California High-Speed Train Project

TECHNICAL MEMORANDUM

Trainset Configuration Analysis and Recommendation
TM 6.3

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Revision	Date	Description
0	23 Sep 09	Initial Release

Note: Signatures apply for the latest technical memorandum revision as noted above.

Prepared by PB

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 memorandums. Technical Leads for each subsystem is 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.

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

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ABSTRACT

The CHSTP system definition has been developed around the premise that the system will procure a 400 meter trainset configuration capable of accommodating between 900 -1000 passengers, traveling at an operating speed of 220 mph. The trainset is to be an existing service proven platform that either currently operates at the desired CHSTP operating speed of 220 mph, or will be proven to operate in service at the desired speed prior to the start of CHSTP revenue service.

There are several trainset configurations that can potentially meet the CHSTP stated requirements. These configurations can be categorized as single-level trainsets utilizing power cars, multi-level (duplex) trainsets utilizing power cars, single-level distributed power electric multiple units and multi-level distributed power electric multiple units.

The purpose of this White Paper is to compare the advantages and disadvantages of each of these categories of trainsets. The Paper will identify which type of trainset configuration best satisfies the CHSTP system objectives and will make a recommendation of the trainset technology that should be selected for the California High-Speed Train Program.

1.0 INTRODUCTION

1.1 STATEMENT OF TECHNICAL ISSUE

The CHSTP desires to procure and operate service proven trainsets capable of operating at 220 mph with a capacity of between 900 – 1000 passengers per 400 meter unit. The CHSTP has evaluated current high speed trainsets, and has determined that there are several trainset configurations that could satisfy the CHSTP system objectives. The challenge facing the Team is to develop an approach for evaluating the trainset configurations against key parameters that relate to the CHSTP system objectives, in an effort to identify the trainset configuration that is the most appropriate to begin CHSTP revenue service.

The table below illustrates potential trainset configurations. The matrix identifies four unique configurations, representative designs for each configuration and primary technical attributes.

Table 1 – Trainset Configurations

Type Code [1]	Trainset Configuration	Representative Designs		Primary Technical Attributes
S-P	Single-level trainsets utilizing power cars		Alstom TGV, Rotem KTX, Rotem KTX-II	Power cars in lead and end positions, non-powered single-level passenger coaches, no passenger space in leading unit.
S-E	Single-level distributed power electric multiple units (Type S-E)		Alstom AGV, Bombardier Zefiro, Shinkansen Series N-700, Siemens Velaro,	Traction power distributed throughout the trainset, single-level coaches, passenger space in leading unit.
M-P	Multi-level (duplex) trainsets utilizing power cars (Type M-P)		Alstom TGV Duplex	Power cars in lead and end positions, non-powered multi-level passenger coaches, no passenger space in leading unit.
M-E	Multi-level distributed power electric multiple units		Alstom V150[2], Shinkansen Series E1, Shinkansen Series E4	Traction power distributed throughout the trainset, multi-level coaches, and passenger space in leading unit.

[1] S = Single level passenger vehicle, P = Passenger vehicles with power cars at each end, E = EMU, M = Multilevel passenger cars (Duplex).
[2] The V150 trainset was developed by Alstom to capture the high speed record for trains running on rails. The V150 is a hybrid configuration consisting of power cars, distributed power on the coaches, and multi-level (duplex) coach configuration.

1.2 GENERAL INFORMATION

As illustrated in Table 1 above, single-level high speed trainsets are currently being produced by several manufacturers. The manufacturers include, Alstom, Bombardier, Rotem, Siemens, and Japanese consortia (Sumitomo/Kawasaki/Hitachi). The single-level trainsets have operating speeds ranging from 186 mph (300 km/h) to 224 mph (360 km/h). Single-level trainsets have been developed in power car, and distributed power EMU trainsets, and offer various interior configurations such as:

- Club, Preferential, or First Class cars that can have 2 x 1 seating and provide in seat steward attention and audio/video facilities.
- Club, Preferential, or First Class Car Lounges
- Tourist, Business or Second Class cars that can have 2 x 2 seating, are less expensive and have less amenities.
- Bar, Bistro or Cafeteria Cars

High-speed multi-level (duplex) trainsets are currently being produced by Alstom and Japanese consortia (Kawasaki/Hitachi). The Alstom Duplex trainsets have a maximum in-service operating speed of 198.84 mph (320 km/h), although, recent test runs at 224 mph (360 km/h) have been successfully conducted by Alstom and SNCF. An Alstom TGV Duplex V150 trainset was developed to capture the high-speed record for trains running on rails. The V150 is a hybrid configuration consisting of power cars, distributed power on the coaches, and successfully operated at 357 mph (574.8 km/h). The Japanese Shinkansen E1 and E4 Series duplex trainsets built by Hitachi and Kawasaki have a maximum in-service operating speed of 149 mph (240 km/h), and have been tested to a maximum speed of 171 mph (275 km/h). Multi-level trainsets have been developed in power car, and distributed power EMU trainsets, and offer various interior configurations similar to the single-level configurations, with the main difference being that passenger space is available on two (2) levels within each multi-level coach accessible via stairways. Multi-level and single-level trainsets can be operated over the same lines.

2.0 DEFINITION OF TECHNICAL TOPIC

2.1 GENERAL

This Technical Memorandum compares attributes of single level high-speed trainsets with high-speed duplex level trainsets. Major characteristics of the two types are discussed and have been rated so an overall recommendation can be made.

3.0 ASSESSMENTOF TRAINSET CONFIGURATIONS

3.1 STANDARDS

It is the stated policy of the California High Speed Rail Authority that the rolling stock shall be service-proven high-speed trainsets. This is referenced in the Technical Memorandum, TM 6.2 Introduction of European and Asian High-Speed Rolling Stock to California. Both single-level and multi-level trainsets are built to the country of origin's standards. In addition, for trains that cross country borders, there are interoperability specifications for the trans-European high-speed rail system. This document is Directive 96/48/EC – Interoperability of the Trans-European High Speed Rail System, Technical Specification for Interoperability "Rolling Stock" Sub System. Trainsets manufactured to European standards follow the EU Technical Specifications for Interoperability regardless of origin country of the manufacturer.

3.2 OPERATING SPEED AND SEATING CAPACITY

The CHSTP operating plan is based on procuring and operating service proven trainsets capable of a maximum in-service speed of 220mph with a capacity of between 900 – 1000 passengers per 400 meter unit. Table 2 below, identifies in-service speeds and seating capacity of trainsets representing each of the four trainset configurations identified in Table 1.

Table 2 – Trainset Speed and Capacity

Type Code	Manufacturer	Trainset	Train Make-up (400m)	Train length	Number of Seats	Max. In-service Speed
S-P	Alstom	TGV (Resau)	4 Power cars 16 Trailer Cars	400m	754 Total 240 - 1st 514 - 2nd	198.84 mph (320 km/h)
S-P	Rotem	KTX-II	4 Power cars 16 Trailer Cars	402m	726 Total 60 – 1st 666 – 2nd	186.4 mph (300 km/h)
S-E	Alstom	AGV	22 Cars 12 - Powered Bogies 12 – Non-powered bogies	400m	892 - 1020 Total 194 – 1st 698 – 2nd	224 mph (360 km/h)
S-E	Japanese Consortia	Shinkansen Series N700	14 Motor Cars 2 Trailer Car	404.7m	1323 Total 200 - 1st 1123 - Std	186.4 mph (300 km/h)[2]
S-E	Siemens	Velaro E/CN	8 Motor Cars 8 Trailer Cars	400m	808/1202 Total 74/144 – C 206 - P 528/1058 - T	217.5 mph (350 km/h)
M-P	Alstom	Duplex	4 Power cars 16 Trailer Cars	400m	1020 Total	198.84 mph (320 km/h)[1]
M-E	Japanese Consortia	Shinkansen Series E4	8 Motor Cars 8 Trailer Cars	402.8m	1634 Total 108 - 1st 1526 - Std	149.1 mph (240 km/h)

[1]Recent test runs of an Alstom Duplex trainset at 224 mph (360 km/h) have been successfully conducted by Alstom and SNCF.
[2]A Japanese trainset, Fastech 360, with maximum service speed of 224 mph (360 km/h) is being tested for next generation Shinkansen scheduled for revenue service in 2011.

As illustrated in Table 2, above, there is currently one single-level distributed power electric multiple unit trainset (Alstom AGV) and one multi-level trainset (Alstom Duplex – demonstrated to travel at 224 mph during testing) that meet the requirements of the CHSTP. Both Siemens and the Japanese Consortia have advised that its Velaro E and Shinkansen trainsets, respectively, can be designed to travel at 220 mph.

With the exception of the Alstom TGV, and Rotem KTX-II trainsets, all of the candidate trainsets would satisfy the CHSTP system requirement of 900 – 1000 passengers per 400m trainset, dependant on the seating density chosen. A comparison of the Alstom AGV and Duplex trainsets shows that the Duplex could provide approximately 15% more seats than the AGV trainset.

3.3 COMPETITION

Competition between manufacturers tends to contain the cost of trainsets on all contracts. In developing its price, each manufacturer arrives at a unit cost that is based on the technical specification and contractual terms and conditions. The manufacturer will also take into consideration several items such as current/projected work load, capacity of the manufacturing facility, delivery schedule, staff availability, and value of non-recurring engineering costs. In addition, when there are several competing manufacturers, the cost per trainset is likely to be influenced, especially if the specified trainsets correspond closely to existing designs.

When we evaluate the marketplace relative to single-level trainsets, we recognize that potential manufacturers of CHSTP trainsets could be Alstom, Bombardier, Chinese Consortia, Japanese Consortia, Rotem, Siemens, and Talgo, or, potentially, a combination of these manufacturers.

The multi-level trainset on the other hand has been designed and produced by two entities, Alstom, and the Japanese consortium of Kawasaki and Hitachi. As stated earlier, the Alstom Duplex trainset is the only multi-level design that has been shown to be able to operate at the speeds necessary for operation on the CHSTP. The market place for multi-level trainsets at speeds of 200+ mph has very limited, if any, competition.

In developing the Duplex trainset configuration, Alstom, had to overcome very difficult design issues such as axle loading, structural integrity, influence of crosswinds, location of equipment and access for maintainability. While all the manufacturers for both single and multi-level designs strive to reduce weight within the parameters of the specified structural strength and maximum axle loads, the Alstom Duplex configuration required the development of a sophisticated lightweight aluminum structure. Alstom expended significant non-recurring costs in the design of the Duplex.

It is interesting to note that Alstom initiated research in 1989 and 1990, revealing the potential to design trainsets with operating speeds between 218 mph (350 km/h) and 249 mph (400 km/h). The official project was led by SNCF and GEC-Alsthom (now Alstom). The objective of the SNCF/Alstom project was to develop a prototype “TGV NG” power car that would be in operation by 2000. The new TGV NG power car was to be developed as part of new TGV Duplex trainset. Alstom suspended the project in 1999, when it decided to concentrate on a new EMU trainset design with distributed power rather than dedicated power cars. This new effort resulted in the development and production of the Alstom AGV single-level trainset.

Regardless of the underlying reasons, as illustrated in Table 3, it is apparent that that the marketplace for high-speed trainsets, capable of operating at 220 mph, has been focused on a single-level distributed power electric multiple unit configuration. A trainset procurement that specifies this type of configuration will result in maximum competition.

Table 3 - Competition

Manufacturer	Single-level Power Cars S-P	Single-level EMU S-E	Multi-level Power Cars M-P	Multi-level EMU M-E
Alstom	X	X	X	X[1]
Bombardier		X		
Chinese Consortia		X		
Japanese Consortia		X		X[2]
Rotem	X	X		
Siemens		X		
Talgo		X		

[1]The V150 trainset was developed by Alstom to capture the high speed record for trains running on rails. The V150 is a hybrid configuration consisting of power cars, distributed power on the coaches, and multi-level (duplex) coach configuration.
[2]The Japanese Shinkansen E1 and E4 Series duplex trainsets built by Hitachi and Kawasaki have a maximum in-service operating speed of 149 mph (240 km/h).

3.4 CAPITAL COST

Accurate comparable capital costs have been difficult to establish. Manufacturers have been very reluctant to divulge the cost of their high-speed trainsets in the past. The information in the public domain is usually combined with costs for a High-Speed Rail system or includes additional power cars or passenger coaches combined with complete trainsets. As illustrated in Table 4 below, in November 2001, SNCF ordered 18 200 meter TGV Duplex trains for €350M. Therefore, the cost per 200 meter train was €19.44M.

Due to the limited cost information available relative to high-speed trainset procurements, it is difficult to develop an accurate comparison of single-level versus multi-level trainset costs projected in future dollars. However, based on the lack of competition (ref section 2.3) and the increased level of complexity in the design of a multi-level trainset, it is reasonable to conclude that the multi-level train would be more expensive to procure than a single level train.

Table 4 – Train Costs

Type Code	Manufacturer	Trainset	Train length	Train Cost
S-E	Siemens	Velaro E	200m	€25.2 M (Average 2001 to 2004)
S-E	Alstom	AGV (New EMU type Articulated)	200m	€26.00M (2008)
M-P	Alstom	Duplex	200m	€19.44M (2001)

3.5 DESIGN

3.5.1 Platform Length

The CHSTP is basing the length of platforms on a 400 meter maximum trainset length. As shown in Table 5 below, all of the potential suppliers of trainsets either have designed or are designing 200 meter trainsets that, when coupled together, conform to the TSI requirement for maximum train length of 400 meters ± 1%.

Table 5 – Trainset Length

Type Code	Manufacturer	Trainset	Train length
S-P	Alstom	TGV (Resau)	400m
S-P	Rotem	KTX-II	402m
S-E	Alstom	AGV	400m
S-E	Japanese Consortia	Shinkansen Series N700	404.7m
S-E	Siemens	Velaro E	400m
M-P	Alstom	Duplex	400m
M-E	Japanese Consortia	Shinkansen Series E4	402.8m

3.5.2 Platform height

There is currently no "standard" platform height. Depending on the line, current HSR operators utilize vehicle-borne steps for boarding, or design platforms that are level with the vehicle floor height. Based on current CFR regulations (ADA), the CHSTP platforms will be designed to allow for level boarding of the trainsets.

Table 6 – Platform Height

Type Code	Manufacturer	Trainset	Vehicle Floor Height
S-P	Rotem	KTX-II	45.47 ins (1155 mm)
S-E	Alstom	AGV	45.47 ins (1155 mm)
S-E	Bombardier	Zefiro	49.21 ins((1250 mm)
S-E	Japanese Consortia	N700	51.18 ins (1300 mm)
S-E	Siemens	Velaro	49.6 ins (1260 mm)
M-P	Alstom	Duplex	12.36 ins (314 mm)
M-E	Japanese Consortia	E4 (multi-level)	51.18 ins (1300 mm)[1]

[1]The Shinkansen Series E4 trainset provides for level boarding into the coach, and utilizes on-board lifts to accommodate wheelchairs.

As shown in Table 6, above, the floor height of the single-level trainsets, and the Shinkansen Series E4 multi-level trainset ranges from 45.47" to 51.18", whereas the floor height of the Alstom Duplex trainset is 12.36".

The initial selection of platform height is a critical decision as the platform height will limit the type of trainsets that can be utilized on the system. As the majority of the candidate trainsets fall within the range of 45.47" to 51.18", it may be prudent to set the platform heights to accommodate a trainset within this range, with the expectation that future development of new multi-level trainsets would be designed to accommodate a platform height similar to the single-level floor height dimensions.

3.5.3 Clearance (Overall Vehicle Height)

When compared against the single-level trainsets, the multi-level trainsets are between 14 - 35 inches taller. This additional height adds difficulty in meeting axle loads, crosswind requirements, and from an observer's point of view may be viewed as looking less "sleek". This may be an issue with the general traveling public who has the choice of traveling by car, airplane or HSR.

Table 7 – Vehicle Height

Type Code	Manufacturer	Trainset	Vehicle Height
S-P	Rotem	KTX-II	13.3 ft (4,100 mm)
S-E	Alstom	AGV	13.5 ft (4,125 mm)
S-E	Bombardier	Zefiro	12.8 ft (3,900 mm)
S-E	Japanese Consortia	N700	11.8 ft (3,600 mm)
S-E	Siemens	Velaro	12.8 ft (3,900 mm)
M-P	Alstom	Duplex	14.1 ft (4,303.5 mm)
M-E	Japanese Consortia	E4 (multi-level)	14.71 ft (4485 mm)

The CHSTP is currently determining the vehicle structure gage which will be utilized to determine the width and height of the tunnels, as well as other critical system attributes. The determination of tunnel width and height is a critical decision as the tunnel dimensions will limit the type of trainsets that can be utilized on the system. While a decreased cross section of a tunnel will equate to lower construction costs, it is important to design a system that will provide the operator with the flexibility to utilize a variety of trainset configurations, as service needs warrant.

3.5.4 Maximum axle loading

The maximum axle loading specified by the TSI 2008, the European Technical Specification for Interoperability is presently 17 metric tons. Although all European and Asian High-Speed vehicles meet this maximum axle loading, it did pose a challenge during the design of the Alstom Duplex vehicle. This challenge was overcome by the judicious use of new materials and using modern analytical tools. With the latest trend to EMU type vehicles, the Europeans are considering a reduction to 16t maximum axle loading and it is reported that the Japanese are considering 11t maximum axle loading.

3.5.5 Train formation

The single-level and multi-level trainsets utilizing powered cars consist of a locomotive at each end of the consist with non-powered passenger cars in between. The locomotives provide the power to the trainset, but do not carry passengers. In contrast, the single-level and multi-level distributed power electric multiple units (EMU) have powered trucks distributed through the train, and have passenger carrying capabilities in the end units.

Current thinking for high-speed trains by most manufacturers is to design EMU trainsets and have distributed power through the train. There is no loss of passenger space in the consist so these trains can carry more passengers over a given length of a conventional power car/passenger car configuration. The EMU concept also distributes the vehicle weight more evenly and therefore can readily accommodate the maximum axle loadings.

3.6 MAINTENANCE

The ability to easily perform maintenance tasks is paramount to keeping the trainsets in revenue service, and well maintained in a cost effective manner. If components are difficult to access, the task of maintaining these components is going to take longer, and may require special tooling.

Typically, single-level trainsets have their equipment installed in modular lockers underneath the vehicles and between the trucks (bogies). The modular units can either be removed from the vehicle, or can be worked on from the side of the vehicle. On multi-level vehicles, the lower floor is dropped down between the trucks to accommodate a second level of passenger seating. As the undercar space is no longer available, the equipment is typically installed in lockers located inside the vehicle or in exterior locations such as on the roof. As the equipment is less accessible on a multi-level trainset, when compared to a single-level design, it is reasonable to conclude that the costs associated with maintaining a multi-level trainset would be higher.

3.7 PASSENGER BOARDING AND EGRESS

Multi-level trainsets incorporate stairwells into the coach design to accommodate passage between lower and upper levels of the coach. These stairwells are typically located in proximity to the exterior doors. Due to the interior configuration of a multi-level trainset, the flow of passengers entering and leaving the train can be restricted. Therefore, the boarding process can take longer when compared to a single-level configuration.

Boarding times are impacted further should passengers have luggage with them. On a multi-level trainset, luggage space is typically limited to luggage racks located in several areas throughout the trainset. Passengers with luggage are required to walk to these luggage racks, oftentimes causing congestion in the train aisles. An increase in passenger boarding times will result in increased station dwell times.

Please refer to section 2.9 for additional information relative to luggage racks.

3.8 CEILING HEIGHTS

In order to keep the overall car height as small as possible, the ceiling height on a multi-level trainset is lower than the height on a single-level trainset. Table 8, below, identifies the ceiling height for several candidate trainsets. The reduction in ceiling heights can become an issue for taller passengers, and for the general population, as the passenger areas tend to have a more claustrophobic effect. A 95th percentile US male according to the Architectural Graphic Standards, 9th Edition, Section 1, Human Dimensions is 6' - 3" tall. This individual would be uncomfortable entering and exiting a Duplex car with a ceiling height of 6'- 4".

Table 8 – Ceiling Height

Type Code	Manufacturer	Trainset	Passenger Compartment Ceiling Height
S-P	Rotem	KTX-II	7.46 ft (2274.4 mm) Seats 6.88 ft (2097 mm) End
S-E	Alstom	AGV	7.46 ft (2274.4 mm) Seats 6.88 ft (2097 mm) End
S-E	Japanese Consortia	N700	7.12 ft (2170 mm)
S-E	Siemens	Velaro	7.38 ft (2250 mm)
M-P	Alstom	Duplex	6.33 ft (1929 mm)
M-E	Japanese Consortia	E4 (multi-level)	6.46 ft (1970 mm) Lower 6.41 ft (1955 mm) Upper

3.9 LUGGAGE AND OVERHEAD STORAGE

Due to the interior configuration of a multi-level trainset, and the inherent reduction in ceiling height, luggage space is at a premium. With the lower ceiling heights, there is a reduced capacity on overhead luggage racks. Oftentimes, the overhead luggage racks are suitable only for small items such as brief cases and small back packs. The reduced capacity in luggage racks is further compounded by the fact that there are more people to be accommodated in a multi-level trainset. As a result, the interiors of multi-level trainsets include floor mounted luggage racks located throughout the trainset. A balance between the amount of luggage racks and passenger seating is required so as to maximize capacity.

3.10 AESTHETICS

When passengers compare train travel against flying or using private car, as well as comparing cost, and convenience, the look of the vehicle and the design of the interiors are foremost.

> François Lacôte, Senior Vice-President, Technical, at Alstom Transport describes the AGV as 'a modern response to the customer'. He explains that, despite strong interest in Alstom's double-deck TGV, customers prefer a single-deck train set because a double-decker 'does not fit in with their own ideas for technical, cultural or other reasons'. Presentations about the TGV Duplex to customers in Italy, Germany, South Korea and China consistently generated the response that 'the double-decker is very good, but we prefer a single-deck train'. In every case, says Lacôte, 'some kind of obstacle' pushed the customer towards a single-decker.
>
> - Railway Gazette, 31 August 2007

The design of the CHSTP trainset needs to take into account both exterior styling and interior layout/amenities that will appeal to a broad base of potential consumers.

4.0 SUMMARY AND RECOMMENDATIONS

4.1 TRAINSET CHARACTERISTICS SUMMARY

The characteristics of the four trainset configurations have been compiled in Table 9, below, and rated as follows:

1 – Current available trainsets EXCEEDS CHSTP requirements (Most Desirable)
2 – Current available trainsets MEETS CHSTP requirements (Desirable)
3 – Current available trainsets FALLS SHORT of CHSTP Requirements (Less Desirable)

Table 9 – Trainset Characteristics Summary

Characteristic	Single-level		Multi-level		Comment
	Power Car S-P	EMU S-E	Power Car M-P	EMU M-E	
2.1 Standards	2	2	2	2	Both need CFR resolution
2.2a Operating Speed	2	1	2	3	The Alstom AGV is the first EMU designed to operate at 224 mph.
2.2b Capacity	3	2	1	1	All configurations rated as "G" will meet the CHSTP requirement of 900 – 1000 seats per 400m trainset.
2.3 Competition	2	1	3	3	Single-level EMUs has the greatest potential for competition.
2.4 Capital Cost	2	2	2	3	There is not enough information to render a clear decision. Although single-level cars should be less costly to design/build, potentially less multi-level cars may be required for service.
2.5 Design:					
2.5.1 Platform Length	2	2	2	2	All trainsets will meet CHSTP criteria of 400m maximum length.
2.5.2 Platform Height	2	2	3	2	Recognizing that level boarding is a key attribute, the lower height associated with the Duplex trainset could prevent single-level trains from operating over similar lines in the future.
2.5.3 Clearance	2	2	2	2	Taller cars mean crosswind & axle load issues are greater. In addition, single level cars are lower and sleeker (see Aesthetics)
2.5.4 Maximum Axle loading	2	2	2	2	Multi-level trainsets require innovative designs to meet axle loading. This issue will intensify as lower axle loadings are being considered.
2.5.5 Train Formation	2	2	2	2	Most manufacturers are designing EMU type vehicles because of ability to carry more passengers in a train and better weight distribution.
2.6 Maintenance	2	2	3	3	Space is at a premium on multi-level cars and may restrict ease of maintenance.

Characteristic	Single-level		Multi-level		Comment
	Power Car S-P	EMU S-E	Power Car M-P	EMU M-E	
2.7 Passenger Boarding and Egress	2	2	3	3	More passengers and steps to upper floor make a multi-level car more difficult to board and egress. This could impact station dwell times.
2.8 Ceiling Heights	2	2	3	3	Lower ceiling heights may cause discomfort for passengers.
2.9 Luggage and Overhead Storage	2	2	3	3	Limited space in multi-level car for overhead luggage storage.
2.10 Aesthetics	2	2	2	2	EMU trainsets are aesthetically more appealing.

4.2 RECOMMENDATION

Based upon the above summary table, the comparison of the key vehicle characteristics illustrate that the single-level distributed power electric multiple unit (EMU) trainset is the most suitable candidate for the CHSTP.

Key issues to making this decision include:

- Operating Speed (2.2a)
- Capacity (2.2b)
- Competition (2.3)
- Platform heights (2.5.2)
- Ceiling Heights (2.8)

The Alstom AGV EMU is the first trainset designed to operate in service at 224 mph. The only other trainset which is near production with speeds near or in excess of 220 mph includes the Siemens Velaro. Both of these trainsets are based on single level, distributed power electrical multiple units.

With a capacity of between 892 – 1020 seats, the AGV satisfies the CHSTP program goals for speed and passenger seating. While the multi-level trainsets offer increases in seating capacity, the performance standards for in production or near production trainsets fall short of the CHSTP performance requirements.

It is essential for the CHSTP to have more than one manufacturer in order for the cost of trainsets to be competitive and to receive cooperation of all the manufacturers. Several manufacturers have already manufactured or have designed single-level vehicles with distributed propulsion that will meet the CHSTP program goals.

The ADA requirements for level boarding pose a unique challenge to HSR trainsets as there is no “industry standard”. Designing the system to accommodate level boarding at a height comparable to the heights of the single–level trainsets and multi-level EMU trainsets, will provide the CHSTP with the greatest flexibility with regards to trainset selection.

Passenger comfort is a key element of any successful transport service. The spaciousness of a single-level trainset and ancillary benefits (e.g. luggage space) will add to the level of comfort experienced by the passenger.

5.0 SOURCE INFORMATION AND REFERENCES

The following documents were referred to for the report:

- Technical Memorandum, Introduction of European and Asian High-Speed Rolling Stock to California TM 6.2
- Directive 96/48/EC – Interoperability of the Trans-European High Speed Rail System,
- Code of Federal Regulations, Title 49, Parts 200 to 399 Transportation
- AGV Testing Times Ahead - Chris Jackson, September 2 2008 Railway Gazette International
- Alstom Press Release TGV, Web – TGV Train set Formations
- Rail Europe TGV International (TGV Reseau) Seating plan – Two Sheets
- Rail Europe TGV Duplex Seating Plan
- Architectural Graphic Standards, 9th Edition, Section 1, Human Dimensions
- Brochures from Alstom, Bombardier, Rotem, Siemens
- The Shinkansen, Japan's High-Speed Railway System, Second Edition, by Japan Overseas Rolling Stock Association
- Alstom AGV GA Drawings
- Alstom Duplex GA Drawings