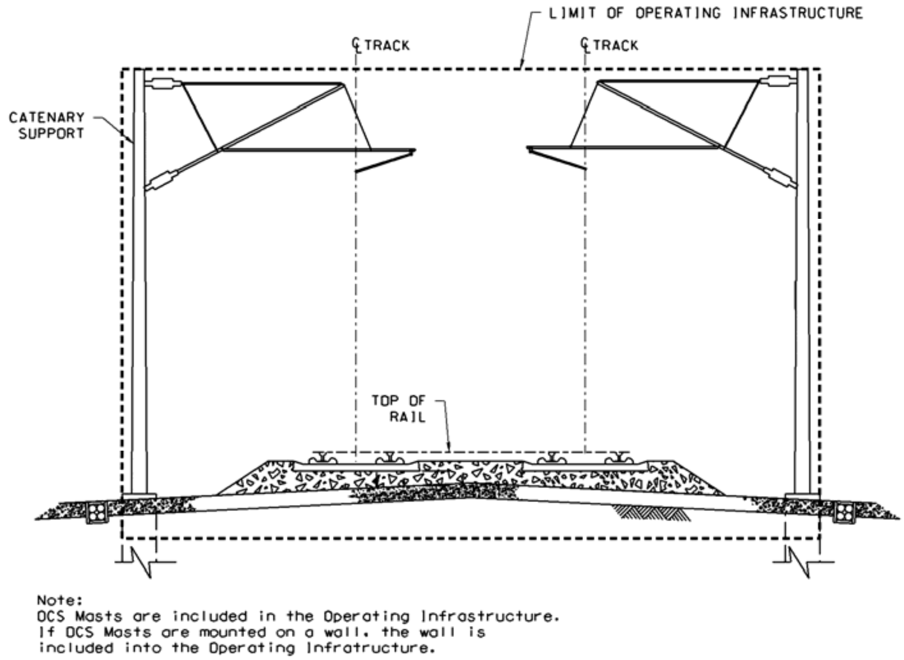


Figure 6.1-1: Limit of Operating Infrastructure

6.1.2 Containment of Conventional Trains

Conventional trains sharing corridors with HST will be prevented from intruding into the HST Operational Infrastructure by physical separation, or by a physical barrier where physical separation is not practical. Physical barriers may include earth berms or swales, and reinforced concrete or steel barriers designed to withstand the anticipated forces from a derailed conventional freight or passenger rail train set. Other mitigation measures could also include the use of check rails at particularly high-risk locations, such as bridge piers.

Protection Measures:

- Locate HST infrastructure at sufficient separation distances to avoid intrusion.
- Design supporting piers to mitigate impact loads.
- Place check rails on high risk lines, especially before and after bridge structures, in order to maintain derailed freight cars within their operating envelope.
- Install earth ditches and berms or other physical barriers between the closest tracks of the adjacent rail infrastructures.

Note that the intent of these measures is to maintain the train within its right-of-way and not to stop the train. Supplemental protection is achieved through the use of intrusion detection technology in the fencing around HST operations. If the intrusion detection system is activated, HST operation is stopped by the signaling system.

6.1.3 Containment of HST Trains

High-speed train sets will be contained within the operational corridor in order to reduce the potential for intrusion into an adjacent transportation corridor. Strategies to ensure containment include operational and maintenance plan elements, which will ensure high-quality tracks and vehicle maintenance to reduce the risk of derailment. In addition, physical elements, such as containment parapets, will be considered for specific areas with a high risk or high impact of derailment including, viaducts, tunnels, and approaches to conventional rail and roadway crossings.

- Ensure the highest appropriate level of maintenance of both infrastructure and rolling stock which will minimize the risk of derailment
- In general, check rails, guard rails and parapets can limit lateral movements, especially in high risk areas.
- On elevated structures, it is even more imperative that HST remains within its operational envelope. Protection can be provided by containment parapets.
- Tunnels: For twin bore, single-track tunnels, containment will be provided by the maintenance and evacuation walkways, which function like a containment parapet. For single bore, twin-track tunnels, additional containment can be provided between the tracks to prevent a secondary collision following initial HST derailment. All tunnels on the HST are currently anticipated to be twin bore with single-track tunnels.

6.1.4 Separation Distance between HST and Adjacent Railroad Systems

A range of separation distances with the associated protection follows. Distances are measured between the centerlines of the closest conventional rail and high-speed tracks.

- No intrusion protection is required for tracks with centerlines separated by 102 ft (31.0 m) or greater;
- Earthworks berms can be used as intrusion protection for tracks with centerline separation of 45 ft (13.7 m) or greater;
- A minimum 29 ft (8.8 m) separation is required between centerlines of HST and adjacent conventional railroad track and requires a physical intrusion barrier;
- The absolute minimum offset to any obstruction is defined by each operator plus the width of the intrusion protection.
- When intrusion protection is needed, minimum total height shall be 10 ft (3.0 m) with either ditch plus berm, concrete wall plus screen or only concrete wall

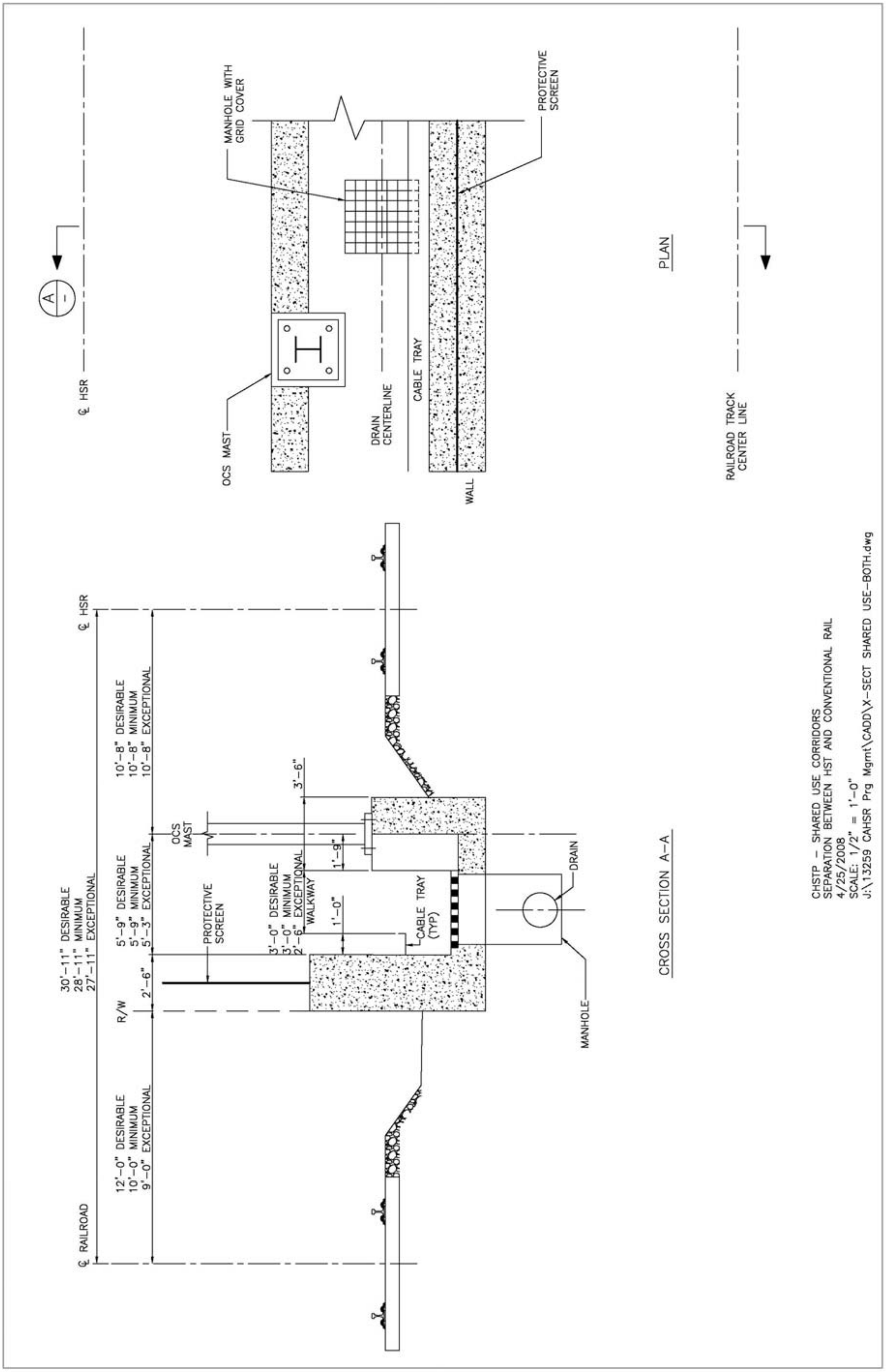
Intrusion protection, if required, is designed in conjunction with the hazard analysis, risk assessment to determine the necessity of the physical barrier.

6.1.5 Pier Protection for Grade Separated Projects

The minimum offset between pier and the closest track shall be 25 ft (7.6 m) as per AREMA recommendation. If this distance is not feasible, crash wall to protect the piers shall be installed.

APPENDIX A

A.1 TYPICAL CROSS SECTION WITH INTRUSION PROTECTION


MANHOLE WITH GRID COVER
PROTECTIVE SCREEN
OCS MAST
DRAIN CENTERLINE
CABLE TRAY
WALL
℄ HSR
RAILROAD TRACK CENTER LINE
PLAN
℄ RAILROAD
R/W
30'-11" DESIRABLE
28'-11" MINIMUM
27'-11" EXCEPTIONAL
12'-0" DESIRABLE
10'-0" MINIMUM
9'-0" EXCEPTIONAL
5'-9" DESIRABLE
5'-9" MINIMUM
5'-3" EXCEPTIONAL
10'-8" DESIRABLE
10'-8" MINIMUM
10'-8" EXCEPTIONAL
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2'-6" EXCEPTIONAL
WALKWAY
1'-0"
1'-9"
3'-6"
CABLE TRAY (TYP)
DRAIN
MANHOLE
CROSS SECTION A-A
CHSTP – SHARED USE CORRIDORS
SEPARATION BETWEEN HST AND CONVENTIONAL RAIL
4/25/2008
SCALE: 1/2" = 1'-0"
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