# Evaluating the Effectiveness of Red Light Running Camera Enforcement in Cedar Rapids and Developing Guidelines for Selection and Use of Red Light Running Countermeasures

MTC
MIDWEST TRANSPORTATION CONSORTIUM

**Final Report**
**November 2011**


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Midwest Transportation Consortium
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The preparation of this (report, document, etc.) was financed in part through funds provided by the Iowa Department of Transportation through its "Agreement for the Management of Research Conducted by Iowa State University for the Iowa Department of Transportation," and its amendments.

**Technical Report Documentation Page**

| | | |
|---|---|---|
| **1. Report No.** InTrans Project 10-386 | **2. Government Accession No.** | **3. Recipient's Catalog No.** |
| **4. Title and Subtitle** Evaluating the Effectiveness of Red Light Running Camera Enforcement in Cedar Rapids and Developing Guidelines for Selection and Use of Red Light Running Countermeasures | | **5. Report Date** November 2011<br>**6. Performing Organization Code** |
| **7. Author(s)** Shauna Hallmark, Nicole Oneyear, and Tom McDonald | | **8. Performing Organization Report No.** InTrans Project 10-386 |
| **9. Performing Organization Name and Address** Center for Transportation Research and Education<br>Iowa State University<br>2711 South Loop Drive, Suite 4700<br>Ames, IA 50010-8664 | | **10. Work Unit No. (TRAIS)**<br>**11. Contract or Grant No.** |
| **12. Sponsoring Organization Name and Address** Iowa Department of Transportation, Office of Traffic and Safety, 800 Lincoln Way, Ames, Iowa 50010<br>Midwest Transportation Consortium, Institute for Transportation, 2711 S. Loop Drive, Suite 4700, Ames, Iowa 50010-8664 | | **13. Type of Report and Period Covered** Final Report<br>**14. Sponsoring Agency Code** |
| **15. Supplementary Notes** Visit www.intrans.iastate.edu for color PDF files of this and other research reports. | | |

**16. Abstract**


Red light running (RLR) is a problem in the US that has resulted in 165,000 injuries and 907 fatalities annually. In Iowa, RLR-related crashes make up 24.5 percent of all crashes and account for 31.7 percent of fatal and major injury crashes at signalized intersections.

RLR crashes are a safety concern due to the increased likelihood of injury compared to other types of crashes. One tool used to combat red light running is automated enforcement in the form of RLR cameras. Automated enforcement, while effective, is often controversial.

Cedar Rapids, Iowa installed RLR and speeding cameras at seven intersections across the city. The intersections were chosen based on crash rates and whether cameras could feasibly be placed at the intersection approaches.

The cameras were placed starting in February 2010 with the last one becoming operational in December 2010. An analysis of the effect of the cameras on safety at these intersections was determined prudent in helping to justify the installation and effectiveness of the cameras.

The objective of this research was to assess the safety effectiveness of the RLR program that has been implemented in Cedar Rapids. This was accomplished by analyzing data to determine changes in the following metrics:

- Reductions in red light violation rates based on overall changes, time of day changes, and changes by lane
- Effectiveness of the cameras over time
- Time in which those running the red light enter the intersection
- Changes in the average headway between vehicles entering the intersection


| | | | |
|---|---|---|---|
| **17. Key Words** automated enforcement—cameras—countermeasures—crash mitigation—intersection safety—red light cameras—signalized intersections—speed cameras | | **18. Distribution Statement** No restrictions. | |
| **19. Security Classification (of this report)** Unclassified. | **20. Security Classification (of this page)** Unclassified. | **21. No. of Pages** 66 | **22. Price** NA |

**Form DOT F 1700.7 (8-72)** **Reproduction of completed page authorized**

# EVALUATING THE EFFECTIVENESS OF RED LIGHT RUNNING CAMERA ENFORCEMENT IN CEDAR RAPIDS AND DEVELOPING GUIDELINES FOR SELECTION AND USE OF RED LIGHT RUNNING COUNTERMEASURES

**Final Report**
**November 2011**


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the Iowa Department of Transportation
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## TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

## ACKNOWLEDGMENTS

The authors would like to thank the Iowa Department of Transportation (DOT) Office of Traffic and Safety for sponsoring this research. They would also like to thank the Midwest Transportation Consortium (MTC) for sponsoring a student to work on the project.

The authors would also like to thank the City of Cedar Rapids and the Cedar Rapids Police Department for their assistance. Finally, the authors would like to thank Gatso USA for providing data for this study.

This work does not reflect the views of the City of Cedar Rapids, Iowa, the Iowa DOT, or Gatso USA.

## EXECUTIVE SUMMARY

### Background

Red light running (RLR) is a problem in the US that has resulted in 165,000 injuries and 907 fatalities each year from 2000 through 2008. In Iowa, RLR-related crashes make up 24.5 percent of all crashes at signalized intersections and account for 31.7 percent of fatal and major injury crashes at signalized intersections.

RLR crashes are a safety concern due to the increased likelihood of injury compared to other types of crashes. One tool used to combat red light running is automated enforcement in the form of RLR cameras. Automated enforcement, while effective, is often controversial.

Cedar Rapids, Iowa installed RLR and speeding cameras at seven intersections across the city. The intersections were chosen based on crash rates and whether cameras could feasibly be placed at the intersection approaches.

The cameras were placed starting in February 2010 with the last one becoming operational in December 2010. An analysis of the effect of the cameras on safety at these intersections was determined prudent in helping to justify the installation and effectiveness of the cameras.

The objective of this research was to assess the safety effectiveness of the RLR program that has been implemented in Cedar Rapids. This was accomplished by analyzing data to determine changes in the following metrics:

- Reductions in red light violation rates based on overall changes, time of day changes, and changes by lane
- Effectiveness of the cameras over time
- Changes in seconds into the red that vehicles running the red light enter the intersection
- Changes in the average headway between vehicles entering the intersection

### Analyses

At the end of the project, most of the cameras had been in place for only one year. As a result, it was not yet feasible to conduct a crash analysis. Consequently, several different types of analyses were completed to evaluate the effectiveness of the RLR cameras using violation and other data collected by the cameras, such as headway and time into red.

Cameras were installed at different times between February and December 2010. Once cameras were installed at each intersection, data were collected for three days to a week before warnings or citations were given (referred to as “stealth mode”).

During stealth mode, the cameras were present but Photo Enforced signs to alert drivers to the cameras were not yet installed and Cedar Rapids was not issuing citations. Data collected during this time period was used as before data.

Next, the cameras were set to collect violations and warnings were given for a 30 day period before actual citations were issued. Data were collected for three different after periods, which occurred after the cameras had been issuing citations actively for at least a month. Data were extracted in June, August, and October 2010 for the same number of days as for the before period.

*Change in Red Light Running Violation Rates*

RLR violation rates were compared from the before to after periods. Violation rates reflected violations per 10,000 vehicles. Violation rates were first compared by approach. Decreases were noted for all three after periods as shown in Figure 1.

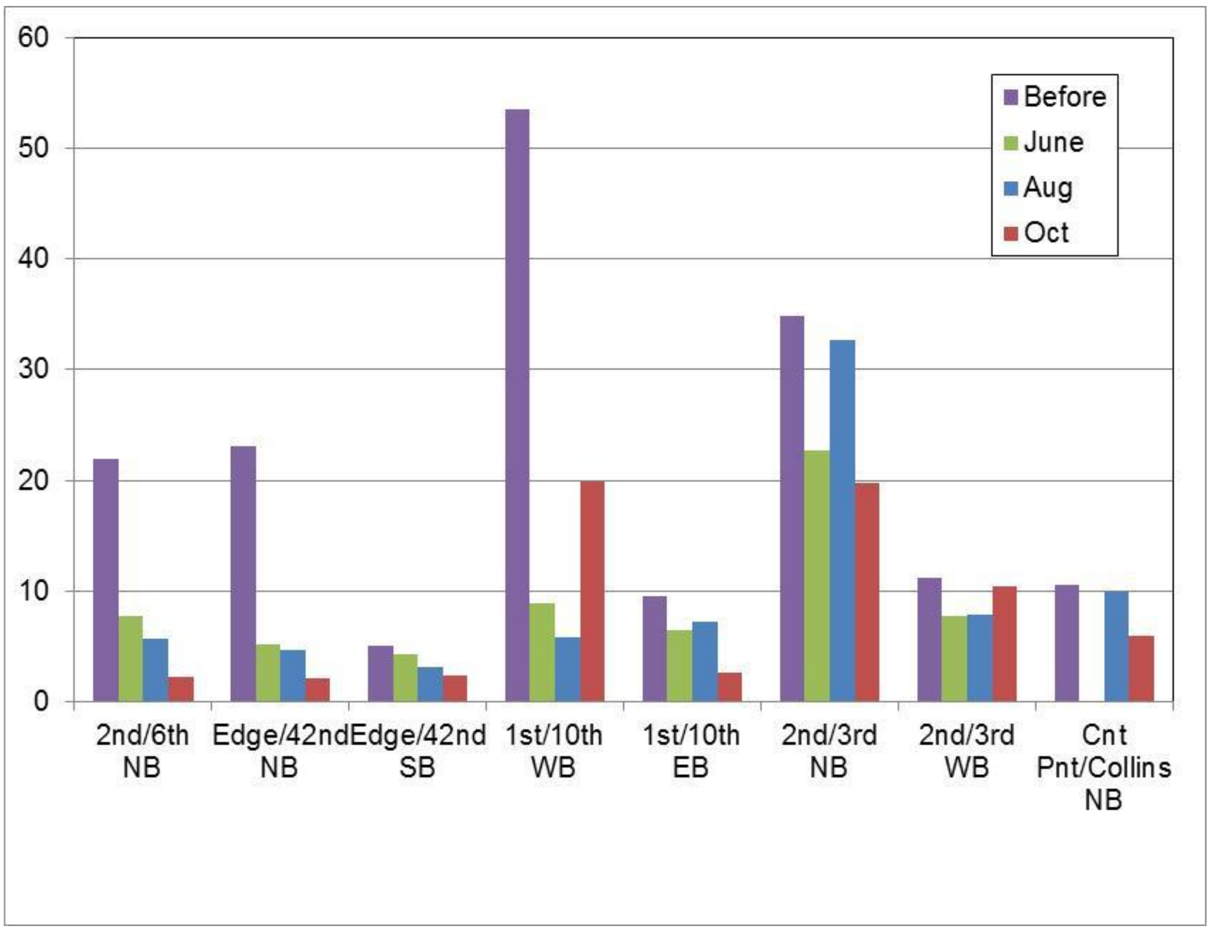


**Figure 1. Decrease in violation rate after activation of red light running cameras**

As shown, some approaches had substantial decreases. Decreases ranged from 16 to 83 percent for the June after period; 6 to 89 percent for the August after period; and 7 to 91 percent for the October after period.

*Time-of-Day Analysis*

Violations were also compared for daytime versus nighttime to determine whether time of day was relevant. Several intersections go into flashing mode during late night hours so only four approaches were included in the analysis.

All approaches evaluated experienced decreases for the daytime period with decreases in violation rates from 29 to 92 percent for the June after period; 12 to 93 percent for the August after period; and 51 to 86 percent for the October after period.

Nighttime results were similar for the June after period with decreases from 8 to 100 percent. Two approaches experienced increases in the violation rate for the August after period (15 percent and 104 percent) with the other two approaches experiencing decreases (48 percent and 81 percent). The final after period (October) had reductions at three approaches (38 to 66 percent) with one approach having an increase of 73 percent.

The time-of-day results suggest the cameras may be more effective in reducing RLR violations during the daytime.

*Evaluation of Change in Red Light Running Violations over Time*

Most studies that have assessed the effectiveness of RLR cameras in reducing RLR violations conduct their analysis for a single after period, which is usually fairly close in time to installation of the cameras. It is not well understood if the cameras have the same impact over time. In some cases, countermeasures become less effective over time because drivers become accustomed to the treatment. On the other hand, enforcement countermeasures may be more effective over time given drivers who speed or run red lights may change their behavior when they or someone they know receives a ticket.

To test this theory, a negative binomial model was used to evaluate whether RLR violations increased or decreased over time. Data were available for seven approaches from zero to 12 months, depending on the intersection and approach.

The model was used to calculate the expected violations per 10,000 vehicles over time. The variables for both intersection ID and month after installation were statistically significant. The model indicated that for each additional month at a given intersection, a 9.3 percent decrease in violations is predicted.

*Time into Red Analysis*

The next analysis assessed whether cameras are effective in reducing late red light runners. Opponents of RLR cameras suggest that red light enforcement cameras are not effective in reducing RLR crashes because cameras are only likely to change the behavior of drivers who run the red light within seconds of the red indication. Drivers who run the red light at the beginning of the red interval are typically intentionally running the red light. Their rationale is that late red light violations are unintentional and are due to driver distraction, impairment, or fatigue and that cameras are not likely to impact unintentional red light running.

Time-stamped violation data were obtained for seven of the approaches where RLR cameras had been installed. RLR violations were binned by time into red by 0 to less than 1 second, 1 to less than 3 seconds, and, finally, violations that occurred 3 or more seconds into the red. These particular intervals were used given other research indicated crashes are unlikely in the first second into the red, only left-turn-opposed crashes are likely to occur from 1 to 3 seconds into the red, and both left-turn-opposing and right-angle crashes occur 3 or more seconds into the red.

The violation rate per 10,000 vehicles was calculated for the seven approaches collectively. During the June after period, the violation rate decreased from 5.29 to 2.69 per 10,000 vehicles (for a 49.1 percent decrease) for the 0.0 to < 1.0 second interval. A decrease from 1.97 to 0.73 (or 63.0 percent) was noted for the 1.0 to < 3.0 second interval. The largest reduction occurred for violations that were 3 or more seconds into the red with a change from 10.35 to 2.87 (or 72.3 percent).

During the August after period, decreases were noted for all of the time intervals with the largest decrease occurring for violations that were 3.0 or more seconds into the red, with a decreased violation rate from 10.35 to 2.59 (or 75.0 percent). The 0.0 to < 1.0 second interval had a decrease from 5.29 to 2.59 (or 51.1 percent), and the 1.0 to < 3.0 second interval had a decrease from 1.97 to 0.56 (or 71.4 percent).

The October after period also had decreases in violation rates for all of the time intervals. Both the 1.0 to < 3.0 second and 3.0 or more second intervals experienced a decrease of 79.6 percent. RLR violations that were 3.0 or more seconds into the red decreased from 10.35 to 2.82 per 10,000 vehicles and had the largest decrease in terms of magnitude (change of 7.54). The 0 to < 1 second interval experienced a decrease of 67.9 percent from 5.29 to 1.70.

As noted, violations that were 3.0 or more seconds into red experienced the greatest decrease in violation rate in terms of magnitude. That interval also experienced the greatest percentage decrease for the June and August after periods.

*Analysis of Change in Headway*

One of the largest concerns when installing red light cameras is that the presence of the cameras causes more people to slam on their brakes resulting in more rear-end crashes. Drivers may be more likely to attempt to stop during the yellow interval to avoid an RLR violation when they would have otherwise proceeded through the intersection.

An unexpected stop by a preceding driver may result in a rear-end crash if the following driver is following too close. Alternatively, drivers who are aware the cameras are in place may leave larger gaps between them and the vehicle in front, anticipating that the lead driver is more likely to stop quickly.

The RLR cameras record time and speed for all vehicles whether or not they commit RLR violations. Headway was next sorted into bins of different lengths and the percent in each bin was found. The bins used were less than 1 second, 1 second, 2 seconds, 3 seconds, 4 seconds, and 5 or more seconds.

At 5 seconds, the gap is sufficiently large enough that even under adverse conditions, the following vehicle will have sufficient time to stop without rear-ending the lead vehicle. More bins were used for the smaller gaps to better determine the cameras' effects on these drivers. Finally, the change in percentages for each bin were found by subtracting the percentage in the before period from the percentage in the after period.

Data were summarized by approach for seven approaches. The analysis showed the percentage of drivers in any headway bin experienced little change between the before and any of the three after periods. In other words, results suggest that driver headway is not affected by presence of the RLR cameras.

# 1. BACKGROUND

## 1.1 Magnitude of Red Light Running

In 2009, red light running (RLR) resulted in 676 fatalities in the US. This represented 10 percent of all intersection-related fatalities as well as two percent of all roadway fatalities in 2009 (FHWA 2011). In addition, the Insurance Institute for Highway Safety (IIHS) estimates that 130,000 people were injured in crashes in 2009 due to red light running (IIHS 2011b).

More than half of the fatalities due to RLR are not the driver of the vehicle running the red light, but passengers in that car, someone in the car they collide with, or pedestrians (IIHS 2007). Retting et al. (1995) indicated that occupant injuries occurred in 45 percent of RLR crashes as compared to other urban crashes and account for 16 to 20 percent of total crashes at urban signalized intersections.

RLR is a safety issue, which 93 percent of respondents of the American Automobile Association (AAA) 2010 Traffic Safety Culture Index considered unacceptable; yet, more than 30 percent of respondents admitted to running a red light in the last 30 days when they could have safely stopped (AAA 2010).

A review was conducted of the Iowa Department of Transportation (DOT) crash database for 2010 to determine the magnitude of RLR crashes in Iowa. A total of 6,007 crashes occurred at signalized intersections in 2010. Crashes at signalized intersections were defined as those coded as a non-freeway intersection, which also had presence of a traffic signal noted.

RLR crashes accounted for 1,525 crashes. RLR crashes were defined as crashes where the major cause or contributing circumstances were listed as “ran traffic signal” or “failure to yield right of way on right turn on red.” Consequently, 24.5 percent of crashes at signalized intersections in Iowa were found to be due to RLR. In addition, RLR crashes were found to make up 31.7 percent of fatal and major injury crashes.

## 1.2 Red Light Running Camera Enforcement

RLR cameras are one solution that have been used to reduce RLR violations and crashes. Red light cameras have been in place in the US for the last 20 years and are estimated to be in use in approximately 538 cities as of May 2011 (IIHS 2011a).

Camera enforcement has generally been found to be effective. Fleck and Smith (1999) found a 42 percent decrease in red light running and a nine percent citywide reduction in collisions and injuries one year after implementation of RLR cameras in San Francisco, California.

Burchfield (2005) found a 60 to 87 percent decline in violations at five intersections in Portland, Oregon where RLR cameras were used.

Retting and Kyrychenko (2001) evaluated the effectiveness of RLR cameras in Oxnard, California and reported the camera system reduced the number of crashes by seven percent.

Hiller et al (1993) conducted a two-year before and after study to evaluate the effectiveness of RLR cameras installed at 16 intersections in Sydney, Australia and found a 50 percent reduction in right-angle and left-turn-opposed crashes and a 25 to 60 percent reduction in rear-end crashes.

Walden (2008) evaluated 56 intersections one year before and after installation of RLR cameras and found a reduction in overall crashes of 30 percent, a reduction in right-angle crashes of 43 percent, and an increase in rear-end crashes of five percent.

Butler (2001) evaluated 25 intersections in a Howard County, Maryland study where cameras were installed. A 32 percent reduction in rear-end crashes, 42 percent reduction in right-angle crashes, and a 22 percent reduction in other crashes was reported.

Winn (1995) compared the effectiveness of cameras at six locations in Glasgow, Scotland and found a 62 percent reduction in RLR injury crashes.

Ng et al. (1997) evaluated 42 intersections in Singapore where RLR cameras were installed. They reported a seven percent reduction in total crashes and an eight percent reduction in right-angle crashes.

Washington and Shin (2005) investigated 14 intersections in Scottsdale, Arizona and 11 intersections in Phoenix, Arizona and found an 11 to 14 percent decrease in right-angle crashes.

Hallmark et al (2010) evaluated five intersections in Davenport, Iowa where RLR cameras were installed. Results of a Bayesian analysis indicated that RLR-related crashes decreased by 40 percent and rear-end crashes decreased by 33 percent.

### 1.3 Violations as a Safety Surrogate for Red Light Running

When evaluating the effectiveness of a red light camera program, a crash analysis is often completed to determine if the presence of the cameras is causing a significant change in the number of crashes. Crash studies often look at changes to both right-angle crashes (those associated most often with RLR) as well as rear-end crashes.

While the best method to evaluate the safety impact of RLR cameras is an analysis of crash reduction, a robust crash study requires several years of data after installation for a representative sample and to avoid regression to the mean.

However, agencies often wish to evaluate the immediate impact of installing RLR cameras to justify their investment. As a result, reduction in the number of RLR violations is sometimes used by agencies as a safety surrogate.

Given red light violations happen much more frequently than red light crashes, a shorter time period can be evaluated to determine significant changes. Use of violations as a safety surrogate is due to the fact that, as the number of violations decreases, the exposure of vehicles to the potential for a red light crash also decreases.

This relationship, however, is not likely a direct one due to the randomness of crashes. In addition, not all RLR violations are equally risky. For example, a driver who runs the red light at the beginning of the red phase during off-peak hours is much less likely to pose a safety risk than a driver who runs the red well into the red phase during peak hours.

Bonneson et al. (2002) developed a crash rate model to determine the relationship between red light violations and crash rates. Using three years of crash data from 20 approaches, they extracted the crashes most associated with red light running: right-angle- and left-turn-related crashes.

Using a non-linear regression analysis, they were able to develop a model that took into account three-year counts of red light-related crashes, annual daily traffic (ADT) of the intersecting streets, and violation rates (per 1,000 entering vehicles). The model was then calibrated and the researchers found that, as the red light violation rates increase (as well as increasing cross street traffic), so does the predicted approach crash frequency.

They also conducted a sensitivity analysis assuming constant ADT on the approaches and developed the trend seen in Figure 1.1. As shown, the relationship is neither direct nor linear. For instance, a 50 percent reduction in RLR would result in a 25 percent reduction in crashes.

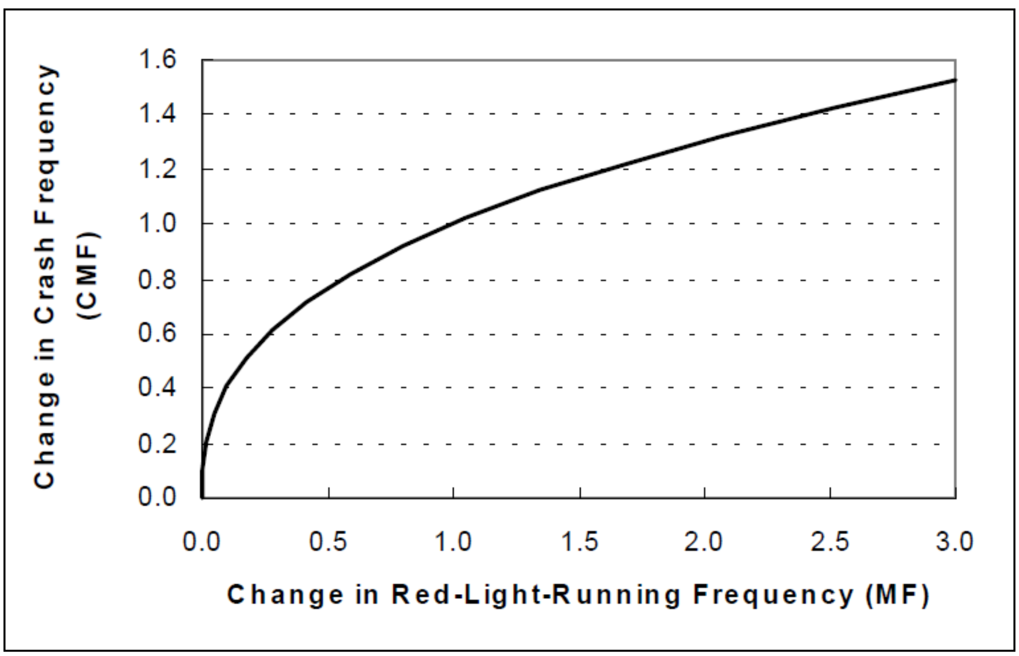


**Figure 1.1. Effect of a change in red light running on crash frequency (Bonneson et al. 2002)**

### 1.4 Effectiveness of RLR Camera Enforcement in Reduction of RLR Violations

Retting et al. (1999a) found around a 40 percent reduction in the violation rate at intersections in Oxnard, California three to four months after red light cameras were installed. They also found a spillover effect at other intersections across the city. Their "before/after quasi-experimental design" included collecting violation data at nine intersections across the city that had red light cameras installed and comparing the changes to three other intersections in the city without cameras, as well as two control sites in nearby Santa Barbara, California.

The violation data used at the camera intersections were collected by the vendor while the data at the non-camera and control intersections were collected by analyzing video collected at the sites by the investigators. Baseline data were collected prior to the 30 day warning period that the city gave before the cameras started issuing citations, while the after data were collected three to four months after the cameras became operational in July 1997.

The researchers defined a red light violation as one where the driver entered the intersection 0.4 or more seconds into the red while traveling at least 15 mph. This was done to eliminate drivers turning right on red and turning left.

The data were analyzed using log-linear models that had variables including the period of data collection (before versus after), as well as the site type (camera, non-camera, and control), which were then tested for statistical significance using an analysis of variance table. The results of the analysis of variance table showed no statistically significant difference between the reductions in violation rates seen at the camera and non-camera sites, but did show a statistically significant difference between the camera and non-camera sites and the control sites.

Retting et al. (1999b) conducted a similar study in Fairfax, Virginia. In this study, only five camera sites were selected along with two non-camera sites in Fairfax and two control sites in nearby counties. All data in this case were collected by the investigators.

The researchers collected data right before the 30 day warning period and then once the cameras had been operational for three months and again after a year. They also defined a red light violation the same as in their other study, as a vehicle entering the intersection at least 0.4 seconds into the red and traveling at a minimum of 15 mph.

An analysis of variance table was again used to determine if changes seen were statistically significant. The study found within the city of Fairfax, violation rates decreased by nine percent three months after the cameras were installed and 40 percent after a year. Similar to the Oxnard study, there were no statistically significant differences between the camera and non-camera sites during either after time period and a statistically significant difference was seen between the camera and non-camera sites compared to the control sites one year after. However, at three months after, there was no statistically significant change between the control, camera, and non-camera sites.

Cunningham and Hummer (2004) performed an analysis where they studied the change in the violations that occurred longer than 2 seconds into the red. They chose to look at violations that occurred 2 seconds or more into the red after studying previous research that suggested this as the time when red light violations would most likely result in collisions.

Cunningham and Hummer obtained their data from the vendor for intersections in Chapel Hill and Raleigh, North Carolina. The before data were from a validation study the vendor conducted before placing the cameras.

This study involved taping the intersections from the side of the road for 16 to 24 hours and then having an individual watch video for each intersection twice to determine the number of violations and the time into the red at which they occurred. The after data were for four months to one year later and were provided by the vendor.

After data were reduced so only the same time of day was used. After data consisted of up to a week of observations to have a large enough sample size. A chi-squared test of independence was used with a two-by-two contingency table. Results showed a significant decrease in the frequency of violations that occurred two or more seconds after the red when the cameras were in place.

Retting et al. (2008) completed an evaluation of the red light camera program in Philadelphia, Pennsylvania. In addition to placing red light cameras, the city also increased the length of the yellow signal prior to installing the cameras.

The study looked at three approaches at two intersections that had cameras installed along with three control intersection approaches in Atlantic County, New Jersey. The cameras had a 120 day warning period once they were installed prior to citations being issued.

Each approach had 24 to 48 hours of video collected during the three phases that were then viewed by one individual and violations were coded. A second individual verified the coding by checking three of the approaches for three 24 hours periods.

Violation rates per 10,000 entering vehicles were determined using the violations found along with the exposure that was collected using road tubes. These rates were then analyzed using a logistic regression to estimate an odds ratio.

Once taking into account the increase in violations seen at the control site, the study sites saw a 36 percent decrease in the odds ratio due to the increase in the length of the yellow phase. The change seen post Phase III, once the cameras had been in place, was an additional 96 percent reduction in the odds ratio. It should be noted the change seen during Phase III may also include residual decreases due to the increased yellow time.

Fitzsimmons et al. (2009) completed a cross-sectional analysis to determine the effect of red light cameras on RLR violations. The cross-sectional analysis was completed in place of a before and after study due to a lack of before data collected.

Four study intersections composed of six approaches in Clive, Iowa were used, as well as 15 control approaches at seven intersections in the Des Moines, Iowa metro area.

One day of video data were collected at the control intersections while data for the study intersections were obtained from the City of Clive. The video data were manually reduced to look at the peak hours.

A red light violation was defined as a vehicle located beyond the approach stop bar when the traffic signal indication is a red ball or arrow, which then proceeds through the intersection for a through or left-turn movement. An average violation rate per 1,000 entering vehicles was then found for the control intersections and study intersections by taking the total red light violations at the intersection (study or control) and dividing it by the total number of vehicles entering the intersection (study or control).

Then, the generalized linear model was found to determine the statistical significance of the violation rates at the control and study intersections. In addition, vehicle movements (i.e., left turn, right turn, through) were modeled separately for each approach and peak-hour period. Results found 25 times more violations to occur at a non-camera intersection compared to an intersection with a camera in place.

### 1.5 Project Objectives

To address RLR crashes in Iowa, a number of communities have installed RLR enforcement cameras. A previous study by the Center for Transportation Research and Education (CTRE) at Iowa State University evaluated the RLR cameras in Davenport, Council Bluffs, and Clive, Iowa (Fitzsimmons et al. 2007). Study results indicated a significant reduction in RLR violations (in Clive) and RLR-related crashes after installation of the cameras.

Several other Iowa communities are in the process of either installing RLR cameras or considering them as a countermeasure. So, this study provided a timely opportunity to evaluate the effectiveness of RLR camera enforcement in Iowa further.

The objective of this research was to assess the effectiveness of the red light running program that was implemented in Cedar Rapids, Iowa.

A toolbox of RLR countermeasures in addition to RLR cameras was also developed as part of this project.

## 2. SITE INFORMATION

### 2.1 Selection of Intersections

Cedar Rapids, Iowa had continuing problems with red light running and speeding at signalized intersections. After other solutions failed, the city decided to implement RLR and speed enforcement cameras at select intersections.

Thirty intersections were identified as locations with high right-angle crash rates. Traffic engineers and police officers from Cedar Rapids reviewed and then narrowed the list to seven intersections that had one or more approaches, which were the best candidates for cameras. The intersections were chosen based on their crash rates as well as the ability for the cameras to be placed (i.e., adequate space for the cameras to be installed), appropriate intersection configurations, and no future plans for intersection improvements.

These cameras were put in place starting in February 2010 with the last one installed in December 2010. Cameras that enforce both red light violations as well as speed violations were installed at the following intersection approaches:

- 2nd Avenue SW and 6th Street SW – northbound and westbound
- Edgewood Road and 42nd Street NE – northbound and southbound
- 1st Avenue and 10th Street – eastbound and westbound
- 2nd Avenue SW and 3rd Street SW – northbound and westbound
- 1st Avenue and L Street SW – eastbound and westbound
- Center Point Road and Collins Road NE – northbound
- Williams Boulevard and 16th Avenue SW – northbound and southbound

Additional information about each of the study intersections is included in the following sections.

#### *2.1.1 2nd Avenue SW and 6th Street SW*

The intersection at 2nd Avenue SW and 6th Street SW is located west of downtown Cedar Rapids. 2nd Avenue SW is a one-way street with traffic traveling southwest through the intersection while 6th Street SW is a two-way street. The intersection configuration is shown in Figure 2.1.


**Figure 2.1. 2nd Avenue SW and 6th Street SW intersection (aerial photo: Google Earth 2011)**

This intersection reverts to flashing yellow/red during the hours of 2 a.m. to 6 a.m. daily; the flashing yellow is to 6th Street SW and flashing red is to 2nd Avenue SW. Cameras monitor the northbound 6th Street approach as well as the westbound 2nd Avenue approach. Cameras were installed in March 2010.

### *2.1.2 Edgewood Road and 42nd Street NE*

Edgewood Road and 42nd Street NE is located northwest of downtown Cedar Rapids. This intersection is made up of two two-way roads with right-turn by-pass lanes as shown in Figure 2.2. The northbound and southbound approaches of Edgewood Road are monitored by the cameras. Cameras started issuing citations in late April 2010.

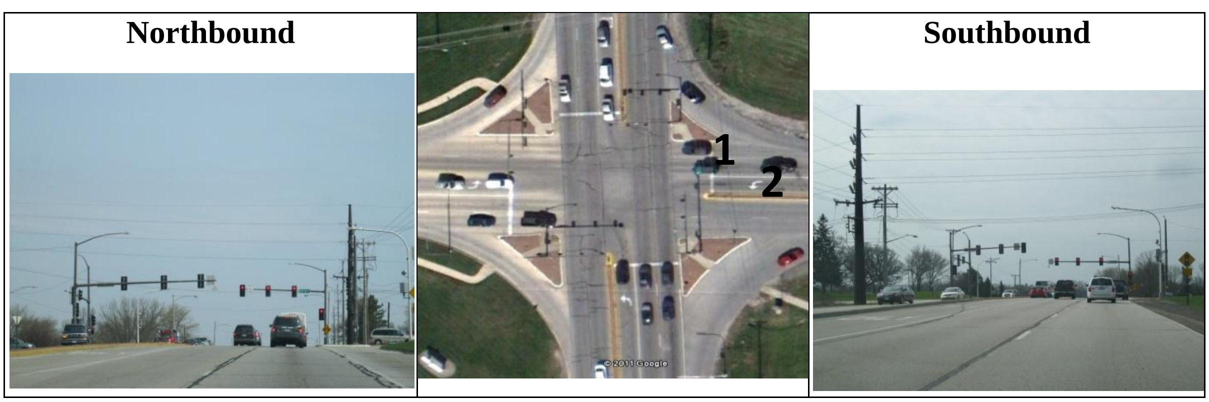


**Figure 2.2. Edgewood Road and 42nd Street NE intersection (aerial photo: Google Earth 2011)**

*2.1.3 1st Avenue and 10th Street*

The intersection of 1st Avenue and 10th Street is located in downtown Cedar Rapids just southeast of St. Luke’s Hospital. This intersection is made up of two two-way streets. Cameras are located on both approaches on 1st Avenue (eastbound and westbound) with cameras being operational starting with the warning period in February 2010 followed by issuing citations in March 2010. Figure 2.3 illustrates the approaches studied and labels the lanes.


**Figure 2.3. 1st Avenue and 10th Street intersection (aerial photo: Google Earth 2011)**

*2.1.4 2nd Avenue SW and 3rd Street SW*

2nd Avenue SW and 3rd Street SW is located east of I-380 and west of the river in downtown Cedar Rapids. This intersection is comprised of two one-way streets. 2nd Avenue SW is one-way with traffic moving westbound and 3rd Street SW is one way with traffic moving northbound. Both approaches are monitored as shown in Figure 2.4. This intersection reverts to flashing yellow/red during the hours of 10 p.m. to 6 a.m. each day. The flashing red is to 3rd Street SW and the flashing yellow is to 2nd Avenue SW. Operations at this intersection started in April 2010.


**Figure 2.4. 2nd Avenue SW and 3rd Street SW intersection (aerial photo: Google Earth 2011)**

*2.1.5 1st Avenue and L Street*

This intersection is located just west of I-380 near downtown Cedar Rapids. L Street is a one-way street with traffic moving southbound. The L Street approach north of the intersection is an off ramp of I-380 as illustrated in Figure 2.5. This intersection reverts to flashing red/yellow during the hours of midnight to 6 a.m. each day. During this time period, the flashing yellow is to 1st Avenue and the flashing red is for L Street. The cameras were active starting in May 2010.


**Figure 2.5. 2nd Avenue SW and 3rd Street SW intersection (aerial photo: Google Earth 2011)**

### *2.1.6 Center Point Road and Collins Road NE*

This intersection is located north of downtown Cedar Rapids. This intersection is a grade separate intersection that allows for north-south traffic along Center Point Road and allows for vehicles to enter or exit Collins Road westbound. This intersection reverts to flashing red/yellow during the hours of 1 a.m. to 6 a.m. each day. The camera is located on the northbound approach of Center Point Road as seen in Figure2.6. The camera was active starting in July 2010.


**Figure 2.6. Center Point Road and Collins Road NE intersection (aerial photo: Google Earth 2011)**

*2.1.7 Williams Boulevard and 16th Avenue SW*

This intersection is located southwest of downtown Cedar Rapids. The intersection is made up of two two-way streets. There are right-turn bypass lanes for all approaches as seen in Figure 2.7. Cameras are located on the northbound and southbound approaches of Williams Boulevard. Cameras were installed in June 2010 but, due to technical issues, were not operational until December 18, 2010.


**Figure 2.7. Williams Boulevard and 16th Avenue SW intersection (aerial photo: Google Earth 2011)**

### 2.2 Description of Camera Systems

The RLR and speed camera system used was installed and operated by Gatso USA. The systems were installed on mast arms, which mounted the Radio Frequency (RF) antennas over each lane. The mast arm and RF antennas are shown in Figure 2.8.

**Figure 2.8. Mast arm and RF antenna setup**

Figure 2.9 shows what the cameras look like at each intersection.

The RF antennae are positioned by marking and aiming the antennae at a point 20 ft from the stop bar. When a vehicle passes through the beam, the radar is triggered (Gatso 2010). As a result, all vehicles are recorded, providing a measure of volume.

When the radar is triggered, speed is measured and considered valid if the vehicle speed is within the limits of the radar (6 mph to 126 mph). Invalid triggers are also recorded and indicated as those vehicles with a speed less than 6 mph or as incomplete or inconsistent Doppler readings. The vendor indicated this often occurs when vehicles slam on their breaks just before the stop bar.

Speed readings are gathered through the same system. When the radar is triggered, the speed is measured. If a vehicle is traveling 7 mph or more over the speed limit, it is marked as a potential speed violation and is then sent to the police department to review. Only the cases for which the speed is valid are reviewed by the police. If the speed cannot be determined to be valid, it is thrown out.

**Figure 2.9. Camera setup**

The cameras are tied into the signal control system. If the proprietary vendor software determines that the vehicle entered the intersection (i.e., crossed the stop bar before the signal turned red) while the signal is in the red phase, two photos are taken, one as the vehicle enters the intersection and another while the vehicle is traveling through the intersection. One of these photos is used to obtain a close-up of the license plate of the vehicle. Five to six seconds of video data are also recorded on violations for all locations except one.

The cameras were installed at each intersection at different times from February 2010 with the last one installed in December 2010. Once the cameras were installed, the system collected data for three days to a week (in “stealth mode”) before warnings or citations were given.

During stealth mode, photo-enforced warning signs were not yet installed. Next, the cameras collected violations and the system issued warnings for 30 days after the first cameras were installed. This warning period lasted from February 13, 2010 through March 14, 2010. After that, the system began to forward potential citations to the Cedar Rapids Police Department.

Violation data and video go to the Police Department where a sworn officer reviews each potential violation and decides if a violation occurred or if, for example, the vehicle was attempting to get out of the way for an emergency vehicle. The officer determines if sufficient evidence is present to support the approval of the violation.

The cost of a red light violation is $100. Fines for speeding are listed in Table 2.1. If the driver runs a red light and is speeding while doing so, they receive a violation for both running the red light and speeding. Tickets are issued at 12 mph over the speed limit or 7mph if in a school zone.

**Table 2.1. Fines for a speed violation (City of Cedar Rapids, 2011)**

| Speed over the Limit | Civil Fine | If in a Construction Zone |
|---|---|---|
| 1 – 5 mph | $25 | $50 |
| 6 – 10 mph | $50 | $100 |
| 11 – 20 mph | $75 | $150 |
| 21 – 25 mph | $100 | $200 |
| 26 – 30 mph | $250 | $500 |
| Over 30 mph | $500 | $750 |

The automated enforcement program was marketed from the very early stages and continues today. The police made their intentions of the system public. These intentions included reducing angle crashes at intersections that showed a history of high rates of angle crashes, reducing the loss of life and property damage caused by these accidents, and changing driver behavior.

The city and police used various forms of media to help with their marketing campaign. These forms included TV, radio, web, flyers, and personal appearances at civic functions. In addition, there was a lot of local press coverage, both news and print. Media releases were also sent at least two days prior to an intersection going live.

Each intersection has signage in place alerting drivers of the photo enforcement and speed enforcement. Signs are also placed at all entrances to the city.

# 3. DATA COLLECTION AND REDUCTION

Ideally, RLR violations would have been collected before drivers were aware that the cameras were going to be installed. However, collection of RLR data without an automated camera system, which can tap into the traffic control signal, is difficult and time consuming and use of trained observers to identify red light runners is subjective. Given the team did not have access to a system to collect RLR data independently, the study relied on data collected by the vendor, Gatso USA.

As noted in Chapter 2, data were collected by the cameras in stealth mode for several days before the cameras began reporting violations. Data collected during this time period were used as before data. Data used for after time periods were collected after the 30 day warning period and after the cameras had been active for at least a month.

The vendor supplied a separate Microsoft Excel spreadsheet for each day of data collection at each approach. A description of the data format is provided in Appendix B.

## 3.1 Data Reduction

As data were received, they were examined for problems and reduced. Data reduction involved making sure all time periods matched. Therefore, if data were not present from 0:00:00 a.m. to 8:59:00 a.m., for example, in one of the time periods for a particular approach, the same block of time was removed from all other time periods for that approach.

In addition, when obvious problems with the data were present, the corresponding data were removed. For instance, one day the northbound approach of 2nd Avenue SW and 6th Street SW had longer than normal times listed for the length of the yellow signal (9.99 seconds), which indicated something was wrong with the signal or the data file. These data were therefore removed.

Next, three intersections, 2nd Avenue and 3rd Street SW, 2nd Avenue and 6th Street SW, and Center Point Road and Collins Road NE Ramp, have a nighttime period when they go into flashing yellow/red mode as described in Chapter 2. Data were also removed for these time periods.

Finally, weather effects were taken into account. Hourly weather data were obtained from the National Climatic Data Center for all time periods when data were collected (NCDC 2011). If the precipitation or fog were considered heavy, the data were then removed for these time periods. It was assumed that when there was accumulating snow, heavy rain (0.05+ in./hr) or dense fog (<0.5 miles of visibility) traffic patterns would be effected.

If data were removed for a specific time period during the before period, they were also removed from the after period. A summary of the data that were removed is provided in Appendix C.

In several cases, before data were not available for several approaches or the data had sufficient problems that they could not be included. The following summarizes data issues:

- 1st Avenue and L Street SW: All approaches had problems with before data and were removed from the analysis (an increase of 25 percent in the recorded vehicles occurred from the before to one-month after period, which could not be explained by seasonal fluctuation)
- 2nd Avenue and 6th Street SW westbound: Before data not available

The approaches that were available for study include the following:

- 2nd Avenue SW and 6th Street SW – northbound
- Edgewood Road and 42nd Street NE – northbound
- Edgewood Road and 42nd Street NE – southbound
- 1st Avenue and 10th Street – eastbound
- 1st Avenue and 10th Street – westbound
- 2nd Avenue SW and 3rd Street SW – northbound
- 2nd Avenue SW and 3rd Street SW – westbound
- Center Point Road NE and Collins Road NE Ramp – northbound

Cameras were installed at different times between February and December 2010. As a result, each intersection had different before dates. Before data were the periods when the cameras were operating in stealth mode.

The vendor collected data continuously once the cameras became active. However, there were time periods in which the data were not able to be backed up. Data from June through October were collected and used as the after data. The time period corresponding closest to the before time period was then used as the after data for the months of June, August, and October.

Rather than having a consistent after period (i.e., one month), different after periods resulted. Due to the range of installation dates, the after data represents anywhere from one to nine months post camera installation. Table 3.1 shows the dates on which the data were collected for each intersection.

**Table 3.1. Data collection dates**

| Intersection | Before Dates (2010) | After Dates | | |
|---|---|---|---|---|
| | | June 2010 | August 2010 | October 2010 |
| 2nd Avenue and 6th Street SW | Feb. 22–28 | 22–28 | 23–29 | 18–24 |
| Edgewood Road and 42nd Street NE | April 16–23 | 4–10 | 13–19 | 22–28 |
| 1st Avenue and 10th Street | Feb. 6–8 | 5–6 | 21–22 | 9–10 |
| 2nd Avenue and 3rd Street SW | March 25–31 | 14–20 | 19–25 | 20–26 |
| Center Point Road and Collins Road NE Ramp | July 17–23 | N/A | 21–27 | 15–21 |

### 3.2 Data Limitations

The data used in this study were provided by the vendor. Therefore, some limitations go along with this. One of these limitations is that this is the raw data before a police officer was able to review the potential violation. Therefore, it is assumed that all violations listed as “red” were in fact a red light violation.

A certain number of red violations were discarded by officers when they reviewed the violation data. This may be due to factors such as an emergency vehicle entering the intersection on the red interval. Given this information was not available, the team had to assume all red violations were equally likely to be valid.

The major limitation to use of the vendor data is that the study did not provide a true naïve before study. At the point data were collected for the before period, a majority of drivers were likely aware that the system was being implemented in Cedar Rapids and cameras would have been visible to drives. As a result, drivers were likely to have already modified their behavior.

# 4. COMPARISON OF VIOLATION RATES AFTER INSTALLATION OF CAMERAS

Violation rates from the before to after periods were evaluated using several different approaches. First, violations were assessed overall; then, they were compared by time of day to determine whether drivers were more or less likely to change behavior at certain times of the day; and, finally, violations by lane were reviewed to determine if drivers in a through lane were more or less likely to change their behavior compared to a right- or left-turn lane.

Reduction in RLR violations was used as a crash surrogate based on the assumption that there is a correlation between RLR violations and crashes. Ideally, a comparison with a control group would have been looked at, but, due to a lack of violation data collected at non enforced intersections, this could not be accomplished.

## 4.1 Methodology

Change in violations from the before and after study was calculated to measure the change in violation rates at the automated enforced intersections. Violation rate was the metric used to compare changes from the before to after period. Violation rate was used rather than number of violations because rate accounts for volume (exposure). Violation rate per 10,000 entering vehicles was calculated using Equation 4-1:

$$violation\ rate = \frac{Total\ Red\ Light\ Violations}{Total\ Vehicles\ Entering\ the\ Intersection} \times 10{,}000 \qquad (4\text{-}1)$$

Violation rates were calculated for each approach in each of the four time periods.

A test of proportions was used to determine if the changes in the violation rate were statistically significant. This test was performed using Equation 4-2:

$$\boldsymbol{Z} = \frac{(\hat{\boldsymbol{\pi}}_{\boldsymbol{b}} - \hat{\boldsymbol{\pi}}_{\boldsymbol{i}})}{\sqrt{\frac{\hat{\boldsymbol{\pi}}_{\boldsymbol{b}}(1-\hat{\boldsymbol{\pi}}_{\boldsymbol{b}})}{\boldsymbol{n}_{\boldsymbol{b}}} + \frac{\hat{\boldsymbol{\pi}}_{\boldsymbol{i}}(1-\hat{\boldsymbol{\pi}}_{\boldsymbol{i}})}{\boldsymbol{n}_{\boldsymbol{i}}}}} \qquad (4\text{-}2)$$

where:

Z = z-test statistics
$\hat{\boldsymbol{\pi}}_{\boldsymbol{b}}$ = violation rate for before period
$\boldsymbol{n}_{\boldsymbol{b}}$ = volume for before period
$\hat{\boldsymbol{\pi}}_{\boldsymbol{i}}$ = violation rate for after period *i*
$\boldsymbol{n}_{\boldsymbol{i}}$ = volume for before period

This z-test statistic was then compared to a Z table with α=0.10 to determine significance at 90 percent confidence. Therefore, if Z was greater than 1.28, the resulting decrease in the violation rate was statistically significant and if Z was less than -1.28, the increase in the violation rate was statistically significant.

**4.1 Results for Overall Change in the Violation Rate**

This section describes results for comparisons of violations over all hours when data were available. In most cases, this represents a 24 hour period. However, at two intersections, the signals are in flashing red/yellow mode at certain times during the night, so data were compared for the period when the signals were operating normally, which was less than a 24 hour interval.

Overall, the cameras decreased the rate of violations at all intersections. Most changes were found to be statistically significant at the intersections, except for 2nd Avenue and 3rd Street westbound. Results are shown in Table 4.1.

The northbound approach at 2nd Avenue SW and 6th Street SW saw consistently large decreases in violation rates once the cameras were installed and violations were being issued. Violation rates steadily decreased the longer the cameras were in place. This is expected as more drivers become aware of the cameras and change their driving behavior. As of October 2010, a 90 percent decrease in the violation rate had been seen at this northbound approach.

Edgewood Road and 42nd Street NE also saw large decreases in violation rates at the northbound approach as shown in Table 4.1. The southbound approach also reported decreases in violation rates; however, they were smaller in magnitude. Similar to reductions at 2nd Avenue SW and 6th Street SW, the change in violations increased the longer the cameras were in place with the largest decreases occurring in October.

The westbound approach of 1st Avenue and 10th Street saw the largest numerical decreases in violation rates for all of the approaches as indicated in Table 4.1. The largest decrease was observed in August 2010 when the violation rate decreased by 47.7 RLR violations per 10,000 entering vehicles. The eastbound approach also saw decreases in the violation rate; however, these were smaller in magnitude and not all were statistically significant.

2nd Avenue SW and 3rd Street SW northbound showed statistically significant decreases as well for the June and October after periods.

The Center Point and Collins Road NE ramp only showed a statistically significant decrease for the October after period as noted in Table 4.1. Data for the June after period were not available for that approach as it was not installed until July of 2010.

**Table 4.1. Changes in violation rates for overall time period**

| Approach | | Before | June 2010 | August 2010 | October 2010 |
|---|---|---|---|---|---|
| 2nd and 6th NB | Violation rate | 21.99 | 7.70 | 5.67 | 2.24 |
| | Sample size | 21832 | 23383 | 22925 | 22367 |
| | Absolute change in violation rate | | -14.29 | -16.32 | -19.75 |
| | Percent change in violation rate | | -65% | -74% | -90% |
| Edgewood and 42nd NB | Violation rate | 23.05 | 5.16 | 4.65 | 2.10 |
| | Sample size | 71161 | 73645 | 70901 | 76244 |
| | Absolute change in violation rate | | -17.89 | -18.40 | -20.95 |
| | Percent change in violation rate | | -78% | -80% | -91% |
| Edgewood and 42nd SB | Violation rate | 5.10 | 4.26 | 3.17 | 2.42 |
| | Sample size | 72618 | 68127 | 66302 | 65981 |
| | Absolute change in violation rate | | **-0.84*** | -1.93 | -2.68 |
| | Percent change in violation rate | | -16% | -38% | -53% |
| 1st and 10th WB | Violation rate | 53.52 | 8.90 | 5.83 | 19.87 |
| | Sample size | 18125 | 15739 | 13718 | 17113 |
| | Absolute change in violation rate | | -44.62 | -47.69 | -33.65 |
| | Percent change in violation rate | | -83% | -89% | -63% |
| 1st and 10th EB | Violation rate | 9.56 | 6.48 | 7.21 | 2.65 |
| | Sample size | 14642 | 13886 | 13870 | 15079 |
| | Absolute change in violation rate | | **-3.08*** | **-2.35*** | -6.91 |
| | Percent change in violation rate | | -32% | -25% | -72% |
| 2nd and 3rd NB | Violation rate | 34.81 | 22.76 | 32.69 | 19.73 |
| | Sample size | 6033 | 6591 | 7036 | 7603 |
| | Absolute change in violation rate | | -12.05 | **-2.12*** | -15.08 |
| | Percent change in violation rate | | -35% | -6% | -43% |
| 2nd and 3rd WB | Violation rate | 11.23 | 7.78 | 7.81 | 10.39 |
| | Sample size | 18700 | 17984 | 17924 | 19246 |
| | Absolute change in violation rate | | **-3.45*** | **-3.42*** | **-0.84*** |
| | Percent change in violation rate | | -31% | -30% | -7% |
| Center Point and Collins NE Ramp (North) | Violation rate | 10.53 | n/a | 9.92 | 5.98 |
| | Sample size | 33227 | n/a | 32267 | 31794 |
| | Absolute change in violation rate | | n/a | -0.61* | -4.55 |
| | Percent change in violation rate | | n/a | -6% | -43% |

* Not statistically significant at the 90 percent level of confidence

### 4.2 Results for Daytime versus Nighttime Changes in Violation Rates

The change in the violation rate was also compared for daytime versus nighttime periods. Drivers may be more or less likely to run red lights during certain times of the day. Daytime and nighttime hours were evaluated separately, given visibility, traffic patterns, and driver behavior are different at night compared to during the day.

Because two of the intersections go into flashing red/yellow overnight, only 1st Avenue and 10th Street and Edgewood Road and 42nd Street NE were studied for the time of day analysis. First, data that had been reduced were divided into daylight and darkness time periods. This was accomplished by first finding out the times that the sun rose and set each day throughout the study using data tables from the U.S. Naval Observatory (USNO 2011). Next, the time period for daylight was found with the latest sunrise being used as the beginning of the period and the earliest sunset being used as the end of the period. For nighttime, the latest sunset was used for the beginning and the earliest sunrise was used as the end of the time period. This was done to ensure that consistent time periods were used.

Once the daylight and night periods were found, data were disaggregated into these two times and then violation rates were calculated for each of the study stages. The violation rates from the after periods were compared to those from the before periods to find the change.

A test of proportions was used to test the statistical significance of the changes. Results are provided in Tables 4.2 and 4.3.

**Table 4.2. Changes in violation rates for daytime period**

| Approach | | Before | June 2010 | August 2010 | October 2010 |
|---|---|---|---|---|---|
| Edgewood and 42nd NB | Violation rate | 20.71 | 6.87 | 5.51 | 2.86 |
| | Sample size | 43453 | 46568 | 43547 | 49035 |
| | Absolute change in violation rate | | -13.84 | -15.20 | -17.86 |
| | Percent change in violation rate | | -67% | -73% | -86% |
| Edgewood and 42nd SB | Violation rate | 4.97 | 3.54 | 3.41 | 2.42 |
| | Sample size | 44252 | 42385 | 41019 | 41343 |
| | Absolute change in violation rate | | **-1.43*** | **-1.56*** | -2.55 |
| | Percent change in violation rate | | -29% | -31% | -51% |
| 1st and 10th WB | Violation rate | 56.08 | 4.23 | 3.73 | 13.08 |
| | Sample size | 11413 | 9454 | 8040 | 9942 |
| | Absolute change in violation rate | | -51.85 | -52.35 | -43.00 |
| | Percent change in violation rate | | -92% | -93% | -77% |
| 1st and 10th EB | Violation rate | 5.44 | 8.43 | 4.80 | 2.21 |
| | Sample size | 9187 | 8307 | 8332 | 9031 |
| | Absolute change in violation rate | -- | **2.98*** | **-0.64*** | **-3.23*** |
| | Percent change in violation rate | -- | 55% | -12% | -59% |

* Not statistically significant at the 90 percent level of confidence

**Table 4.3. Changes in violation rates for nighttime period**

| Approach | | Before | June 2010 | August 2010 | October 2010 |
|---|---|---|---|---|---|
| Edgewood and 42nd NB | Violation rate | 4.02 | 0.00 | 8.66 | 1.75 |
| | Sample size | 4973 | 6556 | 6930 | 5725 |
| | Absolute change in violation rate | | -4.02 | **4.64*** | **-2.27*** |
| | Percent change in violation rate | | -100% | 15% | -57% |
| Edgewood and 42nd SB | Violation rate | 7.87 | 7.26 | 1.46 | 4.91 |
| | Sample size | 6352 | 6884 | 6861 | 6114 |
| | Absolute change in violation rate | | **-0.61*** | -6.41 | **-2.96*** |
| | Percent change in violation rate | | -8% | -81% | -38% |
| 1st and 10th WB | Violation rate | 16.39 | 7.43 | 8.48 | 28.39 |
| | Sample size | 7931 | 2692 | 2358 | 2818 |
| | Absolute change in violation rate | | -8.96 | **-7.91*** | **12.00*** |
| | Percent change in violation rate | | -55% | -48% | 73% |
| 1st and 10th EB | Violation rate | 11.04 | 7.49 | 22.56 | 3.70 |
| | Sample size | 2718 | 2672 | 2659 | 2701 |
| | Absolute change in violation rate | | **-3.55*** | **11.53*** | **-7.34*** |
| | Percent change in violation rate | | -32% | 104% | -66% |

* Not statistically significant at the 90 percent level of confidence

As shown in Table 4.2, 1st Avenue and 10th Street westbound traffic reduced their violation rates by at least 77 percent during daylight hours while Edgewood Road and 42nd Street NE northbound saw decreases of 67 to 86 percent in RLR violation rates.

During nighttime hours, the only changes that were statistically significant were the decreases seen in June and August at the Edgewood Road approaches and the westbound approach of 1st Avenue and 10th Street as shown in Table 4.3.

### 4.3 Results for Changes in Violation Rates by Lane

Violation rates were also analyzed by lane to provide information on violations based on the movement of traffic through the lanes. A reduction in violations at a through lane provides greater benefit than a reduction in a right-turn-only lane that allows right turn on red. This is due to the fact that crashes that occur due to violations in the through lane tend to be more severe right-angle crashes than those that occur due to a right turn on red violation.

Data were disaggregated by lane movement for each intersection approach. Each approach had three lanes except for 2nd Avenue SW and 6th Street SW northbound, where only two lanes were enforced. Movements were separated by combining through and right. When a left turn movement was combined with a through movement, a movement for left/through was utilized. When a left-turn-only lane was present, they were treated separately.

Table 4.4 provides the change in violation rates for the through and left/through movements for the northbound approach of the intersection at 2nd Avenue SW and 6th Street SW. Decreases were roughly similar for the through and left/through movements.

**Table 4.4. Changes in violation rates by movement for 2nd Avenue SW and 6th Street SW northbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Through | Before | 25.83 | 11227 | | |
| | June | 13.51 | 11847 | -12.33 | -48% |
| | August | 9.62 | 11434 | -16.21 | -63% |
| | October | 1.79 | 11172 | -24.04 | -93% |
| Left/ Through | Before | 17.92 | 10605 | | |
| | June | 1.73 | 11536 | -16.18 | -90% |
| | August | 1.74 | 11491 | -16.18 | -90% |
| | October | 2.68 | 11195 | -15.24 | -85% |

Changes in violation rates by movement for the northbound approach of Edgewood Road and 42nd Street NE are provided in Table 4.5. As shown, the decreases were much greater for the through movement (decrease in rate from 34.3 to 37.4) than for the left-turn-only movement (decrease from 4.4 to 8.5). All changes were statistically significant at the 90 percent level of confidence.

**Table 4.5. Changes in violation rates by movement for Edgewood Road and 42nd Street NE northbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Through (lanes 1 and 2) | Before | 40.09 | 29188 | | |
| | June | 5.75 | 29567 | -34.34 | -85.7% |
| | August | 2.89 | 27702 | -37.20 | -92.8% |
| | October | 2.70 | 33299 | -37.38 | -93.3% |
| Left Turn Only | Before | 10.13 | 38490 | | |
| | June | 4.76 | 44078 | -5.37 | -53% |
| | August | 5.79 | 43199 | -4.35 | -43% |
| | October | 1.33 | 42928 | -8.50 | -84% |

Changes in violation rates for Edgewood Road and 42nd Street NE southbound by movement are shown in Table 4.6. Changes were modest but similar for the through and left-turn-only movements.

**Table 4.6. Changes in violation rates by movement for Edgewood Road and 42nd Street NE southbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Through (lanes 1 and 2) | Before | 4.20 | 45306 | | |
| | June | 4.74 | 42177 | **0.54*** | 12.9% |
| | August | 2.43 | 41132 | -1.77 | -42.1% |
| | October | 2.40 | 41627 | -1.90 | -42.8% |
| Left Turn Only | Before | 6.76 | 25156 | | |
| | June | 3.47 | 25950 | -3.29 | -49% |
| | August | 4.37 | 25170 | **-2.39*** | -35% |
| | October | 2.46 | 24354 | -4.29 | -64% |

* Not statistically significant at the 90 percent level of confidence

Table 4.7 shows the violation rates by movement for the westbound approach of the 1st Avenue and 10th Street intersection. Change in violation rates for the left-turn-only movement were much greater (from -76.1 to -90.5) than for the right-turn/through movement (13.0 to -16.3).

**Table 4.7. Changes in violation rates by movement for 1st Avenue and 10th Street westbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Right Turn/ Through (lanes 1 and 2) | Before | 17.36 | 9792 | | |
| | June | 1.09 | 9210 | -16.27 | -93.7% |
| | August | 3.65 | 8221 | -13.72 | -79.0% |
| | October | 30.36 | 9883 | 13.00 | 74.9% |
| Left Turn Only (lane 3) | Before | 96.02 | 8332 | | -- |
| | June | 19.91 | 6529 | -76.10 | -79% |
| | August | 9.10 | 5497 | -86.92 | -91% |
| | October | 5.53 | 7230 | -90.48 | -94% |

Table 4.8 provides changes in violation rates by movement for the eastbound approach of 1st Avenue and 10th Street. Decreases were noted for the left-turn-only movement while no statistically significant changes occurred for the right-turn/through movements.

**Table 4.8. Changes in violation rates by movement for 1st Avenue and 10th Street eastbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Right Turn/ Through (lanes 1 and 2) | Before | 7.09 | 8469 | | |
| | June | 10.27 | 7789 | **3.18*** | 44.8% |
| | August | 8.13 | 7378 | **1.05*** | 14.8% |
| | October | 4.61 | 8669 | **-2.48*** | -34.9% |
| Left Turn Only (lane 3) | Before | 12.96 | 6173 | | |
| | June | 1.64 | 6097 | -11.32 | -87% |
| | August | 6.16 | 6492 | **-6.80*** | -52% |
| | October | 0.00 | 6410 | -12.96 | -100% |

* Not statistically significant at the 90 percent level of confidence

Changes for the northbound approach of 2nd Avenue SW and 3rd Street SW are given in Table 4.9 by movement. As indicated, a larger decrease in violation rates was noted for the June after period for the through movement than for the left-turn/through movement lane. Decreases in violation rate for August and October were much greater for the left-turn/through movement and changes for the through movement were not statistically significant for these time periods.

**Table 4.9. Changes in violation rates by movement for 2nd Avenue SW and 3rd Street SW northbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Through (lanes 1 and 2) | Before | 36.93 | 4062 | | |
| | June | 20.70 | 4347 | -16.23 | -43.9% |
| | August | 46.04 | 4733 | **9.11*** | 24.7% |
| | October | 27.49 | 5457 | **-9.44*** | -25.6% |
| Left Turn/ Through with Left Turn on Red (lane 3) | Before | 30.44 | 1971 | | |
| | June | 26.74 | 2244 | **-3.70*** | -12% |
| | August | 4.44 | 2253 | -26.00 | -85% |
| | October | 0.00 | 2146 | -30.44 | -100% |

* Not statistically significant at the 90 percent level of confidence

Finally, Table 4.10 presents changes in violation rate by movement for the westbound approach of 2nd Avenue SW and 3rd Street SW. In this case, no left-turn movement was present so the only movement was right-turn/through. As shown, minor but statistically significant decreases in violations were noted for all after time periods.

**Table 4.10 Changes in violation rates by movement for 2nd Avenue SW and 3rd Street SW westbound**

| Approach | | Violation Rate | Sample Size | Absolute Change in Violation Rate | Percent Change in Violation Rate |
|---|---|---|---|---|---|
| Right Turn/ Through (lanes 1,2, 3) | Before | 11.23 | 18700 | | |
| | June | 7.79 | 17984 | -3.44 | -30.6% |
| | August | 7.81 | 17924 | -3.42 | -30.4% |
| | October | 10.39 | 19246 | -0.83 | -7.4% |

## 5. EVALUATION OF CHANGE IN RED LIGHT RUNNING VIOLATIONS OVER TIME

Most studies that have assessed the effectiveness of red light running cameras in reducing RLR violations have conducted their analysis for a single after period, which is usually fairly close to installation of the cameras. It is not well understood if the cameras have the same impact over time. In some cases, countermeasures become less effective over time because drivers become accustomed to the treatment. On the other hand, enforcement may be more effective over time. Drivers who speed or run red lights may change their behavior when they or someone they know receives a ticket.

To test this theory, a negative binomial model was used to evaluate whether RLR violations increased or decreased over time.

### 5.1 Data

The study compared RLR violations over time at RLR camera-equipped intersections. This study looked at violations at five of the eight camera-equipped intersections at zero to 12 months, depending on the intersection and approach. The intersections and approaches studied include:

- 2nd Avenue SW and 6th Street SW – northbound
- Edgewood Road and 42nd Street NE – northbound and southbound
- 1st Avenue and 10th Street – eastbound and westbound
- 2nd Avenue SW and 3rd Street SW – northbound and westbound
- Center Point Road and Collins Road NE Ramp – northbound

### 5.2 Methodology

A regression analysis was run to develop a model to describe the effect of red light cameras on violations over time. Using the program R, both a negative binomial model and a Poisson model were fitted to the data. The response variable in this analysis was violations, which is the number of RLR violations seen in each of the study periods at each approach. The number of violations was found by extracting all those with “red” listed in the violation type. Independent variables used in the regression analysis included:

- Location ID – Each approach was given its own ID to take into account the different characteristics of each approach and account for repeated measures at the same intersection
- Time – This variable was used to determine at which point in time (in months) the violations occurred. 0 was used to denote the before period and then the number of months post installation was listed for each of the after periods
- Volume – The number of vehicles entering the approach during the period of time studied

### 5.3 Results

Both a Poisson model and a negative binomial model were fitted to the data. The Poisson regression model assumes that the conditional variance equals the conditional mean; whereas, the negative binomial model has one additional parameter that allows the model to account for over-dispersed count data (i.e., data for which the conditional variance is greater than the conditional mean).

A likelihood ratio test was performed to determine if the negative binomial model is more appropriate than the Poisson model to model the data. The chi-squared test statistic for the likelihood ratio test is 147.87 with one degree of freedom, which corresponds to a p-value less than 0.0001. This result indicates that, given the data, the negative binomial model is more appropriate than the Poisson model.

The best-fit model included time and the location as relevant independent variables. Volume, however, was found to not be a statistically significant variable and was therefore not included in the model. Model statistics are shown in Table 5.1.

**Table 5.1. Best fit model**

| **Parameter** | **Estimate** | **Standard Error** | **Z value** | **Pr<\|z\|** |
|---|---|---|---|---|
| Intercept | 4.0733 | 0.26147 | 15.579 | **<0.0001*** |
| Time | -0.0972 | 0.02764 | -3.514 | **.0004*** |
| ID 102 | -1.4640 | 0.34525 | -4.240 | **<0.0001*** |
| ID 201 | 0.2382 | 0.31485 | 0.757 | 0.4493 |
| ID 202 | -0.4188 | 0.29996 | -1.396 | 0.1626 |
| ID 301 | -0.6378 | 0.30161 | -2.115 | **0.0344*** |
| ID 302 | -0.8501 | 0.32662 | -2.603 | **0.0093*** |
| ID 401 | -0.7400 | 0.32287 | -2.292 | **0.0219*** |
| ID 501 | -0.3391 | 0.32524 | -1.043 | 0.2971 |

* Meets the alpha level of 0.05

The resulting Equation 5-1 is the following:

$$v_i = e^{(4.0733 - 0.0972 \cdot \text{Time} + ß\text{i})} \tag{5-1}$$

where:

$v_i$ = expected violations for approach $i$
Time = the time in months (i.e., 0 = before period, 1 = one month after becoming active, etc.)
$ß_i$ = coefficient for approach $i$ (ID)

Figure 5.1 illustrates the expected violations per 10,000 vehicles for each intersection.

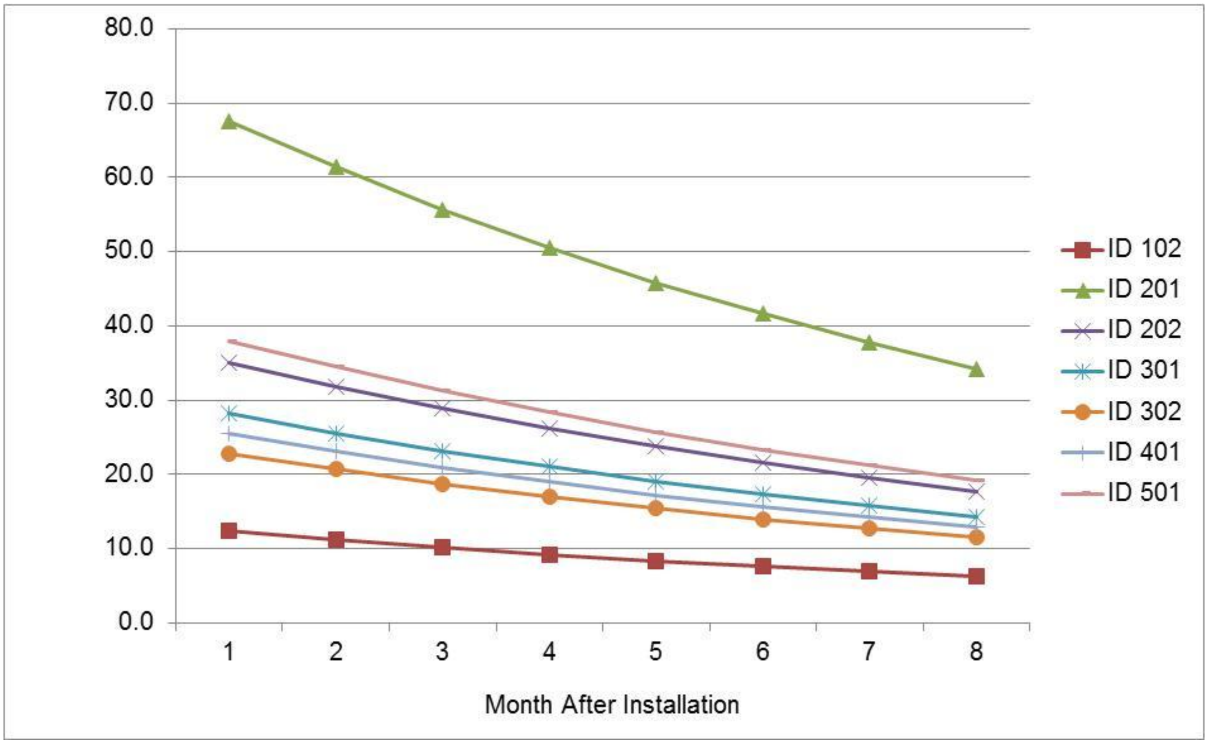


**Figure 5.1. Expected violations over time**

As shown, there is an obvious decrease in violations as the months increase. Based on the model, the ratio of the number of violations at a given time, t+1 (months), to the number of violations at time t (months), for a given approach is equal to $e^{-0.0972}$. Therefore, for each additional month at a given intersection, a 1-0.907375, or 9.26 percent decrease in violations is predicted. Due to the limited nature of data used to develop the model, this result should only be used to describe the trend in the number of violations for the first eight months after camera installations.

The base condition of the model, when ID102 through ID501 is 0, gives the expected number of violations at intersection 101 (1st Avenue and 10th Street westbound). To find the expected violations at any of the other intersections, the dummy variable for that intersection should be 1 while all the others are 0. So, for instance, to find the expected number of violations at Edgewood Road and 42nd Street NE northbound four months after installation, use the equation above with 4 in place of the Time in months and a 1 in place of ID202, while all other IDs would be 0.

When evaluating the approaches on their own, one expects the largest number of violations to occur at Edgewood Road and 42nd Street NE northbound and the smallest number at 1st Avenue and 10th Street eastbound. This can be determined from the coefficients for those variables with Edgewood Road and 42nd Street NE northbound being the only positive variable, which means it’s the only intersection that saw more violations than the base condition (intersection 101), while 1st Avenue and 10th Street eastbound had the smallest coefficient.

## 6. TIME INTO RED ANALYSIS

Opponents of RLR cameras suggest that red light enforcement cameras are not effective in reducing RLR crashes because cameras are only likely to change the behavior of drivers who run the red light within seconds of the red indication. These drivers are frequently the ones who intentionally run the red light. Their rationale is that late red light violations are unintentional and are due to driver distraction, impairment, or fatigue and that cameras are not likely to impact unintentional red light running. Beeber (2011) suggests that 95 percent of red light violations are within the first 2 seconds of the red indication with 80 percent of violations within the first second.

Others have also suggested that crash type is related to amount of time into red. Bonneson and Zimmerman (2004) obtained photos of RLR crashes from several states. They evaluated the photos and aggregated the data by crash type (left-turn-opposed or right-angle). They evaluated 22 left-turn-opposed crashes and determined that the average time into red was 0.9 seconds with a standard deviation of 0.6. Forty one right-angle crashes were evaluated with an average time into red of 14.1 seconds with a standard deviation of 12.0 seconds. Only one right-angle crash occurred within 5 seconds into the red. They concluded that RLR crashes that occur in the first few seconds of red are usually left-turn-opposed crashes where a permitted left-turning vehicle that is attempting to clear the intersection is struck by an opposing through driver who runs the red indication.

Milazzo et al. (2001) evaluated 34 photos from RLR crashes. They evaluated the time into red for right-angle and left-turn-opposed crashes. They found that no right-angle crashes occurred from 0 to 2.9 seconds into the red with all right-angle crashes occurring from 3.0 to 21.8 seconds into the red (average time into red was 8.7 seconds). Left-turn-opposed crashes occurred from 1.0 to 26.9 seconds into the red with an average time into red of 6.0 seconds.

Given there is evidence that RLR cameras are most effective if they reduce late red light runners and given some have suggested that camera enforcements are not likely to reduce late red light running, an analysis of time into red when drivers committed the violations was conducted.

### 6.1 Data

Complete and usable data were available for seven of the approaches where RLR cameras were installed. The number of violations by time into red was summarized for the following approaches:

- Edgewood Road and 42nd Street NE northbound
- Edgewood Road and 42nd Street NE southbound
- 1st Avenue and 10th Street westbound
- 1st Avenue and 10th Street eastbound
- 2nd Avenue SW and 3rd Street SW northbound
- 2nd Avenue SW and 3rd Street SW westbound
- 2nd Avenue SW and 6th Street SW northbound

Data were aggregated for the seven approaches due to low sample size, which would make an analysis by approach difficult. Data were available for before the RLR cameras were ticketing violations and then for June, August, and October after the cameras were fully operational. Figure 6.1 shows violations by time into red before the cameras were ticketing violations.

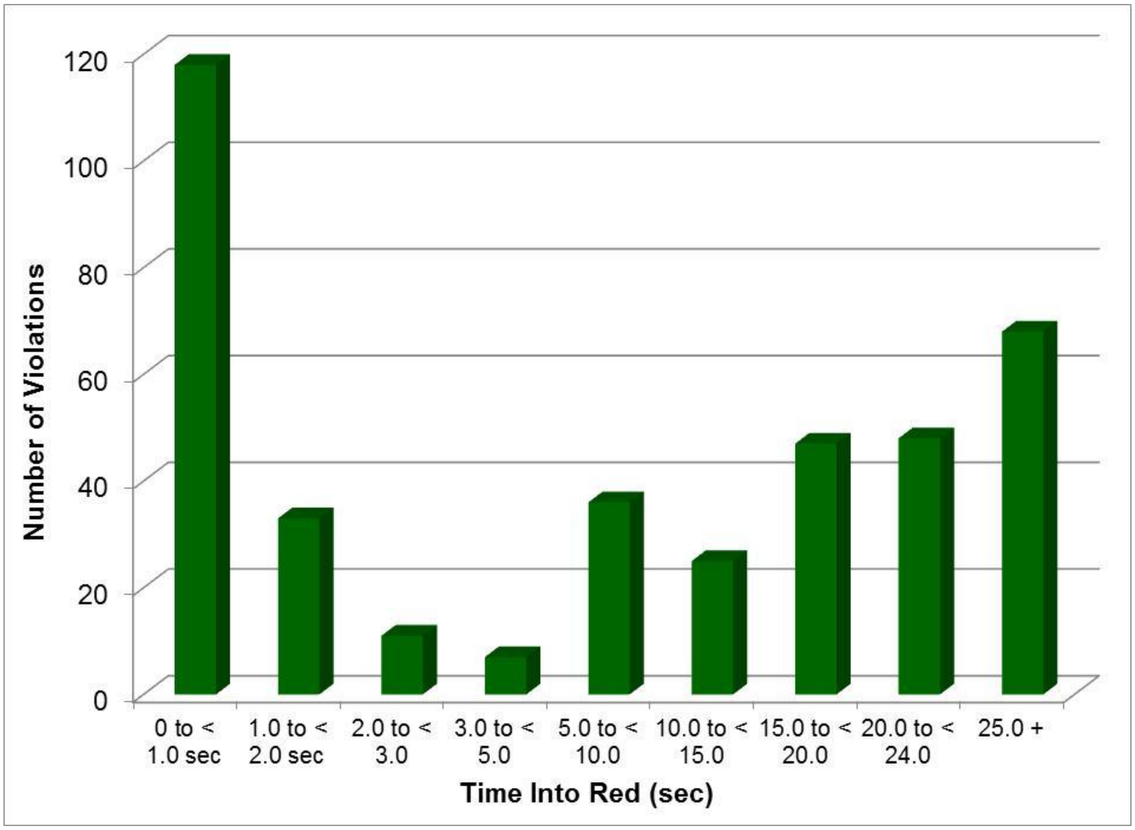


**Figure 6.1. Violations by time into red pre-ticketing period**

A total of 393 violations occurred during this period. As shown, only 38.4 percent of violations occurred in the first 2 seconds into the red (30 percent for less than 1 second and 8.4 percent for 1 to less than 2 seconds). Less than half of the RLR violations (43.0 percent) occurred during the first 0 to less than 5 seconds with 57.0 percent of the violations occurring 5 or more seconds into the red. Almost 30 percent of the violations occurred 20 or more seconds into the red and 13.4 percent were 30 or more seconds into the red.

Table 6.1 provides the number of violations by time into red for each time period.

**Table 6.1. Violations by time into red**

| Time Interval | | Before | June 2010 | August 2010 | October 2010 |
|---|---|---|---|---|---|
| **0.0 to < 1.0 seconds** | Violations | 118 | 59 | 55 | 38 |
| | Violation Rate | 5.29 | 2.69 | 2.59 | 1.70 |
| | Change Before to After | | -2.60<br>-49.1% | -2.70<br>-51.1% | -3.59<br>-67.9% |
| **1.0 to < 3.0 seconds** | Violations | 44 | 16 | 12 | 9 |
| | Violation Rate | 1.97 | 0.73 | 0.56 | 0.40 |
| | Change Before to After | | -1.24<br>-63.0% | -1.41<br>-71.4% | -1.57<br>-79.6% |
| **3.0 + seconds** | Violations | 231 | 63 | 55 | 63 |
| | Violation Rate | 10.35 | 2.87 | 2.59 | 2.82 |
| | Change Before to After | | -7.48<br>-72.3% | -7.77<br>-75.0% | -7.54<br>-79.6% |
| **Total Violations** | | 393 | 138 | 122 | 110 |
| **Total Vehicles** | | 223,111 | 219,355 | 212,676 | 223,633 |

Data were aggregated into bins according to when certain types of crashes are more likely. Bonneson and Zimmerman (2004) and Milazzo et al. (2001) suggest that only left-turn-opposed crashes are likely to occur from 1.0 to 3.0 seconds into the red and both left-turn-opposing and right-angle crashes occur 3 or more seconds into the red. As a result, data were aggregated by 0.0 to less than 1.0 second, 1.0 second to less than 3.0 seconds, and, finally, for 3.0 or more seconds into the red as shown in Table 6.1.

## 6.2 Methodology and Results

To determine whether the proportion of violations by time was different from the before to after periods, reduction in the violation rate by time interval was assessed using a binomial test of proportions. The violation rate was calculated by dividing the number of violations in each time interval by the total number of vehicles that used the study approach during the corresponding period and multiplying by 10,000. Violation rate per 10,000 vehicles was given by Equation 6-1 (and results are shown in Table 6.1):

$$VR_i = \frac{v_i}{vol_a} \times 10{,}000 \qquad (6\text{-}1)$$

where:

$VR_i$ = violation rate per 10,000 vehicles for approach *i*
$v_i$ = violations for approach *i*
$vol_a$ = volume for approach *a*

A total 393 violations occurred in the before period at the seven approaches while 138 occurred in the June after period. Volumes were similar for the two time periods and the violation rate decreased for all of the time intervals from the before to June after period. The violation rate decreased from 5.29 to 2.69, a change of 49.1 percent ($z = -4.33$, $p << 0$) for the 0 to < 1.0 second interval. A decrease from 1.97 to 0.73 (63.0 percent) was noted for the 1.0 to < 3.0 seconds ($z = -3.56$, $p =0.0002$). The largest reduction occurred for violations that were 3.0 or more seconds into the red with a change from 10.35 to 2.87, a change of 72.3 percent ($z = -9.70$, $p << 0$).

During the August after period, the violations decreased to 122 violations. Decreases in violations for each of the time intervals were also noted with the largest decrease occurring for violations that were 3 or more seconds into the red, which posted a decrease in the violation rate from 10.35 to 2.59, a decrease of 75.0 percent ($z = -4.51$, $p << 0$). The 0.0 to < 1.0 second interval had a decrease from 5.29 to 2.59 at 51.1 percent ($z = -4.15$, $p << 0$). Finally, the 1.0 to < 3.0 second interval had a decrease from 1.97 to 0.56 at 71.4 percent ($z = -10.15$, $p << 0$).

The October after period also had decreases in the violation rate for all of the time intervals. The 1.0 to < 3.0 second interval experienced the greatest percentage decrease (79.6 percent) from 1.97 to 0.40 ($z = -4.81$, $p << 0$). RLR violations that were 3 or more seconds into the red decreased from 10.35 to 2.82 ($z = -9.82$, $p << 0$) and had the largest decrease in terms of magnitude (change of 7.54). The 0.0 to < 1.0 second interval experienced a decrease of 67.9 percent from 5.29 to 1.70.

As noted, violations that were 3.0 or more seconds into red experienced the greatest decrease in violation rate in terms of magnitude. That interval also experienced the greatest percent decrease for the June and August after periods.

# 7. HEADWAY ANALYSIS

One of the largest concerns when installing red light cameras is that the presence of the cameras causes more people to slam on their brakes resulting in more rear end crashes. Drivers may be more likely to attempt to stop during the yellow interval to avoid a red light violation when they would have otherwise proceeded through the intersection. An unexpected stop by a preceding driver may result in a rear end crash if the following driver is following too close. Alternatively, drivers who are aware the cameras may leave larger gaps between them and the vehicle in front anticipating that the lead driver is more likely to stop quickly.

Huang et al. (2006) evaluated the relationship between headway and probability of RLR crashes. They collected data at 15 signalized intersections in Singapore using video. Data collected included information on the characteristics of the intersection (both physical and operational), presence of red light cameras, as well as information on the vehicles traveling (i.e., approach speed, leader or follower, etc.). They developed a binary logit model and found that as headway decreases, the probability for rear end crashes increases. In particular, they noted that headways of less than 3 seconds increase the probability of a rear end crash.

## 7.1 Data

Complete and usable data were available for seven of the approaches where RLR cameras were installed. The headway was summarized for the following approaches:

- Edgewood Road and 42nd Street NE northbound
- Edgewood Road and 42nd Street NE southbound
- 1st Avenue and 10th Street westbound
- 1st Avenue and 10th Street eastbound
- 2nd Avenue SW and 3rd Street SW northbound
- 2nd Avenue SW and 3rd Street SW westbound
- 2nd Avenue SW and 6th Street SW northbound

Data were sorted by lane and then sorted sequentially. Data needed to be sorted by lane to determine the gap between subsequent vehicles in the same lane. Then, the gap between vehicles was found by taking the time listed in the “time” column and subtracting it from the time for the vehicle before it. Due to the manner in which the time stamp is recorded, gaps could only be recorded to the nearest second.

Next, the data were cleaned up by removing any values for gaps found when there was a break in data collection. The data were also cleaned up to find the correct value when switching to a new day (i.e., when time in the day before was 23:59:59 and next day was 0:00:01 and the value calculated for the gap would have been 23:59:58 instead of 0:00:02).

Headway was next sorted into bins of different lengths and the percent in each bin was found. The bins used were less than 1 second, 1 second, 2 seconds, 3 seconds, 4 seconds, and 5 or more seconds. At 5 seconds, the gap is sufficiently large enough that even under adverse conditions, the following vehicle will have sufficient time to stop without rear-ending the lead vehicle. More bins were used for the smaller gaps to better determine the camera's effects on these drivers. Finally, the change in percentages for each bin were found by subtracting the percentage in the before period from the percentage in the after period.

### 7.2 Methodology

A test of proportions was used to determine if the changes in the violation rate were statistically significant. This test was performed using Equation 7-1 to calculate a z-test statistic:

$$Z = \frac{(\hat{\pi}_1 - \hat{\pi}_2)}{\sqrt{\frac{\hat{\pi}_1(1-\hat{\pi}_1)}{n_1} + \frac{\hat{\pi}_2(1-\hat{\pi}_2)}{n_2}}} \qquad (7\text{-}1)$$

In this equation, $\hat{\boldsymbol{\pi}}_{\mathbf{1}}$ represents the violation rate in the before period and $\boldsymbol{n}_{\mathbf{1}}$ represents the total number of observations during the before period. The other variables with subscript 2 represent the after rates and observations.

This z-test statistic was then compared to a Z table using $\alpha = 0.10$ to determine significance at 90 percent confidence. Therefore, if Z was greater than 1.28, the resulting decrease in violation rate was statistically significant and if Z was less than -1.28, the increase in violation rate was statistically significant.

### 7.3 Results

Results are shown in the following tables for each of the seven approaches studied. In each table, the numbers of vehicles by bin, as well as the percentage of total vehicles that are in that bin, are listed. Change in the percentage of vehicles in each bin from the before to after periods are also shown. An asterisk (*) indicates that the change was statistically significant at the 90 percent level of confidence.

A study by Huang et al. (2006) indicated that headways of less than three seconds increase the probability of rear end crashes. As a result, the focus was on changes in the headway bins for less than 1 second, 1 second, 2 seconds, and 3 seconds.

As shown in Table 7.1, the northbound approach at 2nd Avenue SW and 6th Street SW saw decreases in all three time periods at the less than 1 second bin. There was no statistically significant change for the 1 second bin for the June after period. A small increase was noted for the August period and a decrease of almost one percent occurred for the October after period. The 2 and 3 second bins saw similar results with increases being seen in June and August followed by decreases in October.

**Table 7.1. 2nd Avenue SW and 6th Street SW northbound**

| Bin (sec) | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | Change | # | % | Change | # | % | Change |
| < 1 | 829 | 3.8% | 607 | 2.6% | -1.2% | 667 | 2.9% | -0.9% | 545 | 2.4% | -1.4% |
| 1 | 1016 | 4.7% | 1119 | 4.8% | 0.1%* | 1185 | 5.2% | 0.5% | 833 | 3.7% | -0.9% |
| 2 | 2703 | 12.4% | 3188 | 13.6% | 1.3% | 3071 | 13.4% | 1.0% | 1940 | 8.7% | -3.7% |
| 3 | 2309 | 10.6% | 2742 | 11.7% | 1.2% | 2581 | 11.3% | 0.7% | 1758 | 7.9% | -2.7% |
| 4 | 1388 | 6.4% | 1433 | 6.1% | -0.2%* | 1432 | 6.3% | -0.1%* | 1067 | 4.8% | -1.6% |
| 5 + | 13569 | 62.2% | 14281 | 61.1% | -1.1% | 13971 | 61.0% | -1.2% | 16207 | 72.5% | 10.3% |

* Not statistically significant at the 90 percent level of confidence

Results for the northbound approach at Edgewood Road and 42nd Street NE are shown in Table 7.2. As indicated, either minor decreases or changes that were not statistically significant were observed for headways less than 1 second or 1 second. Small increases in the percentage of vehicles with headways of 2 seconds were noted for all three after time periods and 3 seconds saw a small increase in the percentage of vehicles with this headway in August.

**Table 7.2. Edgewood Road and 42nd Street NE northbound**

| Bin (sec) | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | Change | # | % | Change | # | % | Change |
| < 1 | 1274 | 1.9% | 1362 | 1.9% | 0.0%* | 1216 | 1.7% | -0.2% | 1492 | 2.0% | 0.1%* |
| 1 | 6855 | 10.1% | 7586 | 10.3% | 0.2%* | 6734 | 9.5% | -0.6% | 7757 | 10.2% | 0.1%* |
| 2 | 18420 | 27.2% | 21747 | 29.5% | 2.3% | 20254 | 28.6% | 1.4% | 21125 | 27.7% | 0.5% |
| 3 | 8925 | 13.2% | 10657 | 14.5% | 1.3%* | 10111 | 14.3% | 1.1% | 10037 | 13.2% | 0.0%* |
| 4 | 3476 | 5.1% | 3773 | 5.1% | 0.0%* | 3741 | 5.3% | 0.1%* | 3744 | 4.9% | -0.2% |
| 5 + | 28725 | 42.4% | 28517 | 38.7% | -3.7% | 28842 | 40.7% | -1.8% | 32086 | 42.1% | -0.4%* |

* Not statistically significant at the 90 percent level of confidence

Results for Edgewood Road and 42nd Street NE southbound are shown in Table 7.3.

**Table 7.3. Edgewood Road and 42nd Street NE southbound**

| Bin (sec) | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | Change | # | % | Change | # | % | Change |
| < 1 | 856 | 1.2% | 542 | 0.8% | -0.4% | 536 | 0.8% | -0.4% | 660 | 1.0% | -0.2% |
| 1 | 5495 | 7.8% | 5281 | 7.8% | 0.0%* | 4697 | 7.1% | -0.7% | 4743 | 7.2% | -0.6% |
| 2 | 16952 | 24.1% | 17020 | 25.0% | 0.9% | 16197 | 24.4% | 0.4%* | 15127 | 22.9% | -1.1% |
| 3 | 9491 | 13.5% | 9776 | 14.4% | 0.9% | 9295 | 14.0% | 0.6% | 8712 | 13.% | -0.3%* |
| 4 | 4228 | 6.0% | 4437 | 6.5% | 0.5% | 4297 | 6.5% | 0.5% | 4019 | 6.1% | 0.1%* |
| 5 + | 33437 | 47.5% | 31068 | 45.6% | -1.9% | 31277 | 47.2% | -0.3%* | 32717 | 49.6% | 2.1% |

* Not statistically significant at the 90 percent level of confidence

The percentage of vehicles with headways less than 1 second had minor decreases from the before to after periods for all three after periods. The June after analysis period showed no change in the percentage of vehicles with headways of 1 second (0.0 percent), while minor decreases occurred for the August and October after periods. The 2 second bin saw a minor increase for the June after period with no statistically significant changes for the August after period and an approximate 1 percent decrease for the October after period. The 3 second bin saw minor increases in June and August.

Table 7.4 provides results for 1st Avenue and 10th Street westbound. As noted, only minor or non-statistically significant changes occurred for the less than 1 second headway bin. An increase of 0.2 percent was observed for the 1 second bin for all three of the after periods. Decreases occurred for the 2 second bin for all three after time periods and for the 3 second bin for August and October.

**Table 7.4. 1st Avenue and 10th Street westbound**

| Bin | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (sec) | # | % | # | % | Change | # | % | Change | # | % | Change |
| < 1 | 142 | 0.8% | 129 | 0.8% | 0.0%* | 85 | 0.6% | -0.2% | 118 | 0.7% | -0.1%* |
| 1 | 673 | 3.7% | 616 | 3.9% | 0.2%* | 537 | 3.9% | 0.2% | 662 | 3.9% | 0.2%* |
| 2 | 3384 | 18.7% | 2827 | 18.0% | -0.7% | 2310 | 16.8% | -1.8% | 2963 | 17.3% | -1.4% |
| 3 | 2823 | 15.6% | 2464 | 15.7% | 0.1%* | 1993 | 14.5% | -1.1% | 2360 | 13.8% | -1.8% |
| 4 | 1199 | 6.6% | 1089 | 6.9% | 0.3%* | 935 | 6.8% | 0.2%* | 1159 | 6.8% | 0.2%* |
| 5 + | 9901 | 54.6% | 8611 | 54.7% | 0.1%* | 7855 | 57.3% | 2.6% | 9848 | 57.6% | 2.9% |

* Not statistically significant at the 90 percent level of confidence

Results for the eastbound approach of 1st Avenue and 10th Street are provided in Table 7.5. No statistically significant changes occurred for the less than 1 second bin for any of the after periods. The 1 second headway bin saw a small increase for the June and October after periods, but no changes for the August after period. No statistically significant changes were noted for the 2 second headway bin. Small decreases were seen for all three time periods for the 3 second bin.

**Table 7.5. 1st Avenue and 10th Street eastbound**

| Bin | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (sec) | # | % | # | % | Change | # | % | Change | # | % | Change |
| < 1 | 50 | 0.3% | 41 | 0.3% | -0.0%* | 33 | 0.2% | -0.1%* | 53 | 0.4% | 0.0%* |
| 1 | 458 | 3.1% | 494 | 3.6% | 0.4% | 452 | 3.3% | 0.1%* | 546 | 3.6% | 0.5% |
| 2 | 2401 | 16.4% | 2223 | 16.0% | -0.4%* | 2198 | 15.9% | -0.6%* | 2430 | 16.1% | -0.3%* |
| 3 | 1961 | 13.4% | 1766 | 12.7% | -0.7% | 1708 | 12.3% | -1.1% | 1893 | 12.6% | -0.8% |
| 4 | 901 | 6.2% | 720 | 5.2% | -1.0% | 764 | 5.5% | -0.6% | 853 | 5.7% | -0.5% |
| 5 + | 8868 | 60.6% | 8639 | 62.2% | 1.6% | 8712 | 62.8% | 2.2% | 9301 | 61.7% | 1.1% |

* Not statistically significant at the 90 percent level of confidence

Results for the northbound approach of 2nd Avenue SW and 3rd Street SW experienced no changes for the less than 1 second headway bin for the June and August after periods and a 0.6 percent decrease for the October after period as shown in Table 7.6. The 1 second headway and 2 second headway bins experienced a 0.5 percent increase for the August after period, but no statistically significant changes for the June and October after periods. The 3 second headway bin saw no statistically significant changes.

**Table 7.6. 2nd Avenue SW and 3rd Street SW northbound**

| Bin | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (sec) | # | % | # | % | Change | # | % | Change | # | % | Change |
| **< 1** | 100 | 1.7% | 112 | 1.7% | 0.0%* | 117 | 1.7% | 0.0%* | 81 | 1.1% | -0.6% |
| **1** | 124 | 2.1% | 137 | 2.1% | 0.0%* | 181 | 2.6% | 0.5% | 137 | 1.8% | -0.3%* |
| **2** | 136 | 2.3% | 172 | 2.6% | 0.4%* | 195 | 2.8% | 0.5% | 195 | 2.6% | 0.3%* |
| **3** | 179 | 3.0% | 214 | 3.3% | 0.3%* | 221 | 3.2% | 0.2%* | 233 | 3.1% | 0.1%* |
| **4** | 98 | 1.6% | 127 | 1.9% | 0.3%* | 114 | 1.6% | 0.0%* | 148 | 2.0% | 0.3%* |
| **5 +** | 5379 | 89.4% | 5793 | 88.4% | -1.0% | 6187 | 88.2% | -1.2% | 6788 | 89.5% | 0.1%* |

* Not statistically significant at the 90 percent level of confidence

Finally, results for the westbound approach of 2nd Avenue SW and 3rd Street SW are presented in Table 7.7.

**Table 7.7. 2nd Avenue SW and 3rd Street SW westbound**

| Bin | Before | | June | | | August | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (sec) | # | % | # | % | Change | # | % | Change | # | % | Change |
| **< 1** | 189 | 1.0% | 173 | 1.0% | -0.0%* | 138 | 0.8% | -0.2% | 246 | 1.3% | 0.3% |
| **1** | 566 | 3.0% | 444 | 2.5% | -0.6% | 459 | 2.6% | -0.5% | 635 | 3.3% | 0.3%* |
| **2** | 1513 | 8.1% | 1391 | 7.7% | -0.4%* | 1339 | 7.5% | -0.6% | 1611 | 8.4% | 0.3%* |
| **3** | 1330 | 7.1% | 1226 | 6.8% | -0.3%* | 1108 | 6.2% | -0.9% | 1406 | 7.3% | 0.2%* |
| **4** | 856 | 4.6% | 893 | 5.0% | 0.4% | 843 | 4.7% | 0.1%* | 986 | 5.1% | 0.6% |
| **5 +** | 14228 | 76.2% | 13839 | 77.0% | 0.9% | 14019 | 78.3% | 2.1% | 14345 | 74.6% | -1.6% |

* Not statistically significant at the 90 percent level of confidence

As shown, no change in the percentage of vehicles in the less than 1 second headway bin was observed for the June after period, a decrease of 0.2 percent and a small increase of 0.3 percent were observed for the August and October after periods, respectively. Decreases of 0.6 percent and 0.5 percent occurred for the 1 second bin for the first two after periods with no change for the October after period. For the 2 second headway bin, a small but not statistically significant decrease occurred for the June after period (0.4 percent) and a small decrease (0.6 percent) occurred for the August after period with no change for the October after period. For the 3 second bin, only one statistically significant change was seen among the three after periods which occurred in August where a small decrease (0.9 percent) occurred.

## 8. CONCLUSIONS AND RECOMMENDATIONS

This study evaluated the RLR program in Cedar Rapids, Iowa, which was implemented starting in February 2010. While a crash analysis is the preferred method to evaluate the effectiveness of the cameras, it cannot be completed reliably in the short term. Therefore, other metrics must be looked at and used to determine the safety effects of the program.

In this instance, a violations study was completed with the assumption that a decrease in violations is a surrogate for a decrease in RLR crashes. In addition, changes in vehicles entering the intersection into the red phase and yellow phase, along with a headway analysis, were completed to determine if the cameras were having the desired effect on safety. These analyses were completed across four periods of data collection (before periods in 2010, June 2010, August 2010, and October 2010).

The general violation study saw decreases in the violation rate at approaches in the range of 6 to 91 percent with an average of about a 50 percent decrease. These findings are similar to those found by Retting et al. (1999a and 1999b) in Oxnard, California and Fairfax, Virginia, as well as the general findings from the studies mentioned in both Retting (2010) and Bochner and Walden (2010).

The findings from the violation rates by time of day study and lane study further support the effectiveness of the cameras. The majority of reductions in violations are occurring during the day when the traffic is heaviest. The decrease seen during the times when traffic is heaviest leads to a reduction in potential crashes as found in the model by Bonneson et al. (2002). The lane study found large decreases in the violation rates for through and either left turn or left turn through movements. Those lanes with right turn movements saw either no changes in the violation rates or modest decreases to the rate. The overall finding was a reduction in violation rates for targeted movements (i.e., left turning and through movements).

In addition, a negative binomial model was developed to evaluate changes to red light violation rates over time. This model found that for each additional month a camera is in use at an intersection, one can predict a 9.3 percent decrease in the violation rate for that intersection. This supports the thought that violation rates decrease additionally each month that the camera is in effect.

The findings of the violation by time into the red study found the largest decrease in violation rates to occur 3.0 or more seconds into the red phase. Additional decreases to the violation rates were also seen for 0.0 to 1.0 seconds into the red and 1.0 to 3.0 seconds into the red. The large decrease 3.0 or more seconds into the red supports the effectiveness of the cameras in increasing safety due to the decrease in violation rates during the time in which severe right-angle crashes are most likely to occur.

The findings of the headway analysis saw the majority of approaches having a statistically significant decrease in the less than 1.0 second bin for at least one after period, which could suggest that drivers were giving each other more space anticipating that some drivers would slam on their brakes. However, the changes were minor. No consistent pattern was noted for the 1.0, 2.0, and 3.0 second bins. In addition, few statistically significant changes were noted for any of the other headway bins. This suggests that driver-following behavior overall did not change after the red light running cameras started ticketing drivers.

Overall, the main findings of the research conducted as a part of this study support the idea that the cameras have had a positive effect on safety at the intersections. This is especially supported by the decreases in violation rates seen at all of the intersections.

## REFERENCES


AAA. *2010 Traffic Safety Culture Index*. October 2010. http://www.aaafoundation.org/pdf/2010TSCIndexFinalReport.pdf. Accessed May 26, 2011.

Beeber, Jay. *Safer Streets in Los Angeles: Why Engineering Countermeasures are More Effective than Photo Enforcement in Reducing Red Light Related Crashes*. Safety Streets L.A. www.saferstreetsla.org. Accessed November 2011.

Bochner, B., and T. Walden. Effectiveness of Red-Light Cameras. *ITE Journal*, Vol. 80, Issue 5, 2010, pp. 18- 24.

Bonneson, James and Karl Zimmerman. Development of Guidelines for Identifying and Treating Locations with a Red Light Running Problem. FHWA/TX-05/0-4196-2. September 2004.

Bonneson, J., K. Zimmerman, and M. Brewer. *Engineering Countermeasures to Reduce Red-Light-Running*. Publication FHWA/TX-03/4027-2. Texas Transportation Institute, College Station, Texas, 2002.

Burchfield, R. M. *Red Light Running Camera Program Biennial Report*. City of Portland, 2005.

City of Cedar Rapids. 2011. Red Light Frequently Asked Questions. Last accessed November 30, 2011. http://www.cedar-rapids.org/government/departments/police/Documents/FAQ%20ATE.pdf

Cunningham, C. M., and J. S. Hummer. *Evaluating the Use of Red Light Running Photographic Enforcement Using Collisions and Red Light Running Violations.* Institute for Transportation Research and Education, North Carolina State University, Raleigh, 2004.

Federal Highway Administration. *Red Light Running Data and Statistics, US DOT.* FHWA Safety. http://safety.fhwa.dot.gov/intersection/redlight/#implement. Accessed March 6, 2010.

Federal Highway Administration (FHWA). *Red-Light Running Fatalities (2000-2009).* FHWA Safety. http://safety.fhwa.dot.gov/intersection/redlight/data/rlr_fatal/. Accessed May 26, 2011.

Fitzsimmons, E. J., S. L. Hallmark, T. McDonald, M. Orellana, and D. Matulac. The Effectiveness of Iowa's Automated Red Light Running Enforcement Programs. Center for Transportation Research and Education at Iowa State University. December 2007.

Fitzsimmons, E. J., S. L. Hallmark, M. Orellana, T. McDonald, and D. Matulac. Investigation of Violation Reduction at Intersection Approaches with Automated Red Light Running Enforcement Cameras in Clive, Iowa, Using a Cross-Sectional Analysis. *Journal of Transportation Engineering*, Vol. 135, Issue 12, 2009, pp. 984-989. Fleck, J. L., and B. Smith. *Can We Make Red Light Runners Stop?* San Francisco Department of Parking and Traffic, 1999.

Gatso USA. Personal communication. March 4, 2010.

Google Earth (Version 6.0.1.1032) [Software]. Mountain View, CA: Google Inc. 2011. Available from http://www.google.com/earth/download/ge/agree.html

Hallmark, S., M. Orellana, E. J. Fitzsimmons, T. McDonald, and D. Matulac. Red Light Running in Iowa: Automated Enforcement Program Evaluation with Bayesian Analysis. In *Transportation Research Record: Journal of the Transportation Research Board*, No. 2182, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 48-54, Hiller, W., J. Ronczka, and F. Schnerring. *An Evaluation of Red Light Cameras in Sydney*. Report Number 1/93. Road Traffic Authority NSW: Road Safety Bureau. Roseberry, Australia, 1993.

Huang, Helai, Hoong Chor Chin, and Alan Heng Hock Heng. Effect of Red Light Cameras on Accident Risk at Intersections. In *Transportation Research Record: Journal of the Transportation Research Board,* No. 1969, Transportation Research Board of the National Academies, Washington, D.C., 2006, pp. 18-26.

Insurance Institute for Highway Safety (IIHS). *Communities Using Red Light and/or Speed Cameras*, May 2011 (a). http://www.iihs.org/laws/auto_enforce_cities.aspx. Accessed May 26 2011.

Insurance Institute for Highway Safety (IIHS). Go for a Philly Cheesesteak? While you're out be sure to mind those traffic lights. *Insurance Institute for Highway Safety Status Report*, Vol. 42, No. 1, Jan 27, 2007, pp. 1-4. http://www.iihs.org/externaldata/srdata/docs/sr4201.pdf. Accessed May 26 2011.

Insurance Institute for Highway Safety (IIHS). *Q &As: Red Light Cameras*, February 2011 (b). http://www.iihs.org/research/qanda/rlr.html. Accessed May 26, 2011.

Milazzo, J. S., J. E. Hummer, and L. M. Prothes. A Recommended Policy for Automated Electronic Traffic Enforcement of Red Light Running Violations in North Carolina. Institute for Transportation Research and Education, North Carolina State University. June 2001.

National Climatic Data Center. *Quality Controlled Local Climatological Data for Cedar Rapids: The Eastern Iowa Airport*. http://cdo.ncdc.noaa.gov/qclcd/QCLCD. Accessed February 1, 2011.

Ng, C. H., Y. D. Wong, and K. M. Lum. The Impact of Red Light Surveillance Cameras on Road Safety in Singapore. *Transportation Research Record*. Vol 6, No. 2, TRB National Research Council, Washington D.C., 1997, pp. 72-80.

Ott, R. L. and M. Longnecker. *An Introduction to Statistical Methods and Data Analysis, 5th Edition.* Duxbury, Pacific Grove, CA, 2001.

Retting, R. A., and S. Kyrychenko. Crash *Reductions Associated with Red Light Enforcement in Oxnard, California*. Insurance Institute for Highway Safety, 2001.

Retting, R. A., A. F. Williams, C. M. Farmer, and A. F. Feldman. Evaluation of Red Light Camera Enforcement in Fairfax, Va., USA. *ITE Journal,* Vol. 69, Issue 8, 1999(a), pp. 30-34.

Retting, R. A., A. F. Williams, C. M. Farmer, and A. F. Feldman. Evaluation of Red Light Camera Enforcement in Oxnard, California. *Accident Analysis and Prevention*, Vol. 31, Issue 3, 1999(b), pp. 169-174.

Retting, R. A., A. F. Williams, D. F. Presusser, and H. B Weinstein. Classifying Urban Crashes for Countermeasure Development. *Accident Analysis and Prevention*, Vol. 27, 1995, pp. 283-294.

Retting, R. A., S. A. Ferguson, and C.M. Farmer. Reducing Red Light Running through Longer Yellow Signal Timing and Red Light Camera Enforcement: Results of a Field Investigation. *Accident Analysis and Prevention*, Vol. 40, Issue 1, 2008, pp. 327-333.

Retting, Richard. Two Decades of Photo Enforcement in the United States: A Brief Summary of Experience and Lessons Learned. *ITE Journal*, Vol. 80, Issue 11, 2010, pp. 20-24, 29.

United States Naval Observatory. *Sun or Moon Rise/Set Table for Cedar Rapids, Iowa.* http://aa.usno.navy.mil/data/docs/RS_OneYear.php. Accessed March 30, 2011.

Washington, S.P. and K. Shin. The Impact of Red Light Cameras (Automated Enforcement) on Safety in Arizona. Transportation and Traffic Institute, University of Arizona, Tucson. June 2005.

Winn, R. *Running the Red and Evaluations of Strathclyde Police's Red Light Camera Initiative*. The Scottish Central Research Unit: Glasgow, Scotland, 1995. http://www.scotland.gov.uk/cru/resfinds/drf7-00.htm. Accessed October, 24, 2006.

# APPENDIX A: CEDAR RAPIDS AUTOMATED ENFORCEMENT ORDINANCE

**61.138 - AUTOMATED TRAFFIC ENFORCEMENT.**

(a) **General.** The City of Cedar Rapids, in accordance with its police powers, may deploy, erect or cause to have erected an automated traffic enforcement system for making video images of vehicles that fail to obey red light traffic signals at intersections designated by the city manager, or his designee, or fail to obey speed regulations at other locations in the city. The systems may be managed by the private contractor that owns and operates the requisite equipment with supervisory control vested in the city's police department. Video images shall be provided to the police department by the contractor for review. The police department will determine which vehicle owners are in violation of the city's traffic control ordinances and are to receive a notice of violation for the offense.

(b) **Definitions.**

1. **Automated Traffic Citation** shall mean a notice of fine generated in connection with the automated traffic enforcement system.

2. **Automated Traffic Enforcement Contractor** shall mean the company or entity, if any, with which the City of Cedar Rapids contracts to provide equipment and/or services in connection with the Automated Traffic Enforcement System.

3. **Automated Traffic Enforcement System** shall mean an electronic system consisting of a photographic, video, or electronic camera and a vehicle sensor installed to work in conjunction with an official traffic controller or police department employee to automatically produce photographs, video or digital images of each vehicle violating a standard traffic control device or speed restriction.

4. **Vehicle Owner** shall mean the person or entity identified by the Iowa Department of Transportation, or registered with any other state vehicle registration office, as the registered owner of a vehicle.

(c) **Vehicle Owner's Civil Liability for Certain Traffic Offenses.**

1. The Vehicle Owner shall be liable for a fine as imposed below if such a vehicle crosses a marked stop line or the intersection plane at a system location when the traffic signal for that vehicle's direction is emitting a steady red light or arrow.

2. The Vehicle Owner shall be liable for a fine as imposed below if such vehicle travels at a speed above the posted limit.

3. The violation may be exempted from liability as outlined below in subsection (f.) of this section, and other defenses may be considered in connection with the appeal process.

4. In no event will an Automated Traffic Citation be sent or reported to the Iowa Department of Transportation or similar department of any other state for the purpose of being added to the Vehicle Owner's driving record.

(d) **Notice of Violation; Fine.**

1. Notice of the violation will be mailed to the Vehicle Owner for each violation recorded by an

Automated Traffic Enforcement System or traffic control signal monitoring device. The Automated Traffic Enforcement Contractor shall mail the notice within 30 days after receiving information about the Vehicle Owner. The notice shall include the name and address of the Vehicle Owner; the vehicle make, if available and readily discernable, and registration number; the violation charged; the time; the date; and the location of the alleged violation; the applicable fine and monetary penalty which shall be assessed for late payment; information as to the availability of an administrative hearing in which the notice may be contested on its merits; and that the basis of the notice is a photographic record obtained by an Automated Traffic Enforcement System.

2. Any violation of subsequent section (c.)(1). above shall be subject to a civil fine of one hundred dollars, payable to the City of Cedar Rapids.

3. Any violation of subsection (c.)(2). above shall be subject to a civil fine as listed in the table below, and the fine for any violation committed in a designated construction zone (as provided by Iowa Code), shall be doubled, as reflected below, subject in any event to the limit on fines sought in municipal infractions. All civil fines shall be payable to the City of Cedar Rapids.

Speed over

the limit

| | Civil Fine | If in Construction Zone |
|---|---|---|
| 1 through 5 MPH | $25 | $50 |
| 6 through 10 MPH | $50 | $100 |
| 11 through 20 MPH | $75 | $150 |
| 21 through 25 MPH | $100 | $200 |
| 25 through 30 MPH | $250 | $500 |
| Over 30 MPH | $500 | $750 |

(e) **Contesting an Automated Traffic Citation.** A Vehicle Owner who has been issued an Automated Traffic Citation may contest the citation as follows:

1. By submitting in a form specified by the City a request for an administrative hearing to be held at the Cedar Rapids Police Department before an administrative appeals board (the "Board") consisting of one or more impartial fact finders. Such a request must be filed within 30 days from

the date on which Notice of the violation is sent to the Vehicle Owner. After a hearing, the Board may either uphold or dismiss the Automated Traffic Citation, and shall mail its written decision within 10 days after the hearing, to the address provided on the request for hearing. If the citation is upheld, then the Board shall include in its written decision a date by which the fine must be paid, and on or before that date, the Vehicle Owner shall either pay the fine or submit a request pursuant to the next paragraph, (e.)(2.).

2. By submitting in a form specified by the City a request that in lieu of the Automated Traffic Citation, a municipal infraction citation be issued and filed with the Small Claims Division of the Iowa District Court in Linn County. Such a request must be filed within 30 days from the date on which Notice of the violation is sent to the Vehicle Owner. Such a request will result in a court order requiring the Vehicle Owner to file an answer and appearance with the Clerk of Court, as well as setting the matter for trial before a judge or magistrate. If the Court finds the Vehicle Owner guilty of the municipal infraction, state mandated court costs will be added to the amount of the fine imposed by this section.

(f) **Exceptions to Owner Liability.** There shall be no liability pursuant to this section if:

1. The operator of the vehicle in question was issued a uniform traffic citation for the violation in question pursuant to Cedar Rapids Code Chapter 61 or Iowa Code Chapter 321 (2008); or

2. The violation occurred at any time after the vehicle in question or its state registration plates were reported to a law enforcement agency as having been stolen, provided, however, the vehicle or its plates had not been recovered by the Vehicle Owner at the time of the alleged violation; or

3. The vehicle in question was an authorized emergency vehicle; or

4. The officer inspecting the recorded image determines that the vehicle in question was lawfully participating in a funeral procession; or

5. The officer inspecting the recorded image determines that the vehicle in question entered the intersection in order to yield the right-of-way to an emergency vehicle.

(g) **Failure to Timely Pay or Appeal.** If the recipient of an Automated Traffic Citation does not either pay the fine by the due date stated in the citation or appeal the citation as provided herein, a municipal infraction citation may be filed by the Cedar Rapids Police Department and a fine may be sought in accordance with Cedar Rapids Code section 1.12 rather than subsection (d.) above. If the Court finds the Vehicle Owner guilty of the municipal infraction, state mandated court costs will be added to the amount of the fine imposed by this section.

(020-09)

## APPENDIX B: DATA DICTIONARY

| | |
|---|---|
| **Date** | The day in which the data were collected listed in month/day/year format |
| **Time** | This is the time during the day in which a vehicle enters the intersection. It is listed in hour: minute: second format using military time. |
| **Site Code** | This column lists the intersection and approach in which the data were collected for. Below are the site codes and which intersection and approach they stand for.<br>• 6THNB – 2nd Avenue and 6th Street SW northbound<br>• EDGNB – Edgewood Road and 42nd Street NE northbound<br>• EDGSB – Edgewood Road and 42nd Street NE Southbound<br>• 1STWB – 1st Avenue and 10th Street westbound<br>• 1STEB – 1st Avenue and 10th Street eastbound<br>• 3RDNB – 2nd Avenue and 3rd Street SW northbound<br>• 3RDWB – 2nd Avenue and 3rd Street SW westbound |
| **Offence Type** | This column lists whether a violation took place for that vehicle. One of four things will be listed in this column:<br>• no violation: In this case no violation occurred and the vehicle proceeded through the intersection without speed or running the red light.<br>• red: In this case the vehicle entered the intersection after the light had been red for at least 0.1 seconds. In this case the vehicle was not speeding.<br>• speed: In this case the vehicle entered the intersection traveling at least 12 mph over the posted speed limit.<br>• speed + red: In this case the vehicle entered the intersection after the light had been red for at least 0.1 seconds and was traveling at least 7 mph over the posted speed limit. |
| **Speed Validation** | This column lists whether a valid length could be determined. If the length is valid and the vehicle enters the intersection the potential violation is reviewed by Cedar Rapids PD to ensure the offender did indeed run the red light. |
| **Speed** | This column lists the speed in which a vehicle is traveling when it enters the intersection. If the speed validation column has an i listed for a vehicle, the speed column will be 0. Speeds are listed in mph. |
| **Length Validation** | This column lists whether a valid speed could be determined. According to the vendor A valid speed measurement means that the vehicle was traveling within the limits of the radar (6 mph to 126 mph). Invalid triggers occur when the radar detected a speed less than 6 mph or the return signature of the Doppler radar was not complete, or found inconsistencies in the Doppler shift.<br>This is seen a lot with cars that slam on their breaks just before the stop bar. These are reviewed by Cedar Rapids PD to ensure the offender did indeed run the red light. |
| **Length** | This is the length used for the length validation. If the length is valid it will list the length (usually 613) and if invalid it will list 0. |

| | |
|---|---|
| **Pardon Time** | This is a length of time into the red before citations are issued. At the intersections in the study this is 0.1 seconds. The column will list 0 if the vehicle enters the intersection in the green or yellow phase. The column will list 100 (time is listed in thousandths of a second) if the vehicle enters the intersection in the red phase. |
| **Yellow Time** | This lists the time into the yellow phase a vehicle entered the intersection. If the signal was green it is listed as 0. If the signal was yellow it lists how far into the yellow that was. If the signal was red it lists the length of the yellow cycle. This time is listed in thousandths of a second. |
| **Red Time** | This lists the time into the red phase a vehicle entered the intersection. If the signal was green or yellow the time listed is 0. If the signal was red it lists the length of time into the red phase that the vehicle entered. This time is listed in thousandths of a second. |

## APPENDIX C: DATES AND TIMES OF DATA REMOVED

| Intersection Approach | Dates Removed [Time] | Reason Dates Removed |
|---|---|---|
| 2nd & 6th NB | 6/23/10 [0:00-9:00] | Heavy rain |
| | 6/24/10 [7:15-9:45] | Error with signal |
| | Each day [2:00-6:00] | Flashing red/yellow |
| Edgewood & 42nd NB | No changes made | N/A |
| Edgewood & 42nd SB | 4/16/10 [0:00-12:00] | Data collection did not start until 12:00 |
| 1st & 10th WB | 2/8/10 [All day] | Accumulating snow during this date |
| 1st & 10th EB | 2/8/10 [All day] | Accumulating snow during this date |
| 2nd & 3rd NB | 6/18/10 [All day] | Dense fog and heavy rain throughout the day |
| | 3/25/10 [0:00-8:30] | Data collection did not start until 8:30 |
| | Each night [22:00-6:00] | Flashing red/yellow |
| 2nd & 3rd WB | 6/18/10 [All day] | Dense fog and heavy rain throughout the day |
| | Each night [22:00-6:00] | Flashing red/yellow |
| Center Point Road NB | Each Night [1:00-6:00] | Flashing red/yellow |
| | 7/20 [All Day] | No Data Collected |
| | 7/22 [18:00 – 243:59] | Missing data |
| | 7/23 [0:00 – 11:59] | Missing Data |