EVALUATION OF INNOVATIVE SAFETY TREATMENTS

Volume 4: A Study of the Effectiveness of Motorist Awareness System in Construction Work Zones

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16. Abstract

In an effort to make work zones safer, the Florida Department of Transportation (FDOT) has developed a new Maintenance of Traffic (MOT) system for work zone traffic control, referred to as Motorist Awareness System (MAS). In addition to traffic control and warning devices used with standard MOT plans, the MAS uses portable changeable message signs, radar speed display units, and regulatory speed limit signs (with flashers) to alert motorists of work zone activities such as lane closures and reduced speed limits. In addition, active enforcement is a critical element of the MAS. Thus, the MAS is intended to reduce travel speeds through work zones.

The MAS was implemented as part of construction projects on two segments of Florida interstate highways I-10 and I-95. These segments are a suburban section of I-10 in Baker County, from US 90 to Columbia County line, and a rural section of I-95 in Flagler County from the Volusia/Flagler County line to the Flagler/St. Johns County line. Both I-10 and I-95 are four lane-divided freeways with 70 mph posted speed limits, though I-95 has three travel lanes in one direction at some locations.

In order to compare the effectiveness of the Motorist Awareness System, a Comparative Parallel evaluation methodology was utilized. This research analyzed speed data as a proxy variable since higher speeds (and variances) are closely associated with crash risk. Speed data from the following three MOT scenarios were compared to determine the effect of the MAS on travel speeds in work zones: i) Standard Maintenance of Traffic (MOT), ii) Motorist Awareness System (MAS) without police enforcement, and iii) MAS with police enforcement.

Measures of effectiveness (MOEs) for this project include differences in average speeds, percent of speeding motorists, and changes in the variability of the speed distribution. Speed studies were conducted at three different locations within each work zone to assess changes in the speed profiles through the work zone: (1) prior to the work zone, (2) in the middle of the work zone, and (3) near the end of the work zone. A total of 179 speed studies were conducted during the control (without MAS) and test (with MAS) conditions.

A number of statistical tests were conducted to determine whether the changes observed in the measures of effectiveness are attributable to the use of the MAS or simply due to chance. The results of the statistical tests indicate that the MAS was effective in reducing vehicular speeds through construction work zones. Targeted enforcement resulted in additional speed reductions. The MAS decreased the proportion of motorists traveling over the posted speed limit. Based on these findings, the use of MAS may be a practical countermeasure to reduce vehicular speeds through the work zone, thereby improving safety for both the motorist and the construction worker.

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Executive Summary

Speeding is a common occurrence in highway work zones. The hazards associated with maintaining traffic are elevated when drivers do not obey reduced work zone speed limits. Although highway work zones are either marked for a reduced speed limit or are covered by a statewide law, driver adherence to such reduced speed limits in work zones is minimal at best. In 2005, the State of Florida experienced 137 fatalities from 4,136 crashes occurred in highway work zones . While construction workers are exposed to heightened risk in work zones, 90% of those killed in highway work zones in Florida are motorists or pedestrians. Speeding and inattentive driving are some of the factors that cause work zone crashes. Drivers need to be alert and travel at a slower speed to be able to safely negotiate often unexpected situations in the work zone. This is due to many factors including abrupt changes in horizontal or vertical alignment, slow moving vehicles leaving/entering the traffic stream from the construction area, and a reduced clear recovery area.

In an effort to make work zones safer, the Florida Department of Transportation (FDOT) has developed a new Maintenance of Traffic (MOT) system for work zone traffic control, referred to as Motorist Awareness System (MAS). In addition to traffic control and warning devices used with standard MOT plans, the MAS uses portable changeable message signs, radar speed display units, and regulatory speed limit signs (with flashers) to alert motorists of work zone activities such as lane closures and reduced speed limits. The radar speed display unit displays individual vehicle speed as compared to the speed limit and as such provides feedback to motorists. In addition, active enforcement is a critical element of the MAS. Thus, the MAS is intended to reduce travel speeds through work zones.

The MAS was implemented as part of construction projects on two segments of Florida interstate highways I-10 and I-95. These segments are a suburban section of I-10 in Baker County, from US 90 to Columbia County line, and a rural section of I-95 in Flagler County from the Volusia/Flagler County line to the Flagler/St. Johns County line . Both I-10 and I-95 are four lane-divided freeways with 70 mph posted speed limits, though I-95 has three travel lanes in one direction at some locations.

The effectiveness of the MAS was determined through a field experiment conducted on I-10 and I-95 at various test (condition with the MAS) and control (condition without the MAS) locations in combination with targeted speed enforcement. This experiment consisted of a number of observations related to travel speeds approaching and within the work zones along the study segments of I-10 and I-95.

Speed studies were conducted at three different locations within each work zone to assess changes in the speed profiles through the work zone: (1) prior to the work zone, (2) in the middle of the work zone, and (3) near the end of the work zone.

Speed data were collected for the control condition (without MAS) along I-95 between June 2005 and May 2007, during which time researchers conducted 48 speed studies at different times of the day and for various days of the week. The contractor began to apply the MAS as a part of setting up the MOT each day starting the second week of August 2005. The researchers began data collection for the test condition (with MAS) in the second week of August 2005 and concluded studies in May 2007. Once again, speed data for the test condition were collected during this period at different times of the day and for various days of the week, with a total of 63 speed studies conducted for the test condition. Similar speed data were collected for the control and test conditions on I-10 between May 2007 and July 2007, during which time researchers conducted an additional 68 speed studies at different times of the day and for various days of the week.

Speed data from the following three scenarios were compared to determine the effect of the MAS on work zone travel speeds.

- Standard Maintenance of Traffic (MOT)
- Motorist Awareness System (MAS) without police enforcement
- MAS with police enforcement

The effectiveness of the MAS was evaluated in several ways including changes in the mean speed, 85th percentile speed, and the characteristics of the speed distribution. In addition, the proportion of motorists driving above the posted speed limit under different MOT scenarios was also compared.

A number of statistical tests were conducted to determine whether the changes observed in the measures of effectiveness are attributable to the use of the MAS or simply due to chance. Statistical tests that were conducted to test the effectiveness of the MAS include:

- One-Sample Kolmogorov-Smirnov (K-S) Test – to determine if the speed distributions are normally distributed
- F-Test – to determine if the variances are equal between the test and control groups
- Student's t-Test and Analysis of Variance (ANOVA) – to determine if differences between mean speed and 85th percentile speed are statistically significant

- Z-Test – to determine if differences between the proportion of vehicles speeding are statistically significant

A summary of the findings is as follows:

- Travel speeds, both the mean and 85th percentile speeds, were consistently lower at the locations within the work zones where the MAS was utilized in comparison to the standard MOT. The implementation of the MAS along I-10 reduced average speeds by an average of 1.5 miles per hour in comparison to standard MOT. Combining MAS with enforcement resulted in additional reduction in mean speeds by 3 to 4 miles per hour in comparison to standard MOT.
- The combination of the MAS with enforcement was also shown to decrease speeds in comparison to the standard MOT with enforcement along I-95. In general, speeds within the work zone were reduced by an average of 4 to 5 miles per hour.
- The variability of travel speeds along I-10 within the work zone was decreased when MAS was utilized in comparison to standard MOT.
- The proportions of drivers speeding within and near the end of the work zones were also substantially reduced when the MAS was utilized in comparison to the standard MOT under all scenarios. Further, combining MAS with enforcement produced more pronounced reductions both within and near the end of the work zone.

Overall, the MAS was effective in reducing vehicular speeds through construction work zones. Targeted enforcement resulted in additional speed reductions. The MAS decreased the proportion of motorists traveling over the posted speed limit. Based on these findings, the use of MAS may be a practical countermeasure to reduce vehicular speeds through the work zone, thereby improving safety for both the motorist and the construction worker.

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1.0 INTRODUCTION

Speeding is a common occurrence in highway work zones. The hazards associated with maintaining traffic are elevated when drivers do not obey reduced work zone speed limits. It is widely accepted by law enforcement and traffic safety professionals that excessive speeds and speed variance are contributing factors in traffic crashes, injuries and fatalities. Although highway work zones are either marked for a reduced speed limit or are covered by a statewide law, driver adherence to such reduced speed limits in work zones is minimal at best.

In 2005, the State of Florida experienced 137 fatalities from 4,136 crashes occurred in highway work zones [1]. While construction workers are exposed to heightened risk in work zones, 90% of those killed in highway work zones in Florida are motorists or pedestrians [1]. Speeding and inattentive driving are some of the factors that cause work zone crashes. Drivers need to be alert and travel at a slower speed to be able to safely negotiate often unexpected situations in the work zone. This is due to many factors including abrupt changes in horizontal or vertical alignment, slow moving vehicles leaving/entering the traffic stream from the construction area, and a reduced clear recovery area.

In an effort to make work zones safer, the Florida Department of Transportation (FDOT) has developed a new Maintenance of Traffic (MOT) system for work zone traffic control, referred to as Motorist Awareness System (MAS). In addition to traffic control and warning devices used with standard MOT plans (Appendix A), the MAS uses portable changeable message signs, radar speed display units, and regulatory speed limits signs (with flashers) to alert motorists of work zone activities such as lane closures, reduced speed limits (see Appendix B). The radar speed display unit displays individual vehicle speed as compared to the speed limit and as such provides feedback to motorists. In addition, active enforcement is a critical element of the MAS. Thus, the MAS is intended to reduce travel speeds through work zones. The MAS will be implemented at those work zones where: (1) the highway is a multilane facility, (2) the posted speed limit is 55 mph or greater, (3) work operations require a lane closure, and (4) workers are present.

A memo dated March 30, 2005 from the FDOT Director of Construction describes the features of the MAS system and outlines when to activate and deactivate the MAS to achieve maximum compliance from motorists. A copy of this memo is included in Appendix C. The FDOT conducted a public information campaign to inform motorists of this change and the need to alter driving behavior. At a

Capitol press conference, in April 2005, the FDOT announced a year-long campaign "Work Zone Safety, It's Everyone's Job" to inform motorists of the dangers of reckless driving through work zones. As part of this campaign, a number of state and national organizations including FDOT, the Florida Highway Patrol (FHP), the Federal Highway Administration (FHWA), the American Traffic Safety Services Association (ATSSA), and the Florida Police Chief's Association (FPCA) have joined forces to make work zones safer.

The MAS was implemented as part of construction projects on two segments of Florida interstate highways I-10 and I-95. These segments are a suburban section of I-10 in Baker County, from US 90 to Columbia County line, and a rural section of I-95 in Flagler County from the Volusia/Flagler County line to the Flagler/St. Johns County line (see Figures 1 and 2). Both I-10 and I-95 are four lane-divided freeways with 70 mph posted speed limits, though I-95 has three travel lanes in one direction at some locations.

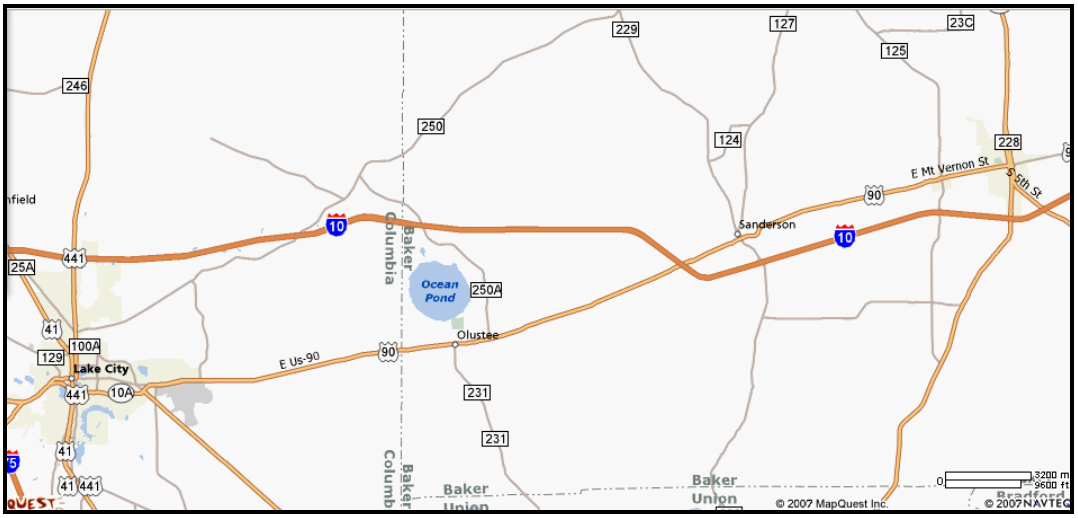


FIGURE 1. I-10 Project Location Map

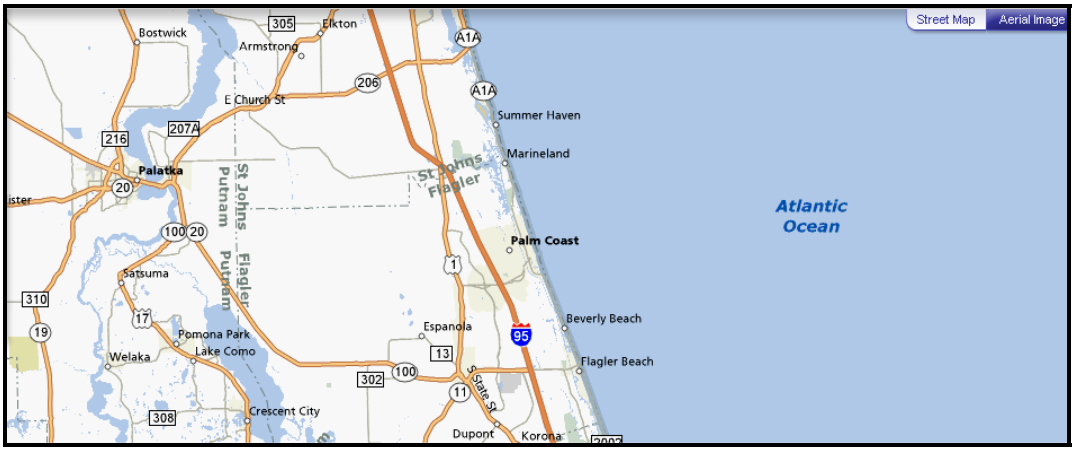


FIGURE 2. I-95 Project Location Map

This research analyzes speed data as a proxy variable since higher speeds (and variances) are closely associated with crash risk. Therefore, the straightforward, low cost, and short time approach to evaluating the MAS would be to compare travel speeds under different MOT scenarios.

The effectiveness of the MAS was determined through a field experiment conducted on I-10 and I-95 at various test (condition with the MAS) and control (condition without the MAS) locations in combination with targeted speed enforcement. This experiment consisted of a number of observations related to travel speeds approaching and within the work zones along the study segments of I-10 and I-95. Several aspects of the speed distribution at the study locations are analyzed. Measures of effectiveness (MOEs) for this project include differences in average speeds, percent of speeding motorists, and changes in the variability of the speed distribution.

2.0 STUDY METHODOLOGY

In order to compare the effectiveness of the Motorist Awareness System, a Comparative Parallel evaluation methodology was utilized. In the Comparative Parallel evaluation study plan, data are compared for the conditions where the MAS was utilized and for conditions where the MAS was not utilized [2]. A test condition refers to a work zone that utilized the MAS, and a control condition refers to a work zone that did not utilize the MAS.

The Maintenance of Traffic (MOT) plans for the control and test conditions are shown in Appendices A and B. The majority of the work zones, including all of the I-10 sites and most of the I-95 sites, consisted of two travel lanes in one direction, which were reduced to one lane during the construction period. Seven of the I-95 sites consisted of three-to-two lane reductions and the data for these locations were analyzed separately from the remaining I-95 data.

Measures of Effectiveness

Speed data from the following three scenarios were compared to determine the effect of the MAS on work zone travel speeds.

- Standard Maintenance of Traffic (MOT)
- Motorist Awareness System (MAS) without police enforcement
- MAS with police enforcement

The effectiveness of the MAS was evaluated in several ways including changes in the mean speed, 85th percentile speed, and the characteristics of the speed distribution. In addition, the proportion of motorists driving above the posted speed limit under both MOT scenarios was also compared.

Thus, the measures of effectiveness (MOEs) for this Comparative Parallel evaluation study were as follows:

- Change in average speed
- Change in 85th percentile speed
- Change in the variance of the speed distribution
- Change in the proportion of speeding vehicles

A number of statistical tests were conducted in order to better understand whether the changes observed in the measures of effectiveness are attributable to the use of the MAS or simply due to chance. Statistical tests that were conducted to test the effectiveness of the MAS include:

- One-Sample Kolmogorov-Smirnov (K-S) Test – to determine if the speed distributions are normally distributed
- F-Test – to determine if the variances are equal between the test and control groups
- Student's t-Test and Analysis of Variance (ANOVA) – to determine if differences between mean speed and 85th percentile speed are statistically significant
- Z-Test – to determine if differences between the proportion of vehicles speeding are statistically significant

3.0 DATA COLLECTION

Speed data were collected for the control condition (without MAS) along I-95 between June 2005 and May 2007, during which time researchers conducted 48 speed studies at different times of the day and for various days of the week. The contractor began to apply the MAS as a part of setting up the MOT each day starting the second week of August 2005. The researchers began data collection for the test condition (with MAS) in second week of August 2005 and concluded studies in May 2007. Once again, speed data for the test condition were collected during this period at different times of the day and for various days of the week, with a total of 63 speed studies conducted for the test condition. Similar speed data were collected for the control and test conditions on I-10 between May 2007 and July 2007, during which time

researchers conducted an additional 68 speed studies at different times of the day and for various days of the week.

Speed studies were conducted at three different locations within each work zone to assess changes in the speed profiles through the work zone; prior to the work zone, in the middle of the work zone, and near the end of the work zone. By comparing travel speeds at different locations, one can see whether motorists are temporarily reducing their speed in response to the signs and/or police officers at the beginning of the work zone and if they resume their normal speed as they travel through the work zone.

The observers collected speed data using a radar gun and the speed of individual vehicle was recorded. Observers recorded the date and time of day for each observational period, the direction of travel, and any other information that could affect the behavior of vehicles entering the work zone. The work zone changed positions as work progressed. Thus, researchers were able to collect data at similar locations with and without MAS; however, not necessarily at the identical location. Because geometric, traffic, and weather conditions are quite similar along the study sections, it is possible to compare the test and control data collected at these sites.

To ensure that the sample speeds are representative of the true speeds at these locations, a minimum number of vehicles must be observed. As the number of vehicles in the sample increases, the variability of the vehicle speeds decreases and the confidence level of any subsequent statistical test increases. Specifying the minimum number of vehicles to observe at each location ensures that the speed distributions are repeatable within an error range that is acceptable in determining the statistical differences in speeds between the MAS and standard MOT groups.

In addition to specifying the minimum number of vehicles to be observed at any site, a minimum number of sites must also be selected to ensure that the sample is large enough to detect a significant difference in speeds between the test and control groups. To determine the variability attributable to differences between study locations, the distribution of means for each speed study is examined.

Table 1 provides the standard deviation of the speed observations, both within and between sites, at each of the three locations (prior to the work zone, within the work zone, and near the end of the work zone). Separate summaries are provided for I-10, the 2-lane segments on I-95, and the 3-lane segments on I-95. The within site values represent the average of the standard deviations of the speed studies at each site within the particular study group. These values quantify the variability due to individual vehicles

within each sample. The between sites values represent the standard deviations of the mean speeds between the individual speed studies in each group. These values quantify the variability due to differences between study locations. As would be expected, the within site variability is significantly less than the between sites variability. This makes sense intuitively, as it would be expected that repeated speed measurements at any one site would be relatively consistent. Conversely, speed measurements taken at various sites would be expected to be somewhat different due to variations in roadway geometry, environmental, and traffic flow characteristics.

To determine an adequate sample size, an appropriate confidence level and statistical power must be selected and assumptions about the characteristics of the speed distribution must be made. The standard research convention is to assume a confidence level of 95% and a power of 80%. Since no prior knowledge existed as to the effectiveness of the Motorist Awareness System, a two-tailed statistical test was used. Given this information, the following equation can be used to compute an adequate sample size:

$$n = \frac{\sigma^2 \left(Z_\beta - Z_{\alpha/2}\right)^2}{\delta^2}$$

where:

n = sample size

σ = standard deviation

Z_β = distance from the critical value to mean in H_a (in standard deviation units); for $\beta = 0.2$, $Z_\beta = -0.842$

$Z_{\alpha/2}$ = distance from the critical value to mean in H_o (in standard deviation units); for a two-tailed test and $\alpha = 0.05$, $Z_{\alpha/2} = 1.96$

δ = detectable difference

TABLE 1: Standard Deviations of Observed Speeds

Site	Location With Respect to Work Zone	Within Site Standard Deviation	Between Sites Standard Deviation
I-10	Prior	5.04	0.71
	Within	5.10	2.38
	End	5.48	2.43
I-95 2-Lane	Prior	4.82	2.25
	Within	4.50	6.51
	End	4.47	5.07
I-95 3-Lane	Prior	4.50	0.71
	Within	5.10	5.40
	End	4.59	2.72

Based upon the standard deviations presented in the above table, the detectable difference both within sites and between sites were calculated based upon the number of vehicles observed at each site and the number of sites. These sample size values are presented in Table 2 and the preceding equation was utilized to calculate the detectable difference both within sites and between sites. The detectable difference refers to the size of the difference in speeds that can be detected between the test and control groups with 95% confidence. These results are presented in Table 3. As expected, the between site variability is substantially larger than the within site variability. In addition, variability was generally lower prior to the work zone than at the two locations within the work zone.

TABLE 2: Number of Observations

Average Number of Vehicles Observed per Group			
Vehicles	**Prior**	**Within**	**End**
I-10	204.50	200.38	199.27
I-95 (2 Lane)	105.07	107.34	107.74
I-95 (3 Lane)	108.82	105.42	104.25
Number of Sites per Group			
Sites	**Prior**	**Within**	**End**
I-10	16	26	26
I-95 (2 Lane)	32	31	29
I-95 (3 Lane)	11	12	12

TABLE 3: Detectable Differences

Within Site			
Sites	**Prior**	**Within**	**End**
I-10	0.99 mph	1.01 mph	1.08 mph
I-95 (2 Lane)	1.32 mph	1.22 mph	1.21 mph
I-95 (3 Lane)	1.21 mph	1.39 mph	1.26 mph
Between Sites			
Sites	**Prior**	**Within**	**End**
I-10	1 mph	2 mph	2 mph
I-95 (2 Lane)	2 mph	5 mph	4 mph
I-95 (3 Lane)	1 mph	5 mph	3 mph

The posted speed limits prior to the work zone were 70 miles per hour (mph) at all locations on both I-10 and I-95. The speed limit within the work zone was 60 mph for both the standard MOT and MAS sites along I-10. For the I-95 locations, the speed limit within the work zone was 70 mph for the standard MOT studies and either 55 mph or 60 mph for the MAS studies.

Summary statistics for each of the 68 speed studies along I-10 are provided in Tables 4 to 6. The evaluation sites along I-10 included three distinct scenarios: (1) Standard MOT, (2) MAS without enforcement, and (3) MAS with enforcement. By examining these scenarios, a determination can be made as to the effectiveness of the MAS system and whether it is effective with or without police enforcement.

Table 4 presents summary statistics for the I-10 speed studies conducted prior to the start of the work zone. Over 200 vehicles were observed in each study. The average and 85th percentile speeds were relatively consistent across locations. The average speeds per location ranged from 68.49 to 70.75 mph and the 85th percentile speeds from 73 to 75 mph.

TABLE 4. Data Summary of I-10 Speed Studies Conducted Prior to Work Zone

MOT Plan	Length (miles)	Date	Start Time	End Time	Vehicles Observed	Average Speed	Standard Deviation	85th Percentile Speed
Standard MOT	1.8	5/9/2007	10:50	12:01	217	69.38	5.34	74.00
	2.1	5/24/2007	8:30	9:21	205	70.75	5.32	75.00
	2.1	5/24/2007	13:50	14:48	202	70.04	5.55	74.80
Motorist Awareness System, No Police	1.8	5/9/2007	9:31	10:45	209	70.70	5.16	75.00
	0.9	6/7/2007	8:32	9:26	205	70.11	4.84	74.00
	1.8	6/14/2007	8:48	9:52	201	70.67	4.38	74.00
	1.8	6/14/2007	12:35	13:50	202	70.03	5.17	75.00
Motorist Awareness System with Police	1.7	5/10/2007	9:33	10:10	204	69.88	4.55	74.00
	2.0	5/22/2007	9:18	10:11	206	68.49	5.51	73.00
	2.0	5/22/2007	15:10	15:58	204	70.53	5.33	75.00
	2.0	5/23/2007	9:04	10:24	202	69.82	5.40	74.00
	2.0	5/23/2007	14:03	14:50	202	68.69	5.73	73.00
	2.0	5/23/2007	17:46	18:14	202	68.88	5.74	74.00
	0.9	6/6/2007	14:44	15:42	202	69.79	5.79	74.00
	0.3	6/13/2007	8:33	9:47	205	70.37	4.60	74.00
	0.3	6/13/2007	12:33	13:26	204	69.44	5.46	74.00

Table 5 presents summary statistics for the I-10 speed studies conducted within the work zone. A minimum of 154 vehicles were observed at each study location and, at most locations, over 200 vehicles were observed. Substantially larger differences in average and 85th percentile speeds were observed depending on the Maintenance of Traffic (MOT) plan utilized. Average speeds ranged from 51.67 to 60.32 mph and 85th percentile speeds from 57.2 to 65 mph.

TABLE 5. Data Summary of I-10 Speed Studies Conducted Within the Work Zone

MOT Plan	Length (miles)	Date	Start Time	End Time	Vehicles Observed	Average Speed	Standard Deviation	85th Percentile Speed
Standard MOT	1.8	5/9/2007	14:22	15:09	208	59.81	5.75	65.00
	2.1	5/24/2007	9:23	11:11	202	58.27	4.20	62.00
	2.1	5/24/2007	14:56	15:50	204	60.32	5.18	64.00
	1.9	6/18/2007	15:46	16:20	202	56.94	5.83	62.00
	1.9	6/18/2007	17:09	17:40	201	57.27	5.53	61.00
	1.9	6/18/2007	17:41	18:09	206	55.08	5.53	60.00
	1.9	7/12/2007	9:03	10:14	203	58.79	5.35	63.00
	1.9	7/12/2007	10:15	10:57	203	59.97	5.84	64.00
	1.9	7/12/2007	10:58	12:05	203	58.33	5.32	62.00
Motorist Awareness System, No Police	1.8	5/9/2007	12:17	13:05	210	53.19	5.52	57.20
	1.8	6/14/2007	10:29	11:33	205	59.08	3.81	62.00
	1.8	6/14/2007	13:58	15:35	204	58.29	3.98	62.00
	1.9	6/19/2007	9:26	10:40	203	55.96	4.12	59.60
	1.9	6/19/2007	14:13	15:03	203	58.33	4.90	62.00
	1.9	6/19/2007	15:04	15:54	204	57.50	4.96	61.00
	1.2	7/11/2007	8:58	10:07	203	55.42	3.99	59.00
Motorist Awareness System with Police	1.7	5/10/2007	11:59	12:58	154	55.28	4.26	59.00
	2	5/22/2007	10:19	11:46	203	51.67	6.43	57.60
	2	5/22/2007	16:21	17:39	202	54.60	5.60	59.00
	2	5/23/2007	10:33	11:32	199	52.44	5.93	57.00
	2	5/23/2007	14:54	16:06	204	54.12	5.58	59.00
	0.9	6/6/2007	15:55	16:50	200	53.75	5.80	59.00
	0.3	6/13/2007	10:12	10:49	202	56.14	4.13	59.00
	1.9	6/20/2007	8:50	11:34	199	57.73	4.99	62.00
	1.9	6/20/2007	11:35	12:45	200	56.78	4.67	60.20
	1.9	6/20/2007	12:46	16:00	183	54.74	5.28	59.00

Table 6 presents summary statistics for the I-10 speed studies conducted near the end of the work zone. For one of the studies, only 107 vehicles were observed, but for all other studies, a minimum of 192 vehicles were observed. There was also substantial of variability in speeds between different Maintenance of Traffic (MOT) plans, with average speeds ranging from 54.31 to 66.02 mph and 85th percentile speeds from 59 to 67 mph.

TABLE 6. Data Summary of I-10 Speed Studies Conducted at End of Work Zone

MOT Plan	Length (miles)	Date	Start Time	End Time	Vehicles Observed	Average Speed	Standard Deviation	85th Percentile Speed
Standard MOT	1.8	5/9/2007	15:12	14:25	201	60.84	5.97	66.00
	2.1	5/24/2007	11:22	12:53	203	60.73	4.69	65.00
	2.1	5/24/2007	16:12	17:28	202	60.33	5.91	65.00
	1.9	6/18/2007	16:28	17:04	207	59.70	5.54	65.00
	1.9	6/18/2007	18:17	18:55	207	60.36	5.97	65.00
	1.9	6/18/2007	18:56	19:23	205	60.39	5.85	65.00
	1.9	7/12/2007	12:10	13:57	201	61.42	5.65	65.00
	1.9	7/12/2007	13:58	14:30	206	62.50	4.87	66.00
	1.9	7/12/2007	14:31	16:06	203	61.51	5.5	66.00
Motorist Awareness System No Police	1.8	5/9/2007	13:10	14:13	207	54.94	5.01	59.00
	1.8	6/14/2007	15:44	17:16	196	62.13	4.64	66.00
	1.8	6/14/2007	11:38	12:24	204	63.15	4.93	67.00
	1.9	6/19/2007	10:43	11:58	203	60.19	5.57	64.00
	1.9	6/19/2007	12:01	13:04	194	62.02	5.33	66.00
	1.9	6/19/2007	13:04	14:06	204	59.85	5.75	65.00
	1.2	7/11/2007	10:50	12:00	203	61.83	5.32	66.00
	1.2	7/11/2007	12:01	13:17	203	61.64	4.54	66.00
	1.2	7/11/2007	13:17	14:30	203	61.10	4.82	65.00
	1.2	7/11/2007	14:31	15:26	208	59.80	4.9	64.00
	1.2	7/11/2007	15:26	16:00	107	62.50	5.69	67.00
Motorist Awareness System with Police	1.7	5/10/2007	15:03	16:15	212	57.37	5.82	62.00
	2	5/22/2007	13:03	14:42	192	55.18	6.14	60.00
	2	5/22/2007	16:48	17:50	196	56.62	6.68	62.00
	2	5/23/2007	11:35	12:58	208	54.31	5.64	59.00
	2	5/23/2007	16:15	17:39	202	58.10	6.48	63.00
	0.9	6/6/2007	16:56	17:34	204	59.66	5.23	64.40

For all of the work zones on I-95, at least one police vehicle was present at the beginning of the lane closure for both the standard MOT and MAS scenarios. This means the evaluation actually results in a comparison between standard MOT and MAS in the presence of police enforcement. Summary statistics for each of the 112 speed studies conducted along I-95 are shown in Tables 7 to 10. The data were divided by number of lane reductions (from two lanes to one lane or from three lanes to two lanes) and Maintenance of Traffic Plan (standard MOT or MAS).

Table 7 presents summary statistics for the I-95 speed studies conducted prior to the start of the work zone. Over 100 vehicles were observed in each study and the average and 85th percentile speeds ranged from 65.51 to 75.35 mph and 69.8 to 79 mph, respectively. The I-95 locations showed greater variability than the I-10 speed studies. The presence of the police vehicle at the beginning of the lane closure may have impacted the travel speeds through the work zone.

Table 8 presents summary statistics for the I-95 speed studies conducted within the work zone. Over 100 vehicles were observed in each study. Substantial differences in travel speeds were observed between the study locations with 3-to-2 lane reductions and the 2-to-1 lane reductions. Table 9 presents summary statistics for the I-95 speed studies conducted near the end of the work zone.

A statistical evaluation was conducted on both the I-10 and I-95 data sets as outlined in the following section to determine the effects of the MAS with and without enforcement.

TABLE 7. Data Summary of I-95 Speed Studies Conducted Prior to Work Zone

MOT Scenario	No. of Lnaes	Length (miles)	Date	Start Time	End Time	Vehicles Observed	Average Speed	Standard Deviation	85th Percentile Speed
Standard MOT with Police	Two Lanes to One Lane	1.1	6/15/2005	20:15	21:00	111	72.08	4.72	77.00
		1.1	6/20/2005	21:00	21:45	106	73.03	5.00	76.00
		1.1	6/21/2005	21:00	21:45	109	70.21	4.22	73.00
		1.5	6/22/2005	21:00	21:40	102	74.06	3.89	77.00
		1.5	6/23/2005	21:00	21:45	109	72.97	4.25	76.00
		0.8	7/5/2005	21:00	21:32	109	70.09	4.46	74.00
		1.3	7/6/2005	21:00	21:51	115	67.45	5.06	72.20
		0.8	7/7/2005	21:00	21:32	112	67.38	4.37	71.00
		1.2	8/4/2005	21:00	21:40	103	74.14	4.30	77.00
		1.2	8/10/2005	21:00	21:35	106	70.15	4.66	74.00
		1.2	8/10/2005	23:05	23:40	104	69.92	4.15	73.00
		2.1	8/11/2005	21:00	21:40	104	72.33	4.25	75.00
		2.1	8/11/2005	22:55	23:30	108	71.01	4.59	75.00
		0.1	9/11/2005	10:22	10:48	106	68.20	4.75	72.00
		0.2	9/12/2006	21:44	22:04	101	69.91	4.77	74.00
		0.4	5/2/2007	1:12	2:14	154	65.96	4.87	70.00
	Three Lanes to Two Lanes	1.2	8/3/2005	21:50	22:25	103	75.21	3.99	78.00
		1.2	8/3/2005	23:45	0:10	105	74.32	4.07	77.00
		1.2	8/8/2005	21:00	21:35	102	73.75	4.31	77.00
		1.2	8/8/2005	23:25	23:45	102	73.88	3.59	77.00
		1.2	8/9/2005	21:00	21:35	105	74.46	4.14	77.00
Motorist Awareness System with Police	Two Lanes to One Lane	1.4	8/15/2005	21:00	21:35	101	72.89	4.40	76.00
		1.4	8/15/2005	23:05	23:40	105	71.97	4.01	75.00
		1.6	8/16/2005	21:00	21:30	102	73.66	4.14	77.00
		1.6	8/16/2005	23:00	23:35	101	71.96	4.32	75.00
		1.3	8/17/2005	21:45	22:15	103	73.53	4.37	76.00
		1.3	8/17/2005	23:30	0:05	106	73.21	4.97	77.00
		1.3	8/18/2005	21:00	21:30	104	73.09	4.49	76.00
		1.9	8/24/2005	21:00	21:35	104	74.15	4.75	78.00
		1.9	8/24/2005	22:50	23:20	103	72.79	4.71	76.00
		2.1	8/28/2005	21:00	21:30	107	74.51	4.66	79.00
		2.1	8/28/2005	22:45	23:15	105	74.65	5.06	79.00
		2.8	8/31/2005	21:00	21:35	104	74.03	4.00	77.00
		1.9	9/11/2005	21:00	21:35	112	75.12	4.57	79.00
		1.9	9/12/2005	21:05	21:40	105	72.66	4.10	77.00
		1.9	9/13/2005	21:00	21:35	110	71.51	4.66	76.00
		1	9/14/2005	21:00	21:30	104	75.35	4.39	78.40
	Three Lanes to Two Lanes	1.2	8/22/2005	21:00	21:35	102	74.98	4.18	78.80
		1.2	8/23/2005	21:00	21:35	103	74.43	4.75	78.00
		4.1	9/17/2006	21:32	22:03	146	68.49	5.43	73.00
		2.6	9/18/2006	21:19	22:32	102	65.51	5.77	69.80
		3	9/20/2006	21:31	22:10	124	67.68	5.47	72.00
		3	9/21/2006	21:33	21:53	103	68.08	4.82	71.00

TABLE 8. Data Summary of I-95 Speed Studies Conducted Within Work Zone

MOT Scenario	No. of Lanes	Length (miles)	Date	Start Time	End Time	Vehicles Observed	Average Speed	Standard Deviation	85th Percentile Speed
Standard MOT with Police	Two Lanes to One Lane	1.1	6/15/2005	21:30	22:40	108	41.67	4.24	46.00
		1.1	6/20/2005	22:00	23:15	104	50.34	4.89	55.00
		1.1	6/21/2005	22:10	23:00	101	51.96	4.62	56.00
		2.1	8/11/2005	21:45	22:15	103	44.14	5.46	48.00
		0.1	9/11/2005	23:24	23:57	112	56.02	5.82	60.00
		0.2	9/12/2006	22:10	22:33	101	52.78	5.49	57.00
		0.4	5/2/2007	0:08	0:53	156	53.79	5.74	59.00
	Three Lanes to Two Lanes	1.2	8/3/2005	0:15	0:45	102	60.14	4.94	64.00
		1.2	8/3/2005	22:40	23:10	102	58.59	5.03	62.80
		1.2	8/4/2005	21:50	22:30	105	59.83	5.8	64.00
		1.2	8/8/2005	0:00	0:35	109	48.69	4.23	53.00
		1.2	8/8/2005	21:40	22:25	109	48.69	4.23	53.00
		1.2	8/9/2005	21:40	22:30	102	60.59	4.63	65.00
Motorist Awareness System with Police	Two Lanes to One Lane	1.4	8/15/2005	21:40	22:25	109	38.46	4.59	42.00
		1.4	8/15/2005	23:45	0:10	103	41.56	4.03	44.60
		1.6	8/16/2005	21:35	22:20	104	41.63	4.06	44.00
		1.6	8/16/2005	23:40	0:10	102	44.06	3.81	47.00
		1.3	8/17/2005	0:05	0:35	103	37.79	4.02	40.60
		1.3	8/17/2005	22:20	22:50	102	35.07	3.38	37.00
		1.9	8/24/2005	21:40	22:10	104	53.92	4.00	57.00
		1.9	8/24/2005	23:25	23:55	103	52.93	5.03	57.00
		2.1	8/28/2005	21:35	22:05	111	53.5	3.89	56.00
		2.1	8/28/2005	23:20	23:50	106	52.65	3.31	55.00
		2.8	8/31/2005	21:40	22:10	106	48.74	4.01	52.00
		1.9	9/11/2005	21:40	22:15	104	49.65	4.28	53.00
		1.9	9/12/2005	21:45	22:30	106	47.91	3.63	51.00
		1.9	9/13/2005	21:40	22:15	105	41.81	4.69	47.00
		1	9/14/2005	21:35	22:15	100	51.85	4.08	55.00
	Three Lanes to Two Lanes	1.2	8/22/2005	21:40	22:10	108	58.21	4.50	62.00
		1.2	8/23/2005	21:40	22:10	101	55.45	5.13	59.00
		4.1	9/17/2006	10:29	11:15	116	46.4	5.63	51.00
		2.6	9/18/2006	11:03	11:32	101	49.88	5.66	54.00
		3	9/20/2006	10:22	10:50	105	49.69	5.54	54.00
		3	9/21/2006	21:15	21:50	105	50.16	5.83	55.00

TABLE 9. Data Summary of I-95 Speed Studies Conducted at End of Work Zone

MOT Scenario	No. of Lanes	Length (miles)	Date	Start Time	End Time	Vehicles Observed	Average Speed	Standard Deviation	85th Percentile Speed
Standard MOT with Police	Two Lanes to One Lane	1.1	6/20/2005	23:25	0:10	105	67.24	5.16	72.00
		1.1	6/21/2005	23:25	0:10	101	53.00	5.25	57.00
		1.2	8/10/2005	0:15	0:45	104	49.31	5.27	52.00
		1.2	8/10/2005	22:25	23:00	103	51.79	4.50	55.00
		2.1	8/11/2005	22:20	22:50	104	49.96	6.46	55.00
		2.1	8/12/2005	0:10	0:40	104	51.05	4.76	55.00
		0.1	9/11/2006	10:49	11:19	104	57.15	5.84	62.00
		0.2	9/12/2006	10:39	11:02	101	55.72	5.68	60.00
	Three Lanes to Two Lanes	1.2	8/3/2005	1:00	1:40	111	59.48	4.93	63.00
		1.2	8/3/2005	23:15	23:35	106	56.57	4.12	60.00
		1.2	8/4/2005	22:40	23:45	104	57.78	4.68	60.00
		1.2	8/8/2005	0:40	1:40	105	55.36	3.95	59.00
		1.2	8/8/2005	22:40	23:15	105	55.21	3.58	58.00
		1.2	8/9/2005	22:40	23:35	101	58.50	4.41	61.00
Motorist Awareness System with Police	Two Lanes to One Lane	1.4	8/15/2005	0:15	0:40	103	49.07	4.45	52.00
		1.4	8/15/2005	22:30	23:00	106	46.77	4.85	51.00
		1.6	8/16/2005	0:15	0:45	106	57.34	4.38	61.00
		1.6	8/16/2005	22:25	23:00	104	55.78	4.57	59.00
		1.3	8/17/2005	0:40	1:10	106	49.12	4.49	53.00
		1.3	8/17/2005	22:55	23:25	105	48.50	4.62	51.00
		1.9	8/24/2005	0:00	0:30	103	53.00	4.52	56.60
		1.9	8/24/2005	22:15	22:45	104	53.47	4.01	57.00
		2.1	8/28/2005	22:10	22:40	104	60.99	4.23	64.00
		2.1	8/28/2005	23:55	0:25	103	60.03	4.67	64.00
		2.8	8/31/2005	22:15	22:45	104	59.82	4.01	63.00
		1.9	9/11/2005	22:20	22:55	105	55.77	5.38	60.00
		1.9	9/12/2005	22:35	23:05	107	43.50	4.08	48.00
		1.9	9/13/2005	22:20	22:55	105	51.12	4.23	55.00
		1	9/14/2006	22:20	22:55	103	56.84	4.70	60.00
	Three Lanes to Two Lanes	1.2	8/22/2005	22:15	22:45	103	52.04	4.82	56.00
		1.2	8/23/2005	22:25	23:05	104	55.63	5.34	61.00
		4.1	9/17/2006	11:41	12:38	101	57.59	4.45	61.00
		2.6	9/18/2006	11:38	12:33	101	53.94	5.00	58.00
		3	9/20/2006	11:01	11:33	109	51.39	4.36	55.00
		3	9/21/2006	11:09	11:39	101	51.67	4.38	55.00

4.0 STATISTICAL EVALUATION

It is customary to use statistical analysis in the effectiveness evaluation process. Such analyses ensure that the observed differences in the test and control conditions are in fact due to the treatment or countermeasure and not due to chance. All statistical analyses require certain assumptions. Validity of the assumptions is critical to the appropriateness of the statistical analyses; therefore, several tests were performed.

Tests for Variability

To test the homogeneity of the variances in the speed data collected at test and control locations, the F-Max test was utilized. In addition to testing for differences in variances, the F-Max test was used to determine whether Analysis of Variance or Student's t-test is appropriate for testing differences in mean speeds. If the variances between the test and control groups are significantly different, alternative testing procedures were utilized as explained in the following sections.

Tests for Differences in the Mean and 85th Percentile Speeds

In order to test the effectiveness of the Motorist Awareness System (MAS) in reducing vehicular speeds, Analysis of Variance (ANOVA) and Student's t-test were utilized to determine if significant differences in the mean and 85th percentile speeds existed between the standard Maintenance of Traffic (MOT) and MAS. Both ANOVA and Student's t-test require data to be normally distributed and have equal variances. The One Sample Kolmogorov-Smirnov Test was used to determine whether the data were normally distributed while the F Test was used to test for homogeneity of variance. If these conditions are satisfied, ANOVA can be utilized to compare three or more groups as was the case for the I-10 data (standard MOT vs. MAS without enforcement vs. MAS with enforcement), while Student's t-test was used to compare two groups as was the case for the I-95 data (standard MOT with enforcement vs. MAS with enforcement).

Z-Test for Differences in Proportion of Speed Limit Violations

In order to test the effectiveness of the MAS on travel speeds, the z-test was used to determine if the differences in the proportion of speeding vehicles with and without the MAS were different. For the z-test, a two-tailed analysis was used with a null hypothesis that states there are no differences between the two proportions. The alternative hypothesis states that the proportions are not similar. As with the Student's t-test, a two-tailed analysis was used for this research as the effectiveness of the MAS is not known.

5.0 RESULTS OF THE STATISTICAL TESTING

Descriptive statistics of the speed studies for the I-10 segments are shown in Table 10. These statistics include the total number of studies at each location (prior to the work zone, within the work zone, near the end of the work zone) and under each MOT scenario (either standard MOT or MAS), as well as mean speeds, 85th percentile speeds, standard deviation and variance of the speed distributions, and the proportion of vehicles traveling over the speed limit. The summary statistics are shown in Table 11 for the 2-lane segments of I-95 that were converted to 1-lane and similar statistics are illustrated in Table 12 for the I-95 segments which were reduced from 3-lanes to 2-lanes.

TABLE 10. Descriptive Statistics for I-10 Segments

Speed Statistics	Location of Speed Study and MOT Scenario								
	Prior to Work Zone			Within Work Zone			End of Work Zone		
	MOT	MAS	MAS + POLICE	MOT	MAS	MAS + POLICE	MOT	MAS	MAS + POLICE
Number of Studies	3	4	9	9	7	10	9	11	6
Mean (mph)	70.06	70.38	69.54	58.31	56.82	54.73	60.86	60.83	56.87
Std. Dev.	0.69	0.35	0.72	1.68	2.08	1.87	0.83	2.24	1.95
Variance	0.47	0.12	0.52	2.83	4.33	3.50	0.69	5.02	3.80
85th Percentile (mph)	74.60	74.50	73.89	62.56	60.40	59.08	65.33	65.00	61.73
Proportion over Speed Limit	48.0%	49.7%	44.9%	33.3%	19.6%	13.2%	55.3%	53.7%	27.8%

TABLE 11. Descriptive Statistics for I-95 2-Lane Segments

Speed Statistics	Location of Speed Study and MOT Scenario					
	Prior to Work Zone		Within Work Zone		End of Work Zone	
	MOT	MAS	MOT	MAS	MOT	MAS
Number of Sites	16	16	7	15	8	15
Mean (mph)	70.55	73.44	50.1	46.1	54.4	53.41
Std. Dev.	2.45	1.14	5.26	6.4	5.85	5.27
Variance	6.00	1.30	27.67	40.96	34.22	27.77
85th Percentile (mph)	74.5	77.03	54.43	49.32	58.97	57.13

TABLE 12. Descriptive Statistics for I-95 3-Lane Segments

Speed Statistics	Location of Speed Study and MOT Scenario					
	Prior to Work Zone		Within Work Zone		End of Work Zone	
	MOT	MAS	MOT	MAS	MOT	MAS
Number of Sites	5	6	6	6	6	6
Mean (mph)	74.33	69.86	56.09	51.63	57.15	53.71
Std. Dev.	0.58	3.89	5.77	4.34	1.73	2.5
Variance	0.34	15.13	33.29	18.84	2.99	6.25
85th Percentile (mph)	77.2	73.77	60.3	55.83	60.17	57.67

Tests for Variability

The F-test for homogeneous variances was conducted to determine whether the MAS had an impact on speed variability. Tables 13 and 14 detail the results of the statistical tests for I-10 and I-95, respectively. The null hypothesis for the F-test is that the variances are equal between the two groups.

In each instance, separate comparisons were conducted at the locations prior to, within, and near the end of the work zone. Each of the F-statistics reported are for the pair-wise comparisons indicated on the left-most column. If the calculated F-statistic (Fcalculated) is within the range of critical values (Fcritical), the null hypothesis that the variances are equal is accepted. If the calculated F-statistic is outside of this critical range, it can be concluded that the variances are unequal between the test and control groups.

For the I-10 sites, the variance of the speed data within the work zone for the Motorist Awareness System Only group was less than that of the Motorist Awareness System with Police and the Standard MOT groups. For the I-95 test sites, there was no significant difference in the variances within the work zone between the MOT and MAS groups, both of which had enforcement vehicles present at the beginning of the lane closure.

TABLE 13. F-test Results for I-10

Scenario and Location		$F_{calculated}$	$F_{critical}$	Degrees of Freedom	Test Results	Greater Variability:
MOT vs. MAS ONLY	Prior	1.22	0.88, 1.13	623, 816	Reject Null	MOT
	Within	1.32	0.92, 1.09	1831, 1431	Reject Null	MOT
	End	1.02	0.93, 1.08	1834, 2131	Accept Null	N/A
MOT vs. MAS W/ POLICE	Prior	1.01	0.90, 1.11	623, 1830	Accept Null	N/A
	Within	1.00	0.93, 1.08	1831, 1945	Accept Null	N/A
	End	0.80	0.92, 1.09	1834, 1213	Reject Null	MAS w/Police
MAS ONLY vs. MAS W/ POLICE	Prior	0.83	0.91, 1.10	816, 1830	Reject Null	MAS w/Police
	Within	0.76	0.93, 1.08	1431, 1945	Reject Null	MAS w/Police
	End	0.79	0.92, 1.09	2131, 1213	Reject Null	MAS w/Police

TABLE 14. F-test Results for I-95

Scenario and Location		$F_{calculated}$	$F_{critical}$	Degrees of Freedom	Test Results	Greater Variability
2-Lane MOT vs. MAS	Prior	1.25	0.92, 1.08	1758, 1675	Reject Null	MOT
	Within	0.99	0.90, 1.11	788, 1567	Accept Null	N/A
	End	1.29	0.87, 1.10	825, 1567	Reject Null	MOT
3-Lane MOT vs. MAS	Prior	0.43	0.84, 1.18	516, 679	Reject Null	MAS
	Within	1.14	0.85, 1.17	628, 635	Accept Null	N/A
	End	0.76	0.85, 1.18	631, 618	Reject Null	MAS

Tests for Differences in Mean Speed and 85th Percentile Speed

Prior to conducting the tests for differences in mean speed and 85th percentile speed among the test and control sites, the assumptions of normality and equal variance were tested using the One-Sample Kolmogorov-Smirnov (K-S) Test and the F Test.

The null hypothesis for the K-S Test is that the distribution is normal. The resulting Z-statistic is compared to the corresponding critical Z value based upon the appropriate degrees of freedom. If the p-value corresponding to this Z-statistic is less than 0.05, it can be concluded that the distribution is not

normally distributed. Results, presented in Table 15, show that all of the p-values are greater than 0.05, indicating that all of the speed distributions are approximately normal and standard test procedures may be utilized.

In addition to the normality test, the homogeneity of variance assumption is tested using the F Test. The null hypothesis for the F Test is that the variances in the groups being compared are all equal. If the variances of all three groups are found to be significantly different with 95% confidence, a non-parametric test must be conducted instead of the standard Analysis of Variance or Student's t-Test. However, the F test results revealed that, even though the variances were not equal between some of the treatment groups, the differences in the variances were not sufficient to reject the homogeneous variance assumption of the standard test procedures. After satisfying the assumptions of the various test procedures, statistical tests were conducted to evaluate differences in both the mean speeds and 85th percentile speeds among different MOT scenarios.

TABLE 15: One-Sample Kolmogorov-Smirnov Test Results

Site	Location	Mean Speed			85th Percentile Speed		
		Z-statistic	P-value	Distribution Normal?	Z-statistic	P-value	Distribution Normal?
I-10	Prior	0.614	0.845	Yes	1.181	0.123	Yes
	Within	0.580	0.889	Yes	0.889	0.503	Yes
	End	1.060	0.211	Yes	1.227	0.098	Yes
I-95 2-Lane	Prior	0.848	0.469	Yes	0.852	0.462	Yes
	Within	0.810	0.528	Yes	0.896	0.398	Yes
	End	0.414	0.996	Yes	0.591	0.876	Yes
I-95 3-Lane	Prior	1.104	0.175	Yes	1.111	0.169	Yes
	Within	0.878	0.424	Yes	0.766	0.600	Yes
	End	0.498	0.965	Yes	0.565	0.907	Yes

The I-10 evaluation consisted of comparisons among three distinctly different scenarios: (1) Standard Maintenance of Traffic versus Motorist Awareness System without enforcement, (2) Standard Maintenance of Traffic versus Motorist Awareness System with enforcement, and (3) Motorist Awareness System without enforcement versus Motorist Awareness System with enforcement. To compare these

scenarios, an Analysis of Variance (ANOVA) was first conducted to determine whether significant differences existed between any of the three groups. Following the ANOVA test, the Tukey HSD procedure was utilized to conduct pair wise comparisons to determine if significant differences existed between each of the groups as shown in Tables 16 and 17. The pair wise comparisons show the mean difference in speeds between the two groups (in miles per hour), the standard error of this difference, an indication of whether this difference is statistically significant at 95 % confidence level (yes or no), and the confidence level of the test. It should be noted that for the "within work zone" location, the "MAS with Police" treatment was found to decrease speeds by an average of 2.097 miles per hour, but this effect had a confidence level of 92.1%, slightly below the established confidence level of 95%.

TABLE 16. Mean Speed Comparisons for I-10

Analysis of Variance (ANOVA)							
Location	**Component**	**SS**	**df**	**MS**	**F**	**P-value**	**Significant Difference**
Prior	MOT	2.104	2	1.052	2.478	0.123	No
	Error	5.520	13	0.425			
	Total	7.624	15				
Within	MOT	61.681	2	30.840	8.862	0.001	Yes
	Error	80.038	23	3.480			
	Total	141.719	25				
End	MOT	72.822	2	36.411	11.215	0.000	Yes
	Error	74.671	23	3.247			
	Total	147.493	25				

Tukey HSD Results						
Location	**Comparison**		**Mean Difference**	**Standard Error**	**Significant Difference?**	**Level of Confidence**
Prior	Standard MOT	MAS Only	-0.321	0.498	No	N/A
	Standard MOT	MAS w/ Police	0.516	0.434	No	N/A
	MAS Only	MAS w/ Police	0.837	0.392	No	N/A
Within	Standard MOT	MAS Only	1.487	0.940	No	N/A
	Standard MOT	MAS w/ Police	3.585	0.857	Yes	99.9%
	MAS Only	MAS w/ Police	2.097	0.919	Yes	92.1%
End	Standard MOT	MAS Only	0.032	0.810	No	N/A
	Standard MOT	MAS w/ Police	3.990	0.950	Yes	99.9%
	MAS Only	MAS w/ Police	3.958	0.914	Yes	99.9%

The analysis revealed that motorist speed prior to the work zone was quite consistent, regardless of the MOT plan or the presence of enforcement. This finding was as expected since these studies were conducted at locations prior to any notice of the upcoming work activity. However, once vehicles entered the work zone, the Motorist Awareness System was found to decrease average speed by 1.5 mph and 85th percentile speed by 2.1 mph in comparison to standard MOT. Combining the MAS with enforcement resulted in even lower speeds than the standard MOT within the work zone. Implementing targeted enforcement in combination with the MAS reduced average speeds by 3 to 4 miles per hour in comparison to standard MOT. This reduction in speeds was significant at a 99.9% confidence level.

TABLE 17. 85th Percentile Speed Comparisons for I-10

Analysis of Variance (ANOVA)							
Location	**Component**	**SS**	**df**	**MS**	**F**	**P-value**	**Significant Difference?**
Prior	MOT	1.701	2	0.851	2.485	0.122	No
	Error	4.449	13	0.342			
	Total	6.150	15				
Within	MOT	57.763	2	28.882	11.565	0.000	Yes
	Error	57.438	23	2.497			
	Total	115.202	25				
End	MOT	54.428	2	27.214	8.775	0.001	Yes
	Error	71.333	23	3.101			
	Total	125.762	25				

Tukey HSD Results						
Location	**Comparison Groups**		**Mean Difference**	**Standard Error**	**Significant Difference?**	**Level of Confidence**
Prior	Standard MOT	MAS Only	0.100	0.447	No	N/A
	Standard MOT	MAS w/ Police	0.711	0.390	No	N/A
	MAS Only	MAS w/ Police	0.611	0.352	No	N/A
Within	Standard MOT	MAS Only	2.156	0.796	Yes	96.8%
	Standard MOT	MAS w/ Police	3.476	0.726	Yes	99.9%
	MAS Only	MAS w/ Police	1.320	0.779	No	N/A
End	Standard MOT	MAS Only	0.333	0.792	No	N/A
	Standard MOT	MAS w/ Police	3.600	0.928	Yes	99.8%
	MAS Only	MAS w/ Police	3.267	0.894	Yes	99.6%

For the I-95 locations, average speeds at the end of the work zone were significantly lower (at a confidence level 98%) for the three-to-two lane segments, while the reduction in average speeds for the two-to-one lane group was not significant. For both the two-to-one lane and three-to-two lane groups, speeds within the work zone were 4 to 5 miles per hour less with the MAS as compared to standard MOT. Under both scenarios, the use of MAS decreased average speeds in the work zone as compared to standard MOT, though the reduction in all cases was not significant at a 95% confidence level. The speed reduction in the 2-Lane case within the work zone is of special interest because the speed prior to the work zone was nearly 3 miles per hour higher under the MAS scenario. Consequently, the 4 mile per hour reduction experienced within the work zone is likely a conservative estimate of the true effect of the MAS.

TABLE 18. Mean Speed Comparisons for I-95

MOT Scenario and Location		MOT Speed (mph)	MAS Speed (mph)	$t_{calculated}$	Degrees of Freedom	Significant Difference?	Level of Confidence
2-Lane MOT vs. MAS	Prior	70.55	73.44	-4.26	21.2	Yes	99.9%
	Within	50.10	46.10	1.44	20.0	Yes	83.4%
	End	54.40	53.41	0.41	21.0	No	N/A
3-Lane MOT vs. MAS	Prior	74.33	69.86	2.77	9.0	Yes	96.3%
	Within	56.09	51.63	1.51	10.0	Yes	83.8%
	End	57.15	53.71	2.77	10.0	Yes	98.0%

The 85th percentile speeds were also examined at each location and under each scenario as shown in Table 19. As with the mean speeds, the 85th percentile speeds also decreased within the work zone under both scenarios. The evaluation of both the mean and 85th percentile speeds consistently showed that the MAS outperformed the standard MOT, though the reduction in all cases was not significant at a 95% confidence level.

Z-Test for Differences in Proportion of Speed Limit Violations

The Z-test was used to compare the proportion of vehicles traveling over the posted speed limit in the test conditions with those speeding in the control conditions. The null hypothesis for the Z-test is that the proportion of speeding violations is equal among the groups.

TABLE 19. 85th Percentile Speed Comparisons for I-95

MOT Scenario and Location		MOT Speed (mph)	MAS Speed (mph)	$t_{calculated}$	Degrees of Freedom	Significant Difference?	Level of Confidence
2-Lane MOT vs. MAS	Prior	74.50	77.03	-3.93	30.0	Yes	99.9%
	Within	54.43	49.32	1.84	20.0	Yes	91.9%
	End	58.97	57.13	0.78	21.0	No	N/A
3-Lane MOT vs. MAS	Prior	77.20	73.77	2.22	9.0	Yes	92.5%
	Within	60.30	55.83	1.58	10.0	Yes	85.4%
	End	60.17	57.67	1.86	10.0	Yes	90.8%

Three proportions were compared for each scenario: (1) vehicles traveling over the speed limit, (2) vehicles traveling more than 5 mph above the speed limit, and (3) vehicles traveling more than 10 mph above the speed limit. Tables 20 to 22 present the results of the analyses for I-10.

TABLE 20. Z-test for MOT vs MAS without Police on I-10

MOT Scenario and Location		Proportion of Speeding Vehicles Standard MOT	Proportion of Speeding Vehicles MAS w/o Police	$Z_{calculated}$	$Z_{critical}$	Test Results
AboveSpeed Limit	Prior	47.9%	49.7%	-0.67	±1.96	Accept Null
	Within	33.3%	19.6%	8.73	±1.96	Reject Null
	End	55.3%	53.7%	1.01	±1.96	Accept Null
5 mph above	Prior	15.5%	14.9%	0.32	±1.96	Accept Null
	Within	9.7%	2.5%	8.20	±1.96	Reject Null
	End	19.2%	18.3%	0.68	±1.96	Accept Null
10 mph Above	Prior	1.3%	1.3%	-0.11	±1.96	Accept Null
	Within	1.7%	0.1%	4.49	±1.96	Reject Null
	End	2.9%	3.1%	-0.28	±1.96	Accept Null

The results reveal that the Motorist Awareness System substantially reduced the proportion of speeding drivers. For all of the scenarios (over the limit, 5 miles over, and 10 miles over), the MAS, whether combined with law enforcement or not, consistently and substantially decreased the proportion of speeding drivers within the work zone. For instance, the proportion of drivers traveling over the speed

limit was reduced from 33.3% under standard MOT to 19.6% with MAS for the I-10 segments. Combining MAS with enforcement further decreased this proportion to 13.2%.

TABLE 21. Z-test for MOT vs. MAS with Police on I-10

Scenario and Location		Proportion of Speeding Vehicles Standard MOT	Proportion of Speeding Vehicles MAS w/Police	$Z_{calculated}$	$Z_{critical}$	Test Results
Above Speed Limit	Prior	47.9%	44.9%	1.29	±1.96	Accept Null
	Within	33.3%	13.2%	14.71	±1.96	Reject Null
	End	55.3%	27.8%	14.92	±1.96	Reject Null
5 mph above	Prior	15.5%	11.7%	2.46	±1.96	Reject Null
	Within	9.7%	1.4%	11.15	±1.96	Reject Null
	End	19.2%	7.3%	9.11	±1.96	Reject Null
10 mph above	Prior	1.3%	1.5%	-0.35	±1.96	Accept Null
	Within	1.7%	0.2%	5.11	±1.96	Reject Null
	End	2.9%	0.7%	4.18	±1.96	Reject Null

TABLE 22. Z-test for MAS with and without Police on I-10

Scenario and Location		Proportion of Speeding Vehicles MAS w/o Police	Proportion of Speeding Vehicles MAS w/ Police	$Z_{calculated}$	$Z_{critical}$	Test Results
Above Speed Limit	Prior	49.7%	44.9%	2.26	±1.96	Reject Null
	Within	19.6%	13.2%	5.04	±1.96	Reject Null
	End	53.7%	27.8%	14.46	±1.96	Reject Null
5 mph above	Prior	14.9%	11.7%	2.28	±1.96	Reject Null
	Within	2.5%	1.4%	2.26	±1.96	Reject Null
	End	18.3%	7.3%	8.73	±1.96	Reject Null
10 mph above	Prior	1.3%	1.5%	-0.26	±1.96	Accept Null
	Within	0.1%	0.2%	-0.11	±1.96	Accept Null
	End	3.1%	0.7%	4.42	±1.96	Reject Null

6.0 CONCLUSIONS

The objective of this study was to determine the effectiveness of the Motorist Awareness System (MAS) on travel speeds in work zones. A field experiment was conducted along I-95 and I-10 to assist in the determination of effectiveness of the MAS. Speed data were collected for the control condition (without MAS) and the test condition (with MAS) at various times of the day and week. Statistical tests were conducted to better understand whether the changes observed in the measures of effectiveness (mean speed, speed distribution and proportion of speeding vehicles) are attributable to the utilization of the MAS. A summary of the findings is as follows:

- Travel speeds, both the mean and 85th percentile speeds, were consistently lower at the locations within the work zones where the MAS was utilized in comparison to the standard MOT. The implementation of the MAS along I-10 was found to reduce average speeds by an average of 1.5 miles per hour in comparison to standard MOT. Combining MAS with enforcement resulted in additional reduction in mean speeds by 3 to 4 miles per hour in comparison to standard MOT.
- The combination of the MAS with enforcement was also shown to decrease speeds in comparison to the standard MOT with enforcement along I-95. In general, speeds within the work zone were reduced by an average of 4 to 5 miles per hour.
- The variability of travel speeds along I-10 within the work zone decreased when MAS was utilized in comparison to standard MOT.
- The proportions of drivers speeding within and near the end of the work zones were also substantially reduced when the MAS was utilized in comparison to the standard MOT under all scenarios. Further, combining MAS with enforcement produced more pronounced reductions both within and near the end of the work zone.

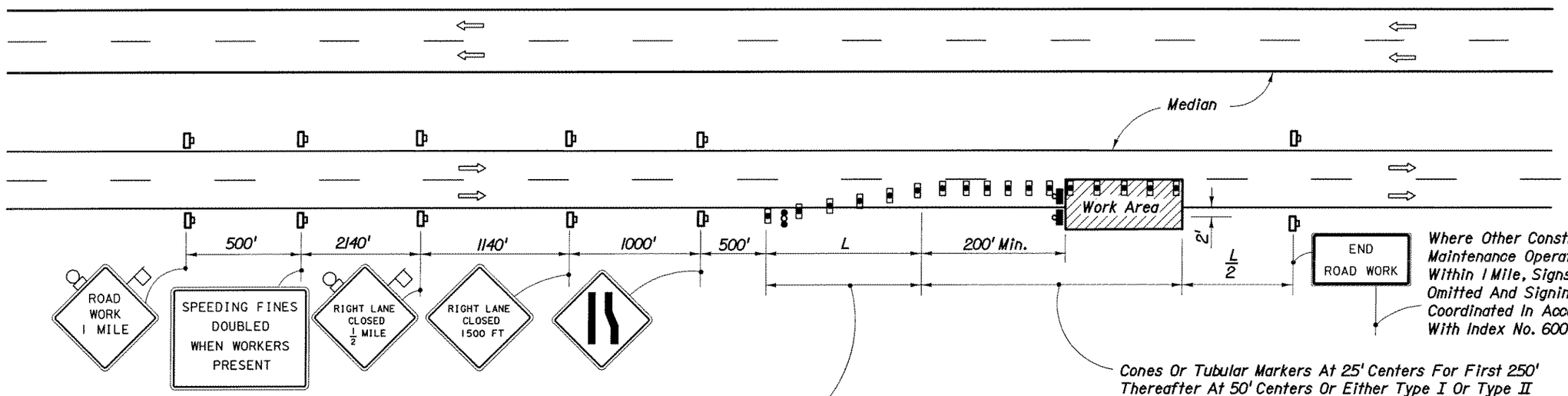
Overall, the MAS was effective in reducing vehicular speeds through construction work zones. Targeted enforcement resulted in additional speed reductions. The MAS was found to decrease the proportion of motorists traveling over the posted speed limit. Based on these findings, the use of MAS may be a practical countermeasure to reduce vehicular speeds through the work zone, thereby improving safety for both the motorist and the construction worker.

7.0 REFERENCES

1. Florida Department of Transportation, "FDOT Continues Safety Push for National Work Zone Awareness Week," http:/itseveryonesjob.com, Accessed August 20, 2007.
2. *Highway Safety Evaluation Procedural Guide,* Federal Highway Administration, March 1981.
3. Field, Andy. *Discovering Statistics Using SPSS, Second Edition*. Sage Publications Ltd., London, 2005.
4. Hinkle, Wiersma, and Jurs. Ap*plied Statistics for the Behavioral Sciences, Fifth Edition.* Houghton Mifflin Company, Boston, MA, 2003.

APPENDIX A

FDOT Standard Index No. 613 (Standard MOT Plan)



Where Other Construction Or Maintenance Operations Occur Within 1 Mile, Signs To Be Omitted And Signing To Be Coordinated In Accordance With Index No. 600.

Maximum Spacing Between Cones And Tubular Markers Shall Be 25' Maximum Spacing Between Type I Or Type II Barricades Or Vertical Panels Or Drums Shall Be Based On The Speed Limit As Follows: 15' Up To 25 MPH; 30' For 30-40 MPH; 50' For 45 MPH And Greater.

Cones Or Tubular Markers At 25' Centers For First 250' Thereafter At 50' Centers Or Either Type I Or Type II Barricades Or Vertical Panels Or Drums At 50' Centers For First 250' Thereafter At 100' Centers.

SYMBOLS

- Work Area
- Sign With 18"x 18" (Min.) Orange Flag And Type B Light
- Type I Or Type II Barricade Or Vertical Panel Or Drum (With Steady Burning Light At Night Only).
  (Tubular Markers May Be Used During Daylight Only. Cones May Be Used - See Index No. 600.)
- Type I, Type II Or Type III Barricade Or Vertical Panel Or Drum (With Flashing Light)
- Work Zone Sign
- Advance Warning Arrow Panel

GENERAL NOTES

1. Work operations shall be confined to one traffic lane, leaving the adjacent lane open to traffic.
2. All vehicles, equipment, workers and their activities are restricted at all times to one side of the roadway.
3. The first two warning signs, each side, shall have a 18" x 18" (min.) orange flag and a Type B light attached and operating at all times.
4. All signs shall be post mounted if the closure time exceeds 12 hours.
5. On undivided highways the median signs as shown are to be omitted.
6. When work is performed in the median lane on divided highways the barricading plan is inverted and left lane closed and lane reduction signs substituted for the right lane closed and lane reduction signs.

   The same applies to undivided highways with the following exceptions: (a) Work shall be confined within one median lane. (b) Additional barricades, cones, or drums shall be placed along the centerline abutting the work area and across the trailing end of the work area.

   When work on undivided highways occurs across the centerline so as to encroach on both median lanes, the inverted plan is applied to the approach of both roadways.
7. Signs and traffic control devices are to be modified in accordance with INTERMITTENT WORK STOPPAGE details (sheet 2 of 2) when no work is being performed and the highway is open to traffic.
8. L (min.) = Length of taper in feet:
   = WS for speeds ≥ 45 mph
   = $\frac{WS^2}{60}$ for speeds ≤ 40 mph

   Where:
   W = Width of lateral transition in feet
   S = Posted speed limit (mph).
9. Arrows denote direction of traffic only and do not reflect pavement markings.
10. Longitudinal dimensions are to be adjusted to fit field conditions. See Index No. 600.
11. When work is being performed on a multilane undivided roadway the signs normally mounted in the median (as shown) shall be omitted.
12. When a side road intersects the highway on which work is being performed, additional traffic control devices shall be erected in accordance with other applicable TCZ Indexes.
13. For general TCZ requirements and additional information refer to Index No. 600.

TYPICAL APPLICATIONS

Pavement Resurfacing
Pavement Repair
Utility Work
Bridge Repair
Guardrail Work

CONDITIONS

WHERE ANY VEHICLE, EQUIPMENT, WORKERS OR THEIR ACTIVITIES ENCROACH ON THE LANE ADJACENT TO EITHER SHOULDER AND THE AREA 2' OUTSIDE THE EDGE OF TRAVEL WAY.

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

TRAFFIC CONTROL THROUGH WORK ZONES

MULTILANE, DIVIDED AND UNDIVIDED • RURAL NIGHT OPERATIONS OR OPERATIONS EXCEEDING ONE DAYLIGHT PERIOD

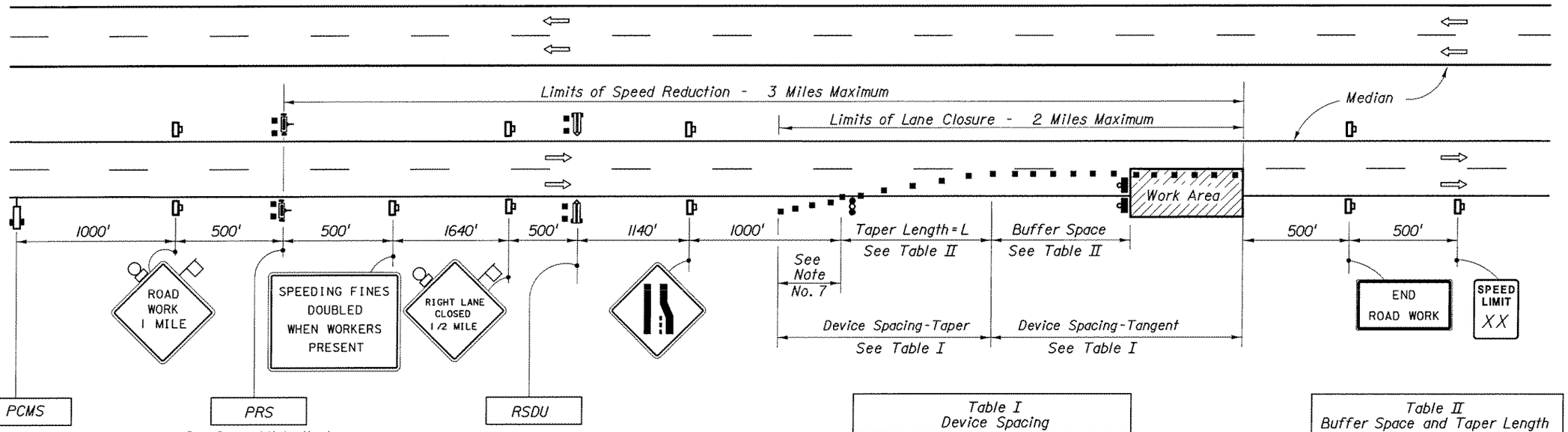
	Names	Dates
Designed By		12/87
Drawn By		12/87
Checked By		12/87

Approved By: Lamell D. Mills, Roadway Design Engineer

Revision	Sheet No.	Index No.
04	1 of 2	613

APPENDIX B

FDOT Standard Index No. 670 (Motorist Awareness System Plan)



See General Note No. 1

Typical PCMS Display

Message 1: WORKERS PRESENT AHEAD
Message 2: SPEED REDUCED NEXT 3MI

SLEO

Speed and Law Enforcement Officer
(Patroling The Active Work Area)

Table I
Device Spacing

Speed (mph)	Max. Distance Between Devices (ft)			
	Cones or Tubular Markers		Type I or Type II Barricades or Vertical Panels or Drums	
	Taper	Tangent	Taper	Tangent
25	25	50	25	50
30 to 45	25	50	30	50
50 to 70	25	50	50	100

Table II
Buffer Space and Taper Length

Speed (mph)	Buffer Space	Taper Length (12' Lateral Transition)	
	Dist. (ft)	L (ft)	Notes (Merge)
25	155	125	$L=\frac{WS^2}{60}$
30	200	180	
35	250	245	
40	305	320	
45	360	540	L = WS
50	425	600	
55	495	660	
60	570	720	
65	645	780	
70	730	840	

When Buffer Space cannot be attained due to geometric constraints, the greatest attainable length shall be used, but not less than 200 ft.

For lateral transitions other than 12', use formula for L shown in the notes column.
Where:
L = Length of taper in feet
W = Width of lateral transition in feet
S = Posted speed limit (mph)

SYMBOLS

- Work Area
- Sign With 18"x 18" (Min.) Orange Flag And Type B Light
- Channelizing Device (See Index No. 600)
- Type I, Type II Or Type III Barricade Or Vertical Panel Or Drum (With Flashing Light)
- Work Zone Sign
- Advance Warning Arrow Panel
- Lane Identification + Direction of Traffic
- (1) PCMS = Portable Changeable(Variable) Message Sign
- (2) PRS = Portable Regulatory Sign - Speed Limit When Flashing
- (2) RSDU = Radar Speed Display Unit
- (1) SLEO = Speed and Law Enforcement Officer (Do Not Bid)

GENERAL NOTES

1. At lane closures where workers are present, reduce the posted speed limit (speed limit that existed prior to construction) by 10 MPH using the Portable Regulatory Sign (PRS), but not less than 55 MPH or to a speed warranted by geometric condition, whichever is lower. Taper lengths, buffer space and device spacing shall be selected using the posted speed, not the reduced speed.
2. All Arrow Panels, Portable Changeable Message Signs, Portable Regulatory Signs and Radar Speed Display Trailers, shall be turned off and moved outside the clear zone or be shielded by a barrier or crash cushion when not in use.
3. Work operations shall be confined to one traffic lane, leaving the adjacent lane(s) open to traffic.
4. All vehicles, equipment, workers and their activities are restricted to one side of the roadway.
5. When work is performed in the median lane on divided highways the barricading plan is inverted and left lane closed and lane reduction signs substituted for the right lane closed and lane reduction signs.
6. When work is being performed on a multilane undivided roadway the signs and traffic control devices normally placed in the median (as shown) shall be omitted.
7. When paved shoulders having a width of 8 ft. or more are closed, channelizing devices shall be used to close the shoulder in advance of the merging taper to direct vehicular traffic to remain within the travel way. See Index No. 612 for shoulder taper formulas.
8. For general TCZ requirements and additional information refer to Index No. 600.

CONDITIONS

The MAS is intended to be used on multilane facilities with posted speeds of 55 MPH or greater where the work operations require a lane closure and workers are present.

APPENDIX C

FDOT Memorandum Regarding the Motorist Awareness System

Florida Department of Transportation

JEB BUSH
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

JOSÉ ABREU
SECRETARY

March 30, 2005

DCE MEMORANDUM NO. 06-05
(FHWA Approval: 3/28/05)

TO: **DISTRICT CONSTRUCTION ENGINEERS**

FROM: Ananth Prasad, Director, Office of Construction

COPIES: Brian Blanchard, Ed Rice, Sharon Holmes, Lap Hoang, David Sadler, Stefanie Maxwell, Ian Satter, Don Davis (FHWA), and Bob Burleson (FTBA)

SUBJECT: **USE OF MOTORIST AWARENESS SYSTEM (MAS) – INTERIM INDEX # 0670 AND CHANGEABLE MESSAGE SIGNS (CMS)**

Effective July 11, 2005, the Motorist Awareness System (MAS), Interim Index # 0670 dated 07/01/2005 of the Design Standards (see attached), shall be used on current and future construction contracts if all of the following conditions exist:

- Multilane facility
- Posted speed limit is 55 mph or greater
- Work operation requires a lane closure
- Workers are present

Please process a Field Supplemental Agreement/Work Order to incorporate this Interim Index. This Interim Index overrides Maintenance of Traffic requirements and speed reduction included in the Contract Documents with the exception of length of lane closure on active contracts. The maximum length of lane closure shall be limited to 2 miles per Index 600 and 670 unless otherwise stated in the Plans. Please ascertain from the Engineer of Record any geometric condition that may arise during the course of construction that would necessitate a longer term reduction of speed. This memorandum serves as a blanket approval to process this change and should be attached to the Field Supplemental Agreement/Work Order.

The Department's goal is to achieve the same respect for Work Zones that School Zones currently receive. The key to achieving this respect is to discontinue blanket speed limit reductions in work zones, increase enforcement, and to remove the MAS when the conditions requiring it no longer exist and restore the

speed limit within the limits of the project to the posted speed limit. Specifically, MAS components are to be activated when the lane closure is setup and deactivated when the lane closure is taken down. All MAS components shall be moved outside of the clear zone or to be shielded by a barrier or crash cushion when not in use.

Reduce the posted speed limit 10 MPH, but not less than 55 MPH, when the above conditions exist and restore the posted speed limit when the conditions no longer exist. Posted Speed limit is defined as the speed limit that existed prior to construction.

Prior to the implementation of the MAS, the project personnel should coordinate with Florida Highway Patrol so that at the onset of MAS, these work zones are enforced aggressively and provide for subsequent periodic stepped-up enforcement. The Department will be conducting a Public Information Safety Campaign blitz during the next year to alert the drivers in the State of Florida of this change and the need to alter behavior.

On active construction contracts, the Department will compensate the Contractor for the following items.

- Portable Regulatory Signs (PRS) – 2 ED (each day) for each lane closure - $ 40.00 ED
- Radar Speed Display Units (RSDU) – 2 ED (each day) for each lane closure - $ 35.00 ED
- Portable Changeable Message Signs (CMS) – 1 ED (each day) for each lane closure - $ 45.00 ED

The State Roadway Design Office will be providing further direction to the designers emphasizing the need to include MAS, where appropriate, in contracts to be let in January 2006 and beyond. As always, the Department's goal is to maintain posted speed limits except under conditions stated above or if temporary geometric design controls dictate a reduction. For contracts let in the period leading up to January 2006, please coordinate incorporating this change while recognizing production deadlines.

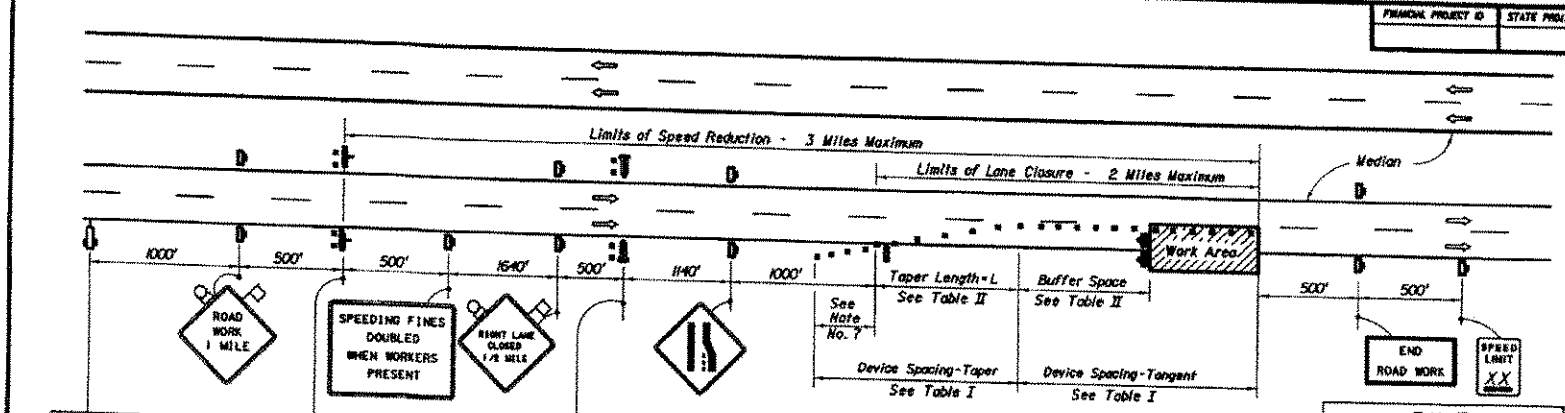
Furthermore, recent focus group discussion has indicated that Changeable Message Signs (CMS) are least effective in alerting drivers to work zones. The appropriate use of a CMS should be limited to managing travel, controlling and diverting traffic, identifying current and anticipated roadway conditions, or regulating access to specific lanes or the entire roadway. When these conditions no longer exist, the CMS should be turned off and moved outside of the clear zone. CMS displaying approved safety messages may also be used during the safety campaigns blitzes, with the use limited to a few weeks. To improve the effectiveness of these, the Department has published a list of approved motorist

safety messages (see attached) to be displayed on such signs. Messages such as "Road Work Ahead", "Use Caution", etc should be discontinued immediately.

There will be a zero tolerance policy when enforcing timely activation/deactivation of the MAS and the use of CMS. The first occurrence will result in a verbal warning, and subsequent occurrences will result in issuance of Deficiency Warning and Deficiency Letter and may result in removal of the Worksite Traffic Supervisor from the project. Failure on the part of the CEI personnel to enforce these requirements should be reflected in their performance grades and may result in removal of such personnel.

If you have any questions, please contact Stefanie Maxwell at (850) 414-4314, SC 994-4314.

AP/mw
Attachments: Interim Index # 0670 (dated 7-1-05)
Approved Motorist Safety Messages for CMS



Typical PCMS Display

With speed reduction:
Message 1: WORKERS PRESENT AHEAD
Message 2: SPEED REDUCED NEXT 3MI

Without speed reduction:
Message 1: WORKERS PRESENT AHEAD
Message 2: NEXT 3 MILES

Table I
Device Spacing

Speed (mph)	Max. Distance Between Devices (ft)			
	Cones or Tubular Markers		Type I or Type II Barricades or Vertical Panels or Drums	
	Taper	Tangent	Taper	Tangent
25	25	50	25	50
30 to 45	25	50	30	50
50 to 70	25	50	50	100

Table II
Buffer Space and Taper Length

Speed (mph)	Buffer Space	Taper Length (12' Lateral Transition)	
	Dist. (ft)	L (ft)	Notes (Merge)
25	155	125	$L=\frac{WS^2}{60}$
30	200	180	
35	250	245	
40	305	320	
45	360	540	L=WS
50	425	600	
55	495	660	
60	570	720	
65	645	780	
70	730	840	

When Buffer Space cannot be attained due to geometric constraints, the greatest attainable length shall be used, but not less than 200 ft.

For lateral transitions other than 12', use formula for L shown in the notes column.
Where:
L = Length of taper in feet
W = Width of lateral transition in feet
S = Posted speed limit (mph)

SYMBOLS

- Work Area
- Sign With 18"x 18" (Min.) Orange Flag And Type B Light
- Channelizing Device (See Index No. 600)
- Type I, Type II Or Type III Barricade Or Vertical Panel Or Drum (With Flashing Light)
- Work Zone Sign
- Advance Warning Arrow Panel
- Lane Identification + Direction of Traffic
- (1) PCMS- Portable Changeable(Variable) Message Sign
- (2) PRS- Portable Regulatory Sign- Speed Limit When Flashing
- (2) RSDU- Radar Speed Display Unit
- (1) SLEO- Speed and Law Enforcement Officer (Do Not Bid)

GENERAL NOTES

1. All lane closures where workers are present, reduce the posted speed limit (speed limit that existed prior to construction) by 10 MPH using the Portable Regulatory Sign (PRS), but not less than 55 MPH or to a speed warranted by geometric condition, whichever is lower. Taper lengths, buffer space and device spacing shall be selected using the posted speed, not the reduced speed.
2. All Arrow Panels, Portable Changeable Message Signs, Portable Regulatory Signs and Radar Speed Display Trailers, shall be turned off and moved outside the clear zone or be shielded by a barrier or crash cushion when not in use.
3. Work operations shall be confined to one traffic lane, leaving the adjacent lane(s) open to traffic.
4. All vehicles, equipment, workers and their activities are restricted to one side of the roadway.
5. When work is performed in the median lane on divided highways the barricading plan is inverted and left lane closed and lane reduction signs substituted for the right lane closed and lane reduction signs.
6. When work is being performed on a multilane undivided roadway the signs and traffic control devices normally placed in the median (as shown) shall be omitted.
7. When paved shoulders having a width of 8 ft. or more are closed, channelizing devices shall be used to close the shoulder in advance of the merging taper to direct vehicular traffic to remain within the travel way. See Index No. 612 for shoulder taper formulas.
8. For general TCZ requirements and additional information refer to Index No. 600.

Date: 07-01-05

CONDITIONS

The MAS is intended to be used on multilane facilities with posted speeds of 55 MPH or greater where the work operations require a lane closure and workers are present.

FINANCIAL PROJECT ID | STATE PROJ. NO. | SHEET NO.

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

MOTORIST AWARENESS SYSTEM

INTERIM STANDARD

THIS INDEX REPLACES INDEX NO. 670 OF THE ROADWAY STANDARDS, DATED JANUARY 2004.

APPROVED BY

DATE | NO. | 1 of 1 | 0670

APPROVED MOTORIST SAFETY MESSAGES FOR PORTABLE CHANGEABLE MESSAGE SIGNS ON THE STATE HIGHWAY SYSTEM

Latest Revision Date: 4/23/04

MESSAGE	
Phase One	Phase Two
BUCKLE UP	SAVE LIVES
SPEEDING WRECKS YOUR DAY	SLOW DOWN
NO EXCUSE	BUCKLE UP
CHECK POINT AHEAD	PREPARE TO STOP
CRASH AHEAD	SLOW DOWN
CRASH AHEAD	ROAD CLOSED
CRASH AHEAD	PREPARE TO STOP
CRASH AHEAD	PREPARE TO MERGE
DUI DECIDE BEFORE	YOU DRIVE
CHECK YOUR SPEED	WE ARE
BELTS WON'T WORK	UNLESS YOU USE THEM
REPORT IMPAIRED DRIVERS	DIAL *FHP
NO WORK DURING HOLIDAYS	DON'T DRINK & DRIVE

MESSAGE	
Phase One	Phase Two
DRINK AND DRIVE	GO TO JAIL
SPEED LIMIT ENFORCED	SLOW DOWN
OBEY SPEED LIMIT	
AN ALERT DRIVER CAN	AVOID A CRASH
HEAVY TRAFFIC	BE PATIENT
HAVE A SAFE HOLIDAY	DRIVE SAFELY
KEEP SAFE DISTANCE	STAY SAFE
RADAR IN USE	ARE YOU SPEEDING
SPEEDING COSTS MONEY	SLOW DOWN
AIRCRAFT SPEED CHECK	NEXT "XX" MILES
REST AREA AHEAD	TAKE A BREAK
SEATBELT DUI CHECK	PREPARE TO STOP
NO WORK DURING HOLIDAYS	OBEY SPEED LIMIT

MESSAGE	
Phase One	Phase Two
WARNING TROOPERS PATROL	IN PLAIN CARS
SIGNAL BEFORE	CHANGING LANES
SLOWER TRAFFIC	KEEP RIGHT
FOG OR RAIN	TURN ON LIGHTS
BUCKLE UP	"XXXX" COUNTY
DUI CHECK AHEAD	PREPARE TO STOP
DRIVERS LICENSE CHECK	PREPARE TO STOP
PREVENT A TRAGEDY	DON'T DRINK & DRIVE
REPORT RECKLESS DRIVERS	DIAL *FHP
BUCKLE UP	JUST DO IT
SPEED CHECK	NEXT "XX" MILES
NO WORK DURING HOLIDAYS	BUCKLE UP
CLICK IT	OR TICKET

APPROVED MOTORIST SAFETY MESSAGES FOR PORTABLE CHANGEABLE MESSAGE SIGNS
ON THE STATE HIGHWAY SYSTEM (Page 2)
Latest Revision Date: 4/23/04

PATROL IN PROGRESS	BUCKLE UP FLORIDA