EVALUATION OF DOWNHILL TRUCK SPEED WARNING SYSTEM ON I-70 WEST OF EISENHOWER TUNNEL

Final Report to the

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EXECUTIVE SUMMARY

The purpose of this study is to evaluate the effectiveness of the downhill truck speed warning system (DTSWS) installed in the westbound lanes of Eisenhower Tunnel on I-70 in Colorado. A long downgrade of at least ten miles with -5% to -7% grades follows the tunnel. Over the period from 1995 to mid-1999, heavy trucks used the two truck runaway ramps downhill from the tunnel a total of 106 times or nearly twice per month. Over the nine years of 1990 to 1998, there have been 125 truck-related accidents on this 10-mile downgrade. The DTSWS has not been operating for a sufficiently long time to assess whether it has significantly reduced truck-related accidents.

The key measures of effectiveness examined by this study are driver awareness and compliance. This report explains our evaluation of driver awareness and compliance with the speed warning system as determined from videotape data of speeds, weights recorded at a weigh station, and a survey of truck operators.

This study performed data collection on four different days – two with the DTSWS display on and two with the DTSWS display off. Data was collected for two hours on each day (11 AM to 1 PM), and all days had very similar weather conditions. Over 100 trucks passed through the Dumont weigh station during each 2-hour session of data recording. Roughly 30-40 trucks were eventually matched on each of these days at all three locations (Dumont, exiting the tunnel, and 2 miles downhill of the tunnel) that we could compare.

Overall, the speed warning system appears to significantly reduce truck descent speeds for most all weight ranges above the 40,000 lb. minimum to which the warning system responds. This conclusion is the outcome of a statistical comparison of mean truck speeds on days with the system on versus days with the system off. This statistical test also controlled for differences in truck weights on the two sets of days, since lighter trucks would be expected to travel faster, and the mean truck weight was different on the two sets of days. Truck drivers surveyed responded very positively to the system and its potential to improve safety.

Our first recommendation is that the advised speeds and their corresponding weight ranges need to be revised. We recommend the following ranges and advised speeds: 40,000 to 48,500 lbs.(advised speed = 35 mph), 48,500 to 55,000 lbs. (advised speed = 25 mph), 55,000 to 80,000 lbs.(advised speed = 15 mph), and above 80,000 lbs.(advised speed = 10 mph). Fifteen of the 53 trucks that we observed on days with the system on were no more than 5 mph over these speeds, whereas only 6 were no more than 5 mph above the advised speeds currently programmed in the system. The risk of advising speeds that are too low is that drivers will tend to ignore the warning as being unrealistic. The advised speeds ought to be within ranges that many drivers will accept as good advice.

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1. OBJECTIVE

The purpose of this study is to evaluate the effectiveness of the downhill truck speed warning system (DTSWS) installed in the westbound lanes of Eisenhower Tunnel on I-70 in Colorado. A long downgrade of at least ten miles with -5% to -7% grades follows the tunnel. Figure 1 shows that the annual westbound traffic of all vehicles through the Eisenhower Tunnel is projected to reach nearly 5 million in 1999. Figure 2 shows that the average monthly counts of heavy trucks is roughly 30,000, or about 1,000 per day. The highest monthly truck counts usually occur in July and August of each year.

Two truck runaway ramps are located on the downgrade within 2 miles of the tunnel. Figure 3 shows that over a five year period, the truck runaway ramps were used 106 times, or nearly twice per month. Figure 4 shows that there have been 125 truck-related accidents over a nine year period on this 10-mile downgrade. The DTSWS has not been operating for a sufficiently long time to assess whether it has significantly reduced truck-related accidents.

The key measures of effectiveness examined by this study are driver awareness and compliance. This report explains our evaluation of driver awareness and compliance with the speed warning system as determined from videotape data of speeds, weights recorded at a weigh station, and a survey of truck operators.

2. OVERVIEW OF THE SYSTEM

The "Dynamic Truck Speed Warning System for Long Downgrades" was proposed in October 1992 by CDOT to be included in the IVHS Field Operational Test Program sponsored by USDOT. That proposal cites several statistics of past truck accidents on steep downgrades of Colorado highways. The need was clearly established to perform a demonstration of existing technology that might reduce the frequency and severity of downgrade truck accidents. A leading vendor of weigh-in-motion technology, International Road Dynamics (IRD), was involved from the start and

donated substantial equipment and time to the project as part of a public/private cost sharing agreement. The Downhill Truck Speed Warning System (DTSWS) calculates and displays a safe downhill descent speed for each passing truck of greater than 40,000 lbs. gross vehicle weight (GVW) based on each truck's axle configuration and gross vehicle weight, and the downgrade of the highway incline.

In 1997, the DTSWS was relocated inside the Eisenhower Tunnel in the westbound lanes just before exiting the tunnel (see diagram of its location in Figure 5). Figure 6 shows a photograph of the system from within the tunnel. The variable message sign (VMS) displaying the advised speed is located 250 feet beyond the loop detectors and weigh-in-motion (WIM) strips. Thus, a driver of a truck traveling 40 mph (60 feet per second) would have about 4.2 seconds to read the advised speed. This section of tunnel and the long downgrade after the tunnel has a posted speed limit of 30 mph for heavy trucks, but trucks often travel above that speed limit in this area. The DTSWS is positioned inside the tunnel so that truckers receive this advice before building up speed on the downgrade. Its position inside the tunnel also removes it from the glare of the sun that can hinder drivers from reading a VMS outside the tunnel.

The WIM strips of the DTSWS record each vehicle's (1) time of passage, (2) dimensions (i.e., length, number of axles, axle separation), (3) speed, and (4) weight. We videotaped trucks at three other locations at the same time. Figure 5 shows these locations relative to the DTSWS. We videotaped trucks as they exited the tunnel so as to match them with our videotape of trucks passing through the Dumont weigh station, where we also obtained a printout of each truck's weigh station information. Although we also obtained weigh-in-motion data from the DTSWS, we were not able to reliably match this WIM data with our Dumont weigh station data as explained later.

3. DATA COLLECTION PROCEDURE

Our main objective was to compare speeds of trucks descending the hill after exiting the tunnel with the DTSWS either on of off. Our data collection plan was originally designed to compare truck speeds with the warning message displayed based on specific truck weights and configurations. However, the study was not able to verify the accuracy of information recorded by the truck weigh-in-motion system of the DTSWS or verify exactly what message was displayed to each truck for two reasons. First, the weigh-in-motion system connected to the DTSWS has a

range of error that prevents the reliable identification of trucks based on their weight as recorded at the Dumont weigh station. Second, the DTSWS does not record the message displayed to each truck. Instead, we later evaluate the numbers of trucks that comply with the advised speeds that the warning system is programmed to display for given ranges of truck weights, knowing the truck weights as recorded at the Dumont weigh station.

The data collection tasks we performed for our analysis design were:

1. Select four days (May 19 and 21 and June 2 and 4) to collect data. Videotape trucks at (1) the Dumont weigh station, (2) as they exit the Eisenhower tunnel seconds after passing the DTSWS, and (3) 2 miles further downhill from the tunnel. Record truck weights and types at the weigh station and videotape trucks to match with trucks recorded by the DTSWS and videotaped outside the tunnel and 2 miles further downhill. Also record trucks speeds using pressure tubes as they exit the tunnel and 2 miles further downhill.

2. Arrange with IRD to archive DTSWS data for several consecutive days covering our videotaping days with the DTSWS display both ON and OFF. IRD data from the DTSWS must include each vehicle's time of passage, length, number of axles, axle separation, speed, and weight.

3. Run a pilot data collection effort around May 17. Refine the data collection plan for any difficulties. We selected data collection periods of two hours each on four days based on the necessary sample size as determined from the pilot data to achieve a 95% confidence level in statistical tests.

4. Perform videotaping and survey truck drivers on each day planned.

5. Process videotapes to match trucks at the tunnel and 2 miles downhill of the tunnel with identifying information videotaped at the Dumont weigh station.

6. Perform statistical comparisons and displays of matched truck speeds with the system on or off.

7. Survey truck drivers that enter the Dumont weigh station as to their awareness of the speed

warning system in the Eisenhower Tunnel and its potential effectiveness.

We performed data collection on four different days – two with the DTSWS display on and two with the DTSWS display off. May 19th and May 21st were the days of data collection with the system on, and June 2nd and June 4th were the days of data collection with the system off. We collected data for two hours on each day (11 AM to 1 PM), and all days had very similar weather conditions. Over 100 trucks passed through the Dumont weigh station during each 2-hour session of data recording. Roughly 30-40 trucks were eventually matched on each of these days at all three locations (Dumont, exiting the tunnel, and 2 miles downhill of the tunnel) that we could compare. Figure 7 shows a photograph of the pressure tubes for recording truck speeds exiting Eisenhower Tunnel. Figure 8 shows a photograph looking back up the downgrade toward the tunnel taken from our videotaping perch 2 miles beyond the tunnel.

Five main reasons explain why trucks observed at Dumont were not later matched at the other sites:

1. Many trucks have intermediate or final destinations between Dumont and the Eisenhower Tunnel for which other routes are taken.

2. Some truckers take rest stops and pass through the tunnel sometime later than our observation period.

3. Some truckers stop just after exiting the tunnel and do not pass the downhill location until after our observation period.

4. Many trucks do not weigh at least 40,000 pounds for which the DTSWS displays an advised speed, and to which we restricted our search for matches.

5. Hazardous material trucks are prohibited from the tunnel and must instead use Route 6 to cross Loveland Pass.

At the weigh station, we manually recorded each truck type, carrier/shipper logo, dominant color and distinctive features, and time-of-day exiting the weigh station. We videotaped trucks exiting

the weigh station so as to improve our percent of usable matches. This data was recorded during the same hours as data is recorded at the tunnel and 2 miles downhill, allowing approximately 30 minutes travel time from the weigh station to the tunnel exit.

We later extracted the following data from these videotapes for all matched trucks:

1. time at which each truck exits the tunnel.
2. time and speed at which each truck passed the downhill location.
3. number of axles.
4. dominant color, distinctive marking, shipper/carrier logo.
5. general truck type (single, double, flatbed, tanker, etc.).

We performed a pilot run of our data collection plan to determine the length of time needed to collect a desired sample size of usable matches. The desired sample size of at least 50 matched trucks on each day was based on a 95% confidence interval and an allowable error of +/-3 miles per hour in the mean sample truck speed. The standard deviation of truck speeds at the downhill location was found to be about 10 mph in the pilot study. The statistical formula to determine a sample size $N = (tS/d)^2$, where t is the t-statistic for the 95% confidence level with N degrees of freedom, S is the standard deviation of truck speeds gathered by a pilot study, and d is the allowable error in the mean sample truck speed from the true unknown mean truck speed of all trucks descending the hill. The pilot sample of truck speeds had a standard deviation of 10 mph. For an allowable error of +/-3 mph, the above formula results in a sample size requirement of at least 50 observations with the system on and 50 more observations with the system off. This sample size assumes normally distributed population of truck speeds. We found the pilot study truck speeds to satisfy this assumption using a Chi-square test of fit to a normal distribution at the 95% confidence level.

4. EVALUATION APPROACH

4.1. Comparison of Truck Speeds with System On versus Off

Our process of attempting to match the trucks recorded by the DTSWS with Dumont weigh

station data and our videotape data was performed as follows: First, we matched the Dumont weigh station data with a visual image of each truck. Second, we searched the videotape of trucks exiting the Eisenhower Tunnel for matches. We succeeded in matching 53 trucks when the DTSWS was on and 64 trucks when it was off. Third, we attempted to match trucks recorded by the DTSWS and our videotape just outside the tunnel by matching the time stamp of the DTSWS data with the time stamp of the video. We knew the weights and dimensions of trucks exiting the tunnel that we matched with our Dumont videotape and weigh station data. We then searched the DTSWS data log for trucks of similar axle configuration and weight that had a DTSWS time stamp just seconds prior to the time stamp of the videotape outside the tunnel. We had synchronized our videotape clock with the DTSWS clock before recording. We discovered that we could reliably match only a few trucks through this process. We learned from IRD that the accuracy of weights recorded by the WIM was approximately +/- 25% for 80% of trucks, and worse for the remainder. It was not possible to videotape trucks inside the tunnel because of insufficient space.

Without being able to match truck weights recorded by the DTSWS with our videotapes, we could not determine whether speed messages displayed by the warning sign were correctly specified for the trucks recorded by the system. However, since we were able to identify truck weights as recorded at Dumont, we were able to perform an overall assessment of whether the speed warning sign had a significant effect on speeds of trucks descending the hill, taking truck weights into account. We applied ANCOVA (a statistical comparison of group means taking an extraneous variable into account) to the comparison of truck speeds at the downhill location when the DTSWS was on versus off, with truck weight being the extraneous variable.

All of the speed data was extracted from the videotapes with frames stamped to $1/30^{th}$ of a second, and distance markers along the roadside. Speeds from the pressure tube detectors were never used because the detectors malfunctioned at the downhill site, and we eventually found no use for speeds recorded near the tunnel. We did have enough data from the downhill speed detector to verify that the speeds we extracted from the videotape were sufficiently accurate.

4.2. Comparison of Truck Speeds to the Speed Warning System

As explained earlier, the weigh-in-motion system connected to the DTSWS has a range of error that prevents the reliable identification of trucks based on their weight as recorded at the Dumont

weigh station. Also, the downhill speed warning system does not record the message displayed to each truck. However, we do know the advised speed that the warning system was programmed to display for given truck weights. Hence, we do later evaluate the numbers of truck speeds that comply with the advised speeds that ought to have been displayed for the truck weights as recorded at the Dumont weigh station. This comparison will also serve to determine whether truck travel speeds are in general agreement with the programmed advisory speed of the truck speed warning system or quite different.

4.3. Truck Driver Survey to Evaluate Driver Awareness of the System

Truckers that visit the Dumont weigh station office were asked six easy questions concerning the DTSWS. Sufficient numbers of drivers visited the office such that we were able to obtain a reasonable survey size over during our data collection days. The truck driver survey consisted of the following questions:

Trucker Survey Regarding Eisenhower Tunnel Speed Warning System

1. How many times in the past year have you traveled through Eisenhower Tunnel?
   None 1-10 10-20 >20

   If answer is None, skip rest of survey.

2. Did you see the speed warning sign in the tunnel that shows a safe descent speed?
   Yes No
   If answer is No, skip rest of survey.

3. Did you have time to read the sign?
   Yes No

4. Did you think that the speed shown by the sign was:
   About right Too fast Too slow

5. Did you drive down the hill at about the speed shown by the sign?
   Close to it Faster Slower

6. Do you think this type of sign can help truckers travel at a safer descent speed?
   Yes No

A later section will present and discuss the numbers of responses to each question.

5. SUMMARY OF FINDINGS

5.1. Comparison of Truck Speeds with System On versus Off

Table 1 shows the summary statistics of truck speeds and weights that we observed at the site 2 miles downhill from Eisenhower Tunnel with the sign on and off. Figure 9 shows the histogram of sampled truck speeds, and Figure 10 shows the histogram of sampled truck weights. All raw data is contained in Appendix A. On days with the sign off, more trucks traveled faster than 45 mph, but there were also more trucks below 40,000 lbs. vehicle weight. The mean truck speed with the sign off was found to be 7.6 mph greater than with the sign on. A two-tailed t-test of means showed that the mean speed of 41.14 mph with the sign off was significantly greater than the mean speed of 33.56 mph with the sign on at the 95% confidence level. Standard deviations in truck speeds (10.75 mph with the sign on and 11.48 mph with the sign off) were very similar.

Figures 11 and 12 show XY plots of these truck speeds versus the corresponding truck weights. The regression line drawn through the data shows the degree to which truck speeds decrease with greater truck weights. A statistical test of the slope of this line indicated that truck speeds do decrease significantly with greater truck weight. Figures 11 and 12 show that truck speeds on days with the sign off generally lie more above the regression line (and thus faster relative to truck weight) than on days with the sign on. Important to note is that the mean weight of trucks that we sampled on days with the sign on (61,174 lbs.) was higher than on days with the sign off (54,048 lbs.). Thus, we must account for the fact that the sampled trucks on days with the sign off may have a higher mean speed than off days with the sign on because of being generally lighter.

Analysis of Covariance (ANCOVA) is a method of comparing the means of two groups after controlling for the possible effect of an extraneous variable (truck weight in this case). ANCOVA revealed that only 2.4 mph of the 7.6 mph greater mean speed of trucks on days with the sign off could be attributed to the lighter weights of these trucks. The remaining 5.2 mph difference in the mean speeds is still significant at the 95% confidence level. Indeed, the test had a p-value less than 0.005, which means that the difference is significant at the 99.5% confidence level. Thus, there is strong evidence that the warning sign is causing truck drivers to descend the hill more slowly.

5.2. Comparison of Truck Speeds to the Speed Warning System

Table 2 lists the advised speeds that the speed warning system is programmed to display for given ranges of truck weights. Table 2 also shows the numbers of trucks that we matched with weights in each of these ranges as measured at the Dumont weigh station on days with the speed warning system on or off. Finally, Table 2 shows the mean speeds of these trucks as observed at the site 2 miles downhill from the tunnel. The mean speed is never below the advised speed for any weight range with the system on or off, which may indicate that the majority of truck drivers consider the advised speed to be too conservative. Only five trucks were observed to be traveling travel below the advised speed, and these were all with the system on and in the lightest weight range for which 30 mph is advised.

Table 2 shows that the mean speed for every range of truck weights except one was substantially higher with the system off than with the system on. Table 2 and Figure 10 show that there were more trucks in the lightest weight range on sampling days with the system off. The potential bias that lighter trucks could have on higher speeds was taken into account with the ANCOVA analysis discussed in the previous section. Moreover, we performed a t-test comparison of mean speeds with the warning sign on or off excluding all trucks below 40,000 lbs. gross vehicle weight and found that the mean speed on days with the system off was still significantly greater at the 95% confidence level. Hence, our analysis excluding the lighter trucks provides additional evidence that the speed warning sign is causing truck drivers to descend the hill more slowly.

5.3. Findings of Truck Driver Survey to Evaluate Driver Awareness

Below are shown the numbers of responses (shown in bold and underlined) to each the survey questions for all days of data collection.

1. How many times in the past year have you traveled through Eisenhower Tunnel?
   None **8** 1-10 **21** 10-20 **5** >20 **6**

2. Did you see the speed warning sign in the tunnel that shows a safe descent speed?
   Yes **25** No **7**

3. Did you have time to read the sign?
   Yes **22** No **3**

4. Did you think that the speed shown by the sign was:
   About right **18** Too fast **2** Too slow **2**

5. Did you drive down the hill at about the speed shown by the sign?
   Close to it **14** Faster **2** Slower **6**

6. Do you think this type of sign can help truckers travel at a safer descent speed?
   Yes **21** No **1**

Since only some drivers entered the weigh station where we could perform the survey, we were only able to collect 40 responses, or ten per day on average. Since the responses were very heavily numbered in just one category of each question, this is a sufficient sample size on which to base our findings. The majority of drivers (32 of 40) had traveled through the Eisenhower Tunnel earlier in the past year, and thus may have seen the speed warning sign on a previous trip. However, 7 of these 32 drivers replied that they had not seen the warning sign on a previous trip. Of the remaining 25 drivers, 22 said that they did have time to read the sign when they had seen it earlier, and 18 said that the advised speed seem about right. Twenty of these 22 drivers that had seen the sign earlier said that they had descended the hill at a speed below or close to the advised speed. (If our speed data is relevant to these drivers, it suggests that they may have driven somewhat faster, although only 2 drivers said so.) Finally, 21 of these 22 drivers that had seen the sign earlier said that they thought it could help truckers descend the hill at a safe speed.

6. CONCLUSIONS AND RECOMMENDATIONS

Overall, the speed warning system appears to significantly reduce truck descent speeds for most all weight ranges above the 40,000 lb. minimum to which the system responds. Truck drivers surveyed responded very positively to the system and its potential to improve safety. Our first recommendation (supported by Table 1) is that the advised speeds and their corresponding weight ranges need to be revised. We recommend the following ranges and advised speeds: 40,000 to 48,500 lbs.(advised speed = 35 mph), 48,500 to 55,000 lbs. (advised speed = 25 mph), 55,000 to 80,000 lbs.(advised speed = 15 mph), and above 80,000 lbs.(advised speed = 10 mph). Fifteen of the 53 trucks that we observed on days with the system on were no more than 5 mph over these recommended speeds, whereas only 6 were no more than 5 mph above the advised speeds currently programmed in the system. The risk of advising speeds that are too low is that drivers will tend to

ignore the warning as being unrealistic. The advised speeds ought to be within ranges that many drivers will accept as good advice.

Tables and Figures

Table 1: Summary Statistics of Sampled Truck Speeds and Weights

	Days with Sign On	Days with Sign Off
No. of Observations	53	64
Average Truck Speed	33.56	41.14
Std. Deviation in Speeds	10.75	11.48
Average Truck Weight	61,174	54,048
Std. Deviation in Weights	17,223	19,762

Note: All speeds are in miles per hour, and all weights are in pounds.

Table 2: Mean Speeds of Trucks Within Weight Ranges

		With System ON		With System OFF	
Upper Bound of Wgt. Range	Advised Speed	Mean Speed	# of Trucks	Mean Speed	# of Trucks
48,600	30	40.1	15	48.4	27
51,200	25	30.5	2	43.5	3
55,500	20	37.6	4	34.9	3
63,500	15	32.8	7	41.5	5
80,900	10	30.0	24	34.4	25
> 80,900	5	16.9	1	25.6	1
Totals			53		64

Note: All speeds are in miles per hour, and all weights are in lbs.

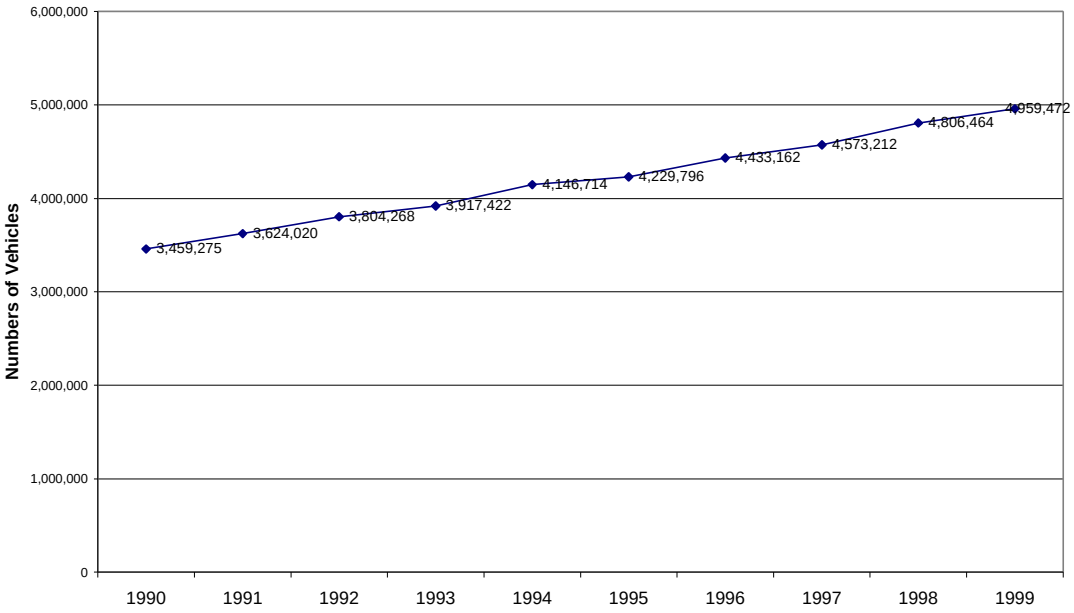

Figure 1: Annual Traffic Counts on WB I-70 at Eisenhower Tunnel

1999 Figures are projected.

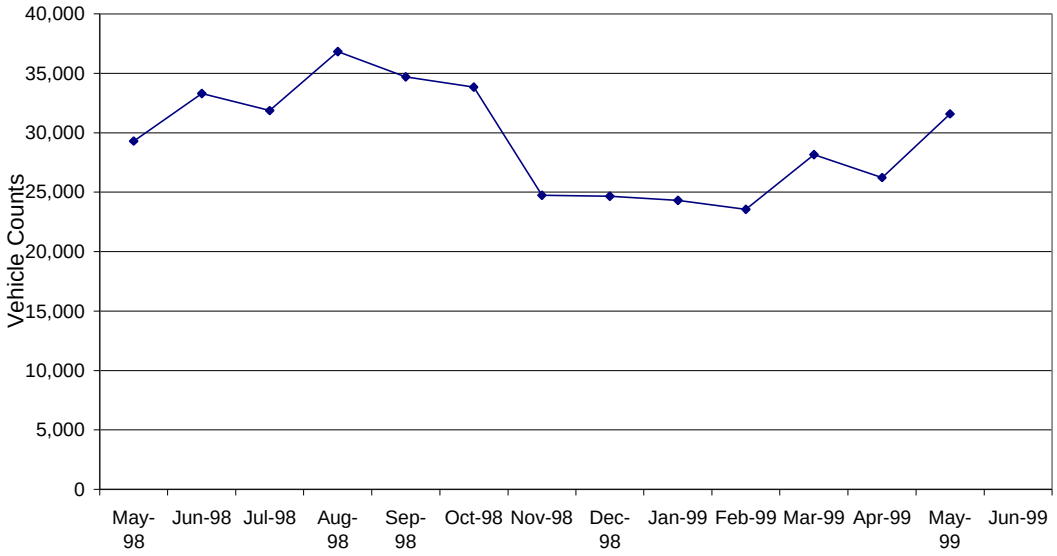

Figure 2: Monthly Truck Counts on WB I-70 at Eisenhower Tunnel

Vehicles included were 40 ft. to 90 ft.

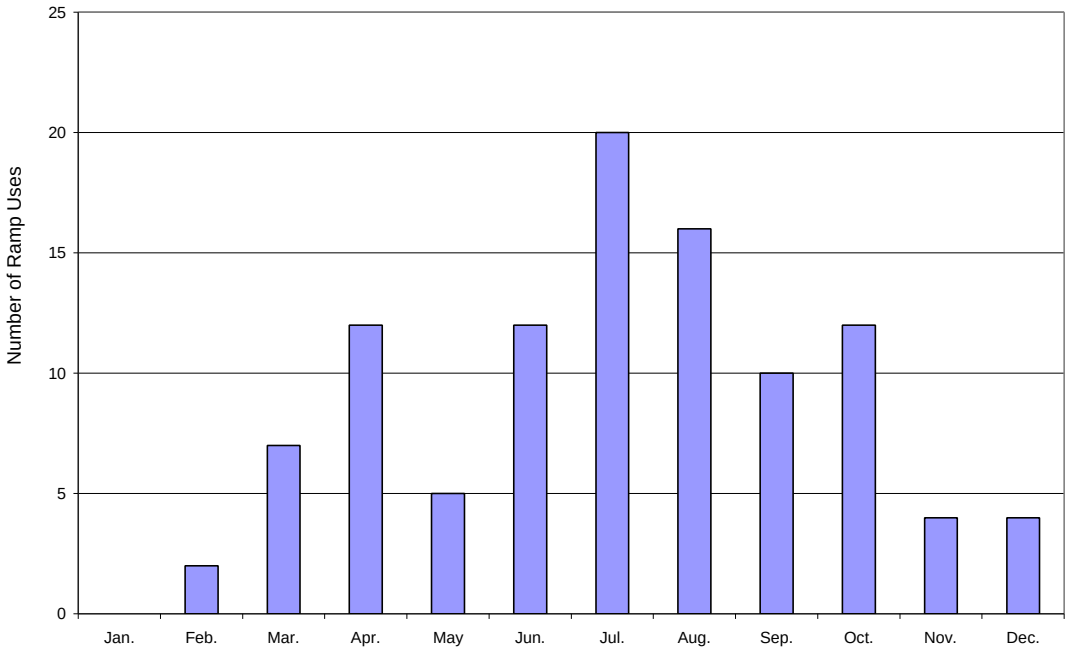

Figure 3: Runaway Truck Ramp Use by Month (1995 to June 1999)

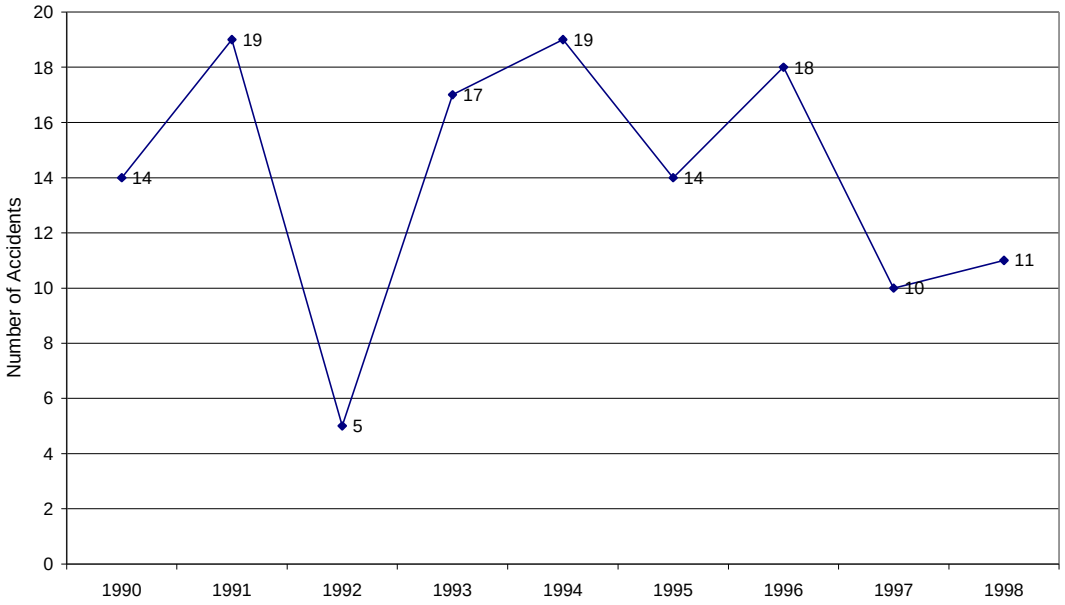

Figure 4: Truck Related Accidents on Westbound I-70 from Eisenhower Tunnel to Silverthorne (Mileposts 204 to 214)

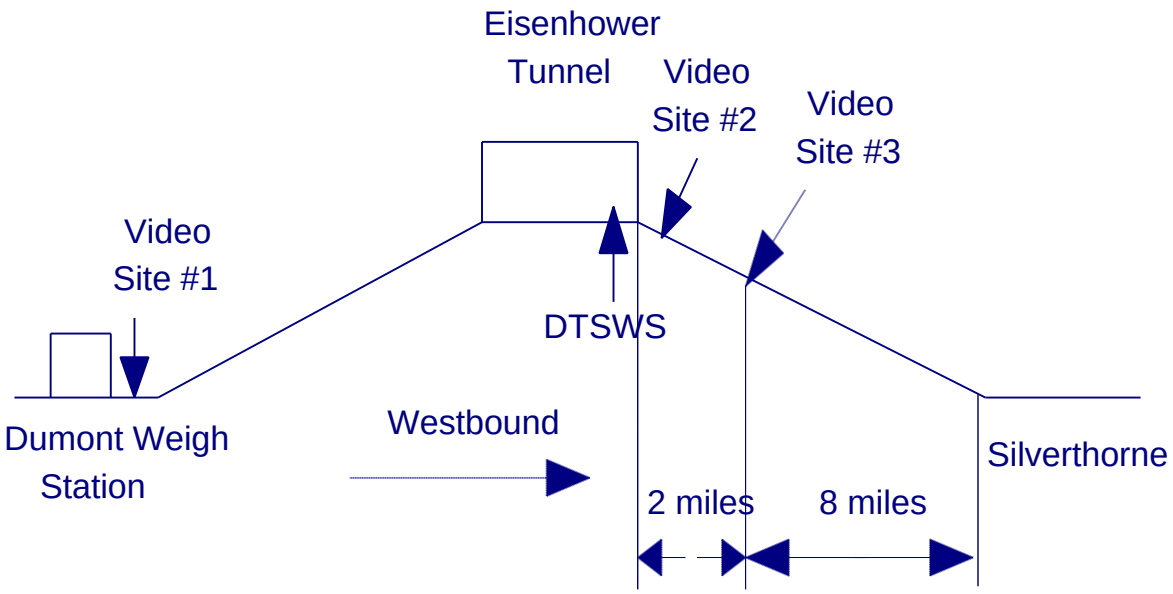

Figure 5: Locations of Data Collection Sites along Westbound I-70

Figure 6: Photo of Speed Warning Message Display in Eisenhower Tunnel

Figure 7: Photo of Pressure Tube Speed Detectors at Eisenhower Tunnel

Figure 8: Photo of I-70 Two Miles West of Eisenhower Tunnel

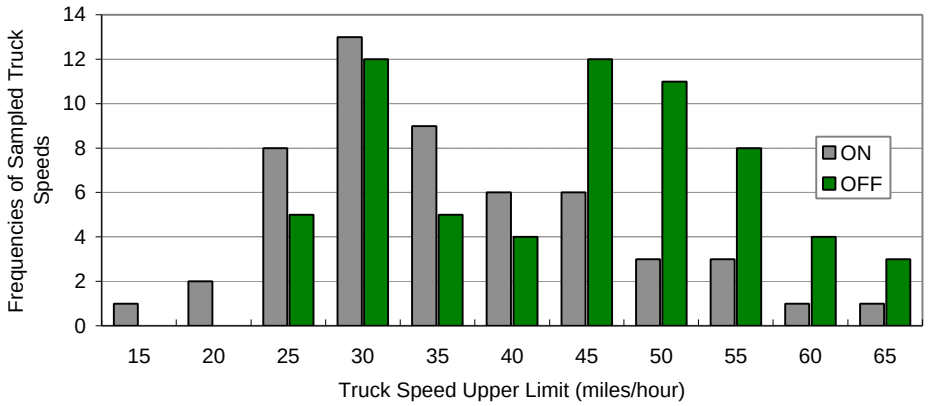

Figure 9: Frequencies of Sampled Truck Speeds with DTSWS On or Off

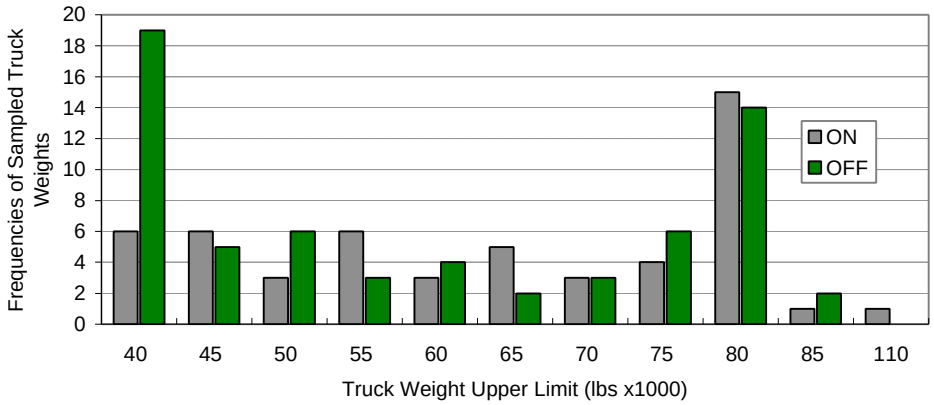

Figure10: Frequencies of Sampled Truck Weights with DTSWS On or Off

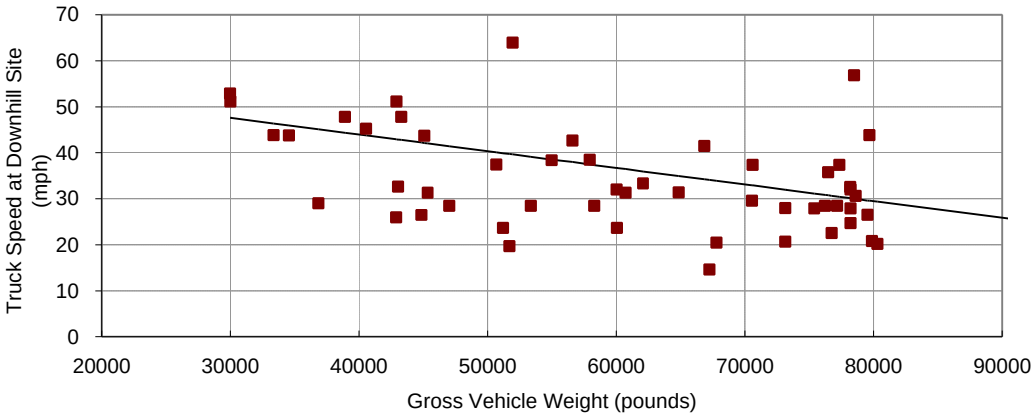

Figure 11: Truck Speeds versus Weights with Speed Warning Sign On

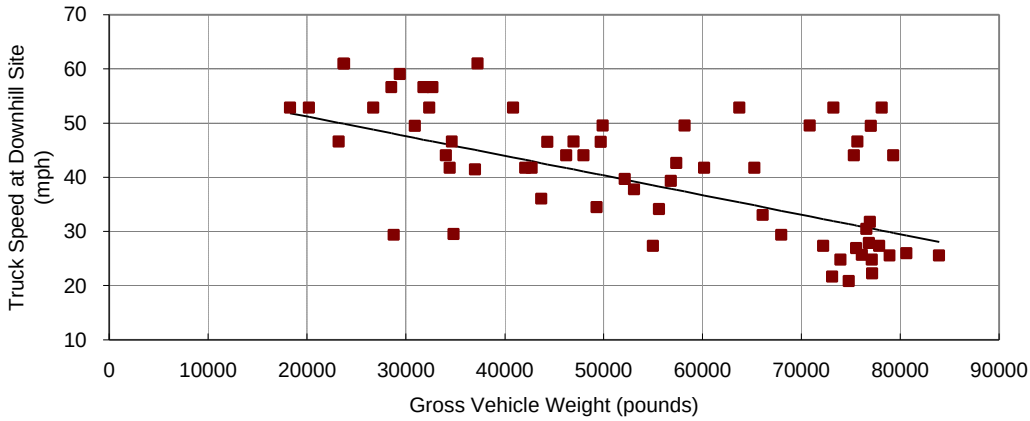

Figure 12: Truck Speeds versus Weights with Speed Warning Sign Off

APPENDIX A: SPEEDS AND WEIGHTS OF MATCHED TRUCKS

05/19/99	Dumont	Tunnel	Downhill	Downhill	Truck
Obs #	Time	Time	Time	Speed	Weight
1a	11:27:59	11:55:58	12:01:02	56.82	78,480
2a	11:31:23	11:58:39	12:04:47	20.45	67,800
3a	11:33:21	11:58:34	12:05:16	20.79	79,880
4a	11:33:54	12:05:22	12:16:33	26.49	79,520
5a	11:35:06	12:00:36	12:04:10	37.33	77,340
6a	11:36:03	11:58:27	12:01:32	37.33	70,600
7a	11:40:05	11:58:16	12:00:56	45.25	40,560
8a	11:42:51	12:06:06	12:10:46	27.94	73,140
9a	11:45:48	12:06:01	12:09:37	38.45	57,940
10a	11:47:34	12:11:53	12:20:16	22.53	76,740
11a	11:48:57	12:13:54	12:32:11	27.89	75,380
12a	11:49:22	12:14:01	12:18:21	32.57	78,200
13a	11:50:35	12:11:43	12:17:46	20.70	73,140
14a	11:51:29	12:08:12	12:10:53	47.79	38,920
15a	11:52:52	12:12:26	12:17:06	31.37	64,860
16a	11:54:30	12:19:08	12:24:45	28.41	76,220
17a	11:56:32	12:15:02	12:20:09	25.96	42,880
18a	11:57:57	12:25:28	12:28:08	63.92	51,940
19a	11:59:23	12:18:19	12:23:13	29.56	70,540
20a	12:00:12	12:30:34	12:35:06	30.62	78,600
21a	12:00:39	12:18:35	12:22:57	28.41	58,280
22a	12:01:17	12:26:27	12:37:39	20.21	80,300
23a	12:04:00	12:31:34	12:35:54	31.31	45,340
24a	12:05:35	12:25:37	12:28:30	47.79	43,300
25a	12:09:32	12:45:24	12:54:29	16.88	111,140
26a	12:10:38	12:31:30	12:41:19	19.67	51,700
27a	12:11:38	12:35:10	12:51:29	27.89	78,220
28a	12:13:24	12:40:14	12:44:35	32.64	43,040
29a	12:14:31	12:31:41	12:36:08	28.95	36,860
30a	12:15:20	12:37:03	12:40:15	31.31	60,740
31a	12:18:05	12:36:15	12:39:18	43.71	45,060
32a	12:23:01	12:44:38	12:48:50	23.60	51,200
33a	12:24:15	12:46:11	01:19:28	35.76	76,480
34a	12:44:56	01:02:42	01:05:29	52.89	29,980
35a	12:45:41	01:03:39	01:18:41	38.35	54,980
36a	12:46:37	01:05:29	01:08:22	51.14	42,920
37a	12:47:36	01:05:32	01:08:30	51.14	30,000
38a	12:48:46	01:04:37	01:08:38	43.83	33,360
39a	12:49:55	01:11:19	01:15:14	33.35	62,080
40a	12:50:46	01:13:45	01:17:05	43.83	79,680
41a	12:51:29	01:16:24	01:28:21	14.61	67,240
42a	12:54:31	01:11:37	01:16:22	28.44	77,160
43a	12:57:37	01:20:53	01:24:28	41.46	66,840
44a	01:01:33	01:21:14	01:24:32	42.61	56,600
45a	01:02:16	01:24:44	01:28:44	28.41	53,360
46a	01:03:00	01:20:27	01:24:21	43.73	34,560
47a	01:04:05	01:26:59	01:32:56	26.45	44,860
48a	01:04:49	01:26:36	01:34:39	31.96	60,040
49a	01:08:19	01:32:08	01:36:12	31.96	78,220
50a	01:09:50	01:35:52	01:40:09	28.41	47,020
51a	01:12:30	01:35:17	01:40:44	24.74	78,220
52a	01:13:06	01:34:10	01:39:01	23.60	60,060
53a	01:20:52	01:42:53	01:46:27	37.42	50,680

06/02/99	Dumont	Tunnel	Downhill	Downhill	Truck
Obs #	Time	Time	Time	Speed	Weight
1c	10:33:21	10:55:52	10:59:05	21.61	73,120
2c	10:34:40	10:59:25	11:01:56	49.49	77,060
3c	10:37:11	11:03:03	11:12:04	22.23	77,160
4c	10:38:50	10:57:33	11:00:04	46.49	44,300
5c	10:41:04	11:07:55	11:16:04	27.89	76,860
6c	10:43:48	11:06:49	11:09:57	42.61	57,340
7c	10:43:58	11:07:06	11:10:37	34.09	55,600
8c	10:44:43	11:08:03	11:12:33	26.91	75,560
9c	10:45:21	11:03:43	11:08:37	41.46	36,980
10c	10:45:51	11:07:24	11:11:28	29.50	34,840
11c	10:46:23	11:08:05	11:10:59	39.34	56,820
12c	10:47:02	11:03:07	11:05:37	59.00	29,400
13c	10:47:24	11:12:35	11:17:10	26.00	80,620
14c	10:48:28	11:10:51	11:13:32	46.49	49,720
15c	10:49:30	11:07:33	11:10:00	49.49	30,920

06/04/99	Dumont	Tunnel	Downhill	Downhill	Truck
Obs #	Time	Time	Time	Speed	Weight
1d	10:32:04	10:47:25	10:49:47	56.61	31,780
2d	10:35:01	10:59:59	11:05:31	25.64	76,140
3d	10:35:36	10:54:34	10:57:44	41.74	34,440
4d	10:37:20	10:53:05	10:55:37	46.62	34,660
5d	10:41:03	10:59:04	11:02:12	41.74	60,160
6d	10:48:02	11:15:30	11:23:21	20.86	74,780
7d	10:48:51	11:05:48	11:08:35	52.84	40,860
8d	10:50:26	11:04:18	11:06:29	52.84	26,720
9d	10:51:28	11:15:34	11:20:42	27.33	72,220
10d	10:52:09	11:22:52	11:26:10	41.74	65,240
11d	10:56:28	11:12:46	11:14:47	56.61	28,540
12d	10:58:41	11:20:29	11:23:27	31.72	76,940
13d	10:59:13	11:23:35	11:28:28	24.77	77,120
14d	10:59:45	11:24:36	11:26:42	52.84	18,280
15d	11:00:52	11:31:35	11:35:56	29.36	67,960
16d	11:02:21	11:19:10	11:21:26	61.02	37,280
17d	11:03:21	11:27:29	11:29:49	46.62	23,200
18d	11:05:28	11:29:06	11:31:41	46.62	46,960
19d	11:06:32	11:32:27	11:35:01	44.04	34,040
20d	11:09:50	11:35:05	11:39:00	30.48	76,580
21d	11:11:14	11:36:46	11:39:51	49.54	58,200
22d	11:12:41	11:42:24	11:47:18	27.33	77,900
23d	11:13:14	11:30:44	11:33:13	52.84	20,220
24d	11:14:02	11:57:07	12:00:30	41.72	42,060
25d	11:18:57	11:37:41	11:39:50	56.61	32,700
26d	11:19:21	11:44:21	11:48:30	33.02	66,120
27d	11:20:06	11:40:29	11:42:45	49.54	49,900
28d	11:22:02	11:48:13	11:51:28	52.84	73,240
29d	11:22:51	11:47:20	11:50:34	34.46	49,300
30d	11:23:34	11:50:04	11:53:26	46.62	75,680
31d	11:25:15	11:47:32	11:51:02	37.74	53,080
32d	11:29:46	11:52:27	11:55:59	39.63	52,140
33d	11:31:09	11:50:48	11:54:33	27.33	54,980
34d	11:32:02	11:59:14	12:02:36	44.04	79,300
35d	11:33:32	11:59:14	12:01:36	52.84	78,140
36d	11:28:58	12:00:38	12:04:04	36.03	43,680
37d	11:35:30	12:09:17	12:14:36	25.57	83,920
38d	11:36:17	12:03:01	12:08:32	24.76	73,960
39d	11:40:54	12:09:20	12:12:35	41.74	42,720
40d	11:48:28	12:13:45	12:16:00	60.97	23,680
41d	11:50:41	12:09:25	12:11:39	60.97	23,760
42d	11:50:57	12:15:47	12:18:37	44.04	46,220
43d	11:51:23	12:19:16	12:21:45	49.54	70,860
44d	11:51:51	12:15:45	12:18:32	44.04	75,320
45d	11:52:21	12:15:59	12:20:50	25.57	78,920
46d	12:12:44	12:30:49	12:32:58	52.84	32,380
47d	12:13:49	12:35:41	12:39:37	29.36	28,800
48d	12:14:24	12:39:21	12:42:10	52.84	63,720
49d	12:15:00	12:37:11	12:40:32	44.04	47,980