Potential Traffic Paralysis Throughout the Peninsula

Blended Caltrain/High Speed Rail Impact on Street Traffic

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Abstract

This engineering analysis, by rail transportation expert Paul S. Jones, whose resume is attached to the report, demonstrates the expected impacts of a "Blended System" Caltrain/High-Speed Rail service currently being proposed as a joint project between the Caltrain Joint Powers Board and the California High-Speed Rail Authority.

Mr. Jones convincingly demonstrates that traffic and congestion impacts on the Peninsula will be severe, and that "it would be fair to describe the result as a 'paralysis' of traffic on the Peninsula." The only acceptable solution is to provide full grade separations at all 40 of Caltrain's grade crossings either prior to or concurrently with the introduction of Blended System service.

Introduction

The proposed Caltrain/high speed rail (HSR) Blended System contemplates six Caltrain and four HSR trains traveling in each direction every hour during each morning and evening rush period. This represents doubling the rail traffic now operated by Caltrain. Each of the 40 grade crossings between San Francisco's Fourth and King Street Station and San Jose's Diridon Station would experience an increase in rail traffic from 10 trains per rush hour to 20 trains per rush hour.

In June, 2013, Caltrain published a report," Caltrain/HSR Blended Grade Crossing and traffic Analysis" to study the impact of the Blended System on street traffic delays. The report produced by that work alleges that the sharp increase in rail traffic will result in only minimal additional delays to street traffic at the grade crossings. In fact, the Caltrain report is seriously flawed. The purpose of this paper is to review the quality and accuracy of Caltrain's grade crossing study and to offer evidence that the delays to street traffic resulting from the increased number of Caltrain and HSR trains would be significant and damaging to all Peninsula cities.

The grade crossing report depended heavily on two other Caltrain studies:

- "Caltrain/California HSR Blended Operations Analysis," prepared by LTK Engineering Services in November 2011
- "Caltrain/California HSR Blended Operations Analysis Supplemental Analysis Requested by Stakeholders," prepared by Cal Mod Program Team in April 2012

These two studies used a computer simulation, "Train Ops," designed and operated by LTK Engineering Services to examine combinations of Caltrain and High Speed trains in simulated operation over the existing Caltrain tracks between San Francisco's Fourth and King Street Station and San Jose's Diridon Station. They also assessed several alternative high speed rail bypass tracks that might be constructed at different locations along the route. The work was carefully done by LTK Engineering, but it was based on schedule modifications and assumptions that cause the results to be questioned.

Critique of Grade Crossing Report

Before addressing the specific shortcomings of the Grade Crossing Report, it is necessary to examine shortcomings of the two Blended Operations Analysis reports, particularly the schedule modifications and the assumption that Caltrain's CBOSS positive train control system will perform as intended.

Schedule Modifications

Rather than starting with a current Caltrain Schedule for the five trains per peak hour and adding an additional train to achieve the combination of six Caltrain and up to four High Speed trains per peak hour for the Blended System, LTK adopted a new set of skip-stop services that vary widely from the existing schedule.

Selecting six northbound trains from the current Caltrain schedule that most closely resemble LTK's skip-stop schedule, the present schedule imposes 76 intermediate stops between San Jose and San Francisco. The number of intermediate stops for individual trains varies from 9 to 17. The six trains from LTK's skip-stop schedule would impose only 67 intermediate stops, with five of the six trains making exactly 11 intermediate stops and the sixth making 12 intermediate stops. The simulated LTK schedule provides more balanced train movements, but it completely disregards differences in traffic volumes at the different stations and differences in origins and destinations. In particular intra-peninsular travelers would suffer decreased service. Eleven Caltrain stations would have fewer train stops per peak hour. Three stations (Palo Alto, Redwood City, and Millbrae) would have more service. In addition, one token stop each would be added at the Atherton and Broadway, stations not presently served by Caltrain on week days. The LTK study did not include Baby Bullet trains in its schedule.

Train Control

The LTK study assumed that Caltrain's CBOSS positive train control overlay system would be in service and performing up to its design objectives. Unfortunately, the installation of the CBOSS System has encountered a number of software and operational problems that have greatly delayed its full implementation. In addition, CBOSS is not compatible with the Union Pacific's positive train control system, nor with the CHSRA's intended positive train control system. Also, the proposed electrification of the Caltrain line, scheduled to take place prior to the utilization of HSR trains on the route, will introduce grounding currents in the rails that will make current impedance measurements inoperative, impacting Caltrain's signaling system. In the process of overcoming these and other teething problems, actual CBOSS system performance may differ substantially from the design performance.

LTK Simulation Results

The November 2011 LTK study simulated train operations over the present Caltrain track infrastructure and four alternatives that added two track bypass/overtake tracks (four track options) that would allow High Speed trains to overtake Caltrain trains. In addition, station siding tracks were added at Fourth and King, Millbrae, and Diridon stations to provide separate boarding platforms for Caltrain and High Speed train passengers. At present, these stations are the only stops to be made by High Speed trains on the Caltrain tracks. LTK investigated combinations with six simulated Caltrain trains and 0, 1, 2, 3, and 4 High Speed trains per peak hour, and at 79 mph and 110 mph peak speeds. It was soon apparent that for a workable schedule, both Caltrain and High Speed trains would need to operate at the same maximum speed. High Speed trains could go faster only on the bypass tracks.

The April 2012 study included additional investigations of the different bypass/overtake options, including the addition of a long single bypass/overtake track (three track option) in which High Speed trains would operate in both directions over the bypass track. This study concluded that the long middle four track option would provide the best results. This bypass/overtake would extend from south of Hayward Park to south of Redwood City.

Grade Crossing and Street Traffic Analysis

The June 2013 study of grade crossings was based on the LTK train simulation work at a top speed of 79 mph for Caltrain and High Speed trains. It began with the skip-stop schedule developed for the LTK simulations which was modified to replace two of the multi-stop trains with Baby Bullet trains. The schedule modification was not well done. For example, Trains 418 and 424 would depart Diridon and Lawrence stations at exactly the same minute, hardly possible. The Baby Bullet trains would require 9 minutes between departures at San Jose's Diridon and Sunnyvale stations, as compared with 13 minutes required by Baby Bullet trains today; again, hardly possible.

The study purported to examine both rail and street traffic together. However, the rail traffic was taken from the 2011/2012 studies and the street traffic was estimated traffic for 2035, 23 years later. Caltrain traffic has been growing steadily since the recession in 2008 and now amounts to more than 60,000 passengers per week day. Many trains are loaded beyond their capacity. Caltrain has purchased used coaches and is extending the length of its trains. If passenger traffic continues to increase to 2035, Caltrain will be severely constrained to handle its traffic with no more than the six trains per peak hour allowed by the Blended System agreement. Caltrain can only increase its capacity by continuing to increase the length of its trains. This would introduce problems concerning platform length and other issues that are likely to impact station dwell times. The time required by trains to traverse grade crossings would also increase.

Street Traffic Delay Analysis

In the June 2013 study, street traffic delays were analyzed using Synchro software, which is designed to perform street and highway analysis. Synchro is a macroscopic traffic analysis tool designed primarily for evaluating arterial corridors. Trains were modeled as large trucks and the Caltrain line as a highway.

Synchro does not analyze individual vehicle movements, but relies on mean performance values. Actual delays at grade crossings are stochastic in nature. Vehicles arrive at grade crossings at irregular intervals. For any mean waiting time, actual vehicle waiting times range from trivial to unbearable. Queues can build up quickly and decline slowly adding to the sense of delay.

The study acknowledged that reductions in gate down times would result only from (1) overlapping train crossings, in which a through train would pass a train that is stopped at the station and from two trains that would cross at the same grade crossing at the same instant, and (2) from the elimination of upstream gate closings at crossings ahead of a train stopped at a station. Scheduling train crossings is very difficult because Caltrain trains cannot operate to precise schedules. Station dwell times are highly variable over a range as long as five minutes. There are delays due to wheelchair and bicycle loading and unloading, variations in passenger boarding queues at different doors, and crowding in vestibules. All have significant impacts on dwell times. If overlapping passes at specific times and places are required, they can only be achieved by slowing one of the passing trains so that a pass can be achieved without additional lowering of crossing gates, or by extending gate down time.

The Synchro model dwelt with only one street intersection at each grade crossing. It did not consider queueing at adjacent intersections or complex multi intersection problems. It examined only five intersections in detail:

- 16th Street, 7th Street, and Mississippi Street in San Francisco
- 25th Avenue and El Camino Real in San Mateo
- 25th Avenue and Delaware Street in San Mateo
- Broadway and El Camino Real in Redwood City
- Churchill Avenue in Palo Alto

It did not examine the complex interactions at Burlingame Avenue in Burlingame, Ravenswood Avenue in Menlo Park, and other complex traffic situations on the Caltrain route.

All of the short comings enumerated above must be corrected before any credence can be placed in Caltrain's grade crossing analysis.

A Straightforward Approach to Grade Crossing Analysis

Caltrain's grade crossings can be divided into two groups: crossings that are adjacent to stations and crossings that are more than one quarter mile distant from the end of the station.

Gate down times at crossings adjacent to stations are longer that those away from the stations because trains entering and leaving the stations are either slowing to stop or accelerating from a stop. Upstream crossings, crossings ahead of a stopped train, also suffer from needless gate down time because the gates lower as the train approaches the station and then rise when the train comes to a stop. Caltrain's CBOSS positive train control system is supposed to eliminate these needless gate closures by knowing that the train will stop and presumably monitoring its speed to ensure that it will stop. The penalties at adjacent crossings are directional. The gate that closes ahead of a stopping northbound train becomes the gate that closes for a southbound train entering the station.

In the Caltrain system between San Francisco's Fourth and King Street Station and San Jose's Diridon Station there are five crossings adjacent to stations for northbound trains and seven crossings adjacent to stations for southbound trains. These are:

	Northbound	Southbound
San Mateo		First Avenue
		Third Avenue
		Fourth Avenue
Redwood City	Brewster Street	Maple Street
	Broadway	
Menlo Park	Oak Grove Avenue	Ravenswood Avenue
	Glenwood Avenue	
Mountain View	Castro Street	
Sunnyvale		Sunnyvale Avenue

Broadway in Burlingame and Fair Oaks and Watkins in Atherton are adjacent to the Broadway and Atherton Stations, but are not included in the list because there is no weekday Caltrain service to either of these stations.

The gate downtimes at crossings away from stations are determined by the speed of the trains through the crossings. By Federal regulation, the crossing bells must sound and the gates come down between 15 and 20 seconds before a train enters the crossing. Gate action typically takes 7 to 10 seconds to raise or lower the gates. There is nothing that CBOSS can do to reduce these times.

Train Crossings

It is difficult to ensure that two opposite bound trains will cross at a particular grade crossing or station because of the critical timing required to effect these efficiently. A station crossing by a through train at 79 mph takes only 13 seconds, and a grade crossing takes only 7 seconds. It is possible to slow one train or the other, but this introduces train control and scheduling difficulties as well as lengthening passenger travel time. One must conclude that train crossings are advantageous when they occur but cannot be scheduled.

The string diagrams in Caltrain's November 2011 report, the latest reference that deals with the existing Caltrain track structure, illustrate tentative schedules for different combinations of Caltrain and HSR trains. The diagram for six Caltrain and four HSR trains per direction at maximum speeds of 79 mph is of particular interest because it is most likely to represent the initial joint operation between Caltrain and HSR. This diagram is based on LTK Engineering's simulation work. The string diagrams illustrate from 0 to 8 crossings at stations during the two-hour peak hour simulation, with an average of 4 per station or 2 per peak hour. With schedule fluctuations due to random differences in station dwell times, it would be overly optimistic to rely on even this small number of station crossings, but with outstanding performance by CBOSS, between 1 and 2 crossings may occur.

Train crossings at grade crossings away from stations are even more problematical because they are literally split second occurrences. To ensure these crossings, it would be necessary to carefully monitor the progress of each train on the Caltrain System and to adjust speeds to make the crossing happen without extensive gate down time.

Gate Down Times

Crossings Adjacent to Stations

Assuming that CBOSS does its job and prevents grade crossing gates upstream from a station from closing before the train accelerates out of the station, the downstream gate will close 15 seconds before the train enters the crossing and remain closed until the last car of the train has cleared the crossing, often until the train comes to a stop at the station. On the average, this the gate is down for 60 seconds. The downstream gate does not lower again until the next train approaches the station.

At present, the upstream gate will close as the train approaches the station and will remain closed until the train comes to a complete stop. Then, the gate will rise, but it will close again as the train accelerates from a stop and stay closed until the train clears the crossing. On average, both the initial and following closures take 60 seconds. With CBOSS functioning as designed, the first gate closure will not occur.

For through trains, both the downstream and upstream gates will perform like crossings away from stations.

Crossings Away from Stations

Gate down times for crossings away from stations depend entirely on the speed of the crossing train. By Federal regulation, the crossing bell must sound and the gate come down 15 to 20 seconds before the train enters the crossing to allow motorists and pedestrians time to clear the crossing. The gates must remain down until the last car of the train clears the crossing. Down times for crossings of wide thoroughfares are longer than those for narrow streets, but the differences are small and are neglected in this analysis.

Allowing 7 seconds for gates to lower and 7 seconds for them to rise, both optimistic, gate down time is 29 seconds longer than the train transit time. Trains crossing a 120-foot roadway would have the following transit times, and corresponding down times for different train speeds:

Train Speed	Transit Time	Total Gate Down Time
Mph	**Seconds**	**Seconds**
25	24	53
40	15	44
55	11	40
70	9	38
79	8	37

The gate down times for high speed rail (HSR) trains will be the same as for Caltrain's EMU trains. As noted above, the LTK study established that a workable schedule for six Caltrain and four HSR trains in each direction per peak hour requires that all trains operate at the same top speed and follow similar speed-distance profiles.

Gate Downtimes by Crossing Type

The total gate down time for each crossing depends on the length and speed of the trains crossing the street and the width of the street. Because the trains proposed by CHSRA are approximately the same length as Caltrain's proposed EMU trains, no distinction need be taken between the two types of trains.

Crossings Adjacent to Stations

The down time per peak hour for gates adjacent to stations depends on the mix and direction of stopping trains and the number of through trains. From analysis of the LTK string charts, the number of stopping trains at Caltrain stations varies from 2 to 12. Thus, the gate down time for stopping trains would be:

Number of Stopping Trains Per peak hour	Gate Down time Minutes
2	3
4	6
6	9
8	12
10	14
12	16

Crossings Away from Stations

As noted, gate down times for crossings away from stations depend largely on the speeds of the crossing trains. For crossings within one half mile of a station, crossing speeds will be lower because the trains that stopped at the station will not yet have accelerated to maximum speed, and the arriving trains are slowing in preparation to stop. These crossings will experience a mix of different down times. Therefore, each crossing has a unique total down time for peak hours. For uniform train speed, the total down time for ten trains in each direction per peak hour would be:

Train Speed, mph	Gate Down Time, min.
25	17.7
40	14.7
55	13.3
70	12.7
79	12.3

Comparison Between Today's Caltrain and Blended Caltrain/HSR System

Gate down times for the Blended Caltrain/HSR operation can be compared with down times experienced by today's Caltrain operations, and how Caltrain's down times would change with the successful implementation of the CBOSS positive train control.

Blended Service			Caltrain Service		With CBOSS	Without CBOSS
Station Stops	**Through**	**Down Time**	**Station Stops**	**Through**	**Down Time**	**Down Time**
8	12	21 min.	8	2	10 min.	14 min.
6	14	19 min.	6	4	9 min.	12 min.
4	16	17 min.	4	6	8 min.	11 min.
2	18	16 min.	2	8	8 min.	8 min.

All times are in minutes per peak hour. Thus, under the Blended service, crossings with 8 station stops would have a total down of 21 minutes per peak hour, more than one third of the elapsed time. In contrast, if CBOSS performs as designed, today's Caltrain would experience only 10 minutes down time per peak hour. The difference is very large, particularly for crossings adjacent to stations that experience large volumes of peak hour automobile traffic.

It is apparent that with a successful CBOSS implementation, the Blended System train traffic will more than double gate down time for all grade crossings adjacent to stations. For crossings away from stations, the gate down times for the Blended System would be exactly double those experienced today.

These very significant increases in crossing gate down times will, of necessity, greatly increase street traffic congestion in and around all grade crossings, with particular emphasis on those near stations. The exact extent of the traffic problem will extend well beyond the immediate proximity of grade crossings to traffic on nearby and some distant arterial streets and other streets.

Significance of Gate Down Time

The significance of the increased gate down time brought about by the Blended System can be presented in terms of a grade crossing that is away from a station in terms of the present Caltrain service and the Blended System. Equally spaced trains operating at different speeds would produce the following down times per peak hour:

	Train Speed		
	40 mph	**55 mph**	**70 mph**
Present operation, 10 trains/hour			
Gate down time/peak hour	7.35 min.	6.67 min.	6.35 min
Gate Up time/peak hour	52.65 min.	53.33 min.	53.65 min.
Mean interval between trains	5.26 min.	5.33 min.	5.36 min.
Cars crossing/interval	39	40	40
Blended System, 20 trains/hour			
Gate down time/peak hour	14.70 min.	13.33 min.	12.70 min.
Gate up time/peak hour	45.30 min.	46.67 min.	47.30 min.
Mean interval between trains	2.26 min.	2.33 min.	2.37 min
Cars crossing per interval	16	1 7	17

The numbers of vehicles crossing are based on an interval of 8 seconds between vehicles.

Thus, by introducing the Blended System the number of vehicles that can cross the rail grade for each gate up period is reduced by almost 60 percent. For busy crossings at the peak hours it is quite likely that not all of the vehicles in a queue in front of the closed gates will be able to cross the tracks in the short interval available. This not only adds additional delay to the stranded drivers and their passengers, it may add appreciably to the overall congestion of the busy streets in the immediate vicinity.

The overall reduction in vehicle traffic per rush hour would be 12 to 14 percent by the introduction of the Blended System, much greater than that predicted by the Caltrain Grade Crossing study.

In reality, the intervals between successive trains at a grade crossing are not uniform, but will vary widely depending on the actual performance of the trains in the system at any particular time. There would certainly be instances where drivers are delayed for more than one gate down interval. Heavy traffic, traffic congestion, overly timid drivers, and other delays will add to the difficulty of crossing the Caltrain tracks. Impatience due to long waits can lead to reckless chances, dangerous acts, and road rage. With even slight irregularities in the train performance, the short mean interval time of less than two minutes will result in some crossing gate up intervals that are very short. It is hoped that the CBOSS System will establish a minimum gate up time that will discourage aggressive motorists when the gate up times are very short. Such a minimum would further reduce the amount of time available for automobile traffic to cross the tracks, adding even more congestion. At very best, the Blended System will greatly degrade the quality of life on the San Francisco Peninsula, and it would be fair to describe the result as a "paralysis" of traffic on the Peninsula. The only acceptable solution is to provide full grade separations at all 40 of Caltrain's grade crossings either prior to or concurrently with the introduction of Blended System service.

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Education

Cornell University, 1951, Bachelor of Mechanical Engineering, with Distinction, (five-year undergraduate program), Academic Standing, Second, Honor Societies: Phi Kappa Phi, National Scholastic, Tau Beta Pi, International engineering, Pi Tau Sigma, National Mechanical Engineering, Kappa Tau Pi, Industrial Engineering

Golden Gate University, 1959, Master of Business Administration,
Thesis: "Organizing the Engineering Function in a Contracting Firm"
Stanford University, 1972, Ph.D. Industrial Engineering,
Dissertation: "A Least Cost Equipment Selection Technique for Distribution Warehouses"

Registration

Registered Mechanical Engineer, 11096, and Industrial Engineer, 571, California

Professional Society Membership

American Society of Mechanical Engineers
Institute of Electrical and Electronic Engineers
INFORMS, Information and Operations Research Society

Professional Experience

1951-3, Lt. JG, USNR, Korean War, Main Propulsion Assistant, USS John R. Craig (DD885)
1953-6, Engineer, Elliott Company, Manufacturer of power plant equipment
1956-9, Engineer, M. W. Kellogg Company, Oil and Chemical Contracting
1959-1972, 1982- 1992, S.R.I. International, Program Manager Transportation and Material Management
1972-77, Associate Professor, Industrial and Systems Engineering, Georgia Institute of Technology
1977-82, Principal, Systan, Inc., Transportation consulting firm
1992-Present, Independent Consultant

High Speed Rail Experience:

Principal in Charge of Initial High Speed Rail Design Study- Madrid to Barcelona, Spain

Beginning with 30 potential route alternatives, civil engineering studies reduced the number to 6. The surviving 6 were studied in detail using 1:20,000 scale maps. Vertical and horizontal alignments were laid out. Cost estimates were prepared for the civil work. Travel demand was estimated considering both present travel along the route and potential induced travel. A modal share was estimated for the high speed service on the basis of different fare levels. High speed travel estimates were used to prepare a schedule of arrivals and departures for each station. Train set procurement was determined for each level of service. An organization structure was designed and operating and maintenance costs were estimated for each route alternative and fare structure. The 6 alternatives were then compared over 20 years of service. The analysis concluded that the line could not be built using private capital alone, but would require public money for most or all of the infrastructure. The line, following the preferred route, was built using public money for the infrastructure. The actual passenger volume for the first year of operation was within five percent of the first year travel volume estimated in the patronage study.

Train set selection for Madrid to Seville and Seoul to Pusan routes.

Principal high speed train offerings were applied to service on the routes. A careful technical assessment was made of each train offering, producing a set of candidate trains. Economic comparisons among candidates were made in terms of first cost, travel times between station pairs, operating costs, maintenance costs, and political considerations.

Conventional Railroad Work

Work has been performed for major U. S. railroads and for railroads in Malaysia and Thailand. Assignments included the following:

- Design of a national railroad network model
- Social and economic impacts of railroad mergers
- Service improvement planning
- Cost reduction opportunities in the movement and storage of export coal
- Inland Container movement
- Economic life of railroad grading and tunnel bores
- Container and trailer-on-flat-car service design and evaluation
- Locomotive replacement policy
- Refrigerated car replacement policy
- Locomotive maintenance policy
- Scheduling track maintenance crews
- Rail replacement policy
- Improved material management procedures