EVALUATION OF PHOTOGRAPHIC TRAFFIC SIGNAL ENFORCEMENT SYSTEMS IN TEXAS

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Executive Summary

The primary objective of this report was to evaluate and determine the effectiveness that automated traffic enforcement systems have on reducing right angle, rear end and other crash types at signal controlled intersections within the State of Texas. A list of communities that maintain automated traffic enforcement systems within the State was obtained along with the intersections that were monitored. Information related to intersection geometry, traffic flow, signalization parameters, and other descriptive data for the intersections were also collected.

Crash information originated from electronic copies of stored crash records maintained in the TxDOT Crash Records Information System (CRIS) data base. The individual crash data for the affected intersections was remotely accessed electronically by interfacing with CRIS and searching the database using crash identification numbers assigned to each intersection crash record. Crash frequency counts from the intersections within each community were assessed individually and then combined in order to develop a State wide estimate of effectiveness.

There were 275 monitored signal controlled intersections from around the State that were considered in this evaluation. From those intersections, 15,144 identified crashes were located in CRIS. Each crash was accessed and evaluated to determine if the collision was or was not intersection related. It was discovered that many of the crashes that were listed as occurring within the intersection were in fact not. A total of 4,039 crash records were identified by the investigator as not being intersection related. These records were removed from the sample which left a total of 11,105 crash records that were used in this investigation.

Right angle, rear end and other crash types were isolated to provide a contextual representation of crashes as well as combined to give a holistic perspective of the incidence of crash events. The crashes were also screened to determine which were red-light related and which were not. Comparison of total crashes from *before*/*after* time periods and through selecting a subset of red light related crashes were used to measure effectiveness of the treatment. In addition to comparing total *before* and *after* intersection crash data, the mean of the *before* crash data was compared against the frequency of the *after* crash data to determine change differences and identify trends over the 2 and 3 year time periods.

A total of 11,122 crashes took place within the intersections identified for this study. Of those crashes, 5,869 crashes occurred "*before*" automated traffic enforcement systems were activated. After the treatments were installed, a total of 5,253 crashes occurred. The number of crashes decreased by 616 events at the treatment intersections. This number represents the results across all three intersection groups. The Crash Records Information System (CRIS) records regarding collision frequency for first, second, and third years *before* and *after* system activation time periods are summarized below.

	Before	***After***	**Frequency Difference**	**Percentage of Change**
1 Year Intersection	2,924	2,742	- 182	- 6%
2 year Intersection	2,246	1,837	- 409	- 18%
3 Year Intersection	699	674	- 25	- 4%

One Year Red Light Related

Prior to installation of the treatment, there were 290 total red light related crashes at one year group intersection. By way of comparison, *after* the activation of the treatment there were 223 red light related crashes for the same time period. Evidence suggests that the activation of the treatment at the signal controlled intersections resulted in 67 fewer red light related crashes. This equates to a 23% reduction in the number of red light related crashes for the treatment site intersections.

Two Year Red Light Related

Prior to installation of the treatment there were 1,373 red light related intersection crashes. By way of comparison, *after* the activation of the treatment there were 1,002 total red light related crashes for the same 2 year time period. Installation and activation of the treatment at the signal controlled intersections resulted in 371 fewer red light related crashes. This equates to a 27% reduction in the number of red light related crashes for the treatment intersections over the 2 year group period.

Three Year Red Light Related

Prior to installation of the treatment there were 1,066 red light related intersection crashes. By way of comparison, *after* the activation of the treatment there were 838 total red light related crashes for the same 3 year time period. Installation and activation of the treatment at the signal controlled intersections resulted in 228 fewer red light related crashes. This equates to a 21% reduction in the number of red light related crashes for the treatment intersections over the 3 year period.

The results of the crash analysis according to intersection type are summarized in the tables below. These tables provide details of the number of each type of intersection along with the number of crashes *before* and *after* the installation of the automatic traffic enforcement system.

Total Crashes According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	2490	2236	-254	-10%
Farm-to-Market (FM) Roads or Spurs	16	255	234	-21	-8%
Interstate Feeder or Access Roads	32	524	457	-67	-13%
State Highways and Loops	53	1290	1091	-199	-15%
US Highways	40	1310	1218	-92	-7%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

Red Light Related Crashes According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	1019	721	-298	-29%
Farm-to-Market (FM) Roads or Spurs	16	111	80	-31	-28%
Interstate Feeder or Access Roads	32	280	197	-83	-30%
State Highways and Loops	53	667	557	-110	-16%
US Highways	40	652	498	-154	-24%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

Red Light Related Crashes (Right Angle Only) According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	948	579	-369	-39%
Farm-to-Market (FM) Roads or Spurs	16	82	47	-35	-43%
Interstate Feeder or Access Roads	32	271	187	-84	-31%
State Highways and Loops	53	632	492	-140	-22%
US Highways	40	608	411	-197	-32%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

Red Light Related Crashes (Rear End Only) According to Intersection Type

Intersection Roadway Type	N	Total Before	Total After	Change	%
Business/Primary Roads	126	45	121	76	169%
Farm-to-Market (FM) Roads or Spurs	16	26	31	5	19%
Interstate Feeder or Access Roads	32	7	6	-1	-14%
State Highways and Loops	53	27	52	25	93%
US Highways	40	35	72	37	106%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

Red Light Related Crashes (Other Only) According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	26	21	-5	19%
Farm-to-Market (FM) Roads or Spurs	16	3	2	-1	33%
Interstate Feeder or Access Roads	32	2	4	2	-100%
State Highways and Loops	53	8	13	5	-63%
US Highways	40	9	15	6	-67%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

Disclaimer

The opinions and conclusions expressed in this document are those of the staff of the Center for Transportation Safety of the Texas Transportation Institute and do not represent those of the State of Texas, the Texas Department of Transportation or any political subdivision of the State or Federal government.

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Background

Motor vehicle travel is the primary means of transportation in the United States. This method of travel provides an unprecedented degree of mobility for most roadway users. However for all its advantages, deaths and injuries resulting from vehicle crashes are the leading cause of death for people aged 3 to 34. In 2008 there were approximately 5.8 million police reported motor vehicle crashes involving 37,261 fatalities, 2.35 million injuries and over 4.15 million property damage crashes. [1] The National Highway Traffic Safety Administration (NHTSA) estimated that a total of 102 people die each day in motor vehicle crashes in the U.S. These figures equate to one death every 14 minutes. [1]

Red light running causes more than 100,000 crashes and 1,000 fatalities annually which results in an economic loss of over $14 billion dollar in the United States (US) each year.[2] Additionally there were more than 2.3 million reported intersection-related crashes, resulting in approximately 7,770 fatalities and 733,000 injuries. Right angle intersection crashes accounted for 46% of the total.[2]

Clearly, red light running poses a significant traffic safety problem for communities across the US. Fortunately there have been great strides made in reducing the number of deaths that occur on our Nations road systems. Between 1998 and 2008, an estimated 4,240 fewer persons were fatally injured in motor vehicle crashes. This equates to a 10% reduction in fatal motor vehicle crashes over the most recent ten year period. Regarding occupant victim fatal crashes (drivers or passengers) there were 6,399 fewer deaths in 2008 than there were in 1998. This represents a 19% reduction of fatally injured occupants in motor vehicle crashes.[2]

In addition to a significant decrease in fatalities, injury crashes have also declined. Between 1998 and 2008 injury related crashes fell from 3.2 million to 2.35 million. This represents a reduction of approximately 846,000 fewer crash related injuries across vehicle and pedestrian collision types nationwide. The number of injury crashes involving occupant victims (drivers and passengers) decreased from approximately 3 million in 1998 to 2.12 million in 2008. This represents a reduction of approximately 900,000 injury related crashes.[2]

Traffic signals are installed to separate conflicting traffic movement through intersections. Enforcement of red light signal violations is a proactive activity intended to increase traffic safety by reducing the overall number of crashes and vehicle conflicts. The number of possible vehicle conflict points within a typical intersection is illustrated in Figure 1.

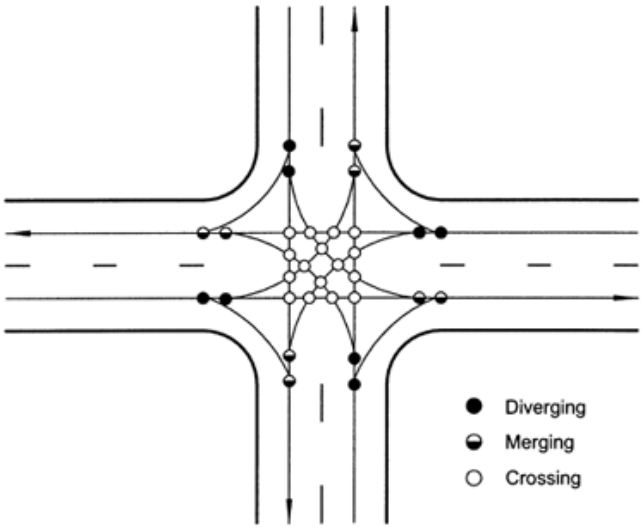


Figure1. Traffic Conflict Points in a Typical Intersection

Research has shown that the more traffic conflicts occur the greater the probability for a higher number of crash events to exist. When behavioral choices disrupt the driving environment, law enforcement addresses the conditions by controlling events that follow the misbehavior. This activity is termed proactive enforcement. Proactive enforcement is usually conducted through law enforcement/violator personal interaction resulting in either verbal warnings, citations or detention/arrest. Recently automated traffic enforcement methods been used as a tool to modify poor driving behavioral choices at signal controlled intersections.

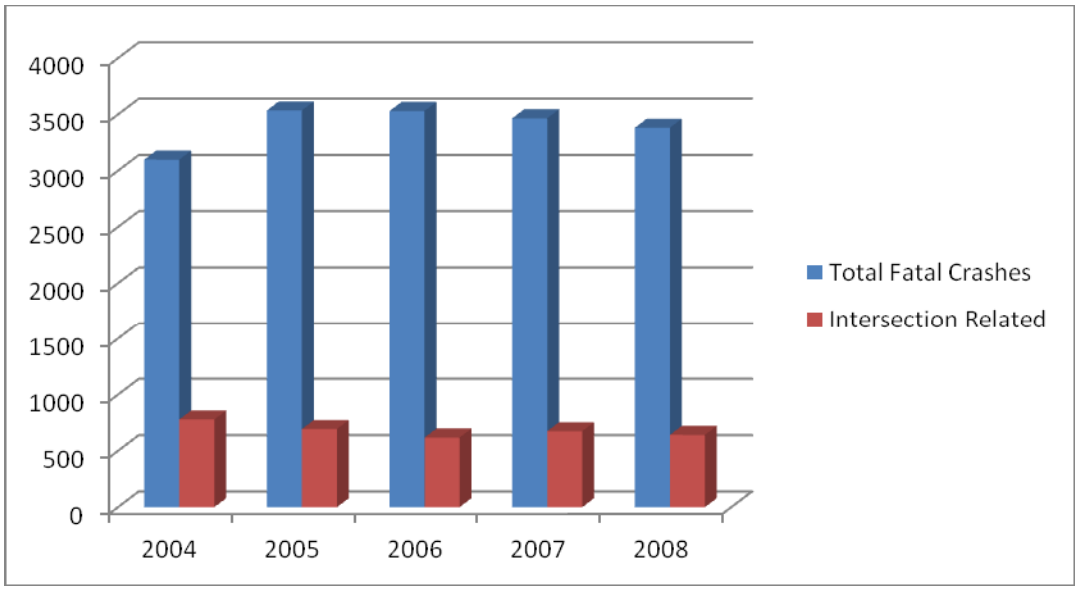
Since a person's decision to disobey traffic law is largely self motivated and often linked to personal choice, a driver will change their behavior only when it is clear that a different response will better serve their interest or to avoid a negative action. The general deterrent effect that automated traffic enforcement has on correcting red light running violations has been repeatedly documented. Evidence suggests that this type of proactive enforcement system provide a specific approach that can be used to effectively augment traditional traffic law enforcement activities. However, even with proactive enforcement methods (personal and automated) in place, not all drivers comply with traffic law. The consequences of poor driver choices at signal controlled intersections continue to result in dangerous vehicle conflicts and collisions.

Unfortunately, Texas is not unfamiliar with fatal and injury intersection crashes. In 2008, TxDOT reported that 829 people were fatally injured in crashes that occurred at intersections.[3] This represents approximately 24% of the 3,468 fatal injury crashes that occurred within that year. Additionally it is estimated that red light running cost the State of Texas over 2 billion dollars annually.[8]

Over a five year period (2004-2008), intersection related crashes claimed approximately 3,400 lives in Texas.[4] The total number of fatal crashes as well as those attributed to intersections

remained relatively consistent across that five year period. The frequency of these crashes is illustrated in Figure 2.

Figure2. Texas Fatal Crashes Involving Intersections, 2004-2008 (FARS Data)



Based on the frequency of intersection related crashes, many communities have chosen to employ automated enforcement systems as a countermeasure to help decrease the number of crashes. The following report details the impact of this countermeasure on crash occurrence at the treatment site intersections.

Objective

As part of an ongoing effort, the Texas Department of Transportation (TxDOT) authorized the Texas Transportation Institute-Center for Transportation Safety (TTI-CTS) to continue its effort of evaluating the effectiveness of automated traffic enforcement systems at signal controlled intersections. The primary objective of this report was to evaluate and determine the effectiveness that automated traffic enforcement systems have on reducing right angle, rear end and other crash types at signal controlled intersections within the State of Texas. The purpose is to provide TxDOT with descriptive information and report the investigative findings surrounding crash incidence at signal controlled intersections that are monitored by this type of enforcement technology. The report is intended to address the following points:

1. Evaluate the effectiveness of automated traffic enforcement systems at one, two and three year increments on each side of the camera activation date at the State, community and individual intersection level.
2. Evaluate the effectiveness that automated traffic enforcement systems have on right angle, rear end and other crash types at the State, community and individual intersection level.

3. Evaluate the effectiveness that automated traffic enforcement systems have on crashes at different roadway types.
4. Evaluate the difference between signal controlled intersections that utilize all red phasing against those that do not in order to assess crash frequency at camera monitored locations.

Operational Definitions

Crash Factor- Crash assessment coding information on what physically occurred in the crash, including the prior movements of vehicles, critical events in the crash, reasons for the critical event, and conditions associated with the crash

Crash Records Information System (CRIS)- In the event of a crash investigated by a law enforcement officer that results in injury or death to any person, it is required that a crash report be made to the Texas Department of Transportation (TxDOT) within 10 days of that event. Additionally, if there is damage to the property of any one person to the apparent extent of $1,000 or more, a crash report shall also be filed within the same 10 day time period. These crashes may be reported to TxDOT through electronic web data entry involving direct data entry into CRIS (requires pre-approval), or paper format submission. Once the crash report(s) is received, the data contained therein is stored in an electronic data base that allows TxDOT to accurately classify the information using nationally accepted standards. The crash record database that contains all of the submitted and TxDOT approved crash reports is referred to as CRIS.

Intersection – The area embraced within the prolongation of connection of the lateral curb lines, or, if none, then the lateral boundary lines of the roadways of two highways which join one another at, or approximately at, right angles or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict.

Where a highway includes two roadways thirty (30) feet or more apart, then every crossing of each roadway of such divided highway by an intersecting highway shall be regarded as a separate intersection. In the event such intersecting highway also includes two roadways thirty (30) feet or more apart, then every crossing of two roadways of such highways shall be regarded as a spate intersection. The junction of an alley with a street or highway shall not be regarded as a spate intersection.

Intersection Related Crash – is a traffic crash in which the first harmful event (1) occurs on an approach to or exit from an intersection and (2) results from an activity, behavior or control related to the movement of traffic units through the intersection.

Other Type Crash - a crash event where one unit swerves or moves into the same direction travel lane and strikes the side of the unit already occupying the travel lane.

Photographic Traffic Signal Enforcement System- consists of a camera system and vehicle sensor installed to exclusively work in conjunction with an electrically operated traffic-control signal; and is capable of producing at least two recorded images that depict the license plate attached to the front or the rear of a motor vehicle that is not operated in compliance with the instructions of the traffic-control signal.

Red Light Related Crash - A traffic crash within the intersection where the first harmful event occurs on an approach to or exit from an intersection, which results from activity related to movement of traffic units through the intersection when the traffic control signal is steady red. Red light related crashes should include those crash events taking place inside the intersection where one vehicle disregards the red signal, plus any intersection-related rear end crash event occurring as a consequence of heavy braking in anticipation of a yellow signal turning to red while the units are traveling in the same approach direction.

Red Light Violation - Driving activity related to movement of a traffic unit approaching a steady red signal where the approach unit fails to stop prior to a clearly marked stop line or in the absence of a stop line, before entering the crosswalk on the nearest approach side of the intersection.

Right Angle Crash - a crash event in which front-to-side contact is made and the vehicles involved are at a right-angle position.

Rear End Crash - a crash event in which the following unit strikes the lead unit from behind while the lead unit is either stopped or traveling in the same approach direction.

Traffic Conflict Point- the point at which a highway user crossing, merging with, or diverging from a roadway conflicts with another user occupying the same road. It is any point where the paths of two or more vehicles diverge, merge, or cross.

Methods

A comprehensive crash analysis was conducted that examined crash trends based on *before* and *after* automated traffic enforcement system activation using 1, 2, and 3 year increments on each side of the system activation date. Placement in these 3 groups was conducted based upon length of time that the system was active. For example, if a system was activated on June 1, 2007 then crash data was collected for a period of time between June 1, 2005 and June 1, 2009. *Before* crash data was specified from June 1, 2005 to May 31, 2007. This provided crash information *before* installation of the system for two years. For the *after* data, crash information was collected from June 1, 2007 to June 1, 2009. This provided crash information *after* installation of the system for two years. The two years of *before* system activation crash data was compared against the two years of *after* system activation crash data. This same method was used for 1, 2 and 3 year data sets.

Individual activation dates for each intersection location monitored by an automated traffic enforcement system were identified. These activation dates served as the tangent for data collection ranges to be generated. While some camera activation dates began in a different months of the year, each individual intersection was measured on like calendar months.

Design

The primary objective of this study was to calculate the rate of change in crash frequency at red light camera monitored intersections. The following crash types were analyzed as part of this assessment:

- Right angle crashes
- Rear end crashes
- Other crashes

The analysis examined safety effects and provides insights into a number of issues within the confines of the available data gleaned from Crash Records Information System (CRIS). TTI investigators retrieved data from multiple communities around the State in order to improve the reliability of the results and to facilitate a broader application of the findings.

Because the intent of the research was to conduct a State wide assessment that represented Texas collectively as well as the individual communities, all communities that maintained automated enforcement intersection sites were chosen for the analysis. This was based upon sample size needs and the data available in as many community locations across the State.

Jurisdictions

TxDOT provided a list of communities that maintain automated traffic enforcement systems within the State. Initially, 41 communities within Texas reported having automated traffic enforcement systems that were operational at signal controlled intersections. Three of the 41 reporting communities chose to deactivate their automated enforcement systems within the period of this analysis. As such, the three communities were removed from the study and a total of 38 were used for this evaluation.

Of the 38 communities, eight had individual intersections that were monitored by automated traffic enforcement systems collected crash data for less than one year *after* activation. This included signal controlled intersections in Austin, College Station, Corpus Christi, Dallas, Fort Worth, Garland, Humble, and Hutto. Twenty-four intersections from these eight communities were removed from the overall sample and not analyzed as part of this report.

Information related to intersection geometry, traffic flow, signalization, and other descriptive data for intersections within each community were used in the assessment. Crash information originated from electronic copies of stored crash records maintained in the TxDOT Crash Records Information System (CRIS) data base. The individual crash data was remotely accessed

electronically by interfacing with CRIS and searching the database using crash identification numbers assigned to each crash record. Each community that reported automated traffic enforcement activity was named and crash records for the intersection locations were obtained. Crash frequency counts from the intersections within each community were assessed individually and then combined in order to develop a State wide estimate of effectiveness. Additionally, each community was assessed to determine the effectiveness that the automated traffic enforcement systems had on crashes within each jurisdiction.

Data Collection and Extraction Methods

There were 275 camera monitored signal controlled intersections from around the State were considered in this evaluation. From the 275 intersections, 15,144 identified crashes were identified in CRIS. Each crash was accessed and evaluated to determine if the collision was or was not related to the intersection. Previous research indicated that crashes were not always coded correctly by law enforcement. [5] Not only was this an issue is determining intersection relationships, it also pertained to identification of which crashes were related to red light violations.

In order to maintain consistency in determining red light related crashes, each of the 15,144 crash reports were assessed to determine specifically which collisions were truly intersection related and to determine which were related to red light violations. It was discovered that many of the crashes that were listed as occurring within the intersection were in fact not. A total of 4,039 crash records were identified as not being intersection related even though they were classified by law enforcement investigators as such. Many of the crashes occurred near but not at the intersection. Others were the result of vehicles entering the roadway from private/public drives, while waiting within a long line of traffic, or occurring within a parking lot. These records were removed from the sample which left a total of 11,105 crash records which were used in this investigation.

Data was grouped to define the intersection related crash as being attributed or not attributed to a red signal violation. Because there are some crashes that occur as a result of red signal violations while others aren't, it was important to determine the frequency of the different crash types and isolate the signal change relationship differences between them. Right angle, rear end and other crash types were isolated to provide a contextual representation of crashes as well as combined to give a holistic perspective of the incidence of crash events.

Three specific factors listed on the CR-3 crash collection form pertain directly to signal controlled intersection crashes: disregard stop and go signal, disregard stop sign or light and fail to yield right of way turn on red. These three crash factors account for 157 fatalities, 5,607 serious body injury, and 8,630 other injury crashes at signalized intersections in Texas for 2008.[6] Crash severity information for the three specific crash factors that are regularly associated with signal controlled intersection crashes are detailed in Table 1.

Table 1. Signalized Intersection Crash Injuries Reported by Contributing Crash Factors

Crash Factor	Fatal Injuries	Serious Injuries	Other Injuries
Disregard stop and go signal	62	2,459	3,932
Disregard stop sign or light	93	3,002	4,430
Fail to yield right of way-turn on red	2	146	268

The three crash factors were collected and the investigators narrative description of the crash was assessed to determine if the collisions were related to red signal violations. This was performed so that a more rigorous investigation could be made on that sub-category of crashes events.

Non-red light related intersection crashes were also evaluated and found to be extremely useful in explaining rear end crash events that occurred at the automated enforcement system monitored intersections. Not all rear end crashes at signal controlled intersections are related to vehicles coming to an abrupt stop to avoid running the red signal and being stuck from behind by the following unit. Crash reports analyzed as part of this investigation indicated other crash causes such as collisions occurring during a lane change not related to a red light, vehicles slowing down due to congestion or vehicle turning into or out of a public/private drive or in cases where the light turns from red to green and the following vehicle accelerates faster than the lead and the lead unit is struck from the rear. Each of these incidents describes crashes that are not associated with red signal violations. As such, the events must be accounted for in order to describe the relevance that each has on the overall signal change relationship at the intersection.

For the purpose of this report, rear end collisions where the law enforcement investigator listed the lead unit as having to stop abruptly for a yellow signal and where the following unit struck the lead unit from the rear were categorized as red light related crashes. Right angle, rear end and other crash types were also examined to establish whether or not the crash type was related to signal change relationships. Roadway systems were also examined in order to determine if automated traffic enforcement systems played a role in treatment effectiveness based upon design features.

One common theme experienced was that each community installed and activated automated traffic enforcement systems on different dates and in some cases, multiple cameras were installed at the same intersection on different dates. In order to pair like groups for 1, 2 and 3 year increments, each intersection camera activation date was identified and an equal period of time for *before* and *after* data periods was derived. This produced three distinct data groups for comparison purposes. To account for duplication of crashes in those intersections that had two or more camera systems activated on different months, the investigator selected the most

recent camera activation date and used the collected data from that system to define crash relevance at the intersection.

Each of the communities intersections were paired into 1, 2 and 3 year data periods. All intersection and the crashes that occurred within them were evaluated and compared against like date range parameters.

Crash Data Links to Intersections

Intersections were defined as the area embraced within the prolongation of connection of the lateral curb lines or if none existed, then the lateral boundary lines of the roadways of two highways which joined one another at or approximately at right angles. The junction of an alley with a street or highway was not considered to be part of the intersection studied.

Crash events that resulted in a collision where the unit(s) was either approaching or exiting an intersection and resulted from activity or behavior related to the controlled movement of the unit(s) through the intersection was counted as an intersection crash for the purpose of this investigation.

Defining Red Light Related vs. Non-Red Light Related

Red light related crashes were identified as being those collisions where the first harmful event took place in an approach to or exit from an intersection that resulted from action related to movement of the unit(s) through the intersection when the traffic control signal was steady red. These included those crash events taking place within the intersection where one vehicle disregards the red signal, plus any intersection related rear end collision the occurred as a result of heavy braking in anticipation of a yellow signal turning to red while the units are traveling in the same approach direction.

Investigation Results

The effectiveness of red light camera systems was evaluated using reductions in crash frequencies *before* and *after* the installation and activation of automated traffic enforcement systems. Comparison of total crashes from *before*/*after* time periods and through selecting a subset of red light related crashes were used to measure effectiveness of the treatment. In addition to comparing total *before* and *after* intersection crash data, the mean of the *before* crash data was compared against the frequency of the *after* crash data to determine change differences and identify trends over the 2 and 3 year time groups. Since the single year group intersection in the *before* period could not be averaged they were not analyzed in this particular manner.

Statewide

This section identifies potential differences between *before* and *after* system activation crash data at signal controlled intersections monitored with automated traffic enforcement system technology. The information contained in this document was derived from the Texas Crash Records Information System (CRIS) for 1, 2 and 3 year time groups immediately *before* and *after* the installation and activation of the treatment.

One year groups were comprised of those treatment monitored intersections that had 1 year of crash data *before* and *after* system activation. Two year groups consisted of system monitored intersections that possessed 2 years of crash data *before* and *after* treatment activation. Three year groups were made up of those system monitored intersections with 3 years of crash data *before* and *after* treatment activation. The total number of intersection crashes for 1, 2, and 3 year groups were individually analyzed to determine the difference in the number of crash events that occurred *before* and *after* activation of the treatment.

While each annual group showed a decrease in the overall number of collisions at the treatment monitored intersections, caution should be used when interpreting the change difference collectively. This is because each annual group is independent of the others and each has a different number of intersections contained within them. One year intersections were comprised of 83 monitored locations that possessed a single year of crash data on each side of the system activation date. The two year groups were made up of 139 intersections that had two years of crash data on each side of the system activation date. The three year groups were comprised of 53 intersections with three years of crash data on each side of the system activation date. Since the 2 year group has a greater number of treatment monitored intersections represented than the 1 and 3 year groups, there is a greater probability that more collisions would be represented in this group when compared to the others.
It should be noted however, that each group shows a decrease in the overall number of crash events at the automated enforcement site intersections after the activation of the treatment. The Crash Records Information System (CRIS) records regarding collision frequency for first, second, and third years *before* and *after* system activation time periods are summarized in Table 2.

Table 2. Summary Comparison of CRIS Crashes at Automated Traffic Enforcement System Monitored Signal Controlled Intersections in Texas.

	Before	***After***	**Frequency Difference**	**Percentage of Change**
1 Year Intersection	2,924	2,742	- 182	- 6%
2 year Intersection	2,246	1,837	- 409	- 18%
3 Year Intersection	699	674	- 25	- 4%

A total of 11,122 crashes took place within the intersections identified for this study. Of those crashes, 5,869 crashes occurred "*before*" automated traffic enforcement systems were installed and activated. After the treatments were installed at the intersections a total of 5,253 crashes occurred. The number of crashes decreased by 616 events at the treatment intersections. This difference represents the results across all three intersection groups.

One Year Red Light Related Group Intersections

The intersections in the one year group were assessed to determine the overall change in red light related crash frequency. The intersections were evaluated by assessing the crash rate at each of the treatment intersections within each individual community across the State where the treatment was active for one year. Red light related crash data was collected for the year immediately prior to and following the treatment activation date to create "*before*" and "*after*" data sets. The *before* and *after* data was evaluated to determine the overall reduction in total red light related crashes at the treatment site intersections.

Each community was evaluated to determine the effectiveness of the treatment on the site intersections then each community *before* and *after* red light related crash totals were summed to create the 1 year group total for the State. The "*before*" and "*after*" red light related crash information that describes the frequency of crashes that occurred within the one year group intersection communities is summarized in Table 3.

Table 3. Red Light Related Crash Frequency Change Rate at 1 Year Group Intersections

Community	**Total RLR Crashes**	***Before***	***After***	**Frequency Change**	**% of Change**
Amarillo	34	22	12	-10	-46%
Arlington	20	15	5	-10	-67%
Austin	78	47	31	-16	-34%
Baytown	45	29	16	-13	-45%
Bedford	20	13	7	-6	-46%
Burleson	33	16	17	+1	+6%
College Station	15	5	10	+5	+100%
Dallas	35	19	15	-3	-16%
Denton	4	1	3	+2	+200%
El Paso	29	12	17	+5	+42%
Farmers Branch	2	0	2	+2	+200%
Fort Worth	44	25	19	-6	-24%
Grand Prairie	13	6	7	+1	+17%
Haltom City	20	11	9	-2	-18%
Humble	3	2	1	-1	-50%
Jersey Village	48	30	18	-12	-40%
Killeen	38	19	19	0	0%
Mesquite	4	2	2	0	0%
North Richland Hills	4	3	1	-2	-68%
Richardson	10	5	5	0	0%
Roanoke	7	5	2	-3	-60%
Terrell	7	3	4	+1	+33%

Prior to installation of the treatment, there were 290 total red light related crashes. By way of comparison, *after* the activation of the treatment there were 223 total red light related crashes for the same time period. Installation and activation of the treatment at the signal controlled intersections resulted in 67 fewer red light related crashes. This equates to a 23% reduction in the number of red light related crashes for the treatment site intersections.

Twelve of the 22 communities showed red light related crash reductions at the treatment intersections ranging from 16 to 68 percent. Three communities showed no change in red light related crash frequency while 7 showed an increase in red light related cashes ranging from 6 to 200%. Of those 7 communities showing an increase only 2 had 20 or more collisions (El Paso and Burleson) that occurred within the treatment intersections. Because of the low number of crashes occurring within these 5 intersections, small frequency increases in collisions played a significant role on the percentage of change.

By way of comparison, the intersections that showed an overall decrease in crashes, 10 of the 12 communities recorded a total of more than 20 red light related crashes. This suggests that at least within those intersections, the treatment showed evidence of reducing the overall number of red light related crash events at locations with higher incidences of collisions.

Right Angle Crashes: 1 Year Group Intersections

Right angle crashes for red light related and non- red light related crashes were assessed. Two hundred and sixty (260) red light related right angle crashes occurred prior to the activation of the treatment at the intersection. *After* the activation of the treatment there were 210 red light related right angle collisions. This represents a reduction of red light related right angle crashes by 50 crash events. Evidence suggests that the installation and activation of the treatment at the intersection reduced crash frequency by 19%.

By way of comparison there were 94 non-red light related right angle crashes that occurred *before* the installation and activation of the treatment while 97 occurred *after*. This represents an increase of 3 red light related right angle crashes at the treatment intersection. While there is an increase in the number of non-red light related right angle crashes there is little evidence to suggest the treatment was a catalyst in changing the rates at the affected intersections.

Rear End Crashes: 1 Year Group Intersections

Rear end crashes were assessed to determine whether or not the use of the treatment at the intersections affected the frequency of collisions. There were a total of 21 red light related rear end crashes that occurred prior to the activation of the treatment at the intersection. *After* the treatment had been installed and activated there were 44 red light related rear end crashes, 23 more than in the1 year *before* period. This represented an increase in red light related rear end crashes of 110%.

By way of comparison, there were a total of 530 non-red light related rear end crashes that occurred at the treatment intersections. Prior to the activation of the treatment there were a total of 260 collisions that occurred. *After* the activation of the treatment there was a total of 270 non- red light related rear end crashes. While there was an increase of 10 additional non-red light related rear end crashes *after* the activation of the treatment the number was not considerable suggesting that the treatment was responsible for the increase.

It is interesting to note that there were many more non-red light related rear end collisions at the treatment intersections than there were red light related. In fact there were 465 fewer red light related rear end crashes than non- red light related. While there was a reported increase in the number of total rear end collisions (+33) at the 1 year group intersections far more crashes appeared to be the result of driver error on the part of the following unit as opposed to the lead unit applying the brakes hard to avoid violating the red signal. This was supported by the qualitative data found in the law enforcement narratives in each individual crash record examined as well as from the list of causal factors noted in the law enforcement cash record.

Other Crashes: 1 Year Group Intersections

Other crash types for red light related and non- red light related crashes were also assessed. There were a total of 21 red light related other crashes that occurred at the treatment intersections. Eleven red light related other crashes occurred prior to the activation of the treatment at the intersection. *After* the activation of the treatment there were ten red light related other collisions which represents a reduction of one crash event.

By way of comparison, there were a total of 319 non- red light related other crashes. Of those collisions 156 crashes occurred *before* the installation and activation of the treatment while 163 occurred *after*. This represents an increase of 7 non- red light related other crashes at the treatment intersection. While there is an increase in the number of non-red light related other crashes there is little to no impact that suggests the treatment was a factor in changing the rates at the affected intersections.

As was found with the non-red light related rear end crashes, it was interesting to note that there were much fewer red light related crashes. The majority of the crashes that were other related also appeared to be the result of driver error with many crashes being a result of failing to yield right of way while turning.

All Red Phasing and Yellow Interval Timing

The function of a traffic signal is to exchange the right of way between conflicting traffic movements with the purpose of assigning right of way to different users. The intent is to provide for orderly movement of traffic that minimizes delay, maximizes the capacity for use and reduces the potential for crash conflicts.[7]

Yellow signals are warnings to drivers that the related green movement will soon be terminated and that a red signal will immediately follow. Selection of appropriate yellow interval lengths and the decision to employ all red phase signaling are important to traffic safety and user mobility. This is because short yellow interval lengths can create problems with a driver's ability to clear their vehicle from the intersection *before* other traffic is released to use the same intersecting roadway space.

Generally, yellow interval lengths range from three to six seconds. However, most drivers are usually unaware of the actual duration of the yellow clearance interval when they estimate their arrival time to the intersection and decide whether to stop or proceed forward. Often drivers are caught off-guard by the duration of yellow and end up running a red light, accelerating dangerously through the intersection or stopping abruptly. Brought about by uncertainty, the scenario creates a decision dilemma in which the driver must choose to either continue through the intersection and risk running the red signal or stop suddenly and risk being involved in a rear-end collision. When other vehicles are involved, these conflicts often result in collisions.

The yellow change interval must be long enough to avoid creating a "dilemma zone" which is defined as a condition where the driver can neither stop nor proceed through the intersection safely. Conventional analysis of the dilemma zone problem is adequate to select a reasonable yellow interval duration, however it ignores critical issues such as: driver expectations; drivers estimated arrival time at the intersection; presence and spacing of multiple vehicles using the roadway; different driver reaction times and operator capabilities; and varying speeds that different vehicles travel. Unfortunately these conditions are not consistent across all drivers and as such, variability between these conditions impact the ability to create a specific standardized yellow interval time for all intersections and conditions.

While programming correct yellow intervals provide some safety benefits for the intersection, the yellow interval timing approach is effective only if all motorists drive at the same speed and use similar driver capabilities. Since many operators drive at differing range of speeds and react to things in different ways, there is no singular correct or safe duration for the yellow interval duration. Unfortunately, some driver dilemma will continue to exist regardless of what yellow interval time exists.

> *"Engineers must use judgment in the application of the procedure to ensure that yellow signal length is compliant with any local or state laws that govern the jurisdiction and suitable to the unique characteristics of the intersection".* [7] *(P.4)*

The Institute of Transportation Engineers (ITE) is one organization that publishes proposed recommended practices for yellow interval timing at signal controlled intersections. ITE has not published a recommended procedure for applying the yellow interval instead, they have published guidance through different publications. [7] A widely used formula for determining the minimum length of yellow change interval to avoid the dilemma zone is: $Y = t + v/2\alpha$. This formula is known as the "ITE Formula." In this equation, the variables represent the following;

Y = minimum yellow change interval length
t = reaction time, sec
v= approach speed
α= deceleration rate

In an earlier evaluation conducted for TxDOT, TTI suggested that yellow signal interval timing and all red phasing information be collected from cities that use automated traffic enforcement systems. The purpose for suggesting that this information be captured was to determine which communities in Texas were following the suggested ITE yellow interval timing guidance in addition to finding out those who were also using optional "all red" phasing as a safety countermeasure at the treatment intersections. Twenty nine communities across the State employed all red signal phasing in addition to following the ITE yellow interval guidance for intersections that used automated enforcement.

Yellow Interval Timing and All Red Phasing for 1 Year Group Intersections

This investigation assessed the yellow timing at the treatment intersection to determine if the yellow phase was set according to the ITE suggested yellow intervals. Interestingly of the one year group intersections, 5 of the 22 communities (Bedford, Farmers Branch, Humble, Jersey Village and Roanoke) were discovered to not use all red phasing at their treatment locations.

A summary of the yellow timing intervals that were reported by communities for intersections where treatments were installed is illustrated in Table 4.

Table 4. Yellow Timing Intervals at 1 Year Group Intersections without All Red Signal Phasing

City	Intersection	Speed Limit	Yellow Interval Timing
Bedford	Central & L. Don Dodson	40	4 seconds
	Central & SH 183	40	4 seconds
	SH 183 & Bedford	40	4 seconds
Farmers Branch	Spring Valley & Inwood	40	4.5 seconds
Humble	FM 1960 & North Houston	35	4.1 Seconds
Jersey Village	US 290 & FM 529	45	4.1 Seconds
	US 290 & Jones	35	4.1 Seconds
	US 290 & Sam Houston Parkway	35	4.1 Seconds
	US 290 & Senate	45	4.1 Seconds
Roanoke	SH 114 & North Oak	40	4 Seconds
	SH 114 & US 377	55	5 Seconds

The yellow timing intervals reported at the treatment intersections appeared to be within the acceptable timings suggested by ITE. While these intersections did not have the added safety benefit of all red phasing, red light related crash frequency decreased in 4 of the 5 treatment site locations.

Bedford and Jersey Village were the only communities within this group that recorded 20 or more crashes within the treatment intersections. Interestingly, Bedford (20 red light related crashes) and Jersey Village (48 red light related crashes) showed a 40-46% decrease in red light related crashes at their treatment intersection location.

Farmers Branch, Humble and Roanoke had very few red light related intersection crashes and as a result of the low number of collisions the findings for the intersections were limited. Farmers Branch was the only community among those with no all red phasing (1 year group) that showed a rise in red light related crashes at the treatment site intersections.

Two Year Group Red Light Related Intersections

Two year group information was evaluated to determine the overall change in red light related crash frequency at the treatment site intersections. The intersections were evaluated in two different manners to determine the effectiveness that the treatment had on crash reduction at the monitored sites. Intersection crash data was collected for 2 years on each side of the treatment activation date to create *before* and *after* data sets.

Each community was individually evaluated to determine the effect that the treatment had on the site intersections. *Before* and *after* red light related crash totals were summed to create 2 year group State totals. The "*before*" and "*after*" red light related crash information that describes the frequency of crashes that occurred within the two year group intersection communities is summarized in Table 5.

Table 5. Red Light Related Intersection Crash Frequency Change at 2 Year Intersection Sites

Community	**Total Crashes**	***Before***	***After***	**Frequency Change**	**% of Change**
Arlington	96	49	47	-2	-4%
Cedar Hill	47	27	20	-7	-26%
Coppell	24	13	11	-2	-15%
Corpus Christi	72	32	40	+8	+25%
Dallas	585	362	223	-139	-38%
Diboll	15	2	13	+11	+550%
Farmers Branch	15	8	7	-1	-13%
Grand Prairie	15	11	4	-7	-64%
Houston	846	491	355	-136	-28%
Humble	97	49	48	-1	-2%
Irving	63	41	22	-19	-46%
Lake Jackson	23	4	19	+15	+375%
Lufkin	123	70	53	-17	-24%
Marshall	55	28	27	-1	-4%
McKinney	4	3	1	-2	-68%
North Richland Hills	53	35	18	-17	-49%
Plano	170	101	69	-32	-32%
Richland Hills	5	3	2	-1	-33%
Rowlett	10	7	3	-4	-57%
Sugar Land	57	37	20	-17	-46%

Prior to installation of the treatment there were 1,373 red light related intersection crashes. By way of comparison, *after* the activation of the treatment there were 1,002 total red light related crashes for the same 2 year time period. Installation and activation of the treatment at the signal controlled intersections resulted in 371 fewer red light related crashes. This equates to a 27% reduction in the number of red light related crashes for the treatment intersections over the 2 year group period.

Seventeen of the 20 communities showed red light related crash reductions at the treatment intersections ranging from 2% to 68%. There were no communities within the 2 year group that recorded no change in the crash rate.

Of interest were the communities of Dallas, Houston, Lufkin and Plano which reported over 100 red light related crashes within the treatment site intersection locations. These 4 communities combined for 1,724 total red light related crashes which represents 72% of all 2 year group intersection crashes occurring within the State.

The highest reported number of red light related intersection crashes occurred in Houston which recorded 846 collisions at 31 individual treatment sites. Prior to activation of the treatment these intersection were reported to have had 491 red light related crashes. *After* the treatment was activated there were 355 red light related crashes. A total of 136 fewer red light related crashes occurred at intersection with the treatment across the community as opposed to when it was not in place and active. The 136 fewer collisions equates to a 28% reduction in red light related intersection crashes at the treatment site locations.

Dallas reported a total of 585 red light related collisions within 31 community intersections over the 2 year period group. There were 362 red light related crashes prior to the activation of the treatment. *After* the treatment was activated, there were 223 red light related crashes at the same intersections over the same 2 year time period. This equates to 139 fewer red light related crashes accounting for a 38% reduction in the number of red light related crashes at treatment site intersections.

The community of Plano experienced 170 total red light related crashes at 9 treatment intersections prior to system activation. A total of 101 red light related intersection crashes occurred *before* the treatment was activated. Once the treatment was installed and active there were a total of 69 red light related crashes over the same 2 year time period. There were 32 fewer red light related crash events at the treatment intersections. This number represents a 32% reduction in the number of red light related crashes over the 2 year group time periods.

Lufkin experienced 123 red light related crashes at 8 treatment intersections prior to system activation. There were 70 red light related crashes that occurred *before* and 53 red light related crashed that occurred *after* the activation of the treatment. The treatment intersections reported 17 fewer red light related crashes *after* the activation which represents an 11% reduction in red light related collisions.

Three (3) communities reported an increase in the number of red light related crashes occurring at their treatment site intersections (Corpus Christi, Diboll and Lake Jackson). The communities of Corpus Christi and Lake Jackson each reported having over 20 red light related signal controlled intersection crashes. Corpus Christi increased by 8 the number of red light related crashes and Lake Jackson increased by 15. The community of Diboll reported an increase in the number of red light related intersection collisions as well recording a total of 15 crashes.

Right Angle Crashes: 2 Year Group Intersections

Right angle crashes for red light related and non- red light related crashes were evaluated. There were a total of 2,079 red light related right angle crashes that occurred at the treatment intersections. One thousand two hundred seventy eight red light related right angle crashes happened prior to the activation of the treatment. *After* the activation of the treatment there were 801 red light related right angle collisions. This represents a reduction of red light related right angle crashes by 477 crash events. Evidence suggests that the installation and activation of the treatment at the intersection reduced right angle red light crashes by 37%.

By way of comparison there were a total of 1,045 non-red light related right angle crashes. Of those collisions 527 occurred *before* the installation and activation of the treatment while 518 occurred *after*. This represents a decrease of 9 non- red light related right angle crashes at the treatment intersection. While there was a 2% decrease in the number of non-red light related right angle crashes there is limited inference that can be made associating the treatment to significant decreases in non- red light related right angle crashes.

Rear End Crashes: 2 Year Group Intersections

Two hundred sixty one red light related rear end crashes were assessed to determine whether or not the use of the treatment at the intersections reduced the frequency of collisions at the 2 year group intersections. There were a total of 89 red light related rear end crashes that occurred prior to the activation of the treatment. *After* the treatment had been installed and activated there were 172 red light related rear end crashes, 83 more than in the 2 year *before* period. This represents an increase in red light related rear end crashes of 93%.

By way of comparison, there were a total of 1,456 non-red light related rear end crashes that occurred at treatment intersections over the 2 year period. Prior to the activation of the treatment there were 681 non-red light related rear end crashes. *After* the activation of the treatment there was a total of 775 non-red light related rear end collisions, 94 additional collisions. This represents an increase in non-red light related rear end crashes of 14%.

Other Crashes: 2 Year Intersections

Other crash types for red light related and non- red light related crashes were also assessed over a two year *before* and *after* period. There was a total of 54 red light related other crashes that occurred at the treatment intersections. Twenty five (25) red light related other crashes occurred prior to the activation of the treatment at the intersection. *After* the activation of the treatment there were 29 red light related other collisions which represents an increase of 4 additional crashes or 16%.

By way of comparison there were a total of 870 non-red light related other crashes. Of those collisions, 429 occurred *before* the activation of the treatment while 441 occurred *after*. This represents an increase of 12 non- red light related other crashes at the treatment intersections.

It is interesting to note that there were many more non-red light related other collisions at the treatment intersections than there were red light related. In fact there were 816 fewer red light related other crashes than non- red light related. While there was a reported increase in the number of total other collisions (+16) at the 2 year group intersections far more crashes appeared to be not related to red signal violations and appear to be attributed more to driver error. This was supported by the qualitative data contained within the law enforcement narratives in each individual crash record examined as well as from the list of causal factors noted in the law enforcement cash records.

All Red Phasing and Yellow Interval Timing for 2 Year Group Intersections

Five of the 20 communities (Farmers Branch, Humble, Irving, Lufkin and Rowlett) were discovered to have not employed all red phasing at their treatment intersections. Yellow timing at the treatment intersection was examined to determine if the yellow phase was set according to the ITE suggested timing interval. The yellow timing intervals that were reported by communities for intersections where treatments were installed are illustrated in Table 6.

Table 6. Yellow Timing Intervals at 2 Year Group Intersections without All Red Signal Phasing

City	Intersection	Speed Limit	Yellow Interval Timing
Farmers Branch	Marsh & Valley View	35	4 Seconds
	Valley View & Luna	40	4.5 Seconds
Humble	FM 1960 & SH 59	35	3.6 Seconds
	FM 1960 & Townsen	50	4.7 Seconds
	FM 1960 & Whitaker	35	4.7 Seconds
Irving	Beltline & Pioneer	35	4.9 Seconds
	Beltline & SH 183	35	4.6 Seconds
	Irving & Walton Walker	35	4.1 Seconds
	O'Conner & Lane	35	4 Seconds
	SH 114 & SH 161	45	4.5 Seconds
	SH 161 & Gateway	45	4.9 Seconds
Lufkin	Loop 287 & Copeland	30	4.5 Seconds
	Loop 287 & FM 1271	40	4.5 Seconds
	US 59 & FM 58	45	4 Seconds
	US 59 & FM 819	45	4 Seconds
	US 59 & Loop 287	45	4 Seconds
	US 59 & Paul	40	4 Seconds
	US 59 & US 69	40	4 Seconds
	US 69 & Loop 287	50	4 Seconds
Rowlett	Rowlett & Chaha	40	4.5 Seconds
	Rowlett & Hickox	40	4 Seconds
	SH 66 & Chiesa	Unknown	Unknown

The yellow timing intervals reported at the treatment intersections appeared to be within the acceptable timings suggested by ITE. While these intersections did not have the added safety benefit of all red phasing, red light related crash frequency decreased in all 5 treatment locations.

Of interest were the communities of Lufkin, Humble and Irving. Lufkin recorded the greatest number of red light related collisions at the treatment site intersections with 123 events. Prior to treatment activation there were a total of 70 red light related intersection crashes. *After* activation there were 53 which represented a reduction of 24% within the 8 Lufkin intersections.

Humble reported 97 red light related intersection crashes. There were 49 crashes *before* the treatment was activated and 48 *after* resulting in a decrease of 1 less crash over the *before* and *after* period.

Irving reported a total of 63 red light related intersection crashes. Prior to activation there were 41 red light related intersections crashes. *After* the treatment was activated the red light related crashes fell to 22 representing a reduction of 19 fewer collisions. This equated to a reduction of 46% at the 2 year group intersections in Irving.

While there is evidence that crashes are reduced at signal controlled intersection monitored with automated traffic enforcement systems, a closer assessment of the individual rate of change by comparing the 2 year group "*before*" crash averages against the annual crash frequency "*after*" group provides another opportunity for a descriptive inquiry toward evaluating the treatment effectiveness at the site intersections. In addition to measuring combined data for each two year period on each side of the treatment activation date, each community two year *before* period was summed and then averaged in order to be compared against each annual *after* period. Each annual *after* period was then assessed against the mean of the *before* period to determine the overall rate of change. The 2 year "*before*" average and the annual group for 2 years "*after*" treatment activations are illustrated in Table 7.

Table 7. Two Year "*Before*" Average Comparison against Annual Group for Two Years "*After*" Treatment Activation

Community	**Total *Before* RLR Crashes**	**2 Year *Before* Average**	***After* Year 1**	**Difference**	***After* Year 2**	**Difference**	**% *Before* to Yr. 1**	**% Yr. 1 to Yr. 2 *After***
Arlington	49	26	22	-4	25	+3	-15	+14
Cedar Hill	27	14	10	-4	10	0	-29	0
Coppell	13	7	9	+2	2	-7	+29	-78
Corpus Christi	32	19	19	0	21	2	0	+11
Dallas	362	188	114	-74	109	-5	-39	-4
Diboll	2	2	5	3	8	3	+150	+60
Farmers Branch	8	4	4	0	3	-1	0	-25
Grand Prairie	11	7	1	-6	3	2	-86	+200
Houston	491	252	163	-89	192	29	-35	+18
Humble	49	25	28	+3	20	-8	+12	-29
Irving	41	23	10	-13	12	2	-56	+20
Lake Jackson	4	3	12	9	17	-5	+300	-42
Lufkin	70	38	31	-7	22	-9	-18	-29
Marshall	28	16	11	-5	16	5	-31	+45
McKinney	3	2	1	-1	0	-1	-50	-100
North Richland Hills	35	18	15	-3	3	-12	-17	-80
Plano	101	53	31	-22	38	+7	-42	+23
Richland Hills	3	2	2	0	0	-2	0	-100
Rowlett	7	4	1	-3	2	1	-75	+100
Sugar Land	37	19	16	-3	4	-12	-16	-75

It is interesting to note that 15 of the 20 communities with 2 year group intersections reported a consistent drop in red light related crashes over the 2 year *before* and *after* time periods. Furthermore two communities, Coppell and Humble reported an increase in the number of red light related crashes at the treatment intersections for the first year but had a reduction in red light related crashes *after* the second year. These two cities eventually ended up showing an overall decrease in the number of red light related collisions within their communities. As a result, there were 3 communities across the State that showed an increase in red light related crashes across the 2 year group; Corpus Christi, Diboll and Lake Jackson.

Three Year Group Red Light Related Intersections

Three (3) year group information was evaluated to determine the overall change in red light related crash frequency at the treatment site intersections. As was with the 2 year group intersections, 3 year group treatment sites were evaluated in two different manners to determine crash reduction effectiveness. Intersection crash data was collected for 3 years on each side of the treatment activation date to create *before* and *after* data sets.

Each community was individually evaluated to determine the effect that the treatment had on the site intersections. *Before* and *after* red light related crash totals were summed to create 3 year group State totals. The crash frequency differences between *before* and *after* red light related crashes that occurred within the 3 year group at treatment site intersection locations are illustrated in Table 8.

Table 8. Red Light Related Intersection Crash Frequency Change at 3 Year Intersection Sites

Community	**Total Crashes**	***Before***	***After***	**Frequency Change**	**% of Change**
Denton	62	34	28	-6	-18%
Duncanville	55	39	16	-23	-56%
El Paso	110	63	47	-16	-25%
Farmers Branch	25	14	11	-3	-21%
Garland	113	74	39	-35	-47%
Houston	1,290	695	595	-100	-14%
Plano	167	105	62	-43	-41%
Richardson	76	39	37	-2	-5%
Rowlett	6	3	3	0	0

Prior to installation of the treatment there were 1,066 red light related intersection crashes. By way of comparison, *after* the activation of the treatment there were 838 total red light related crashes for the same 3 year time period. Installation and activation of the treatment at the signal controlled intersections resulted in 228 fewer red light related crashes. This equates to a 21% reduction in the number of red light related crashes for the treatment intersections over the 3 year period.

Eight of the 9 communities showed red light related crash reductions at the treatment intersections ranging from 5% to 56%. There were no communities within the 3 year group that recorded an increase in red light related intersection collisions. Only 1 community (Rowlett) reported no change in red light related crashes at the treatment intersection.

Of interest were the communities of Houston, Plano, Garland and El Paso which each reported over 100 red light related crashes within the treatment site intersection locations. These 4

communities combined for 1,680 total red light related crashes which represents 88% of all 3 year group intersection crashes occurring within the State.

The highest reported number of red light related intersection crashes occurred in Houston which recorded 1,290 collisions at 19 individual treatment sites. Prior to activation of the treatment these intersection were reported to have had 695 red light related crashes. *After* the treatment was activated there were 595 red light related crashes. A total of 100 fewer red light related crashes occurred at intersection with the treatment across the community as opposed to when it was not in place and active. The 100 fewer collisions equate to a 14% reduction in red light related intersection crashes at the 3 year treatment site locations.

Plano reported a total of 167 red light related collisions at 4 community intersections over the 3 year period group. There were 105 red light related crashes prior to the activation of the treatment. *After* the treatment was activated, there were 62 red light related crashes at the same intersections over the same 3 year time period. This equates to 43 fewer red light related crashes accounting for a 41% reduction in the number of red light related crashes at treatment site intersections.

The community of Garland experienced 113 total red light related crashes at 5 treatment intersections prior to system activation. A total of 74 red light related intersection crashes occurred *before* the treatment was activated. Once the treatment was installed and active there were a total of 39 red light related crashes over the same 3 year time period. There were 35 fewer red light related crash events at the treatment intersections. This number represents a 47% reduction in the number of red light related crashes over the 2 year group time periods.

El Paso experienced 110 red light related crashes at 9 treatment intersections prior to system activation. There were 63 red light related crashes that occurred *before* and 47 red light related crashed that occurred *after* the activation of the treatment. The treatment intersections reported 16 fewer red light related crashes *after* the activation which represents a 25% reduction in red light related collisions.

Right Angle Crashes: 3 Year Group Intersections

Right angle crashes for red light related and non- red light related crashes were evaluated. There were a total of 1,782 red light related right angle crashes that occurred at the treatment intersections. One thousand twenty three red light related right angle crashes happened prior to the activation of the treatment. *After* the activation of the treatment there were 759 red light related right angle collisions. This represents a reduction of red light related right angle crashes by 264 crash events. Evidence suggests that the installation and activation of the treatment at the intersection reduced right angle red light crashes by 26%.

By way of comparison there were a total of 690 non-red light related right angle crashes. Of those collisions 362 occurred *before* the installation and activation of the treatment while 328 occurred *after*. This represents a decrease of 34 non- red light related right angle crashes at the

treatment intersection. While there was a 9% decrease in the number of non-red light related right angle crashes there is limited inference that can be made associating the treatment to significant decreases in non- red light related right angle crashes.

Rear End Crashes: Three Year Group Intersections

Ninety five red light related rear end crashes were assessed to determine whether or not the use of the treatment at the intersections reduced the frequency of collisions at the 3 year group intersections. There were a total of 31 red light related rear end crashes that occurred prior to the activation of the treatment. *After* the treatment had been installed and activated there were 64 red light related rear end crashes, 33 more than in the 3 year *before* period. This represents an increase in red light related rear end crashes of 106%.

By way of comparison, there were a total of 692 non-red light related rear end crashes that occurred at treatment intersections over the 3 year period. Prior to the activation of the treatment there were 347 non-red light related rear end crashes. *After* the activation of the treatment there was a total of 345 non-red light related rear end collisions, 2 fewer collisions. This represents a decrease in non-red light related rear end crashes of less than 1%.While there was a decrease in the number of non-red light related rear end crashes there is limited inference that can be made associating the treatment to significant decreases in this type of crash.

Other Crashes: Three Year Group Intersections

Other crash types for red light related and non- red light related crashes were also assessed over a 3 year *before* and *after* period. There was a total of 27 red light related other crashes that occurred at the treatment intersections. Twelve red light related other crashes occurred prior to the activation of the treatment at the intersection. *After* the activation of the treatment there were 15 red light related other collisions which represents an increase of 3 additional crashes.

By way of comparison there were a total of 527 non-red light related other crashes. Of those collisions, 284 occurred *before* the activation of the treatment while 243 occurred *after*. This represents a decrease of 41 non-red light related other crashes at the treatment intersections.

It is interesting to note that there were many more non-red light related other collisions at the treatment intersections than there were red light related. In fact, there were 500 fewer red light related other crashes than non- red light related. However, the overall crash rate for red light related other crashes dropped over the 3 year time frame by 228 crashes. This represents a 21% reduction at the 3 year treatment site locations.

All Red Phasing and Yellow Interval Timing for 3 Year Group Intersections

Five (5) of the 20 communities (Farmers Branch, Humble, Irving, Lufkin and Rowlett) were discovered to have not employed all red phasing at their treatment intersections. Yellow timing at the treatment intersection was examined to determine if the yellow phase was set according to the ITE suggested timing intervals. The yellow timing intervals reported at the treatment intersections appeared to be within the acceptable timings suggested by ITE. The yellow timing intervals that were reported by communities for intersections where treatments were installed for 3 years are illustrated in Table 9.

Table 9. Yellow Timing Intervals at 3 Year Group Intersections without All Red Signal Phasing

City	Intersection	Speed Limit	Yellow Interval Timing
Farmers Branch	Josey & Valwood	35	4 Seconds
	Midway & Alpha	35	4.5 Seconds
	Valley View & Webb Chapel	35	4 Seconds
	Webb Chapel & Valwood	35	4 Seconds
Rowlett	Rowlett & Beech	40	4 Seconds

While there is evidence that crashes are reduced at signal controlled intersection monitored with automated traffic enforcement systems, a closer assessment of the individual rate of change by comparing the 3 year "*before*" crash averages against the annual crash frequency "*after*" group provides another opportunity for a descriptive inquiry toward evaluating the treatment effectiveness at the site intersections. In addition to measuring combined data for each 3 year period on each side of the treatment activation date, each community 3 year *before* period was summed and then averaged in order to be compared against each annual *after* period. Each annual *after* period was then assessed against the mean of the *before* period to determine the overall rate of change. The 3 year "*before*" average comparison against annual groups for 3 years "*after*" treatment activations are listed in Table 10.

Table 10. Three (3) Year "*Before*" Average Change Comparison against Annual Group for 3 Years "*After*" Treatment Activation

Community	**Total *Before* RLR Crashes**	**3 Year *Before* Average**	***After* Year 1**	***After* Year 2**	***After* Year 3**	**% *Before* to Yr. 1**	**% Yr. 1 to Yr. 2 *After***	**% Yr. 2 to Yr. 3 *After***
Denton	62	12	13	7	8	+8%	-46%	+14%
Duncanville	55	14	8	5	3	-43%	-38%	-40%
El Paso	110	24	16	17	14	-33%	+6%	-18%
Farmers Branch	25	5	1	6	4	-80%	+500%	-33%
Garland	113	26	11	14	14	-58%	+27%	0%
Houston	1,290	240	209	184	202	-13%	-12%	+10%
Plano	167	36	26	17	19	-29%	-35%	+12%
Richardson	76	14	18	6	13	+29%	-67%	+117%
Rowlett	6	1	1	2	0	0	+100%	-100%

It is interesting to note that when the 3 year *before* average is measures against each annual *after* period there are only 4 times that the *after* period is greater than the three year *before* average. Denton and Richardson reported an increase in red light related intersection crashes at the treatment location within the first year post activation of the treatment. However, year 2 and 3 showed a reduction in the total number of red light related collisions at the treatment intersections.

The community of Farmers Branch and Rowlett reported a drop in red light related crashes within the first year *after* period but indicated there was a rise in crashes the second year. However, the red light related crashes were reduced below the 3 year *before* crash average in the third *after* year.

Roadway System Types

This section of the paper evaluates crashes at different types of signal controlled intersections. The objective is to determine if red light camera treated intersections have a different effect on crash frequency at one roadway type in comparison to others.

Functional classification of roadways into different operational systems or types is necessary for efficient and effective movement of motorists. Grouping roadways by characteristics of service they provide allows for distinct travel movement. Each intersection has unique features that distinguish it in some way from others. There are legitimate differences in local preferences that have created a set of equally acceptable alternatives for some intersection treatments.

There are six recognizable stages in most trips including main movement, transitioning, distribution, collection, access and finally termination. Main vehicle movement is usually uninterrupted high speed travel. When approaching the point of destination vehicles are required to reduce speed via transition roads such as freeway ramps and feeder roads. The transitionary roadways enter into moderate speed arterial roads that allow for distribution roads which bring the driver into the vicinity of their destination. Drivers then enter onto collector roads that enter into neighborhoods or shopping districts which are comprised of local access roadways. The local access roads then provide the driver access to the final point of destination.

Each stage of travel is handled by a separate roadway type designed specifically for functionality. Because movement order is based upon traffic volume, freeway travel is generally at the top of the travel hierarchy followed by distribution arterial roads, collectors and finally local roads.

Intersection Roadway Types

There are several basic intersection types. Descriptions of these have been provided to give the reader additional information in regard to how the potential for at intersection crashes may increase based on the possible conflict points. The following provides operational definition for those intersection types as well as diagrams that illustrate typical roadway designs.

3-way intersection - a junction between three road segments (arms) is a T junction (two arms form one road) or a Y-junction.

4-way intersection- usually involves a crossing over of two streets or roads. In areas where there are blocks and in some other cases, the crossing streets or roads are perpendicular to each other. However, two roads may cross at a different angle. In a few cases, the junction of two road segments may be offset from each when reaching an intersection, even though both ends may be considered the same street. One and two way travel lanes that occur at an intersection are illustrated in Figure 3, 4 & 5.

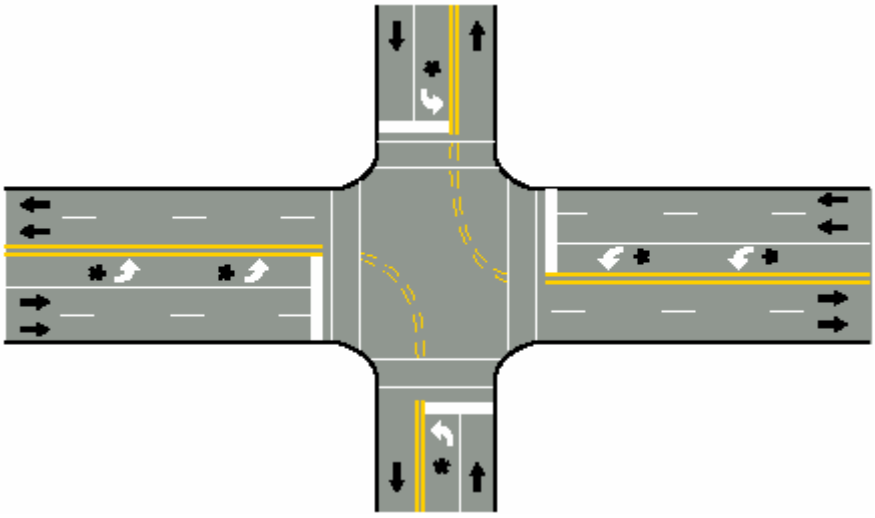


Figure 3. Two Way Divided Intersection with Left Turn Lane

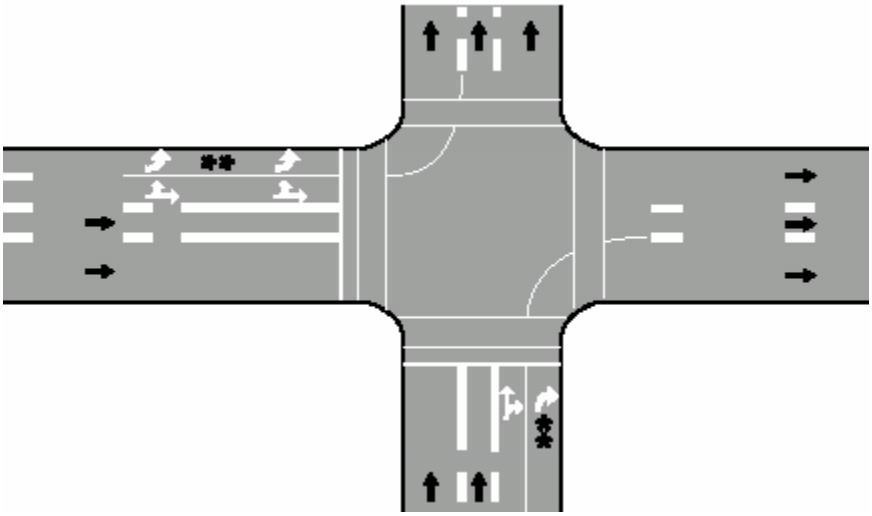


Figure 4. One Way Travel Lane Intersection with Right and Left Turn Lanes

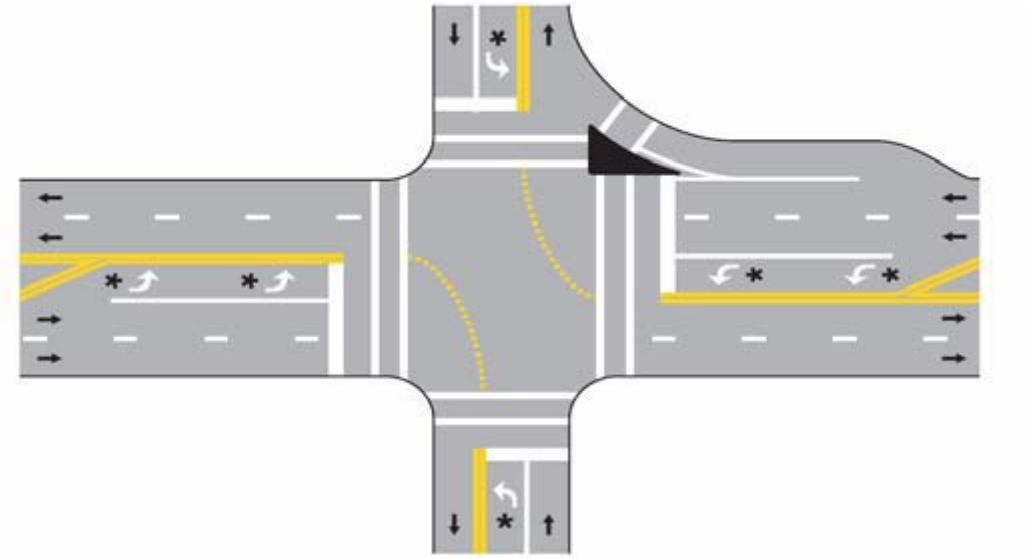


Figure 5. Two Way Divided Intersection with Left Turn Lane and Yield Control

Definition of Roadway Groups

As previously discussed, there can be a number of environmental and/or engineering variables that can impact the crash rate at an intersection. Given the influence of these variables, it is of interest to examine the difference in the number of crashes between types of intersections with automatic traffic enforcement systems in place.

The selected intersections were classified according to the following five categories or roadway classifications:

- Business/Primary Roads
- Farm-to-Market (FM) or Spurs
- Interstate Feeders or Access Roads
- State Highways and Loops
- US Highways

The crashes are further classified as red light and non-red light related. Red light related crashes were analyzed in total as well as according to right angle, rear end and other collision events. The following section operationally defines the categories of roadway intersections followed by crash analysis.

Business/Primary Road: These types of roads are usually comprised of serve as collector and local access roads that permeate neighborhoods and shopping districts. These roadways usually provide direct approaches to destinations and points of travel termination. An example of a Business/Primary roadway and the geometric design that regulates travel upon them is provided in Figure 6

Figure 6. Primary and Secondary Roadway

Farm to Market/Spur: Farm to Market roads are part of the State's system of secondary and connecting roadways that provide access to rural areas. The routes consist primarily of paved, two-lane roads. As a result of population growth and the growth of some urban areas, many of these roads now serve urban areas exclusively and are larger than the usual two lane routes.

Spurs are usually highways that diverge from a primary parent highway to serve a specific area or connect to another highway. An example of FM and Spur roadways and some of the different geometric designs that regulate travel upon them is provided in Figure 7.

Figure 7. Farm to Market/Spur Roadway

State Highway/Loop: A State highway is a numbered highway system primarily administered by a state government. These are generally a mixture of primary and secondary roads, although some freeways double as state highways. An example of a State highway and the geometric design that regulate travel upon them is provided in Figure 8.

A loop is a highway that extends out from its primary parent highway and usually circles larger metropolitan areas. A loop can function as a bypass for through traffic or can service outlying suburbs.

Figure 8. State Highway

United States (US) Highway: The United States numbered highways are a nationwide grid of highways similar to interstates but with less regulation. These roadways serve as important regional connection transportation corridors. United States highway system roads are not usually controlled-access (stoplight free) roads. Many are the main streets of the cities and towns they run through.

The American Association of State Highway and Transportation Officials (AASHTO) collectively agree on the route numbers to be assigned. The designation consists of a one, two, or three digit numbers. Odd numbers represent north-south highways and even numbers represent east-west. The numbers increase moving east to west and north to south and is opposite of the modern Interstate designations.

For the purpose of this study US highways will also include the transitional feeder roadways that intersect with distributor roadway cross streets at signalized intersection locations. An example of a US highway and its geometric design is provided in Figure 9.

Figure 9. United States Highway

Interstate: The major interstate highways of the United States and are usually uninterrupted high speed multi-lane roadways. Even route interstate numbers are assigned for east/west routes, with the lower numbered routes being further south and higher numbered routes being designated in the north. Similarly, odd route numbers are assigned to north/south travel directions, with the lower numbered routes being further west and the higher numbered routes being further east (I-95).

For the purpose of this study, interstate roads will also include the transitional feeder roadways that intersect with distributor roadway cross streets at signalized intersection locations. An example of an interstate and some of the different geometric designs that regulate travel upon them is provided in Figure 10.

Figure 10. Interstate Highways

The intersections analyzed as part of this report were categorized to the roadway types described in the previous section of this report. The number of intersections and their grouping according to the length of time the automated enforcement system has been operational have been summarized in Table 11.

Table 11. Total Intersections According to Roadway Type and Number of Years

Type of Roadway Intersection	Year 1 Group	Year 2 Group	Year 3 Group	Total by Type	Proportion of Total Intersections
Business/ Primary	33	52	41	126	47%
FM/Spurs	6	10	0	16	6%
Interstates	7	23	2	32	12%
State Highway/Loops	18	31	4	53	20%
US Highway	14	20	6	40	15%
Total by Group	78	136	53	267	

Note: Data for Year 1 Group intersections represents one year prior to installation and one year after; Data for Year 2 Group intersections represents two years prior to installation and two years after; Data for Year 3 Group intersections represents three years prior to installation and three years after.

The results of the crash analysis according to intersection type are summarized in Tables 12-16. These tables provide details of the number of each type of intersection along with the number of crashes before and after the installation of the automatic traffic enforcement system. Additionally, red light related crash data (right angle, rear end, and other) according to intersection type have been detailed so that the reader can understand the types of crash events that contributed to the overall crash frequency. The listed data accounts for all groups of intersections: 1 Year Group, 2 Year Group, and 3 Year Group.

The total number of crashes at the selected intersections decreased by 11% (633 crashes). The details related to the total number of crashes according to roadway type are summarized in Table 12.

Table12. Total Crashes According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	2490	2236	-254	-10%
Farm-to-Market (FM) Roads or Spurs	16	255	234	-21	-8%
Interstate Feeder or Access Roads	32	524	457	-67	-13%
State Highways and Loops	53	1290	1091	-199	-15%
US Highways	40	1310	1218	-92	-7%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

The percent decrease (11%) in the total number of crashes ranged from a low of 7% on US highway intersections to a high of 15% for State highway intersections. The Business/Primary Road Category (126 intersections) accounted for 40% of this decrease which is proportional to the number of crashes the roadway type represents in the before and after installation totals.

Table 13. Red Light Related Crashes According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	1019	721	-298	-29%
Farm-to-Market (FM) Roads or Spurs	16	111	80	-31	-28%
Interstate Feeder or Access Roads	32	280	197	-83	-30%
State Highways and Loops	53	667	557	-110	-16%
US Highways	40	652	498	-154	-24%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

The percent decrease (25%) was more significant when only red light related crashes were analyzed. The Business/Primary roads account for 47% of the selected intersections and 44% of the decrease in red light related crashes. The US highway intersections account for 15% of the intersections in the report but 24% of the decrease in crashes was attributed to its roadway type.

Table 14. Red Light Related Crashes (Right Angle Only) According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	948	579	-369	-39%
Farm-to-Market (FM) Roads or Spurs	16	82	47	-35	-43%
Interstate Feeder or Access Roads	32	271	187	-84	-31%
State Highways and Loops	53	632	492	-140	-22%
US Highways	40	608	411	-197	-32%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

The most severe type of crash is attributed to right angle conflicts. The decrease in these crashes was even more pronounced than in the total number of crashes and total of all red light related crashes. There was a 32% decrease in the number of red light related crashes classified as right angle crashes. More than 40% of this decrease can be attributed to the decrease in crashes at Business/Primary road intersections.

Table 15. Red Light Related Crashes (Rear End Only) According to Intersection Type

Intersection Roadway Type	N	Total Before	Total After	Change	%
Business/Primary Roads	126	45	121	76	169%
Farm-to-Market (FM) Roads or Spurs	16	26	31	5	19%
Interstate Feeder or Access Roads	32	7	6	-1	-14%
State Highways and Loops	53	27	52	25	93%
US Highways	40	35	72	37	106%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

As expected the number of rear end crashes did increase with four out of the five different types of intersections. There was an increase of 142 red light related rear end crashes over a total of 267 intersections. More than half of the increase can be attributed to intersections on Business/Primary roads.

Table 16. Red Light Related Crashes (Other Only) According to Intersection Type

Intersection Roadway Type	n	Total Before	Total After	Change	%
Business/Primary Roads	126	26	21	-5	19%
Farm-to-Market (FM) Roads or Spurs	16	3	2	-1	33%
Interstate Feeder or Access Roads	32	2	4	2	-100%
State Highways and Loops	53	8	13	5	-63%
US Highways	40	9	15	6	-67%

Note: Included crashes from all intersection groups (1, 2, & 3 Year Groups)

The red light related crashes classified as other (not right angle or rear end) do not represent a significant portion of the red light related crashes. There was a slight overall increase (15%) in the number of other crashes. Two types of roadway intersections, Business/Primary and FM/Spurs, had a decrease while the other three experienced an increase of more than 60% due to the small number of crashes prior to the installation of the automated enforcement systems.

Conclusions

Based upon the findings of this investigation there is evidence that suggests automated traffic enforcement systems are effective countermeasures in reducing the overall number of crashes events at signalized intersections. In addition to reducing the overall number of crash events, there is strong evidence that suggests that automated traffic enforcement systems are effective at reducing the overall number of crashes at different roadway system types.

While rear end collisions did appear to rise, the majority of those type crashes were not related to red light violations. In those cases where a greater number of rear end collisions occurred, the majority were found to be a result of the “following” driver traveling too closely to the lead unit or failing to control speed. Evidence suggests that rear end crashes are not a result of the lead unit braking hard to avoid running a red signal and being struck from the rear. Crashes of this type were clearly defined in the frequency of non-red light related collisions that were evaluated.

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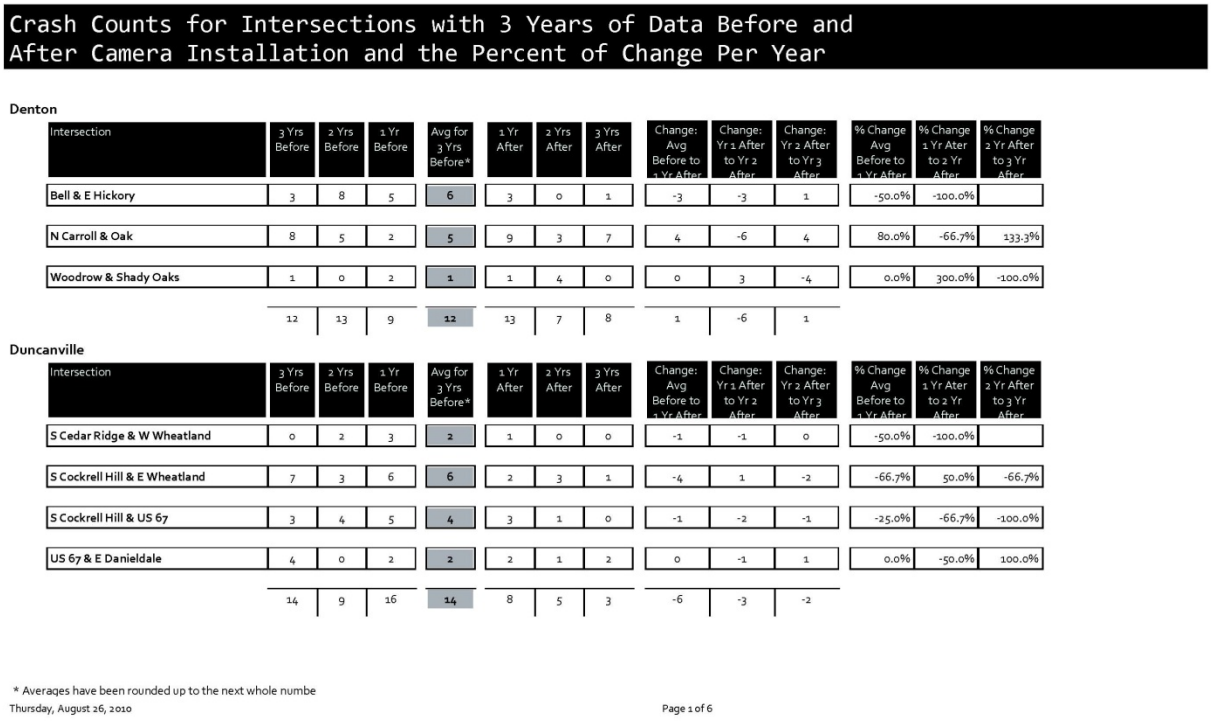
Appendices

Appendix 1. Crash Count for Intersections with 3 Years of Data Before and After Camera Installation and the Annual Percent of Change



Crash Counts for Intersections with 3 Years of Data Before and After Camera Installation and the Percent of Change Per Year

Denton

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Bell & E Hickory	3	8	5	6	3	0	1	-3	-3	1	-50.0%	-100.0%	
N Carroll & Oak	8	5	2	5	9	3	7	4	-6	4	80.0%	-66.7%	133.3%
Woodrow & Shady Oaks	1	0	2	1	1	4	0	0	3	-4	0.0%	300.0%	-100.0%
	12	13	9	12	13	7	8	1	-6	1			

Duncanville

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
S Cedar Ridge & W Wheatland	0	2	3	2	1	0	0	-1	-1	0	-50.0%	-100.0%	
S Cockrell Hill & E Wheatland	7	3	6	6	2	3	1	-4	1	-2	-66.7%	50.0%	-66.7%
S Cockrell Hill & US 67	3	4	5	4	3	1	0	-1	-2	-1	-25.0%	-66.7%	-100.0%
US 67 & E Danieldale	4	0	2	2	2	1	2	0	-1	1	0.0%	-50.0%	100.0%
	14	9	16	14	8	5	3	-6	-3	-2			

* Averages have been rounded up to the next whole numbe

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El Paso

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Gateway & Kenworth	2	0	0	1	0	1	1	-1	1	0	-100.0%		0.0%
Gateway & Zaragoza	8	3	1	4	2	3	3	-2	1	0	-50.0%	50.0%	0.0%
McCombs & Sun Valley	1	3	3	3	1	0	0	-2	-1	0	-66.7%	-100.0%	
Mesa & Resler	8	5	4	6	3	4	5	-3	1	1	-50.0%	33.3%	25.0%
Mesa & Sunland	1	1	1	1	1	1	1	0	0	0	0.0%	0.0%	0.0%
Missouri & Campbell	3	6	4	5	4	4	4	-1	0	0	-20.0%	0.0%	0.0%
Montana & Hawkins	1	3	2	2	1	3	0	-1	2	-3	-50.0%	200.0%	-100.0%
Sunland Park & Mesa Hills	0	0	2	1	4	0	0	3	-4	0	300.0%	-100.0%	
Woodrow Bean & Rushing	0	1	0	1	0	1	0	-1	1	-1	-100.0%		-100.0%
	24	22	17	24	16	17	14	-8	1	-3			

Farmers Branch

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Josey & Valwood	1	2	0	1	0	0	1	-1	0	1	-100.0%		
NO ALL RED PHASE													

* Averages have been rounded up to the next whole numbe

Midway & Alpha	0	2	3	2	1	2	3	-1	1	1	-50.0%	100.0%	50.0%
NO ALL RED PHASE													
Valley View & Webb Chapel	4	0	2	2	0	2	0	-2	2	-2	-100.0%		-100.0%
NO ALL RED PHASE													
Webb Chapel & Valwood	0	0	0	0	0	2	0	0	2	-2			-100.0%
NO ALL RED PHASE													
	5	4	5	5	1	6	4	-4	5	-2			

Garland (Dallas)

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Beltline & Shiloh	5	1	4	4	3	3	2	-1	0	-1	-25.0%	0.0%	-33.3%
Broadway & Centerville	3	2	6	4	2	3	3	-2	1	0	-50.0%	50.0%	0.0%
Centerville & Northwest Hwy	7	5	2	5	0	2	7	-5	2	5	-100.0%		250.0%
First St & Kingsley	2	6	1	3	2	3	0	-1	1	-3	-33.3%	50.0%	-100.0%
Forest & Jupiter	15	10	5	10	4	3	2	-6	-1	-1	-60.0%	-25.0%	-33.3%
	32	24	18	26	11	14	14	-15	3	0			

Houston

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Bay Area & El Camino Real	6	4	2	4	10	2	4	6	-8	2	150.0%	-80.0%	100.0%
Bellaire & Wilcrest	12	6	4	8	2	4	9	-6	2	5	-75.0%	100.0%	125.0%

* Averages have been rounded up to the next whole numbe

Bissonnet & Beltway 8 South	39	38	44	41	38	40	36	-3	2	-4	-7.3%	5.3%	-10.0%
Brazos & Elgin	3	1	1	2	2	2	1	0	0	-1	0.0%	0.0%	-50.0%
Chimney Rock & US 59 South	0	2	12	5	5	11	14	0	6	3	0.0%	120.0%	27.3%
Elgin & Milam	4	5	2	4	0	3	3	-4	3	0	-100.0%		0.0%
FM 1960 & SH 249	30	58	75	55	61	48	40	6	-13	-8	10.9%	-21.3%	-16.7%
Hillcroft & Harwin	6	0	4	4	2	4	3	-2	2	-1	-50.0%	100.0%	-25.0%
Hillcroft & US 59 South	20	22	25	23	14	15	10	-9	1	-5	-39.1%	7.1%	-33.3%
IH 10 & Uvalde	5	2	3	4	4	2	1	0	-2	-1	0.0%	-50.0%	-50.0%
John F Kennedy & Greens	3	5	6	5	7	8	19	2	1	11	40.0%	14.3%	137.5%
Pease & La Branch	5	6	9	7	2	4	4	-5	2	0	-71.4%	100.0%	0.0%
Richmond & Dunvale	7	5	11	8	4	6	5	-4	2	-1	-50.0%	50.0%	-16.7%
Richmond & Hillcroft	6	0	6	4	3	2	7	-1	-1	5	-25.0%	-33.3%	250.0%
S Gessner & Beechnut	11	15	18	15	21	8	8	6	-13	0	40.0%	-61.9%	0.0%
Travis & Webster	25	8	4	13	5	6	5	-8	1	-1	-61.5%	20.0%	-16.7%
US 59 & Fountainview	9	9	8	9	9	7	12	0	-2	5	0.0%	-22.2%	71.4%

* Averages have been rounded up to the next whole numbe

West Beltway 8 & Beechnut	12	14	9	12	9	4	9	-3	-5	5	-25.0%	-55.6%	125.0%
Westpark & US 59 South	18	23	8	17	11	8	12	-6	-3	4	-35.3%	-27.3%	50.0%
	221	223	251	240	209	184	202	-31	-25	18			

Plano

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
15th & Independence	1	5	5	4	2	1	0	-2	-1	-1	-50.0%	-50.0%	-100.0%
Legacy & Dallas Pkwy	19	18	23	20	18	15	13	-2	-3	-2	-10.0%	-16.7%	-13.3%
Park & Ventura	2	7	8	6	6	1	3	0	-5	2	0.0%	-83.3%	200.0%
West Spring Creek & Custer	2	8	7	6	0	0	3	-6	0	3	-100.0%		
	24	38	43	36	26	17	19	-10	-9	2			

Richardson

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Centennial & Greenville	1	9	9	7	10	4	5	3	-6	1	42.9%	-60.0%	25.0%
Coit & Campbell	6	2	6	5	7	0	4	2	-7	4	40.0%	-100.0%	
Plano & Arapaho	0	3	3	2	1	2	4	-1	1	2	-50.0%	100.0%	100.0%
	7	14	18	14	18	6	13	4	-12	7			

* Averages have been rounded up to the next whole numbe

Rowlett

Intersection	3 Yrs Before	2 Yrs Before	1 Yr Before	Avg for 3 Yrs Before*	1 Yr After	2 Yrs After	3 Yrs After	Change: Avg Before to 1 Yr After	Change: Yr 1 After to Yr 2 After	Change: Yr 2 After to Yr 3 After	% Change Avg Before to 1 Yr After	% Change 1 Yr Ater to 2 Yr After	% Change 2 Yr After to 3 Yr After
Rowlett & Beech	0	0	3	1	1	2	0	0	1	-2	0.0%	100.0%	-100.0%
NO ALL RED PHASE													
	0	0	3	1	1	2	0	0	1	-2			

* Averages have been rounded up to the next whole numbe

Appendix 2. State Totals of Crashes by Years of Data Before and After Camera Installation, Roadway Type, Intersection Relation, and Crash Type

Thursday, August 26, 2010
5:41:15 PM

State Totals of Crashes by Years of Data Before and After Camera Installation, Roadway Type, Intersection Relation, and Crash Type

Road Type

Years of Data: 1

Business/Primary Road	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes	Right Angle		1	98	61	1		-37
		Rear End			2	19			17
		Other			3	4			1
		Totals:		**1**	**103**	**84**	**1**		-19
	No	Right Angle		1	47	53	1		6
		Rear End		2	80	101			19
		Other			43	48			5
		Totals:		**3**	**170**	**202**	**1**		30
		Road Type Totals:		**4**	**273**	**286**	**2**		**11**

FM/Spur	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes	Right Angle			15	3			-12
		Rear End			3	4			1
		Other			1				-1
		Totals:			**19**	**7**			-12
	No	Right Angle		1	8	6			-3
		Rear End			13	29			16
		Other			4	9			5
		Totals:		**1**	**25**	**44**			18
		Road Type Totals:		**1**	**44**	**51**			**6**

Interstate Hwy	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change

Note: Blanks cells and missing categories indicate zero values.

Road Type

	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle			46	36			-10
		Rear End			1	2			1
		Other			2	4			2
		Totals:			**49**	**42**			-7
	No								
		Right Angle			7	11			4
		Rear End			20	17			-3
		Other			8	10			2
		Totals:			**35**	**38**			3
		Road Type Totals:			**84**	**80**			**-4**
State Hwy/Loop	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle			33	32			-1
		Rear End			7	10			3
		Other			3	2			-1
		Totals:			**43**	**44**			1
	No								
		Right Angle		1	13	11			-3
		Rear End			82	50			-32
		Other			16	17			1
		Totals:		**1**	**111**	**78**			-34
		Road Type Totals:		**1**	**154**	**122**			**-33**
US Hwy	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle			66	33			-33
		Rear End			7	11			4
		Other			2	1			-1
		Totals:			**75**	**45**			-30
	No								

Note: Blanks cells and missing categories indicate zero values.

Road Type

Right Angle		1	15	18			2
Rear End			63	78	2		17
Other		1	88	79			-10
Totals:		**2**	**166**	**175**	**2**		9
Road Type Totals:		**2**	**241**	**220**	**2**		**-21**
Data Years Totals:		**8**	**796**	**759**	**4**		**-41**

Years of Data: 2

Business/Primary Road

Yes

Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Right Angle		208	132	93	83		-164
	Rear End		8	8	21	26		31
	Other		9	4	3	4		-6
	Totals:		**225**	**144**	**117**	**113**		-139

No

Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Right Angle	4	127	118	129	93	2	-25
	Rear End	1	92	97	136	131	3	80
	Other		50	62	67	60	1	16
	Totals:	**5**	**269**	**277**	**332**	**284**	**6**	71
Road Type Totals:		**5**	**494**	**421**	**449**	**397**	**6**	**-68**

FM/Spur

Yes

Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Right Angle		36	31	25	19	1	-22
	Rear End		10	13	13	14		4
	Other		2		2			0
	Totals:		**48**	**44**	**40**	**33**	**1**	-18

No

Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Right Angle		17	6	16	13		6
	Rear End		31	44	32	34		-9
	Other		6	14	7	8		-5

Note: Blanks cells and missing categories indicate zero values.

Road Type

	Totals:		**54**	**64**	**55**	**55**		-8
	Road Type Totals:		**102**	**108**	**95**	**88**	**1**	**-26**
Interstate Hwy	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle		113	102	73	60	11	-71
		Rear End		2	4	1	3		-2
		Totals:		**115**	**106**	**74**	**63**	**11**	-73
	No								
		Right Angle		33	26	27	21	3	-8
		Rear End		27	18	29	22	3	9
		Other	1	37	30	37	46	3	18
		Totals:	**1**	**97**	**74**	**93**	**89**	**9**	19
	Road Type Totals:		**1**	**212**	**180**	**167**	**152**	**20**	**-54**
State Hwy/Loop	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle		136	146	100	79	9	-94
		Rear End		8	10	18	23		23
		Other		4	1	5	3		3
		Totals:		**148**	**157**	**123**	**105**	**9**	-68
	No								
		Right Angle		73	66	69	64	4	-2
		Rear End		73	95	81	67	7	-13
		Other		47	48	48	36	2	-9
		Totals:		**193**	**209**	**198**	**167**	**13**	-24
	Road Type Totals:			**341**	**366**	**321**	**272**	**22**	**-92**
US Hwy	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle	3	211	141	119	116	13	-107
		Rear End	1	8	17	25	27	1	27

Note: Blanks cells and missing categories indicate zero values.

Road Type								
	Other		3	2	7	5		7
	Totals:	**4**	**222**	**160**	**151**	**148**	**14**	-73
No								
	Right Angle		30	27	40	35	2	20
	Rear End	4	85	110	110	117	3	31
	Other		62	72	68	55	3	-8
	Totals:	**4**	**177**	**209**	**218**	**207**	**8**	43
	Road Type Totals:	**8**	**399**	**369**	**369**	**355**	**22**	**-30**
	Data Years Totals:	**14**	**1548**	**1444**	**1401**	**1264**	**71**	**-270**

Years of Data: 3

Business/Primary Road	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle	185	153	171	126	101	114	-168
		Rear End	11	7	9	17	17	21	28
		Other	1	7	2	4	3	3	0
		Totals:	**197**	**167**	**182**	**147**	**121**	**138**	-140
	No								
		Right Angle	118	97	110	95	99	96	-35
		Rear End	97	101	63	88	86	95	8
		Other	48	71	42	41	43	50	-27
		Totals:	**263**	**269**	**215**	**224**	**228**	**241**	-54
		Road Type Totals:	**460**	**436**	**397**	**371**	**349**	**379**	**-194**

Interstate Hwy	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle	5	2	3	4	2	1	-3
		Totals:	**5**	**2**	**3**	**4**	**2**	**1**	-3
	No								
		Right Angle	4	1	4	2			-7
		Rear End	5	3	3	2	1	5	-3

Note: Blanks cells and missing categories indicate zero values.

Road Type								
	Other	6	5	6	3	10	8	4
	Totals:	**15**	**9**	**13**	**7**	**11**	**13**	-6
Road Type Totals:		**20**	**11**	**16**	**11**	**13**	**14**	**-9**

State Hwy/Loop	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle	81	109	127	106	92	83	-36
		Rear End		1	1			1	-1
		Other				2		1	3
		Totals:	**81**	**110**	**128**	**108**	**92**	**85**	-34
	No								
		Right Angle	2		5	5	3	3	4
		Rear End	11	11	8	1	8	10	-11
		Other	28	15	29	14	16	22	-20
		Totals:	**41**	**26**	**42**	**20**	**27**	**35**	-27
	Road Type Totals:		**122**	**136**	**170**	**128**	**119**	**120**	**-61**

US Hwy	Red Light Related?	Crash Type	3 Yrs Before	2 Yrs Before	1 Yr Before	1 Yr After	2 Yrs After	3 Yrs After	Change
	Yes								
		Right Angle	53	68	66	40	39	51	-57
		Rear End	2			4	2	2	6
		Other	1		1		2		0
		Totals:	**56**	**68**	**67**	**44**	**43**	**53**	-51
	No								
		Right Angle	4	13	4	11	9	5	4
		Rear End	13	15	17	8	21	20	4
		Other	10	11	13	9	15	12	2
		Totals:	**27**	**39**	**34**	**28**	**45**	**37**	10
	Road Type Totals:		**83**	**107**	**101**	**72**	**88**	**90**	**-41**
	Data Years Totals:		**685**	**690**	**684**	**582**	**569**	**603**	**-305**
	State Totals:		**699**	**2246**	**2924**	**2742**	**1837**	**674**	**-616**

Note: Blanks cells and missing categories indicate zero values.

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Appendix 3. Intersection Locations by Intersection and Roadway Type

Intersection Locations by Road Type and City

Years of Data 1 Count of Intersections: 83

Business/Primary Road
Count of Intersections: 38

Amarillo
Coulter & Elmhurst
1

Arlington
Cooper & W Rd to Six Flags
Little & W Poly Webb
2

Austin
S Pleasant Valley & E Riverside
US 290 & Loop 1
2

Baytown
BS 146 & SH 146
BS 146 & Wyoming
W Baker & Garth
3

Bedford NO ALL RED PHASE
Central & L Don Dodson
Harwood & Brown
2

Dallas
Ferguson & Peavy
Lombardy & Webb Chappel
Forest & Plano
Keller Springs & Knoll Trail
Forest & Schroeder
5

Denton
Mayhill & Spencer
1

El Paso
Redd & Resler
Joe Battle & Montwood
Joe Battle & Rojas
Montana & Airway
4

Farmers Branch NO ALL RED PHASE
Spring Valley & Inwood
1

Fort Worth
McCart & Westcreek
Western Center & Beach

S Hulen & Overton Ridge
S Hulen & Bellaire
E Lancaster & Riverside
8th Ave & Elizabeth
Bryant Irvin & W Vickery
NW 25th St & Clinton
Long & Deen
Lancaster & Sandy
W Weatherford & Houston

11

Grand Prairie

Pioneer Pkwy & Carrier Pkwy
Beltline & Tarrant

2

Killeen

Trimmier & Lowes

1

Mesquite

Bryan-Beltline & Grubb
N Galloway & Grubb

2

Richardson

Beltline & US 75

1

FM/Spur

Count of Intersections: 6

Arlington

Spur 303 & S Collins
FM 157 & W Park Row
FM 157 & W Main

3

Baytown

W Baker & Spur 330

1

College Station

FM 2154 & FM 2347

1

Humble (Harris) NO ALL RED PHASE

FM 1960 & North Houston

1

Interstate Hwy

Count of Intersections: 8

Amarillo

Coulter & IH 40
Ross & IH 40 SR

2

Austin

IH 35 & 15th St
IH 35 & 11th St
2

Baytown

Garth & IH 10
1

Grand Prairie

S Carrier Pkwy & IH 20
1

Haltom City

SH 377 & IH 820
1

Terrell

SH 34 & IH 20
1

State Hwy/Loop
Count of Intersections: 18

Arlington

Tx 180 & Collins
Tx 180 & Cooper
2

Austin

Loop 1 & Howard Ln
1

Baytown

Garth & SH 146
1

Bedford NO ALL RED PHASE

SH 183 & Bedford
Central & SH 183
2

Burleson

SH 174 & Elk
SH 174 & Spur 50
SH 174 & Newton
SH 174 & Gardens
SH 174 & FM 731
5

College Station

SH 30 & George Bush
SH 30 & Munson
SH 6 & Walton
3

Dallas

Dallas North Tollway & Keller Springs
1

Haltom City

	Haltom Rd & SL 820	
		1
North Richland Hi		
	NE Loop 820 & Rufe Snow	
		1
Roanoke	NO ALL RED PHASE	
	SH 114 & North Oak	
		1
US Hwy		
Count of Intersections:	**13**	
Amarillo		
	US 60 & SE 11th	
	US 60 & SE 3rd	
		2
Jersey Village	NO ALL RED PHASE	
	US 290 & FM 529	
	US 290 & Jones	
	US 290 & Senate	
	US 290 & Sam Houston Pkwy	
		4
Killeen		
	US 190 & FM 3470	
	US 190 & Trimmier	
	US 190 & WS Young	
	US 190 & SH 195	
		4
Richardson		
	US 75 & Campbell	
		1
Roanoke	NO ALL RED PHASE	
	SH 114 & US 377	
		1
Terrell		
	US 80 & FM 148	
		1
Years of Data **2**	**Count of Intersections:**	**139**
Business/Primary Road		
Count of Intersections:	**54**	
Arlington		
	Collins & E Sublett	
	Matlock & Arbrook	
		2
Cedar Hill		
	E Belt Line & Joe Wilson	
	E Belt Line & Waterford Oaks	
	E Belt Line & Clark	
		3

Coppell

MacArthur & Sandy Lake
Denton Tap & Sandy Lake
Beltine & MacArthur

3

Corpus Christi

McArdle & Airline
Ocean & Doddridge
Staples & Williams
Yorktown & Cimarron
Holly & Weber
Greenwood & Gollihar
Everhart & Holly
Ayers & Gollihar
Ayers & Baldwin

9

Dallas

Bruton & 2nd
Beckley & Colorado
Banner & Coit
Central Expry & Commerce
Ferguson & Gus Thomasson
Camp Wisdom & Westmoreland
Forest & Inwood
Jefferson & Tyler
Miller & Plano
Lindsley & Munger
Lemmon & Oak Lawn
Lemmon & Mockingbird
Alpha & Dallas Pkwy
Hamptom & Wheatland
Abrams & Cimarron

15

Farmers Branch NO ALL RED PHASE

Valley View & Luna
Marsh & Valley View

2

Grand Prairie

Jefferson & Carrier Pkwy
Beltline & Lone Star Pkwy
Carrier Pkwy & Roy Orr

3

Houston

Chartes & St Joseph Pkwy

1

Irving NO ALL RED PHASE

Irving & Walton Walker
O'Conner & Lane
Belt Line & Pioneer
3

McKinney

Virginia & Stonebridge
1

North Richland Hi

Rufe Snow & Mid Cities
Rufe Snow & Dick Lewis
2

Plano

Jupiter & East Plano Pkwy
Coit & Park
Preston & West Plano Pkwy
Coit & West Spring Creek
Preston & West Spring Creek
West Parker & Dallas Pkwy
West Plano Pkwy & Dallas Pkwy
7

Richland Hills

Glennview & Booth Calloway
1

Rowlett NO ALL RED PHASE

Rowlett & Chaha
Rowlett & Hickox
2

FM/Spur

Count of Intersections: 10

Arlington

FM 157 & Spur 303
FM 157 & SW Green Oaks
2

Dallas

Olive & Spur 366
1

Humble (Harris) NO ALL RED PHASE

FM 1960 & Whitaker
FM 1960 & Townsen
2

Lake Jackson

FM 2004 & Hwy 288
1

North Richland Hi

FM 1938 & Lola
FM 1938 & Harwood
FM 1938 & Mid Cities

FM 1938 & Maplewood

4

Interstate Hwy

Count of Intersections: 22

Dallas

IH 635 & Montfort
IH 635 & SH 289
Coit & IH 635
Mockingbird & IH 35
Harwood & IH 30

5

Houston

Post Oak & IH 610
FM 2351 & IH 45 South
IH 10 & Market
IH 10 & Normandy
IH 10 & North Wayside
IH 45 & Woodridge
IH 45 & South Wayside
El Dorado & IH 45
North Shepherd & IH 610
Greens & IH 45 North
Scott & IH 610
SH 3 & IH 45
West & IH 45 North
West IH 610 & San Felipe
Westheimer & IH 610
Stella Link & South IH 610 West
IH 45 North & West Rankin

17

State Hwy/Loop

Count of Intersections: 27

Arlington

Hwy 360 & Ave H
Hwy 360 & Six Flags
Hwy 360 & Park Row

3

Cedar Hill

E Belt Line & Hwy 67

1

Dallas

Cockrell Hill & SH 180
Spur 348 & Loop 12
SH 342 & Loop 12
Dallas North Tollway & Loop 12
Lemmon & Loop 12

	Frankford & SH 289	
	Harry Hines & Loop 12	
	Bruton & Loop 12	
	Loop 12 & John West	
		9
Grand Prairie		
	SH 360 & Carrier	
		1
Houston		
	West Beltway 8 & Bellaire	
	West Beltway 8 & Westpark	
	South Beltway 8 & SH 35	
		3
Humble (Harris)	NO ALL RED PHASE	
	FM 1960 & SH 59	
		1
Irving	NO ALL RED PHASE	
	SH 161 & Gateway	
	SH 114 & SH 161	
	Belt Line & SH 183	
		3
Lake Jackson		
	Hwy 288/332 & This Way	
		1
Lufkin	NO ALL RED PHASE	
	Loop 287 & FM 1271	
	Loop 287 & Copeland	
		2
Plano		
	SH 121 & Dallas Pkwy	
	Custer & SH 121	
		2
Rowlett	NO ALL RED PHASE	
	SH 66 & Chiesa	
		1
US Hwy		
Count of Intersections:	**26**	
Dallas		
	US 75 & Lemmon	
	US 75 & Lovers	
		2
Diboll		
	US 59 & Lumberjack	
	US 59 & FM 1818	
		2
Houston		
	US 59 & Fondren	

Bissonnet & US 59
US 59 & Bellaire
US 290 & Mangum
Fairbanks N Houston & US 290
US 59 & Bellfort
Antoine & US 290
US 59 & Beechnut
Hollister & US 290
US 90 A & IH 610
US 59 & Wilcrest

11

Lufkin NO ALL RED PHASE

US 59 & FM 819
US 59 & FM 58
US 69 & Loop 287
US 59 & US 69
US 59 & Loop 287
US 59 & Paul

6

Marshall

US 59 & SH 43
US 59 & US 80
US 80 & N Alamo
US 59 & East Travis

4

Sugar Land

US 59 & SH 6

1

Years of Data 3 **Count of Intersections: 53**

Business/Primary Road
Count of Intersections: 42

Denton

N Carroll & Oak
Bell & E Hickory
Woodrow & Shady Oaks

3

Duncanville

S Cockrell Hill & E Wheatland
S Cedar Ridge & W Wheatland

2

El Paso

Mesa & Resler
Missouri & Campbell
McCombs & Sun Valley
Woodrow Bean & Rushing
Sunland Park & Mesa Hills

	Gateway & Zaragoza
	Mesa & Sunland
	Gateway & Kenworth
	Montana & Hawkins
	Gateway North & Woodrow
	10
Farmers Branch	NO ALL RED PHASE
	Webb Chapel & Valwood
	Midway & Alpha
	Josey & Valwood
	Valley View & Webb Chapel
	4
Garland (Dallas)	
	Broadway & Centerville
	Beltline & Shiloh
	Centerville & Northwest Hwy
	First St & Kingsley
	Forest & Jupiter
	5
Houston	
	Hillcroft & Harwin
	Brazos & Elgin
	Bellaire & Wilcrest
	Bay Area & El Camino Real
	Elgin & Milam
	Richmond & Dunvale
	Richmond & Hillcroft
	S Gessner & Beechnut
	Travis & Webster
	Pease & La Branch
	John F Kennedy & Greens
	11
Plano	
	Park & Ventura
	15th & Independence
	Legacy & Dallas Pkwy
	3
Richardson	
	Plano & Arapaho
	Coit & Campbell
	Centennial & Greenville
	3
Rowlett	NO ALL RED PHASE
	Rowlett & Beech
	1
Interstate Hwy	
Count of Intersections:	1

Houston	
IH 10 & Uvalde	
	1
State Hwy/Loop	
Count of Intersections:	3
Houston	
Bissonnet & Beltway 8 South	
West Beltway 8 & Beechnut	
FM 1960 & SH 249	
	3
US Hwy	
Count of Intersections:	7
Duncanville	
S Cockrell Hill & US 67	
US 67 & E Danieldale	
	2
Houston	
Chimney Rock & US 59 South	
Westpark & US 59 South	
Hillcroft & US 59 South	
US 59 & Fountainview	
	4
Plano	
West Spring Creek & Custer	
	1