California High-Speed Train Project

TECHNICAL MEMORANDUM

California High-Speed Train Project (CHSTP) Test Track TM 600.02

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ABSTRACT

An important element on the critical path for implementation of the California High Speed Train Project (CHSTP) is the provision of a section of track (test track) directly connected with and located adjacent to a heavy maintenance facility that is equipped with the capability of being utilized for trainset commissioning activities. This test track, and associated heavy maintenance facility are necessary to support the delivery, testing, commissioning, and acceptance of the high-speed trainsets for the CHSTP. As one of the long lead time items in the procurement chain, from a project schedule and implementation standpoint, it is important to begin the design and construction of the test track and heavy maintenance facility in parallel with the procurement cycle for the rolling stock. To accomplish this, the CHSTP Program Management Team (PMT) staff has performed a series of analyses to determine the characteristics (e.g. length) of the test track. The results of actual AGV trainset test data together with associated estimates indicating the required test track length have been discussed with the manufacturing community along with an invitation to comment. Responses from the manufacturers have been factored into the PMT staff recommendation together with additional analysis that extrapolates from the AGV test data to take into account the higher speeds required of the CHSTP trainsets.

1.0 INTRODUCTION

1.1 PURPOSE OF TECHNICAL MEMORANDUM

The purpose of this memorandum is to present the series of analyses that determine the characteristics of the test track.

2.0 DEFINITION OF TECHNICAL TOPIC

Plans for the design and procurement of a new fleet of high speed trains for the CHSTP are moving forward with ongoing input and commentary from the major manufacturers around the world. The basic premise of standard gauge, steel wheeled, single-level, electric multiple unit, 220 mph (354 km/h) trainsets has been definitively communicated to the leading rolling stock suppliers.

One of the important elements to be addressed in support of a successful service start is the nature of a test track facility to allow for the delivery, testing (and debugging), acceptance and commissioning of new trainsets. This test track must be designed with the capability of supporting high speed operations of up to 220+ mph (354+ km/h) and provide sufficient capacity for testing. The test track must also be in proximity to and directly connected with the requisite maintenance and support facilities to allow for the efficient assembly, testing, and acceptance of new trains.

To this end, the PMT staff developed an illustrative model based on a “straw man" set of factors, derived from AGV tests in France; the results of this analysis contributed to an initial recommendation for a minimum test track length of approximately 79 mi (127 km), inclusive of a 25% contingency. As with previous important elements of the CHSTP, the information was discussed with leading global equipment suppliers. Each supplier was provided the opportunity to comment on the assumptions made. Based upon their feedback, original staff recommendations have been modified and are presented herein.

In addition to the AGV data, PMT staff developed supplemental information based upon the recognition that while AGV tests were conducted at a maximum speed of 224 mph (360 km/h), the maximum speed requirement for testing CHSTP equipment would be 242 mph (390 km/h). Performance data for the AGV were extrapolated to develop revised estimates of the distance required for adequate testing of new trainsets. The extrapolated data indicate that a test track of approximately 104 mi (167 km), inclusive of a 25% contingency, is necessary.

Note that only the data based on actual AGV tests were submitted to manufacturers for comment. The revised extrapolated data were developed after receipt of comments. Because the additional data represents a conservative extrapolation consistent with the actual data, and because there were no conflicts with responses received, the revised material was not circulated for further comment.

3.0 ASSESSMENT / ANALYSIS

The table below summarizes testing performed on the Alstom AGV prototype trainset operating on a section of SNCF's (French National Railway Corporation) railroad at speeds up to 224 mph (360 km/h). The data reflect the actual tests and do not indicate whether the distance or times involved could have been compressed. To replicate the AGV tests and to add a 25% distance contingency would require a track length of 79 mi (127 km).

3.1 CHSTP Test Track Requirements – Initial Analysis

Methodology/Assumptions:

1. Acceleration/deceleration data per Alstom operational testing of an AGV.
2. Alstom performed high speed testing of the AGV on a 106 mi (170 km) portion of SNCF railroad.
3. Alstom testing was performed over 12 nights with a total distance traveled of 4,660 mi (7,500 km).

Test mode	Time		Distance	
	sec	min	km	mi
Acceleration to 224 mph (360 km/h)	504	8.40	37.00	22.99
Sustained running at 224 mph (360 km/h)	600	10.00	60.00	37.28
Deceleration from 224 mph (360 km/h)	87	1.45	4.70	2.92
Contingency (25%)			25.43	15.80
Total	**1191**	**19.85**	**127.13**	**78.99**

3.2 Industry Review

The test track requirements identified above were sent to Alstom, Siemens, and Sumitomo, together with an invitation to comment both generally and on a set of specific questions. The specific questions included:

1. Maximum test speed for the train.
2. Minimum length of test track desired to safely test a single train.
3. Minimum length of test track needed to safely conduct a test and acceptance program.
4. Preference regarding ability to run two trains simultaneously (double the length of single track or double track).
5. Suggestion regarding whether the track should be a part of the main line or a standalone separate section.
6. Number of mi (km) of running necessary for testing of prototype sets.
7. Number of mi (km) of running without failure to consider a production train acceptable for service.
8. Need to connect to the general railway system for delivery.
9. Comments on the nature of a facility to support the test track.

Responses were received from Alstom and Siemens. A summary of general comments are as follows:

1. PMT staff had suggested that individual components and potentially entire trainsets, both prototype and production units, would undergo testing at the manufacturing facilities, followed by testing and commissioning in the CHSTP service environment. Alstom suggested that the first two production trains be designated as prototypes (PS1 and PS2), and that at least these trains be manufactured offshore. The recommendation was that the first two trains undergo validation tests on the offshore network likely to be connected to the manufacturing facility. Overseas testing would include dynamic behavior tests, traction, and braking tests. In the respondent's opinion, these need only be supplemented in California by a limited set of additional tests. Nevertheless, Alstom agrees that routine tests of production units and final validation tests of PS1 and PS2 need a track in California , which will allow running at the maximum operating speed of 220+ mph (354+ km/h). Siemens suggested that virtually all testing beyond the static activities that could be done in a workshop could be accomplished either on a purpose-built facility such as those in existence in Europe, or on portions of the public network, which in this case would be the CHSTP system.

2. Respondents agreed with staff regarding the need for early implementation of a suitable test track facility. It was emphasized that the test track and the heavy maintenance facility need to be substantially complete when the first train arrives. Alstom emphasized that since the test track is not a preexisting service proven facility, it needs to be completed and validated before being used for train testing. The track should be representative of an in service operating system, fully equipped so that trains may be able to run without any technical restrictions and under automatic train protection. Alstom offered advice regarding test track validation, noting that such validation should include sub-system testing of track and catenary geometry, signaling, and ATP. They recommended that train PS1 be equipped with instrumentation to detect possible long wave track defects as well as other dynamic problems. It was emphasized that validations of the test track and of the trains should not be undertaken simultaneously. Siemens endorsed the concept of co-locating the test track and a heavy maintenance facility, since both facilities will become integral parts of the CHSTP system.

The following comments relate to the specific questions noted previously:

1. Respondents agreed that the maximum test speed should be based upon the maximum in-service speed plus 10%. Hence, a 220 mph (354 km/h) maximum operating speed indicates a test speed of 242 mph (390 km/h).

2. Alstom suggested that the minimum test track length should allow 25 mi (40 km) for acceleration and deceleration and 19 mi – 37 mi (30 km – 60 km) for running at the maximum speed. Thus, the total length of track should be approximately 44 mi – 62 mi (70 km – 100 km).

3. Alstom suggested that the minimum length of track necessary to safely conduct testing and acceptance was 44 mi – 62 mi (70 km – 100 km) provided that the PS1 prototype trainset validation was successfully conducted off shore. Siemens stated that static tests could be accomplished over as little as 0.5 mi (0.8 km) of track. All other dynamic tests would require a test track or the public network.

4. Regarding the ability to run two trains independently, respondents stated that there is no advantage in having this capability. However, Alstom noted that it would be desirable to be able to test two coupled sets operating as one train. Alstom noted that while a single track would likely be sufficient for testing, it is a common best practice to construct a double track section of a future main line. The double track was also seen as a good way to fine tune some of the subsystems that could be affected by parallel installations or by passing trains.

5. In regards to whether the test track should be separate from the main line, both respondents indicated that constructing the test track as part of a future main line is the most common and cost effective approach and is consistent with past and present best practices.

6. While the question was posed in terms of the number of mi (km) necessary for the testing of prototypes, Alstom suggested that this number would be developed after determining the degree of modification of PS1 and PS2 from the already service proven designs. Alstom noted that prototype testing would require access to 124 mi – 186 mi (200 km – 300 km) of validated track for these tests. Siemens suggested that the distance accumulated during prototype testing might be as high as 5,000 mi – 6,000 mi (8,047 km – 9,656 km). Prototype testing will typically be conducted off shore, with additional testing of the prototype units conducted on the CHSTP test track.

7. In response to the question regarding the minimum distance needed for the trainsets to be run without failure in order to consider a production train acceptable for service, Alstom indicated that new trainsets typically operate between 621 mi – 1,243 mi (1,000 km – 2,000 km) prior to entering service. The accumulated distance is dependent on issues identified during testing.

8. Alstom does not typically utilize the general railway system for delivery of rolling stock, preferring instead to deliver equipment by truck. On the other hand, Siemens believes that easy access to and from the general railway system to the test site and to the maintenance or assembly location is desirable.

9. Respondents agreed that it is essential to construct a heavy maintenance facility in conjunction with the test track. Sufficient equipment should be installed to potentially assemble and then fully service the trains as they are being tested. Overall implementation planning will stage for

construction and activation of yard tracks and complete service capabilities for the number of trains that will be based at the facility.

Suppliers were also invited to provide general comments about the test facility. Alstom offered important reflections on the value of this aspect of the project:

"On a 'green field' project such as the CHSTP, the test track can be [seen] not only as a necessary facility to test and validate the rolling stock, but also as an opportunity for a full scale experiment in terms of integration, technical interface management and construction methods of the very high speed railway infrastructure. Even if California is primarily looking for service proven technologies, specific constraints, operational requirements, local conditions, and environmental [issues] will make this project a unique blend of technical solutions and raise new integration, interface, and construction issues. Therefore, the realization of the test track can be seen as a turnkey project '[within] the project' and [can] serve as a prototype for the full system. This would secure the further stages of the project. It would be a good opportunity for local companies to familiarize [themselves] with the construction requirements/methods of the high speed railway infrastructure. It is also the fastest way to have a full scale demonstration of the chosen technology, and a very powerful communication tool."

4.0 SUMMARY AND RECOMMENDATIONS

4.1 CONCLUSION

Initial staff projections together with the comments received from the international manufacturing community confirm the need for a well-equipped test track and heavy maintenance and storage facility. The test track should be validated to represent the actual railroad in its in-service operating condition. The heavy maintenance facility should be equipped to completely support the number of prototype and newly delivered trains as they are received, but certain parts can be sequenced over time for storage and running repairs for the eventual fleet to be stabled there.

The required length of the test track was initially estimated by PMT staff based upon AGV test data. The data suggested that a minimum length of approximately 79 mi (127 km) would be sufficient to conduct the required acceleration, full speed (220+ mph (354+ km/h)) and deceleration tests. Alstom commented that prototype testing is typically accomplished at a manufacturing facility off shore and on a railway system connected to that facility. Therefore, the CHSTP test track could be compressed to a minimum length of between 44 mi – 62 mi (70 km – 100 km).

However, it was further noted in Alstom's comments that after initial testing, trains typically undergo endurance testing of 621 mi – 1,243 mi (1,000 – 2,000 km) to validate trouble free operation prior to placing the train in service. Siemens also stated that the usual all-inclusive prototype testing could entail between 5,000 mi – 6,000 mi (8,047 – 9,656 km) of running. The overall conclusion is that in order to accomplish prototype testing, access is required to

124 mi – 186 mi (200 km – 300 km) of railroad built to the configuration which the trains will see in service. Since the CHSTP system is a "green field" project, this kind of railroad does not exist and will likely be constructed at the same time as the test facility. It is prudent (and is considered best practice) to build such a section of the railroad system to be utilized initially as the test track.

Such an approach is consistent with respondent's suggestion that typical test track installations abroad are most often a portion of an actual in service rail line, thus saving construction costs for a duplicate facility. Further, although the test track can function with a single track facility, a double track line is preferred because it provides the opportunity to test in an environment that will further validate not only the behavior of the trains, but of the railway infrastructure and all of the subsystems, (e.g. electrification, signaling, etc.) in conditions where trains are fully operational in both directions over the line. It is important to note that the test track should be fully validated prior to the beginning of the rolling stock test program.

While the recommendation to construct a section of double track line that contains a section designated for testing offers advantages in cost saving and familiarization, it will have to be considered in the CHSTP implementation plan that hours available for testing will be reduced after initial system start-up for revenue service.

As noted earlier, PMT staff extrapolated the higher performance requirements of the CHSTP trains (i.e. up to a test speed of 242 mph (390 km/h)) onto actual AGV test data. The results are shown in the next section.

4.2 CHSTP TEST TRACK REQUIREMENTS – REVISED FROM INITIAL ANALYSIS

Methodology/Assumptions:

1. Acceleration/deceleration data referenced below was extrapolated from performance curves provided by Alstom to simulate speeds up to 242 mph (390 km/h).

Test mode	Time		Distance	
	sec	min	km	mi
Acceleration to 242 mph (390 km/h)			63.00	39.15
Sustained running at 242 mph (390 km/h)	600	10	65.00	40.39
Deceleration from 242 mph (390 km/h)			5.50	3.42
Contingency (25%)			33.38	20.74
Total			**166.88**	**103.70**

The extrapolation was based upon train performance characteristics which show that acceleration decreases as the trainset approaches the upper end of the speed range. Therefore, estimates of the resulting distances required to accommodate speeds higher than achieved in the actual tests are consistent with the data received and sufficiently conservative to accommodate CHSTP's requirements.

4.3 RECOMMENDATION

In summary, after the needs for acceleration, maximum speed, deceleration, and endurance testing are analyzed, a section of double track with a minimum length of 104 mi (167 km) is recommended to support the necessary testing. This section of track is to be co-located in proximity to and connected directly with a heavy maintenance facility. The track length includes a 25% contingency to account for the identified assumptions.

5.0 SOURCE INFORMATION AND REFERENCES

1. CHSTP Test Track Requirements; Banko, F; 4/01/09
2. California High Speed Rail System Test Track; Silien, J; 4/08/09
3. CHSRS Test Track; Alstom; Wochele, C; 4/29/09
4. CHSTP Test Track Requirements (Revised); Yanitskaya, V; 7/22/09
5. CHSTRS Test Track doc; Siemens; Guzzo, F. et al; 7/29/09

6.0 DESIGN MANUAL CRITERIA

None applicable