California High-Speed Train Project

TECHNICAL MEMORANDUM

Terminal and Heavy Maintenance Facility Guidelines
TM 5.1

Prepared by: *Signed document on file* _25 AUG 2009_
James Campbell and Yu Hanakura Date

Checked by: *Signed document on file* _25 AUG 2009_
Paul Mosier, O & M Manager Date

Approved by: *Signed document on file* _25 AUG 2009_
Ken Jong, Engineering Manager Date

Released by: *Signed document on file* _25 AUG 2009_
Tony Daniels, Program Director Date

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Prepared by PB

for the California High-Speed Rail Authority

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5.0 GUIDELINES FOR FACILITY DESIGN AND LOCATION

This section presents guidelines associated with the design basis and location of overnight layup and inspection and maintenance facilities, and the Heavy Maintenance Facility (HMF) for the CHSTP. These guidelines were developed after extensive review of maintenance and inspection protocols in practice on the French and Japanese HST systems and detailed operational analysis for the proposed California HST project. A separate Technical Memorandum entitled "Maintenance of Way Facilities – Site Locations and Layouts", TM 5.3 is being prepared to provide guidance associated with requirements for Maintenance of Way bases on the CHSTP. In comparison to the guidelines previously provided in the engineering criteria during the CHSTP programmatic phase, many of the key maintenance and inspection protocols used on the French and Japanese HST networks that are unique to HST systems were not entirely known at that time and not fully represented in those earlier concepts. Having developed a better understanding of the proposed HST operations and the maintenance requirements, the information recently developed from the HST systems in operation in Europe and Asia, contributed to the application of refinements to these concepts and the associated facility footprints for the overnight layup, inspection and maintenance facilities and the HMF proposed for the CHSTP. To present this information, this section is organized as follows:

- Facility Types and Function: describes the levels of inspection and maintenance required for the HST, the frequency of the inspections and maintenance, and proposed location (in reference to terminal stations proximity) for the types of facilities and the HMF.
- Facility Footprint and Site Guidelines: describes the approximate size and support requirements based on the level of service required at each terminal and for the HMF.

The guidelines presented in this memorandum are consistent with the maintenance functions and requirements described during the programmatic phase but are updated with considerably more detail and additional maintenance protocols. In addition, the recommended size, location(s) and appropriate support functions for the overnight layup facilities have been modified based on current information developed for CHSTP forecast service levels and improved knowledge regarding inspection and maintenance best practices.

It is important to emphasize the importance of the HMF as an integral component of the CHSTP. Specifically, this facility is assumed to support the assembly, testing and commissioning of the train-sets as they arrive from the manufacturer prior to the start-up of Phase 1 operations and then transition to the full operation of a "typical" HST heavy maintenance workshop. During its useful life, the HMF may support the following examples of facility functions:

- Assembly
- Testing & Commissioning
- Train Storage
- Inspection
- Maintenance
- Retrofitting
- Overhaul

The relative importance of the HMF inspired a thorough review of the practices and procedures that will affect its size, location and design. As such, this section also describes key reasons that influenced the proposed size and functions of the HMF and why it is assumed for this facility to support assembly, testing and commissioning of trains as well as start-up operations.

5.1 FACILITY TYPES AND FUNCTIONS

It is proposed that the CHSTP proceed with an approach founded on the principles of the five-level maintenance and inspection protocols used by the SNCF (French National Railway) for HST operations. This approach also considers certain elements of the Japanese maintenance philosophy and, where appropriate, is modified to conform with the fundamental safety principles associated with the inspection and maintenance of rolling stock (as enforced by the Federal Railroad Administration (FRA) and as concerns the expected applicable provisions of the Code of Federal Regulations that will be included in the CHSTP Rule of Particular Applicability. This five-level classification "system" was identified as the most straightforward method for defining and applying established and proven inspection and maintenance protocols that can be easily referenced in describing the functions and services required at each CHSTP facility. As an initial step in describing what activities are proposed for each level of the CHSTP, a summary table is provided below.

Level of Inspection And Maintenance	Description
Level 1	Daily pre-trip inspections and testing. This level is carried out primarily by the operators before departure. This inspection checks the pantographs, bogies, brakes and includes restocking perishables and expendables. This level also consists of enroute and in station inspections, as well as monitoring by the automatic on-board and on-ground sensors. It includes visual inspections of the onboard train control systems and components. This level is similar to the current daily (or calendar day) inspections described in the US CFR-49.
Level 2	This level includes verifications, tests, quick replacement of components that can be replaced directly on the train set, and short-duration interventions that can usually be carried out quickly at a specialized site either near a terminal station or at a layup or maintenance facility.
Level 3	Level 3 is a standard periodic inspection regimen similar in principle to those performed every 30/45/60/90 days by FRA regulated railroads in the U.S. This inspection requires more specialized equipment and a larger maintenance facility than provided for the level 1 and 2 inspections. The functions of this inspection and maintenance level includes examining the interior fittings and all parts situated in the immediate environment of the passengers, bogie and underbody inspections and replacement of bogies if necessary. Tests, verifications and checks are performed that identify necessary adjustments or the replacement of onboard service "modules". This includes a detailed component inspection of the train control system and replacement of parts as necessary.
Level 4	This level includes component and train set overhauls, similar to the "Class A", mid-life overhauls currently performed in the U.S. This work is done exclusively at the HMF.
Level 5	Special inspections and/ or repairs associated with mechanical failures or accidents. Level 5 also includes application of major design modifications necessary to increase equipment reliability, safety and/or passenger comfort. All level 5 work occurs at the HMF.

The Levels (i.e. 1,2,3,4,5) of inspection and maintenance vary for each terminal layup/storage yard facility included in the CHSTP based upon location and train storage capacity requirements. The Levels of maintenance and inspection are performed in three facility types or categories:

- Overnight Layup Facility – Provides Level 1 and 2 maintenance and inspections
- Periodic Inspection Facility – Provides Level 1 to 3 maintenance and inspections
- HMF (Heavy Maintenance Facility) – Provides Level 1 to 5 maintenance and inspection, including overhauls and component refurbishment.

A review of SNCF best practice and a lesson learned from the implementation of the KTX HST System in Korea identified the need for the HMF to provide the capability for new fleet delivery, assembly, testing, and storage prior to start-up of revenue service. It is concluded that this facility will be located somewhere "central" to the CHSTP system and initially be connected to a "high-speed" double track segment for testing, acceptance and commissioning. The required length of this test track segment is estimated to be between 79 miles and 105 miles and is based upon current high speed train manufacturers' recommendations for testing and commissioning which includes a protocol for sustained running for ten minutes at either 360 kph or 390 kph (these are design speeds that are higher than in-service maximum speeds i.e. 350 kph).In order to operate the train at these speeds the also requires a tangent (straight) alignment for the aforementioned distances. This standard testing, acceptance and commission procedure requires the significant distances due to:

- 360 kph scenario (total 79 miles of straight, high speed double track)
    1. Acceleration to 360 kph is achieved at 23 miles
    2. Sustained running at 360 kph for ten minutes requires 37 miles
    3. Deceleration from 360 kph requires 3 miles
    4. 25% contingency for variability = 16 miles
- 390 kph scenario (total 104 miles of straight, high speed double track)
    1. Acceleration to 390 kph is achieved at 39 miles
    2. Sustained running at 390 kph requires 41 miles
    3. Deceleration from 390 kph requires 4 miles
    4. 25% contingency for variability = 21 miles

Preliminary operating plan analysis for Phase 1 (as presented in Technical Memorandum, TM 4.2 Phase 1 Service Plan dated November 20, 2008,) of the CHSTP system between Anaheim, Los Angeles and San Francisco identified the need for a Level 1,2 and 3 facility (one site) in both northern and southern California to provide daily inspection and maintenance functions, support the periodic inspection program and provide wheel re-profiling capability.

A similar operating plan analysis for the CHSTP Full System Build-Out (as presented in Technical Memorandum 4.3 , High Speed Train Service Plan – Full Build Network with Links to Sacramento and San Diego dated January 14, 2009) revealed that additional overnight layup/storage facilities to support Level 1 and Level 2 daily inspections and cleaning will be needed close to the "end points" of the branch line extensions to Sacramento and San Diego. The San Diego facility will also be required to support Level 3 inspection and maintenance protocols

In summary, it is concluded that:

- The HMF will be implemented so as to be available to support assembly, testing, acceptance and commissioning prior to start up of revenue service for Phase 1.
- The HMF will support inspection/maintenance Levels 1,2,3,4 and 5 and the desired location is on the main trunk line of the system, centrally located and positioned to connect directly to a double track test segment for purposes of acceptance testing as described above.
- The layup/storage facilities in proximity to San Francisco and Los Angeles (including capacity for Anaheim trains) will support inspection/maintenance Levels 1, 2 and 3 during Phase 1 of the CHSTP. If Anaheim is a "stand alone" separate facility (from Los Angeles) it (Anaheim) will support only Levels 1 and 2

- The layup/storage facility in proximity to San Diego in the Full System Build-Out will support inspection/maintenance Levels 1,2 and 3
- The layup/storage facility in proximity to Sacramento will support inspection/maintenance Levels 1 and 2

5.2 FACILITY FOOTPRINT AND SITE REQUIREMENTS

Based on the proposed maintenance levels presented in Section 5.1 and the results of the operations analysis conducted for the Phase 1 and Full Build-Out service plans, site guidelines related to the type, capabilities, capacities and size of each layup/storage inspection and maintenance facility have been developed and are presented in this section.

It should be noted that these are guideline-level recommendations, which the Regional Teams are encouraged to follow in designing these facilities resident on their segment of the CHSTP. The proposed configuration requirements, design components and equipment types that are anticipated to be required at each type of maintenance facility are summarized below:

Level 1, 2 & 3 Facilities

- Storage tracks (guidelines described in 5.2.1)
- Enclosed inspection tracks (guidelines described in 5.2.1)
- Exterior train washing machines
- Automated wheel inspection machine
- Wheel truing/re-profiling machine(s) (Level 3 only)
- Heavy duty interior cleaning platform(s)
- Toilet servicing system
- Inspection “pit” tracks
- Traction power inspection
- Sanding system replenishment
- Inspection/maintenance crew support facilities
- Operation crew support facilities
- Yard traffic control tower

Level 4 & 5 Facilities

Equipment and components provided for Level 1, 2 & 3 facilities, plus:

- Layup/storage tracks
- Detailed bogie inspection/maintenance facility
- Train exterior workshop facility
- Electric components inspection/maintenance facility
- Heavy machinery
- Machining tool facility

5.2.1 Facility Guidelines

This section describes the basic requirements definition criteria and guidelines on the dimensions and physical characteristics for each type of facility to be considered in the design and site identification for the layup/storage, inspection and maintenance facilities.

Layup Tracks

The configuration, capacity and length of the tracks in the layup/storage area of the facilities is based primarily on the number of train-sets identified in the operating plan that are required for morning start-up of daily service at each terminal (i.e. San Francisco, Los Angeles, Anaheim for phase 1, etc.).

Minimum length of tracks are assumed to conform with a "standard" train set (400 meters) plus 7-8 percent (additional 15 meters for 200-meter and 30 meters for 400-meter train sets, respectively) to allow for a safety "buffer" on either end of a parked train and to accommodate access between the trains for maintenance personnel.

A walkway between yard tracks is necessary to provide access to trains for operating crews and cleaning, inspection and maintenance personnel. The walkways should be of sufficient width to:

- Allow crews to access trains safely
- Allow maintenance employees to efficiently transport tools and maintenance and repair materials
- Allow cleaning/inspection/ maintenance employees to work safely on the trains
- Provide access to trains for commissary servicing (restocking food and beverages etc.)
- Allow clearance for an electric "cart" type vehicle to use the toilet servicing system

In addition, it is assumed that the following items will be considered in the facility designs:

- Adequate lighting throughout the layover section for safety and security
- Catenary positioned over a layup track will have the capability of being isolated; turned on and off to perform inspections and maintenance
- A double-sided (one track on each side) full train length platform fully equipped to perform heavy-duty interior car cleaning

Level 1, 2 and 3 Inspection and Maintenance Tracks

Tracks that are designated for programmed inspection and maintenance activities are assumed to be enclosed and protected against the elements for crews, vehicles, and components of the vehicles. Trains on these tracks will be accessible from both sides and aisle ways should be wide enough to accommodate an electric powered cart to transport tools and spare parts. If possible, inspection tracks facing the side of a building should have an aisle with extra width to accommodate special maintenance that may require larger equipment and/or vehicles (i.e. forklifts etc.)

Inspection tracks equipped with pits are assumed to be well lit for inspection and maintenance on the vehicle undercarriages and deep enough to provide sufficient vertical clearance for crews to work on a train while in a full upright, standing position. It is important that a roof platform be provided and equipped with fail-safe protection against high-voltage associated with overhead catenaries. In addition, platforms of sufficient height for train crews and cleaning crews to board and alight from the train, multiple toilet dumping connections on each equipped track, and adequate electrical utilities in the aisle and pit areas should be provided.

Level 4 and 5 Heavy Inspection and Maintenance Tracks

The fundamental facility requirements to support Level 4 and 5 inspection and maintenance activities should include:

1. An adequate number of heavy lifts capable of lifting vehicles for disassembly and inspection.
2. An adequate number of storage tracks to store train sets before, during and after the heavy maintenance process.
3. Switching tracks to allow vehicle rearrangements and switching moves within the facility.
4. Support facilities in the workshop designed to a size suitable to address the type of maintenance and repair required.
5. The test track segment previously described of between 79 miles to 105 miles in length will ultimately become part of the CHSTP system main trunk line for revenue service.

A detailed description of the specific guidelines for a Level 4 and 5 facility is provided in the following section.

5.2.2 Heavy Maintenance Facility (HMF) Guidelines

The maintenance capabilities attributable to the Level 4 and 5 (in addition to Levels 1,2,3) HMF are significantly enhanced when compared to the previously described overnight layup/storage facilities that support daily cleaning, inspection and maintenance. In addition to providing for Level 1, 2 and 3 maintenance and inspections activities, the HMF supports the requirements associated with assembly, disassembly and complete rehabilitation of the train fleet and all on-board components of the train-sets.

Service Capability and Sub-Facilities

The HMF requires “specialty” shops for specific equipment components and inspection/maintenance activities including a:

- Bogey shop: for disassembly and assembly of bogies to provide detailed inspections and rehabilitation of components, including wheel sets and bogey frames
- Vehicle assembly shop: for disassembly and assembly of the major mechanical and electrical components of the train-sets where a full range of tests and diagnostics after re-assembly are performed. This shop includes overhead cranes and heavy lifting equipment to facilitate vehicle assembly and disassembly
- Body shop: for maintenance and treatments of car bodies, including exterior painting and extensive cleaning; maintenance on certain large components that are attached to the vehicle body are also performed
- Electrical shop: for detailed maintenance and reconditioning for electrical and computer components, such as transformers, motors, compressors and diagnostic hardware
- Pneumatic/Brake shop: for maintenance and tests on the braking and shock-absorbing components on the vehicles
- Comfort shop: for maintenance on sanitary, comfort and interior components of the vehicles, such as seats, restrooms and HVAC units
- Warehouse: for efficient organization, storage and distribution of parts, modules, and components on train-sets and heavy machineries used for specialized tasks.

The total coverage area for the maintenance building may be subdivided into light and heavy maintenance operations locations. It is assumed that an adequate number of enclosed maintenance tracks with pits and high-platforms within the facility to accommodate lighter maintenance activities during testing will be provided.

Required Tracks

In addition to the "specialty" shops located in the HMF building, this facility will require storage, layup, testing and maintenance tracks. The number of storage and layup tracks is based upon the operations analysis of the Phase 1 and Full Build-Out service plans which yielded the requirement for the number of trains needed for morning start-up of revenue service in proximity to the HMF. Track capacity is also needed for the storage of train-sets during the assembly, testing, acceptance and commissioning period prior to introduction into revenue service.

Other "specialized" functions in the HMF may also require tracks to support:

- Low-speed dynamic testing
- Static testing
- Coupling, uncoupling and lifting of train cars
- External train washing/cleaning
- Switching

5.2.3 Guidelines for Physical Size of Facilities

The spatial requirements for each facility is based on the Level (1,2, 3 etc.) of cleaning, inspection and maintenance as well as the number of layup/storage tracks required to support the number of trains estimated to be assigned to each location. For the CHSTP, the storage capacity of each facility is based on the number of trains described in the Phase 1 and Full Build-Out Service Plans and is summarized in the tables below.

Layup/Storage Track Requirements – Phase 1

Location	200 m Sets	400 m Sets	Total Sets	200 m Equivalents	400 m-long Tracks
San Francisco	14	13	27	40	20
Sacramento					
Merced	5	1	6	7	4
Los Angeles	13	2	15	17	9
Anaheim/Irvine	4	13	17	30	15
San Diego					
Total	36	29	65	94	48

Layup/Storage Track Requirements – Full Build-Out Low Estimate

Location	200 m Sets	400 m Sets	Total Sets	200 m Equivalents	400 m-long Tracks
San Francisco	12	18	30	48	24
Sacramento	6	9	15	24	12
Merced					
Los Angeles	8	11	19	30	15
Anaheim/Irvine	8	9	17	26	13
San Diego	8	11	19	30	15
Total	42	58	100	158	79

Layup/Storage Track Requirements – Full Build-Out High Estimate

Location	200 m Sets	400 m Sets	Total Sets	200 m Equivalents	400 m-long Tracks
San Francisco	6	24	30	54	27
Sacramento	3	14	17	31	16
Merced	0	3	3	6	3
Los Angeles	2	16	18	34	17
Anaheim/Irvine	9	8	17	25	13
San Diego	2	20	22	42	21
Total	22	85	107	192	97

To obtain a frame of reference for the minimum “footprint” size, a comparison was made to examples of the Shinkansen and TGV facilities. This comparison revealed that, among other things, the overall width (of one of these facilities) is influenced by the need for full access walkways/cart-ways on both sides of every inspection track.

An illustration of the “preferred” width and clearances taken from the Japanese Shinkansen is:

- Maintenance building clearance between train set and structure: Width 14.4 feet X Height 25.3 feet
- Width of aisle/walkway: 5 feet

Based on this example, a layup track with an aisle-way on either side could be up to twenty feet wide. Assuming the Japanese approach, the table below shows both minimum and desirable requirements for the width of layup tracks for each facility based on the assumptions above.

Example: Minimum and Desirable Width of Parcel for CHSTP Layup/Storage – Inspection/Maintenance Facilities

	Minimum (Feet)			Desirable (Feet)		
	Phase 1	**Full Build Low**	**Full Build High**	**Phase 1**	**Full Build Low**	**Full Build High**
San Francisco	394	472	531	433	512	590
Sacramento		236	315		256	354
Merced	79		59	98		79
Los Angeles	177	295	335	197	335	374
Anaheim/Irvine	295	256	256	335	276	276
San Diego		295	413		335	453

5.2.4 Heavy Maintenance Facility (HMF) Space Estimates

The guidelines presented in this section are based on the information obtained from a review of existing HST systems, which provided a foundation for understanding the functional requirements and "footprint" of the HMF that will be needed to support the CHSTP. This information may be updated and refined as decisions that are continue to evolve the physical characteristics and train-set technology for the CHSTP.

The intent, therefore, is to present guidelines relevant to fleet storage capacity requirements, the estimated size of the facility's land parcel, and the estimated footprint needed for the maintenance building and associated support shops.

Storage Requirements

Generally, the size of the facility is influenced not only by function, but also by projected capacity, which comes from the estimated fleet size and conceptual approach for maintenance cycles. Since each HST manufacturer prescribes specific minimum maintenance requirements, the estimated inspection and maintenance capability for the HMF considers these attributes. The specific trainset technology for the CHSTP has not been selected; therefore the estimated capacity for the HMF considered a range of capability considerations that are based on a review of the existing Japanese (Shinakansen) and French (TGV) requirements.

As previously noted, an essential factor for estimating the size of the HMF is the train storage capacity needed during the assembly, testing, acceptance and commissioning stage. A number of storage tracks may have to be provided in order to store new train-sets once they have been assembled, during the commissioning period, and possibly until they are ready for revenue service. The timing of the completion of the overnight layup/ storage facilities located in proximity to the end terminals may also affect how newly commissioned trains are deployed. Consequently, three concepts have been developed to serve as illustration to consider and may provide guidance in understanding the potential train set storage requirements and configuration for the HMF.

Concept 1: Capacity to Store All Train Sets

In this concept, all train-sets are assumed to not only be assembled but also stored at the HMF until Phase 1 of the CHSTP is fully implemented. This approach is dependent on the construction and implementation of the complete Phase 1 System and requires a larger storage capacity at the HMF. To accommodate the layup capacity for all 200 meter train-sets estimated in the Phase 1 Operations & Service Plan, the footprint for the HMF would be the largest of the three concepts and require an estimated twenty- four 800-meter (or forty-eight 400-meter) storage tracks, in addition to the inspection/maintenance tracks necessary to support the activities and functions of the facility. A significant disadvantage to this approach, from a cost and efficiency standpoint, is that after Phase 1

is fully implemented and all trains begin revenue service operations, the addition storage capacity which was needed during commissioning would no longer be required.

Concept 2: Coordinated Construction of Phase 1 Infrastructure and Commissioning of Train Fleet

This concept assumes coordination of the construction and activation (for train operations) of the alignment segments between the HMF and the layup, storage and inspection/maintenance facilities at San Francisco and Los Angeles to allow train-sets to be deployed to these locations as they are assembled and commissioned. This approach considers scheduling the train assembly and commissioning as an integral activity with the construction of the Phase 1 track, signal and electric propulsion system and layup/storage facilities. This concept would not require as many storage tracks at the HMF, allowing for a smaller footprint (for the HMF). A critical factor associated with this strategy is, of course, coordination between construction of the Phase 1 system infrastructure and assembly of the train-sets to ensure train commissioning and infrastructure construction are "synchronized" to avoid a cascading schedule delay that could result in "overflow" of the layup yard capacity at the HMF.

Concept 3: Phasing in Revenue Service

The third concept considers a staged transition into Phase 1 revenue service. This approach assumes that trains are assembled and commissioned as they are needed for phased revenue service, allowing for less storage capacity (at the HMF) and a smaller footprint at the HMF. Trains required for "opening day" would be ready for introduction into revenue service and the HMF would continue assembling train-sets (after opening day) in a gradual transitional "build-up" to ultimately correspond to the proposed Phase 1 Service Plan requirements. This concept also allows for the HMF storage tracks to continue to be used for overnight layup functions and to store train sets as they are cycled through the maintenance facility once the Phase 1 level of service is fully implemented.

Capacity of Maintenance Building

In addition to the overall train storage requirements of the HMF, Level 4 and/or 5 maintenance/production capacity is an important consideration, in terms of the number of train sets per year that the facility can inspect and maintain. Maintenance capacity is dependent on the protocols adopted and, a basic understanding of these procedures was obtained by reviewing the approaches employed on existing HST systems around the world.

As an example, for the Japanese Shinkansen, full inspections and overhauls are mandated every three years. This process typically takes about ten days (or two work weeks) to complete. Assuming an estimated fleet size based on the estimate for the CHSTP, and with a cycle of three years, a minimum of forty-four trains each year would be processed through the HMF. This means that, at any one time, the HMF would have to accommodate (ongoing) an average of approximately two train-sets per every two week period.

The illustration for the French TGV system references Level 4 overhauls that are scheduled once every eight to nine years. These overhauls typically take about thirty days to complete. Assuming the estimated CHSTP fleet size, and with a cycle of eight to nine years, a minimum of fifteen train sets would be processed through the HMF annually. Considering the thirty-day duration for this activity, the HMF would have to continuously support a Level 4 overhaul on three train-sets throughout the year on an ongoing basis.

It is also important to note that some measure of additional production/maintenance capacity, i.e. one additional train-set, is typically provided beyond the planned maintenance cycles to account for unexpected requirements, such as train-sets that must remain at the facility for three to four months (at a time) to address repairs associated with accidents or other unplanned incidents.

Considering the information presented above, a HMF that supports maintenance protocols and technology based on the Japanese Shinkansen approach would have to accommodate three train sets in the heavy maintenance shop at all times. By contrast, a facility designed to support maintenance protocols and technology based on the French TGV would have to accommodate four train sets at all times.

Size of Facility

The overall footprint of the HMF will largely be based on the estimated storage capacity of the facility and the plan adopted to inspect, maintain and overhaul the fleet. The information presented in this section is based on the requirements similar to those employed by existing HST heavy maintenance facilities in Europe and Asia and are intended to serve as guidelines for planning the footprint and layout of the HMF.

Shape and Layout of Parcel

The overall footprint of the HMF should be based on the following guidelines:

- Maximize the land usage within the facility to minimize switching movements, a long and narrow parcel is typically more desirable over a short and wide parcel if possible.
- The parcel should be connected to a test track.
- Width of the parcel needs to take into account the necessary shop facilities and support and storage tracks required to perform all inspection and maintenance activities. The width of the facility will also depend on the level of storage desired prior to system start-up when train-sets are being assembled and commissioned, in addition to their frequency of operation after service is implemented.

Maintenance Building Layout

Shop buildings should be configured in a manner that maximizes land utilization but workshop functional productivity. This layout must take into account the following specialty functions:

- Entrance/Assembly shop (see 1)
- Car-body shop (see 2)
- Car-body Pretreatment & Painting Shop (see 3)
- Heavy components shops (see 4)
- Light components shops (see 5)

Included within these shops would also be a parts inventory/storage warehouse and a designated bogey shop with a wheel re-profiling machine (which would be located either in or near the heavy components shop). In addition, the bogey shop should accommodate bogies that may be undergoing repair and inspection for additional train-sets not yet assigned for their cycle in the heavy maintenance facility, but were “changed out” in one of the two periodic inspection facilities and shipped to the HMF for overhaul.

International Heavy Maintenance Facility Dimensions (Examples)

The tables below present the average size for each shop estimated to support a HST fleet using statistics obtained for French (Korean), and Japanese maintenance facilities. It should be noted that the sizes of the assembly and bogey shops (Japan) and the primary vehicle overhaul area (France, Korea) were adjusted to estimate a fleet size of similar to the number of train-sets estimated for the CHSTP.

Table 5.2.4.1: Required Size of Each Shop in Heavy Maintenance Facility Based on French TGV (Standard Used For Korean KTX)

Shop	Sub shop	Size (sq.ft.)	Total Size (sq.ft.)	Total Size (acre)
Bogie shop	Dummy bogie storage area	5,400	**69,000**	**1.58**
	Bogie storage area	5,400		
	Bogie Dis/Assembly Shop	29,100		
	Bogie repair Shop	29,100		
Carbody Pretreatment & Painting Shop	Steel structure repairing shop	9,700	**39,000**	**0.9**
	Washing, brushing, air blowing shop	3,300		
	Blasting shop	3,300		
	Soft Grinding/Putty/Sticky/Masking Shop	9,700		
	Carbody painting shop	6,500		
	Carbody drying shop	6,500		
Heavy electric shop	Main Transformer Shop	4,900	**34,100**	**0.78**
	Power Block Shop	9,700		
	Pantograph and roof apparatus	4,900		
	Aux. Motor Shop	4,900		
	Traction Motor Shop	9,700		
Heavy mecanical shop	Gangway Ring Shop (articulation TGV only)	9,700	**34,100**	**0.78**
	Coupler/Buffer Shop	4,900		
	Motor Reduction Unit and Transmission	9,700		
	Air Spring Shop	4,900		
	Oil Damper Shop	4,900		
Pneumatic shop	Brake Unit Shop	4,900	**34,100**	**0.78**
	Air Compressor Shop	9,700		
	Brake Panel /Dryer Shop	4,900		
	Door Shop	14,600		
Comfort shop	Sanitary parts Shop	4,900	**80,900**	**1.86**
	Interior Fittings Shop	32,300		
	Seat Shop	29,100		
	Polyester and carpentry Shop	14,600		
Wheelset Shop	Wheelset storage area	15,100	**66,300**	**1.52**
	Wheelset Dis/Assembly Shop	48,500		
	Bearing laboratory shop	2,700		
Air conditionning Shop		9,700	**9,700**	**0.22**
Cable/wire Shop		1,100	**1,100**	**0.03**
Battery Shop		2,200	**2,200**	**0.05**
Electric/Electronics Shop		7,600	**7,600**	**0.17**
Unitary Test Area (simulator)		14,600	**14,600**	**0.34**
Common Parts Cleaning shop		6,500	**6,500**	**0.15**
Common Parts painting shop		6,500	**6,500**	**0.15**
Automatic Warehouse		21,600	**21,600**	**0.5**
Subtotal			***427,300***	***9.81***
Primary Vehicle Overhaul Area			**203,525**	**4.67**
Total			**630,825**	**14.48**

Table: 5.4.2.2 Required Size of Each Shop In Heavy Maintenance Facility Based on Japanese Shinkansen Standard

Shop	Sub shop	Total Size (sq. ft.)	Total Size (acre)
Bogie Shop	Dummy bogie storage area	768,900	17.65
	Bogie storage area		
	Bogie Dis/Assembly Shop		
	Bogie repair Shop		
	Wheelset storage area		
	Wheelset Dis/Assembly Shop		
	Bearing laboratory shop		
	Brake Unit Shop		
	Brake Panel /Dryer Shop		
	Aux. Motor Shop		
	Traction Motor Shop		
	Motor Reduction Unit and Transmission		
	Air Spring Shop		
	Bogie Test Area		
Assembly Shop	Oil Damper Shop	390,000	8.95
	Sanitary parts Shop		
	Interior Fittings Shop		
	Seat Shop		
	Polyester and carpentry Shop		
	Air Compressor Shop		
	Door Shop		
	Main Transformer Shop		
	Power Block Shop		
	Pantograph and roof apparatus		
	Air conditioning Shop		
	Cable/wire Shop		
	Battery Shop		
	Electric/Electronics Shop		
	Body Test Area		
Body Shop	Steel structure repairing shop	210,500	4.84
	Washing, brushing, air blowing shop		
	Blasting shop		
	Soft Grinding/Putty/Sticky/Masking Shop		
	Carbody painting shop		
	Carbody drying shop		
	Coupler/Buffer Shop		
Total		1,369,400	31.44

The difference in size between the two maintenance building footprints and the function of each building are a result of the different technology requirements and associated maintenance cycles.

The Japanese system is based on an Electric Multiple Unit (EMU) technology where most individual cars within the train set have powered traction motors. The French system includes conventional locomotives and coaches as well as EMU articulated coach train set configurations. The size of shops supporting bogey maintenance and vehicle assembly for the Shinkansen system are typically larger than that for the TGV system since, among other factors, the Shinkansen train-sets are typically longer (therefore more bogies) and have a more frequent maintenance cycle requirement.

The French maintenance concept is based on the modular design of the train and is thus planned to conform to the "rules" and requirements specific to each of the component parts (each component has its own maintenance cycle). The Japanese maintenance concept applies systematic maintenance cycles as a function of the entire train, where a function includes a multitude of components.

Using the information presented in this technical memorandum, it is estimated that the HMF support building for the CHSTP could require a footprint of 14.5 to 19.3 acres (or 631,000 to 840,000 ft^2). The ranges presented in this assessment will be refined as determinations are made regarding the maintenance protocols, specific train-set technology and implementation plan for service activation.

5.2.5 Guidelines for Facility Locations

The location of the facilities is a significant factor for maximizing safety, Levels of (maintenance) service, and operation and maintenance (O&M) costs. It is preferred that layup/storage, inspection/maintenance facilities are located adjacent to terminal stations to minimize the volume of deadhead moves and associated added train miles, which adversely affect operational efficiency and operating. The following guidelines are provided for locating the maintenance facilities:

- Facilities serving layup/storage functions for morning start-up of revenue services should be located as close as possible to the terminal station (Sacramento, San Francisco, Los Angeles, Anaheim/Irvine, and San Diego) to minimize the distance of deadhead train movements.
- Approach from terminal stations to the layup/storage facilities should be in a manner that does not create conflicting train movements between "deadhead" trains and trains in revenue service.
- For the HMF, being central is important. Merced-Bakersfield is the "Central Part" of the system, is part of the trunk line (Anaheim-SF), and has the ability to include the high-speed test track (no other part of the system meets these criteria).

In summary, it is desirable for the CHSTP layup/storage, inspection and maintenance facilities to be located near the terminal stations in a configuration designed to avoid potential dispatching conflicts between deadhead train movements and revenue trains and the HMF should be central to the system.

5.2.6 California High Speed Train Yard and Maintenance Facility Footprint Guidelines

Utilizing the information provided in this document and referring to the "Technical Memorandum – High-Speed Train Service Plan – Full Build Network with Links to Sacramento and San Diego", and the Operations and Service Plan for Phase 1, conceptual configurations have been developed to provide a basis for describing the "footprints" for the major terminal yard/shop sites and the HMF. These concepts emerged from an examination of the CHSTP full-build network requirements to associated with estimated facility needs based upon train-set assignments (for layup/storage, inspection/maintenance) to the six major terminals. Maintenance concepts were reviewed, identifying a fundamental approach for inspection, maintenance and repair founded on existing HST operations in Europe and Asia. These attributes were considered in identifying the space parameters needed to support the primary inspection and maintenance functions for the CHSTP. Ancillary requirements to the primary functions were also considered, such as space requirements for personnel and material, and cleaning and testing activities.

As previously described, the examination of existing high speed train inspection and maintenance best practices has been applied in the development of a conceptual description of the facilities that may be required for the CHSTP. These concepts have been prepared locating maintenance facilities in the following CHSTP sections: Los Angeles; San Francisco; San Diego; Anaheim; Sacramento; Los Angeles/Anaheim; Central Valley (Heavy Maintenance Shop). The following Table (5.2.6.1) presents a summary of the characteristics of these concepts.

Table 5.2.6.1 Terminal Lay-up and Maintenance Facility Features

FACILITY LOCATIONS	ACREAGE	WIDTH	STORAGE TRACKS	SHOP TRACKS	HEAVY CLEANING TRACKS	OTHER TRACKS
Central Valley (HMF)	111 acres	1182 ft.	9	19	2	6
Los Angeles	58 acres	834 ft.	17	8	2	4
San Francisco	84 acres	1081 ft.	27	8	2	4
San Diego	65 acres	917 ft.	21	8	2	4
Sacramento	33 acres	428 ft.	17	0	0	1
Anaheim	30 acres	350 ft.	13	0	0	1
LA/Anaheim	79 acres	1109 ft.	30	8	2	4

In addition, a conceptual schematic illustrating the layout and dimensions for each of these facilities is provided in Appendix A, drawing numbers 5.1A through 5.1G.

5.2.7 RIGHT OF WAY MAINTENANCE

Adequate space will be required to “park” on-track right of way maintenance equipment, store maintenance of way material inventory and replacement parts, and support a “headquarters” and staging area for HST System “sub-division” maintenance personnel. The locations that support an effective Maintenance of Way program strategy are envisioned to be located within close proximity to Gilroy, Merced, Visalia, Bakersfield, and Palmdale for Phase I, with Stockton, City of Industry and Temecula added later for the Full System Build-Out. The selection of right of way maintenance facilities will be based on servicing a track distance of 75 miles in each direction from the maintenance site for a total coverage of 150 miles. This is to accommodate the time for equipment traveling at 60 mph to reach locations along the alignment needing maintenance during the five hour non-revenue period.

The site for each MOWF must be located immediately adjacent to the main line trunk of the HST System and be connected to the main line with a standard turnout. Also required is effective connectivity to the highway road network and access to utilities including water, gas, electricity, sewer and communications.

Based on a conceptual rendering of a “typical” MOWF as depicted in the attached schematics entitled “MOWF Concept Plan”, Alternative A (wide configuration) TM 5.2-A and Alternative B (narrow configuration) TM 5.2-B the size of these facilities would require a land parcel “footprint” of between approximately 17 to 18 acres each, inclusive of roadways and parking.