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SafeTREC Safe Transportation Research & Education Center

Applying Safety Treatments To Rail-Highway At-Grade Crossings

Douglas L. Cooper and David R. Ragland
SafeTREC

May 2012
RR-2012-2

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EXECUTIVE SUMMARY

At-grade rail crossings provide different levels of warnings and/or barriers to alert drivers to the potential dangers presented by approaching trains. For some drivers, an activated warning system, rather than being a signal to stop, merely serves as a cue for the need to make a decision whether or not to cross. In California, for the ten-year period from 2001 to 2010, the result was 1,033 train-vehicle crashes resulting in 157 deaths and 458 injuries.

The best solution to rail crossing crashes is to remove the need for the driver to engage in a potentially faulty decision-making process by making it impossible, or at least very difficult, for the driver to bypass lowered gates. Two low-technology, low-cost, low-maintenance methods: median separators and long-arm gates, have been deployed in many locations and have been shown to prevent deaths and injuries while remaining economically feasible.

Highway-railway grade crossing collisions tend to be spread over a vast number of sites, with few (if any) occurring at any given site in any given year. To improve safety at all 6,443 grade crossings in California to some uniform standard would be prohibitively expensive and impractical. Therefore, any comprehensive safety program must begin by first identifying crossings where the risk of collision is unacceptably high, and where safety countermeasures are most warranted.

Predicting the degree of safety present at highway-railroad grade crossings using accident prediction models is a common approach. These models are usually developed using a highway-railroad grade crossing database (primarily that maintained by the Federal Railroad Administration using data supplied by each state) consisting of crossing characteristics and accident data for a given period of time. From the perspective of the California Division of Rail, however, the search for the ideal formula or ranking system is immaterial given the current state of its rail crossing inventory database (which is the responsibility of the California Public Utilities Commission) with its often inaccurate as well as incomplete information.

At present, the only meaningful statistic for which there is data is crash history, which leads to the difficult question of what constitutes a dangerous rail-highway crossing. If a crossing has an incident every twenty years, it would be hard to argue that the crossing is dangerous. But what if a crash occurs there every ten years, or every five years? At what point does a crossing become dangerous and in need of remedial action?

An examination of gated sites with multiple crashes between 1986 and 2010 shows that the median time between crashes ranges from 6.1 years at sites with two crashes to 2.75 years at sites with five crashes. Also of interest is the length of time it took each site to accumulate its crashes. These range from 5 days to 24 years for sites with two crashes to 8 to 23 years at sites with five crashes. Certainly a crossing with five incidents over the course of eight years can be labeled as dangerous, but what about those crossings with incidents spread out over twenty or more years? If a crossing is truly dangerous and in need of remedial action, how do so many vehicles make it safely across resulting in several years passing without an incident?

Since so much depends on the accuracy of our state’s inventory database, bringing it up to date and putting it into a readily accessible format should be the top priority for all involved in California rail. Once that is accomplished, crossings will be able to be properly evaluated by looking for commonalities at sites where crashes have occurred in the past.

SECTION 1: CALIFORNIA INCIDENT DATA

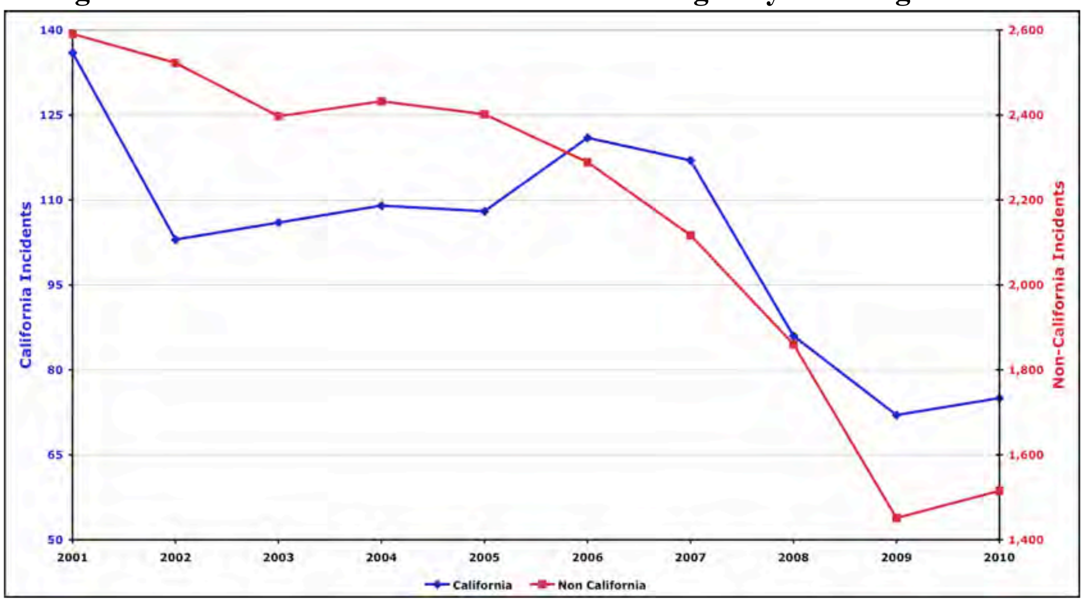
There are currently 6,433 public at-grade rail-highway crossings in California, down from 7,719 such crossings in 2005 (FRA, 2005, 2010). During the ten-year period from 2001 to 2010, there were 1,033 train-vehicle crashes at these crossings. While the majority of crossings with collisions experienced only one crash (71%), a significant number of crossings (29%) had multiple collisions, ranging in number from two to ten. The crashes resulted in a total of 157 deaths and 458 injuries.

The 1,033 crashes exhibited a number of characteristics, including:

- 76.0% occurred at crossings equipped with gates
- 28.4% involved vehicles that had driven around or through lowered gates
- 20.0% involved a vehicle running into the side of the train

Over the last ten years the number of grade crossing incidents in California has fallen 44.9%, from 136 at the end of 2001 to 75 at the end of 2010 (Figure 1). During this same period, the number of incidents in the other 49 states has decreased 41.5%, from 2,727 to 1,590.

Figure 1: Ten-Year U.S. and California Rail-Highway Crossing Incidents



Source: FRA

Rail crossings provide different levels of warnings and/or barriers to alert drivers to the potential dangers presented by the at-grade crossing. These protective devices range from four-quadrant gates with medians to mere stop signs or crossbucks. Since some type of warning device is always present, crashes are caused either by people violating the signs/signals/gates or not perceiving/misperceiving an approaching train's distance and speed.

An important finding in a study by Meeker and Barr (1989) was that two thirds of the 57 drivers who approached a rural rail grade crossing in the presence of activated warning flashers crossed the tracks despite the warnings and the approaching train. This would appear to indicate that crossing an activated warning device is a widespread activity not limited to a small proportion of drivers. Clearly, the activated devices in their observations were *not* commonly perceived as a signal that the risk was too great and that the driver should not cross. Rather, the results are consistent with the view of Leibowitz (1985), who suggested that "active" warning systems merely cue drivers as to the need to make a decision whether or not to cross.

Meeker and Barr (1989) go on to say that "…it is not entirely satisfactory to conclude that two thirds of all drivers in our sample were engaging in life-threatening behavior when they decided to cross. One might argue that pedestrians regularly cross busy thoroughfares with a much smaller safety margin than the margin that drivers we observed allowed themselves."

Drivers crossing around barrier gates tended to stop or slow on approach significantly less than those crossing with flashers only. It was suggested that the gates themselves provided an impediment to crossing which forced drivers inclined to cross into making a hurried and sometimes perilous decision. Their behavior was seen as explaining the surprisingly high number of accidents that occur at barrier-gate crossings. Perhaps the only way that drivers at these barrier-gate crossings can achieve an acceptable safety margin is to make the decision to proceed through the crossing without stopping or slowing their vehicles early on. The fact that a substantial number of accidents tend to occur at these crossings is not surprising given this behavior (Meeker et al., 1997).

A common driver error is misjudgment of the time remaining until the train arrives at the crossing (i.e., train speed and distance). Speed estimation can be influenced by a number of factors, including driving experience, visual cues available, light conditions, the presence of visual information in the background, and adaptation to previously encountered train speed levels (Dewar and Olson, 2002). Additionally there are two perceptual problems associated with rail crossing decisions. First, humans have difficulty judging the approach speed of a vehicle when it is seen nearly head on, as their only indication of speed is the rate of change in the size of the object. Second, Leibowitz (1985) noted that there is the illusion that large object appear to move more slowly than small ones which are actually traveling at the same speed.

To assist the state of California in efficient utilization of state and federal funding available for increasing the safety at public at-grade rail-highway crossings, the results of this project aim to recommend effective countermeasures and an implementation strategy that provides drivers with a sufficient level of warning and motivates them to comply with cues. This report presents ten-year crash data for California in order to assess the magnitude and nature of the problem, as well as information on crossing safety equipment, incident data, and inventory data to formulate a strategy to increase crossing safety.

CALIFORNIA CRASH DATA

The statistics used in this section were obtained from the FRA Office of Safety Analysis website (http://safetydata.fra.dot.gov/officeofsafety/Default.asp), the California Public Utilities Commission (CPUC) Crossing Inventory, police reports, and California municipal and county personnel and websites.

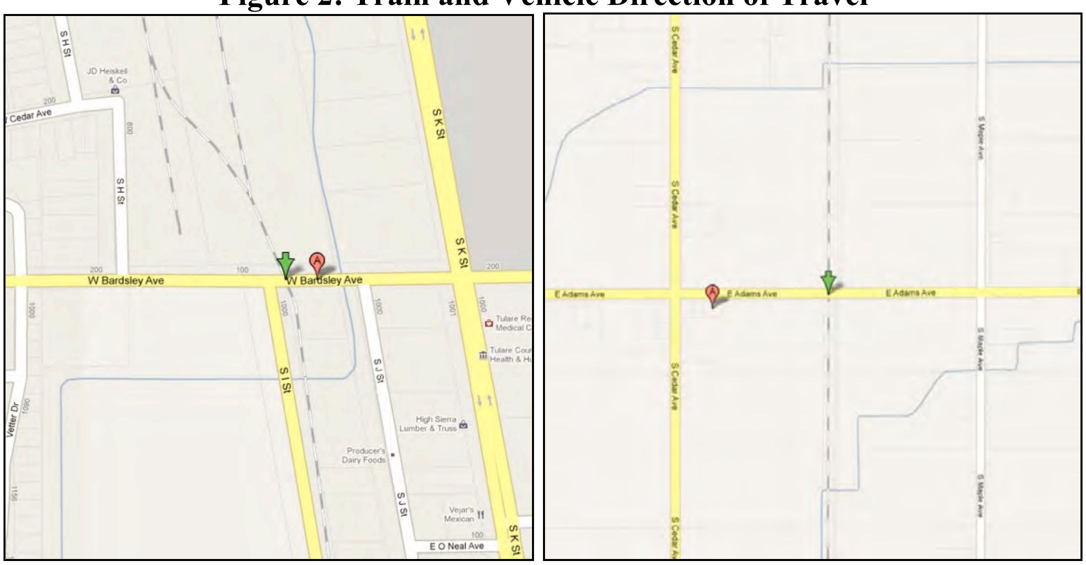
The FRA website allows access to railroad safety information including accidents and incidents, inspections and highway-rail crossing data. Users can run dynamic queries, download a variety of safety database files, publications and forms, and view current statistical information on railroad safety. The data are organized into the following nine categories:

1. Overview
2. Query Accident/Incident Trends
3. Train Accidents
4. Casualties
5. Highway-Rail Crossing Accidents
6. FRA Inspections
7. Downloads
8. Highway-Rail Crossing Inventory
9. FRA Safety Reporting

While these sources provide the best available and most complete information on railroad-related issues, there are a number of significant problems that undermine the reliability of the data. As noted in a number of reports (e.g., FRA, 2004), both the inventory and accident/incident databases contain inaccurate as well as incomplete information. As an example, highway traffic information for the 6,433 open, at-grade public crossings in California is often out of date with 15% of the vehicular traffic counts dating from the 1970s, 65% from the 1980s, and 18% from the 1990s. Another example involves location information contained in the FRA crossing inventory database. As part of this report, a random sample of rail crossings was needed to determine the role of crossing/roadway angle in crashes. This required the examination of 680 crossings in order to achieve the desired sample size of 500, which means that roughly one out of every four crossings checked could not be found at the location given in the FRA database. As noted by the FRA (2004), its Inventory Data File, a record of grade crossing location, physical, and operational characteristics, is dependent on voluntary state reporting.

The crash records in the FRA database are often lacking in detail. While there is a narrative section that should describe the circumstances of the crash, for the most part this section appears to be constructed from checked boxes or short statements recorded elsewhere in the record. This makes interpreting the data difficult. For example, according to FORM FRA F 6180.57 (Highway-Rail Grade Crossing Accident/Incident Report), vehicles and trains only travel in one of four directions: north, south, east, or west. There are no other choices. Combined with inaccurate incident reporting, the results are often similar to those depicted in Figure 2, in which the car in a) was reported to have been traveling north on Bardsley Avenue, while in b) the train was reported to have been traveling east.

Figure 2: Train and Vehicle Direction of Travel



a) b)

The California Public Utility Commission maintains its own incident and inventory database. Lack of funding has prevented the CPUC from keeping its inventory up to date, although some crossing information is more recent than that of the FRA database. The last time the CPUC issued its "Annual Report of Railroad Accidents Occurring in California" was in 1999.

CRASH AND CROSSING CHARACTERISTICS

What is it about a crossing that would cause it to have ten vehicle-train incidents over a ten-year period while a nearby crossing has none? Incident data will be examined in the hope that some key differences can be seen that can then be used to mitigate future incidents. In many of the following categories we compare data from multi, single, and non-crash sites

Crossing Safety Equipment

At the present time there are 6,433 public at-grade crossings in California of which 37% are passive and 63% are active (Table 1). Most of the active crossings (75%) are equipped with gates and flashing lights. Equipment at public crossings where train-vehicle crashes occurred during 2001 through 2010 is shown in Table 2. Perhaps the most significant statistic from this table is that 778 crashes (75%) occurred at crossings equipped with gates, which would seem to indicate that, for some drivers, standard two-quadrant gates are not a deterrent. It should be noted that the high percentage of incidents that occur at gated crossings should not be interpreted as a lack of efficacy of gates but rather that gates are installed at the busiest, and therefore most dangerous, crossings.

Table 1: California Public At-Grade Crossing Warning Equipment (2010)[1]

Traffic Control Device Type	Number	Percentage
No Signs or Signals	90	1.4%
Other Signs or Signals	15	0.2%
Crossbucks	2,074	32.2%
Stop Signs	223	3.5%
Special Active Warning Devices	28	0.4%
Hwy Traffic Sig, Wigwags, or other Activated	198	3.1%
Flashing Lights	806	12.5%
All Other Gates	2,980	46.3%
4 Quad	19	0.3%
Total Public At Grade	6,433	100%

1. The devices listed are the highest level of warning at a particular crossing.
Source: FRA

Table 2: Warning Equipment for California Public Crossings with Crashes 2001-2010[1]

Control Device	Number of Train/Vehicle Crashes	Percentage of All Train/Vehicle Crashes
Gates	778	75.0%
Cantilever Flashing Lights	35	3.4%
Std Flashing Lights	64	6.2%
Wig Wags	9	0.9%
Hwy Traffic Sig	4	0.4%
Audible	1	0.1%
Cross Bucks	113	10.9%
Stop Signs	23	2.2%
Watchman	0	0.0%
Flagged by Crew	1	0.1%
Other	1	0.1%
None	4	0.4%
Total	1,033	100%

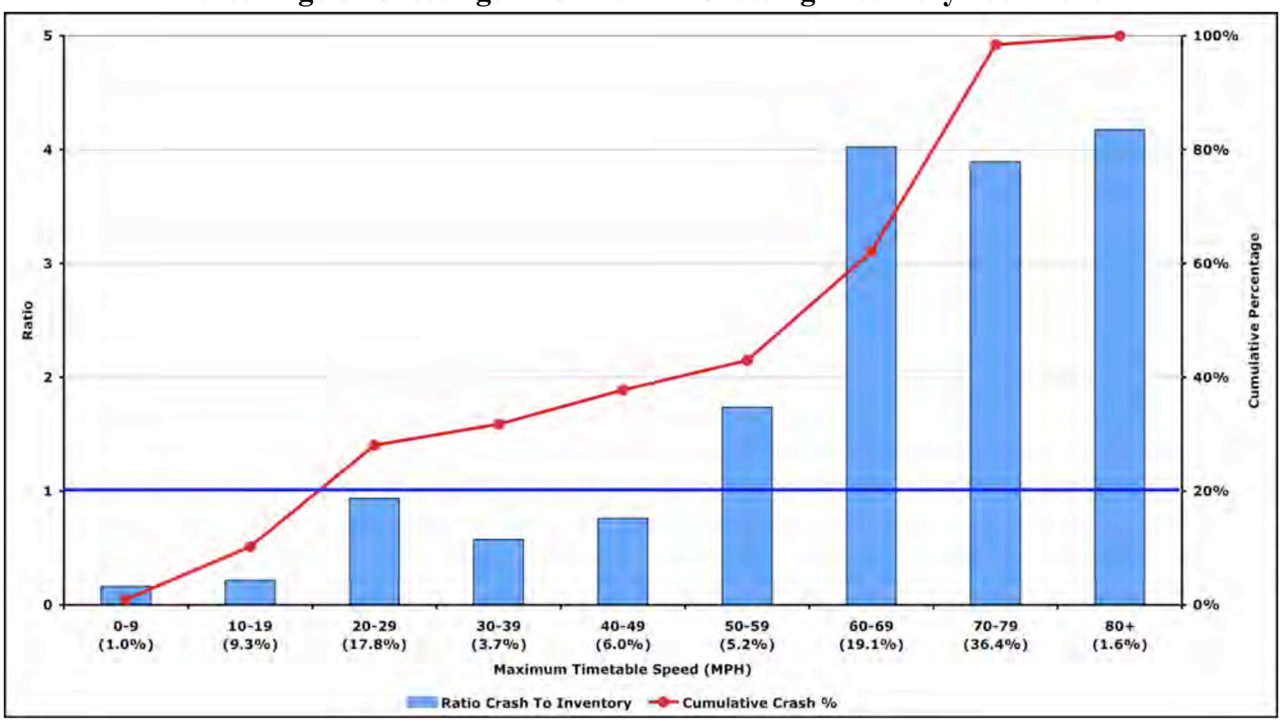
1. The devices listed are the highest level of warning at a particular crossing. Thus a crossing with gates and flashing lights would be listed only under the "Gates" category.
Source: FRA

Train Speed
For the 1,000 California train-vehicle crashes at public rail-highway crossings with speed information, Figure 3 shows both the cumulative distribution of train speeds (indicated by the line) and the ratio of the percentage of crashes at that speed to the percentage of such crossings in the inventory (indicated by the bars). The numbers shown below each speed category are the percentage of crashes that occurred within that speed category from 2001 to 2010 (e.g., 19.1 % of crashes occurred at crossings with a maximum timetable speed of between 60 and 69 MPH).

If speed has no effect on crashes (i.e., considering speed only, crashes are evenly distributed across all crossings in the inventory regardless of the maximum timetable speed at that crossing), then the percentage of crashes occurring in that crossing speed category would be the same as the percentage of crossings in the state's entire inventory in that speed category and every bar, representing the ratio of the two, would be equal to one (the dark blue line). This is obviously not the case. Crashes at crossings with a maximum timetable speed of 60 to 69 MPH, for example, occur at a rate four times what would be expected if speed was not a factor in crash causation. All crash timetable speed categories greater than 50 MPH are over-represented, showing that higher speed crossings are more dangerous.

Each point on the cumulative distribution line represents the percentage of total crashes that have occurred at that speed or less. For example, approximately 60% of total crashes occurred at crossings with a maximum timetable speed of 69 MPH or less.

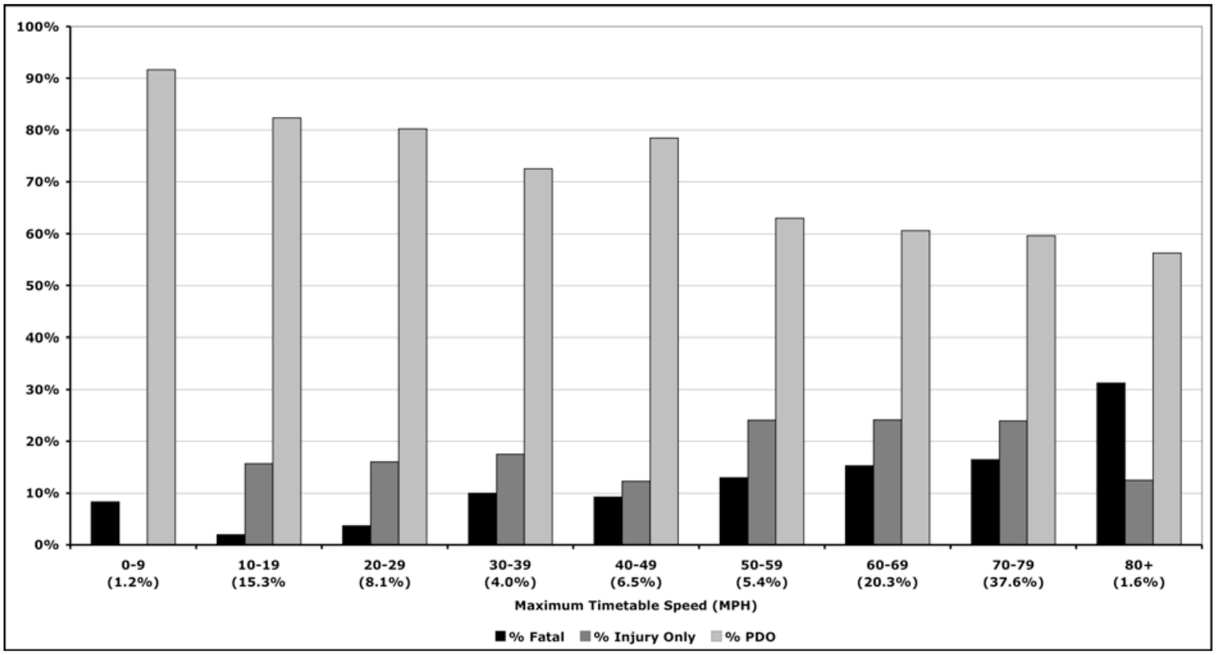
Figure 3: **Ratio of Maximum Timetable Speed Percentages at Crash Crossing to Percentage of Crossings in California Crossing Inventory 2001-2010**



Source: FRA

In Figure 4, the relationship between train speed and crash severity is shown. Within each speed grouping, the percentages for all three crash types total 100%. Thus, for example, for those crashes that occur with a train speed between 40 and 49 MPH (6.5% of all crashes), 78.5% are Property Damage Only (PDO), 12.3% involve injuries, and 9.2% involve fatalities. The injury and fatality categories are mutually exclusive in that a crash that has both injuries and at least one fatality is counted as a fatal crash. As can be seen, train speed is a factor in crash severity.

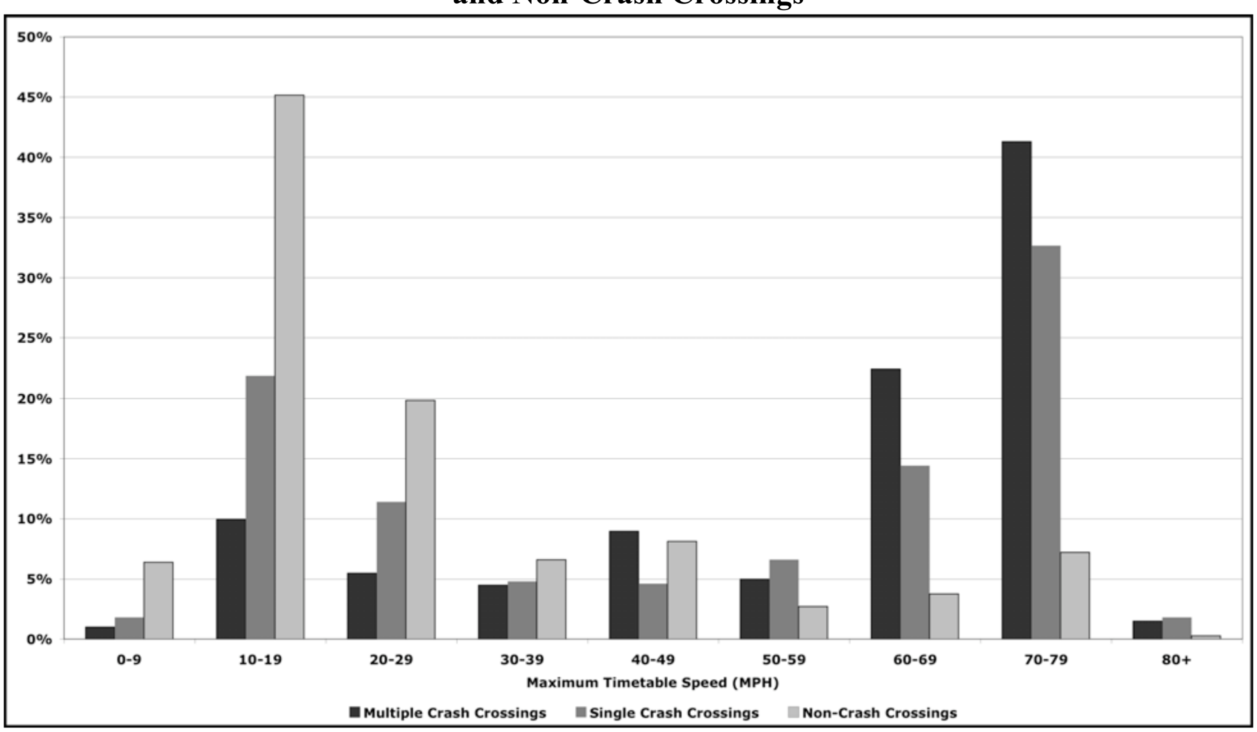
Figure 4: Crash Severity by Train Speed at Public Crossings in California (2001-2010)



Source: FRA

A comparison of maximum timetable speeds at crossings with multiple crashes, single crashes, and no crashes for the period from 2001 to 2010 is shown in Figure 5. For each of the crash categories (Single, Multiple, Non-Crash), the sum of all of the bars in the graph for that category is 100%. As an example, 45% of all non-crash crossings have a maximum timetable speed of 10 to 19 MPH while only 7% have a speed of 70 to 79 MPH. As demonstrated by this graph, the majority of non-crash crossings have a low timetable speed while the majority of multi-crash sites are at the high end of the scale.

Figure 5: Maximum Timetable Speeds at California Multiple, Single, and Non-Crash Crossings



Drive-Around Crashes
As noted earlier, 75% of at-grade crashes over the past ten years occurred at crossings equipped with gates. While some of these involved vehicles trapped in the crossing due to traffic and thus did not represent a driver's willful disregard of activated warning devices, some were the result of a deliberate attempt to get through the crossing before the arrival of a train. Given that preventing such behavior is one of the key elements of this project, it is important to learn all we can about such cashes.

The first task was to determine which crashes involved a drive-around. Unfortunately, the FRA accident report format does not explicitly capture this information. Under "Action of Motorist" (Block #41 on Form 6180.57), the relevant choice is "drove around or thru the gate." "Around" is quite different from "thru" and except for information that <u>might</u> be contained in the narrative section, there is no way to separate the two. The only option, then, was to search the narrative section of crash reports looking for the term "drove around." In California, for the ten-year period from 2001 to 2010, this yielded only 64 crashes. Since this was too small a number to provide an accurate analysis, the search was expanded to all 50 states. This resulted in a list of 617 incidents.

The first statistic of note for drive-around crashes is that they appear to result in a higher percentage of fatalities and injuries than crashes at gated and level crossings in general as shown in Table 3.

Table 3: Comparison of Crash Severity at Gate Drive-Around, All Gated, and All Level Crossing Crashes

	Gate Drive Around Crashes		All Gated Crossings Crashes		All Level Crossing Crashes	
Severity	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**
Fatal	127	20.6%	713	8.8%	1,944	8.6%
Injury Only	178	28.8%	1,733	21.3%	5,711	25.3%
PDO	312	50.6%	5,694	70.0%	14,955	66.1%
Total	617	100.0%	8,140	100.0%	22,610	100.0%

Source: FRA

Table 4 compares the gender of incident drivers for drive-around crashes with those that occurred at all gated and all level crossings. For all, the ratio of males to females is almost three to one.

Table 4: Comparison Of Driver Gender At Gate Drive-Around, All Gated, And All Level Crossing Crashes

	Gate Drive Around Crashes		All Gated Crossings Crashes		All Level Crossing Crashes	
Gender	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**
Male	435	70.5%	5,507	67.6%	16,148	71.4%
Female	147	23.8%	2,148	26.4%	5,555	24.6%
Not Given	35	5.7%	485	6.0%	907	4.0%
Total	617	100.0%	8,140	100.0%	22,610	100.0%

Source: FRA

Crossing Angle
It is plausible that the direction the driver must look to view an approaching train might play a role in crossing crashes. The combination of the approach direction of both the train and the driver in

relation to the intersection play a role in the viewing angle of the driver. In a non-perpendicular crossing, the tracks on one side of the driver will be difficult to see, and will require the driver to look back over his/her shoulder. However, the tracks on the other side of the driver will be very easily viewed. It may be that the increased visibility in one direction offsets poor visibility in the other direction. On the other hand, better visibility could lead to increased risk-taking if the driver feels overly confident about gauging the train's position and speed.

In order to determine whether crossing angle does play a role we would like to compare the crossing angles at crossings with crashes to a random sample of crossings. The FRA inventory database contains the field "Smallest Crossing Angle" which, unfortunately, does not convey the required information. This is demonstrated in Figure 6, in which two crossings, both with a listed smallest crossing angle of 30 degrees, present very different pictures to the vehicle's driver. In the first, an approaching train would appear either from ahead and to the left or from behind and to the right. In the second, the train would appear either from ahead and to the right or from behind and to the left.

Because of this shortcoming in the FRA database, it is necessary, for both the crash and sample crossings, to measure the viewing angle of the approaching train from the vantage point of the driver. For the sample, 502 crossings were chosen at random from the national database of crossings, yielding 1,004 possible approach angles. The angles were measured using Google Maps and a screen protractor. The crash approach angles required not only information about which crossing was involved but also the directions of travel for both the vehicle and train prior to the crash. As discussed earlier, this information is often in error in the crash reports.

Figure 6: Smallest Crossing Angle and Viewing Angle of Approaching Train Relative to the Driver

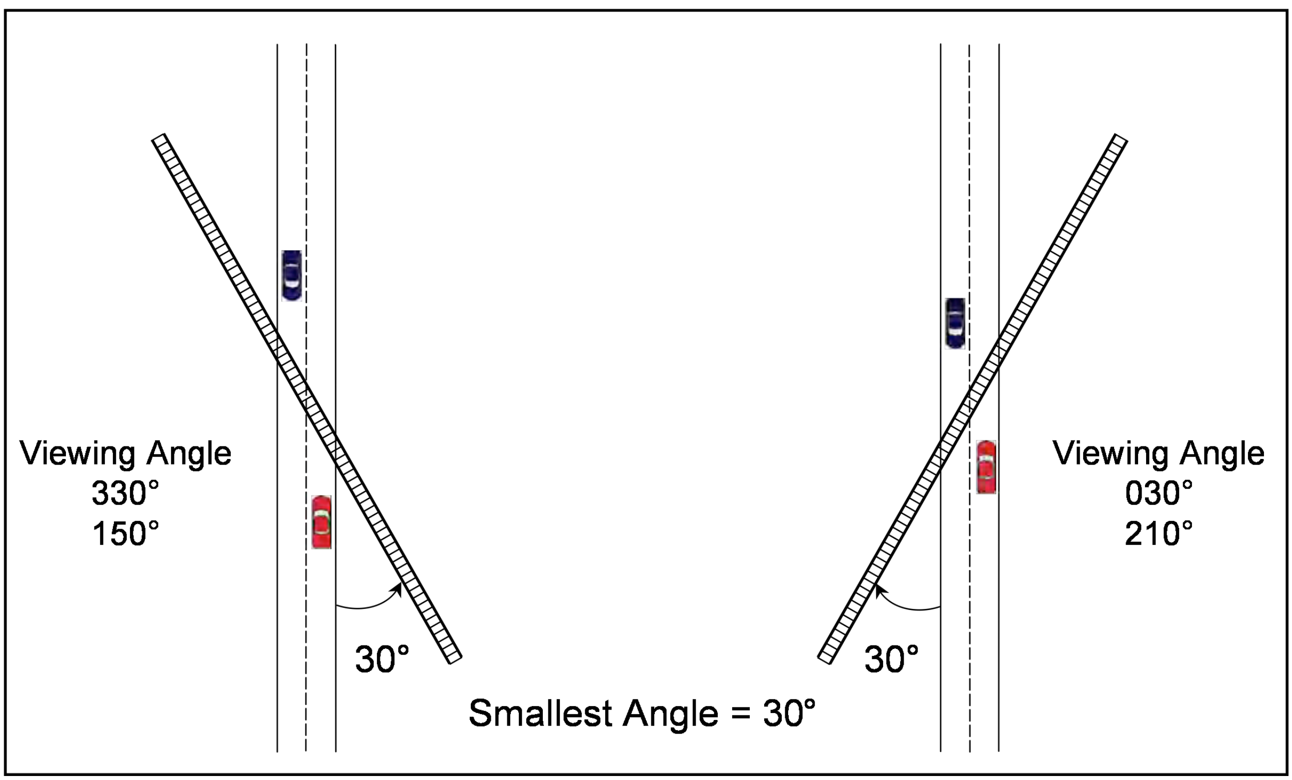
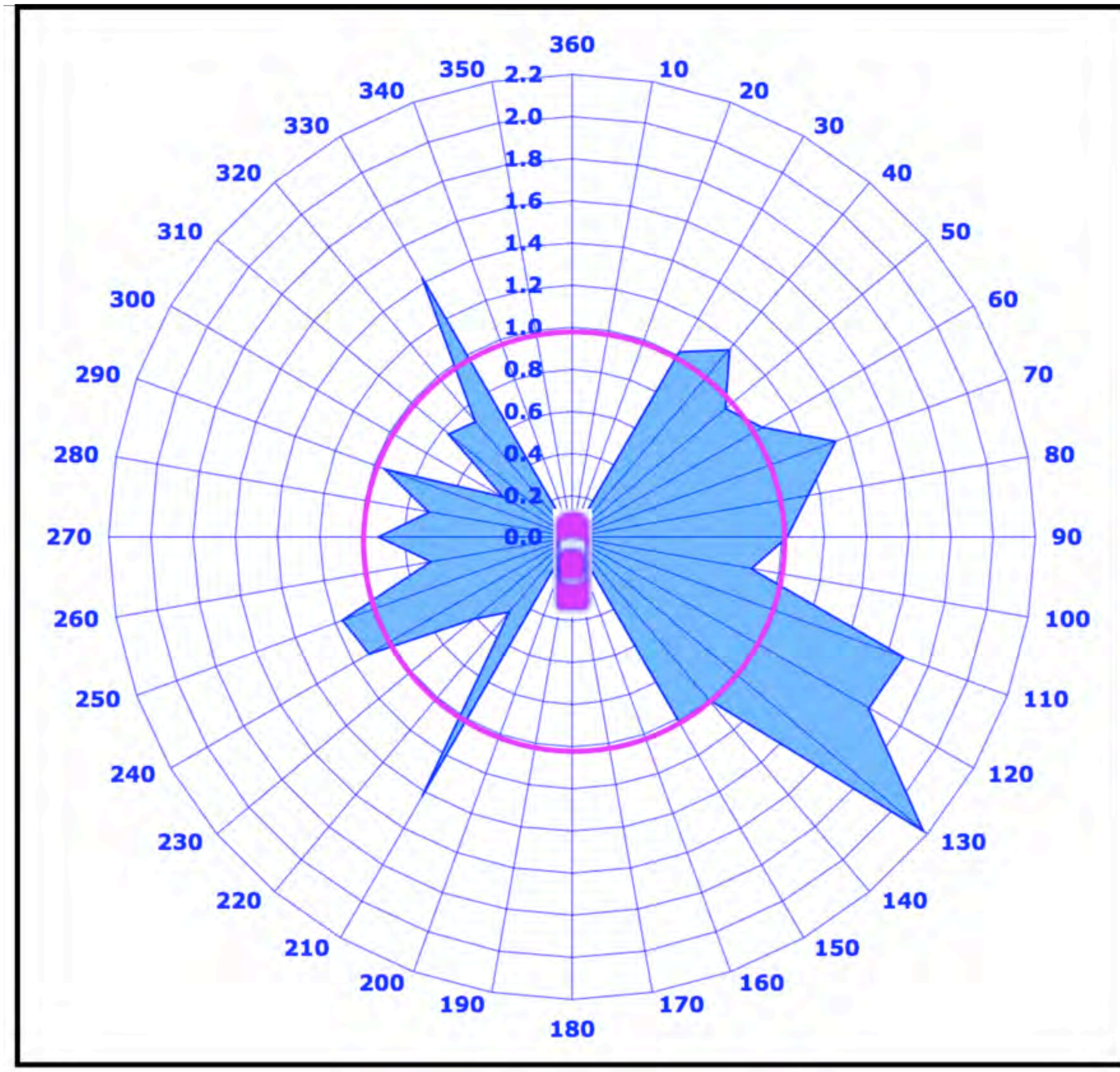


Figure 7 depicts the ratio of the percentage of gate-running crashes (617 total) at a specific angle, relative to the driver, of the approaching train to a random sample (1,004) of crossing approach angles. Both the crash and random sample angles are rounded to the nearest 10 degrees. If the percentage of crashes at a specific angle matches the percentage of crossings at that angle in the random sample, the ratio is 1, which is the dark red ring on the graphic. Where the percentage of crashes at an angle exceeds the percentage found in the sample, the plotted point is outside the blue ring.

From this graphic, it appears that trains approaching from the right present more of a problem than those approaching from the left, with the right-rear quadrant being the most dangerous.

Figure 7: Ratio of Percentage of Crash Crossing Approach Angles to Percentage of Random Sample of Crossing Approach Angles



Crossings With Multiple Crashes
Table 5 shows that most crossings with crashes (71.5%) experienced only a single crash during the ten-year period from 2001 to 2010. The other 28.5% of crossings with crashes experienced between two and ten crashes. The table shown in Appendix A lists crossings that experienced four or more crashes during this period, and includes information on the crash dates, crossing equipment, the direction relative to the direction of the car that the driver would have to look to see an approaching train, and the crossing location. Of the 125 crashes at these sites, 115 occurred at gated crossings.

Table 5: California Motor Vehicle/Train Crash Counts per Public Crossing 2001-2010

Number of Crashes at Crossing	Number of Crossings
1	505
2	128
3	49
4	10
5	5
6	6
7	2
8	0
9	0
10	1
Ten-Year Total Crossings With Crashes	706

Source: FRA

Setting

The type of land development surrounding crossings in California is shown in Table 6. The categories show the predominant type of development in the vicinity (up to 1000 feet) of the crossing based on the following categories:

1. Open Space: Sparsely developed, lightly populated, and/or agricultural
2. Residential: Built-up residential area
3. Commercial: Retail stores and businesses, offices, and/or personal services
4. Industrial: Manufacturing, construction, heavy products, factories, and/or warehouses
5. Institutional: Schools, churches, hospitals, parks, and/or other community facilities

Land use across each of the crossing crash categories appears to be quite consistent.

Table 6: Land Development Around California Crossings

Type of Development	Single Crash Crossings	Multi-Crash Crossings	All At-Grade Crossings
Open Space	25.1%	25.9%	22.6%
Residential	14.3%	13.4%	14.3%
Commercial	36.7%	33.8%	33.1%
Industrial	23.4%	25.9%	28.7%
Institutional	0.6%	1.0%	1.4%

Source: FRA

Table 7 shows the functional classification for the roadway that crosses the tracks. The various categories are based on Federal Highway functional classification guidelines. The fact that urban arterials, which are some of the busiest streets, are over-represented in multi-crash crossings is in all likelihood due to exposure, a subject that will be discussed in greater depth in the “Traffic” section.

Table 7: Roadway Classification

Road Type*	Single Crash Crossings	Multi-Crash Crossings	All At-Grade Crossings
R. Interstate	0.0%	0.0%	0.0%
R. Oth. Prin. Arterial	0.6%	1.5%	0.9%
R. Minor Arterial	1.6%	2.5%	1.6%
R. Major Collector	5.3%	7.0%	3.8%
R. Minor Collector	4.7%	4.5%	4.3%
R. Local	15.7%	10.9%	16.2%
U. Interstate	0.0%	0.5%	0.0%
U. Oth. Freeway/Expressway	0.4%	2.5%	0.8%
U. Oth. Prin. Arterial	16.9%	21.9%	13.1%
U. Minor Arterial	23.3%	22.4%	15.7%
U. Collector	14.1%	8.5%	11.1%
U. Local	17.3%	17.9%	32.5%

*R=Rural; U=Urban
Source: FRA

Like roadway classification, the number of lanes that cross a track is usually a function of the vehicle traffic on that roadway. Thus roads with at least two lanes in each direction appear more often in the crash-crossing categories (Table 8).

Table 8: Number of Traffic Lanes Crossing Tracks

Number of Traffic Lanes	Single Crash Crossings	Multi-Crash Crossings	All At-Grade Crossings
1	1.6%	0.5%	5.2%
2	59.3%	56.7%	69.0%
3	1.8%	2.0%	2.5%
4	28.3%	24.4%	18.4%
5	4.7%	7.5%	2.0%
6	4.1%	6.0%	2.4%
7	0.2%	2.0%	0.2%
8	0.0%	0.5%	0.2%
9	0.0%	0.5%	0.1%

Source: FRA

The number of tracks at a crossing can increase the risk of a collision in several ways including more train traffic and the possibility of a first train masking the presence of a second train coming from the opposite direction. Table 9 reflects this risk with both crash categories over-represented, when compared with the state’s crossing inventory, at sites with two tracks.

Table 9: Total Number of Tracks at Crossing

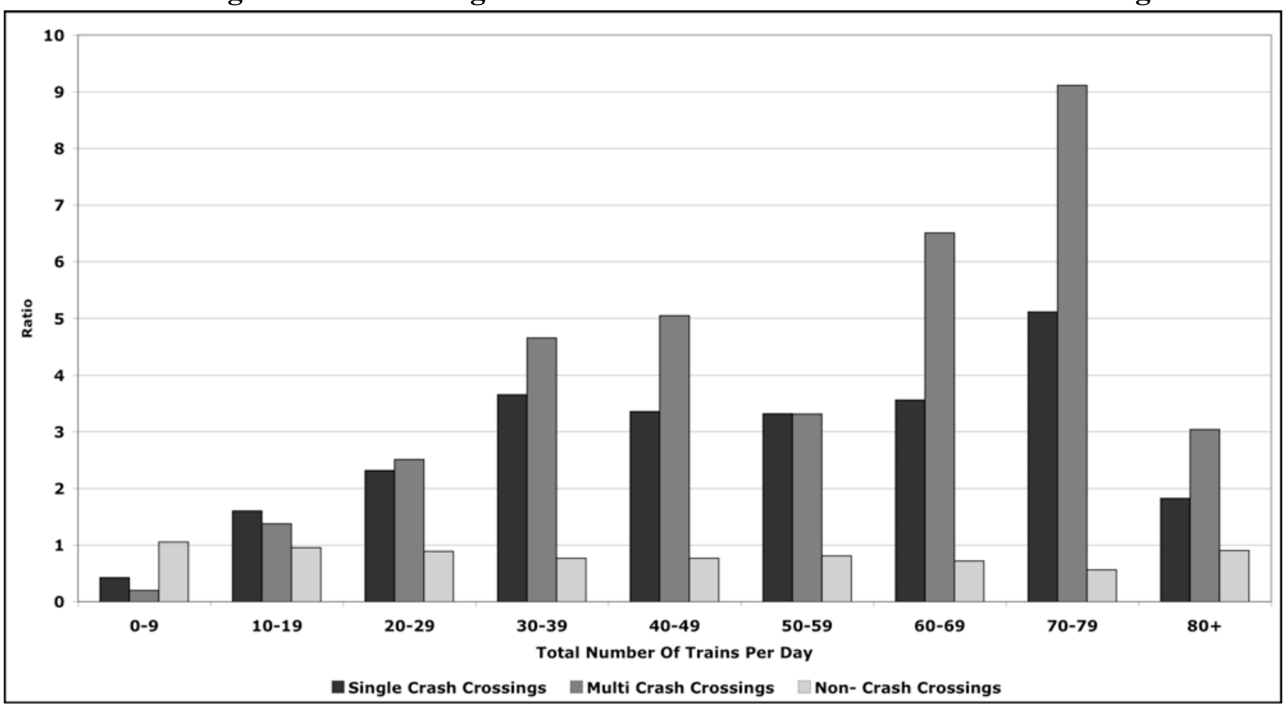
Number of Tracks	Single Crash Crossings	Multi-Crash Crossings	All At-Grade Crossings
1	55.9%	47.8%	69.3%
2	29.8%	35.3%	19.9%
3	8.1%	10.9%	6.7%
4	2.8%	2.0%	2.2%
5	1.0%	0.5%	1.0%
6	0.6%	3.0%	0.4%
7	0.0%	0.0%	0.2%
8	0.2%	0.0%	0.1%
9	0.0%	0.5%	0.1%

Source: FRA

Traffic
Virtually all states include the number of trains and motor vehicle counts in their assessment of the relative risks of rail-highway crossings within their state. These data, which represent exposure, will doubtless play a key role for California as well. The main problem at present is that our vehicular traffic counts (and probably train counts since there is no information available on when the train counts were made) are often quite old. As discussed earlier, 15% of the vehicular traffic counts date from the 1970s, 65% from the 1980s, and 18% from the 1990s. Since this is the case, no attempt will be made here to assess the effect of vehicular traffic on crossing incidents.

Since it is possible that train counts may be current, Figure 8 compares the percentage of crossings within each crash category having a specific train count with the percentage of crossings in California's total crossing inventory that have the same train count. Thus, for example, if the percentage of all non-crash crossings having between 10 and 19 trains per day matches the percentage of all crossings in the state with between 10 and 19 trains per day, the ratio would be 1, which is what is depicted in the figure below. As can be seen, crossings with higher train counts are over-represented in both crash categories.

Figure 8: Ratio of Percentage of Number of Trains at Single, Multi, and Non-Crash Crossings to the Percentage of Number of Trains at All California Crossings



Source: FRA

DISCUSSION
In order to make at-grade rail-highway crossings safer, the size and scope of the problem must first be assessed. Over the past ten years, the number of grade crossing incidents has fallen 44.9% in California while for the rest of the U.S. it has fallen 41.5%. These decreases were due to a combination of railroad crossing closures, upgrading of warning devices, and the efforts of grassroots organizations such as Operation Lifesaver. However, despite decreasing numbers, crash counts remain undesirably high and ongoing efforts to improve rail crossing safety are a priority.

One of the most effectiveness means of reducing crossing incidents is the installation of gates, which have been determined to reduce such incidents by 88% at passive crossings and 44% at crossings with flashing lights. However, 75% of the past decade's crashes occurred at crossings equipped with gates, indicating that for some drivers, standard two-quadrant gates are not a deterrent. Data on crashes caused by drivers going around lowered gates show them to be substantially more dangerous than other incidents at these crossings. For this reason, further measures must be taken at these sites (e.g., channelization devices).

One factor to consider in choosing which crossings to improve, is train speed since both the number of crashes as well as crash severity have been shown to increase as train speed increases. Another factor that appears to play a role is the angle of an approaching train, with crossings that go from ahead left to behind right of the vehicle being the most dangerous. Additionally, the number of tracks is important because of both the potential for more train traffic and the possibility of a first train masking the presence of a second train. Finally, the exposure of a particular crossing, which is a combination of vehicular and train traffic, plays a significant role since the number of potential conflicts increases with increasing numbers of trains and motorized vehicles.

The data from this report, in combination with information from a previous report on crossing safety devices, will be used to recommend both a strategy to update California's inventory database and to formulate a strategy to increase crossing safety.

SECTION 2: AT-GRADE RAIL CROSSING SAFETY DEVICES

There exists a subset of drivers who will go around lowered gates if they think it is “safe” to do so. The only way to absolutely prevent these violations is to make it physically impossible for them to occur. This can be accomplished by constructing a separation of grade, closing the crossing, or by deploying an impenetrable barrier, all of which carry a high monetary or social (e.g., such as loss of convenience, slower response times for emergency vehicles, or loss of potential customers driving by a business) cost.

There are other approaches that, while not being 100% effective, can be used to find a middle ground that can prevent deaths and injuries while remaining economically feasible. Two of these, channelization devices and long-arm gates, will be described in this section along with their associated costs, potential ability to reduce crashes when added to a two-quad gate system, durability, and observations from transportation representatives in areas where they have been deployed. Because efficacy and installation costs are relatively unambiguous and uniform, emphasis will be on durability and recommendations.

CHANNELIZATION DEVICES

For our purposes, channelization devices are defined as mountable centerline medians with upright reflectors that can be applied directly to the existing roadway, as shown in Figure 9, or be part of a more complex structure consisting of an island with the device mounted on the top, as shown in Figure 10. Such systems present drivers with a visual cue intended to impede crossing to the opposing traffic lane. The curbs are no more than six inches in height, usually less than twelve inches in width, and built with a rounded design to create minimal deflection upon impact. The reflectorized paddle delineators or tubes, typically 24-36 inches high, are built to be able to bounce back up after being hit or run over. These systems are designed to allow emergency vehicles to cross over into opposing lanes to go back in the opposite direction but <u>not</u> for the purpose of circumventing the traffic control devices at the crossing. Usually, such a system can be placed on existing roads without the need to widen them.

Efficacy and Cost

Channelization devices are currently being used in a large number of locations across the country, from Massachusetts and North Carolina in the east to Washington State in the west. Their efficacy has been well documented. Research reports on installations in Florida (Ko et al., 2007), Washington State (Transpo Group, 2000), Nebraska (Khattak and McKnight, 2008; Khattak et al., 2007) and Canada (Caird et al., 2002) indicate that, when added to two-quad gate crossings, violations are cut by 75% to 80%.

The most widely used rail-crossing product at this time is Qwick Kurb, manufactured in Ruskin, Florida. An email from the company (2006) stated that “a typical crossing involves about $10,500 of material...We do not install Qwick Kurb ourselves, but have noted that installation costs vary quite a bit from state to state. Perhaps $1,500 give or take $500 is a reasonable estimate.” Recent experience at North Carolina DOT leads them to estimate a cost of around $10,000 for materials and $3,000 for labor for a new installation in NC consisting of 200 linear feet total median length for two roadway approaches to a crossing.

Figure 9: Street Mounted Channelization

Figure 10: Island Mounted Channelization

With regard to alternative manufacturers, correspondence from the North Carolina Rail Division, Engineering & Safety Branch stated:

> "Qwick Kurb [Figures 11a &11b] was first available and was therefore first deployed by NCDOT. Qwick Kurb is somewhat higher in cost than its competitors; delineators are proprietary, as is delineator mounting system, driving higher costs (without significantly better durability) than more generic tubular markers that one of the

competing products can accommodate. Options in types of delineators are wider than most competitors offer. Qwick Kurb has not been receptive to NCDOT's suggested modifications in its products to lower costs. Qwick Kurb is a high-density recycled rubber product, and is paintable. This product meets NCHRP 350 requirements.

“SafeLane was the second product offered and the second used. SafeLane agreed to accommodate in its extrusion process low-cost tubular markers by other manufacturers in its design for delineators. SafeLane also was willing to build an extrusion mold and set up a production sequence to manufacture a curb section to NCDOT specs if we could commit to a specified minimum linear footage (we could not, as we were already deep into installation of standard sections of this product and others, so we did not pursue this option). NCDOT experienced lower costs for materials and equivalent costs for installation labor. SafeLane is also a high-density recycled rubber product, and is paintable.

“The third product NCDOT installed was the FG 300 Curb System [Figure 11c] from Davidson Traffic Control Products (mfg. by Filtrona Extrusion). We installed this product at one crossing outside the Sealed Corridor, as it came to market later than the other two and our Sealed Corridor construction was complete with regard to modular medians. FG 300 is a more rigid plastic than the recycled rubber products. It is a molded product (as opposed to extruded) with internal radial rib construction (as opposed to solid), making it lighter in weight than the other two products. While I cannot provide evidence of such, we have concerns that this product may fracture more easily, given its rigidity. This product meets NCHRP 350 requirements.”

Figure 11:Channelization Examples

a: Qwick Kurb b: Qwick Kurb c: FG 300

Durability
For the most part, users of traffic channelization devices have been satisfied with their durability although the need for upright replacement has varied widely from location to location. Along the North Carolina Sealed Corridor, the devices were found to be "durable, but not indestructible." Snow removal operations damaged curb sections, some beyond repair, and resurfacing operations did not often take time or effort to properly remove or replace curb. Delineators were subject to damage by wide vehicles (mobile homes, farm equipment, wide-load lowboys) and drivers with intent to damage or destroy the materials, and therefore required relatively frequent repair and/or replacement. As a result, NCDOT retained a contractor for maintaining the curbs and delineators (plus special signage) at a cost approaching $100,000 per year. About 60% of the cost is for quarterly inspections at the 17 locations currently equipped with modular median products, while the other 40% is for removal/replacement for maintenance activities and replacement of materials damaged by highway traffic or highway maintenance operations.

There was significant damage to a Qwick Kurb installation at the US 98 site in Frostproof, Florida. Nine consecutive markers were completely removed from the traffic separator, apparently by the impact of a large motor vehicle such as a semi-trailer. Factors that may have contributed to the collision include narrow lane width (9.2 feet) and the number of lanes (2). With additional lanes, motorists have the ability to compensate for the presence of the traffic separator and may be able to avoid collision with the markers (Ko et al. 2003). Nearby, on State Route 17, there was also substantial damage to another channelization device (Figure 12).

Figure 12: Frostproof, Florida

Khattak et al. (2007) compared two sites in Massachusetts that had channelization devices installed at rail crossings:

> "While the barriers installed at the two study locations were similar in construction material and installation, the observed maintenance needs were different due to differences in roadway traffic, geometry, and traffic composition. The barrier at Waverly received more abuse due to higher roadway traffic and higher percentage of

truck volume compared with the Fremont site. Also, the Waverly site involved a 90-degree turn from Highway 6 onto North 141St street, which exacerbated the situation with trucks frequently overrunning the end of the barrier [Figure 13]. Hence, maintenance needs were higher at the Waverly location. Since relatively little truck traffic volume and no significant turning traffic were involved at the Fremont site, the barrier was much less abused at that location. Nonetheless, the barrier at Fremont was overrun by roadway traffic and damaged as evident from tire tread and scuff marks [Figure 14], which required some maintenance."

Figure 13: Flattened Curbing Caused by Trucks

Figure 14: Scuff and Tread Marks

In Houston, Texas, trucks have also been a problem. The city, which has a quiet-zone program, found that while delineators such as Qwick Kurb are initially cheaper than concrete medians, they may require frequent maintenance in areas with heavy truck traffic. For example, at San Felipe Road, five or six panels on average are replaced three times per year. The problem arises when drivers of 18-wheelers on high volume streets choose not wait in queue while the arm is down and instead execute U-turns over the median.

Replacement demand at other sites in Houston is much lower as suggested by the fact that the city continues to use Qwick Kurb for new installations. However, that this may be due in part to the approval process for such devices being substantially easier than for concrete medians, perhaps because the Qwick Kurb installations are not considered a change to the roadway. Another benefit is that channelization devices are easily removed and replaced for street maintenance.

The Oakland County, Michigan road commission removed the traffic separators at the Andersonville Road crossing due to the high maintenance cost. The commission stated that their roads were experiencing premature edge cracking from vehicles driving on the edge due to the narrow lane width and motorists shying away from the separators. They also indicated that damage to the markers, markers being ripped from the curb, and fracturing of the curb continued to occur (Ko et al. 2007).

Other installations throughout the country have fared much better:

Wyoming—"We have been very pleased with the low maintenance needed. These have taken a beating. You can see on the painted surfaces where the bumper height is on the vehicles that have been harassing them."

Illinois—"We have one installation for a quiet zone and are satisfied with Qwick Kurb which was installed due to cost of concrete median. The biggest problem is with snowplows. We've had no vandalism to speak of. Ideally it would be good to have a concrete raised median, but for what it is doing it has worked out well. We've had to replace 3 or 4 uprights in last couple of years."
Puyallup, Washington—Seven sites, with average AADTs of 9,800, have required replacement of three to four upright tubes per site per year.

North Carolina—While the DOT's first choice is concrete, given money or other constraints, they would not hesitate to install channelization. "You can get 200' of channelization for $12,000 and concrete is 2-2.5 times that. We developed a median standard of 4' width with a 2' width option. A 4' median almost always requires some changes to the roadway and a 2' median usually does. Maintenance department does not want to maintain narrower medians. They have a tendency to break easily when hit by large trucks or snow removal equipment."

Observations

In their 2007 study, Khattak et al. noted that the amount of damage was a function of traffic volume, percentage of trucks, and whether sharp turns were involved. Ko et al., 2007, also warned of truck traffic and added that channelization devices could pose a maintenance problem if the lane width is less than 3.4 m (11 ft.). Additionally, the length of the traffic separator system should be based on the maximum queue lengths on the approach to discourage vehicles stopped at the back of the queue from entering the crossing from the wrong side of the road.

At the North Carolina, DOT, a concrete median was the first choice, and is substantially more expensive up front. However, while a concrete median is unlikely to require any maintenance for ten to twenty years, the other devices (i.e., Qwick Kurb) require inspection at least several times a year and are subject to vandalism.

In Fort Worth, Texas, there was an instance of a neighborhood whose residents wanted a quiet zone, and where there was federal money for the project. A concrete median with extension of flexible delineators was planned but residents objected to the way it looked. A similar project was planned for a second location, but was also rejected based on its appearance. In both locations standard raised concrete medians were to be installed instead.

In Florida, it was shown that channelization devices hold up much better in urban rather than rural settings, with vandalism cited as the main reason.

LONG-ARM GATES

The best source of information for long-arm gates (or longer-arm gates) is the North Carolina Department of Transportation which is responsible for the NC Sealed Corridor (173 miles and 216 at-grade crossings) portion of the Southeast High Speed Rail Corridor that runs through the state. Forty-nine of those crossing have been equipped with these gates.

As reported in the North Carolina Sealed Corridor Phase I, II, and III Assessment study, the longer-arm gate systems must cover at least three quarters of the roadway. Tests at the Orr Road Crossing in Charlotte were conducted by the state's DOT to evaluate the effectiveness of longer-arm gates to reduce drivers' ability to drive around the gates (Figure 15). A total of three tests were conducted with the first gathering driver violation data before the gate was installed, the second test gathering post-treatment violation data which showed a 67 percent reduction in crossing violations, and a third test which gathered "after" data on long gate arms a year after the first test to determine whether long-arm gates retain their effectiveness. The results from the third test showed an even higher reduction in crossing violations of 84 percent compared with pretreatment "before" numbers. Longer gate arms are used in conjunction with traffic channelization devices in some locations, but not where they would block a street or driveway intersection close to the crossing. The gates provide considerable discouragement to drivers who start to drive around and then realize how great the distance is.

Figure 15: Orr Road, North Carolina

As with channelization devices, maintenance on the long-arm gates is problematic where there is a lot of heavy vehicle traffic (large trucks, buses, etc.). The problem with these vehicles, particularly tractor-trailers, is that they could conceivably enter the crossing legally and, if running slowly, the gate on the exit side could get snagged on the trailer and break off, leaving the crossing unguarded. NCDOT has become very conscientious about not installing long-arm gates on routes with significant (more then 1 or 2 percent) truck traffic.

It was also determined that long-arm gates are only valid for two-lane roads. In their engineering assessment, DOT planners look for a shoulder that is wide enough to allow a perceived escape route so that vehicles can get around it on the exit side of the crossing.

In general, NCDOT's first choice is be channelization. The long-arm gates are effective but more extensive engineering study is required to determine their suitability at a specific location. The NCDOT now require a classification traffic count to determine the number of heavy vehicles, the combination of vehicles and their proportions, and whether the proportion of heavy vehicles is significant.

LEDS

At the present time there is no quantitative evidence to show that replacing incandescent warning lights with light-emitting diodes (LEDs) at rail-highway level crossings will decrease the number of crashes or that the failure or inability on the part of drivers to see warning lights in sufficient time to stop has been a factor in crashes. However, that the absence of evidence does not constitute evidence that there is no safety benefit. It simply means that currently there is no statistical evidence either way.

Logically, it seems reasonable that LEDs should increase safety given that they are easier to see and can be seen at greater distance, and this is the view taken by virtually all of the state DOTS contacted for this project. Whenever practicable, incandescent lights are being phased out in favor of LEDs.

DISCUSSION

Research has shown that the addition of channelization devices can dramatically reduce the number of violations at level rail-highway crossings. Unfortunately, even when overall rail crash totals for the country or for a given state are high, crashes at specific crossings are relatively rare events, making it extremely difficult to show that the addition of a safety treatment at a particular site prevented a crash. However, based on the efficacy of channelization devices (75%, cf. Appendix B), the experiences of agencies discussed in this report, and by looking for commonalities at sites where crashes have occurred in the past, insight can be gained to determine how best to deploy the limited resources available for crossing safety in California.

SECTION 3: SHSP CHALLENGE AREA 7—IMPROVE INTERSECTION AND INTERCHANGE SAFETY FOR ROADWAY USERS OF AT-GRADE RAILROAD-HIGHWAY CROSSINGS

One of the major technical challenges facing anyone seeking to evaluate highway-railway grade crossings for collision potential or to estimate the safety effect of countermeasures is the extreme rarity of collisions (in California, on average less than 0.02 collisions/year/crossing for the 10-year period 2001-2010). Given that the collision process is essentially random with significant variation over time and space, it is difficult to judge whether a specific crossing is safe or safer than other crossings solely based on the number of collisions in a given year. Further complicating the picture, this randomness and variation result in regression-to-the-mean bias (discussed later in this report).

Nonetheless, given that grade crossings are an inevitable part of the railway and highway network, decision makers must find ways of making crossings safer with the available resources by providing cost-effective countermeasures that maintain grade crossing safety within a tolerable level. This pursuit of safety at grade crossings can be expressed in terms of providing answers to two fundamental questions:

1. Where should scarce safety funds be directed? Which crossings have the highest risk of collisions, meaning that some form of safety intervention is justified?
2. Which countermeasures should be considered to enhance safety at "hotspots" (i.e., crossings with unacceptable risks) in a cost effective and practicable manner? (Saccomanno et al., 2006)

In 2005, the Volpe research center was asked to determine the most influential safety factors responsible for the 41% reduction in incidents at highway-rail grade crossings between 1994 and 2003 (Horton et al., 2006).

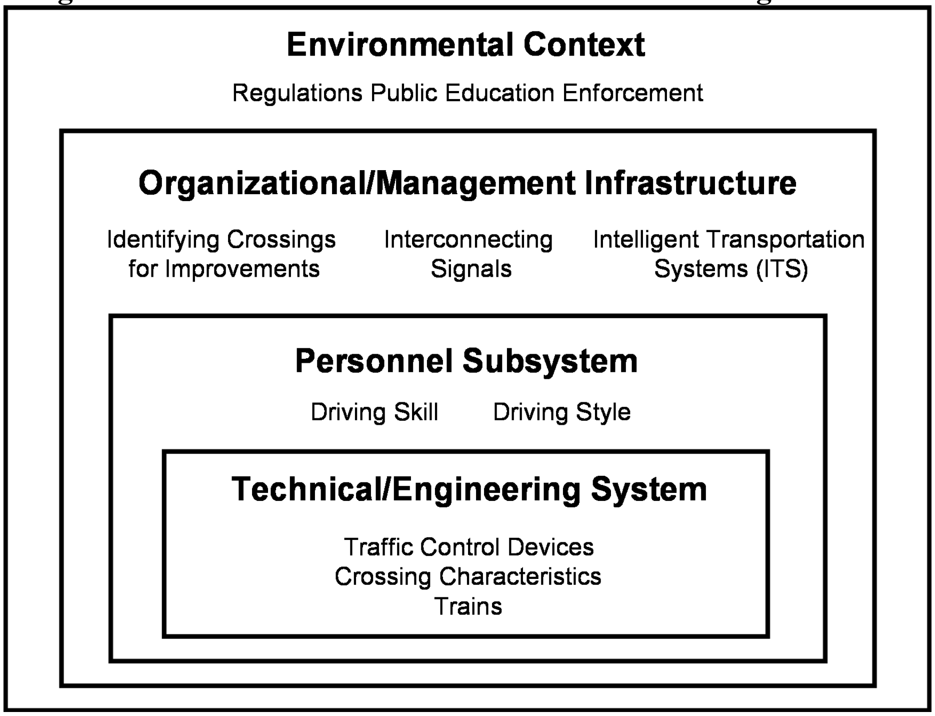
Using both qualitative and quantitative methods, potential contributing factors were analyzed and investigated, resulting in ten factors being identified as the most influential safety factors accounting for the majority of the reduction in incidents. Of these, five can be influenced by Caltrans policies and procedures:

- Sight Lines Clearance
- Grade Crossing Maintenance Rule
- Crossing Closure and Grade Separation
- Warning Device Upgrades
- The Section 130 Program

The other five factors were: commercial driver safety, locomotive conspicuity, more reliable motor vehicles, operation lifesaver, and railroad mergers.

In addition to site-specific crossing factors, the FRA wanted to better understand how drivers' decisions and actions at-grade crossings affected safety. They funded a study (Yeh and Multer 2007), which examined human factors contributing to noncompliance at grade crossings using a sociotechnical framework with four elements: the design of the grade crossing environment, driver characteristics, the role of organizations and management, and social and political forces (Figure 16).

Figure 16: Sociotechnical Framework of Rail Crossing Incidents



The innermost layer of the model represents the *technical/engineering system*, and comprises the physical elements of the grade crossing. How drivers process the information from the grade crossing environment depend not only on its specific design but also on driving skill and driving style, as represented by the next layer, the *personnel subsystem*. Noncompliance may be the result of error (a deficiency in skill) or intention (style). According to Yeh and Multer, 2007:

> "To positively impact driver behavior, organizations must have an appropriate view of the driver. A "typical" driver is a rational, but imperfect, decision maker. Decisions are not based solely on the information at the crossing but are also determined by one's perceptions and experiences. Thus, a driver's decision at a grade crossing, derived from a weighting of the costs and benefits of various actions, may differ from that determined by a highway-safety specialist. Consideration of the driver as a reasonable decision maker allows the evaluation of countermeasures in the full context of the driving task, placing less emphasis on countermeasures that are aimed at informing drivers of rules and more emphasis on countermeasures that target the driver's decision making process."

The third element of the model considers the role of organizations and management. Improving grade crossing safety requires coordination among agencies at the federal, state, and local levels. All these elements function within a political and social context, as described by the *environmental subsystem*. This layer addresses the regulatory oversight and the development of policies requiring safe practices. It includes educating the public about their responsibilities at grade crossings and enforcement of appropriate traffic regulations (Yeh and Multer, 2007).

Keeping both crossing characteristics and human factors in mind, the process for determining which crossings to upgrade and the specific treatments to apply will be considered below.

HAZARDOUS CROSSING DETERMINATION

Highway-railway grade crossing collisions tend to be spread over a vast number of sites, with few (if any) occurring at any given site in any given year. To improve safety at all 6,443 grade crossings in California to some uniform standard would be prohibitively expensive and impractical. Therefore, any comprehensive safety program must begin by first identifying crossings where the risk of collision is unacceptably high, and where safety countermeasures are most warranted (Saccomanno et al., 2003).

Models

Predicting the degree of safety present at highway-railroad grade crossings using accident prediction models is a common approach. These models are usually developed using highway-railroad grade crossing databases consisting of crossing characteristics and accident data for a given period of time (Fitzpatrick et al., 1997). A number of studies (e.g., Qureshi et al., 2003 and 2005) have been implemented to compare various models under different circumstances and locations. Through consideration of these studies and conversations with personnel at several state DOTs, a number of variables have been identified as playing a role in crossing evaluation and have been divided into three categories: Vehicular Traffic, Rail Traffic, and Crossing Specifications. All variable marked with an asterisk are included in the FRA inventory database:

Vehicular Traffic
- AADT*
- School buses*
- Trucks*
- Hazmat
- Speed of highway traffic*

Rail Traffic
- Number of fast trains
- Number of slow trains
- Number of passenger trains*
- Number of freight trains*
- Total number of trains*
- Maximum timetable speed*
- Switching movements*

Crossing Specifications
- Number of main tracks*
- Land development*
- Crash experience*
- Highway paved*
- Number of highway lanes*
- Type of warning device*
- Sight distance
- Highway alignment
- Clearance time

Three factors that are not included in most models but which appear to influence crossing incidents based on analysis of FRA crash data and review of the literature are: crossing angle, proximity to highway intersection, and crossing delay. These will be discussed later in this report.

Given the number of items from this list that are included in the FRA database, it should be fairly simple to test various models using California incident data to determine which is most appropriate for use by the California PUC in ranking crossings. Unfortunately, from the perspective of the California Division of Rail, the search for the ideal formula or ranking system is immaterial due to the current state of the state's rail crossing inventory. The FRA inventory and accident/incident databases contain inaccurate as well as incomplete information. As an example, highway traffic information for the 6,433 open, at-grade public crossings in California is often out of date with 15% of the vehicular traffic counts dating from the 1970s, 65% from the 1980s, and 18% from the 1990s. Crossing location information in the database is also a problem. A random sample of rail crossings taken to determine the role of crossing/roadway angle in crashes required the examination of 680 crossings in order to achieve the desired sample size of 500, which means that roughly one out of every four crossings checked could not be found at the location given in the FRA database. While this sample contained crossing from all states, there is no reason to believe that California's inventory would fare any better.

At present, the only meaningful statistic for which we have data is crash history, which brings up the difficult question of what constitutes a dangerous rail-highway crossing. If a crossing experiences a crash every twenty years, it would be hard to argue that the crossing is dangerous. But what if an incident occurs there every ten years, or every five years? At what point does a crossing become dangerous and in need of remedial action? As briefly mentioned earlier, selecting sites for action simply by virtue of incident involvement (a non-random sample of sites) would introduce regression-to-the-mean bias. When a non-random sample is selected (crossings with incidents), a later re-test of the average (in this case number of crashes per site) of that sample tends to regress towards the mean, which for crossings is virtually zero crashes per site per year. Therefore, if we upgrade every site that experiences a crash and then monitor those sites for subsequent incidents, we would find that the upgrades were remarkably successful. Of course, had we done nothing to these sites, the results in the following years would be virtually the same.

Time Between Incidents

To explore this phenomenon from a different perspective, sites with multiple incidents were examined for the time between incidents. In Table 10, the mean and median times between crashes are given for gated crossings that experienced two, three, four, and five crashes between 1986 and 2010. In the last column, for each of the crossings with the number of crashes shown in column one, the range of times it took for the crashes to occur is given. For example, at crossings with five crashes (there were 34 such crossings), the shortest amount of time it took to accumulate that number of crashes was 8.01 years while the longest time was 23.32 years. Figures 17 and 18 are graphical representations of the data in the last two rows of the table, with the time between incidents at each crossing shown.

Certainly a crossing with four incidents over the course of five years or five incidents over eight years can be so labeled, but what if those incidents are spread out over more than twenty years? If a crossing is truly dangerous and in need of remedial action, how do so many vehicles make it safely across, resulting in a median time between incidents of 2.75+ years?

Table 10: Time Between Incidents at Gated Sites with 2, 3, 4 & 5 Incidents 1986-2010

Number of Incidents	Mean Number of Years Between Incidents	Median Number of Years Between Incidents	Range of Years Between First And Last Incidents
2	7.34	6.10	0.01 – 23.86
3	5.53	4.23	0.41 – 21.90
4	4.22	2.83	2.45 – 23.01
5	3.90	2.75	8.01 – 23.32

Figure 17: Time Between Incidents at Gated Crossings with Four Incidents 1986-2010

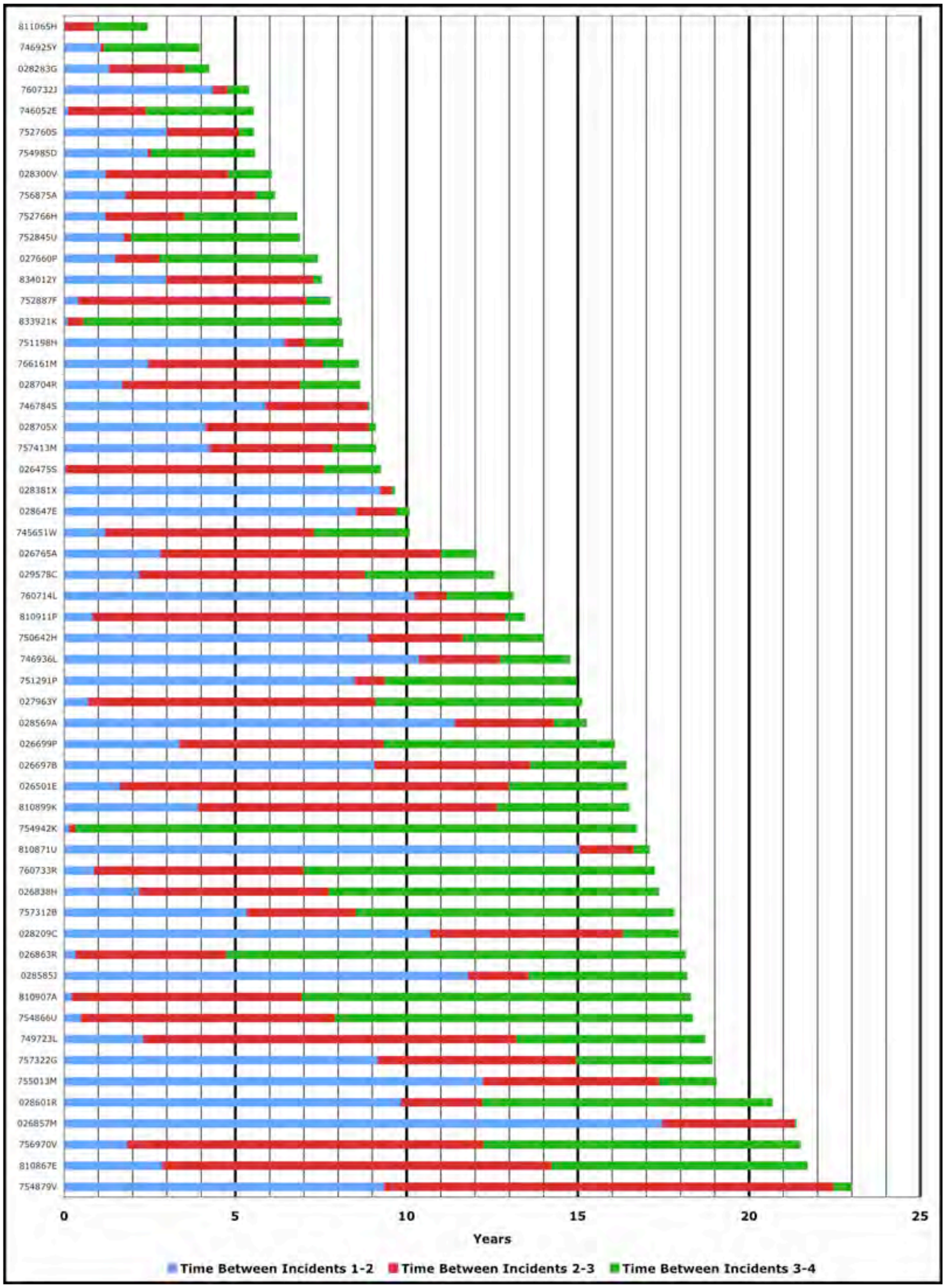
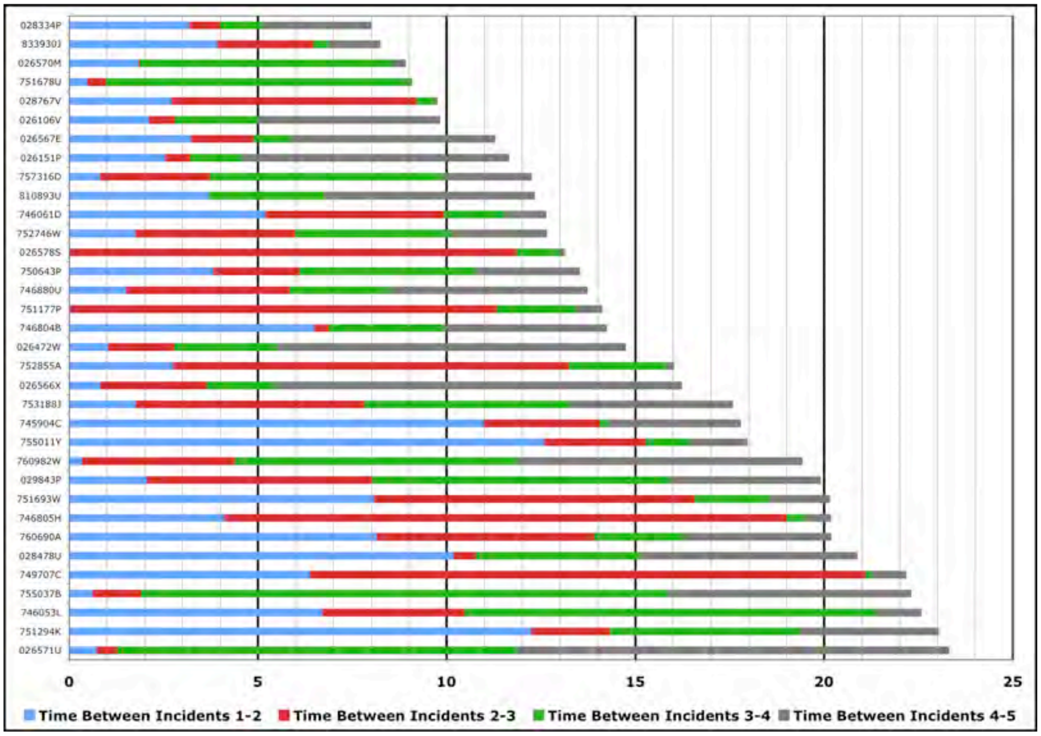


Figure 18: Time Between Incidents at Gated Crossings with Five Incidents 1986-2010



Crossing Angle

As more fully discussed in Section 1 of this report, it is plausible that the direction the driver must look to view an approaching train might play a role in crossing crashes. While there are a number of formulas used by state DOTs when ranking rail-highway crossings that include crossing angle (e.g., Kansas, Montana, and New Jersey) most do not. The primary reason is that most, if not all, research that has been done on crossing models has not found this variable to be significant. The problem, however, is not that the crossing angle does not play a role but simply that the angle used in the study is not the correct one.

The FRA database, which is the crossing angle source for most of these studies, lists the "Smallest Crossing Angle" at the site. What should be included in the database, however, is the direction that a driver at the crossing must look in order to see an approaching train. These are not the same thing (Figure 6 in Section 1) nor may the latter be derived from the former.

From a comparison of crossing angles at a random sample of 1,004 crossings with those at 617 gate-running crashes, it appears that trains approaching from the right present more of a problem than those approaching from the left, with the right-rear quadrant being the most dangerous.

Proximity to Highway Intersection And Interconnection

When a highway-railroad grade crossing is located near a signalized intersection, it is possible that queues from the intersection could extend over the grade crossing and potentially cause stopped vehicles to become trapped on the tracks. To avoid this, traffic signals located near highway-railroad grade crossings need to be preempted when trains approach in order to clear vehicles off the tracks before the train arrives. The geometric design of any signalized intersection near a highway-railroad grade crossing should consider interconnection and preemption (Wooldridge et al., 2000).

According to the MUTCD (FHA 2000), preemption should be considered when the distance between the highway-railroad grade crossing and the signalized intersection is less than 60 m (200 ft). While this is a reasonable rule-of-thumb to use as a starting point, according to a recent National Cooperative Highway Research Program (NCHRP) Synthesis (Korve, 1999), many state departments of transportation believe that "the need for preemption should be based on a detailed queuing analysis, considering items such as roadway approach traffic volumes, number of lanes, nearby traffic signal timing, saturation flow rates, motor vehicle arrival characteristics, motor vehicle classes, etc., rather than a prescribed distance such as 60 m (Wooldridge et al., 2000).

In a review of the literature on driver behavior at highway-railroad grade crossings, Yeh and Multer (2008) state that, "different states have taken different approaches to preemption and coordination. For example, Michigan and South Carolina reported success with pre-signals (traffic signals upstream of the standard highway traffic signals controlling the intersection). In Michigan, the use of pre-signals made additional preemption unnecessary, and in South Carolina, enforcement of pre-signals actually encouraged drivers not to stop their vehicles on the tracks, regardless of whether a train was approaching or not."

To determine whether proximity to an intersection may play a role in crossing incidents, inventory and incident data for the period 2001 through 2010 was examined (Table 11). Distance from nearby intersections appears to play a role in crossing safety with 56.6% of incidents occurring at crossings that have an intersection within 75 feet, compared with only 45.2% of crossings in the state's inventory being located within 75 of an intersection.

Table 11: Proximity of Rail Crossings to Nearby Intersections

Distance From Crossing to Intersection	Number of Incidents	Percentage of Incidents	Number in Inventory	Percentage in Inventory
Less than 75 ft	580	56.6%	2,906	45.2%
75 to 200 ft	8	0.8%	38	0.6%
200 to 500 ft	6	0.6%	16	0.2%
Greater than 500 ft	430	42.0%	3,471	54.0%

Crossing Delay

There are two general approaches to improve compliance at active crossings: the first is to explicitly improve compliance by providing barriers that prevent drivers from circumventing lowered gates. The second is to implicitly encourage compliance by improving the credibility of active warning systems (e.g., by reducing the waiting time at the crossing or by improving the perceived credibility of the warning system) (Yeh & Multer, 2007).

In a focus group examining attitudes towards warning devices, many drivers indicated that they did not rely on the information provided by active warning devices because they felt that warning devices operated improperly. The reasons cited for the perceived failure were that the warning devices were activated too early, remained active for too long past the crossing event, or malfunctioned frequently (Yeh & Multer, 2007). Wilde, et al. (1987) video recorded vehicles at seven grade crossings. Although some drivers violated the crossing unintentionally, observations also showed drivers deliberately disregarding signals. The authors noted that the rate of violations was highest at the crossing with the highest warning time relative to the other crossings (Yeh & Multer, 2007).

As the warning time increases, the number of violations also increases. A 1990 study found that most drivers expect a train to arrive within 20 seconds of the onset of the active control device, and that the number of drivers who stop and wait at a crossing declines when the waiting time extends beyond that (Yeh & Multer, 2007).

At the two flashing light crossings in the study, over 95% of drivers stopped and waited when arriving at the crossing within 10 seconds of the train, over 50% stopped when arriving within 10 to 20 seconds of the train, but only 30% stopped and waited when arriving with more than 20 seconds before the train. At the gated crossing, over 80% of drivers arriving at the crossing within 20 seconds of the train stopped and remained stopped, but the number of drivers who did so decreased sharply as the waiting time increased beyond 20 seconds (Yeh & Multer, 2007).

Discussion

There is a subset of drivers for whom active warning signals such as descending gates and flashing lights do not cue them to stop. Rather, the active warning systems merely act as a signal that a decision must be made, and the driver uses his/her own judgment of train location and speed to decide whether or not to yield to the train. For those people, the ‘problem’ is determining the speed and proximity of the train, rather than establishing its presence. However, the interplay of perception, expectation, and human information processing that is required can easily lead to failures in judgment.

The best solution to rail crossing crashes is to remove the need for the driver to engage in a potentially faulty decision-making process by making it impossible, or at least very difficult, for the driver to bypass lowered gates. Two low-technology, low-cost, low-maintenance methods, median separators and long-arm gates, while not 100% effective, have been deployed in many locations and shown to prevent deaths and injuries while remaining economically feasible.

Since there is not enough money to upgrade all crossings, the question of ranking crossings for remediation becomes the overriding issue. Unfortunately, in California, the data available for use in this determination is badly out of date. Additionally, an examination of California at-grade rail crossing incident data has shown that there are variables (e.g., driver viewing angle of approaching train) that need to be added. Until the inventory can be updated, the current CPUC methodology (Appendix C), which is heavily dependent on both crossing incidents and the FRA’s Web Accident Prediction System, will suffer.

Since so much depends on the accuracy of our state’s inventory database, bringing it up to date and putting it into a readily accessible format should be the top priority for all involved in California rail. Once that is accomplished, properly evaluating crossings will be possible by looking for commonalities at sites where crashes have occurred in the past as well as considering the experiences of other agencies as discussed in Section 2.

SECTION 4: CROSSING INVENTORY DATA

In order to choose the correct safety treatment for a specific rail-highway crossing, accurate details about the crossings physical layout, train traffic, and vehicle traffic must be available. As noted in a number of reports (e.g., FRA, 2004 *Audit Of The Highway-Rail Grade Crossing Safety Program*), the FRA inventory database contains inaccurate as well as incomplete information. As an example, highway traffic information for the 6,433 open (2010), at-grade public crossings in California is often out of date with 15% of the vehicular traffic counts dating from the 1970s, 65% from the 1980s, and 17% from the 1990s. As reported by the FRA (2004), its "Inventory Data File," a record of grade crossing location, physical, and operational characteristics, is dependent on voluntary state reporting.

The agency responsible for maintaining California's inventory is the Public Utility Commission. As stated in the March 2009 document "CPUC Analysis of Senate Bill No. 53 Submission to the California Research Bureau," the commission's rail crossing engineering section's responsibilities include:

- Performing field reviews of crossings to update the crossing inventory database
- Administering and maintaining the CPUC Rail Crossing Inventory Database and the Commission's Rail Accidents Database

Additionally, the CPUC's *FY 2009 through FY 2012 Rail Safety Action Plan* calls for the commission to "Work with the Federal Railroad Administration and the affected railroads to develop a comprehensive inventory of highway-rail crossings in the State of California."

While not responsible for maintaining the states' rail crossing inventory, Caltrans' Division of Rail relies on crossing information to carry out a number of its assigned tasks, therefore the accuracy and availability of the data is essential. Much of the information in the FRA's inventory database can be verified and/or updated using web-based resources, a methodology for which is discussed in the section "Verifying and Updating Crossing Information" below.

CROSSING INFORMATION MANAGEMENT SYSTEM

Even with updated information, data must be readily accessible to those who need to use it. Currently, the two primary sources of crossing information are the FRA database and the CPUC Rail Crossing Engineering Section database, both of which are web-based. The FRA site allows one to query for both inventory and incident information for specific crossings whereas the CPUC site simply provides for the downloading of a spreadsheet showing inventory information for all crossings in the state.

A more useful solution would be a local or intranet-based site that provides searchable inventory and incident data. There are essentially three options for developing such a system:

1. Buying an "off-the-shelf" software program
2. Customizing and expanding an existing application
3. Developing a new application

Given Caltrans' role in evaluating crossings and maintaining the state's crossing inventory (both primarily CPUC functions), as well as lack of resources to expend on development, customizing an existing application makes the most sense. An example of such a system, based on FileMaker Pro®, is shown in the final section of this report.

VERIFYING AND UPDATING CROSSING INFORMATION

The first step is to query the FRA for data on the crossing of interest by going to the agency's "Generate Crossing Inventory and Accident Reports" page (http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/crossing/crossing.aspx) and entering the DOT crossing number. This information will serve as the basis for verification and updating the crossing data. The sample FileMaker Pro Database discussed in the final section of this report would already contain both inventory and incident data downloaded from the FRA for all California crossings.

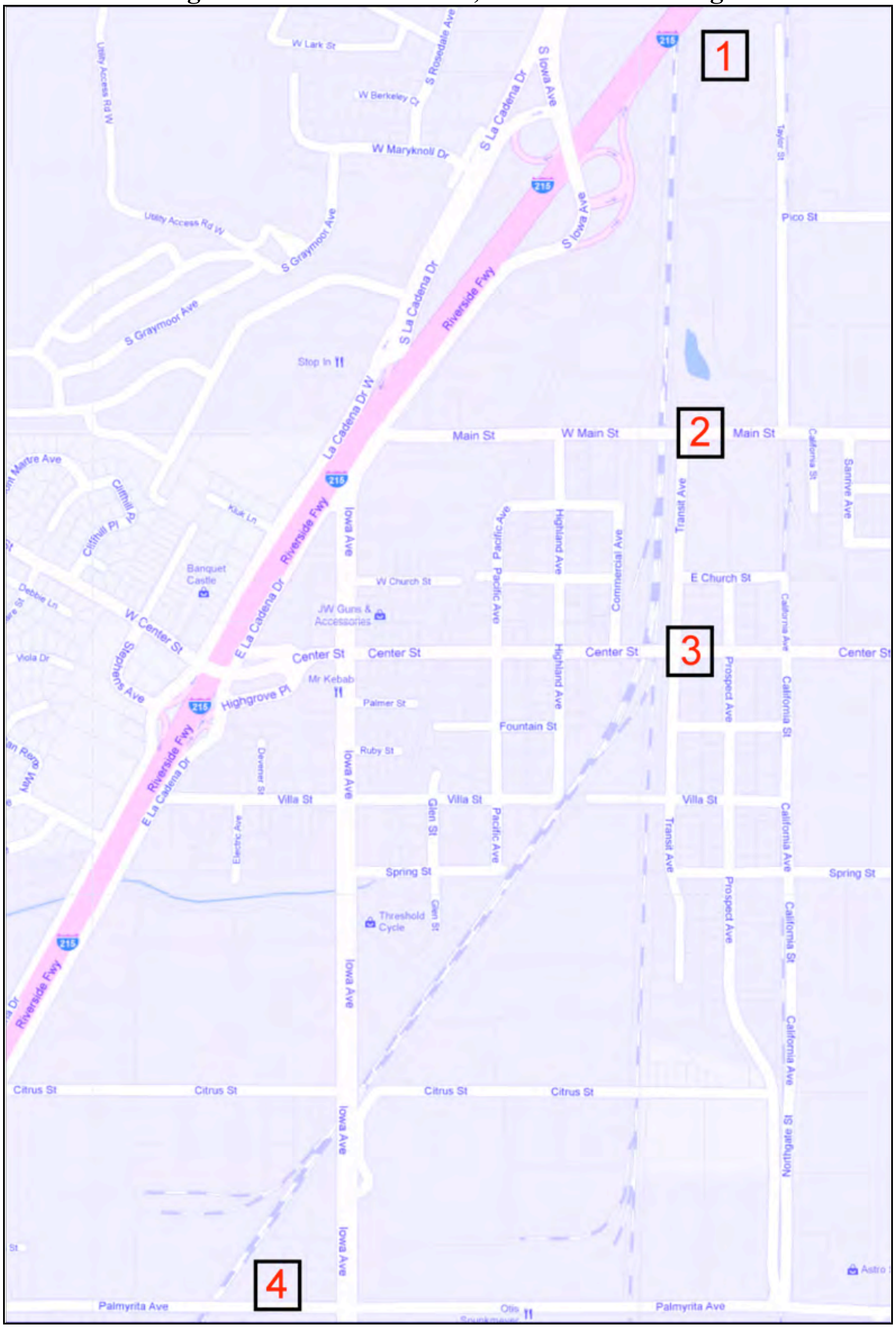
A problem often encountered with the information contained in the FRA inventory database involves the location of the crossing. As part of an earlier report, a random sample of 500 rail crossings with accurate location information was required to determine the role of crossing/roadway angle in crashes. In order to achieve the desired sample size it was necessary to examine 680 crossings, which means that roughly one out of every four crossings checked could not be found at the location given in the FRA database.

An example of this problem involves four crossings in Riverside, California as shown in Figure 19. A comparison of the street names given in the inventory to the street names at the given latitude/longitude is shown in Table 12.

Table 12: Four Riverside, California Crossings

	DOT Crossing Number	Street Name in FRA Inventory	Street Name at Listed Lat/Long	Street Name Listed in Crash Reports
1	026469N	Interstate 15	Main Street	N/A
2	026470H	Main Street	Center Street	Main Street
3	026471P	Center Street	Iowa Avenue	Center Street
4	026472W	Iowa Avenue	Palmyrita Avenue	Iowa Avenue

Figure 19: Four Riverside, California Crossings



Verify location

Check latitude/longitude—Google Maps (http://maps.google.com/)

If there is no crossing at this location:

Try street name and city—Google Maps

Use street name, city, and milepost on FRA GIS Website

(fragis.frasafety.net/GISFRASafety/default.aspx)

Once located, obtain lat/long from Google Maps and enter into DB

Record Overhead Map and Picture Views
Using Google Maps, record the two views as shown in Figure 20. While these two views can be seen in the embedded viewer in the sample database, there may be times when an Internet connection is not available

Figure 20: Overhead Map and Picture View 028714W

Record Street Level Views
Using Google Maps street view, record the six views as shown in Figures 21 and 22.

Figure 21: Six Street Level Views of Crossing

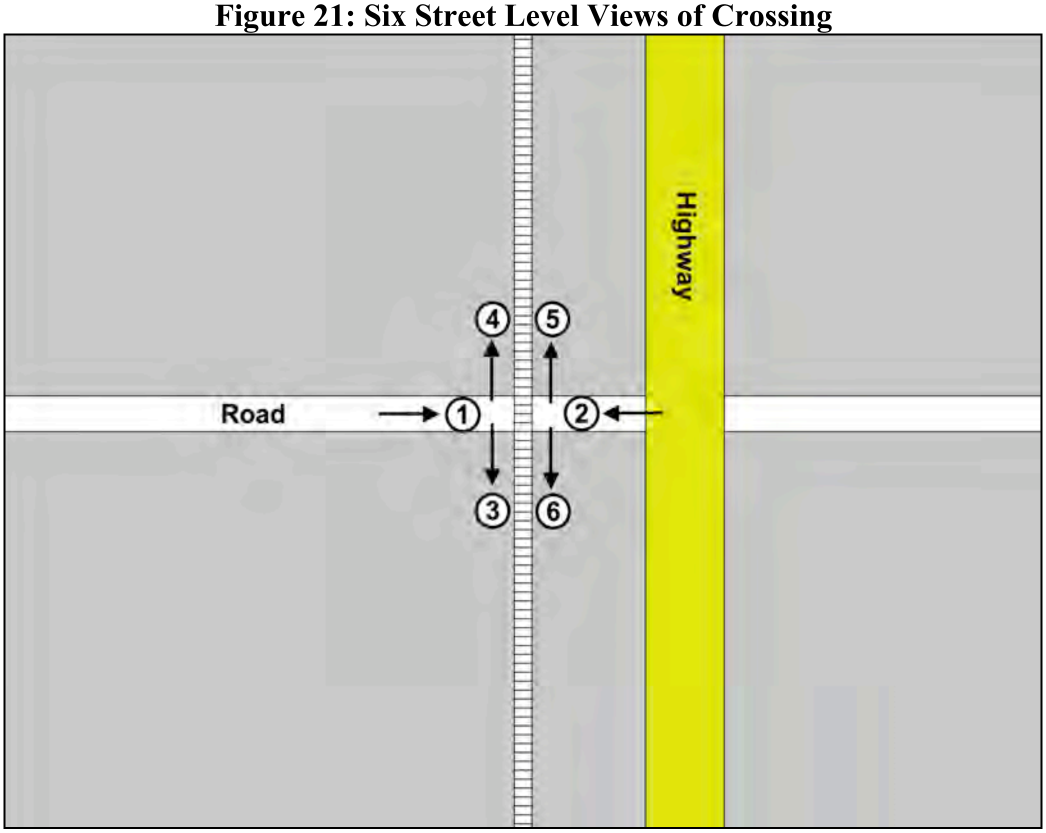
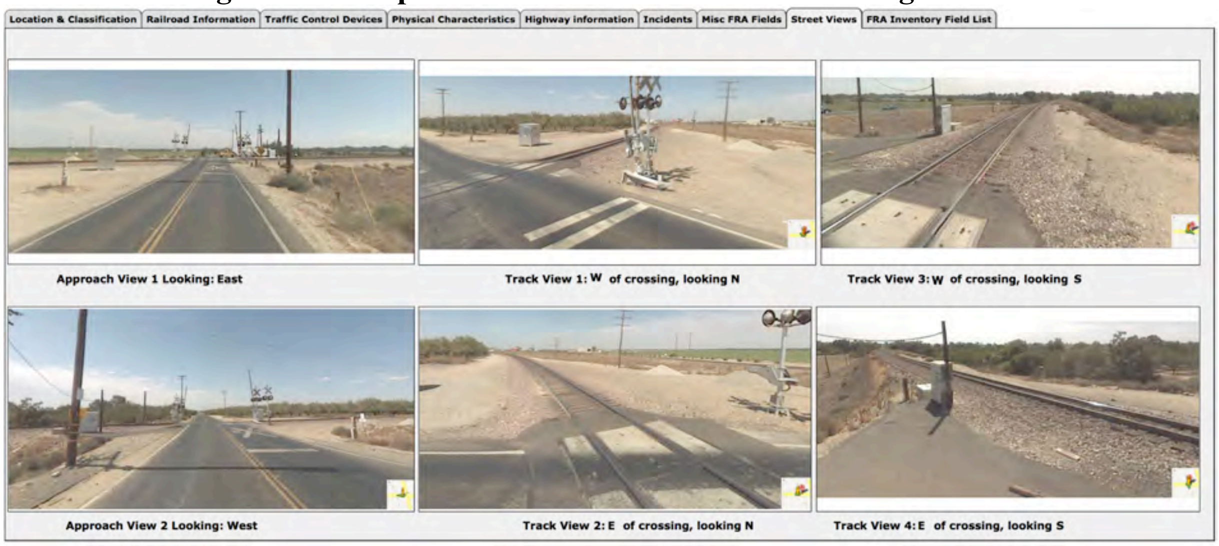


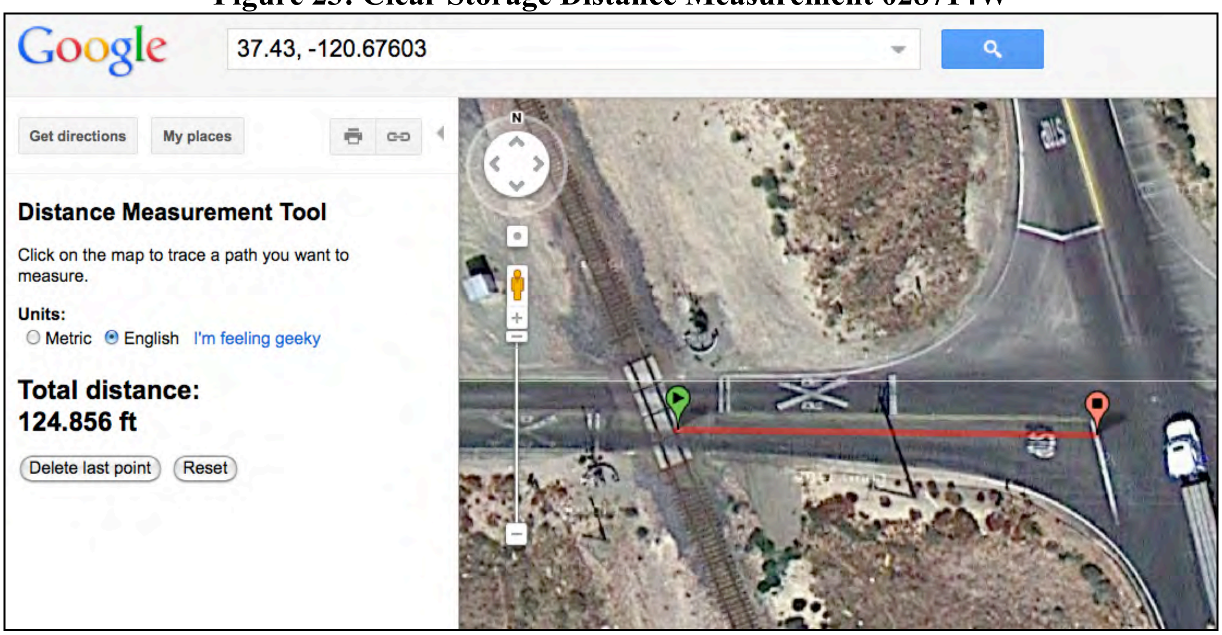
Figure 22: Sample Six Street Level Views of Crossing 028714W



Measure and Record Storage Distance

Using Google Maps Distance Measurement Tool (Figure 23), measure distance between track and stop line at intersection, subtract six feet, and record as Clear Storage Distance.

Figure 23: Clear Storage Distance Measurement 028714W



Update Crossing Vehicle Traffic

If the crossing is on a roadway that is part of the state highway system (Interstate, California, U.S. highways) vehicle counts can often be found at the Caltrans Traffic Data Branch website. For non-state roadways, information is often available at the respective city or county DOT website. A link to many city sites can be found at http://events.cacities.org/cgi-shl/TWServer.exe/Run:CITYINFO. A list of county sites is provided in Appendix B.

For those crossings for which AADT information is not available, it may be necessary to employ an outside contractor to perform the counts. Table 13 contains cost information for four firms that have been used by a number of California public agencies.

Table 13: Vehicle and Train Volume Count Costs

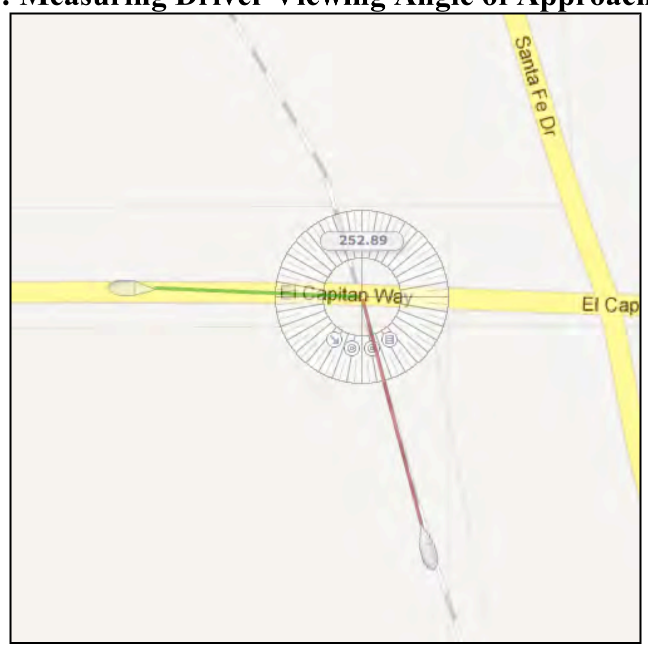
	Metrotrafficdata.com*	Qualitytrafficdata.com	Markstrafficdata.com	Trafficdataservices.com
Directional 24-Hour Volume	$90-$100	$50	$140	$110
Each Additional Day	$5-$10	$15	$40	$70
Directional 24-Hour Classification	$150-$300	$65	$180	$100
Each Additional Day	$15-$25	$15	$40	$100
Rail Crossing Train Volume & Delay (Video)	$400-$800	$350		$520

*The range of prices is based on the number of crossings covered at a given time, size of the roadway (such as number of lanes and whether they are divided) and configuration of the crossing.

Crossing Angle

The FRA inventory database contains the field, "Smallest Crossing Angle" which, unfortunately, does not convey useful information. What is important is the direction the driver must look in order to see an approaching train, which does not always correspond to the crossing's smallest crossing angle. Using Google Maps overhead view and an on-screen protractor (e.g., M-B Ruler http://www.markus-bader.de/MB-Ruler/index.htm, Screen-Protractor http://www.iconico.com/protractor/) measure an angle the driver would have to look relative to his/her direction of travel to see the approaching train. In Figure 24, a westbound driver would have to look south at a relative heading of 253 degrees to see the northbound train. A train coming from the other direction would be seen at a relative heading of 073 degrees (253°-180°) to the driver.

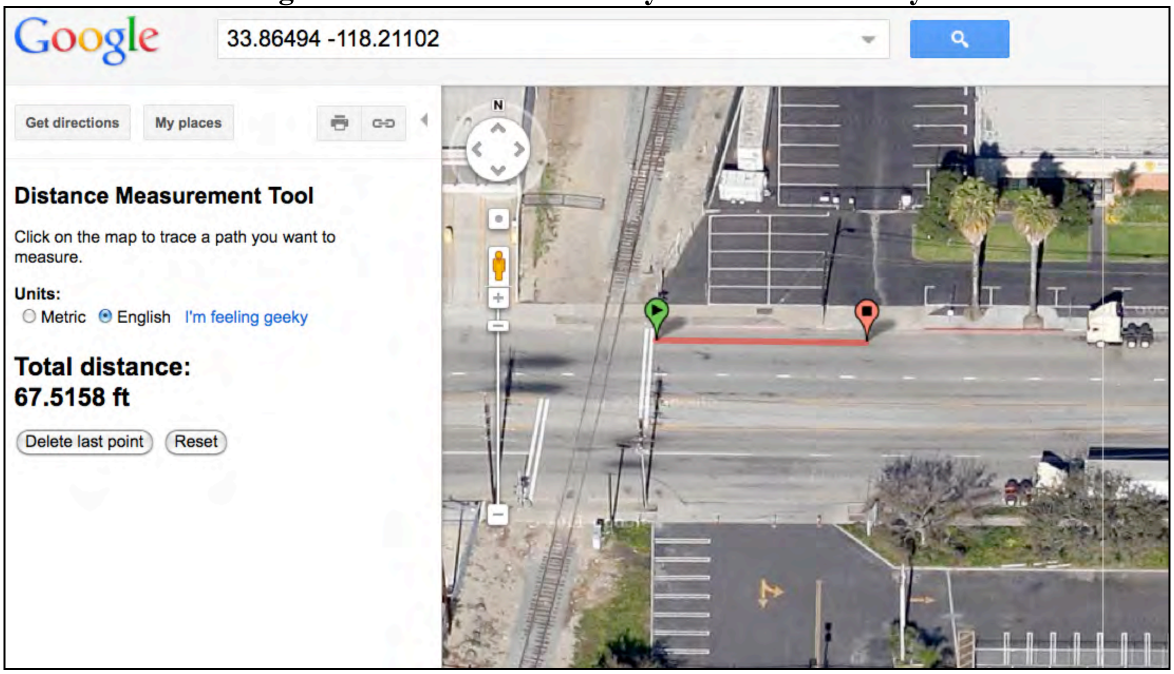
Figure 24: Measuring Driver Viewing Angle of Approaching Train



Driveways

The list of acceptable supplementary safety measures in the FRA's "Train Horn Final Rule" (2006) includes medians and channelization devices. The rule requires that these devices "must extend at least 100 feet from the gate arm, or if there is an intersection within 100 feet of the gate, the median or channelization device must extend at least 60 feet from the gate arm." When considering the use of these devices, it is necessary to consider the effect on nearby businesses if the medians or channelization devices prevent vehicles from making a left-hand turn into businesses' driveways. By using Google Maps Distance Measurement Tool, a preliminary measurement can be made (Figure 25).

Figure 25: Distance to Nearby Business Driveway



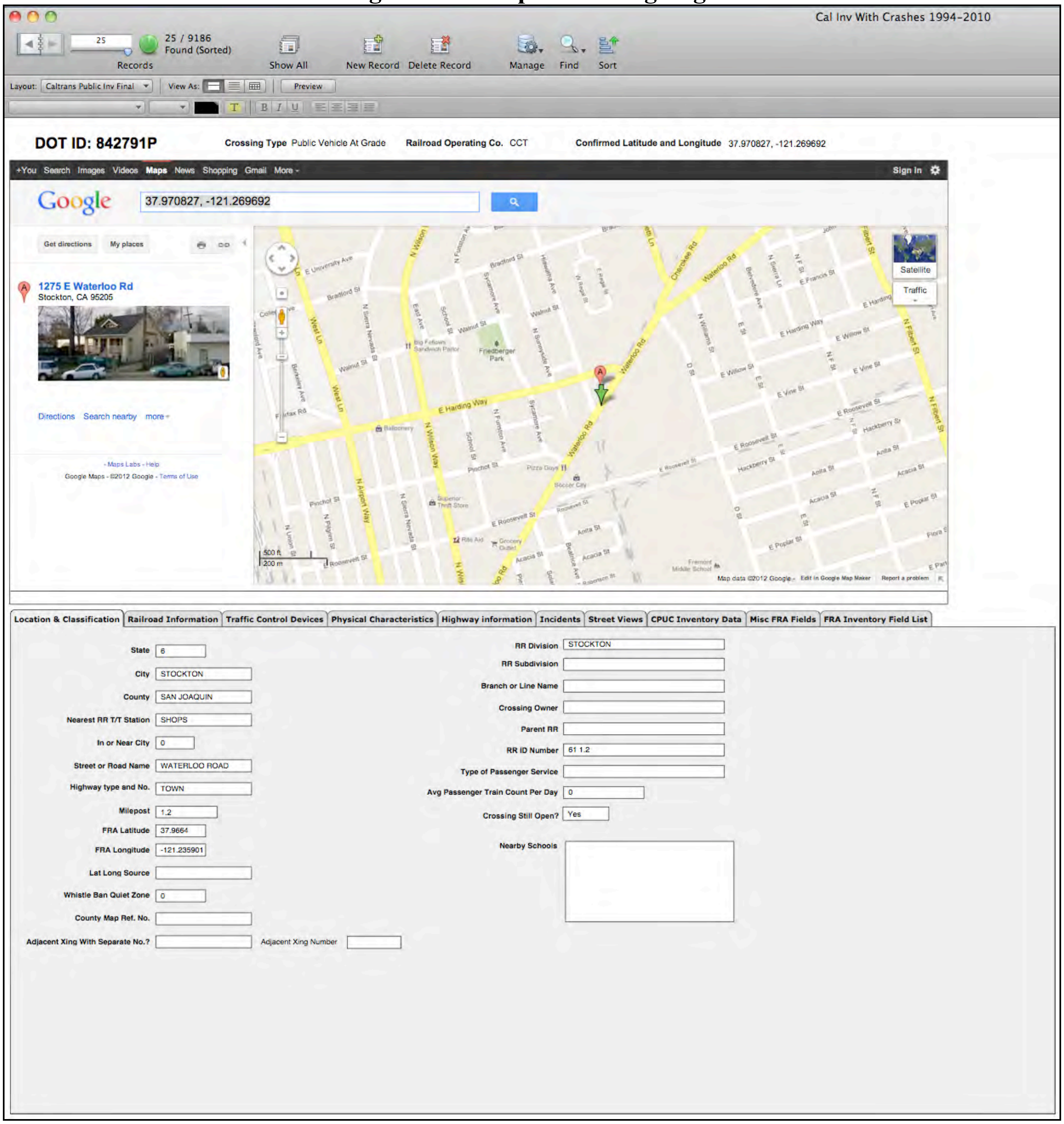
SAMPLE DATABASE

The sample database that follows was developed using FileMaker Pro®. Each crossing has its own page which includes basic information such as DOT crossing ID number, type of crossing (e.g., Public At-Grade), latitude and longitude, as well as an imbedded Google Maps viewer which utilizes the crossing's latitude and longitude. Additionally, the page has ten tabs, each containing a different category of crossing data for that specific crossing. These are:

1. Location & Classification
2. Railroad Information
3. Traffic Control Devices
4. Physical Characteristics
5. Highway Information
6. Incidents
7. Street Views
8. CPUC Inventory Data
9. Misc FRA Fields
10. FRA Inventory Field List

The first five tabs correspond to the five sections of information contained in the inventory report available on the FRA website (See Appendix G).

Figure 26: Sample Crossing Page



Tab 1: Location and Classification

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

State	6	RR Division	STOCKTON
City	STOCKTON	RR Subdivision	
County	SAN JOAQUIN	Branch or Line Name	
Nearest RR T/T Station	SHOPS	Crossing Owner	
In or Near City	0	Parent RR	
Street or Road Name	WATERLOO ROAD	RR ID Number	61 1.2
Highway type and No.	TOWN	Type of Passenger Service	
Milepost	1.2	Avg Passenger Train Count Per Day	0
FRA Latitude	37.9664	Crossing Still Open?	Yes
FRA Longitude	-121.235901	Nearby Schools	
Lat Long Source			
Whistle Ban Quiet Zone	0		
County Map Ref. No.			
Adjacent Xing With Separate No.?		Adjacent Xing Number	

Tab 2: Railroad Information

Location & Classification | **Railroad Information** | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Number of Daily Train Movements

Day Thru Train Movements	23
Night Thru Train Movements	19
Total Trains	45
Switching	0
Night Switching Movements	0
Total Switching Trains	0
Maximum Timetable Speed	70
From Min Speed	1
To Max Speed	70

Number of Main Tracks	1		
Number of Other Tracks	0	Specify	
Does Another RR Operate a Separate Trk _Y_N_	2	Specify	
Does Another RR Operate Over Your Trk _Y_N_	1	Specify	ATK

Updated Train Count	
Updated Train Count Date	
Updated Train Count Source	

< 1 Movement/Day: 0

Tab 3: Traffic Control Devices

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Signs

Crossbucks: 2

Highway Stop Signs: 0

Other Stop Sign: 0

Other Signs: 0 Specify:

_Other Signs: 0 Specify:

Hump Signs:

Pavement Markings: 4

1 = Stop lines,
2 = RR Xing Symbols,
3 = No Markings
4 = Stop lines and RR Xing Symbols

Warning Device Code: 8 Warning Device Type: All other Gates

Channelization Devices With Gates: 1 = All Approaches, 2 = One Approach, 3 = None

Other Train Activated Warning Devices:

Interconnection Pre-emption:

0 = not interconnected
1 = simultaneous preemption
2 = advance preemption
9 = n/a

RR Advance Warning Signs: 1

Train Activated Devices

Train Detection: 3

1 = Constant Warning Time
2 = Motion Detectors
3 = DC/AFO
4= other
5 = none

Gates: 2

Cantilevered _or bridged_ Flashing Lights_Over Traffic: 0

Cantilevered _or bridged_ Flashing Lights_Not Over Traffic: 0

Mast Mounted Flashing Lights: 2

Other Flashing Lights: 0 Specify:

Number of Flashing Light Pairs: 0

Wigwags: 0

Bells: 2

_No_Signs_or_Signals: 0

Specify Warning Device:

Hwy Traffic Signals: 0

Crossbucks Reflectorized: 2

Gates Red _ White: 2

Gates_Other: 0

Crossbucks Non Reflectorized: 0

Tab 4: Physical Characteristics

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Type of Development	1 (1=Open Space, 2=Residential, 3=Commercial, 4=Industrial, 5=Institutional)
Crossing Direction Of Approaching Train Relative To Driver 1	73
Crossing Direction Of Approaching Train Relative To Driver 2	253
No. of Traffic Lanes Crossing RR	2
Are Truck Pullout Lanes Present _Y_N_	2
Is Highway Paved	1
Crossing Surface	4
Does Track Run Down a Street _Y_N_	2
Nearby Intersecting Highway?	1
Is Xing Illuminated?	
Commercial Power Available _Y_N_	1
Clear Storage Distance (ft)	110

DOT Predicted Casualty Rate	.011819
DOT Predicted Fatality Rate	.004626
DOT Accident Pred Value	.02566
Date Acc Pred Value Generated	12/12/2007

Tab 5: Highway Information

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | **Highway information** | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Functional Classification of Road at Crossing: 8

01=R. Interstate
02=R. Oth. Prin. Arterial
06=R. Minor Arterial
07=R. Major Collector
08=R. Minor Collector
09=R. Local
11=U. Interstate
12=U. Oth. Freeway and Expressway
14=U. Oth. Prin. Arterial
16=U. Minor Arterial
17=U. Collector
19=U. Local
[R=Rural, U=Urban]

FRA AADT: 1000

Estimate Percent Trucks: 15

Year for FRA AADT: 1975

Avg. No of School Buses Passing Over the Crossing on a School Day: 0

Posted Hwy Speed: 0

Updated AADT:

Updated AADT Date:

Updated AADT Source:

Is crossing on State Highway System _Y_N_: 2

Highway System: 8

01=Interstate National Highway System
02=Other National Highway System
03=Other Federal-Aid Highway - Not NHS
08=Non Federal-Aid (NHS=National Highway System)

Nearby Intersection Highway? Is It Signalized?:

_Crossing Surface:

Tab 6: Incidents

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Crash Dates	Number Killed	Number Injured	Vehicle Type
3/4/2001	1	0	Van
9/6/2001	0	0	Auto
6/23/2010	0	0	Truck-Trailer

This tab includes information on incidents that occurred at this crossing from 1994 to 2010. Additional incident related information can also be displayed on this tab if desired.

Tab 7: Street Views

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Approach View 1 Looking: East

Track View 1: W of crossing, looking N

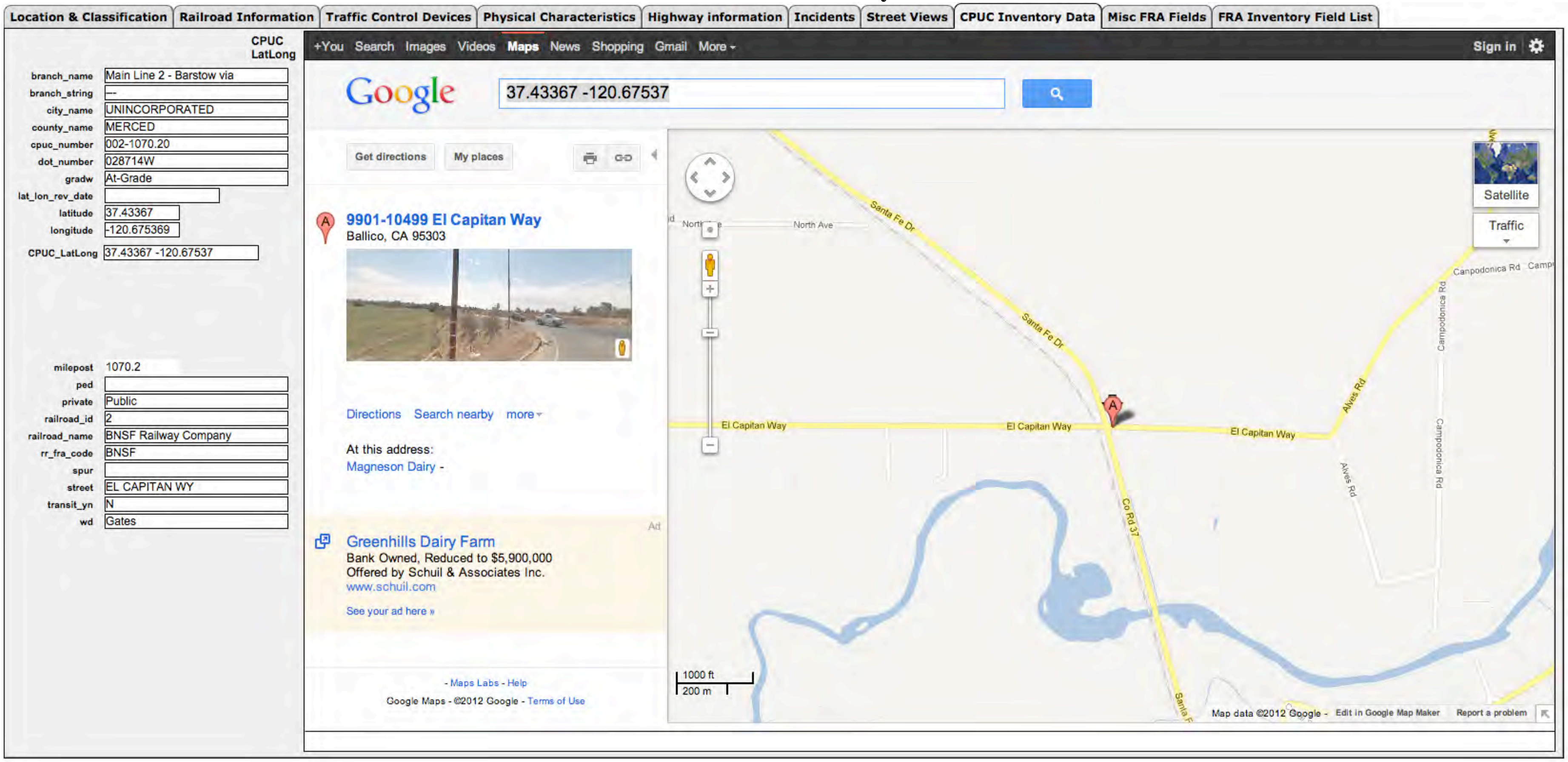
Track View 3: W of crossing, looking S

Approach View 2 Looking: West

Track View 2: E of crossing, looking N

Track View 4: E of crossing, looking S

Tab 8: CPUC Inventory Data



The information on this tab was downloaded from the CPUC website.

Tab 9: Misc FRA Fields

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

Effective Date YYMMDD 950328
End Date 999999
Reason for Update 1
State 6

Effective Date 3/28/1995
_End Date

Signs_ Signals (Private Xing)
Signs_Specify (Private Xing)

High Speed_ Corridor Code

Last Record Update Date

Initiating Agency 2
1=Railroad
2=State
[3=DOT
4=Original

Acc History Curr Year 0
Acc History Prior Year 1
Acc History Two Years Prior 0
Acc History Three Years Prior 1
Acc History Four Years Prior 0
Date Acc Histories Generated 12/19/2007

Four_quad gates preser
Two quad gates present

Type of Crossing 3
Position of Crossing 1

Source of Last Update

Smallest Crossing Angle 2

Smallest Crossing Angle 2 30-59

Private Xing Category
1=Farm, 2=Residential, 3=Recreational, 4=Industrial, 5=Commercial

Railroad Contact
State Contact
Emergency Contact
Narrative

Private Crossing_Public Access

Signaling for Train Opeation: Is Track Equiped with Train Signals 1

Emergency Notification System Sign

Private Signals _Specify

Tab 10: FRA Inventory Field List

Location & Classification | Railroad Information | Traffic Control Devices | Physical Characteristics | Highway information | Incidents | Street Views | CPUC Inventory Data | Misc FRA Fields | FRA Inventory Field List

1	B.	CROSSING	Crossing No.	
2	D.	EFFDATE	Effective Date	
3		EDATE	End Date	
4	C.	REASON	Reason for Update	
5	I.2.	STATE	State	
6	I.3.	CNTYCD	County	
7		STATE2	State	
8	I.12.	CITYCD	City	
9	I.12.	NEAREST	In or Near City	
10	I.1.	RAILROAD	Railroad Operating Company	
11	I.4.	RRDIV	RR Division	
12	I.5.	RRSUBDIV	RR Subdivision	
13	I.14.	HIGHWAY	Highway type and No.	
14	I.13.	STREET	Street or Road Name	
15	I.8.	RRID	RR I.D. No	
16	I.9.	TTSTN	Nearest RR Timetable Station	
17	I.6.	BRANCH	Branch or Line Name	
18	I.7.	MILEPOST	RR Milepost	
19	I.22.	MAPREF	County Map Ref. No.	
20	I.17	TYPEXING	Type of Crossing	1=Pedestrian 2=Private Vehicle 3=Public Vehicle
21	I.18.	POSXING	Position of Crossing	1=At grade 2=RR under 3=RR over
22	I.27.A	PRVCAT	Private Xing Category	1=Farm, 2=Residential, 3=Recreational, 4=Industrial, 5=Commercial
23	I.27.C.	PRVIND	Signs/ Signals	1=signs, 2=signals, 3=no signs or signals, 4=both signs and signals
24	I.27.C.	PRVSIGN	Signs-Specify	
25	A.	INIT	Initiating Agency	
26		BATCH	System coded Field	
27		USERCD		
28		UPDATE		
29		LINK		
30	II.1.C.	DAYTHRU	Day Thru Train Movements	
34	II.1.D.	LT1MOV	Less Than One Movement Per Day?	0 = At least one train per day, 1=Less than one train per day
35	II.2.A.	MAXTTSPD	Maximum Timetable Speed	
36	II.2.B	MINSPD	From Min Speed	
37	II.2.B.	MAXSPD	To Max Speed	
38	II.3.	MAINTRK	Main	
39	II.3.	OTHRTRK	Other	
40	II.3.	OTHRDES	Specify	
41	II.4.	SEPIND	Does Another RR Operate a Separate Trk	1=Yes, 2=No
42	II.4.	SEPRR	Specify	
43	II.5.	SAMEIND	Does Another RR Operate Over Your Trk (Y/N)	1=Yes, 2=No
44	II.5	SAMERR	Specify	
45		WDCODE	Warning Device Code	9 - Four Quad (full barrier) Gates, 8 - All other Gates, 7 - Flashing lights, 6 - Highway signals, wigwags, bells, other activated, 5 - Special Active Warning Devices, 4 - Stop signs, 3 - Crossbucks, 2 - Other signs or signals, 1 - No signs or signals
48	III.2.B.	STOPSTD	Highway Stop Signs	
49		STOPOTH	Other Stop Sign	
50	III.2.F.	OTHSGN1	Other Signs	
51	III.2.F.	OTHDES1	Specify	
52	III.2.F.	OTHSGN2	Other Signs	
53	III.2.F.	OTHDES2	Specify	
56	III.3.C.	FLASHOV	Cantilevered (or bridged) Flashing Lights-Over Traffic	
57	III.3.C.	FLASHNOV	Cantilevered (or bridged) Flashing Lights-Not Over Traffic	
58	III.3.D.	FLASHMAS	Mast Mounted Flashing Lights	
59	III.3.F.	FLASHOTH	Other Flashing Lights	
60	III.3.F.	FLASHDES	Specify	
61	III.3.G.	HWYSGNL	Hwy Traffic Signals	
62	III.3.H.	WIGWAGS	Wigwags	
63	III.3.J.	BELLS	Bells	
64	III.4.	SPECPRO	Specify Warning Device	
65	III.1.	NOSIGNS	No Signs or Signals	1=No signs or signals, 0=At least one sign or signal
66	IV.10.	COMPOWER	Commercial Power Available (Y/N)	1=Yes, 2=No
67	III.7.	SGNLEQP	Signaling for Train Opeation: Is Track Equiped with Train Signals	1=Yes, 2=No
68	III.6.	SPSEL	Train Detection	1=Constant Warning Time, 2= Motion Detectors, 3=DC/AFO, 4=other, 5=none
69	IV.1.	DEVELTYP	Type of Development	1=Open Space, 2=Residential, 3=Commercial, 4=Industrial, 5=Institutional
70	IV.5	HWYPVED	Is Highway Paved	1=Yes, 2=No
71	IV.7.	DOWNST	Does Track Run Down a Street (Y/N)	1=Yes, 2=No
72	III.2.E.	PAVEMRK	Pavement Markings	1=Stoplines, 2=RR Xing Symbols, 3=No Markings 4=Stoplines and RR Xing Symbols
73	IV.8.	HWYNEAR	Nearby Intersecting Highway?	
74	III.2.C.	ADVWARN	RR Advance Warning Signs	1=Yes, 2=No
75	IV.2.	XANGLE	Smallest Crossing Angle	1=0-29, 2=30-59, 3=60-90
76	IV.6.	XSURFACE	Crossing Surface	1. Timber, 2. Asphalt, 3. Asphalt and Flange, 4. Concrete, 5. Concrete and Rubber, 6. Rubber, 7. Metal, 8. Unconsolidated, 9. Other (Specify)
77	IV.3.	TRAFICLN	No. of Traffic Lanes Crossing RR	
78	IV.4.	TRUCKLN	Are Truck Pullout Lanes Present (Y/N)	1=Yes, 2=No
79	V.2.	STHWY1	Is crossing on State Highway System (Y/N)	1=Yes, 2=No
80	V.1.	HWYSYS	Highway System	01=Interstate National Highway System, 02=Other National Highway System, 03=Other Federal-Aid Highway- Not NHS, 08=Non Federal-Aid (NHS=National Highway System)
81	V.3.	HWYCLASS	Functional Classification of Road at Crossing	01=Interstate National Highway System, 02=Other National Highway System, 03=Other Federal-Aid Highway- Not NHS, 08=Non Federal-Aid (NHS=National Highway System)
82	V.5.	AADT	AADT	
83	V.6.	PCTTRUK	Estimate Percent Trucks	
84	I.23.	LATITUDE	Latitude	
85	I.24.	LONGITUD	Longitude	
86	I.25.	LLSOURCE	Lat Long Source	
87	III.8.	INTRPRMP	Interconnection Pre-emption	
88	III.2.D.	HUMPSIGN	Hump Signs	
89	I.21.	HSCORRID	[High Speed] Corridor Code	
90		DOTACPD	DOT Accident Prediction Value	
91		ACPDDATE	Date Acc Pred Value Generated	
92		ACCCNT1	Accident History Curr Year	
93		ACCCNT2	Accident History Prior Year	
94		ACCCNT3	Accident History Two Years Prior	
95		ACCCNT4	Accident History Three Years Prior	
96		ACCCNT5	Accident History Four Years Prior	
97		HISTDATE	Date Acc Histories Generated	
98	V.7.	SCHLBUS	Avg. No of School Buses Passing Over the Crossing on a School Day	98. Avg. No of School Buses Passing Over the Crossing on a School Day
99	I.16	WHISTBAN	Whistle Ban (Quiet Zone)	0=no, 1=24 hour, 2=partial, 9=unknown
100	I.19	PASSCD	Type of Pannenger Service	A = AMTRAK operates over crossing, B = AMTRAK and other passenger train operates over crossing, C = Other passenger train operates over crossing, including seasonal, D = None
101	I.20	PASSCNT	Avg Passenger Train Count Per Day	
102	I.10	RRMAIN	Parent RR	
103	I.11	XINGOWNR	Crossing Owner	
104		SOURCE	Source	
105		UPDATDAT	Last Record Update Date	
106		LONGBDAT	Effective Date	
107		LONGEDAT	End Date	
108	III.3.B.	FOURQUAD	Four-quadrant gates present	
109		TWOQUAD	Two-quadrant gates present	
110	I.27.B.	OPENPUB	Private Crossing-Public Access	
119	V.5.	AADTYEAR	Year for AADT	
120		AADTCALC		
128		DOTCASPD	DOT Predicted Casualty Rate	
129		DOTFATPD	DOT Predicted Fatality Rate	
130		FUNCCAT		
131	I.32.	RRCONT	Railroad Contact	
132	I.33.	HWYCONT	State Contact	
133	I.31.	POLCONT	Emergency Contact	
134	I.30.	NARR	Narrative	
135	II.1.A.	TOTALTRN	Total Trains	
136	II.1.B.	TOTALSWT	Total Switching Trains	
137	I.15.	ENSSIGN	ENS Sign	1=Yes, 2=No
138	III.2.A.	XBUCK	Crossbucks	
139	III.3.A.	GATES	Gates	
140	I.27.C.	PRVSIGNL	Signals -Specify	
141	III.3.E.	FLASHPAI	Number of Flashing Light Pairs	
142	III.3.K.	WARNACTO	Other Train Activated Warning Devices	
143	III.5.	CHANNEL	Channelization Devices With Gates	1=All Approaches, 2=One Approach, 3=None
144	I.26.	XINGADJ	Adjacent Xing With Separate No.?	1=Yes, 2=No
145	I.26.	XNGADJNO	Adjacent Xing With Separate No.? Provide #	
146	IV.9.	ILLUMINA	Is Xing Illuminated?	1=Yes, 2=No
147	V.4.	HWYSPEED	Posted Hwy Speed	
148	I.3.	[CNTYNAM]	County	
149	I.9.	[TTSTNNAM]	Nearest RR Timetable Station	
150	I.12.	[CITYNAM]	City	
151	IV.6.	XSUROTHR	Crossing Surface	
152	IV.8.	HWYNRSIG	Nearby Intersection Highway? Is It Signalized?	1=Yes, 2=No

These are the fields contained in the FRA's "Highway-Rail Grade Crossing Accident/Incident Form F 6180.57: Data File Structure And Field Input Specifications"

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APPENDIX A: CALIFORNIA PUBLIC CROSSINGS WITH FOUR OR MORE CRASHES 2001-2010

Fed ID	# Crashes 2001-2010	Crash Dates	Crossing Equipment[1]	Xing Angle[2]	City	County
026517B	10	11/01, 12/02, 12/03, 8/04, 11/04, 12/04, 12/05, 12/05, 12/1/06, 3/07	11-G	12/192	Riverside	Riverside
028380R	7	6/02, 5/03, 6/05, 1/06, 11/06, 12/07, 7/08	2-G 5-FL	45/225	Unincorporated	Kern
811479J	7	8/03, 12/04, 11/08, 7/09, 8/09, 3/10, 7/10	7-G	80/260	City of Industry	Los Angeles
027650J	6	12/03, 12/03, 9/04, 1/08, 10/09, 3/10	6-G	25/205	Santa Fe Springs	Los Angeles
027656A	6	4/01, 5/01, 3/02, 9/03, 8/06, 11/09	6-G	35/215	Santa Fe Springs	Los Angeles
028688J	6	3/01, 11/01, 1/02, 11/02, 11/04, 10/10	6-G	37/217	Unincorporated	Merced
746903Y	6	10/02, 8/04, 4/05, 1/07, 9/07, 3/10	6-G	93/273	City of Industry	Los Angeles
761540V	6	5/01, 3/04, 6/04, 3/05, 7/06, 11/08	6-Xbucks	101/281	Long Beach	Los Angeles
765937U	6	2/01, 8/01, 11/01, 1/02, 12/04, 12/06	6-G	128/308	Merced	Merced
026476Y	5	3/05, 3/06, 8/07, 1/10, 8/10	5-G	35/215	Riverside	Riverside
027657G	5	12/01, 10/04, 11/05, 1/06, 9/07	5-G	124/304	La Mirada	Los Angeles
749712Y	5	3/06, 5/06, 6/06, 6/06, 5/07	5-G	85/265	Oakland	Alameda
749720R	5	4/05, 5/06, 6/06, 3/10, 4/10	5-G	76/256	Oakland	Alameda
833921K	5	5/01, 6/01, 6/01, 11/01, 6/09	5-G	86/266	Lathrop	San Joaquin
026560G	4	12/04, 12/07, 7/08, 10/08	4-G	88/268	Yorba Linda	Orange
028379W	4	1/02, 3/04, 9/07, 12/09	4-G	45/225	Bakersfield	Kern
028395F	4	12/05, 1/06, 11/07, 6/08	4-FL	47/227	Shafter	Kern
028553D	4	3/01, 11/01, 2/02, 12/09	4-G	75/255	Fresno	Fresno
028582N	4	7/02, 3/03, 2/04, 11/04	4-G	136/316	Fresno	Fresno
745855H	4	3/08, 8/09, 8/10, 11/10	4-G	90/270	Oxnard	Ventura
746964P	4	1/01, 3/06, 10/08, 12/10	4-G	108/288	Ontario	San Bernardino
751224V	4	10/05, 10/06, 9/07, 5/08	4-G	105/285	Davis	Yolo
755011Y	4	5/01, 1/04, 3/05, 10/06	4-G	86/266	Palo Alto	Santa Clara
833930J	4	9/04, 4/07, 9/07, 1/09	4-G	91/271	Stockton	San Joaquin

Source: FRA

1. Entries in this column are in the form: Number of Crashes-Equipment. FL-Flashing Lights, G-Gates, Stop-Stop sign
2. Potential position, in degrees, of approaching train relative to the direction of the car.

APPENDIX B: Effectiveness* of Adding Safety Treatments at Rail-Highway Level Crossings

	Upgrade Equipment To:								
Current Treatment	Stop Signs	Flashing Lights	2-Quad Gates	2-Quad Gates + Photo	2-Quad Long-Arm Gates, FL	2-Quad Long-Arm Gates + Photo	2-Quad Gates + Median Separator	2-Quad Gates + Median Separator + Photo	4-Quad Gate System
No Signs or Signals		64% (3)	88% (3)	97%	97%	99%	98%	99%	98%
Cross buck	35% (4)	64% (3)	88% (3)	97%	97%	99%	98%	99%	98%
Stop Signs at Passive Crossings			81%**	95%	95%	99%	96%	99%	97%
WigWags, Audible, Other Activated			44%	84%	86%	96%	89%	97%	90%
Flashing Lights			44% (3)	84%	86%	96%	89%	97%	90%
2-Quad Gates				72% (1)	75% (1)	93%	75% (2) 80% (3)	94%	82% (1)

*FRA (2005) ‘‘Effectiveness rate’’ means a number between zero and one which represents the reduction of the likelihood of a collision at a public highway-rail grade crossing as a result of the installation of an SSM or ASM when compared to the same crossing equipped with conventional active warning systems of flashing lights and gates. These have been converted here to percentages.

** FHWA 1985 - Stop signs 35% effective. Xbuck to 2-quad = 88%, so stop sign to 2 quad = 81%

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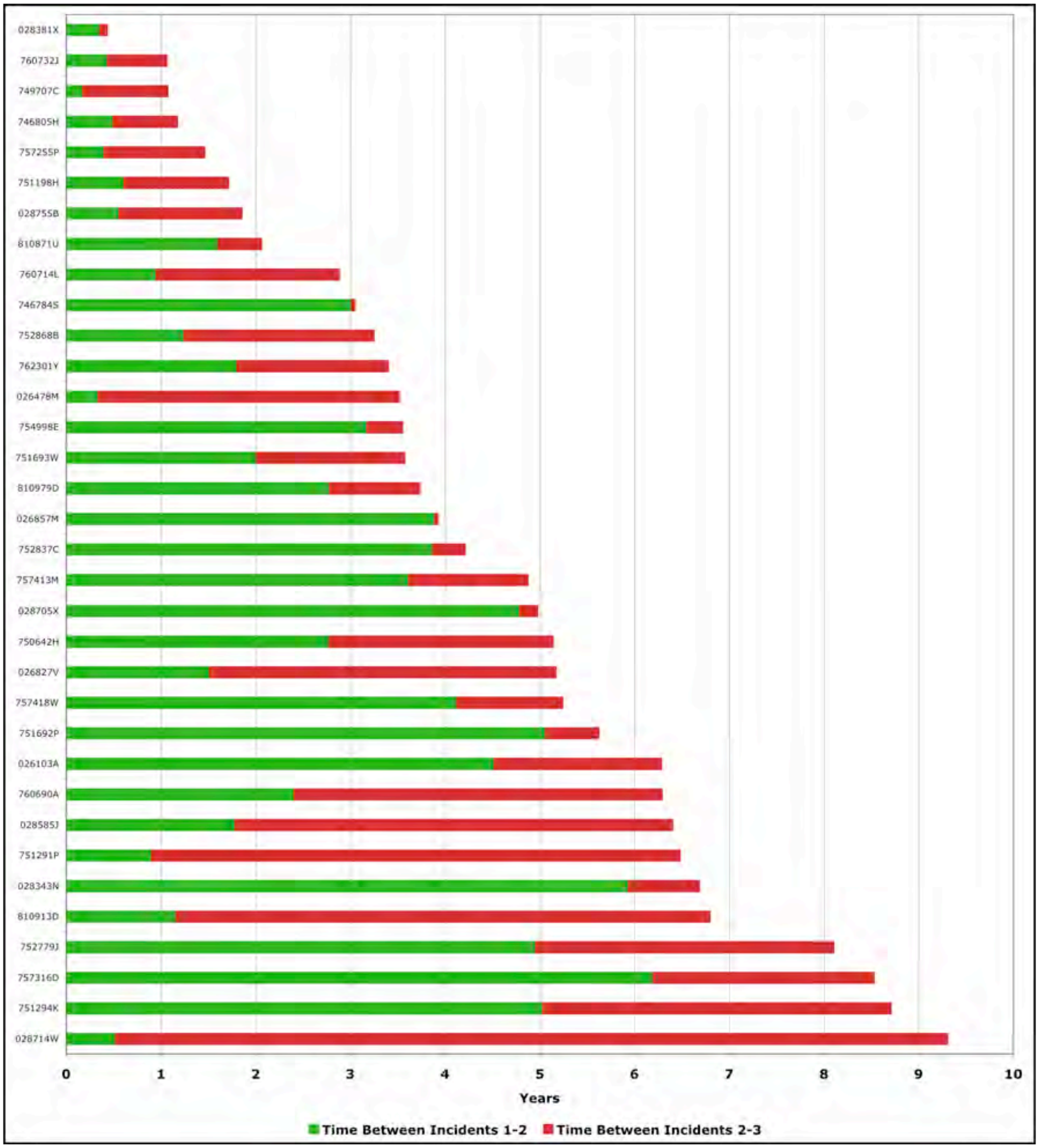
3. Caird, J.K., Creaser, J.I. , Edwards , C. J., Dewar, 2002, A Human Factors Analysis Of Highway-Railway Grade Crossing Accidents In Canada

4. Farr, E.H. and Hitz, J.S. (1985), Effectiveness of Motorist Warning Devices at Rail-Highway Crossings, Publication No. FHWA-RD-85-015. Federal Highway Administration, Washington, D.C.

APPENDIX C: Time Between Incidents at Crossings with Three Incidents 2001-2010



APPENDIX D: CPUC Priority List Methodology

The CPUC process is split into two essential parts: identifying crossings and evaluating crossings. This process is conducted annually; the annual process is also referred to as one "cycle."

Identifying Crossings

23CFR924.9(2) [See Attachment B] requires that there be a process for identifying hazardous locations. We use the following process to identify projects in consideration of identifying hazardous locations while utilizing available data sources and the most efficient use of our limited staff resources.

1. Generate a Pool of Crossings for CPUC Staff review.
    a. Accident History
        i. The train-vehicle and train-pedestrian accident history is retrieved from the CPUC accident database for approximately the past five years. Crossings which show two or more accidents within this time period are selected. Crossings which have been reviewed in the last five previous cycles are removed. SWITRS data is not used to identify crossings as the CPUC accident data contains that information for crossings, but is used later in the process in identifying secondary (non-train) crashes.
        ii. In the future, once all multiple crash locations are reviewed, crossings with one accident will be included.
    b. FRA Web Based Accident Prediction System (FWBAPS).
        i. The FWBAPS is generated online using the internet. This program generates crossings using the DOT's normalized accident prediction formula with the DOT's database to rank by accident potential. The resultant crossings are filtered to remove ineligible crossings and those which have already been reviewed in previous cycles.
            1. Ineligible crossings in California include: Grade Separations, Closed Crossings, Light-Rail only crossings, Pedestrian only crossings, or crossings which have been recently upgraded or are approved for upgrades which address the identified hazards.
        ii. The depth (number of crossings) we examine varies each year depending upon staffing resources and how many new crossings the list generates.
        iii. Attachment C is the disclaimer generated by FWBAPS indicating this is not a list of the most dangerous crossings, but rather a tool which can be used.
    c. Near-Hit Data.
        i. Some near-hit data (often erroneously referred to as near-miss data) has been provided by the two largest railroads in California, Union Pacific Railroad and BNSF Railway since 2005. The data is not consistent throughout the State, and details of the near-hit are not generally provided. However, near-hits are often an indicator of issues at a crossing, and have been shown to have some correlation as a predictor of future crashes.
        ii. The available data is analyzed and crossings with ten or more near-hit reports are selected and filtered to remove previously reviewed crossings. The limit of ten near-hit reports is chosen based on resource limitations and generation of a crossing list of reasonably manageable size. The limit of ten near-hits appears to provide a reasonable balance in the number of crossings identified and of which staff will reasonably be able to review in the time period allotted.
            1. The cutoff number of near-hit is reviewed each cycle and altered as appropriate.

d. Local Input.
    i. Local input (Local Agency, Caltrans District, or Railroad) received by email or phone contact with CPUC staff is important as these agencies are often more familiar with the specific hazards, and most hazardous crossings in their territory. Requests for funding consideration are received throughout the year and are held until the next review period.
        1. The CPUC Section 130 Guidelines posted on the CPUC website will be updated to clearly reflect the process for submitting this information. Information about this option has also been shared during on-site meetings with outside agencies for the past several years.
        2. Local input is not intended to allow politically sensitive projects to be identified, but to allow a forum whereby agencies more familiar with their crossings may present hazards which are not always readily apparent due to their local knowledge.

e. Staff Input
    i. Staff identify crossings throughout the year which may be good candidates for Section 130 through their normal work duties such as: crash investigation, inventory, and informal complaints. The CPUC crossings database contains a field where staff may make a note to consider the crossing for funding in the next cycle.

f. Hazard Trends.
    i. Periodically hazard trends are identified, generally through accident data, or risk analysis. These trends provide a means of identify crossings which have a high potential for crashes, based on specifically identified factors, even if they may not have recently experienced a crash.
        1. Example: One trend was to identify all passive or flasher level crossings on mainline track with passenger service. This was identified based on accident trends with Amtrak, and in consideration of the potential for the scope of severity if a crash were to occur.

g. Other Data Sources.
    i. Other data sources periodically become available to staff which may identify hazardous location, but are not necessarily routinely available every year.
        1. Example: One cycle included BNSF maintenance data. BNSF had provided one years worth of railway maintenance data, specifically where gate arm breakage was reported. Frequently, broken gate arms are an indication of near-hits, and other hazard issues at the crossing.

2. CPUC staff reviews each location. This may be done in the office and/or by field visit.
    a. In the office staff filters out crossings which are: closed, grade separated, private, light rail transit only, or have recently been upgraded or are approved for upgrades (Application or GO88B) where no further hazard mitigation is identified.
    b. In the field, staff evaluates the crossing using the diagnostic form and instructions incorporating review of all of the data and hazards equally at each crossing. There are no specific weighting numbers and crossings are not compared relatively, each is taken on its own merits. This step primarily identifies specific hazards and if they can be mitigated or not. If none of the hazards can be mitigated by the Section 130 program, the crossing is rejected and staff fills out the rejection form. If improvements are identified then staff fills out the diagnostic form to the extent possible and submits the crossing a nomination to the Section 130 Coordinator. The evaluation may involve contacting the railroad and local agency for additional data. Some crossings are already at their ultimate build out and nothing short of closure or grade separation will mitigate the hazards present, as well in other locations the root causes of the crashes can not be addressed through this program (such as drunk drivers).
3. The nomination pool is then generated by combining the nominations from the above process with crossings nominated in previous cycles which did not rank high enough to be added to the Priority List. The nomination pool generally runs between 100-300 crossings. The nomination pool is then evaluated.

Evaluating Crossings

23CFR924.9(4) requires that there be a process for establishing priorities and lists six specific factors for consideration. We use the following process to prioritize and refine projects from the nomination pool, incorporating the guidelines set and the best practices listed in the Railroad-Highway Grade Crossing Handbook, revised August 2007.

1. Ranking the Nomination Pool
    a. The crossings are divided into separate candidate pools based on their existing warning device level (passive, flashers and gated). This separation is made in order to compare and contrast the crossings as equitably as possible. The six factors listed in statute for consideration are noted in cells on the excel worksheets.
    b. Each of the three pools of crossings is then evaluated and preliminarily ranked. The top ranked crossings are selected and reviewed relative to each other. As costs are not available, the cost-benefit is not a factor taken into as specific a consideration at this part of the evaluation. The application of cost-benefit is done later in the process. Where possible however, costs are considered in relative terms at this step.
        i. For example: Given three essentially similar crossings of which two recommend traffic signal installation and one recommends a median, the median only project would rank higher than the other two projects.
    c. A CPUC Section 130 Team consisting of the Program Manager, Section Supervisor, Section Seniors and Section 130 Coordinator meet to review the selection process and the three pools of specific crossings and determine the final pool of projects which will move on to Phase 2 (diagnostic review) of the CPUC's process. The Team selects a limited number of projects to receive diagnostic reviews due to the limited annual funding available, as well as limited staff resources.
        i. An example of a common discussion item would be the relative merits of gating a passive crossing with low ADT (often less than 1000 ADT) as compared to selecting an already gated crossing ranked lower in its pool of crossings to evaluate for improvements. Since there is no formulaic process to which this sort of evaluation lends itself, the experience and knowledge of RCES engineering staff is utilized.
2. Conduct On-Site Diagnostic Team Review
    a. For each location identified to receive a full Diagnostic Team review the CPUC staff arranges and facilitates the on-site meeting. The Diagnostic Team shall at minimum consist of representatives from the affected Local Agency(s), Railroad(s), CPUC and Caltrans, unless any party provides in writing that their presence is not necessary. The Diagnostic Teams builds upon the initial CPUC analysis in fully vetting the crossing and determines preliminary recommendations of improvements to be funded by the Section 130 Program.
3. Final Ranking and Project Selection
    a. The updated and resulting information from the field review is inputted into a spreadsheet which lists all of the Phase 2 projects. Specific cells refer to items relative to each of the six factors for consideration. In the event that there are any crossings unfunded from the prior years' list, these carry-over projects will be added to the final ranking pool.
    b. The crossings are given a preliminary rank based on the analysis of the Section 130 Coordinator using the information which has been gathered, the guidance available, and engineering judgment.
        i. The potential reduction in number and/or severity of crashes is incorporated by use of actual crash data, predicted crash data, and predicted severity formula. [23CFR924.9(a)(4)(i)]
        ii. The cost-benefit factor is evaluated in a relative perspective (high – medium – low) as there are not specific cost figures available (and actual costs will increase due to the length of time the project is on the Priority List before funding is available) as well there are not well defined benefit factors for

most of the improvements which are made. As such a literal cost-benefit number is not practicable to produce. [23CFR924.9(a)(4)(ii)]

iii. The DOT's accident prediction formula is used as the Hazard Index. [23CFR924.9(a)(4)(iii)]

iv. Onsite inspection is taken into consideration by using the findings and observations of the Diagnostic Team of items which may be unique, or are particularly relevant in contributing to hazards at that particular crossing. [23CFR924.9(a)(4)(iv)]

v. The potential danger is incorporated by whether or not each of the listed factors is applicable to the crossing, as well as considering crash history. [23CFR924.9(a)(4)(v)]

vi. Other criteria in each State is incorporated by identification of those locations which have the same factors as identified hazard trends. [23CFR924.9(a)(4)(vi)]

c. The CPUC Section 130 Team meets and reviews the crossings, and the analysis. The Team determines the final ranking.

A cutoff is drawn based on estimated costs and anticipated funds available, thus creating the final priority list. Any projects which do not make the final cut are returned to the nomination pool for consideration in the next cycle

APPENDIX E: California County Links (in Alphabetical Order)

1. Alameda http://www.co.alameda.ca.us/
2. Alpine http://www.alpinecountyca.gov/
3. Amador http://www.co.amador.ca.us
4. Butte http://www.buttecounty.net/
5. Calaveras http://www.co.calaveras.ca.us
6. Colusa http://www.ccdpw.com
7. Contra Costa http://www.co.contra-costa.ca.us/
8. Del Norte http://www.co.del-norte.ca.us/
9. El Dorado http://www.co.el-dorado.ca.us/
10. Fresno http://www.co.fresno.ca.us/portal/Default.asp
11. Glenn http://www.countyofglenn.net/
12. Humboldt http://www.co.humboldt.ca.us/
13. Imperial http://www.imperialcounty.com/
14. Inyo http://www.countyofinyo.org/
15. Kern http://www.co.kern.ca.us/
16. Kings http://www.countyofkings.com/
17. Lake http://www.co.lake.ca.us
18. Lassen http://www.lassencounty.org/
19. Los Angeles http://lacounty.info/
20. Madera http://www.madera-county.com/
21. Marin http://www.marin.org/
22. Mariposa http://www.mariposacounty.org/
23. Mendocino http://www.co.mendocino.ca.us/
24. Merced http://www.co.merced.ca.us/
25. Modoc http://www.alturaschamber.org
26. Mono http://www.monocounty.org/
27. Monterey http://www.co.monterey.ca.us/
28. Napa http://www.mynapa.info/SiteDirectory.asp
29. Nevada http://new.mynevadacounty.com/Home/
30. Orange http://www.oc.ca.gov/
31. Placer http://www.placer.ca.gov/
32. Plumas http://www.countyofplumas.com/
33. Riverside http://www.countyofriverside.us
34. Sacramento http://www.co.sacramento.ca.us/
35. San Benito http://www.san-benito.ca.us/
36. San Bernardino http://www.co.san-bernardino.ca.us/
37. San Diego http://www.co.san-diego.ca.us/
38. San Francisco http://www.ci.sf.ca.us/
39. San Joaquin http://www.co.san-joaquin.ca.us/
40. San Luis Obispo http://www.SLOCounty.ca.gov
41. San Mateo http://www.co.sanmateo.ca.us/portal/site/SMC
42. Santa Barbara http://www.countyofsb.org/index.asp
43. Santa Clara http://www.SCCGov.org
44. Santa Cruz http://www.co.santa-cruz.ca.us/
45. Shasta http://www.co.shasta.ca.us/
46. Sierra http://www.sierracounty.ws/
47. Siskiyou http://www.co.siskiyou.ca.us/
48. Solano http://www.co.solano.ca.us/

49. Sonoma	http://www.sonoma-county.org/
50. Stanislaus	http://www.co.stanislaus.ca.us/
51. Sutter	http://www.co.sutter.ca.us/
52. Tehama	http://www.shastacascade.org/tehama/tepage.htm
53. Trinity	http://www.trinitycounty.org/
54. Tulare	http://www.co.tulare.ca.us/
55. Tuolumne	http://www.tuolumnecounty.ca.gov
56. Ventura	http://www.countyofventura.org/index.asp
57. Yolo	http://www.yolocounty.org/
58. Yuba	http://www.co.yuba.ca.us/

APPENDIX F: Web Resources

FRA 5.02—Generate Crossing Inventory and Accident Reports
http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/crossing/crossing.aspx

FRA GIS Mapping Application
http://fragis.frasafety.net/GISFRASafety/default.aspx

CPUC Highway-Rail Crossing Inventory
http://www.cpuc.ca.gov/PUC/transportation/crossings/crossinginventory.htm

Google Maps
http://maps.google.com/

Caltrans Traffic Data Branch
http://traffic-counts.dot.ca.gov/

Screen Protractor
http://www.markus-bader.de/MB-Ruler/index.htm
http://www.iconico.com/protractor/

APPENDIX G: U.S DOT Crossing Inventory Form

U.S. DOT - CROSSING INVENTORY INFORMATION
AS OF 2/8/2012

Crossing No.: ***842791P*** Update Reason: ***Changed Crossing*** Effective Begin-Date of Record: ***03/28/95***

Railroad: ***CCT Central Calfornia Traction Co. [CCT]*** End-Date of Record:

Initiating Agency ***State*** Type and Positiion: ***Public At Grade***

Part I Location and Classification of Crossing

Division:	***STOCKTON***	State:	***CA***
Subdivision:		County:	***SAN JOAQUIN***
Branch or Line Name:		City:	***In STOCKTON***
Railroad Milepost:	***0001.20***	Street or Road Name:	***WATERLOO ROAD***
RailRoad I.D. No.:	***61 1.2***	Highway Type & No.:	***TOWN***
Nearest RR Timetable Stn:	***SHOPS***	HSR Corridor ID:	
Parent Railroad:		County Map Ref. No.:	
Crossing Owner:		Latitude:	***37.9664000***
ENS Sign Installed:		Longitude:	***-121.2359010***
Passenger Service:		Lat/Long Source:	
Avg Passenger Train Count:	***0***	Quiet Zone:	***No***
Adjacent Crossing with Separate Number:			

Private Crossing Information:

Category: Public Access:

Specify Signs: Specify Signals:

	ST/RR A	ST/RR B	ST/RR C	ST/RR D
Railroad Use:				
State Use:				

Narrative:

Emergency Contact: Railroad Contact: State Contact: ***(213)576-7078***

Part II Railroad Information

Number of Daily Train Movements: Less Than One Movement Per Day: ***No***

Total Trains: ***4*** Total Switching: ***0*** Day Thru: ***2***

Typical Speed Range Over Crossing: From ***1*** to ***5*** mph Maximum Time Table Speed: ***5***

Type and Number of Tracks: Main: ***1*** Other ***0*** Specify:

Does Another RR Operate a Separate Track at Crossing? ***No***

Does Another RR Operate Over Your Track at Crossing? ***No***

U.S. DOT - CROSSING INVENTORY INFORMATION
Continued

Crossing **842791P**

Effective Begin-Date of Record: **03/28/95**
End-Date of Record:

Part III: Traffic Control Device Information

Signs:

Crossbucks:	***0***	Highway Stop Signs:	***0***
Advanced Warning:	***Yes***	Hump Crossing Sign:	
Pavement Markings:	***Stop Lines and RR Xing Symbols***	Other Signs: ***0*** ***0***	Specify:

Train Activated Devices:

Gates:	***0***	4 Quad or Full Barrier:	
Mast Mounted FL:	***0***	Total Number FL Pairs:	***0***
Cantilevered FL (Over):	***1***	Cantilevered FL (Not over):	***0***
Other Flashing Lights:	***0***	Specify Other Flashing Lights:	
Highway Traffic Signals:	***0***	Wigwags: ***0***	Bells: ***0***
Other Train Activated Warning Devices:		Special Warning Devices Not Train Activated:	***FLAGGED BY TRAINMEN***
Channelization:		Type of Train Detection:	***DC/AFO***
Track Equipped with Train Signals?	***Yes***	Traffic Light Interconnection/Preemption:	

Part IV: Physical Characteristics

Type of Development:	***Commercial***	Smallest Crossing Angle:	***30 to 59 Degrees***
Number of Traffic Lanes Crossing Railroad:	***4***	Are Truck Pullout Lanes Present?	***Yes***
Is Highway Paved?	***Yes***		
Crossing Surface:	***Asphalt***	If Other:	
Nearby Intersecting Highway?	***N/A***	Is it Signalized?	
Does Track Run Down a Street?	***No***	Is Crossing Illuminated?	
Is Commercial Power Available?	***Yes***		

Part V: Highway Information

Highway System:	***Other FA Highway - Not NHS***	Functional Classification of Road at Crossing:	***Urban Other Principal***
Is Crossing on State Highway System:	***No***		
Annual Average Daily Traffic (AADT):	***013519***	AADT Year:	***1995***
Estimated Percent Trucks:	***13***	Avg. No of School Buses per Day:	***0***
Posted Highway Speed:	***0***		