EVALUATION OF THE ALABAMA TICKETING AGGRESSIVE

CARS AND TRUCKS SELECTIVE

ENFORCEMENT PROGRAM

by

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A THESIS

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ABSTRACT

Crashes involving passenger vehicles and large commercial motor vehicles have a greater potential for being severe. A summary of crash statistics involving these types of crashes is presented and the problem is examined. Selective Traffic Enforcement Programs attempt to curb particular causes of crashes by using media campaigns and high-visibility enforcement. A background on the Click It or Ticket and Ticketing Aggressive Cars and Trucks programs is given. The focus of this research was to evaluate the effectiveness of the Alabama implementation of the Ticketing Aggressive Cars and Trucks program from January 2010-August 2015.

Data was collected from various sources to evaluate the program. This included crash data as well as officer reports from each program shift completed. The crash data was mapped and evaluated for hotspots. Officer reports were evaluated for how many hours were worked, where officers focused their enforcement, how many and what types of citations were written, and the effects of varying levels of enforcement on crash rates. Analysis of Variation and Fisher's Least Significant Difference post-hoc tests were performed to evaluate this data. In addition to the above sources of data, video observation of traffic events were also recorded and analyzed for effects of the program. Evaluators scored each car-truck interaction as safe, or unsafe, with unsafe actions including changing lanes too close to the front of a truck, remaining in a truck's blind spot for an unsafe amount of time, or following too close to another vehicle.

The results of the analysis showed that the program was effective. Officers successfully focused their enforcement on areas with the highest density of the targeted crashes. Medium levels of enforcement decreased crashes versus low levels (506 versus 555 crashes, significant at p-value 0.003.) High and medium enforcement was shown to reduce the number of crashes compared with low levels of enforcement (509 versus 555 crashes, significant at p-value 0.004.) Observational data was not able to demonstrate any noticeable effects of the program.

Recommendations to improve the program include increasing public awareness of the program, increasing officer contacts per hour, concentrating officer enforcement over designated periods and designating months as enforcement or non-enforcement months for purposes of evaluation. Ways to improve the evaluation of the program included the introduction of a control corridor and automation of observational analysis.

DEDICATION

I dedicate this thesis to my wife for encouraging me and supporting me through my college education, my professors for their wisdom and guidance through the process, and my colleagues for their help and assistance.

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variation
CAPS	Center for Advanced Public Safety
CARE	Critical Analysis Reporting Environment
CIoT	Click It or Ticket
CMV	Commercial Motor Vehicle
CMV 2+	CMV Involved plus at least one other vehicle
FMCSA	Federal Motor Carrier Safety Administration
NHTSA	National Highway Transportation Safety Administration
STEP	Selective Traffic Enforcement Program
TACT	Ticketing Aggressive Cars and Trucks
VMS	Variable Message Sign

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Due to a kinetic energy differential, crashes involving the passenger vehicles and large commercial motor vehicles (CMVs) have a greater potential for being severe. Using Center for Advanced Public Safety (CAPS) data, this differential can be quantified. In Alabama from January 2010-August 2015, some 35,000 crashes involved a CMV and at least one other vehicle (CMV 2+). Of these crashes, 437 were fatal crashes (492 total fatalities), 1,791 crashes involved incapacitating injuries, and 2,530 involved non-incapacitating injuries (10,454 total incapacitating and non-incapacitating injuries). The causal unit was a CMV in about 50% of these crashes, while a non CMV unit caused the crash in 45% of crashes. From this statistic, it was seen that both CMVs and passenger vehicles contributed to CMV involved crashes. For this reason, targeting both CMVs and passenger vehicles had the capacity to reduce crashes and injuries by any safety program. When examining fatalities across all crashes, both CMV involved and CMV not involved, CMV involved fatalities were overrepresented. During this time period, fatalities occurred at a higher rate in CMV involved crashes (1.24% of all crashes) than CMV not involved crashes (0.56% of all crashes). (CAPS, 2016) Similar statistics were seen nationwide in large truck and bus crash statistics. From January 2011-November 2015, 700,783 crashes involved a large truck or bus. As a result of these crashes, 21,573 fatalities and 410,823 injuries occurred. (FMCSA, 2016)

1.2 Background

Selective Traffic Enforcement Programs (STEPs) have been used for decades to address specific traffic violation types that lead to an increase in unsafe behavior, crashes, injuries and fatalities. Canada was the first to show that highly publicized enforcement programs aimed at increasing seat belt usage could be an effective way to increase overall compliance, not just during enforcement periods (NHTSA, 2001), (FMCSA, 2007). Due to the success of the Canadian occupant protection enforcement program, the United States National Highway Traffic Safety Administration (NHTSA) considered how to replicate the program and devised the widely deployed Click It or Ticket (CIoT) seat belt usage selective enforcement program. CIoT was devised to encourage the increase of seat belt use due to frighteningly low rates and high chances of fatalities in crashes without seat belt usage. The CIoT program was a successful demonstration of how STEPs can achieve high rates of compliance even outside of enforcement periods. The seat belt usage rate went from as low as 14 percent in 1984 to 84 percent in 2011 (Nichols & Solomon, Click It or Ticket Evaluation 2011, 2013), (NHTSA, 2001). Following the successful implementation of the CIoT program and other STEPs, Congress directed NHTSA and the Federal Motor Carrier Safety Administration (FMCSA) to develop a STEP aimed at making passenger vehicle and CMV interactions safer. These agencies worked with the Washington (State) Traffic Safety Commission to develop a STEP program which has since expanded nationwide (FMCSA, 2007).

1.3 Purpose

STEPs are widely used to target law enforcement efforts at particular behaviors that are linked to high crash, injury, and fatality rates with a goal of changing overall driver behavior. With each STEP, a variety of methods for analyzing the effectiveness of the program are employed. The purpose of this thesis is to perform a comprehensive evaluation of the Ticketing Aggressive Cars and Trucks (TACT) program for the entire program implementation in Alabama. Traditional analysis methods such as crash data, citation data, and observed behavior will be applied to the Alabama TACT implementation as well as less common methods of analysis, such as geographic comparisons based on where enforcement was focused and officer hour analysis.

1.4 Thesis Breakdown

This thesis is organized in five chapters. Chapter 2 Literature Review presents a literature review of various selective enforcement program evaluations. A summary of how each program was evaluated was prepared in order to form the basis for how and why this evaluation was performed. Chapter 3 Methodology presents how all data was collected and processed. Furthermore, it presents how each type of evaluation, including spatial, temporal, and observational analysis was performed. Chapter 4 Results reports the outputs of these three analysis methods. Chapter 5 Recommendations for Future TACT Enforcement and Evaluation discusses ways to increase the effectiveness of the TACT program.

CHAPTER 2: LITERATURE REVIEW

2.1 Literature Review

Selective enforcement programs traditionally used officer hours above and beyond normally budgeted levels. Funding for these additional officer hours often came from federal agencies, state Departments of Transportation (DOTs) or other agencies than the actual enforcement agency. These funds have paid for such programs as CIoT, alcohol impaired driving countermeasures enforcement, and TACT. As a condition of this funding, most STEPs included a mechanism to evaluate the effectiveness of the program to ascertain if they are worth the investment and whether they achieve the stated objectives of the STEP. A literature review was conducted to ascertain how STEPs are evaluated both in the United States and worldwide. The results of this search were summarized below in Table 1. Through the literature review, four measures of effectiveness were found as the basis for evaluation of each STEP: observation, citations, surveys, and crashes.

Table 1: Review of STEP evaluation methods

Citation	Location	Agency	Enforcement Focus	Measures of effectiveness				Time Frame
				Observation	Citations	Surveys	Crashes	
Solomon, Compton, Preusser	Nationwide	NHTSA	Click it or Ticket	✓	✓	✓		2000-2004
NHTSA, 2001	Nationwide	NHTSA	Click it or Ticket	✓	✓	✓		2001
Luca	Massachusetts	MHSD	Click it or Ticket		✓		✓	2002
Chaudhary, Solomon, Cosgrove	Nationwide	NHTSA	Click it or Ticket			✓		2003
Ledingham, Tison, Casanova, Preusser	New York City	NHTSA	Click it or Ticket	✓	✓	✓		2007-2008
Nichols, Solomon	Nationwide	NHTSA	Click it or Ticket	✓	✓	✓	✓	2010
Meed	Canada	CVSA	CMV Air Brakes	✓	✓			1999-2000
Geary, Ledingham, Maloney	Conneticut	CDOT	Seat Belt	✓	✓			1997-2005
Dee	Nationwide	NHTSA	Seat Belt	✓	✓	✓	✓	1998
Amiotte, Balany, Humphrey	Pine Ridge Indian	Indian Health	Seat Belt	✓	✓		✓	2007-2012
Hellemons	The Netherlands	Dutch Police	Speed	✓				1993-1994
Blais, Carnis	France	ONISR (France)	Speed cameras	✓	✓		✓	2003-2010
Abdulsalam, Hassan, Abd El Halim	Kuwait	(Kuwait)	Speed cameras	✓	✓		✓	2008-2010
Thomas, Blomberg, Peck, Cosgrove, Salzberg	Washington	WTSC	TACT	✓	✓	✓		2004-2005
FMCSA, 2007	Washington	FMCSA	TACT		✓	✓	✓	2007
Cambridge Systematics	Pennsylvania	PennDOT	TACT	✓	✓	✓	✓	2008
Green	Kentucky	KY State Police	TACT	✓		✓	✓	2010
Cunningham, Schroeder, Vaughan, Hughes	North Carolina	NC ITRE	TACT	✓				2010
Tarko, Anasstasopoulos, Zuriaga	Indiana	IDOT	TACT	✓		✓		2011
Kostyniuk, Blower, Molnar, Eby, St. Louis,	Michigan	MSP	TACT	✓		✓	✓	2014
Nazif-Munoz, Quesnel-Vallée, van den Berg	Chile	(Chile)	Traffic General		✓		✓	2000-2012
Blais, Dupont	Worldwide	N/A	Traffic General				✓	Meta Analysis

2.2 Evaluation Types

Observation was found as the most common evaluation method, used in seventeen of the twenty-two studies. As seen in Table 1, CIoT evaluations most often relied directly upon observation as the National Occupant Protection Use Survey (NOPUS) was an existing program that observes a simple binary of whether occupants were or were not using their seat belt

(Nichols & Solomon, Click It or Ticket Evaluation 2010, 2013), (Ledingham, Tison, Casanova, & Preusser, 2009), (Solomon, Compton, & Preusser, 2004). Programs such as Operation Air Brake, which was aimed at reducing air brake related safety violations in CMVs, observed whether air brakes where properly maintained at roadside checks across periods of the STEP (Meed, 2000). Observation has also been used for TACT evaluation. While observation is not as straightforward for TACT as it is for CIoT due to the non-binary and subjective nature of potential unsafe behavior around trucks, several studies have used some form of this evaluation. One TACT study used unmarked moving patrol vehicles to record video along with officer narration of car/truck interactions (Cambridge Systematics, 2009). Another TACT study used temporary sensors placed in the middle of interstate lanes to collect data on trucks and cars tailgating each other through various phases of the program (Green). North Carolina evaluated TACT effectiveness using stationary video processed automatically by software to detect following too close behavior (Cunningham, Schroeder, Vaughan, & Hughes, 2010). Indiana used a mobile traffic camera to record video of traffic and extracted similar data (Tarko, Anastasopoulos, & Zuriaga, 2011). Observation methods such as these were used in this evaluation to determine the effectiveness of the Alabama TACT implementation

The second most common form of evaluation was citation analysis. Citations were used for evaluations in fifteen of twenty-two studies. Citations have been used to analyze program effectiveness in multiple CIoT applications by comparing before, during and after levels of seat belt violations (Solomon, 2002), (Ledingham, Tison, Casanova, & Preusser, 2009), (Solomon, Compton, & Preusser, 2004), (NHTSA, 2001). Citation statistics have also been used in TACT program evaluations. Pennsylvania evaluated the severity of the problem of aggressive cars and trucks via citation analysis, however, due to privacy laws, state police personnel had to transcribe citations to remove identifying information, leading to a somewhat limited dataset of two weeks' worth of citations (Cambridge Systematics, 2009). Another TACT program used citation data to evaluate a profile of those cited and times of the day that led to a disproportionate amount of TACT violations (Thomas, Blomberg, Peek, Cosgrove, & Salzberg, 2008). Citation analysis was used in the evaluation of the Alabama TACT program in order to consider how many citations and warnings were written as part of the program.

Surveys have been used as part of evaluations of STEPs; twelve of twenty-two studies used surveys. CIoT has often utilized driver surveys to evaluate motorists awareness of the media component of the program in several states (Nichols & Solomon, Click It or Ticket Evaluation 2010, 2013), (Ledingham, Tison, Casanova, & Preusser, 2009), (NHTSA, 2001). Driver surveys have also been used to evaluate TACT programs, with distribution through driver's license offices in some cases (Thomas, Blomberg, Peek, Cosgrove, & Salzberg, 2008), (Cambridge Systematics, 2009). However, one report raised concerns that surveys are not very well thought out, miss large proportions of the overall driving demographic pool, and that having surveys filled out in driver's license offices may lead to less thoughtful survey responses (Cambridge Systematics, 2009). It was decided not to use survey evaluation in this analysis of the Alabama TACT implementation due to low survey turnout and concerns about survey design and distribution.

The last common type of evaluation method was crash data. Crash data was used in twelve of twenty-two studies. Crash data was usually analyzed for number of crashes applicable to a particular STEP, injury severity or fatality, as well as other items for each period in a STEP. Crash data has been analyzed in a variety of CIoT evaluations by comparing fatalities and injuries with and without seatbelt usage across periods of the program (Nichols & Solomon, Click It or Ticket Evaluation 2010, 2013), (Solomon, Compton, & Preusser, 2004), (NHTSA, 2001). Crash analysis has also been used in general moving violation selective enforcement evaluation. One such study performed a meta-analysis of 38 selective enforcement program evaluations mostly on the basis of crash data (Blais & Dupont, 2005). Crash data has also been used for TACT both for site selection and program evaluation. The FMCSA Guidelines for TACT suggested that sites be selected in areas with a history of high car-truck crashes in order to be most effective and that they also be evaluated using crash statistics (FMCSA, 2007). Crash data was used extensively in the evaluation of the Alabama TACT program through hotspot and temporal analyses.

Each selective enforcement evaluation technique has its own applicability to a particular program. Another complicating factor could be the type of data available to the evaluator. However, the most common evaluation techniques for STEP evaluation are observation, citations, surveys, and crash data. There are potentially other ways to evaluate a STEP depending on the data available to a researcher such as geographic analysis or temporal analysis.

CHAPTER 3: METHODOLOGY

3.1 Introduction

A methodology was developed to use multiple sources of data available across the Alabama implementation of the TACT program in order to provide a thorough evaluation. The evaluation will examine crash data, citation data, officer hour data, geographical evaluation, and observation data. Work to begin this evaluation involved collecting all necessary data from the sources and ensuring that the data was in a useable form.

3.2 Data Sources

Data was collected in a variety of ways. Crash data was aggregated by CAPS at The University of Alabama from individual electronic crash reports from law enforcement agencies across the state. CAPS then processed this data into databases for use in their Critical Analysis Reporting Environment (CARE) software that allows for a wide range of analytical and statistical examinations of the entire database or a subset of filtered results. A specialized version of this database was created by CAPS personnel to cover the entire TACT program implementation analyzed in this paper from January 2010-August 2015. These dates were chosen due to the major TACT implementation beginning in January 2010 and August 2015 was the most recent quality checked crash data available at the time of data gathering. Citation data, officer hour, and geographic data for the TACT program was also collected by CAPS via spreadsheet filled out by law enforcement officers after each TACT overtime shift. Officers filled out several fields regarding their TACT activity and location, then uploaded the worksheet to a CAPS web server where the data was stored in an SQL database. Observation data was collected by study team members by placing a stationary camera on a tripod on an overpass over interstate in the study corridor with an unobstructed view of a length of roadway.

3.3 Crash Data Methodology

Crash data was analyzed using the CARE software. CARE allows for filtering specific crashes from the overall database of all recorded crashes. First, crashes involving a CMV and at least one other vehicle were filtered out to examine crashes that could involve a TACT targeted causation. This methodology differs from the CAPS analysis of the TACT program that evaluated all heavy truck crashes (Brown, Smith, Dixon, Engelke, & Jones, 2014). The choice to only include CMV 2+ crashes was found in other literature as well and more closely target crashes that could be curbed by TACT efforts (Cambridge Systematics, 2009). From January 2010-August 2015, there were some 740,000 reported crashes in Alabama, of which some 42,000 involved a CMV and some 35,000 involved CMV 2+. Intestate routes in particular were examined to arrive at about 7,300 crashes. The filtered crashes are shown in Figure 1.In addition to viewing all crashes, particular areas of concern were determined using CARE. CARE allows users to find areas of particular crash densities using mileposted strip map function to find hotspots. A density of 30 CMV 2+ crashes over a two-mile segment produced 85 hotspots across the state. These hotspots, shown in Figure 2, amount to the 170 miles of interstate where truck and passenger vehicle accidents are most dense.

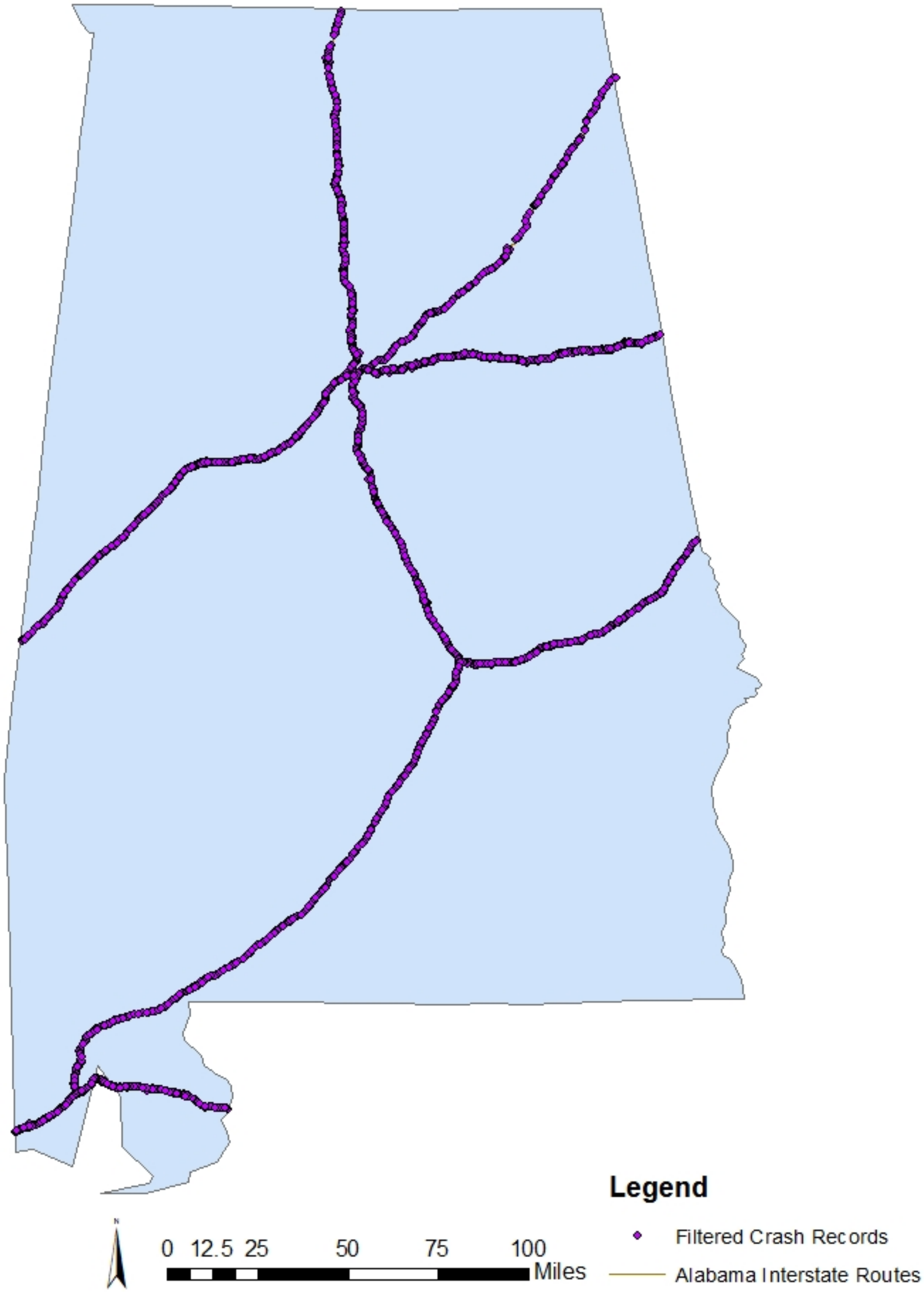

Figure 1: Filtered CMV 2+ crashes, January 2010-August 2015

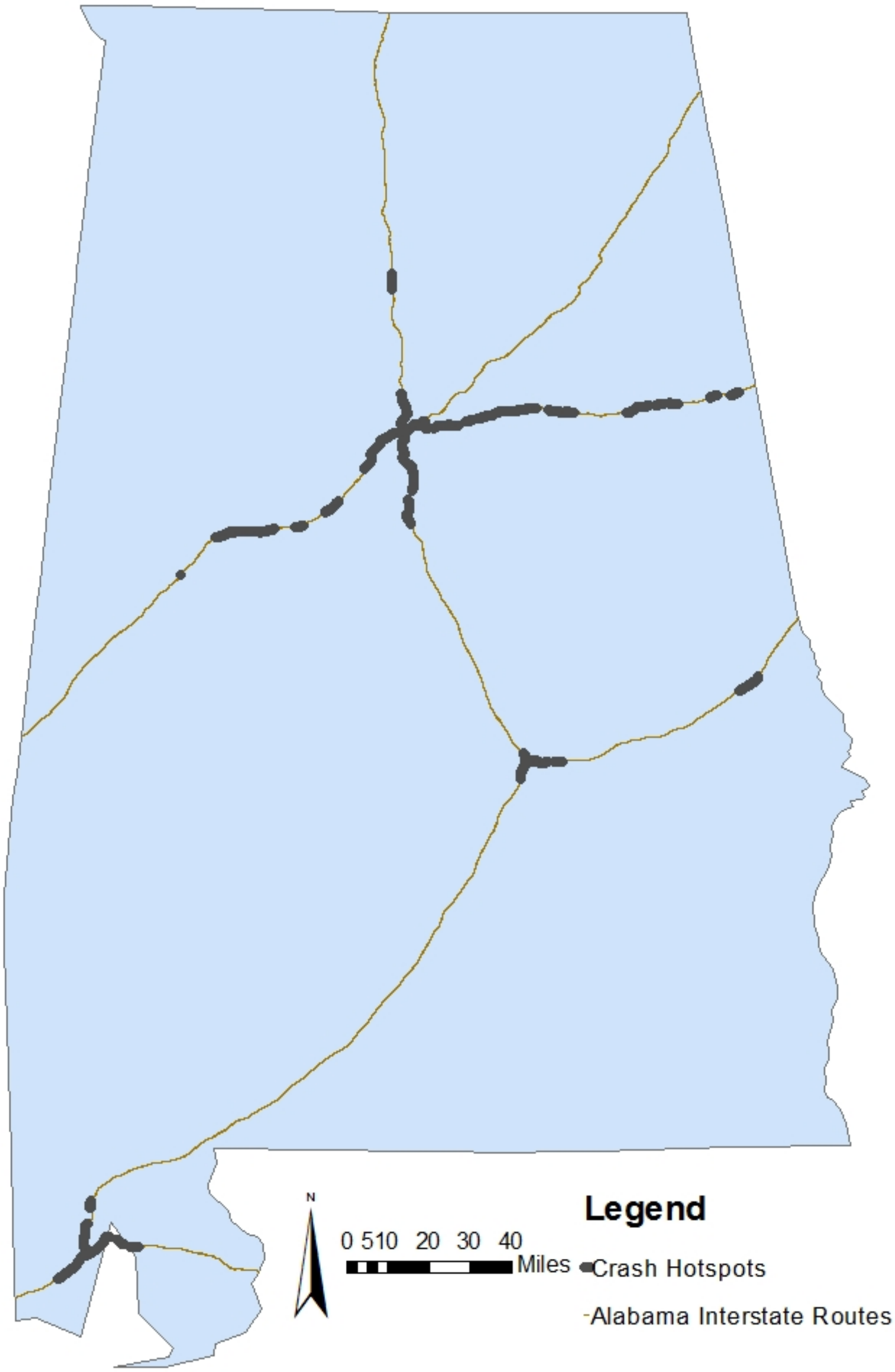

Figure 2: CMV 2+ crash hotspots

3.4 Officer Worksheet Data

The worksheet officers filled out after each TACT shift provided a large amount of the data analyzed in this paper. This data was extracted from a Structured Query Language (SQL) database and analyzed using Microsoft Excel and a Geographic Information System (GIS). Fields on the officer worksheet are shown below in Figure 3. From this data, a wide range of information was available to analyze the effectiveness of the TACT program. From January 2010-August 2015, some 9,500 officer reports were filed for TACT shifts. These reports covered many interstate, US highway, and state highway routes throughout the state. All total officers worked over 43,000 hours of TACT enforcement for this time period. A summary of all TACT related citations issued was shown in Table 2.

Interstate routes were singled out for a brief analysis of TACT hours on these roads. TACT enforcement heavily focused on interstate routes, about 50% of officer hours were worked on these routes. Despite the real-life sharing of routes for Interstates 20 & 59 in the western portion of the state, in the interest of separating routes and eliminating double counting of data, all officer reports on the shared portion are reported as Interstate 59. Therefore, the Interstate 20 reports only cover the eastern half of the state. Once these routes were selected, data from these routes were imported into ArcGIS for further geographic analysis. This was accomplished by joining a state mileposted route shapefile (Alabama Department of Transportation, 2016) and filtered sets of TACT officer reports by route. Although officer reports are shown as points, it should be noted that the vast majority of TACT shifts worked a 10-mile stretch of interstate, with 5 miles of coverage on either side of the point. All selected officer reports are shown in Figure 4.

TACT SUMMARY

Ticketing Aggressive Cars and Trucks

Name		Location	
Beginning Mile Post		Ending Mile Post	
Department		Beginning Time	
Date		Ending Time	

	Commercial Vehicle			Non-Commercial Vehcile		
	Citation	Warnings	Total	Citation	Warning	Total
Speeding			0			0
Following to Close			0			0
Improper Lane Change			0			0
Failure to Signal			0			0
Aggressive Driving			0			0
Total	**0**	**0**	**0**	**0**	**0**	**0**

Inspections	Driver Violations	Vehicle Violations	Drivers OS	Vehicle OS
Level 1				
Level 2				
Level 3				
Total	**0**	**0**	**0**	**0**

Other Violations

	Commercial Vehicle			Non-Commercial Vehcile		
	Citation	Warnings	Total	Citation	Warning	Total
Seatbelt Violation			0			0
No Insurance			0			0
DL Violation			0			0
Improper Passing			0			0
Other Traffic Violations			0			0
Total	**0**	**0**	**0**	**0**	**0**	**0**

Figure 3: TACT officer worksheet

Table 2: TACT Citation Summary

	CMV		Non-CMV	
	Citation	Warning	Citation	Warning
Speeding	930	1024	37478	21034
Following Too Close	61	127	824	1734
Improper Lane Change	33	87	670	1746
Improper Passing	11	11	123	108

Table 3: Number of reports per route

Route	Number of Reports	Miles of Route	Reports/Mile
Interstate 10	273	66	4.1
Interstate 20	706	84	8.4
Interstate 59	970	241	4.0
Interstate 65	2090	366	5.7
Interstate 85	790	80	9.9

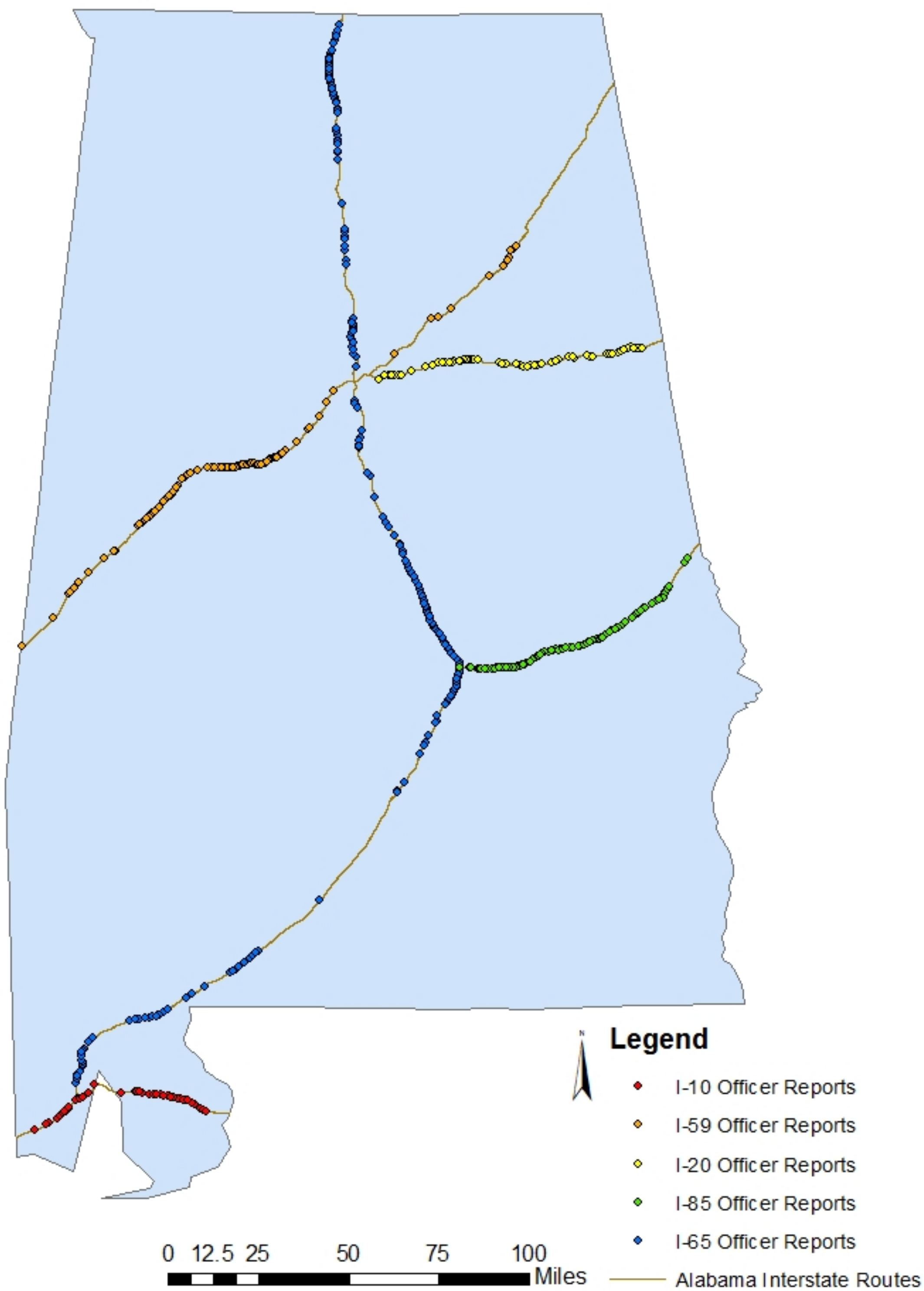

Figure 4: Map of TACT officer reports, January 2010-August 2015 for major interstate routes

3.5 Spatial Analysis

Although some STEPs are analyzed by comparing control and study corridors, this was not possible due to the widespread implementation of TACT in Alabama. Instead, areas of low and high enforcement were considered as an alternate method of analysis. Once the officer reports and routes were joined, data on CMV 2+ crashes on the selected routes were exported from CAPS and joined to GIS. Approximately 145 crash records (out of some 7,300) were removed from the dataset due to erroneous GPS coordinates that precluded these sites from any geographical analysis.

In order to perform the evaluation, hotspots of officer enforcement were determined so that crash data could be compared to less active areas of TACT enforcement. This was accomplished by creating Kernel Density displays using the Spatial Analyst extension in ArcGIS. For each interstate route, a kernel density was created and the resulting density was classified using standard deviation to provide break points. The lowest density for each route was made invisible in order to see clearly where enforcement was heavier. Due to different enforcement levels on each route, the density levels are not directly comparable. The hotspots of TACT enforcement are shown in Figure 5.

Once these hotspots were mapped, the mileposts of the starting and ending of each high density enforcement area were recorded. Some high density areas were close to another high density area with a lower density area between points, but when the range patrolled by the officer was considered it was clear that the area of lower density was patrolled at a high rate. Table 4 showed the hotspot locations and number of TACT shifts completed in each hotspot. The crash hotspots were shown in the same format in Table 5. If the crash hotspots were within one mile of the next closest hotspot, they were combined to reduce the number of hotspots and consider the overall crash areas.

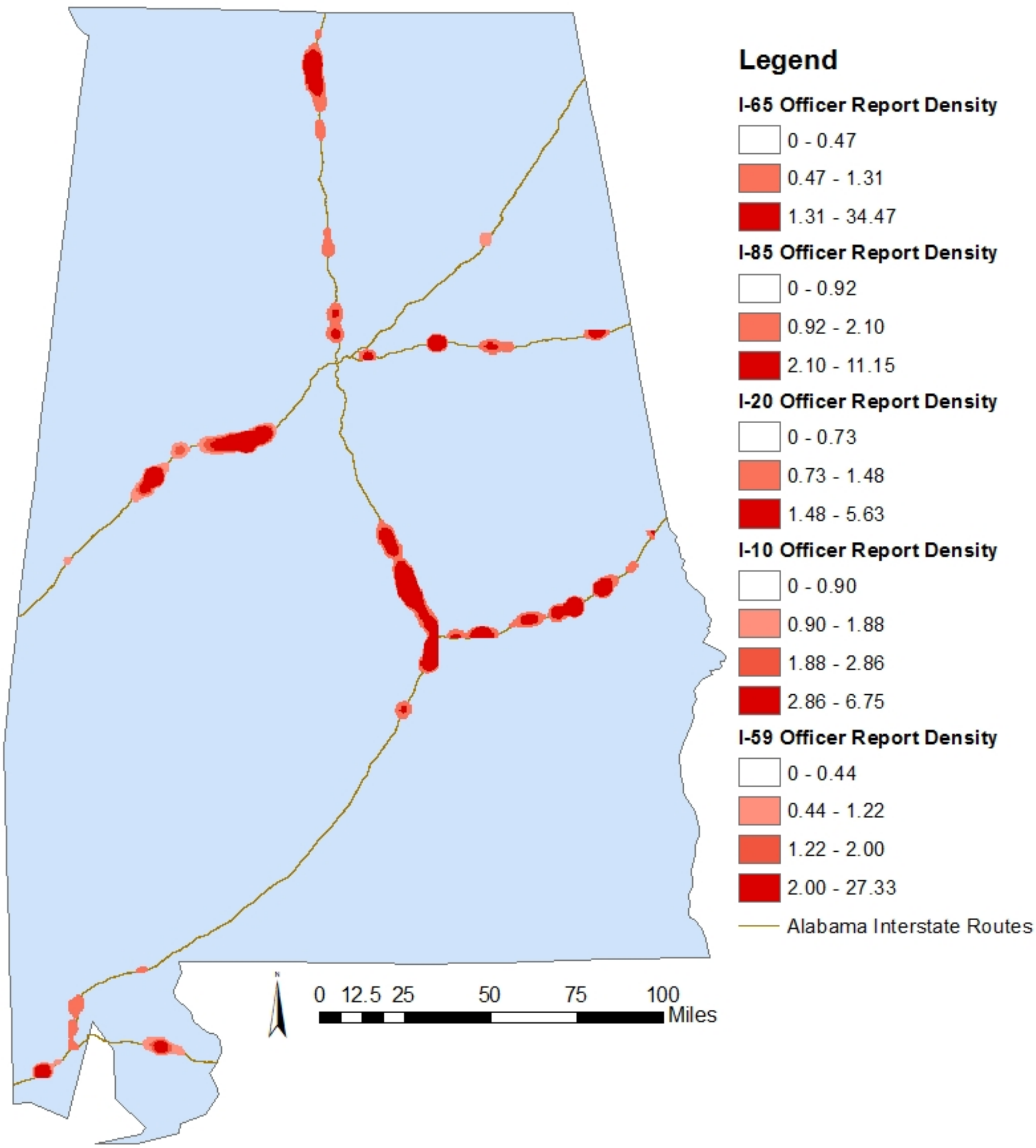

Figure 5: TACT officer report hotspots

Table 4: TACT Enforcement hotspots

Route	Number of TACT Shifts	Beginning MP	Ending MP	Distance	Number of Shifts per mile
Interstate 10	99	4	15	11	9
Interstate 10	81	41	56	15	5
Interstate 20	82	130	142	12	7
Interstate 20	215	150	164	14	15
Interstate 20	64	168	180	12	5
Interstate 20	141	197	212	15	9
Interstate 59	196	50	65	15	13
Interstate 59	662	70	100	30	22
Interstate 65	22	142	152	10	2
Interstate 65	1527	157	210	53	29
Interstate 65	49	264	280	16	3
Interstate 65	255	339	360	21	12
Interstate 85	238	1	21	20	12
Interstate 85	443	22	60	38	12
Interstate 85	39	70	80	10	4

Table 5: Crash hotspots

Route	Crashes	Beginning MP	Ending MP	Distance	Number of crashes per mile
Interstate 10	441	11	28	17	26
Interstate 10	30	30	32	2	15
Interstate 10	36	33.5	35.5	2	18
Interstate 20	39	130.2	132.2	2	20
Interstate 20	124	134	140	6	21
Interstate 20	31	142	144	2	16
Interstate 20	291	145	160	15	19
Interstate 20	93	163	169	6	16
Interstate 20	157	182	188	6	26
Interstate 20	30	190	192	2	15
Interstate 20	30	193	195	2	15
Interstate 20	31	203	205	2	16
Interstate 20	32	208	210	2	16
Interstate 59	373	68	83	15	25
Interstate 59	31	88	90	2	16
Interstate 59	65	96	100	4	16
Interstate 59	679	111	132	21	32
Interstate 65	232	0	8	8	29
Interstate 65	33	12	14	2	17
Interstate 65	136	167	173	6	23
Interstate 65	128	235	242	7	18
Interstate 65	920	245	271	26	35
Interstate 65	66	297	301	4	17
Interstate 85	129	0	6	6	22
Interstate 85	33	8	10	2	17
Interstate 85	125	57	63	6	21

3.6 Temporal Analysis

In addition to spatial analysis, another method of analyzing the TACT program not found in the literature search was comparing crash rates to enforcement levels for each month of the analysis program. Although the ongoing nature of the TACT program made it impossible to compare direct before/during/after enforcement levels of crashes, it was possible to examine crashes with respect to low, medium or high levels of enforcement during the evaluation period.

For each calendar month during the analysis period, the overall statewide TACT enforcement hours were tabulated and months were broken into a high, medium, or low enforcement months. The choice was made to use a mean absolute deviation method to develop the category breaks to reduce the effect of outliers. The breakpoint between low and medium enforcement was 322 hours, and the breakpoint between medium and high was 955 hours. This method resulted in 14 low enforcement months, 40 medium enforcement months, and 14 high enforcement months. Analysis of variation (ANOVA) was performed using SPSS to statistically test whether enforcement levels affected the overall number of CMV 2+ crashes. ANOVA is a statistical tool for comparing means between sets of data and analyzing if they are statistically different. It was hypothesized that low enforcement level months would have higher average CMV 2+ crashes as compared to medium and high moths of TACT enforcement. In order to prove that the means are different, ANOVA tests the null hypotheses that the mean number of crashes for low, medium, and high enforcement are the same.

After finding the means were significantly different, a post-hoc test was necessary to determine which pairings were significantly different. While ANOVA demonstrated that at least one mean was different, it cannot tell if low and medium, medium and high, and low and high levels of enforcement are each different. A Fisher's Least Significant Difference test was performed in order to determine which pairings were significant and which were not.

3.7 Observation Methodology

Video of traffic was recorded during distinct periods of the TACT implementation from 2012-2014 as shown in Table 6. Examples of public awareness methods are shown below as well in Figure 6 & Figure 7.

Table 6: TACT Video Recording Periods

Period	Years	Comment (description of event)
Before	2012-2014	Video data collection prior to any enforcement or awareness campaigns
Awareness	2012-2013	Video data collection while wrapped trucks (see Figure 6.) drove the corridor in 2012 and Dynamic Message boards were placed in 2013 (see Figure 7)
Enforcement	2012-2014	Video data collection during the summer TACT enforcement period in the corridor.
After	2012 & 2014	Video data collection after the awareness and enforcement ended

Figure 6: Wrapped Truck used for Public Awareness Campaign in Study Corridor

Figure 7: Dynamic Message Board used for Public Awareness Campaign in Study Corridor

Video was recorded via consumer grade video cameras mounted on tripods on overpasses over Interstate 20/59 near Tuscaloosa. The camera location is shown in Figure 8. Because of the geometry of interstate at this point, traffic was visible and discernable for more than one mile as shown by the yellow line. The camera was placed on the far side of the overpass to observe traffic moving away rather than towards the camera. This provision ensured that drivers could not detect the camera and consequently change their behavior, and also gave a better view of tailgating behavior. An example of the video collected from this position is shown in Figure 9. Video was also collected from an overpass at Exit 110 in 2013.

Figure 8: Location of Video Data Collection

Figure 9: Sample Screenshot from Video Data Collection (Exit 89)

Once video data was recorded, clips were brought back to the lab and edited to break them down into smaller clips. The clips were then assigned a randomized name in order to remove information about which period the clip had been recorded in. This randomization was performed by a team member that did not participate in the analysis in order to eliminate bias in the observer. Select clips were pulled from the general pool to develop methodology and perform training. In order to define when a car and truck was considered to have interacted, an event was defined that stated that at least one truck and at least one care were within three truck lengths of one another. The team worked with Alabama State Troopers to define criteria for when events were safe or unsafe. Unsafe events were defined as the following:

1. Lane Changing event: A car or truck pulled in front of another vehicle within one truck length. (See Figure 10)
2. Blind Spot event: A vehicle that remained in any of a truck's blind spots for 3 or more seconds without a relative difference in speed between vehicles. (See Figure 11)

3. Tailgating event: a vehicle that followed too close behind another vehicle without relative movement away from the front vehicle. (See Figure 12)

Figure 10: Screenshot of middle truck changing lanes too close to first and last truck

Figure 11: Still image of car remaining in truck's blind spot

Figure 12: Screenshot of SUV tailgating truck in center lane

Once the unsafe events were defined, a yearly training meeting was held at the start of the analysis efforts. Over the course of the training, project members were briefed on what to look for and shown videos and asked to score each event as safe, or unsafe, and if unsafe note which unsafe events occurred. This scoring was recorded in a spreadsheet as shown in Table 7.

Table 7: Example of data collection form for observation analysis

Event #	**Time Truck Appears**	**Safe**	**Unsafe**	**Comment (description of event)**

Once each event was scored, discussion took place to ensure a consistent agreement for each analysis. After training, the randomized videos were assigned to project members and analysis was conducted to obtain as large a sample of events as was feasible. Due to the randomization, it was ensured that each reviewer would get a mix of videos from each period as opposed to certain reviewers getting all videos from one-time period and potentially weakening the analysis. Reviewers recorded the number of unsafe events and types, number of safe events, average speed of traffic, and vehicles per hour to ensure outside traffic conditions did not skew the data across time periods. Unfortunately, the project team changed from year to year, so a subjective comparison between years cannot be considered valid, however relative trends among each year are valid as each year was analyzed by the same project team.

CHAPTER 4: RESULTS

4.1 Introduction

The TACT program in Alabama was an ongoing project from 2008 to the current day. Data from January 2010-August 2015 was analyzed multiple ways in order to complete a broad evaluation of the effectiveness of the program. The results of the various analysis methods were reported below.

4.2 Spatial Results

Several attempts were made to examine the relationship between officer enforcement hotspots and crash hotspots. However, no reliable method to evaluate the relationship was found. If there had been a control corridor where enforcement did not take place such a comparison would have been possible. Another method attempted was to find comparable locations where enforcement did or did not take place to evaluate effectiveness. Unfortunately, due to the enforcement taking place in higher volume areas around cities, comparable sites with low or not enforcement were not found.

One method was found to compare the enforcement and crash hotspots. Although the effectiveness of the TACT program cannot be determined from this method, we can consider whether officer hours were weighted more heavily to where crashes are densest Figure 13 shows the crash hotspots overlaid on top of the officer report densities.

Table 8 shows the overlaps between the crash hotspots and the officer hour hotspots. From this overlap list, it was determined that officers enforced TACT the most heavily on 75 miles out of the 175 miles of crash hotspots. Officers successfully enforced most heavily on the crash hotspots, however, little enforcement was done on major metro areas where crashes are densest. Reasons for the lower urban enforcement could include officer safety and the ability to observe infractions.

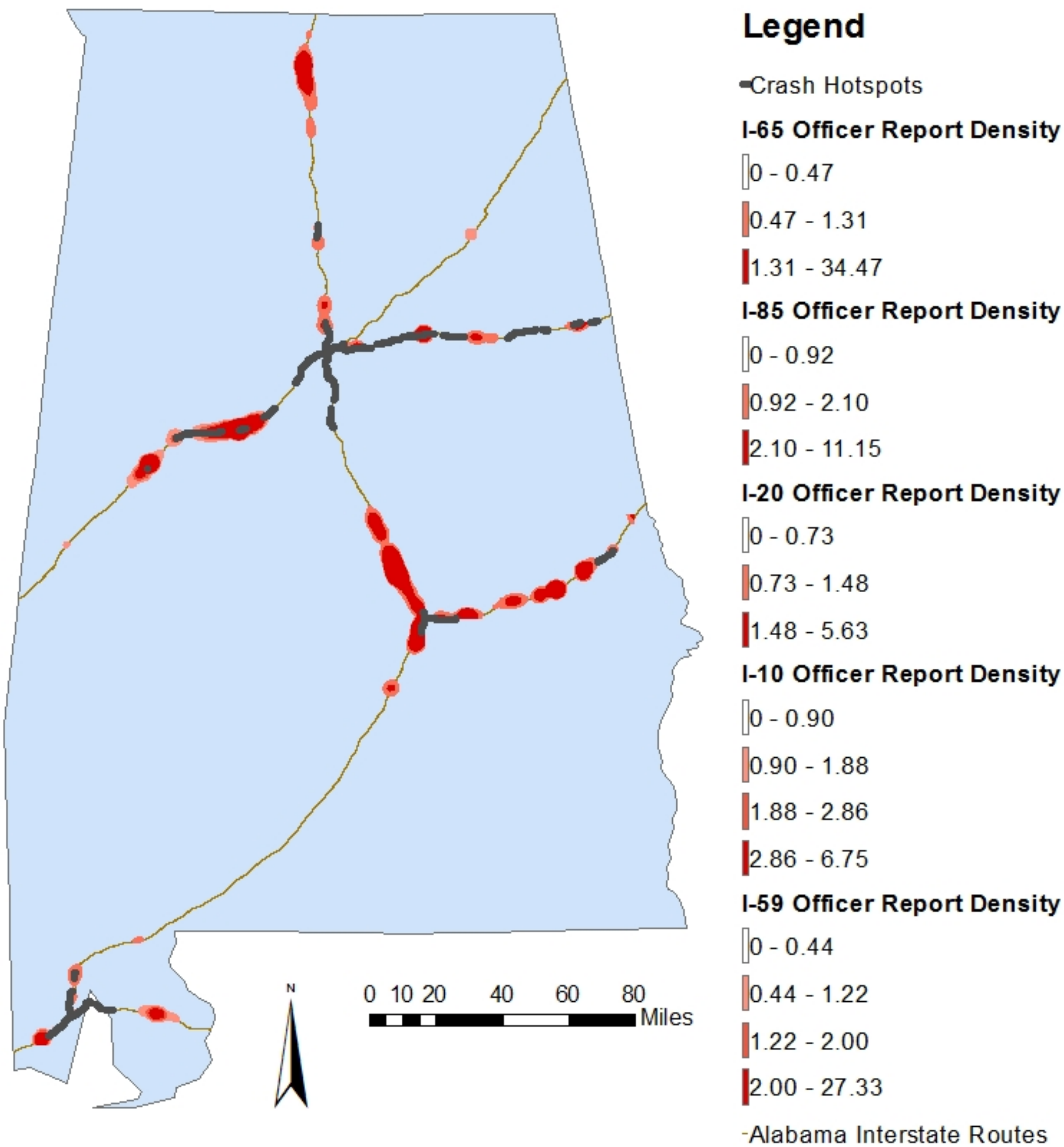

Figure 13: Crash hotspots and officer report densities

Table 8: Overlaps of Crash hotspots and officer report hotspots

Route	**Beginning MP**	**Ending MP**
Interstate 10	11	15
Interstate 20	130	142
Interstate 20	150	160
Interstate 20	163	164
Interstate 20	168	169
Interstate 20	203	205
Interstate 20	208	210
Interstate 59	70	83
Interstate 59	88	90
Interstate 59	96	100
Interstate 65	167	173
Interstate 65	264	271
Interstate 85	1	6
Interstate 85	8	10
Interstate 85	57	60

4.3 Temporal Results

Data was analyzed statewide to determine the effect of varying levels of enforcement on overall crash numbers. ANOVA testing confirmed that varying levels of enforcement did relate to changes in the number of crashes (p value=0.012), assuming significance at a p-value less than or equal to 0.05. By performing a Fisher's Least Significant Distance (LSD) post-hoc test, medium enforcement months (322-955 hours of enforcement) were found to have significantly lower crash rates than low enforcement months (less than 322 hours of enforcement) (p-value=0.003). For medium enforcement months, the average number of crashes was 506, while for low enforcement months the average was 555. However, the same conclusions were not found for the difference between low and high nor medium and high levels of enforcement. The results of the Fisher's LSD test are seen in Table 9 below. The ANOVA and Fisher's LSD Analyses were performed in SPSS. Summary results are provided in the appendix

Table 9: Results of Fisher's post-hoc test between enforcement levels

Enforcement Level		Significance
Low	Medium	.003
	High	.070
Medium	Low	.003
	High	.409
High	Low	.070
	Medium	.409

4.4 Observation Results

The video data were evaluated to determine whether any change in driving behavior occurred over the study periods. A total of 5,743 events were observed on the video clips, 2,788 of which were determined to be unsafe events. Two to four days of video data were collected for the *Before, Public Awareness, Enforcement, and After* study periods each year. The breakdown of events and unsafe events from each year is shown in Table 10.

Table 10: Observations by Year

	Observations	Unsafe Events	% Unsafe
2012	1138	479	42.1%
2013	1322	867	65.6%
2014	3283	1442	43.9%
Totals	**5743**	**2788**	**48.5%**

In order to provide a more direct comparison, the number of unsafe events observed divided by the total number of minutes of video collected in each study period was analyzed. Figure 14 presented a summary of the average rate of unsafe events observed per minute in each of the study periods at the study locations.

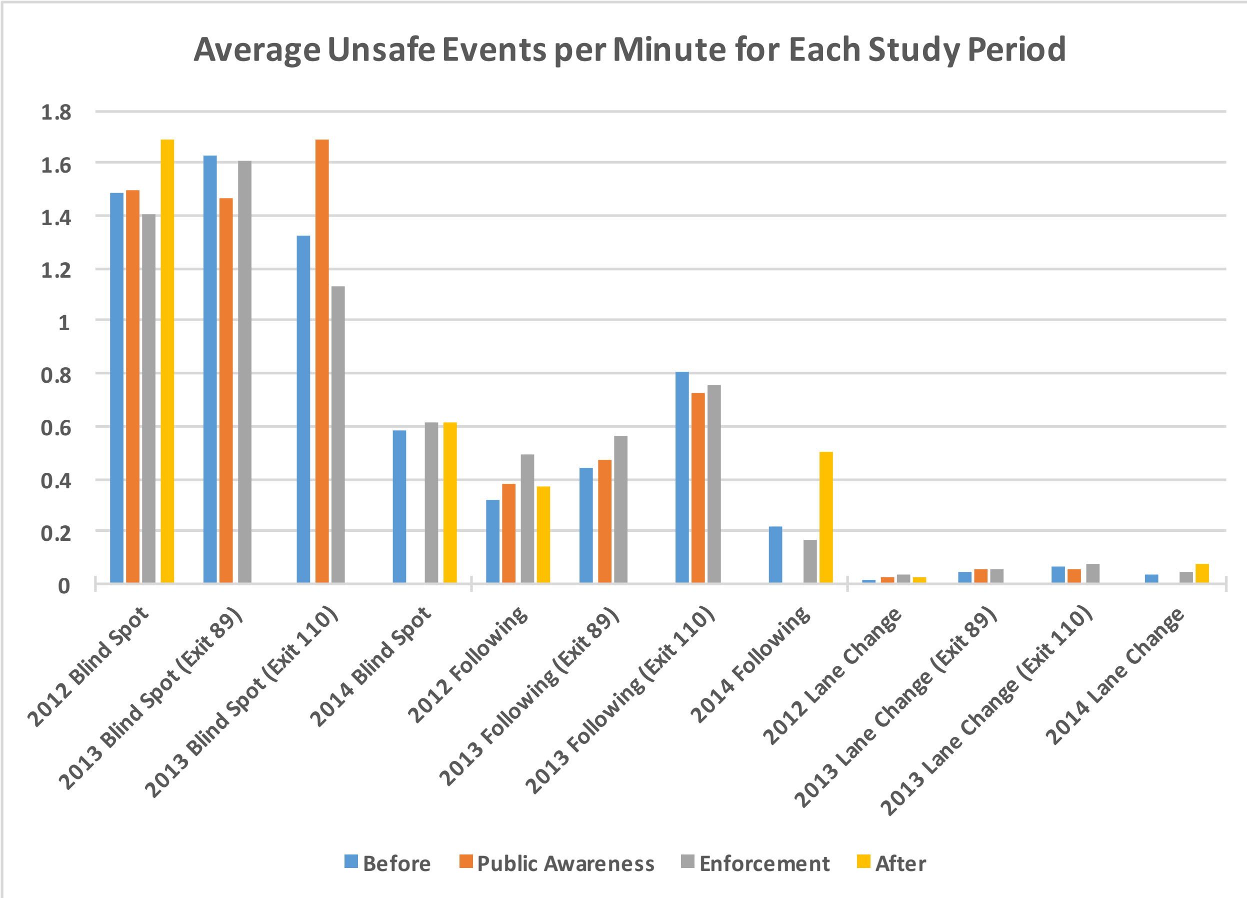

Figure 14: Average unsafe events per minute for each study period

Figure 14 showed that blind spot violations were observed most often, followed by following too close (tailgating), with unsafe lane changes shown the least often. Trends varied for each location and year between periods and no specific change was discernible.

In order to investigate these trends further, Figure 15 showed the level of unsafe events in the *Public Awareness, Enforcement* and *After* periods as a percentage of the number observed during the *Before* period. Categories above 100% showed an unfavorable increase in unsafe events compared to the *Before* period, while those less than 100% showed a desired decrease in unsafe events.

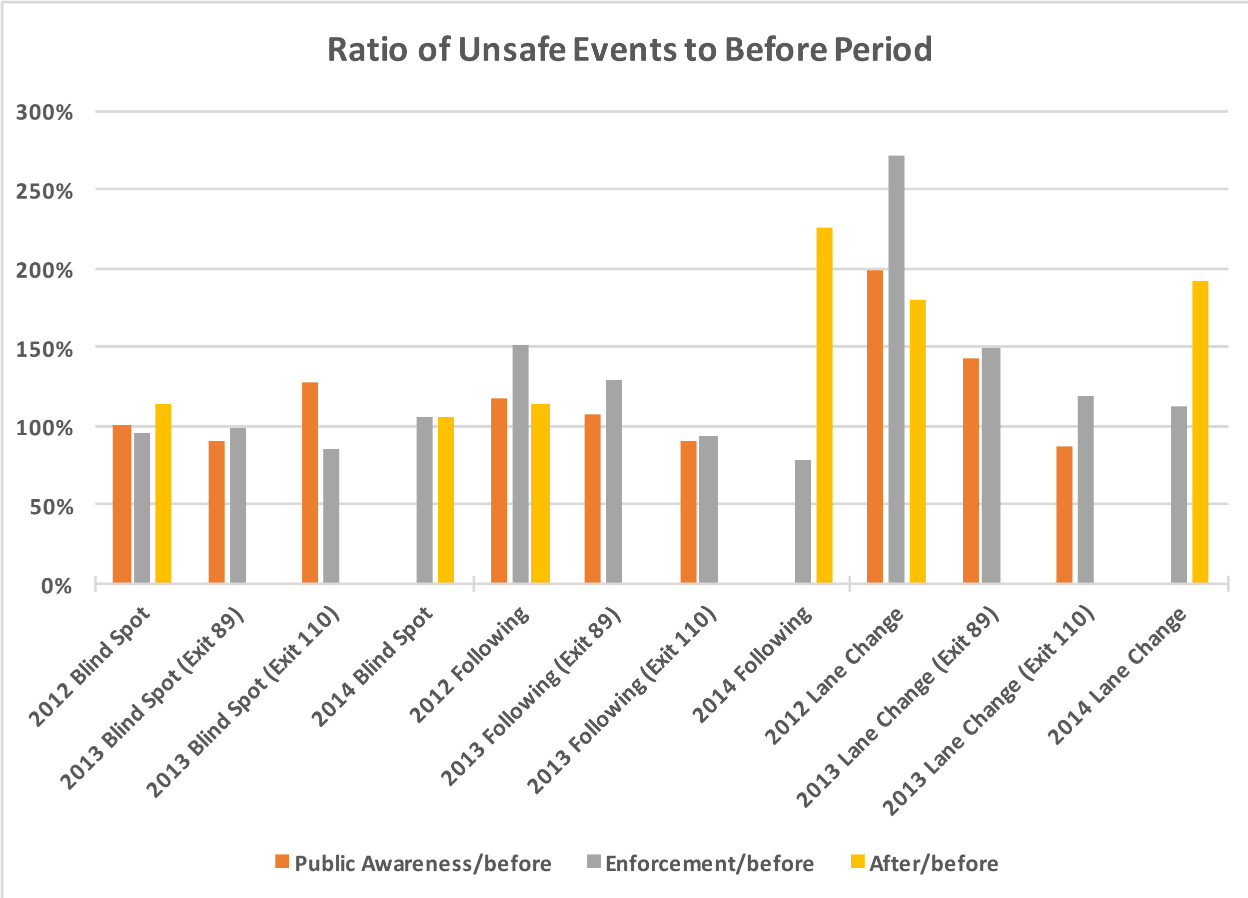

Figure 15: Ratio of unsafe events to before period

Figure 15 illustrated that no discernible trends are seen from year to year. Lane changes did appear to increase compared to the before period significantly, however due to low numbers of observed lane change events (1-2 orders of magnitude smaller) changes in this trend were not statistically significant.

It was theorized that the number of occurrences of unsafe events would be a function of traffic levels. The observational data was collected over three-four study periods each year. As the traffic volume and composition was likely to be different among different study periods, the occurrence of unsafe events was analyzed within the context of traffic conditions. Table 11 presented the average hourly number of unsafe events observed during each study period, hourly traffic volumes per lane and the percentage of the traffic comprising trucks. Using the methodology set out by TRB, with a truck equivalency factor of 1.5 per passenger car, the peak hour traffic was converted to a passenger car equivalency (PCE) (Transportation Research Board, 2010). The number of unsafe events occurring per PCE was then calculated by dividing the average hourly number of unsafe events by the PCE per lane. Again, no meaningful trend was discernable in the observational data.

Table 11: Relationship Between Observed Total Unsafe Events and Traffic

Study Period	Avg Unsafe Events/ Hour	Average Hourly Traffic Volume Per Lane	Average % Trucks	Unsafe Events/ PCE
2012 Before	108	588	0.27	0.1620
2012 Awareness	115	702	0.24	0.1460
2012 Enforcement	116	633	0.26	0.1620
2012 After	125	631	0.24	0.1770
2013 Before (89)	128	519	0.26	0.0727
2013 Awareness (89)	122	559	0.23	0.0646
2013 Enforcement (89)	136	566	0.23	0.0723
2013 Before (110)	134	1001	0.15	0.0613
2013 Awareness (110)	150	1073	0.12	0.0668
2013 Enforcement (110)	120	984	0.14	0.0570
2014 Before	51	504	0.19	0.0050
2014 Enforcement	50	586	0.18	0.0044
2014 After	71	499	0.21	0.0072

The 2012 evaluation showed no substantial differences among the *Before*, *Enforcement* and *After* periods. A very slight numerical increase in the rate of occurrence of unsafe events after enforcement was over was shown. The 2013 study, on the other hand, showed a very slight decrease in the rate of unsafe events after enforcement – neither the 2012 or 2013 evaluations, however, were able to offer meaningful conclusions about the efficacy of the enforcement in affecting driving behavior. It was also interesting to observe that the 2012 and 2013 results indicated that the occurrence of one unsafe driving behavior, riding in the blind spot, decreased with the presence of enforcement in the corridor - whereas the 2014 results indicated no change in blind spots but did show a slight reduction in tailgating (i.e., following too closely). The qualitative comparison of the 2013-2014 TACT evaluation results indicated that the TACT program did not yield any measurable changes in driver behavior using the study methodology.

CHAPTER 5: RECOMMENDATIONS FOR FUTURE TACT ENFORCEMENT AND EVALUATION

5.1 TACT Enforcement Recommendations

Throughout the process of this evaluation, several methods to increase the effectiveness of the TACT enforcement program were theorized. One way to potentially increase effectiveness is to increase the public awareness of the program. Although public awareness of the program was not measured, it is reasonable to think that although there was a push to raise awareness when the program began in 2010 through a press conference, billboard placement, and a significant number of variable message sign reminders to stay safe around trucks, these efforts dropped off as the program aged. The CIoT campaign benefits from the long-running and pervasive nature of the program. An evaluation of public awareness in 2010 found that about 80% of survey respondents knew the CIoT slogan or heard messages reminding them to wear their seat belt, and 40% believed they are likely to be ticketed if they do not wear their seat belt (Nichols & Solomon, Click It or Ticket Evaluation 2010, 2013). While hard numbers are not available for Alabama, other TACT implementations have found about 30% public awareness rates (Cambridge Systematics, 2009), (Green). An increased public awareness campaign could provide a better TACT program outcome as only a miniscule number of drivers will directly be impacted by enforcement action. One way to increase this public awareness would be to schedule annual or bi-annual news conferences, use the VMS boards more often for TACT messages, and increase paid media usage such as billboards.

On the enforcement side of increasing TACT program effectiveness, one way to impact more drivers would be increasing officer contacts per hour. Officer contacts per hour for speeding, following too close, improper lane change, and improper passing only totaled 2.8 contacts per TACT enforcement hour. If officers were able to more efficiently stop aggressive cars and trucks, more drivers would be exposed to the program and potentially correct their behavior. Another enforcement modification would be to designate months as non-TACT months and prevent any TACT enforcement from occurring. This could provide a control to more closely evaluate the effectiveness of the enforcement component of TACT. One last officer suggestion was to follow the CIoT model and concentrate TACT enforcement around certain dates each year. CIoT enforcement has been very concentrated around the Memorial Day weekend each year and this concentration has led to greater public awareness.

5.2 TACT Evaluation Recommendations

Ways to improve the evaluation of the TACT program were also conceptualized. Defining a control corridor for the purposes of comparison would greatly increase the effectiveness of any TACT evaluation. Without a control corridor, it is difficult to compare crash reductions as there is nothing to compare them to. In addition, factors such as the economy can have a great effect on vehicle miles traveled and truck percentages of volume, leading to temporal analysis not being very useful.

A way to increase the effectiveness of the observation analysis is to automate the process. This can be done by using sensors (Green) or using software to detect following distances (Cunningham, Schroeder, Vaughan, & Hughes, 2010) for a far larger number of observations than is feasible for a team of human evaluators. However, this automation mostly focuses on following too close and only humans can determine if vehicles are changing lanes to close too another vehicle or remaining in a truck’s blind spots.

CHAPTER 6: CONCLUSIONS

The results of this research paint a mixed picture of TACT enforcement. However it does seem clear that certain enforcement levels do contribute to decreased CMV 2+ crashes. Several methods were used for analysis using several different software tools. These tools included SQL Database, GIS, Excel, CARE, and SPSS. Data was evaluated spatially, temporally, and via observation of driving behavior.

Officer data was imported and processed to evaluate where and when TACT enforcement took place. Crash data was processed to determine when and where crashes between cars and trucks were most likely to occur. Video data was examined to determine if any noticeable driving behavior change could be shown.

Officers were shown to be enforcing in areas of high TACT crash density. Statistical testing showed that medium and high enforcement levels for each month decreased the occurrence of car and truck crashes. Medium levels of enforcement decreased crashes versus low levels (506 versus 555 crashes, significant at p-value 0.003.) High and medium enforcement was shown to reduce the number of crashes compared with low levels of enforcement (509 versus 555 crashes, significant at p-value 0.004.) Observational analysis did not show any overall trend related to TACT enforcement affecting targeted driving behaviors.

Recommendations to improve the program include increasing public awareness of the program, increasing officer contacts per hour, concentrating officer enforcement over designated periods and specifically designating months as enforcement or non-enforcement months for purposes of evaluation. Future TACT programs should be implemented in such a way as to allow for control versus treatment analysis at different sites. Also, the use of automated data collection techniques (e.g., machine vision, image processing) should be investigated to enhance the effectiveness of observational analyses of driving behaviors related to TACT enforcement.

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APPENDIX: SPSS STATISTICAL OUTPUT

Overall ANOVA and Fisher's Least Significant Difference Post-hoc Test between groups

Descriptives

Crashes

	N	Mean	Std. Deviation	Std. Error	for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	14	554.79	52.521	14.037	524.46	585.11	436	635
Medium	40	506.05	51.768	8.185	489.49	522.61	398	599
High	14	519.21	47.129	12.596	492.00	546.43	429	591
Total	68	518.79	53.794	6.524	505.77	531.82	398	635

ANOVA

Crashes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24634.503	2	12317.252	4.730	.012
Within Groups	169252.614	65	2603.886		
Total	193887.118	67			

Multiple Comparisons

Dependent Variable: Crashes

Fisher's LSD

(I) Enforcement Level		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Medium	48.736*	15.846	.003	17.09	80.38
	High	35.571	19.287	.070	-2.95	74.09
Medium	Low	-48.736*	15.846	.003	-80.38	-17.09
	High	-13.164	15.846	.409	-44.81	18.48
High	Low	-35.571	19.287	.070	-74.09	2.95
	Medium	13.164	15.846	.409	-18.48	44.81

*. The mean difference is significant at the 0.05 level.

Enforcement Level		Significance
Low	Medium	.003
	High	.070
Medium	Low	.003
	High	.409
High	Low	.070
	Medium	.409

ANOVA for Low versus Medium-High Levels of Enforcement

Descriptives

Crashes

	N	Mean	Std. Deviation	Std. Error	for Mean Lower Bound	Upper Bound	Minimum	Maximum
Low	14	554.79	52.521	14.037	524.46	585.11	436	635
Medium/High	54	509.46	50.505	6.873	495.68	523.25	398	599
Total	68	518.79	53.794	6.524	505.77	531.82	398	635

ANOVA

Crashes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22837.335	1	22837.335	8.812	.004
Within Groups	171049.783	66	2591.663		
Total	193887.118	67			