California High-Speed Train Project

Agreement No. HSR 13-06
Book 3, Part A, Subpart 1

Basis of Design

HSR 13-06 - EXECUTION VERSION

Prepared for
CALIFORNIA
High-Speed Rail Authority

California High-Speed Train Project

TECHNICAL MEMORANDUM

Basis of Design
TM 0.3

Prepared by: ______________________ ____________

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Revision	Date	Description
0	01 Mar 07	Initial Release
1	20 Dec 07	General Update
2	01 Sep 10	General Update, revise design speeds, delete text not related to design
3	22 Feb 12	General Update, revise seismic design approach, revise to be consistent with FRA High-Speed Passenger Rail Safety Strategy

HSR 13-06 - EXECUTION VERSION

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for the California High-Speed Rail Authority

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 memoranda. 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:	Rick Schmedes	Date
Infrastructure:	John Chirco, PE	Date
Operations:	Joe Metzler	Date
Maintenance:	Joe Metzler	Date
Rolling Stock:	Frank Banko	Date
Project Management Oversight:	Michael D. Lewis, PE	Date

Note: Signatures apply for the technical memorandum revision corresponding to revision number in header and as noted on cover.

HSR 13-06 - EXECUTION VERSION

TABLE OF CONTENTS

HSR 13-06 - EXECUTION VERSION

HSR 13-06 - EXECUTION VERSION

ACRONYMS

ACE JPA	Altamont Commuter Express Joint Powers Authority
BNSF	Burlington Northern Santa Fe Railway
Caltrans	California Department of Transportation
CCF	Central Control Facility
CCJPA	Capital Corridor Joint Powers Authority
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CHST	California High-~~-~~Speed Train
CHSTP	California High-~~-~~Speed Train Project
CPUC	California Public Utilities Commission
~~DBE~~	~~Design Base Earthquake~~
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EMU	Electric Multiple Unit
ERTMS	European Railway Traffic Management System
FRA	Federal Railroad Administration
g	Standard gravity (9.81m/sec^2)
GO	General Order
HSR	High Speed Rail
HST	High Speed Train
IA	Interagency Agreements
~~LDBE~~	~~Lower-level Design Basis Earthquake~~
LEED	Leadership in Energy and Environmental Design
LOS	Level of Service
LOSSAN	Los Angeles to San Diego operated by the Southern California Regional Rail Authority
MOU	Memorandum of Understanding
MOI~~W~~	Maintenance of Infrastructure~~Way~~
mph	Miles per hour
NCTD	North County Transit District
NEPA	National Environmental Protection Act
NFPA	National Fire Protection Association
NOD	Notice of Determination (CEQA)
OCS	Overhead Contact System
PCJPB	Peninsula Corridor Joint Powers Board
PMT	Program Management Team
PTC	Positive Train Control
RAMS	Reliability, Availability, Maintainability, and Safety
RC	Regional Consultant
ROD	Record of Decision (NEPA)
RPA	Rule of Particular Applicability
SCRRA	Southern California Regional Rail Authority
TAP	Technical Advisory Panel
TPSS	Traction Power Supply System
TSI	Technical Specifications for Interoperability
TOD	Transit Oriented Development
UPRR	Union Pacific Railroad
VHS	Very High Speed

1.0 INTRODUCTION

1.1 PURPOSE OF BASIS OF DESIGN POLICY

This Basis of Design Policy document defines the major components and performance objectives of the California High-Speed Train (CHST) System as envisioned by the California High-Speed Rail Authority (Authority) to support development of the engineering and regulatory basis for the California High-Speed Train Project (CHSTP). Specifically, it focuses on components, objectives, processes, requirements, and assumptions which are governed by Authority policy. The Basis of Design Policy document is considered a living document and will be updated as the California High-Speed Train Project (CHSTP) is further developed and defined. The policies determining processes, standards, and sub-systems of the CHST System are generally divided in this document into:

- Program Implementation
- Performance Requirements
- Infrastructure
- Systems (Electrification, Train Controls, and Communications)
- Rolling Stock
- Maintenance
- Operations

1.2 BACKGROUND

The California High-Speed Rail Authority is the nine-member state governing board responsible for planning, designing, constructing, and operating a HST system that will serve California's major metropolitan areas.

The purpose of the Statewide HST System is to provide a safe and reliable high-speed electrified train system that links the major metropolitan areas of the state, and that delivers predictable and consistent travel times. A further objective is to provide an interface with commercial airports, mass transit and the highway network and relieve capacity constraints of the existing transportation system as increases in intercity travel demand in California occur, in a manner sensitive to and protective of California's unique natural resources.

Following a review of a range of alternatives to meet the growing demand for intercity travel in California, the CHST System Alternative was identified as the environmentally preferred alternative under the National Environmental Policy Act (NEPA), as well as the environmentally superior alternative under the California Environmental Quality Act (CEQA). The studies included the identification of a preferred alignment and station locations. The Authority, in cooperation with the Federal Railroad Administration (FRA), certified the Statewide Final program-level Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) in November 2005, allowing the Authority to begin the implementation of the CHST System. The Bay Area to Central Valley Final program-level EIR/EIS was initially certified in December 2008. Due to a lawsuit, the environmental document was revised and re-released in March 2010 for public review and comment. The Bay Area to Central Valley Final program-level EIR/EIS was certified in September 2010.

1.3 PROJECT DESCRIPTION

The proposed CHST System encompasses approximately 800 route miles and will provide intercity travel in California between the major metropolitan centers of Sacramento, the San Francisco Bay Area, the Central Valley, Los Angeles, the Inland Empire, Orange County, and San Diego. The CHST System is envisioned as a state-of-the-art, electrically powered, high-speed, steel-wheel-on-steel-rail technology, including, state-of-the-art safety, signaling, and train-control systems.

The CHST System will operate primarily on dedicated track with about six to ten percent of the tracks in the route expected to be shared with other passenger rail operations (Peninsula Corridor in the San Francisco Bay area, and potentially the LOSSAN Corridor between Los Angeles and Anaheim). Dedicated high-speed train alignment options for the Peninsula Corridor were evaluated and eliminated from further consideration during the program-level studies

The CHSTP System route will be constructed at-grade, in an open trench, in a tunnels, or on an elevated guideway, depending on the terrain and physical constraints encountered. Extensive portions of the CHST System may lie within, or adjacent to, existing rail or highway rights-of-way (rather than new alignment) to reduce potential environmental impacts and minimize land acquisition costs.

The CHST System will be capable of operating speeds up to 220 miles per hour (mph) and the alignment will be designed for a maximum design speed of 250 mph, where feasible and practicable, on a fully grade-separated alignment with an expected trip time objective from San Francisco to Los Angeles of two hours and forty minutes. Interfaces with commercial airports, mass transit, and the highway network is are provided as part of the CHST System. As the CHST program and sections are developed, updated,, and refined, ridership data will be used to confirm desired system capacity, service levels and frequency of service, and operating plans.

HSR 13-06 - EXECUTION VERSION

2.0 PROGRAM IMPLEMENTATION

2.1 GOVERNING LEGISLATION AND ENVIRONMENTAL DOCUMENTATION

Governing legislation and other legal documentation dictate performance characteristics of the CHSTP. Proposition 1A was passed by the voters of the state of California on November 4, 2008. The following language outlines the requirements from the proposition which have since been added as Chapter 20 to Division 3 of the State Streets and Highways Code:

> *2704.09. The high-speed train system to be constructed pursuit to this chapter shall have the following characteristics:*
>
> *(a) Electric trains that are capable of sustained maximum revenue operating speeds of no less than 200 miles per hour.*
>
> *(b) Maximum nonstop service travel times for each corridor that shall not exceed the following:*
>
> *(1) San Francisco-Los Angeles Union Station: two hours, 40 minutes.*
> *(2) Oakland-Los Angeles Union Station: two hours, 40 minutes.*
> *(3) San Francisco-San Jose: 30 minutes.*
> *(4) San Jose-Los Angeles: two hours, 10 minutes.*
> *(5) San Diego-Los Angeles: one hour, 20 minutes.*
> *(6) Inland Empire-Los Angeles: 30 minutes.*
> *(7) Sacramento-Los Angeles: two hours, 20 minutes.*
>
> *(c) Achievable operating headway (time between successive trains) shall be five minutes or less.*
>
> *(d) The total number of stations to be served by high-speed trains for all of the corridors described in subdivision (b) of Section 2704.04 shall not exceed 24. There shall be no station between the Gilroy station and the Merced station.*
>
> *(e) Trains shall have the capability to transition intermediate stations, or to bypass those stations, at mainline operating speed.*
>
> *(f) For each corridor described in subdivision (b), passengers shall have the capability of traveling from any station on that corridor to any other station on that corridor without being required to change trains.*
>
> *(g) In order to reduce impacts on communities and the environment, the alignment for the high-speed train system shall follow existing transportation or utility corridors to the extent feasible and shall be financially viable, as determined by the authority.*
>
> *(h) Stations shall be located in areas with good access to local mass transit or other modes of transportation.*
>
> *(i) The high-speed train system shall be planned and constructed in a manner that minimizes urban sprawl and impacts on the natural environment.*
>
> *(j) Preserving wildlife corridors and mitigating impacts to wildlife movement, where feasible as determined by the authority, in order to limit the extent to which the system may present an additional barrier to wildlife's natural movement.*

In addition, the Mitigation, Monitoring and Reporting Plans from approved environmental documents will be implemented, including:

- Final Program Environmental Impact Report/Environmental Impact Statement (EIR/EIS)
- Bay Area to Central Valley Final Program EIR/EIS

2.2 PROJECT DEVELOPMENT PROCESS

Project development for the California High-Speed Train system adheres to a prescriptive regulatory process to ensure that issues are assessed, impacts are identified, and mitigation is included in the final project. Included are the fulfillment of the requirements of the National Environmental Protection Act (NEPA) and California Environmental Quality Act (CEQA).

The major milestones in this process are:

- Program EIR/EIS, Conceptual Engineering
- Draft Project Specific EIR/EIS, Preliminary Engineering (15% Design)
- Final Project Specific EIR/EIS
- Preliminary Engineering (~~30% Design~~to support procurement)
- Record of Decision (ROD)/Notice of Determination (NOD)
- Procurement Documents
- Permitting

Following receipt of the Record of Decision from the Federal Railroad Administration (FRA), implementation activities will culminate in the start of revenue service for the California High-Speed Train, including:

- Land Acquisition and Utility Relocation
- Design and Construction
- Testing, Commissioning, and Training
- Start of Revenue Service

2.3 DEVELOPMENT OF TECHNICAL REQUIREMENTS

2.3.1 State and Federal Regulating Agencies

Development of high-speed rail in California will ~~need to~~ address applicable regulatory safety requirements. These include but are not limited to:

- Federal Railroad Administration, 49 CFR Part 200-299
- California Public Utilities Commission (CPUC), General Orders

In order to commence operation and address applicable regulations, the California High-Speed Rail system will need to obtain a FRA Rule of Particular Applicability (RPA)~~,~~ and approval of new General Orders or waivers from existing and applicable CPUC General Orders (GO).

2.3.2 System Design Approach

Due to the complex and high-speed operating conditions, high-speed railways need to be developed from the beginning as a system, integrating all elements to work together in an efficient, safe, and reliable manner. The U.S. has no specific or current guidelines for the development of a high-speed rail system capable of 220 mph operating speeds. However, there is a history of long-term success in the development of the European and Asian HST systems. For the development of the California High-Speed Train Project, it is prudent to consider adaptation of existing and available HST system approaches from Asia and Europe to guide a system design approach, one that meets the requirements of applicable and developing federal and state safety regulations.

2.3.3 Safety and Reliability

Safety and reliability are achieved by the application of proven technical standards commensurate with the specified level of performance. The technical standards must reflect a comprehensive set of proven principles and system requirements to ensure that all aspects of a high-speed rail network are addressed and integrated.

A Reliability, Availability, Maintainability, and Safety (RAMS) plan will be developed consistent with best practices for international high speed rail and *EN 50126, Railway applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*.

2.4 CHSTP System Requirements

The development of design criteria and standards will be based on a proven and accepted set of requirements that provide a safe and reliable high-speed rail system. For existing railroad systems in the U.S. and high-speed rail in Europe and Asia, rail safety requirements are communicated in the form of regulatory statute.

Given the multiple sources to guide CHSTP safety standards, a common platform is needed to compare and relate requirements between U.S. and global HST safety regulations. Regulatory requirements for railroad systems in the U.S. are embodied in 49 CFR Parts 200-299, CPUC General Orders, and European Union's Technical Specifications for Interoperability (TSI) for the trans-European high-speed rail system. Application of the state and federal regulations will ensure that applicable U.S. safety requirements are incorporated into the design and operations of the CHST system. Review and reference of the existing European and Asian ~~–~~high-speed rail regulations will ensure that ~~all~~ system elements necessary for a safe and reliable high-speed train network have been addressed by the CHSTP design and operational requirements. Additionally, as existing regulatory requirements support multiple operational levels, it is necessary to have a CHSTP specific document to identify the performance specifications in which to apply the regulations. ~~.~~

CHSTP regulations must be derived from a common source as regulations are interdependent and exclusion of some regulations or integration of different regulatory systems could lead to unsafe infrastructure and operations. For the CHSTP, a set of CHSTP System Requirements will be developed to provide an integrated and common platform to direct completion of the regulatory documentation, design criteria and other implementation documents

2.5 Design Development

To facilitate the project development process, the project is being developed in geographic regions with a separate design team or Regional Consultant (RC) for each region. Overall design management is provided by a Program Management Team (PMT) to promote~~ensure~~ technical consistency across the CHST System. The PMT is responsible for design of the system-wide elements to meet system performance objectives. The general responsibilities of the Program Management Team and the Regional Consultants, with respect to system and design development, are outlined as follows:

2.5.1 Program Management Team

- Basis of Design
- System Level Design
    - Ridership Forecasts
    - System Capacity
    - Rolling Stock Performance
    - Train Simulation and Dispatch Modeling
    - Traction Power Modeling and Electrification
    - Train Control System
    - Communications System
    - Preliminary Operations Plan
    - Preliminary Maintenance Plan
- Design Manual, including Design Criteria and Standards
    - Track Alignment
    - Stations
    - Bridge / Elevated Structures
    - Tunnels
    - Buildings and Facilities
    - Drainage and Grading

  - Utilities
  - Safety and Security
  - Geotechnical
  - Seismic
  - Traction Power and Electrification
  - Train Control
  - Communications
  - Rolling Stock
- Oversight to ensure technical consistency across the CHST system and conformance with standards
- Procurement of ~~D~~designers, ~~/B~~builders,~~ and O~~operators, and ~~/M~~maintainers
- Coordination and monitoring of testing and commissioning
- Final Acceptance and Recommendation for Start up and Revenue Service

2.5.2 Regional Consultants

- Environmental Technical Studies and Approval, including Project–level EIR/EIS and applicable permits
- Preliminary Engineering (15% Design and Preliminary Engineering to support procurement~~30% Design~~), including preparation of Design Variances where minimum criteria are not achieved.

Design variances from adopted minimum design standards, standard drawings, standard specifications, adopted standards or design guidelines established for CHSTP will go through an extensive review, assessment, approval, and documentation process by the Program Management Team and the Authority.

2.5.3 Design/Builder

- Final Design
- Construction
- Testing and Commissioning

2.5.4 Operator/Maintainer

- Operations Plan
- Maintenance Plan
- Revenue Service

2.6 HST PROJECT SECTION LIMITS

Environmental Approval and Preliminary Engineering for the CHST System will be accomplished by utilizing locally-focused, regional efforts. The section limits for environmental review of the CHST System is as follows (see Figure 1):

- San Francisco to San Jose
- San Jose to Merced
- Merced to Fresno
- Fresno to Bakersfield
- Bakersfield to Palmdale
- Palmdale to Los Angeles
- Los Angeles to Anaheim
- Sacramento to Merced

- Los Angeles to San Diego via the Inland Empire

Although a high-speed connection across Altamont Pass is not part of the currently approved CHST system, Altamont Pass studies are currently in progress as a separate but related effort to review the feasibility of connections between San Jose and Stockton.

Figure 1. CHSTP Preferred Alignment

HSR 13-06 - EXECUTION VERSION

2.7 Coordination with Agencies and Railroad Operators

For those areas where the HST line might enter, intersect or impact the jurisdiction of other owner-operators, the Authority shall establishhas or will establish a statewide memorandum of understandings (MOUs) with the owner-operator for implementation throughout the system. In some cases, Interagency Agreements (IA) shall be established. Owner-operators may include, but are not limited to:

- Amtrak
- BNSF Railway
- Caltrans (California State Department of Transportation)
- Capitol Corridor Joint Powers Authority (CCJPA, governing body for Capital Corridor intercity passenger rail)
- North County Transit District (NCTD, governing body for the San Diego Coaster commuter rail)
- Peninsula Corridor Joint Powers Board (PCJPB, governing body for Caltrain commuter rail)
- San Joaquin Regional Rail Commission (SJRRC, governing body for ACE commuter rail)
- Southern California Regional Rail Authority (SCRRA, governing body for Metrolink commuter rail)
- Union Pacific Railroad (UPRR)

2.8 Cost Estimating

Cost estimates will be updated annually based on the best available information and from the environmental and preliminary engineering studies. Capital cost estimates will include standard values for environmental mitigation, program implementation, and contingency costs. Where required, unit prices will be escalated using standard construction estimating practices. Cost estimate updates will be formally released by the Authority with the issuance of a Business Plan or other formal report.

HSR 13-06 - EXECUTION VERSION

3.0 PERFORMANCE REQUIREMENTS

To meet the travel time and service quality goals of the CHSTP, the Authority has established performance requirements to guide the development of the CHST System.

3.1 SYSTEM CAPACITY AND RIDERSHIP

The California High-Speed Rail system will be developed to accommodate the level of passengers anticipated in the year 2035, consistent with the demand forecast model and a feasible fare structure approved by the Authority.

Computer-based simulation modelling will be used to develop a ridership demand model which considers future population and employment distribution, income growth, transportation networks, travel conditions and patterns, and the speed, frequency and cost of available transportation modes.

The ridership and travel time projections for the CHST System will be updated and refined as the HST route sections are further developed during the project-level environmental and engineering studies. Additional operational modelling efforts will be concurrent with the preliminary engineering studies and will be the primary tool to confirm performance levels of the CHST System.

3.2 DESIGN/OPERATING SPEEDS

The speed criteria for the system are as follows:

- ~~**Maximum**~~ **Design Speed:** The design of the CHST System will incorporate a maximum design speed of 250 mph where cost-effective, practicable, and environmentally feasible.

  In areas of shared-use track, maximum design speed will be 125 mph including:

  - Peninsula Corridor in the San Francisco to San Jose Section
  - LOSSAN Corridor in the Los Angeles to Anaheim Section

  Due to significant topographical constraints, the following areas will apply a maximum design speed of 220 mph:

  - Pacheco Pass - Gilroy to the Central Valley floor
  - Tehachai~~i~~pi Mountains – Bakersfield to the Mojave Desert
  - Soledad Canyon – Sylmar to Palmdale

- **Maximum Operating Speed:** The design of the CHST System will incorporate a maximum operating speed of 220 mph where geometry, operational, and environmental conditions permit.

3.3 TRIP TRAVEL TIMES

Intercity trip travel times are dictated by Chapter 20, Division 3 of the California Streets and Highway Code as referenced in Section 2.1.

3.4 PHYSICAL REQUIREMENTS

The CHST System will meet the following physical requirements:

General

- Electrified Steel-Wheel-On-Steel-Rail very high speed (VHS) system
- Capable of safe, comfortable, and efficient operation at speeds of up to 220 mph
- Passenger comfort (smoothness of ride) with a lateral acceleration equal to or less than 0.05 g for the maximum design speeds as noted in Section 3.2.

HSR 13-06 - EXECUTION VERSION

Infrastructure

- Fully grade-separated track consistent with the draft FRA safety guidance for Tier III HSR operations.
- Fully dual-track mainline with off-line station stopping tracks, unless otherwise determined to not be required.
- Fully access-controlled railway with intrusion detection monitoring systems and intrusion protection systems when adjacent to other transportation facilities and as required.

Traction Power

- Electric traction system – 2x25kV, 60 Hz

Capable of accommodating a minimum of 12 ~~double~~ trainsets per hour per direction ~~, as follows~~

~~9 double trains (16 car trains)~~

~~3 single trains (8 car trains)~~

Train Controls and Communications

- Capable of operating 3-minute headways practical capacity
- Automatic Train Control system targeted to be equivalent to the European Railway Traffic Management System (ERTMS) standard ~~of Level 2~~ with the capability ~~to upgrade to Level 3 or equivalent~~for operating speeds up to 220 mph, subject to FRA approval~~.~~
- Equipped with high-capacity and redundant communications systems capable of supporting fully automatic train operations

Rolling Stock

- Trainsets using a distributed traction power configuration, approximately 660 feet in length capable of coupling to provide 1320-foot long double trainsets during peak operating hours and as required by ridership demand~~.~~
- Approximately 450 to 500 passengers per 660-foot long trainset (900 to 1000 passengers for a 1320-foot double trainset)
- Support an open competitive procurement and not preclude Asian or European manufacturers
- Maximum annual average mileage of 400,000 miles per trainset per year

Operations

- All-weather/all-season operation
- Capable of accommodating normal maintenance activities without disruption to daily operations
- Capable of operating on shared-use tracks (i.e., Caltrain~~,~~ and possibly LOSSAN corridors)

3.5 DESIGN LIFE

A design life will be established for elements selected based on industry best practices. Determination of design life will take into account technology, maintenance cycles, operating and maintenance costs, and other factors.

HSR 13-06 - EXECUTION VERSION

4.0 INFRASTRUCTURE

4.1 TRACK ALIGNMENT

CHST alignments are generally established along or adjacent to existing railroad and highway transportation facilities, where possible, instead of creating new transportation corridors. Alignments will be grade separated at rail, highway, and roadway crossings.

~~The~~ HST technology requires a dual-track mainline system to support the ridership volumes, frequency of service, scheduling flexibility, and delay recovery required for the proposed system.

Unless otherwise documented, the dual-track mainline will be maintained through station areas to allow for run-through or express service. Off-line stopping tracks are provided at all intermediate stations unless otherwise determined to not be required.

4.1.1 Track Structure

The track structure selection includes consideration of conventional ballasted track and non-ballasted track forms (slab track). Selection will be dependent on the alignment configuration, maintenance accessibility, and cost effectiveness.

4.1.2 Intrusion Protection

Conventional trains and highway vehicles sharing corridors with or operating adjacent to CHST will be restrained from intruding into HST operational infrastructure by physical separation, or by a physical barrier where adequate separation is not practical.

Where required, ~~,The~~ an intrusion detection system will be integrated with the signaling system to automatically notify the Operating Control Center and, if required, stop the HST if there has been intrusion into the operating envelope. Where warranted, risk of intrusion will be assessed and mitigated as necessary.

4.1.3 Tunneling

Due to the high cost of tunneling, it is the Authority's goal to thoroughly evaluate and minimize the amount of tunneling needed for the CHSTP. The CHSTP program will consider and document the trade-offs associated with lower grade/longer tunnels versus higher grade/shorter tunnels. Additionally, different configurations (including single or twin tunnels) and types of construction~~,~~ (including bored, cut and cover, and mined tunnels) will be considered and evaluated. Such factors as normal maintenance, emergency access/egress, fire and life safety requirements, vehicle aerodynamics and ~~,~~passenger health, travel time impacts, power usage, costs, construction feasibility, and train operations are to be included in these analyses.

4.1.4 Aerial Structures

~~A consistent approach to simply supported aerial structures will be developed and applied throughout the CHST network. This s~~Structures carrying high-speed trains will be designed to achieve~~address~~ the performance, functionality, safety, serviceability, economic~~y~~, aesthetics requirements defined by the project~~, and structural integrity~~. ~~-~~Development and implementation of ~~A~~ standard, simply-supported structures ~~can~~ may be considered to reduce costs and risk as these may~~nd~~ improve constructability, quality control, ease of maintenance, and system integration.

4.1.5 Corridor Grade Separation

Consistent with FRA preliminary guidance, ~~T~~there will be no at-grade vehicular ~~at-grade~~ crossings permitted on the CHST System where ~~design~~operating speeds exceed 125 mph~~ so as to support the safety and performance requirements~~. For areas where design speeds are 125 mph or less and where there is shared-use track (see ~~s~~Section 4.2.2), grade crossings may be considered consistent with FRA preliminary guidance for mixed fleet operations.

Grade separations projects required for the CHST System will be a high priority, particularly those grade separations projects that affect other existing and planned rail and road facilities. Early implementation of the grade separation projects can may improve local safety, circulation, and reduce air pollution and noise impacts.

4.1.6 Seismic Design Reliability

The primary structural seismic performances goals are to safeguard against catastrophic failures, loss of life, and prolonged interruption of operations due to structural damage. To address reliability for structures supporting high-speed trains, the seismic design criteria uses a hybrid probabilistic-deterministic approach using industry best practices. Two design earthquakes and performance levels are used:

The Maximum Considered Earthquake (MCE) is the maximum of the probabilistic 950 year return period event, or the site-specific deterministic event based upon the maximum rupture of any fault(s) within the vicinity. The main performance goal for the MCE is no collapse. Significant damage may occur which requires extensive repair of replacement. Occupants not on trains are able to evacuate safely. Damage and collapse due to Potential for train derailment will be mitigated through structural design. If derailment occurs, train occupants are able to evacuate derailed trains safely.

The Operating Basis Earthquake (OBE) is the probabilistic 50 year return period event. The main performance goals for the OBE are elastic response with no spalling, limits to structural deformation to minimize the probability of derailment and excessive rail stress, trains to safely brake from the maximum design speed to a safe stop, and train occupants to evacuate stopped trains safely.

At hazardous fault zones, the alignment depends upon the dominant direction of fault displacement.

Where the dominant displacement is lateral, the alignment shall consist of at-grade track, oriented as near to perpendicular as feasible to the fault trace, in order to minimize the fault zone length beneath the alignment. For at-grade fault crossings, additional mitigation measures include providing an increased right-of-way. The width of right-of-way shall anticipate damage to adjacent embankments and retaining walls provide separation between the tracks and improvements, provide access for emergency rescue, and add flexibility for realignment and reconstructive work.

Where the dominant displacement is vertical, the alignment shall consist of a structural solution in the form of an elevated or tunnel structure. For such structures, design mitigation strategies include those that provide seismic isolation/dissipation, increase large displacement compatibility, provide access for emergency rescue, accommodate track realignment, and facilitate reconstructive work.

Oversight by a Technical Advisory Panel (TAP) provides an independent assessment of technical issues during development of the project's seismic criteria. The panel is represented by multiple technical disciplines with recognized technical expertise and practical experience in seismic design. The seismic design criteria associated with the MCE and OBE has been will be reviewed with the TAP., and meets or exceeds the criteria of Caltrans, the Transportation Safety Institute, and the Railway Technical Research Institute of Japan.

A system-wide risk evaluation may be performed as a means to further assess and mitigate risk. A likely product of this risk evaluation would be the inclusion of a third design earthquake, with return period of approximately 500 years, and performance goals of repairable damage resulting in temporary service suspension while short term repairs to structure and track components are made.Seismic design will use a hybrid probabilistic-deterministic approach with oversight by a Technical Advisory Panel (TAP) and will implement industry best practices. A system-wide risk evaluation will be performed to assess and mitigate risks.

Oversight by a Technical Advisory Panel will provide an independent identification and assessment of technical issues during development of the project's seismic criteria. The panel will be represented by multiple technical disciplines with recognized technical expertise and practical experience in industry's

HSR 13-06 - EXECUTION VERSION

~~best practices pertaining to seismic design. The panel will meet at periodic intervals during the preliminary engineering phase to review the reasonableness of the expected structural performance levels, and assist in development of a hybrid probabilistic-deterministic seismic approach and review of seismic design criteria for the high-speed rail system.~~

~~Continuing safe revenue operation of the CHST System during and after a strong seismic event is a priority of the Authority. Because of the high likelihood of major seismic activity during the life of the facility, preventive measures will be made to avoid an unnecessarily long shut-down of the system after a major earthquake and to avoid catastrophic failure during such an event. To this end, in the determination of the horizontal and vertical alignment, it is desirable to cross fault zones at-grade without structures at fault crossings where mitigating designs can be more cost-effectively employed. Faults shall be crossed perpendicular to reduce the extent of damage. The system will also be designed to withstand smaller, more common earthquakes without impact to passenger safety or service interruption.~~

~~The goal of the CHSTP, in terms of structural performance during a seismic event, is to safeguard against major failures, loss of life, and to prevent a prolonged interruption of CHST System operations caused by structural damage. In order to achieve this, the following three seismic performance levels are under consideration.~~

~~Ensure that the CHST System facilities are able to undergo the effects of the Maximum Considered Earthquake (MCE) without collapse although significant repairs will be necessary.~~

~~Ensure that CHST System facilities are able to undergo the effects of the Design Basis Earthquake (DBE) without collapse and that damages are repairable. Train operations can resume immediately or within a reasonable amount of time.~~

~~Ensure that the CHST System will be able to operate safely, at the maximum operating speed when subjected to the Lower-level Design Basis Earthquake (LDBE).~~

~~The ground motion criteria and probabilistic-deterministic levels associated with the MCE, the DBE, and the LDBE will be established and reviewed by the TAP. These performance levels will be compared to other rail and high speed rail seismic design criteria and meet or exceed guidance criteria by Caltrans, Transportation Safety Institute, and the Railway Technical Research Institute of Japan.~~

4.2 STATIONS

It is the Authority's objective to minimize impacts associated with growth by selecting multi-modal transportation hubs as potential CHSTP stations. These locations will maximize access and connectivity, and facilitate transit oriented development (TOD). The CHST System will be ~~compatible~~ coordinated with local and regional plans that support rail systems and TOD, offering opportunities for increased land use efficiency. Intermodal connectivity with local and regional transit, airports, and highways will also be supported.

The specific station configuration will be defined as necessary to accommodate train and passenger volumes and frequency required to serve the forecasted demand. Overall station size will also consider access facilities, parking facilities, and passenger facilities.

Stations and station areas will be designed to reflect the surrounding natural and manmade landscape yet include some CHSTP standardized elements, including signage and graphics, fare collection and train boarding process, ticket sales office location and configuration, and communications systems, in order to provide a consistent image for the system.

Where applicable, stations and maintenance facility buildings will target sustainable designs in accordance with guidelines established for Leadership in Energy and Environmental Design (LEED) "Silver" or better.

4.2.1 Terminal Stations / Intermediate Stations

Terminal stations are those ~~where a revenue service trip originates and/or~~located at the "end points" of the HST system, ~~ends~~ and where all trains are planned to stop upon arrival and perhaps lay-over during non-peak periods. ~~Terminal stations are generally located at the "end points" of the HST system.~~ Los

Angeles is the exceptionatypical because it is both terminal (some trains originate and end a revenue service trip and all trains stop upon arrival) and a run-through intermediate station (most some trains will run through to Anaheim or San Diego)

The following stations are designated as terminal stations:

- Sacramento
- San Francisco
- Los Angeles (both Terminal and Intermediate)
- San Diego
- Anaheim*

Intermediate stations are defined as "line" stations providing service along the dedicated CHST route and located between San Diego, Anaheim/Irvine, Sacramento, and San Francisco. The following stations were designated as possible intermediate stations:

- Stockton
- Modesto
- Merced (potential Terminal Station for Phase 1)
- Millbrae/San Francisco Airport
- Redwood City or Palo Alto
- San Jose
- Gilroy
- Fresno
- Kings/Tulare Regional
- Bakersfield
- Palmdale
- Sylmar
- Burbank
- Norwalk or Fullerton
- City of Industry
- Ontario Airport
- Riverside
- Murrieta
- Escondido
- University City

The station locations and alignments are under review and final number of stations and locations will be confirmed consistent with the requirements of Proposition 1A (now embodied in Chapter 20 to Division 3 of the Streets and Highways Code, see also Section 2.1 of this document)

* The Authority has not precluded the potential for a future extension to Irvine.

4.2.2 Shared-use Tracks

It may be possible to integrate the CHST System into existing conventional rail lines in congested urban areas subject to resolution of potential equipment and operating compatibility issues and working in cooperation with the FRA. Preliminary FRA guidelines for mixed fleet or 'blended' operations for conventional passenger, freight, and high-speed passenger services.

Some stations in this type of shared-use condition may accommodate both the conventional rail services and the CHST System. Shared-use stations may occur in the following rail corridors:

- **Peninsula Corridor:** Corridor between San Francisco and San Jose, operated by the Peninsula Corridor Joint Powers Board, providing Caltrain commuter rail service. Temporally or physically separated freight service will be operated in this corridor.
- **LOSSAN Corridor:** The section between Los Angeles and Anaheim, dispatched by the Southern California Regional Rail Authority (SCRRA) and owned by BNSF Railway in Los Angeles County and OCTA in Orange County, supports Metrolink commuter rail service, passenger service by Amtrak, and freight by the Burlington Northern Santa Fe (BNSF) Railroad. It should be noted that while freight service is provided in the LOSSAN Corridor, freight and CHST service will generally operate on separate tracks or with temporal separation in limited locations.

4.2.3 Passenger Facilities

The configuration of station passenger facilities will depend upon many variables including, station location, ridership demand, interaction with intermodal connections (if available), mix of trip purposes served, local land use, and building code requirements. The development of passenger facilities will also consider the need for waiting areas, concourses, ticketing, restrooms, safety and security, as well as other support services.

Passenger tickets may be purchased in person at stations potentially with staffed ticketing booths, at a ticket vending machine at the station, or by phone or internet. Ticketing procedures will encourage use of pre-purchased tickets and automated ticket vending machines thereby reducing the need for ticketing booths.

CHSTP will not have formal~~ized~~ baggage handling. Luggage storage facilities shall be considered at stations for passenger convenience.

~~Only b~~Basic concessionary spaces will be included in pre-procurement designs.

4.2.4 Station Security

Station security will be commensurate with station security on existing high speed rail networks in the USA, Europe and Asia. Unless otherwise exempted, the CHST System will conform to the current Federal requirements regarding transportation security as developed and implemented by the FRA and TSA.~~.~~

4.2.5 Track and Platform Configuration

Station platforms are planned for a length of approximately 1400~~10380~~ feet to accommodate a range of existing high-speed trainsets.

Intermediate station platform configurations must ensure customer safety as trains may operate through or in proximity to the station area without stopping. Platform layout and station operations will ~~look to~~ mitigate potential hazards and noises from trains running through the station at high-speeds. Turn~~-~~outs to stations will be designed to maintain headways and allow efficient train operations by not slowing or stopping following trains. Because of this, intermediate station platforms will:

- Provide off-line passenger platforms allowing for pass-through express services on the dual-track mainline.
- Provide side platforms with center running tracks as the desirable configuration for operational considerations.

Terminal stations may have center or side platforms based on the specific station. Center platforms have two platform "edges" with a track on each side to allow boarding and alighting on either side from either of the two tracks. Because all trains will stop at terminal stations, there is no need to mitigate issues created by ~~a~~ fast-moving through trains.

4.2.6 Station Area Amenities

Design of the station site and surrounding area will adhere to the Authority's Adopted "HST Station Development Policies" (May 14, 2008), which states that that the Authority will encourage the following development patterns: higher density development in relation to the existing land uses; a mix of land uses and housing types; compact, pedestrian-oriented design; context-sensitive buildings; and limits on the amount of parking for new development and a preference for structured parking.

The full "HST Station Development Policies" can be found on the Authority's website at:

http://www.cahighspeedrail.ca.gov/images/chsr/20080605123121_Station%20Policies.pdf

4.2.6.1 Intermodal Connectivity

Station area amenities ~~shall~~ will be designed with a focus on convenience and ease of transfer to and from the CHST System and to other modes of transportation.

Development of station areas requires a hierarchy between modes of access and egress: Pedestrians will have~~th~~ the highest priority, followed by public transit, bicycles, pick-up and drop-off, and ~~finally~~ park-and-ride. In addition~~ to this~~, modes ~~shall~~ will be integrated ~~while preserving safety~~ in order to make the station site an active place.

Level of service for all modes within a CHST station area will be commensurate with best practices for high-speed train stations.

Facilities for other transportation operators including right-of-way, parking spaces, offices, information booths and layover space will be provided based on the terms of memorandums of understanding as outlined in Section 2.7.

4.2.6.2 Parking

The Authority will oversee conceptual design and environmental clearance for parking facilities at each of the stations. However, the parking facilities will be constructed and operated by others, with parking offered at market rates.

4.2.7 Postal/Mail Capabilities

The CHST system infrastructure could be used to carry small packages, parcels, letters, or any other freight. Such a system may utilize dedicated trains and distribution facilities. The postal system would operate during CHSTP service hours using potentially available capacity and without impacting passenger revenue service.

4.3 UTILITIES

Utility construction and location within the high-speed rail right-of-way ~~shall~~ will be related directly to the design, construction, and operations of CHSTP and ~~shall~~ will not be used by utility agencies/owners for betterments to existing facilities. Betterments are the responsibility of the utility owner.

4.3.1 Right of Way Encroachment

An encroachment is defined as a structure or object that is within the high-speed rail right-of-way and is not a CHSTP facility. CHSTP policy is to exclude public and private utilities from being located within the access controlled high-speed rail right of way where possible.

Existing longitudinal utilities located within the existing or proposed right of way shall be relocated to the outside of the CHSTP right of way, unless otherwise determined by the Authority.

New utility installations, and adjustments or relocation of existing utilities, will be permitted to transversely cross the Authority right-of-way, subject to review and confirmation that no there are no adverse effects on the safety and reliability of the high-speed rail system.

5.0 SYSTEMS

5.1 ELECTRIFICATION / TRACTION POWER SYSTEM

The traction power supply system (TPSS) will be a 2 x 25kV autotransformer system with center-feed and/or single-end feed segments, utilizing supply stations that have utility supply circuits, switching stations with autotransformers, and paralleling stations with autotransformers. The TPSS will be able to support the ultimate level of service (LOS) proposed without degradation when a single power supply system component is out of service.

Design of the TPSS will be developed using a system-wide, computer-simulated traction power model based on the ridership demand forecast and supporting train timetable for the CHST System. The model will identify the electrification requirements for confirming the size and location of supply stations, switching stations, and paralleling stations.

An auto-tensioned Overhead Contact System (OCS) will distribute electric power to rolling stock. The OCS may be a simple two-wire system supported by cantilevers and attached to track-side poles, (and/or gantries or headspans).

Traction power return system will return traction power supply current to the center tap of the autotransformers at supply, switching, and paralleling stations.

5.2 TRAIN CONTROL SYSTEM

The train control system will safely support the ultimate level of service proposed for the grade-separated CHST System and will address the following:

- Train maximum operating speed of ~ 220 mph (350 kph) maximum
- Safe braking criteria in exclusive HSR dedicated guideway
- Safe braking criteria for the Caltrain and LOSSAN segments, considering other railroads trainset technologies on shared-use tracks
- Compatibility with shared-use track train control equipment specifications
- System operations plan requirements
- Design headway of 3 minutes practical capacity

The CHSTP ATC (Automatic Train Control) system will adopt a collision avoidance approach by employing Positive Train Control (PTC) to significantly reduce the risk of collisions between trains and maximize overall system safety by focusing on the key train control and signaling functional requirements. The CHSTP ATC system will include, but not be limited to, the elements of precise train location detection,, safe train separation, worker protection, and automatic train stop enforcement in the event of overspeed, system failure, or other incident..

The CHSTP ATC system will be fully coordinated with the FRA in terms of the technical development and implementation.

5.3 COMMUNICATIONS

The CHST System will have a central Operational Control Center (OCC) for supervisory monitoring and control and monitoring of the CHST system operations.

The system will have redundancyies through ERTMS Level 2 or 3 and be capable of supporting fully automatic train control.

The OCC is envisioned to be co-located with the main repair and heavy maintenance facility, with supporting Regional Control Centers (RCC) established as needed to support operation control and provide system back-up.

HSR 13-06 - EXECUTION VERSION

6.0 ROLLING STOCK

The CHST vehicles will be steel-wheel-on-steel-rail very high-speed (VHS) technologies, using distributed power cars and a catenary capable of revenue service operating speeds of 220 mph (354 kph). The trains must be capable of integrating into existing conventional rail lines where shared-use is expected to occur in the Caltrain corridor and potentially in the LOSSAN corridor. Performance objectives for the HST trainsets include:

- Capable of revenue service operating speeds of 220 mph (354 kph)
- 900 to1000 passengers per double trainset capacity (1320 foot length)
- Pressure-sealed trainsets to maintain passenger comfort and safety regardless to mitigateof aerodynamic changes along the line
- Level boarding at stations
- Compliant with U.S. Americans with Disability Act requirements

In order to minimize costs, facilitate competition, and take advantage of service proven global technology, the Authority is seeking to utilize currently available high-speed train technology on the California high-speed rail system.

Until final selection of the trainset technology, the CHSTP will move forward with the design of infrastructure elements such as alignment, track design, stations, electrification, etc. in a manner that will accommodate high speed trainsets from different manufacturers expected to be capable of 220 mph revenue service speeds by the year 2015.

HSR 13-06 - EXECUTION VERSION

7.0 TRAIN STORAGE AND MAINTENANCE FACILITIES

7.1 VEHICLE STORAGE AND MAINTENANCE

Fleet storage, cleaning, servicing, inspection, maintenance, and repair requirements will be supported at three types of facilities that are defined as follows:

- Overnight layup and storage facilities (Level 1/2) which provide in-service inspection, cleaning and maintenance (locations in proximity to San Diego, Los Angeles/Anaheim, San Francisco, and Sacramento terminal stations, and possibly Merced Station during Phase 1)
- Periodic inspection facilities (Level 3) which provide in-service maintenance and periodic inspections (locations in proximity to the Los Angeles/Anaheim and San Francisco terminal stations, and potentially the San Diego terminal station)
- Heavy maintenance and rehabilitation facility (Level 4/5) which provides in-service maintenance and periodic inspections in addition to programmed overhauls, accident repair and design modifications (one location, on main trunk line between Merced and Bakersfield)

7.2 MAINTENANCE OF INFRASTRUCTUREWAY

Facilities will be provided for the storage of maintenance-of-way infrastructure (MOIW) equipment at appropriately-spaced intervals. The MOIW facilities include areas for the storage of extra parts and inventories associated with the track way and systems, and areas for associated MOIW personnel facilities.

MOIW facilities may be combined with vehicle maintenance facilities and/or stations where feasible and appropriate.

HSR 13-06 - EXECUTION VERSION

8.0 OPERATIONS

8.1 SERVICE DESCRIPTION

The CHST System will be developed in a manner capable of accommodating a wide range of service types, from express services between northern and southern California to localized regional trips. The types of services in the operating pattern for both Phase 1 and Full Build Service Plans include:

- **Express service:** Serves San Francisco to Los Angeles/Anaheim only. Skips all intermediate stations, offers the fastest trip time between San Francisco and Los Angeles, generally limited to morning and afternoon peaks. Express trains may include a single stop in San Jose.
- **Limited-stop service:** Skips selected stops along a route, offers some of the trip time benefits of express-style service to intermediate stations as well as the major terminals.
- **All-stop service:** "Local" trains that make all stops along a particular route section, ensures direct service to and from all stations on the network.

8.2 HOURS/DAYS OF OPERATION

The CHST System will operate seven days a week. The hours of operation are assumed to be from 5:00 a.m. to midnight .(revenue service begins at 6:00 a.m.).

8.3 MODELING EFFORT

Operations will be confirmed using computer-based modelling including simulated intercity travel times and operating speeds. Optimal theoretical trip time targets will be developed using a computer-based train performance calculator (TPC), providing speed profiles depicting performance of single trains between specific locations on the system, including stations. Train performance calculations will use published train set performance specifications for the assumed trainset and alignment attributes as included in the environmental assessment. Unique geometric parameters, infrastructure configurations and identified operating restrictions will be applied.

Conceptual service plans will be developed and updated as required for both the Phase 1 System and the Full Build System based on ridership demand forecasts. Infrastructure design and construction, rolling stock acquisition, and operating plans will take into account a range of interim and future operating scenarios and conditions.

8.4 SAFETY/SECURITY

The CHST will incorporate or exceed the best practices in HST network safety and security commensurate with HST systems around the world. Unless otherwise exempted, the CHST system will conform withto United States Federal, State, and Local governing rules requirements and regulations.

In the areas of dedicated HST service, Tthe CHST System will be a fully grade-separated and fully access-controlled with intrusion monitoring, detection and protection, as required and consistent with FRA guidelines.

The CHST System will incorporate climatic and seismic monitoring facilities that include automatic train protection when climate or seismic events exceed specified thresholds of operational safety.

8.5 SHARED USE/COMPATIBILITY ON TRACKS

In order for the CHST system to operate under shared use with other passenger traffic, the CHSTP train sets and train control system will be developed in consultation with the FRA.

HSR 13-06 - EXECUTION VERSION

Under no circumstances is it to be considered that the HST system will operate over conventional freight lines and freight trackage. ~~Shared-use operations with conventional freight traffic will be avoided through the use of physical or temporal separation.~~

HSR 13-06 - EXECUTION VERSION