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SAFETY EVALUATION OF RED LIGHT RUNNING CAMERA INTERSECTIONS IN ILLINOIS

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A report of the findings of
ICT PROJECT R27-SP32
Crash-Based Evaluation of
Red Light Running Cameras in Illinois

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16. Abstract

As a part of this research, the safety performance of red light running (RLR) camera systems was evaluated for a sample of 41 intersections and 60 RLR camera approaches located on state routes under IDOT's jurisdiction in the Chicago suburbs. Comprehensive traffic crash analyses based on 3 years of before-installation crash data and 3 years of after-installation crash data were conducted in order to evaluate the safety effects of the RLR cameras. Two methods were used to evaluate the crash experience at the RLR camera locations: the naïve before and after, and the empirical Bayes. The observed crash reductions were tested for statistical significance using the Poisson test at a 95% level of confidence. Using the empirical Bayes method for those crash types where safety performance factors (SPFs) were available, crash modification factors were developed for statistically significant crash reductions based on the unbiased index of effectiveness metric. The results of the naïve before and after and the empirical Bayes methods indicated statistically significant reductions in total intersection crashes of 36% to 34% and in angle RLR intersection crashes of 53% to 67%, respectively. Other findings of the installation of the RLR camera system based on the naïve before and after method indicated significant reductions in intersection injury crashes of 18% and a non-significant change in rear-end RLR crashes. The resulting crash modification factors are 0.656 for total intersection crashes and 0.331 for angle RLR intersection crashes. Overall, the safety evaluation provides evidence that the installation of RLR camera systems on state routes reduces angle RLR crashes, which are associated with severe injury; has a nominal impact on rear-end RLR crashes; and has a positive impact on reducing total intersection crashes, as studied in Chicago suburbs. It is recommended that IDOT continue to support the installation of RLR cameras at locations where justified, thereby improving intersection safety for Illinois motorists.

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Red light running, RLR camera systems, angle RLR crashes, safety evaluation, empirical Bayes, naïve before and after, crash modification factors

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EXECUTIVE SUMMARY

Introduction and Study Purpose

On U.S. roads in 2014, 709 people were killed and an estimated 126,000 were injured in crashes that involved red light running. Crashes caused by drivers running red lights are often associated with injuries and in some instances fatalities, and thus pose serious concerns to safety professionals. Many agencies have become aware of the serious consequences of red light running and have implemented a variety of safety initiatives that include stricter enforcement, engineering measures, and automated enforcement.

Agencies in the United States began implementing automated enforcement systems (red light running cameras) at intersections where red light running was identified as a problem. As of March 2017, 426 communities in 23 states and the District of Columbia have red light camera programs in their jurisdictions. Currently in Illinois, red light running cameras are in operation at intersections located on state and local roads in eight counties in the Chicago area and Metro East (St. Louis), including Cook, DuPage, Kane, Lake, Madison, McHenry, St. Clair, and Will counties, and in municipalities within these counties.

The Illinois Department of Transportation (IDOT), through the Illinois Center for Transportation (ICT), commissioned two special projects to evaluate the effectiveness of red light running (RLR) cameras and sought researchers from Bradley University (BU) and the University of Illinois at Urbana-Champaign (UIUC). Although the BU and UIUC special projects are funded separately, it was agreed that the projects would be collaborative. It was agreed that the scope of work between BU and UIUC would be allocated as follows in order to meet IDOT's needs for the research results.

- BU researchers were to conduct the crash-based effectiveness evaluation using two methodologies: the naïve before and after and the empirical Bayes. Three years of before- and 3 years of after-installation data was used for as many candidate locations as possible to quantify the safety benefits of RLR cameras on state routes in the Chicago suburbs. The BU researchers were also to summarize the geometric, traffic, and operational data at the RLR camera sites.

- UIUC researchers were to perform the analysis of the spillover effects to determine whether crashes were reduced at intersections adjacent to RLR camera intersections, and also to perform the economic analysis of the RLR camera locations included in the study, based on the results of the before and after crash–based evaluation.

This report documents the activities performed and results of the research conducted by BU researchers, as a part of ICT project R27-SP32. The findings of the UIUC research is contained in a separate report as a part of ICT project R27-SP33.

Characteristics of Test Sites

As a part of this research, the safety performance of RLR camera systems installed at a sample of 60 approaches of 41 signalized intersections was evaluated. These intersection approaches are located on state routes under IDOT's jurisdiction in the Chicagoland area, but outside of the City of Chicago limits, in Cook, DuPage, Kane, and Lake counties. Other criteria for the selection of sites to be included in this research included the following:

- No other geometric and/or traffic signal improvements were made at the sites following installation of the RLR camera system.
- The installation date of the RLR camera at a site would permit access to 3 years of before-installation and 3 years of after-installation traffic crash data.

Geometric, traffic, and operational data were obtained or collected for the RLR camera study sites to document their characteristics. The geometric characteristics, such as number of through lanes, number and type of dedicated lanes, and presence of channelized right-turn islands, were extracted from current aerial images available online and recorded. Traffic operations data were obtained for each of the test sites, including speed limits and average daily traffic (ADT) volumes for the intersection approaches. The ADT data were obtained from IDOT's traffic count website. Traffic signal timing and phasing details were provided by IDOT and included cycle length operated during the AM, midday and PM peak periods, length of the yellow change interval, and left-turn control being permissive, protected, or protected/permissive.

Safety Evaluation Results

Comprehensive traffic crash analyses based on 3 years of before-installation crash data and 3 years of after-installation crash data were conducted in order to evaluate the safety effects of the RLR cameras. A total of 60 approaches located at 41 test intersections were included in the evaluation, focusing on the targeted crash types of angle RLR and rear-end RLR crashes. Comparisons of other crash types were made as well on an intersection level and an RLR camera approach level. Two methods were used to evaluate the crash experience at the RLR camera locations: the naïve before and after, and the empirical Bayes. The observed crash reductions were tested for statistical significance using the Poisson test at a 95% level of confidence. Using the empirical Bayes method for those crash types where safety performance functions (SPFs) were available, crash modification factors were developed for statistically significant crash reductions based on the unbiased index of effectiveness metric.

The results of the naïve before and after and the empirical Bayes methods indicated:

- Total intersection crashes significantly reduced by 36% to 34%, respectively for the two evaluation methods
- Angle RLR intersection crashes significantly reduced by 53% to 67%, respectively for the two evaluation methods

Other findings of the installation of the RLR camera system based on the naïve before and after method are as follows:

- Intersection injury crashes (K, A, B, C) significantly reduced by 18%.

  In the case of injury crashes, traffic crash severity is defined as follows: K represents a fatal crash, A represents a crash with an incapacitating injury, B represents a crash with a non-incapacitating injury, and C represents a crash with a possible injury.

- Rear-end RLR crashes experienced a non-significant change.

It should be noted that the necessary SPFs required for the empirical Bayes method were not available for all of the crash types, and thus some crash types could be analyzed using only the naïve before and after method.

Using the procedures outlined in the *Highway Safety Manual*, crash modification factors (CMFs) were developed for total intersection crashes and angle RLR intersection crashes based on the empirical Bayes results. The resulting CMFs, along with their confidence intervals (CI), are as follows:

- **Total Intersection CMF = 0.656** with 95% CI = 0.602 to 0.710
- **Angle RLR Intersection CMF = 0.331** with 95% CI = 0.185 to 0.478

Overall, the safety evaluation provides evidence that the installation of RLR camera systems on state routes reduces angle RLR crashes, which are associated with severe injury; has a nominal impact on rear-end RLR crashes; and has a positive impact on reducing total intersection crashes, as studied in Chicago suburbs.

It is recommended that IDOT continue to support the installation of RLR cameras at locations where justified, thereby improving intersection safety for Illinois motorists.

CONTENTS

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AADT	annual average daily traffic
ADT	average daily traffic
BU	Bradley University
CI	confidence interval
CMF	crash modification factor
CRF	crash reduction factor
EB	eastbound
FHWA	Federal Highway Administration
ICT	Illinois Center for Transportation
IDOT	Illinois Department of Transportation
IIHS	Insurance Institute for Highway Safety
LOC	level of confidence
MUTCD	*Manual on Uniform Traffic Control Devices*
mph	miles per hour
NB	northbound
PDO	property damage only
RLR	red light running
SB	southbound
SPF	safety performance function
UIUC	University of Illinois Urbana-Champaign
vpd	vehicles per day
WB	westbound

CHAPTER 1: INTRODUCTION

On U.S. roads in 2014, "709 people were killed and an estimated 126,000 were injured in crashes that involved red light running" (IIHS/HLDI 2016). Crashes caused by drivers running red lights are often associated with injuries and in some instances fatalities. Many agencies have become aware of the serious consequences of red light running and have implemented a variety of safety initiatives that include stricter enforcement, engineering measures, and automated enforcement.

Traditional law enforcement methods to cite drivers who run red lights are often ineffective. The implementation of such enforcement initiatives lies at the discretion of the police officers because they must follow the offender through the intersection during the red signal in order to cite them. Due to the hazard involved, agencies in the United States began implementing automated enforcement systems (red light running cameras) at intersections where red light running was identified as a problem. As of March 2017, 426 communities in 23 states and the District of Columbia have red light camera programs in their jurisdictions (IIHS/HLDI 2017), as shown in Figure 1.1.

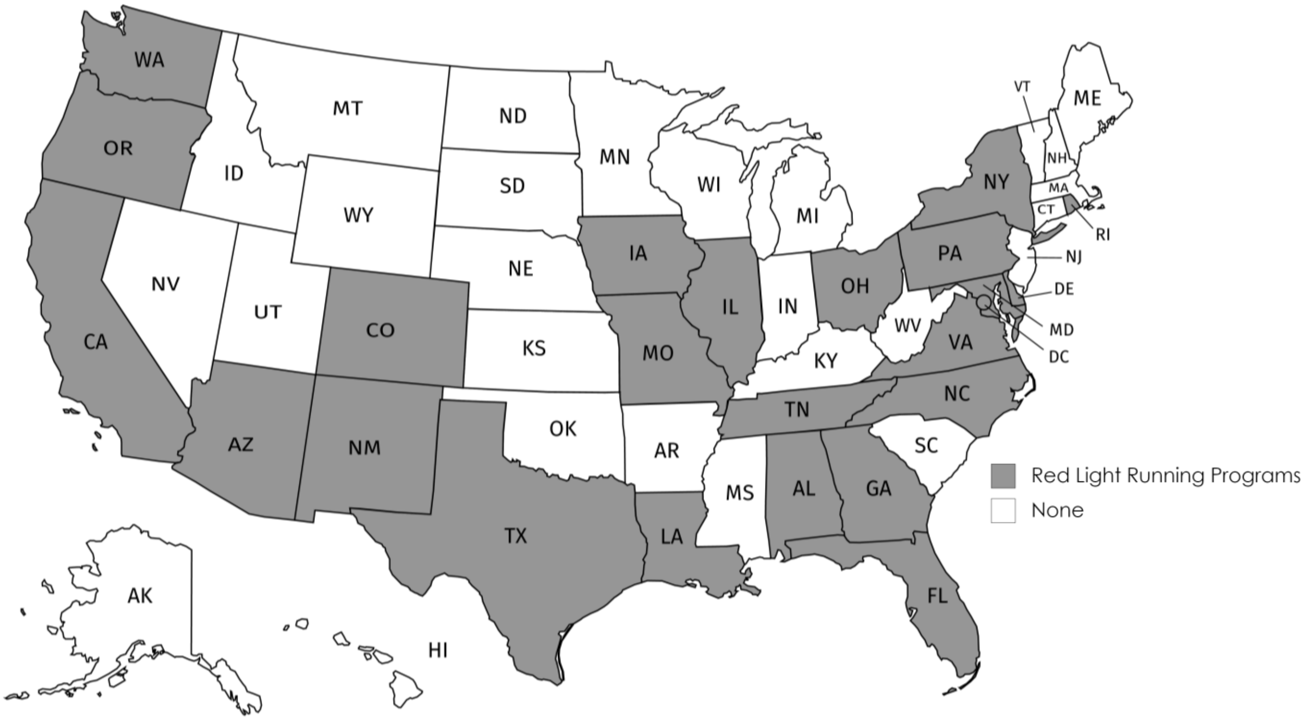

Figure 1.1 States where red light running cameras are used (Modified from source: IIHS/HLDI 2017).

In a 2005 report published by the Federal Highway Administration, red light running camera systems in seven cities were found to reduce right-angle crashes by 25%, despite a 15% increase in rear-end crashes (Council et al. 2005). The aggregated economic benefit in the seven cities was more than

$18.5 million, with between $39,000 and $50,000 economic benefit per red light camera site per year (Council et al. 2005).

A study published in 2016 compared large cities with red light cameras to those without found the red light cameras "reduced the fatal red light running crash rate by 21 percent and the rate of all types of crashes at signalized intersections by 14 percent" (Hu and Cicchino 2016). The authors of this same study examined the impacts of communities removing red light cameras. In 14 cities that terminated their red light running (RLR) camera program during 2010–14, "the fatal red light running crash rate was 30 percent higher than would have been expected if they had left the cameras on. The rate of fatal crashes at signalized intersections was 16 percent higher" (Hu and Cicchino 2016).

To improve intersection safety, beginning in 2003 red light running cameras were installed in the City of Chicago, Illinois. Currently in Illinois, red light running cameras are in operation at intersections located on state and local roads in eight counties in the Metro East (St. Louis) and Chicago area.

The Illinois Department of Transportation (IDOT), through the Illinois Center for Transportation (ICT), commissioned two special projects to evaluate the effectiveness of red light running (RLR) cameras and sought researchers from Bradley University (BU) and the University of Illinois (UIUC) to undertake the following tasks:

- Estimate the crash and associated economic effects of RLR camera systems, specifically for rear-end and right-angle crash types, and for various severity levels (K, A, B, C, PDO)
- Examine the extent to which the anticipated increase in rear-end crashes offsets the benefits for reduced right-angle crashes
- Determine the aggregated benefits of RLR camera systems from a traffic crash and economic perspective
- Summarize roadway type, number of lanes, dedicated turn lanes, presence of protected left-turn phases, ADT, length of signal yellow interval, and other critical features for each intersection leg at the study intersections
- Determine whether spillover effects to adjacent signalized intersections are present

Although the BU and UIUC special projects were funded separately, it was agreed that the projects would be collaborative. It was agreed that the scope of work between BU and UIUC would be allocated as follows in order to meet IDOT's needs for the research results.

- BU researchers, led by Dr. Kerrie Schattler, were to conduct the crash-based effectiveness evaluation using two methodologies: the naïve before and after and the empirical Bayes. Three years of before- and 3 years of after-installation data were used for as many candidate locations as possible to quantify the safety benefits of RLR cameras on state routes in Chicago suburbs. The BU researchers were to also summarize the geometric, traffic, and operational data at the RLR camera sites.
- UIUC researchers, led by Dr. Yanfeng Ouyang, were to perform the analysis of the spillover effects to determine whether crashes were reduced at intersections adjacent to RLR camera

intersections, and also to perform the economic analysis of the RLR camera locations included in the study, based on the results of the before and after crash–based evaluation.

This report documents the activities performed and results of the research conducted by BU researchers, as a part of ICT project R27-SP32. The findings of the UIUC research are contained in a separate report as a part of ICT project R27-SP33.

This report contains the following chapters:

Chapter 2—Study Methodology

Chapter 3—Characteristics of Test Sites

Chapter 4—Traffic Crash–Based Safety Evaluation

Chapter 5—Summary and Conclusions

CHAPTER 2: STUDY METHODOLOGY

The Bradley University research team conducted a traffic crash–based effectiveness evaluation to assess the safety performance of the RLR camera systems installed in the Chicago suburbs. The naïve before and after and the empirical Bayes evaluation methodologies were used to compare before- and after-installation crash data, categorized by crash type. Emphasis was placed on targeted crashes types—the types of crashes that are likely influenced by RLR cameras—mainly angle and rear-end crash types. Crashes involving injuries were also carefully noted by severity (K, A, B, C). In the case of injury crashes, traffic crash severity is defined as follows: K represents a fatal crash, A represents a crash with an incapacitating injury, B represents a crash with a non-incapacitating injury, and C represents a crash with a possible injury (FHWA 2010). When no injuries result from a crash, the label PDO is given, representing a property-damage-only crash. The crash is represented by the highest severity observed in the incident.

Comprehensive traffic crash analyses based on 3 years of before-installation crash data and 3 years of after-installation crash data were conducted in order to evaluate the safety effects of the RLR camera system. A total of 60 approaches located at 41 test intersections were included in the evaluation. Two methods were used to evaluate the crash experience at the RLR camera locations: the naïve before and after, and the empirical Bayes. These two methods seek to determine the effectiveness, or percent reduction in crashes, that can be attributed to the countermeasure or improvement. In both methods, the actual after-installation crash frequency is compared with an expected value. The expected value represents the crashes that would have occurred in the after-installation period had the RLR cameras not been installed at the test site. This expected value will never be known with 100% certainty because the conditions at the test site changed due to the treatment. The difference in the two evaluation methods lies in the determination of the expected value of the crashes without treatment. The percent reductions were determined for each of the two methods. The observed crash reductions were tested for statistical significance using the Poisson test at a 95% level of confidence (LOC). Crash modification factors (CMFs) based on the empirical Bayes analysis were also calculated.

2.1 NAÏVE BEFORE AND AFTER

In the naïve before and after method, as shown in Figure 2.1, the expected crash frequency in the after period, had the improvements not been made, is assumed to be the before-crash frequency. Because the only major change made to the intersection was the installation of the RLR cameras, it can be assumed that any significant change observed in crash frequencies would be a result of the RLR cameras. Although this method fails to account for fluctuations common in crash frequencies over time, it still provides useful insight into the impact of the treatment.

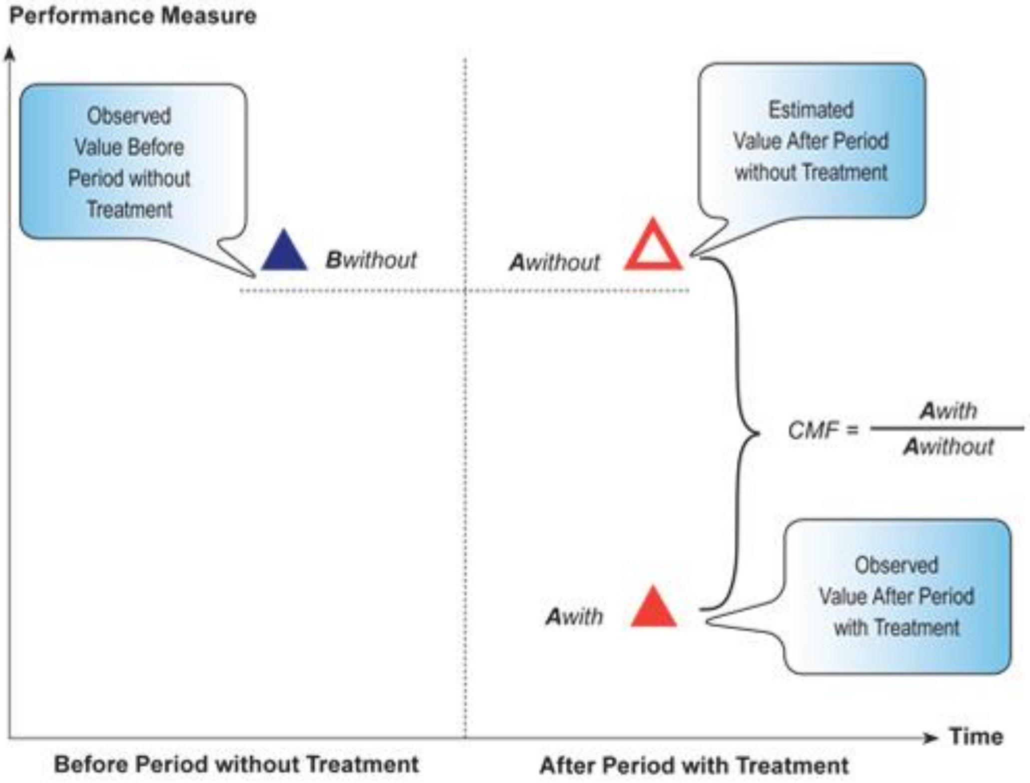

Figure 2.1 Naïve before and after method (Source: FHWA 2010).

2.2 EMPIRICAL BAYES

The random nature of crashes makes it impossible to truly predict the expected number of crashes in an after-installation period, had the improvements not been made. Because of its ability to account for regression-to-the-mean bias, the empirical Bayes method is commonly accepted as a more precise estimation of the expected crashes than any other method.

Regression-to-the-mean effects are typically observed at sites with very high values for crash frequencies and are defined as “the tendency of the response variable to fluctuate about the true mean value” (FHWA 1980). Thus, the decrease in the crash frequency during the after-installation period cannot be completely attributed to the improvements made at the site unless proper care has been taken to guard against regression-to-the-mean effects. The regression-to-the-mean phenomenon is illustrated in Figure 2.2.

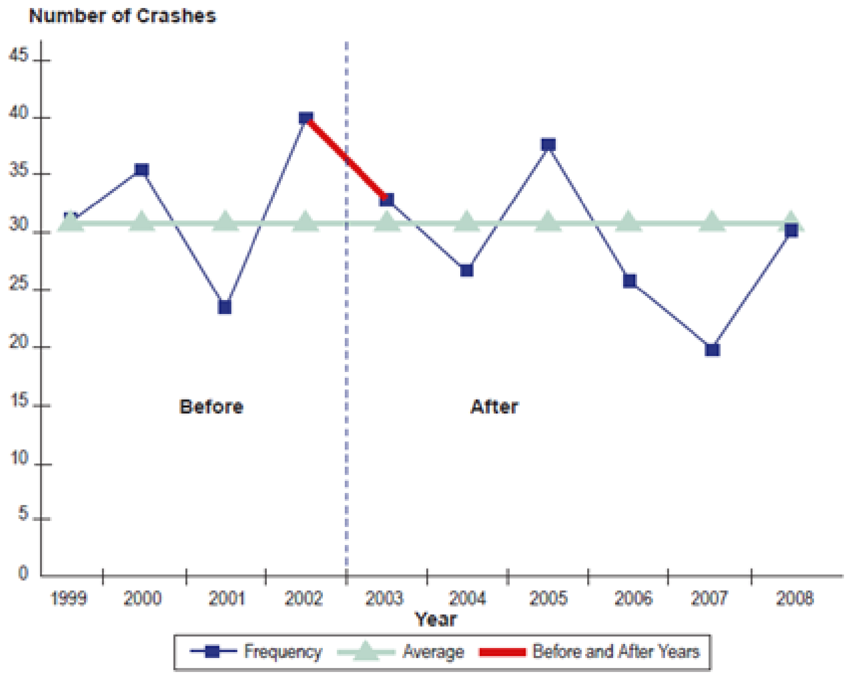

Figure 2.2 Regression-to-the-mean phenomenon (Source: FHWA 2010).

The empirical Bayes method takes into account both the crash experience of the test sites and a crash prediction model, called a safety performance function (SPF), derived from the crash experience of numerous comparison sites (Figure 2.3). The predictions from the SPF models are then weighted against the observed crash experience of the test site to more accurately predict the expected crashes.

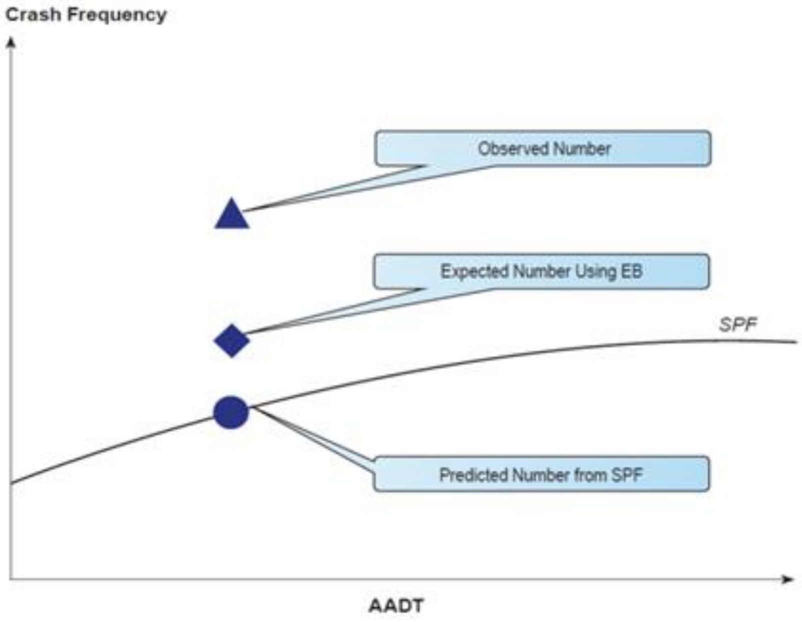

Figure 2.3 Empirical Bayes method (Source: FHWA 2010).

CHAPTER 3: CHARACTERISTICS OF TEST SITES

As a part of this research, the safety performance of RLR camera systems installed at 60 approaches of 41 signalized intersections was evaluated. These intersection approaches are located on state routes under IDOT's jurisdiction in the Chicagoland area, but outside of the City of Chicago limits. Other criteria for the selection of sites to be included in this research included the following:

- No other geometric and/or traffic signal improvements were made at the sites following installation of the RLR camera system.
- The installation date of the RLR camera at a site would permit access to 3 years of before-installation and 3 years of after-installation traffic crash data.

Based on these criteria, IDOT provided the research team with a list of 47 intersections. Of the 47 intersections included in this list, six intersections either did not have specific installation dates available or would not have crash data available for 2 months or more, over the 6-year study period. As a result, 41 intersections with RLR cameras installed at 60 approaches formed the sample of test sites for inclusion in this safety evaluation research. Figure 3.1 shows the geographical location of the 41 test sites, and Table 3.1 lists the test intersection and approaches.

It should be noted that at five of the study approaches, traffic crash data was not available for only 1 to 1.5 months of the entire 6-year study period. Because the lack of 1 to 1.5 months of crash data was considered nominal, these five approaches remained as study approaches and are included in the stated 60 approaches and 41 intersection sample size. The crash data at these five approaches were normalized to represent annual crash frequencies.

3.1 RLR CAMERA SYSTEM

In Illinois, the installation of red light running camera systems, by legislation, may be established in eight counties located in the Chicago area and Metro East (St. Louis) area including Cook, DuPage, Kane, Lake, Madison, McHenry, St. Clair, and Will counties, and in municipalities within these counties.

Per IDOT's Safety Engineering Policy Memorandum SAFETY 2-13, where installed, RLR cameras monitor the movements of vehicles approaching signalized intersections and the traffic signal indication displayed. Vehicle detection, usually via video detection, is used to verify whether a vehicle has traversed through the intersection after the onset of a red signal indication. If a red light violation is detected, pole-mounted cameras will record pictures of the vehicle position and license plate. The RLR camera technology is able to differentiate vehicles running red lights versus vehicles stopping slightly beyond the stop bar or making a right turn on red when allowed (IDOT 2013). Per the Illinois MUTCD, the R10-I104 traffic sign (Figure 3.2) shall be posted on all photo-enforced approaches in advance and on the far side of a signalized intersection equipped with the RLR camera system (IDOT 2014). Sample photographs of the Red Light Photo Enforced sign placement are shown in Figure 3.3 at the westbound approach of the US-34/Ogden Road and Yackley Road intersection in Lisle, Illinois.

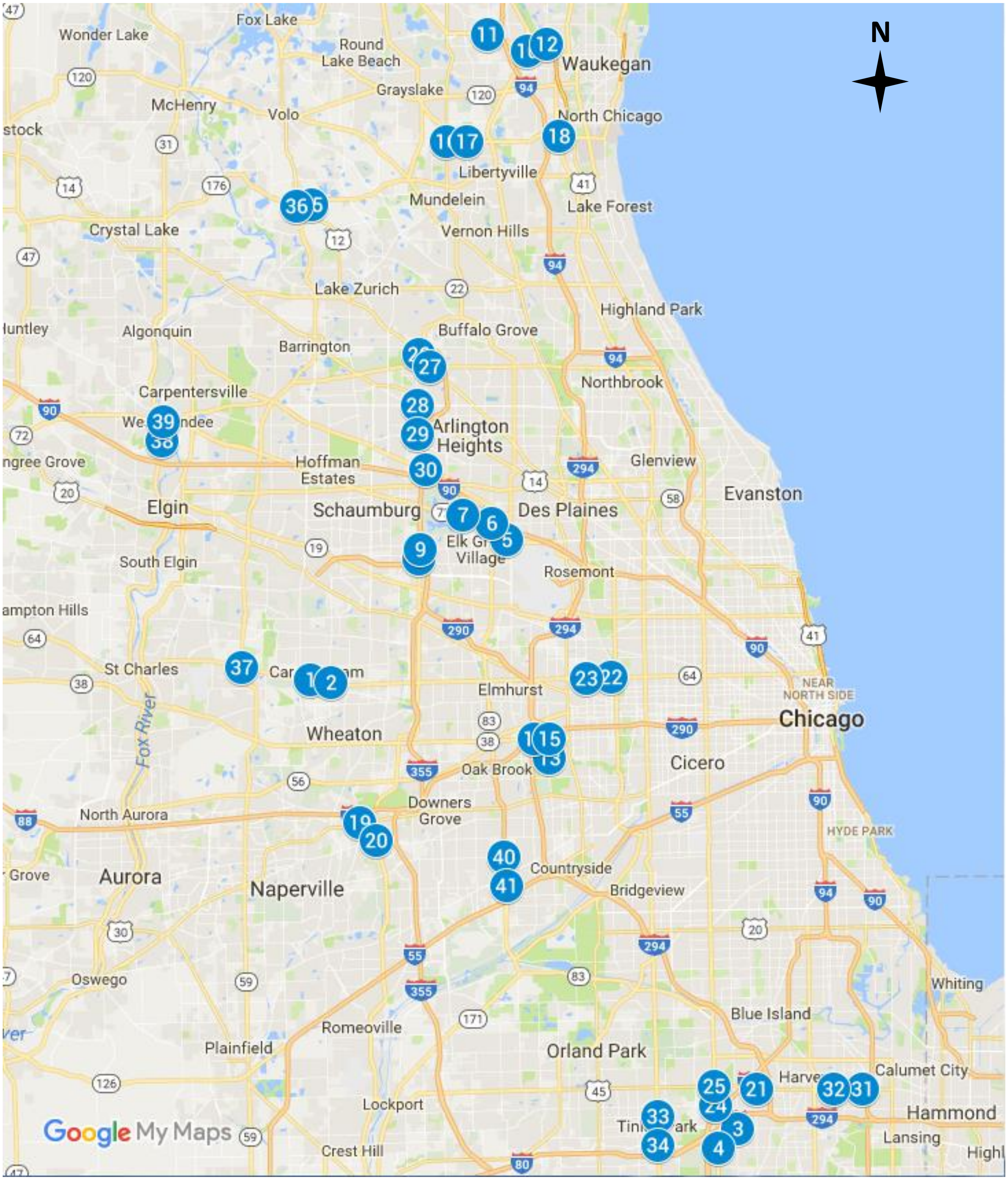

Figure 3.1 Location map of the 41 study RLR camera intersections.

Table 3.1 List of 41 Test Intersections and 60 RLR Camera Approaches

Intersection No. / Name		Municipality	County	RLR Camera Approach No., Direction, and Name		
1	IL-64/North & Kuhn	Carol Stream	DuPage	1	EB	EB IL-64/North @ Kuhn
2	IL-64/North & Gary	Carol Stream	DuPage	2	EB	EB IL-64/North @ Gary
				3	WB	WB IL-64/North @ Gary
3	Crawford/Pulaski & 175th Street	Country Club Hills	Cook	4	NB	SB Crawford/Pulaski @ 175th
				5	SB	NB Crawford/Pulaski @ 175th
4	IL-50/Cicero & 183rd Street	Country Club Hills	Cook	6	SB	SB IL-50/Cicero & 183rd
5	IL-72/ Higgins & Landmeier	Elk Grove Village	Cook	7	EB	EB Landmeier@ IL-72/ Higgins
6	IL-72/ Oakton & Busse	Elk Grove Village	Cook	8	SB	SB Busse @ IL-72/ Oakton
				9	WB	WB IL-72/ Oakton @ Busse
7	IL-72/ Higgins & Arlington Hts Rd	Elk Grove Village	Cook	10	WB	WB IL-72/ Higgins @ Arlington Hts Rd
8	Rohlwing & Nerge	Elk Grove Village	Cook	11	WB	WB Nerge @ Rohlwing
				12	EB	EB Nerge @ Rohlwing
9	IL-53/Biesterfield & IL-53/ Rohlwing	Elk Grove Village	Cook	13	NB	NB IL-53/ Biesterfield @ IL-53/ Rohlwing
10	IL-21 & IL-132	Gurnee	Lake	14	EB	EB IL-132 @ IL-21
				15	WB	WB IL-132 @ IL-21
11	IL-132 & Hunt Club Rd	Gurnee	Lake	16	EB	EB IL-132 @ Hunt Club Rd
				17	WB	WB IL-132 @ Hunt Club Rd
12	US-41 & Delany Rd	Gurnee	Lake	18	WB	WB US-41 @ Delany Rd
				19	EB	EB US-41 @ Delany Rd
13	22nd St./Cermak & Wolf	Hillside	Cook	20	SB	SB Wolf @ 22nd St/Cermak
14	IL-38/ Roosevelt & Hamilton/ Harrison	Hillside	Cook	21	WB	WB IL-38/ Roosevelt @ Hamilton/ Harrison
15	IL-38/ Roosevelt & Wolf	Hillside	Cook	22	NB	NB Wolf @ IL-38/ Roosevelt
16	US-45 & Peterson	Libertyville	Lake	23	NB	NB US-45 @ Peterson
17	IL-137 & Butterfield	Libertyville	Lake	24	WB	WB Il-137 @ Butterfield
18	IL-137 & IL-43	Libertyville	Lake	25	NB	NB IL-43 @ IL-137
19	US-34 & Yackley	Lisle	DuPage	26	EB	EB US-34 @ Yackley
				27	WB	WB US-34 @ Yackley
20	IL-53 & Maple	Lisle	DuPage	28	SB	SB IL-53 @ Maple

(table continues next page)

Table 3.1 (continued) List of 41 Test Intersections and 60 RLR Camera Approaches

Intersection No. / Name		Municipality	County	RLR Camera Approach No., Direction, and Name		
21	US-6/ 159th & Kedzie	Markham	Cook	29	EB	EB US-6/ 159th @ Kedzie
				30	WB	WB US-6/ 159th @ Kedzie
22	IL-64/ North & 5th Street	Melrose Park	Cook	31	EB	EB IL-64/ North @ 5th
				32	WB	WB IL-64/ North @ 5th
23	IL-64/ North & 25th Street	Melrose Park	Cook	33	SB	SB 25th @ IL-64/ North
				34	EB	WB IL-64/ North @ 25th
				35	WB	EB IL-64/ North @ 25th
24	IL-50/ Cicero & 167th Street	Oak Forest	Cook	36	NB	NB IL-50/ Cicero @ 167th
				37	SB	SB IL-50/ Cicero @ 167th
25	US-6/ 159th & IL-50/ Cicero	Oak Forest	Cook	38	SB	SB IL-50/ Cicero @ US-6/ 159th
				39	NB	NB IL-50/ Cicero @ US-6/ 159th
26	US-12/ Rand & IL-53/Hicks	Palatine	Cook	40	WB	WB US-12/ Rand @ IL-53/Hicks
27	US-12/IL-53/Rand & IL-53/IL-68/Dundee	Palatine	Cook	41	WB	WB IL-68/Dundee @ US-12/IL-53/Rand
				42	EB	EB IL-68/Dundee@ US-12/IL-53/Rand
28	US-14 & Palatine	Palatine	Cook	43	WB	WB Palatine @ US-14
29	Hicks & Euclid	Rolling Meadows	Cook	44	SB	SB Hicks & Euclid
30	IL-53 East Ramp & IL-62/Algonquin	Rolling Meadows	Cook	45	SB	WB IL-62 @ IL-53 East Ramp
				46	WB	SB IL-53 East Ramp @ IL-62
31	US-6/159th & Woodlawn East	South Holland	Cook	47	EB	EB US-6/ 159th @ Woodlawn East
32	US-6/159th & State/ Indiana	South Holland	Cook	48	WB	WB US-6/159th @ State/ Indiana
33	IL-43/Harlem & 171st Street	Tinley Park	Cook	49	SB	SB IL-43/Harlem @ 171st
34	IL-43/ Harlem & 183rd Street	Tinley Park	Cook	50	SB	SB IL-43/ Harlem @ 183rd
35	IL-176 & Old Rand/Main	Wauconda	Lake	51	SWB	SWB IL-176 @ Old Rand/Main
36	IL-176 & US-12/IL-59/West/Liberty	Wauconda	Lake	52	EB	EB IL-176 @ US-12
37	IL-59 & IL-64	West Chicago	DuPage	53	SB	SB IL-59 @ IL-64
				54	EB	EB IL-64 @ IL-59
38	RT-31 & Boncosky	West Dundee	Kane	55	SB	SB RT-31 @ Boncosky
39	RT-31 & RT-72	West Dundee	Kane	56	NB	NB RT-31 @ RT-72
40	IL-83 & 63rd Street	Willowbrook	DuPage	57	NB	NB IL-83 @ 63rd
				58	SB	SB IL-83 @ 63rd
41	IL-83 & 75th Street	Willowbrook	DuPage	59	NB	NB IL-83 @ 75th
				60	SB	SB IL-83 @ 75th

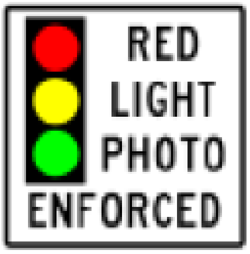

Figure 3.2 R10-I104 sign mounted at RLR camera approaches.

Photo Enforced Traffic Sign Mounted on Far-Side Signal Pole

Photo Enforced Traffic Sign in Advance of the Approach

Close-up of Photo Enforced Traffic Sign Mounted on Far-Side Signal Pole

Figure 3.3 Photo-enforced sign placement at a sample test intersection.

3.2 TEST SITE DESCRIPTION

Geometric, traffic, and operational data were obtained or collected for the RLR camera study sites to document their characteristics. The geometric characteristics, such as number of through lanes, number and type of dedicated lanes, and presence of channelized right-turn islands, were extracted from current aerial images available online and recorded (Table 3.2). Traffic operations data were obtained for each of the test sites, including posted speed limits and average daily traffic (ADT) volumes for the intersection approaches, and are shown in Table 3.3. The ADT data were obtained from IDOT's traffic count website. Traffic signal timing and phasing details were provided by IDOT and included cycle length operated during the AM, midday, and PM peak periods; length of the yellow change interval; and left-turn control being permissive, protected, or protected/permissive (Table 3.4).

Table 3.2 Laneage Characteristics at the Test Intersections

Intersection No./ Name		Northbound Approach Laneage			Southbound Approach Laneage			Eastbound Approach Laneage			Westbound Approach Laneage		
		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
1	IL-64/North & Kuhn	1	1	flare	1	1	flare	1 (L/U)	3	1	1 (L/U)	3	1
2	IL-64/North & Gary	2	2	1*	2	2	1*	2 (L/U)	3	1	2 (L/U)	3	1
3	Crawford/Pulaski & 175th	1	2	flare	1	2	flare	1	2	flare	1	2	flare
4	IL-50/Cicero & 183rd	1	2	1	1	2	1	1	2	0	1	2	0
5	IL-72/ Higgins & Landmeier	1	1	0	1	2	0	1	1	1*	1	2	0
6	IL-72/ Oakton & Busse	1	3	1*	1	3	1*	1	3	1*	1	3	1*
7	IL-72/ Higgins & Arlington Hts Rd	2	3	0	2	3	1	2	3	1	2	3	1
8	Rohlwing & Nerge	1	2	0	1	2	1	1	2	1	1	2	1
9	IL-53/ Biesterfield & IL-53/ Rohlwing	1	2	1	2	2	0	2	1	0	2	2	1
10	IL-21 & IL-132	1	2		1	2	0	1	2	0	1	2	0
11	IL-132 & Hunt Club Rd	1	2	1*	1	2	flare*	2	3	flare*	2	3	1*
12	US-41 & Delany Rd	1	2	0	2	1	0	1	2	0	1	2	1*
13	22nd St/Cermak & Wolf	1	2	1	1	2	1	1	2	1	1	2	1
14	IL-38/ Roosevelt & Hamilton/ Harrison	0	1	0	0	1	1*	1	3	0	1	2	0
15	IL-38/ Roosevelt & Wolf	1	2	0	1	2	0	1	2	0	1	2	0
16	US-45 & Peterson	2	2	1	2	2	1	1	2	1	1	2	1
17	IL-137 & Butterfield	1	1 (L/T)	1	1	1	0	1	2	1*	2	2	0
18	IL-137 & IL-43	2	3	1*	2	3	2*	2	3	1	2	3	1
19	US-34 & Yackley	1	2	0	1	2	0	1	2	0	1	2	0
20	IL-53 & Maple	1	2	1	1	2	1	2	2	0	2	2	0
21	US-6/ 159th & Kedzie	1	2	0	1	2	0	1	2	0	1	2	0
22	IL-64/ North & 5th Street	1	2	0*	1	2	0*	1	3	0*	1	3	1*

(table continues next page)

Table 3.2 (continued) Laneage Characteristics at the Test Intersections

Intersection No./ Name		Northbound Approach Laneage			Southbound Approach Laneage			Eastbound Approach Laneage			Westbound Approach Laneage		
		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
23	IL-64/ North & 25th Street	1	2	0	1	2	1	1	3	0	1	3	0
24	IL-50/ Cicero & 167th Street	1	2	1*	1	2	0	1	2	0	1	2	1*
25	US-6/ 159th & IL-50/ Cicero	1	2	1	1	2	0	1	2	0	1	2	1
26	US-12/ Rand & IL-53/Hicks	1	2	0	1	2	0	1	2	0	1	2	0
27	US-12/IL-53/Rand & IL-53/IL-68/Dundee	1	2	0*	1	2	0*	1	2	1	1	2	1
28	US-14 & Palatine	1	2	0	1	2	0	1	2	0	1	2	0
29	Hicks & Euclid	1	2	0	1	2	1	1	2	0	1	2	flare
30	IL-53 East Ramp & IL-62/Algonquin	0	0	0	2	0	2*	2	3	0	0	3	1*
31	US-6/159th & Woodlawn East	0	1	0	0	1	0	1	2	0	1	3	0
32	US-6/159th & State/ Indiana	1	2	1	1	2	0	1	2	0	1	2	1
33	IL-43/Harlem & 171st Street	1	2	1	1	2	0	1	2	0	1	2	0
34	IL-43/ Harlem & 183rd Street	2	3	1	2	2	1	2	2	2*	2	2	1
35	IL-176 & Old Rand/Main	1	1	0	1	1	1	1	0	1	1	1	1
36	IL-176 & US-12/ IL-59/West/Liberty	0	0	0	0	1	0*	0	1	1	1	1	0
37	IL-59 & IL-64	2	3	1*	2	3	1*	2	3	1*	2	3	1*
38	RT-31 & Boncosky	1	2	2	0	2	1	1	0	1	0	0	0
39	RT-31 & RT-72	2	2	1	2	2	0	1	2	0	1	2	1
40	IL-83 & 63rd Street	2	3	1*	1	2	1*	2	2	1*	1	2	1*
41	IL-83 & 75th Street	2	2	1*	1	2	1*	1	2	1*	1	1	1*

* Denotes presence of channelized right-turn island.

Table 3.3 Traffic Signal Operations Data at the Test Intersections

Intersection No./ Name		Speed Limit		Year of Average Daily Traffic	Current Average Daily Traffic (Vehicles per day)				
		NS Road (mph)	EW Road (mph)		NB	SB	EB	WB	Total
1	IL-64/North & Kuhn	35	45	2012(NS) 2013 (EW)	900	2,775	18,950	18,850	41,475
2	IL-64/North & Gary	45	45	2012(NS) 2013 (EW)	7,550	13,200	18,850	21,250	60,850
3	Crawford/Pulaski & 175th	40	40	2014(NS) 2014 (EW)	5,450	4,475	3,050	5,550	18,525
4	IL-50/Cicero & 183rd	50	40	2015(NS) 2014 (EW)	8,050	7,400	7,800	4,025	27,275
5	IL-72/ Higgins & Landmeier	45	40	2015(NS) 2014 (EW)	16,700	17,900	7,450	7,450	49,500
6	IL-72/ Oakton & Busse	45	40	2015(NS) 2014 (EW)	15,600	11,350	14,700	14,700	56,350
7	IL-72/ Higgins & Arlington Hts Rd	45	40	2014(NS) 2015 (EW)	12,400	16,650	16,850	17,900	63,800
8	Rohlwing & Nerge	40	40	2015(NS) 2014 (EW)	5,050	9,350	7,050	3,950	25,400
9	IL-53/ Biesterfield & IL-53/ Rohlwing	40	25	2015(NS) 2015 (EW)	9,350	6,650	7,450	16,950	40,400
10	IL-21 & IL-132	40	40	2013(NS) 2015 (EW)	7,000	5,500	12,300	12,300	37,100
11	IL-132 & Hunt Club Rd	45	45	2015(NS) 2015 (EW)	10,700	7,600	16,150	18,950	53,400
12	US-41 & Delany Rd	40	45	2015(NS) 2013 (EW)	3,300	11,600	18,950	18950	52,800
13	22nd St/Cermak & Wolf	35	35	2014(NS) 2014 (EW)	8,700	7,750	6,275	13,300	36,025
14	IL-38/ Roosevelt & Hamilton/ Harrison	35	45	2014(NS) 2015 (EW)	450	450	12,250	12,250	25,400
15	IL-38/ Roosevelt & Wolf	35	45	2014(NS) 2015 (EW)	7,750	6,500	12,250	14,350	40,850
16	US-45 & Peterson	45	50	2015(NS) 2015 (EW)	13,350	14,250	6,600	5,450	39,650
17	IL-137 & Butterfield	40	45	2015(NS) 2015 (EW)	8,950	1,500	14,150	14,150	38,750
18	IL-137 & IL-43	45	45	2015(NS) 2015 (EW)	12,000	13,050	9,550	16,100	50,700
19	US-34 & Yackley	40	40	2012(NS) 2015 (EW)	8,200	6,750	12,300	14,100	41,350
20	IL-53 & Maple	35	35	2015(NS) 2012(EW)	12,800	11,000	11,600	11,600	47,000
21	US-6/ 159th & Kedzie	45	35	2014(NS) 2015(EW)	9,150	6,800	10,450	13,850	40,250

(table continues next page)

Table 3.3 (continued) Traffic Signal Operations Data at the Test Intersections

Intersection No./ Name		Speed Limit		Year of Average Daily Traffic	Current Average Daily Traffic (Vehicles per day)				
		NS Road (mph)	EW Road (mph)		NB	SB	EB	WB	Total
22	IL-64/ North & 5th Street	35	40	2014(NS) 2015(EW)	2,000	6,550	22,250	18,150	48,950
23	IL-64/ North & 25th Street	35	40	2014(NS) 2015(EW)	8,900	9,200	25,200	22,250	65,550
24	IL-50/ Cicero & 167th Street	45	45	2015(NS) 2014(EW)	8,000	12,450	7,600	12,400	40,450
25	US-6/ 159th & IL-50/ Cicero	35	40	2015(NS) 2015(EW)	12,450	15,750	15,850	14,300	58,350
26	US-12/ Rand & IL-53/Hicks	45	35	2015(NS) 2015(EW)	9,700	8,950	13,500	13,650	45,800
27	US-12/IL-53/Rand & IL-53/IL-68/Dundee	35	35	2015(NS) 2015(EW)	14,650	13,650	12,650	12,150	53,100
28	US-14 & Palatine	30	35	2015(NS) 2014(EW)	12,450	12,900	7,050	7,750	40,150
29	Hicks & Euclid	40	45	2015(NS) 2014(EW)	975	5,350	10,400	10,400	27,125
30	IL-53 East Ramp & IL-62/Algonquin	30	35	2015(NS) 2014(EW)	-	11,900	14,850	17,900	44,650
31	US-6/159th & Woodlawn East	25	35	2015(EW)	750	750	12,950	12,950	27,400
32	US-6/159th & State/ Indiana	40	35	2014(NS) 2015(EW)	7,400	6,400	13,650	13,650	41,100
33	IL-43/Harlem & 171st Street	40	35	2015(NS) 2014(EW)	15,700	15,600	8,150	11,700	51,150
34	IL-43/ Harlem & 183rd Street	45	40	2015(NS) 2010(EB) 2014(WB)	12,950	15,100	9,650	6,350	44,050
35	IL-176 & Old Rand/Main	40	25	2015(NS) 2015(EW)	8,150	8,150	3,925	2,250	22,475
36	IL-176 & US-12/ IL-59/West/Liberty	N/A	30	2015(NS) 2014(EB)2015(WB)	-	1,650	6,250	9,400	17,300
37	IL-59 & IL-64	45	45	2015(NS) 2015(EW)	15,050	17,100	19,250	19,550	70,950
38	RT-31 & Boncosky	35	45	2015(NS) 2014(EB)	11,200	15,100	1,950	-	28,250
39	RT-31 & RT-72	35	30	2015(NS) 2015(EW)	15,100	15,350	12,150	15,350	57,950
40	IL-83 & 63rd Street	45	35	2015(SB) 2013(NB) 2012(EW)	23,650	22,100	13,050	6,150	64,950
41	IL-83 & 75th Street	45	30	2013(NS) 2012(EW)	23,650	23,650	7,350	7,350	62,000

Table 3.4 Traffic Signal Timing Data at the Test Intersections

Intersection No./ Name		Cycle Length (seconds)			Yellow Change Interval (seconds)		Left-Turn Control
		AM Peak	Midday Peak	PM Peak	Left	Thru	
1	IL-64/North & Kuhn	140	125	140	3.5	4.5	Protected
2	IL-64/North & Gary	140	125	140	3.5	4.5	Protected
3	Crawford/Pulaski & 175th	130	115	130	3.5	4.5	Protected- Permissive
4	IL-50/Cicero & 183rd	120	110	120	3.5	4.5	Protected-Permissive
5	IL-72/ Higgins & Landmeier	120	100	120	3.5	4.5	Protected- Permissive
6	IL-72/ Oakton & Busse	150	125	150	3.5	4.5	SB-Protected WB Protected/Permissive
7	IL-72/ Higgins & Arlington Hts Rd	150	125	150	3.5	4.5	Protected
8	Rohlwing & Nerge	120	110	110	3	4.5	Protected - Permissive
9	IL-53/ Biesterfield & IL-53/ Rohlwing	120	110	110	3.5	4.5	Protected
10	IL-21 & IL-132	125	120	135	3.5	4.5	Protected- Permissive
11	IL-132 & Hunt Club Rd	120	110	140	3.5	4.5	Protected
12	US-41 & Delany Rd	N/A	N/A	N/A	N/A	N/A	Protected - Permissive
13	22nd St/Cermak & Wolf	130	115	130	3.5	4.5	Protected - Permissive
14	IL-38/ Roosevelt & Hamilton/ Harrison	130	115	130	3.5	4.5	Protected - Permissive
15	IL-38/ Roosevelt & Wolf	130	115	130	3.5	4.5	Protected- Permissive
16	US-45 & Peterson	120	110	125	3.5	4.5	Protected
17	IL-137 & Butterfield	N/A	N/A	N/A	3.5	4.5	Protected
18	IL-137 & IL-43	110	100	115	3.5	4.5	Protected
19	US-34 & Yackley	135	110	145	3.5	4.5	Protected - Permissive
20	IL-53 & Maple	150	100	150	3.5	4.5	Protected - Permissive
21	US-6/ 159th & Kedzie	120	100	140	3.5	4.5	Protected - Permissive

(table continues next page)

Table 3.4 (continued) Traffic Signal Timing Data at the Test Intersections

Intersection No./ Name		Cycle Length (seconds)			Yellow Change Interval (seconds)		Left-Turn Control
		AM Peak	Midday Peak	PM Peak	Left	Thru	
22	IL-64/ North & 5th Street	150	140	160	3.5	4.5	Protected - Permissive
23	IL-64/ North & 25th Street	150	140	160	3.5	4.5	Protected - Permissive
24	IL-50/ Cicero & 167th Street	Runs Free	Runs Free	Runs Free	3	4.5	Protected - Permissive
25	US-6/ 159th & IL-50/ Cicero	120	115	140	3.5	4.5	Protected - Permissive
26	US-12/ Rand & IL-53/Hicks	150	120	150	3.5	4.5	Protected - Permissive
27	US-12/IL-53/Rand & IL-53/IL-68/Dundee	130	120	130	3.5	4.5	Protected - Permissive
28	US-14 & Palatine	130	105	130	3.5	4	Protected - Permissive
29	Hicks & Euclid	Runs Free	Runs Free	Runs Free	3.5	4.5	Protected - Permissive
30	IL-53 East Ramp & IL-62/Algonquin	140	120	140	3	4.5	Protected
31	US-6/159th & Woodlawn East	110	120	125	3.5	4.5	Protected - Permissive
32	US-6/159th & State/ Indiana	110	120	125	3.5	4.5	Protected - Permissive
33	IL-43/Harlem & 171st Street	120	130	140	3.5	4.5	Protected - Permissive
34	IL-43/ Harlem & 183rd Street	110	140	150	3.5	4.5	Protected
35	IL-176 & Old Rand/Main	Runs Free	Runs Free	Runs Free	3.5	4.5	Protected- Permissive
36	IL-176 & US-12/ IL-59/West/Liberty	Runs Free	Runs Free	Runs Free	3.5	4.5	Protect-Permissive
37	IL-59 & IL-64	130	110	130	3.5	4.5	Protected
38	RT-31 & Boncosky	130	115	130		SB- 5.0	T- Intersection
39	RT-31 & RT-72	120	110	140	3.5	4.5	Protected
40	IL-83 & 63rd Street	140	125	140	3.5	4.5	Protected
41	IL-83 & 75th Street	140	125	140	3	4.5	Protected

CHAPTER 4: TRAFFIC CRASH–BASED SAFETY EVALUATION

Three years of before- and after-installation data were obtained and analyzed for each of the 41 test intersections and 60 test approaches. The specific dates of the before- and after-installation periods for each intersection were determined, assuming a 1-year "during" period between before and after periods to account for the installation of the RLR camera system and an adjustment period for traffic and drivers. For example, if the installation date of a RLR camera system at a particular intersection was 12/11/2008, then the 3-year before-installation period would be from 12/11/2005 to 12/10/2008, and the 3-year after-installation period would be 12/11/2009 to 12/10/2012. Data for the 1-year installation period, in this example from 12/11/2008 to 12/10/2009, were not considered in this evaluation study. The before-, during-, and after-installation periods for each of the intersections and approaches are shown in Table 4.1.

At the time of this research, traffic crash data was available from January 1, 2005 through February 28, 2015. It should be noted that at five of the study approaches, located at four test intersections, traffic crash data was not available for only 1 to 1.5 months of the entire 6-year study period. Because the lack of 1 to 1.5 months of crash data was considered nominal, these five approaches remained as study approaches and are included in the safety evaluation study. The crash data at these five approaches were normalized to represent annual crash frequencies and are denoted with an asterisk in Table 4.1

Table 4.1 Before-, During-, and After-Installation Dates for the RLR Camera Approaches

Intersection No. / Name		RLR Camera Approach & Date Installed		Dates of 3-Year Before Period	Dates of 1-Year During Period	Dates of 3-Year After Period
1	IL-64/North & Kuhn	EB	12/11/2008	12/11/05-12/10/08	12/11/08-12/10/09	12/11/09-12/10/12
2	IL-64/North & Gary	EB	7/15/2009	07/15/06-07/14/09	07/15/09-07/14/10	07/15/10-07/14/13
		WB				
3	Crawford/Pulaski & 175th Street	SB	9/19/2010	09/19/07-09/18/10	9/19/10-9/18/11	9/19/11-9/18/14
		NB				
4	IL-50/Cicero & 183rd Street	SB	8/7/2009	8/7/06-8/6/09	8/7/09-8/6/10	8/7/10-8/6/13
5	IL-72/ Higgins & Landmeier	EB	1/28/2010	1/28/07-1/27/10	1/28/10-1/27/11	1/28/11-1/27/14
6	IL-72/ Oakton & Busse	SB	7/7/2008	7/7/05-7/6/08	7/7/08-7/6/09	7/7/09-7/6/12
		WB				
7	IL-72/ Higgins & Arlington Hts Rd	WB	1/7/2009	1/7/06-1/6/09	1/7/09-1/6/10	1/7/10-1/6/13
8	Rohlwing & Nerge	WB	10/10/2010	10/10/07-10/9/10	10/10/10-10/9/11	10/10/11-10/9/14
		EB				

(table continues next page)

Table 4.1 (continued) Before-, During-, and After-Installation Dates for the RLR Camera Approaches

Intersection No. / Name		RLR Camera Approach & Date Installed		Dates of 3-Year Before Period	Dates of 1-Year During Period	Dates of 3-Year After Period
9	IL-53/Biesterfield & IL-53/ Rohlwing	NB	11/20/2008	11/20/05-11/19/08	11/20/08-11/19/09	11/20/09-11/19/12
10	IL-21 & IL-132	EB	6/1/2009	6/1/06-5/31/09	6/1/09-5/31/10	6/1/10-5/31/13
		WB				
11	IL-132 & Hunt Club Rd	EB	6/1/2009	6/1/06-5/31/09	6/1/09-5/31/10	6/1/10-5/31/13
		WB				
12	US-41 & Delany Rd	WB	6/1/2009	6/1/06-5/31/09	6/1/09-5/31/10	6/1/10-5/31/13
		EB				
13	22nd St./Cermak & Wolf	SB	4/16/2011	4/16/08-4/15/11	4/16/11-4/15/12	4/16/12-4/15/15*
14	IL-38/ Roosevelt & Hamilton/ Harrison	WB	4/16/2011	4/16/08-4/15/11	4/16/11-4/15/12	4/16/12-4/15/15*
15	IL-38/ Roosevelt & Wolf	NB	4/16/2011	4/16/08-4/15/11	4/16/11-4/15/12	4/16/12-4/15/15*
16	US-45 & Peterson	NB	5/22/2010	5/22/07-5/21/10	5/22/10-5/21/11	5/22/11-5/21/14
17	IL-137 & Butterfield	WB	5/22/2010	5/22/07-5/21/10	5/22/10-5/21/11	5/22/11-5/21/14
18	IL-137 & IL-43	NB	5/22/2010	5/22/07-5/21/10	5/22/10-5/21/11	5/22/11-5/21/14
19	US-34 & Yackley	EB	6/10/2008	6/10/05-6/09/08	6/10/08-6/09/09	6/10/09-6/09/12
		WB				
20	IL-53 & Maple	SB	5/8/2008	5/8/05-5/7/08	5/8/08-5/7/09	5/8/09-5/7/12
21	US-6/ 159th & Kedzie	EB	1/19/2009	1/19/06-1/18/09	1/19/09-1/18/10	1/19/10-1/18/13
		WB	1/24/2009	1/24/06-1/23/09	1/24/09-1/23/10	1/24/10-1/23/13
22	IL-64/ North & 5th Street	EB	12/3/2007	12/3/04*-12/2/07	12/3/07-12/2/08	12/3/08-12/2/11
		WB				
23	IL-64/ North & 25th Street	SB	12/17/2010	12/17/07-12/16/10	12/17/10-12/16/11	12/17/11-12/16/14
		WB	12/21/2010	12/21/07-12/20/10	12/21/10-12/20/11	12/21/11-12/20/14
		EB	12/22/2010	12/22/07-12/21/10	12/22/10-12/21/11	12/22/11-12/21/14
24	IL-50/ Cicero & 167th Street	NB	9/13/2008	9/13/05-9/12/08	9/13/08-9/12/09	9/13/09-9/12/12
		SB				
25	US-6/ 159th & IL-50/ Cicero	SB	9/13/2008	9/13/05-9/12/08	9/13/08-9/12/09	9/13/09-9/12/12
		NB				
26	US-12/ Rand & IL-53/Hicks	WB	10/27/2008	10/27/05-10/26/08	10/27/08-10/26/09	10/27/09-10/26/12

(table continues next page)

Table 4.1 (continued) Before-, During-, and After-Installation Dates for the RLR Camera Approaches

Intersection No. / Name		RLR Camera Approach & Date Installed		Dates of 3-Year Before Period	Dates of 1-Year During Period	Dates of 3-Year After Period
27	US-12/IL-53/Rand & IL-53/IL-68/Dundee	WB	1/6/2009	1/6/06-1/5/09	1/6/09-1/5/10	1/6/10-1/5/13
		EB				
28	US-14 & Palatine	WB	10/25/2008	10/25/05-10/24/08	10/25/08-10/24/09	10/25/09-10/24/12
29	Hicks & Euclid	SB	6/3/2008	6/3/05-6/2/08	6/3/08-6/2/09	6/3/09-6/2/12
30	IL-53 East Ramp & IL-62/Algonquin	WB	9/9/2008	9/9/05-9/8/08	9/9/08 - 9/8/09	9/9/09 - 9/8/12
		SB	9/29/2009	9/29/06-9/28/09	9/29/09-9/28/10	9/29/10-9/28/13
31	US-6/159th & Woodlawn East	EB	4/13/2009	4/13/06-4/12/09	4/13/09-4/12/10	4/13/10-4/12/13
32	US-6/159th & State/ Indiana	WB	4/13/2009	4/13/06-4/12/09	4/13/09-4/12/10	4/13/10-4/12/13
33	IL-43/Harlem & 171st Street	SB	7/1/2009	7/01/06-6/30/09	7/01/09-6/30/10	7/01/10-6/30/13
34	IL-43/ Harlem & 183rd Street	SB	7/1/2009	7/01/06-6/30/09	7/01/09-6/30/10	7/01/10-6/30/13
35	IL-176 & Old Rand/Main	SWB	8/13/2009	8/13/06-8/12/09	8/13/09-8/12/10	8/13/10-8/12/13
36	IL-176 & US-12/IL-59/West/Liberty	EB	1/19/2010	1/19/07-1/18/10	1/19/10-1/18/11	1/19/11-1/18/14
37	IL-59 & IL-64	SB	5/24/2008	5/24/05-5/23/08	5/24/08-5/23/09	5/24/09-5/23/12
		EB				
38	RT-31 & Boncosky	SB	9/1/2008	9/1/05-8/31/08	9/1/08-8/31/09	9/1/09-8/31/12
39	RT-31 & RT-72	NB	12/1/2008	12/1/05-11/30/08	12/1/08-11/30/09	12/1/09-11/30/12
40	IL-83 & 63rd Street	NB	9/1/2009	9/01/06-8/31/09	9/01/09-8/31/10	9/01/10-8/31/13
		SB				
41	IL-83 & 75th Street	NB	9/1/2009	9/01/06-8/31/09	9/01/09-8/31/10	9/01/10-8/31/13
		SB				

4.1 DATA COLLECTION

Crash data were obtained from IDOT for the period January 1, 2005 through February 28, 2015. Crash data for 2004 and earlier years was no longer available from IDOT because these data files had been purged. Once the crash database files were received, the research team extracted the data for each intersection, downloaded the police traffic crash report forms, and then filed them for ease of use and organization. Because the police traffic crash reports were used in this evaluation study, the research team extracted data from the report forms one crash at a time.

All crash types were determined by reviewing the diagrams/narratives prepared by the police officers on the form and/or from the direction of movements of the involved drivers as noted on the crash report forms. The crash diagrams and narratives included on the crash report provided an accurate assessment of the type of crash that actually occurred, regardless of the crash type coded on the form, which helped minimize potential coding errors. For each test approach, crashes were collected within a 250-foot radius, and information was summarized for location details, crash details, and driver characteristics.

Data extracted from the crash report forms included the following:

- Date, time, and day of week of crash
- Weather conditions
- Road surface conditions
- Crash type
- Crash severity (K, A, B, C, PDO)
- Approach of intersection that the crash occurred at
- Primary contributory cause of crash

The traffic crash data were aggregated into the categories listed below for analyses at an intersection level and at an approach level:

- Total crashes
- Injury crashes
- Angle RLR crashes, and by severity (K, A, B, C, PDO)
- Angle other crashes
- Rear-end RLR crashes, and by severity (K, A, B, C, PDO)
- Rear-end other crashes
- Other RLR crashes
- All other crash types (such as single-vehicle, parked, sideswipe same, sideswipe opposite, head-on, left-turn opposing-through, etc.) not involving one or more vehicles running the red light

These categories were chosen to gain a comprehensive understanding of the safety effects of the RLR camera system. The targeted crash types for RLR camera systems were considered to be *rear-end* crashes and *angle* (right-angle) crashes. However, not all rear-end and right-angle crashes may have resulted due to red light running. Thus, the following crash categories were defined and used in the crash analysis as a part of this research:

- ***Angle RLR crashes***—a right-angle crash with initial vehicle directions coming from perpendicular approaches that are likely influenced by red light violators. These crashes take place inside the intersection, where one vehicle disregards the traffic control (i.e., red signal).
- ***Rear-end RLR crashes***—a rear-end crash that is likely influenced by the RLR cameras or caught in a dilemma zone, occurring at the intersection approaches. Any intersection-related rear-

end crash occurring as a result of the lead vehicle braking abruptly in anticipation of the yellow light changing to red, while the following vehicle is unable to stop.

- ***Other RLR crashes***—any other crash type, excluding rear-end or angle crashes, that is likely to have resulted due to one or more drivers running a red light. Examples include left-turn opposing through crashes, sideswipe crashes, etc.
- ***Angle other crashes***—a right-angle crash occurring outside the intersection influence area (i.e., driveway crash or far-side crash) or resulting due to inclement weather (unable to stop due to snow/ice), signal malfunction, police/EMS/funeral procession, or other unusual circumstance.
- ***Rear-end other crashes***—a rear-end crash occurring outside the intersection influence area, at driveway locations, at the far side of the intersection, in channelized right-turn lanes, or far in advance of the approach typically due to long queues and congestion. Crashes resulting due to backing, inclement weather (unable to stop due to snow/ice), signal malfunction, police/EMS/funeral procession, or other unusual circumstance.

Once the traffic crash data had been extensively analyzed and summarized, crash comparisons were made to determine whether the RLR camera system had statistically significant effects on reducing crashes.

A total of 6,859 traffic crashes occurred over a 6-year period at the 41 test intersections. Table 4.2 presents the overall crash frequencies for the before- and after-periods. It should be noted that some decimals resulted in the 3-year crash totals because at five of the study approaches, traffic crash data was not available for 1 to 1.5 months, and the data were normalized to represent annual crash frequencies. However, the 3-year crash frequencies were rounded to the nearest whole number in Table 4.2. Additionally, in Table 4.2, the annual average crash values represent the average of the normalized crash frequencies, and not just the 3-year crash frequencies divided by three. Details of the annual average before- and after-crash frequencies by crash type and severity can be found in Appendix A for the 41 test intersections and in Appendix B for the 60 RLR camera approaches.

Table 4.2 Aggregated Crash Frequencies Before and After Treatment at the Test Sites

	Intersection-Level (41 RLR camera intersections)				**Approach Level (60 RLR camera approaches)**			
	3-Year Crash Data Totals		**Average Annual Crashes per Year**		**3-Year Crash Data Totals**		**Average Annual Crashes per Year**	
Crash Type	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Total	4,192	2,667	1397.4	889.0	1,704	1,117	568.0	372.4
Injury (K, A, B, C)	750	614	250.1	204.5	315	261	104.8	87.0
Angle RLR	153	72	50.9	24.0	55	32	18.3	10.7
Rear-End RLR	367	354	122.2	118.0	176	163	58.7	54.3
Other RLR	94	44	31.5	14.7	48	19	16.0	6.3
RLR Crashes(all types)	614	470	204.6	156.7	279	214	93.0	71.3
Angle Other	373	242	124.2	80.6	106	82	35.3	27.4
Rear-End Other	1,912	1,126	637.2	375.3	795	487	265.1	162.5
All Other Crash Types	1,293	829	431.4	276.4	524	334	174.6	111.2

It should be noted that in 2009, IDOT changed its reporting methodology for certain crash types to include only crashes resulting in $1,500 or more in property damage (increased from $500). This may have an effect on the comparison of crashes reported.

Figure 4.1 provides a graphical display of the before- and after-installation crash comparisons (3-year crash totals) at an intersection level and at an approach level for total crashes, injury crashes, and RLR crashes of all types (including angle RLR, rear-end RLR and other RLR crashes).

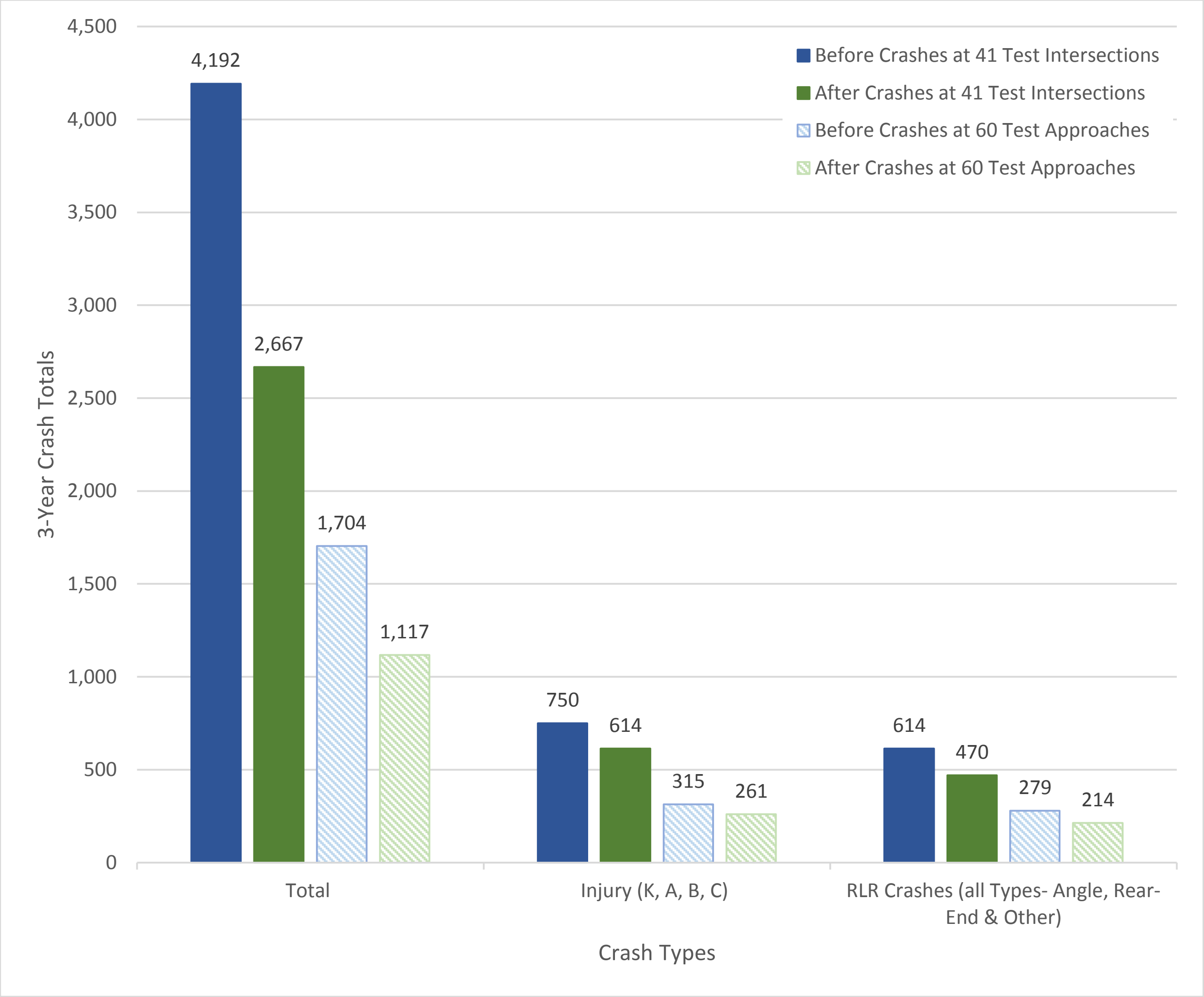

Figure 4.1 Comparison of before- and after-installation crashes at test intersections and approaches.

The trends in Figure 4.1 indicate that crashes were reduced after the RLR camera systems were installed. It should be noted that although the RLR cameras were not installed at all approaches of the test intersections, similar reductions in RLR crashes can be observed at the intersections compared to the approaches.

Figure 4.2 shows the trends in crashes over 6 years, the 3 year before installation period and the 3 year after installation period, at an intersection level and an approach level for total crashes, injury crashes and RLR crashes (all types – Angle, Rear-End and Other). Please note that crashes are not displayed for the 1 year "during" period, since not all of the crashes were thoroughly analyzed by type for this period.

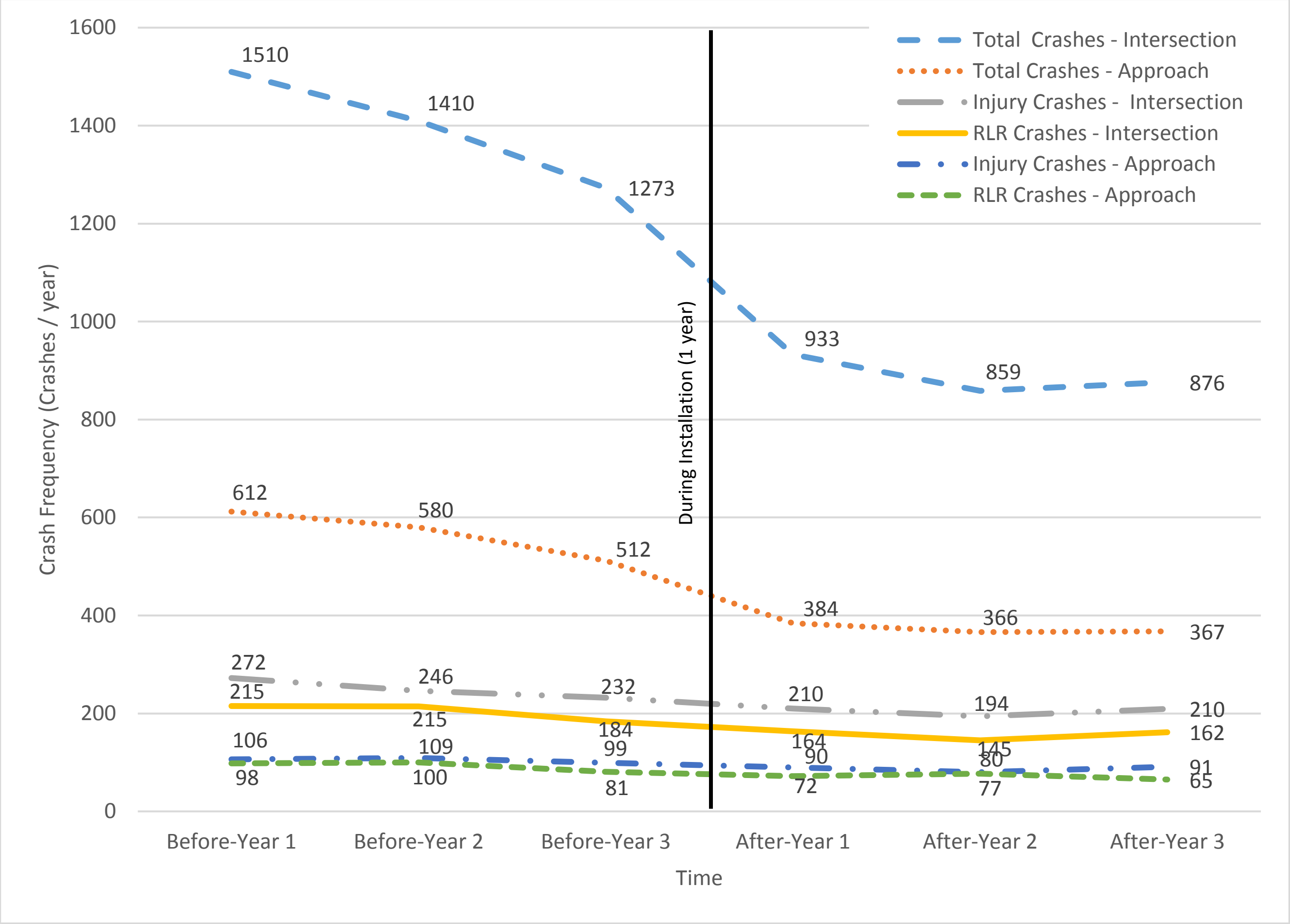

Figure 4.2 Trend analysis of crashes over six-year period at test intersections and approaches.

4.2 ANALYSIS AND RESULTS OF RLR CAMERA SYSTEM

Two methods were used to evaluate the crash experiences at the 41 RLR camera test intersections: the naïve before and after, and the empirical Bayes method. These two methods seek to determine the effectiveness, or percent reduction in crashes, that can be attributed to the countermeasure or treatment. In this research, the treatment is the installation of the RLR camera system. In both methods, the actual after-installation crash frequency is compared with an expected value. The expected value represents the crashes that would have occurred in the after-installation period had the RLR cameras not been installed at the test site. This expected value will never be known with 100% certainty because the conditions at the test site changed as a result of the treatment. The difference in the two evaluation methods lies in the determination of the expected value of crashes.

4.2.1 Naïve Before and After (B&A)

The naïve before and after method involves comparing the crash frequency of the before-installation period (without RLR camera system) to the crash frequency in the after-installation period (with RLR camera system). The before-installation crashes are considered to be the “expected” value, based on the assumption that the crashes would have remained the same over time had the treatment not been installed. The result of this comparison is a theoretical difference in crash frequency that can be attributed to the treatment (RLR camera system) if the finding is found to be statistically significant at 95% LOC. The naïve before and after analysis was performed for each of the crash categories analyzed as a part of this study at an intersection level and at an approach level.

The observed crash reductions were tested for statistical significance using the Poisson test of significance. Because traffic crash data are discrete and assumed to occur randomly, the Poisson test was used to test the significance of changes in crash frequencies. A one-tailed test was used at a 95% LOC and significance level (α) of 0.05 because it was hypothesized that traffic crash frequencies would be reduced as a result of the installation of the RLR cameras. The null (H_o) and alternative (H_a) hypotheses used in the statistical analysis of the average/mean (μ) crash frequencies are as follows:

$$H_o\text{: } \mu_{\textit{after crashes}} = \mu_{\textit{before crashes}}$$

$$H_a\text{: } \mu_{\textit{after crashes}} < \mu_{\textit{before crashes}}$$

The aggregated before and after results for the 41 test intersections and 60 RLR camera approaches are shown in Table 4.3 by crash type. The approach-level analysis provides a direct measure of the crash reductions due to the installation of the RLR cameras. The intersection-level analysis provides additional insights into their effectiveness because not all approaches of the intersection were equipped with RLR cameras. The observed percent reductions in crash frequency were tested for statistical significance using the Poisson test at 95% LOC, and the p-values were also obtained. For a one-tailed test, if the p-value is less than 0.05, then the null hypothesis is rejected and the finding is significant.

Table 4.3 RLR Camera Safety Evaluation Results—Naïve Before and After Method

	Intersection Level (41 Test Intersections)				**Approach Level (60 RLR Camera Approaches)**			
Crash Type	**Avg. Annual Before-Crashes**	**Avg. Annual After-Crashes**	**% Reduction**	**Significant?* (p-value)**	**Avg. Annual Before-Crashes**	**Avg. Annual After-Crashes**	**% Reduction**	**Significant?* (p-value)**
Total	1397.4	889	**36%**	Yes (< 0.01)	568.0	372.4	**34%**	Yes (< 0.01)
Injury (K, A, B, C)	250.1	204.5	**18%**	Yes (0.01)	104.8	87.0	**17%**	Yes (0.05)
Angle RLR	50.9	24	**53%**	Yes (< 0.01)	18.3	10.7	**42%**	Yes (0.04)
Rear-End RLR	122.2	118	3%	No (> 0.20)	58.7	54.3	7%	No (> 0.20)
Other RLR	31.5	14.7	**53%**	Yes (< 0.01)	16.0	6.3	**61%**	Yes (0.01)
RLR Crashes (All Types)	204.6	156.7	**23%**	Yes (< 0.01)	93.0	71.3	**23%**	Yes (0.02)
Angle Other	124.2	80.6	**35%**	Yes (< 0.01)	35.3	27.4	**22%**	No (0.10)
Rear-End Other	637.2	375.3	**41%**	Yes (< 0.01)	265.1	162.5	**39%**	Yes (< 0.01)
All Other Crash Types	431.4	276.4	**36%**	Yes (< 0.01)	174.6	111.2	**36%**	Yes (0.02)

* Based on Poisson test of crash frequencies at a 95% LOC and significance level α = 0.05

When comparing the naïve before and after crash frequencies of the crash types studied, it was found that total crashes were reduced by 34% to 36%, while injury crashes were reduced by 17% to 18%. Angle RLR crashes were reduced by 42% to 53%, and other RLR crashes were reduced by 53% to 61%. Each of these crash reductions are statistically significant at 95% LOC. In terms of rear-end RLR crashes, statistically significant changes in crashes were not found. Combining all three of the RLR crash types (angle RLR, rear-end RLR, and other RLR) yields a statistically significant reduction of 23%. Significant reductions in non-RLR angle, non-RLR rear-end crashes, and all other non-RLR crash types can also be observed, which indicates that factors other than the RLR camera system may have influenced the crash reductions at the test intersections.

It should be noted that in 2009, IDOT changed its reporting methodology for certain crash types to include only crashes resulting in $1,500 or more in property damage (increased from $500). This may have an effect on the comparison of crashes reported, and the general crash trends over time.

In order to further investigate the potential impact of the crash reporting change in 2009 on the crash trends at the study intersections, additional comparisons were made for two subsets of the test intersections: (1) intersections that would be *most influenced* by the crash reporting change, and (2) intersections that would be *least impacted* by the crash reporting change. The crash trends at intersections that would potentially be the *most influenced* by the crash reporting change had RLR camera installation dates in 2008. This results in before-installation periods containing the years

2007, 2006, and 2005, (all pre-crash reporting change years), and an after-installation period of the years 2009, 2010 and 2011 (all post-crash reporting change years). The crash trends at intersections that would be impacted the least by the crash reporting change in had RLR camera installation dates in late 2010 or 2011. This would result in before-installation periods containing the years 2010, 2009 and 2008 (≈ 2 post-crash reporting change years), and after-installation periods containing the years 2012, 2013 and 2014 (all post-crash reporting change years). In the sample of 41 test intersections, 13 intersections had RLR camera installation dates in 2008 and comprised the *most influenced group*, while at six test intersections the installation dates were in late 2010 or 2011 and comprised the *least impacted* group. Comparisons of the before- and after-installation period percent reduction in intersection crashes by type for the *most influenced* and *least impacted* groups are show in Table 4.4.

Table 4.4 Comparison of Before and After Percent Reductions in Crashes for Intersections *Most Influenced* and *Least Impacted* by the Crash Reporting Change in 2009

	Before and After % Reduction in Crashes for 2 Subsets of Test Intersections	
Crash Type	**13 *Most Influenced* Intersections (RLR Camera Installation Dates in 2008)**	**6 *Least Impacted* Intersections (RLR Camera Installation Dates in late 2010 or 2011)**
Total	41.9%	17.5%
Injury (K, A, B, C)	28.7%	–1.2%[a]
Angle RLR	69.4%	61.6%
Rear-End RLR	-7.4%[a]	–34.2%[a]
Other RLR	63.9%	78.6%
Angle Other	37.2%	3.6%
Rear-End Other	47.0%	21.8%

[a] Negative decrease (- value) denotes an increase in crashes

Although the percent reductions in Table 4.4 vary for many of the crash types, there are consistencies in the percent reduction for RLR angle crashes (69.4% and 61.6%) regardless of the installation date and impact of the statewide crash reporting change in 2009.

As a part of this research study, the BU research team was charged with the task of developing a one-page white paper based on the findings of the before and after method. The white paper on the safety evaluation of red light running cameras in Illinois is included in Appendix C.

4.2.2 Empirical Bayes

The random nature of crashes makes it impossible to truly predict the expected number of crashes in an after-installation period had the improvements not been made. The empirical Bayes method is commonly accepted as a more precise estimation of the expected crashes than any other method because of its ability to account for regression-to-the-mean bias. This method takes into account both the crash experience of the test sites and a crash prediction model, called a safety performance function (SPF), derived from the crash experiences at numerous comparison sites. The SPF-predicted crashes are then weighted against the observed crashes at the test site to more accurately predict the expected crashes. In this research, the procedure for the empirical Bayes method, as documented in the *Highway Safety Manual* (AASHTO 2010), was used to conduct the analysis.

In the empirical Bayes method conducted in this research, SPF models available in the literature (Zarei and Izadpanah 2014) were used to predict crashes on an intersection basis. The empirical Bayes method was conducted for the crash types that experienced statistically significant crash reductions per the naïve before and after method, and had SPFs available in the literature for predicting crashes. As a result, the empirical Bayes method was conducted for total crashes and angle RLR crashes on an intersection basis. The SPFs developed by Zarei and Izadpanah, as used in this research, are shown in Equations 4.1 and 4.2:

$$\mu_{\text{Total}} = 1.736 \times 10^{-4} (AADT_{Total})^{1.0774}, \; k = 0.2503 \tag{4.1}$$

$$\mu_{AngleRLR} = 8.5563 \times 10^{-2} (AADT_{Total})^{0.3182}, \; k = 0.6608 \tag{4.2}$$

where

μ_{Total} = Average annual expected total intersection crashes
μ_{AngleRLR} = Average annual expected intersection-angle RLR crashes
$AADT_{TOTAL}$ = Total intersection average annual daily traffic (AADT), in vehicles per day

To predict crashes in the before- and after-installation periods, intersection AADTs were required. The AADTs obtained from IDOT's traffic count website for the before- and after-installation periods for each approach of each test intersection are provided in Appendix D.

Using the predicted crashes per year from the SPFs, the overdispersion factor, and the weight factor, the expected number of after crashes without treatment can be predicted using the empirical Bayes method, according to the specific steps listed below, per the *Highway Safety Manual* (AASHTO 2010).

Step 1—Calculate the predicted average crash frequency, $N_{predicted,\,B}$ for each site *i* using a SPF

Step 2—Calculate $N_{expected,\,B}$

$$N_{expected;\,B} = w_{i,B} N_{predicted,B} + (1 - w_{i,B}) N_{observed,B}$$

where the weight, $w_{i,B}$, for each site *i*, is determined as

$$w_{i,B} = \frac{1}{1 + k \times N_{predicted,B}}$$

and

$N_{expected}$ = Expected average crash frequency at site *i*

$N_{observed}$ = Observed crash frequency at site *i*

$N_{predicted}$ = Predicted crash frequency at site *i* from a safety performance function

k = Overdispersion parameter for the applicable SPF

A, B = After period and before period, respectively

Step 3—Calculate the predicted average crash frequency, $N_{predicted, A}$ for each site *i* using a SPF

Step 4—Calculate r_i, an adjustment factor to account for differences between before- and after-installation periods in duration and traffic volume at each site *i*

$$r_i = \frac{\sum N_{predicted,A}}{\sum N_{predicted,B}}$$

Step 5—Calculate $N_{expected,A}$, the expected average crash frequency for each site *i* in the after-installation period without treatment

$$N_{expected,A} = N_{expected,B} \times r_i$$

Step 6—Calculate the crash modification factor (CMF), θ′, for all sites combined

$$\theta' = \frac{\sum_{All\ sites} N_{observed,A}}{\sum_{All\ sites} N_{expected,A}}$$

Step 7—Calculate the unbiased estimate of the CMF, θ

$$\theta = \frac{\theta'}{1 + \frac{Var\left(\sum_{All\ sites} N_{expected,A}\right)}{\left(\sum_{All\ sites} N_{expected,A}\right)^2}}$$

where

$$Var\left(\sum_{All\ sites} N_{expected,A}\right) = \sum_{All\ sites} \left[(r_i)^2 \times N_{expected,B} \times \left(1 - w_{i,B}\right)\right]$$

Step 8—Calculate the unbiased safety effectiveness, or unbiased percent reduction, for all sites combined

$$Safety\ Effectiveness = Percent\ Reduction = 100 \times (1 - \theta)$$

Step 9—Calculate the variance of the unbiased crash modification factor, Var(θ)

$$Var(\theta) = \frac{(\theta')^2 \left[\frac{1}{\sum_{All\ sites} N_{observed,A}} + \frac{Var\left(\sum_{All\ sites} N_{expected,A}\right)}{\left(\sum_{All\ sites} N_{expected,A}\right)^2}\right]}{\left[1 + \frac{Var\left(\sum_{All\ sites} N_{expected,A}\right)}{\left(\sum_{All\ sites} N_{expected,A}\right)^2}\right]}$$

Step 10—Calculate the standard error of the unbiased crash modification factor, SE(θ), as the square root of its variance

$$SE(\theta) = \sqrt{Var(\theta)}$$

Step 11—Assess the statistical significance of the estimated safety effectiveness by making comparisons with the following measure and criteria:

If $\left|\frac{Safety\ \ Effectiven\,ess}{SE(Safety\ \ Effectiven\,ess)}\right|$ > 2.0, conclude that the treatment effect is significant at the (approximate) 95% confidence level.
where SE(Safety Effectiveness) = 100 x SE(θ)

The effectiveness evaluation results and the crash reduction factors (CRFs) based on the empirical Bayes methods are shown in Table 4.5. The observed crash reductions were tested for statistical significance using the Poisson test and according to Step 11 above at 95% LOC. Because traffic crash data are discrete and assumed to occur randomly, the Poisson test was used to test the significance of changes in crash frequencies. A one-tailed test was used at a 95% LOC and significance level (α) of 0.05 because it was hypothesized that traffic crash frequencies would be reduced as a result of the implementation of the RLR cameras. The null (H_o) and alternative (H_a) hypotheses used in the statistical analysis of the average/mean (μ) crash frequencies are as follows:

H_o: $\mu_{\text{after crashes}} = \mu_{\text{before crashes}}$

H_a: $\mu_{\text{after crashes}} < \mu_{\text{before crashes}}$

The Poisson charts of significance were used to determine the significance and corresponding p-values. For a one-tailed test, if the p-value is less than 0.05, then the null hypothesis is rejected and the finding is significant.

Table 4.5 Empirical Bayes Evaluation of Test Intersections

Intersection-Level (41 Test Intersections)	Aggregated Annual Average Crash Frequency: Before-Installation Period: Observed	Before-Installation Period: Predicted	Before-Installation Period: Expected	After-Installation Period: Observed	After-Installation Period: Predicted	After-Installation Period: Expected	Unbiased Safety Effectiveness*/ Crash Reduction Factor	Significant?** (p-value)
Total Crashes	1397.4	717.2	1279.2	889.0	751.3	1354.7	34.4%	Yes (<0.01)
Angle RLR	50.9	104.1	70.9	24.0	105.5	71.9	66.9%	Yes (<0.01)

*Unbiased safety effectiveness = Unbiased percent reduction = Crash reduction factor.

**Based on Poisson test of crash frequencies at 95% LOC and significance level α = 0.05.

As shown in Table 4.5, the empirical Bayes method predicted significant reductions in total crashes and angle RLR crashes on an intersection basis. Significant reductions in intersection angle RLR crashes of 66.9% were observed, as well as a significant reduction in total intersections crashes of 34.4%. The RLR camera system implemented in the Chicago suburbs provides significant safety improvements at intersections where installed.

4.2.3 Crash Modification Factors

The expected countermeasure effectiveness is commonly expressed as a crash modification factor (CMF). A CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The crash reduction factors (CRFs) presented in Table 4.5, as the unbiased safety effectiveness, provide the percentage crash reduction that might be expected after implementing RLR camera systems at locations similar to the ones studied as a part of this research.

Using the procedures outlined in the *Highway Safety Manual* (AASHTO 2010), CMFs were determined, per the empirical Bayes results by crash type. The procedure and equations used to calculate the unbiased index of effectiveness (θ)—which is the CMF—as well as the variance and standard error, were presented in Section 4.2.2. The confidence interval on the CMF was also calculated. The 95% confidence interval is $\theta \pm Z_{\alpha/2} \times$ standard error, where $Z_{\alpha/2}$ is the two-tailed Z-statistic = 1.96. Table 4.6 provides the unbiased safety effectiveness (percent reduction), the unbiased CMFs, and the variance and standard error of the CMFs.

Table 4.6 Crash Modification Factors for RLR Cameras (Empirical Bayes Method)

Intersection-Level (41 Test Intersections)	Unbiased Safety Effectiveness	CMF (θ)	Variance of θ	Standard Error (SE) of θ	Standard Error of Safety Effectiveness	Ratio of Safety Effectiveness/ SE of (Safety Effectiveness)* and Significance?
Total Crashes	34.4%	0.656	0.0008	0.0276	2.76	23.7, Significant
Angle RLR	66.9%	0.331	0.0056	0.0748	7.64	4.4, Significant

* If ratio > 2.0, conclude that the treatment effect is significant at the (approximate) 95% confidence level, according to Step 11.

In summary, the resulting crash modification factors along with their confidence intervals for the RLR camera system are as follows:

- Total Intersection Crash CMF = 0.656
    - 95% Confidence Interval = $0.656 \pm 1.96 \times 0.0276 = 0.602$ to 0.710
- Angle RLR Intersection Crash CMF = 0.331
    - 95% Confidence Interval = $0.331 \pm 1.96 \times 0.0748 = 0.185$ to 0.478

These CMFs can be used to estimate the expected safety benefits of installing RLR camera systems, as a part of benefit/cost analyses.

CHAPTER 5: SUMMARY AND CONCLUSIONS

As a part of this research, the safety performance of RLR camera systems was evaluated for a sample of intersection approaches located on state routes under IDOT's jurisdiction in the Chicago suburbs in Cook, DuPage, Kane, and Lake counties. Comprehensive traffic crash analyses based on 3 years of before-installation crash data and 3 years of after-installation crash data were conducted in order to evaluate the safety effects of the RLR cameras. A total of 60 approaches located at 41 test intersections were included in the evaluation, focusing on the targeted crash types of angle RLR and rear-end RLR. Comparisons of other crash types were made as well on an intersection level and a RLR camera approach level. Two methods were used to evaluate the crash experience at the RLR camera locations: the naïve before and after, and the empirical Bayes. The observed crash reductions were tested for statistical significance using the Poisson test at a 95% level of confidence. Using the empirical Bayes method for those crash types where SPFs were available, crash modification factors were developed for statistically significant crash reductions based on the unbiased index of effectiveness metric.

The results of the naïve before and after and the empirical Bayes method, respectively, indicated:

- Total intersection crashes significantly reduced by 36% to 34%, respectively
- Angle RLR intersection crashes significantly reduced by 53% to 67%, respectively

Other findings of the installation of the RLR camera system based on the naïve before and after are as follows:

- Intersection injury crashes (K, A, B, C) significantly reduced by 18%
- Rear-end RLR crashes experience a non-significant change

Additionally, in 2009, IDOT changed its reporting methodology for certain crash types to include only crashes resulting in \$1,500 or more in property damage (increased from \$500). This may have an effect on the comparison of crashes reported, and the general crash trends over time for some of the crash types.

It should be noted that the necessary SPFs required for the empirical Bayes method were not available for all of the crash types, and thus some crash types could be analyzed using only the naïve before and after method.

Using the procedures outlined in the *Highway Safety Manual* (AASHTO 2010), crash modification factors (CMFs) were developed for total intersection crashes and angle RLR intersection crashes based on the empirical Bayes results. The resulting CMFs, along with their confidence intervals (CI), are as follows:

- **Total Intersection Crash CMF = 0.656** with 95% CI = 0.602 to 0.710
- **Angle RLR Intersection Crash CMF = 0.331** with 95% CI = 0.185 to 0.478

Overall, the safety evaluation provides evidence that the installation of RLR camera systems on state routes reduce angle RLR crashes, which are associated with severe injury; have a nominal impact on rear-end RLR crashes; and have a positive impact on reducing total intersection crashes, as studied on state routes in the Chicago suburbs.

It is recommended that IDOT continue to support the installation of RLR cameras at locations where justified, thereby improving intersection safety for Illinois motorists.

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APPENDIX A: AVERAGE ANNUAL BEFORE AND AFTER CRASH FREQUENCIES AT THE 41 TEST INTERSECTIONS BY TYPE AND SEVERITY

		Intersection No. & Name						
		1	2	3	4	5	6	7
Average Annual Crash Frequency by Type and Severity		IL-64/North & Kuhn	IL-64/North & Gary	Crawford/Pulaski & 175th	IL-50/Cicero & 183rd	IL-72/ Higgins & Landmeier	IL-72/ Oakton & Busse	IL-72/ Higgins & Arlington Hts Rd
Total Crashes	Before	9.0	33.0	14.7	14.0	20.0	68.7	33.3
	After	8.3	22.0	11.3	8.7	15.3	41.0	21.3
Injury Crashes	Before	2.7	5.7	3.7	5.0	3.3	14.0	4.7
	After	1.7	4.3	5.0	3.3	3.7	11.3	2.7
Angle RLR	Before	1.0	1.3	0.3	1.0	2.0	5.0	1.3
	After	0.3	0.7	1.3	1.0	2.0	2.7	0.3
Rear-end RLR	Before	1.7	7.3	1.3	1.0	0.7	2.7	2.0
	After	2.7	7.7	2.7	1.7	2.0	8.0	1.3
Other RLR	Before	0.0	1.3	1.0	1.0	0.3	1.7	0.0
	After	0.0	1.3	0.0	0.0	0.0	1.7	0.7
Angle Other	Before	0.0	1.0	0.7	0.7	0.7	0.3	3.7
	After	0.0	0.0	0.0	0.0	0.7	0.7	1.0
Rear-End Other	Before	4.3	13.7	3.7	2.0	10.3	26.0	15.3
	After	2.3	6.3	2.0	3.0	6.7	14.7	9.7
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Angle RLR Injury A	Before	0.3	0.0	0.0	0.0	0.3	0.7	0.0
	After	0.0	0.0	0.0	0.3	0.3	0.7	0.0
Angle RLR Injury B	Before	0.0	1.3	0.0	0.0	0.7	1.0	0.0
	After	0.0	0.3	0.3	0.3	0.3	1.0	0.0
Angle RLR Injury C	Before	0.7	0.0	0.0	0.7	0.0	1.0	0.3
	After	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.0	0.3	0.3	1.0	2.3	1.0
	After	0.3	0.3	0.7	0.0	1.3	1.0	0.3
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Rear-End RLR Injury B	Before	0.0	0.3	0.0	0.3	0.0	0.3	0.0
	After	0.3	0.7	0.3	0.0	0.3	0.7	0.0
Rear-End RLR Injury C	Before	0.0	0.7	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.7	0.0	0.3	0.3	0.7	0.3
Rear-End RLR PDO	Before	1.7	6.3	1.0	0.3	0.7	2.3	2.0
	After	2.3	6.3	2.3	1.3	1.3	6.3	1.0
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.3	0.0	0.0	0.7	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	1.3	0.7	0.7	0.3	0.7	0.0
	After	0.0	1.3	0.0	0.0	0.0	1.0	0.7

		Intersection No. & Name						
		8	9	10	11	12	13	14
Average Annual Crash Frequency by Type and Severity		Rohlwing & Nerge	IL-53/ Biesterfield & IL-53/ Rohlwing	IL-21 & IL-132	IL-132 & Hunt Club Rd	US-41 & Delany Rd	22nd St/Cermak & Wolf	IL-38/ Roosevelt & Hamilton/ Harrison
Total Crashes	Before	11.3	20.0	30.7	72.7	31.0	29.3	6.0
	After	8.0	9.0	28.0	41.7	31.0	22.8	7.4
Injury Crashes	Before	3.0	1.0	6.3	12.3	6.3	8.0	1.0
	After	2.7	2.3	7.7	8.3	8.7	6.3	2.6
Angle RLR	Before	0.3	0.7	0.3	1.0	1.0	1.0	0.0
	After	0.0	0.3	0.7	1.3	0.7	0.0	0.4
Rear-end RLR	Before	0.3	1.7	4.7	4.3	1.0	1.3	0.3
	After	0.0	2.0	5.3	5.0	1.3	0.3	0.7
Other RLR	Before	0.3	0.3	0.7	1.3	0.7	0.3	0.0
	After	0.0	0.0	0.3	1.3	0.0	0.3	0.0
Angle Other	Before	1.0	1.3	4.7	0.0	3.0	12.3	0.3
	After	0.0	0.7	4.0	0.3	2.0	9.3	1.4
Rear-End Other	Before	5.0	11.0	10.0	51.3	11.0	7.7	2.3
	After	4.0	4.7	8.7	21.7	11.3	6.4	1.7
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.7	0.0	0.0	0.0
Angle RLR Injury C	Before	0.3	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Angle RLR PDO	Before	0.0	0.7	0.0	0.7	1.0	1.0	0.0
	After	0.0	0.3	0.3	0.7	0.3	0.0	0.4
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.0	0.3	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.7	0.7	0.0	0.0	0.0
	After	0.0	0.3	1.0	0.7	0.0	0.0	0.0
Rear-End RLR PDO	Before	0.3	1.7	4.0	3.3	1.0	1.0	0.3
	After	0.0	1.7	4.3	4.0	1.0	0.3	0.7
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.3	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.3	0.7	1.3	0.7	0.0	0.0
	After	0.0	0.0	0.0	1.0	0.0	0.0	0.0

		Intersection No. & Name						
		15	16	17	18	19	20	21
Average Annual Crash Frequency by Type and Severity		IL-38/ Roosevelt & Wolf	US-45 & Peterson	Il-137 & Butterfield	IL-137 & IL-43	US-34 & Yackley	IL-53 & Maple	US-6/ 159th & Kedzie
Total Crashes	Before	22.0	17.7	26.7	32.0	31.3	62.0	42.7
	After	21.7	12.3	14.0	19.0	18.7	34.7	17.7
Injury Crashes	Before	6.0	3.7	4.7	8.3	6.0	10.7	8.0
	After	3.0	2.0	3.0	2.3	4.3	6.7	7.0
Angle RLR	Before	2.7	0.7	1.3	2.3	1.7	2.0	2.0
	After	0.0	0.0	0.0	1.3	0.7	0.0	1.0
Rear-end RLR	Before	3.3	3.3	6.0	1.0	0.0	1.3	1.7
	After	4.2	0.7	2.0	1.7	0.3	0.7	0.3
Other RLR	Before	1.0	0.7	0.0	0.3	1.7	1.7	1.3
	After	0.4	0.7	0.3	0.7	0.0	0.3	0.0
Angle Other	Before	1.3	0.0	1.0	0.0	8.0	16.0	3.3
	After	4.2	0.0	1.7	0.0	6.0	9.0	1.3
Rear-End Other	Before	6.7	5.7	12.0	17.0	12.3	26.7	19.0
	After	8.0	5.3	7.3	11.7	5.3	15.3	8.7
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Angle RLR Injury B	Before	0.3	0.3	0.7	1.3	0.0	0.3	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Angle RLR Injury C	Before	0.3	0.0	0.3	0.3	0.0	0.3	0.7
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.3
Angle RLR PDO	Before	2.0	0.3	0.3	0.7	1.7	1.3	1.0
	After	0.0	0.0	0.0	1.0	0.7	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.3	0.3	0.0	0.0	0.0	0.0	0.3
	After	0.3	0.0	0.7	0.3	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.7	0.3	1.3	0.0	0.0	0.0	0.0
	After	0.4	0.0	0.3	0.3	0.3	0.3	0.0
Rear-End RLR PDO	Before	2.3	2.7	4.7	1.0	0.0	1.3	1.3
	After	3.5	0.7	1.0	1.0	0.0	0.3	0.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.3	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	1.0	0.3	0.0	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.3	0.0	0.3	1.0	1.3	1.0
	After	0.4	0.7	0.3	0.7	0.0	0.3	0.0

		Intersection No. & Name						
		22	23	24	25	26	27	28
Average Annual Crash Frequency by Type and Severity		IL-64/ North & 5th	IL-64/ North & 25th	IL-50/ Cicero & 167th	US-6/ 159th & IL-50/ Cicero	US-12/ Rand & IL-53/Hicks	US-12/IL-53/Rand & IL-53/IL-68/Dundee	US-14 & Palatine
Total Crashes	Before	66.4	46.7	41.0	52.3	41.0	80.3	33.3
	After	41.0	36.0	29.3	32.3	19.3	43.7	17.3
Injury Crashes	Before	8.9	6.7	10.0	9.0	9.3	11.3	6.7
	After	7.0	9.0	4.3	10.7	2.3	6.3	3.0
Angle RLR	Before	1.7	1.0	1.7	2.0	1.7	0.7	2.0
	After	1.0	0.3	0.3	0.3	0.0	1.0	0.7
Rear-end RLR	Before	1.7	1.0	1.7	3.0	1.3	5.3	0.0
	After	1.0	2.3	3.3	4.7	2.0	4.7	0.3
Other RLR	Before	2.5	0.7	1.0	0.3	1.0	0.0	1.0
	After	1.0	0.0	0.3	1.0	0.0	0.3	0.0
Angle Other	Before	7.4	4.0	3.7	0.7	5.7	9.0	6.3
	After	4.3	4.0	2.0	1.3	2.7	2.7	5.0
Rear-End Other	Before	28.6	21.3	16.7	28.3	19.7	47.7	13.3
	After	20.3	14.3	9.7	15.3	8.7	21.7	6.3
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.3	0.3	0.3	0.3	0.7	0.0	0.0
	After	0.3	0.0	0.3	0.3	0.0	0.0	0.0
Angle RLR Injury C	Before	0.3	0.0	0.3	0.0	0.3	0.3	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	1.0	0.7	0.7	1.7	0.7	0.3	2.0
	After	0.7	0.0	0.0	0.0	0.0	1.0	0.7
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	1.0	0.0	0.3	0.0
Rear-End RLR Injury C	Before	0.3	0.0	0.3	0.0	0.0	0.3	0.0
	After	0.3	1.0	0.3	0.3	0.0	0.7	0.0
Rear-End RLR PDO	Before	1.4	1.0	1.3	3.0	1.3	5.0	0.0
	After	0.7	1.3	3.0	3.3	2.0	3.7	0.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Other RLR Injury B	Before	0.3	0.3	0.7	0.3	0.0	0.0	0.3
	After	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.4	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	2.6	0.3	0.0	0.0	1.0	0.0	0.3
	After	0.7	0.0	0.3	0.3	0.0	0.3	0.0

		Intersection No. & Name						
		29	30	31	32	33	34	35
Average Annual Crash Frequency by Type and Severity		Hicks & Euclid	IL-53 East Ramp & IL-62/Algonquin	US-6/159th & Woodlawn East	US-6/159th& State/ Indiana	IL-43/Harlem & 171st	IL-43/ Harlem & 183rd	IL-176 & Old Rand/Main
Total Crashes	Before	24.0	33.3	22.3	21.0	38.7	58.3	8.0
	After	17.3	10.8	16.3	14.3	27.7	35.3	7.3
Injury Crashes	Before	5.3	4.2	4.3	3.0	5.3	9.3	1.0
	After	3.7	1.8	3.7	3.3	6.0	8.7	2.0
Angle RLR	Before	0.0	1.2	1.7	0.3	1.3	1.3	0.7
	After	0.7	0.3	0.3	0.7	2.3	0.7	0.0
Rear-end RLR	Before	0.7	7.8	0.7	0.3	4.0	11.3	1.7
	After	0.7	1.7	2.3	1.3	3.3	10.7	3.0
Other RLR	Before	1.3	1.7	0.3	0.3	0.0	0.7	0.7
	After	0.3	0.3	0.0	0.0	0.7	0.0	0.3
Angle Other	Before	3.3	0.5	2.0	3.0	5.0	3.0	0.3
	After	2.7	0.0	1.3	2.7	2.3	2.0	0.0
Rear-End Other	Before	14.3	17.0	7.3	5.0	14.3	30.3	3.3
	After	7.0	6.5	3.7	4.0	10.7	15.7	3.3
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.3	0.0	0.0	0.0	0.7	0.0
	After	0.0	0.0	0.3	0.0	0.3	0.7	0.0
Angle RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.3	0.3	0.0	0.0
Angle RLR Injury C	Before	0.0	0.2	0.3	0.0	0.0	0.0	0.0
	After	0.3	0.3	0.0	0.0	0.7	0.0	0.0
Angle RLR PDO	Before	0.0	0.7	1.3	0.3	1.3	0.7	0.3
	After	0.3	0.0	0.0	0.3	1.0	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.3	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.7	0.0
Rear-End RLR Injury B	Before	0.0	0.3	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.3	0.3	0.0	0.0	0.3	0.0
Rear-End RLR Injury C	Before	0.0	1.0	0.0	0.3	0.3	1.0	0.0
	After	0.3	0.0	0.0	0.0	1.0	1.3	1.3
Rear-End RLR PDO	Before	0.7	6.2	0.3	0.0	3.7	10.0	1.7
	After	0.3	1.3	2.0	1.0	2.3	8.3	1.7
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.7	0.3	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.7	1.3	0.3	0.3	0.0	0.3	0.7
	After	0.3	0.3	0.0	0.0	0.7	0.0	0.3

		Intersection No. & Name					
		36	37	38	39	40	41
Average Annual Crash Frequency by Type and Severity		IL-176 & US-12/IL-59/West/Liberty	IL-59 & IL-64	RT-31 & Boncosky	RT-31 & RT-72	IL-83 & 63rd	IL-83 & 75th
Total Crashes	Before	8.7	73.3	9.0	41.3	33.0	37.3
	After	5.0	38.7	6.0	22.3	24.3	30.7
Injury Crashes	Before	1.7	10.3	2.0	6.0	7.0	4.3
	After	1.3	5.3	2.7	8.0	9.7	6.7
Angle RLR	Before	0.3	1.3	0.0	1.7	1.0	0.3
	After	0.0	0.0	0.0	0.3	0.3	0.0
Rear-end RLR	Before	4.3	16.0	2.0	4.0	7.0	1.3
	After	0.7	10.0	1.3	2.7	7.0	4.3
Other RLR	Before	0.0	1.7	0.0	0.3	1.0	1.3
	After	0.0	0.7	0.0	0.0	0.0	1.7
Angle Other	Before	1.0	3.0	0.0	6.3	0.0	0.7
	After	0.3	1.0	0.0	3.3	0.3	0.3
Rear-End Other	Before	2.7	34.3	2.0	11.0	18.3	28.7
	After	3.3	18.3	2.0	7.0	12.3	20.3
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.3	0.0	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.0	1.0	0.0	0.3	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.3	0.0	0.7	0.3	0.3
	After	0.0	0.0	0.0	0.3	0.3	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.3	0.3	0.0
	After	0.0	0.3	0.7	0.0	0.3	0.0
Rear-End RLR Injury B	Before	0.3	0.3	0.3	0.0	0.7	0.0
	After	0.0	1.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	1.7	0.3	0.3	1.3	0.0
	After	0.0	0.0	0.3	1.3	2.3	0.0
Rear-End RLR PDO	Before	4.0	14.0	1.3	3.3	4.7	1.3
	After	0.7	8.7	0.3	1.3	4.3	4.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.3	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	1.0	0.0	0.3	0.3	1.3
	After	0.0	0.3	0.0	0.0	0.0	1.7

APPENDIX B: AVERAGE ANNUAL BEFORE AND AFTER CRASH FREQUENCIES AT THE 60 RLR CAMERA APPROACHES BY TYPE AND SEVERITY

		RLR Camera Approach No. & Name						
		1	2	3	4	5	6	7
Average Annual Crash Frequency by Type and Severity		EB IL-64/North @ Kuhn	EB IL-64/North @ Gary	WB IL-64/North @ Gary	SB Crawford/ Pulaski @ 175th	NB Crawford/ Pulaski @ 175th	SB IL-50/Cicero & 183rd	EB Landmeier @ IL-72/ Higgins
Total Crashes	Before	2.0	6.3	10.3	4.7	4.7	3.3	9.7
	After	2.7	4.7	7.3	4.7	2.7	3.0	5.7
Injury Crashes	Before	0.3	0.7	2.7	1.7	1.0	1.7	0.7
	After	0.0	1.7	1.3	2.0	1.3	1.7	1.0
Angle RLR	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.3
	After	0.0	0.0	0.3	0.7	0.0	0.0	0.7
Rear-end RLR	Before	0.3	1.0	4.0	0.3	0.7	0.0	0.0
	After	1.0	1.7	2.3	0.3	1.0	0.3	0.7
Other RLR	Before	0.0	0.3	0.3	0.0	0.7	0.0	0.0
	After	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Angle Other	Before	0.0	0.7	0.0	0.0	0.3	0.3	0.7
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End Other	Before	1.0	3.0	3.3	1.7	1.0	0.0	8.0
	After	0.7	3.7	2.3	1.3	0.3	1.0	3.0
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.3
	After	0.0	0.0	0.3	0.3	0.0	0.0	0.7
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.3	0.0	0.3	0.0	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rear-End RLR PDO	Before	0.3	1.0	3.3	0.3	0.3	0.0	0.0
	After	1.0	1.3	2.3	0.3	1.0	0.3	0.7
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.3	0.3	0.0	0.7	0.0	0.0
	After	0.0	0.3	0.3	0.0	0.0	0.0	0.0

		RLR Camera Approach No. & Name						
		8	9	10	11	12	13	14
Average Annual Crash Frequency by Type and Severity		SB Busse @ IL-72/ Oakton	WB IL-72/ Oakton @ Busse	WB IL-72/ Higgins @ Arlington Hts Rd	WB Nerge @ Rohlwing	EB Nerge @ Rohlwing	NB IL-53/ Biesterfield @ IL-53/ Rohlwing	EB IL-132 @ IL-21
Total Crashes	Before	11.3	22.3	4.3	3.0	4.7	4.0	13.0
	After	5.3	14.0	4.0	0.7	3.7	2.7	9.7
Injury Crashes	Before	3.0	4.0	1.3	0.0	1.0	0.0	2.0
	After	2.3	3.7	0.7	0.0	1.3	0.7	2.0
Angle RLR	Before	1.0	1.7	0.3	0.0	0.3	0.0	0.0
	After	0.3	1.3	0.3	0.0	0.0	0.0	0.0
Rear-end RLR	Before	1.0	0.3	0.3	0.3	0.0	0.0	2.7
	After	3.0	1.7	0.3	0.0	0.0	0.3	3.0
Other RLR	Before	0.0	0.7	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Angle Other	Before	0.0	0.3	0.7	1.0	0.0	0.0	0.7
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Rear-End Other	Before	4.3	7.0	1.7	1.0	3.0	3.3	6.7
	After	1.7	4.7	1.7	0.7	2.3	2.0	3.3
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.3	0.0	0.0	0.0	0.0	0.0
	After	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.3	0.3	0.3	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.7	1.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Rear-End RLR PDO	Before	0.7	0.3	0.3	0.3	0.0	0.0	2.3
	After	2.3	1.3	0.3	0.0	0.0	0.3	2.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.7	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0

		RLR Camera Approach No. & Name						
		15	16	17	18	19	20	21
Average Annual Crash Frequency by Type and Severity		WB IL-132 @ IL-21	EB IL-132 @ Hunt Club Rd	WB IL-132 @ Hunt Club Rd	WB US-41 @ Delany Rd	EB US-41 @ Delany Rd	SB Wolf @ 22nd St/Cermak	WB IL-38/ Roosevelt @ Hamilton/ Harrison
Total Crashes	Before	7.3	12.3	15.3	4.0	6.7	6.3	0.7
	After	5.3	14.0	7.0	4.0	5.7	5.2	0.7
Injury Crashes	Before	1.7	2.0	3.3	1.3	1.7	2.3	0.0
	After	1.0	1.7	1.7	1.0	1.7	0.7	0.0
Angle RLR	Before	0.3	0.0	0.3	0.0	0.3	0.7	0.0
	After	0.3	0.3	0.3	0.3	0.0	0.0	0.0
Rear-end RLR	Before	1.0	1.3	2.3	0.0	0.0	0.0	0.0
	After	0.7	2.3	1.7	0.0	0.3	0.0	0.0
Other RLR	Before	0.0	0.0	0.7	0.0	0.0	0.0	0.0
	After	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Angle Other	Before	1.0	0.0	0.0	0.0	0.7	3.3	0.0
	After	0.7	0.3	0.0	0.3	1.3	2.4	0.0
Rear-End Other	Before	1.7	7.7	8.0	1.7	2.3	0.7	0.3
	After	3.0	7.0	3.3	1.0	1.7	1.4	0.3
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.0	0.0	0.0	0.3	0.7	0.0
	After	0.3	0.3	0.0	0.3	0.0	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.7	0.0	0.0	0.0	0.0
	After	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Rear-End RLR PDO	Before	1.0	1.3	1.3	0.0	0.0	0.0	0.0
	After	0.7	2.0	1.0	0.0	0.3	0.0	0.0
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.0	0.7	0.0	0.0	0.0	0.0
	After	0.0	1.0	0.0	0.0	0.0	0.0	0.0

Average Annual Crash Frequency by Type and Severity		RLR Camera Approach No. & Name						
		22	23	24	25	26	27	28
		NB Wolf @ IL-38/ Roosevelt	NB US-45 @ Peterson	WB Il-137 @ Butterfield	NB IL-43 @ IL-137	EB US-34 @ Yackley	WB US-34 @ Yackley	SB IL-53 @ Maple
Total Crashes	Before	3.0	4.7	10.3	4.0	9.3	10.3	12.3
	After	4.5	3.3	4.7	4.3	3.3	6.3	10.0
Injury Crashes	Before	1.0	0.7	2.0	0.7	1.7	2.3	3.3
	After	0.3	0.7	0.7	1.0	1.7	1.7	2.3
Angle RLR	Before	0.0	0.0	0.3	0.3	0.7	0.7	1.0
	After	0.0	0.0	0.0	0.3	0.3	0.0	0.0
Rear-end RLR	Before	0.3	1.0	3.7	0.0	0.0	0.0	0.3
	After	0.3	0.3	0.3	1.0	0.0	0.3	0.3
Other RLR	Before	0.3	0.3	0.0	0.0	1.0	0.7	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Angle Other	Before	0.0	0.0	0.7	0.0	1.3	3.3	3.0
	After	0.4	0.0	1.3	0.0	0.3	3.0	1.7
Rear-End Other	Before	1.0	0.7	3.7	1.3	4.3	2.7	3.7
	After	3.1	1.0	2.0	2.3	0.7	1.0	3.7
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.3	0.3	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.0	0.0	0.0	0.7	0.7	0.3
	After	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.7	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.3	0.0
Rear-End RLR PDO	Before	0.3	1.0	3.0	0.0	0.0	0.0	0.3
	After	0.3	0.3	0.0	0.7	0.0	0.0	0.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.3	0.3	0.0	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.0	0.0	0.0	0.7	0.3	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0

		RLR Camera Approach No. & Name						
		29	30	31	32	33	34	35
Average Annual Crash Frequency by Type and Severity		EB US-6/ 159th @ Kedzie	WB US-6/ 159th @ Kedzie	EB IL-64/ North @ 5th	WB IL-64/ North @ 5th	SB 25th @ IL-64/ North	WB IL-64/ North @ 25th	EB IL-64/ North @ 25th
Total Crashes	Before	8.7	12.3	16.5	18.5	11.0	10.0	12.7
	After	3.0	5.0	10.7	14.3	7.7	13.3	8.7
Injury Crashes	Before	2.0	1.7	3.8	1.7	1.0	2.0	2.0
	After	1.7	1.7	2.3	2.0	1.3	3.3	3.7
Angle RLR	Before	0.7	0.3	0.7	0.0	0.3	0.0	0.3
	After	0.3	0.0	0.0	0.7	0.0	0.0	0.3
Rear-end RLR	Before	0.7	0.3	0.0	1.0	0.3	0.3	0.3
	After	0.0	0.0	0.7	0.3	0.3	1.3	0.7
Other RLR	Before	1.3	0.0	0.3	1.0	0.0	0.0	0.7
	After	0.0	0.0	0.3	0.3	0.0	0.0	0.0
Angle Other	Before	0.7	0.0	0.3	0.0	0.0	0.7	0.3
	After	0.0	0.3	0.0	0.7	1.7	0.3	1.3
Rear-End Other	Before	3.7	5.0	5.8	9.6	5.0	6.3	5.0
	After	2.0	2.0	4.7	7.3	3.0	6.0	4.0
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Angle RLR Injury C	Before	0.3	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Angle RLR PDO	Before	0.3	0.3	0.0	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.3	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.0	0.0	0.7	0.3
Rear-End RLR PDO	Before	0.7	0.0	0.0	1.0	0.3	0.3	0.3
	After	0.0	0.0	0.3	0.3	0.3	0.7	0.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.3	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	1.0	0.0	0.3	0.7	0.0	0.0	0.3
	After	0.0	0.0	0.3	0.3	0.0	0.0	0.0

		RLR Camera Approach No. & Name						
		36	37	38	39	40	41	42
Average Annual Crash Frequency by Type and Severity		NB IL-50/ Cicero @ 167th	SB IL-50/ Cicero @ 167th	SB IL-50/ Cicero @ US-6/ 159th	NB IL-50/ Cicero @ US-6/ 159th	WB US-12/ Rand @ IL-53/Hicks	WB IL-68/Dundee @ US-12/IL-53/Rand	EB IL-68/Dundee@ US-12/IL-53/Rand
Total Crashes	Before	10.3	7.3	17.0	11.3	5.0	25.0	22.0
	After	6.7	6.7	5.7	7.0	4.3	8.7	13.0
Injury Crashes	Before	3.0	1.7	3.7	2.0	1.3	5.0	2.3
	After	0.7	1.3	2.0	3.0	0.3	0.7	0.3
Angle RLR	Before	1.0	0.0	0.3	0.7	0.0	0.3	0.3
	After	0.0	0.3	0.0	0.3	0.0	1.0	0.0
Rear-end RLR	Before	1.0	0.0	1.0	0.7	0.0	1.0	1.3
	After	1.3	0.7	0.7	1.0	0.3	0.0	2.3
Other RLR	Before	0.0	0.3	0.3	0.0	0.0	0.0	0.0
	After	0.3	0.0	1.0	0.0	0.0	0.3	0.0
Angle Other	Before	2.7	0.0	0.0	0.3	1.7	1.0	1.3
	After	1.7	0.0	0.3	0.0	2.0	1.7	0.3
Rear-End Other	Before	3.0	3.7	8.0	6.0	2.3	19.3	15.0
	After	1.3	1.7	2.3	3.3	0.3	3.3	8.0
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.3	0.0	0.3	0.0	0.0	0.0
Angle RLR Injury C	Before	0.3	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.3	0.0	0.3	0.3	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Rear-End RLR PDO	Before	1.0	0.0	1.0	0.7	0.0	0.7	1.3
	After	1.3	0.7	0.7	1.0	0.3	0.0	2.0
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.3	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.7	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.3	0.0	0.3	0.0	0.0	0.3	0.0

		RLR Camera Approach No. & Name						
		43	44	45	46	47	48	49
Average Annual Crash Frequency by Type and Severity		WB Palatine @ US-14	SB Hicks & Euclid	WB IL-62/Algonquin @ IL-53 East Ramp	SB IL-53 East Ramp @ IL-62/Algonquin	EB US-6/ 159th @ Woodlawn East	WB US-6/159th @ State/ Indiana	SB IL-43/Harlem @ 171st
Total Crashes	Before	5.0	6.7	3.7	18.3	7.0	6.3	13.7
	After	2.0	4.7	0.7	6.7	8.3	4.3	6.0
Injury Crashes	Before	1.0	1.3	1.3	2.0	0.7	1.7	2.0
	After	0.7	1.7	0.3	0.3	1.3	1.0	0.7
Angle RLR	Before	0.3	0.0	0.7	0.3	0.3	0.3	0.7
	After	0.0	0.0	0.3	0.0	0.3	0.3	0.3
Rear-end RLR	Before	0.0	0.0	1.0	3.7	0.3	0.3	1.0
	After	0.0	0.3	0.0	0.3	1.7	0.3	0.7
Other RLR	Before	0.3	1.0	1.3	0.3	0.3	0.3	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Angle Other	Before	2.0	0.3	0.3	0.0	0.7	0.3	1.3
	After	1.3	0.7	0.0	0.0	0.7	0.0	0.0
Rear-End Other	Before	1.7	3.7	0.3	12.3	4.0	2.7	4.3
	After	0.3	1.7	0.3	5.0	3.3	1.0	3.0
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.3	0.0	0.3
Angle RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.3	0.0	0.3	0.0	0.3	0.3	0.7
	After	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Rear-End RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.3	0.3	0.0	0.3	0.0
	After	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rear-End RLR PDO	Before	0.0	0.0	0.7	3.3	0.3	0.0	1.0
	After	0.0	0.0	0.0	0.3	1.7	0.0	0.7
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.7	0.3	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.3	1.0	0.3	0.3	0.3	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0

		RLR Camera Approach No. & Name						
		50	51	52	53	54	55	56
Average Annual Crash Frequency by Type and Severity		SB IL-43/ Harlem @ 183rd	SWB IL-176 @ Old Rand/Main	EB IL-176 @ US-12/IL-59/West/ Liberty	SB IL-59 @ IL-64	EB IL-64 @ IL-59	SB RT-31 @ Boncosky	NB RT-31 @ RT-72
Total Crashes	Before	18.0	1.3	4.7	15.3	23.0	3.3	8.0
	After	9.7	2.3	1.0	12.0	6.0	1.7	5.7
Injury Crashes	Before	3.0	0.0	0.7	1.7	3.7	0.7	1.0
	After	3.3	0.7	0.3	2.0	0.3	0.3	2.7
Angle RLR	Before	0.3	0.0	0.0	0.3	0.0	0.0	0.3
	After	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Rear-end RLR	Before	3.0	0.3	2.3	4.0	6.0	0.3	1.0
	After	2.0	0.7	0.3	2.7	1.7	0.7	1.0
Other RLR	Before	0.0	0.3	0.0	0.3	0.3	0.0	0.3
	After	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Angle Other	Before	0.7	0.0	0.3	0.0	2.0	0.0	0.3
	After	0.3	0.0	0.0	0.3	0.0	0.0	1.0
Rear-End Other	Before	10.7	0.7	2.0	6.0	11.3	1.0	2.0
	After	5.0	1.3	0.3	6.3	3.3	0.0	1.7
Angle RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.0	0.0	0.3	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	After	0.3	0.0	0.0	0.0	0.3	0.3	0.0
Rear-End RLR Injury B	Before	0.3	0.0	0.0	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.0	0.0	0.0	0.3	1.0	0.0	0.0
	After	0.7	0.0	0.0	0.0	0.0	0.0	1.0
Rear-End RLR PDO	Before	2.7	0.3	2.3	3.3	5.0	0.3	0.7
	After	1.0	0.7	0.3	2.7	1.3	0.3	0.0
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.0	0.3	0.0	0.3	0.0	0.0	0.3
	After	0.0	0.0	0.0	0.3	0.0	0.0	0.0

		RLR Camera Approach No. & Name			
		57	58	59	60
Average Annual Crash Frequency by Type and Severity		NB IL-83 @ 63rd	SB IL-83 @ 63rd	NB IL-83 @ 75th	SB IL-83 @ 75th
Total Crashes	Before	9.7	11.0	9.0	6.0
	After	8.7	8.0	11.3	9.7
Injury Crashes	Before	2.7	2.7	1.0	0.7
	After	3.3	4.0	2.3	1.7
Angle RLR	Before	0.3	0.7	0.0	0.0
	After	0.3	0.0	0.0	0.0
Rear-End RLR	Before	2.3	2.7	0.7	0.7
	After	4.0	1.0	2.7	1.3
Other RLR	Before	0.7	0.3	0.7	0.0
	After	0.0	0.0	0.3	0.3
Angle Other	Before	0.0	0.0	0.0	0.0
	After	0.0	0.3	0.3	0.0
Rear-End Other	Before	4.0	6.7	4.7	4.7
	After	2.7	5.3	6.7	5.7
Angle RLR Fatal K	Before	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0
Angle RLR Injury A	Before	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Angle RLR Injury B	Before	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Angle RLR Injury C	Before	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Angle RLR PDO	Before	0.0	0.3	0.0	0.0
	After	0.3	0.0	0.0	0.0
Rear-End RLR Fatal K	Before	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Rear-End RLR Injury A	Before	0.0	0.3	0.0	0.0
	After	0.3	0.0	0.0	0.0
Rear-End RLR Injury B	Before	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Rear-End RLR Injury C	Before	0.3	0.7	0.0	0.0
	After	1.3	0.3	0.0	0.0
Rear-End RLR PDO	Before	1.7	1.7	0.7	0.7
	After	2.3	0.7	2.7	1.3
Other RLR Fatal K	Before	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Other RLR Injury A	Before	0.3	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Other RLR Injury B	Before	0.0	0.0	0.0	0.0
	After	0.0	0.0	0.0	0.0
Other RLR Injury C	Before	0.0	0.3	0.0	0.0
	After	0.0	0.0	0.0	0.0
Other RLR PDO	Before	0.3	0.0	0.7	0.0
	After	0.0	0.0	0.3	0.3

APPENDIX C: WHITE PAPER: SAFETY EVALUATION OF RED LIGHT RUNNING CAMERAS IN ILLINOIS

DRAFT White Paper: Safety Evaluation of Red Light Running Cameras in Illinois

In 2016, the Illinois Department of Transportation (IDOT) through the Illinois Center for Transportation (ICT) commissioned a special project to evaluate the effectiveness of RLR cameras in terms of reduction in motor vehicle crash frequencies in Illinois.

According to 2014 data provided by the Insurance Institute for Highway Safety (IIHS), 709 people in the US were killed and an estimated 126,000 were injured in crashes involving red light running (RLR) at signalized intersections[1]. In order to reduce RLR crashes and injuries, 426 communities in 23 states and the District of Columbia have implemented RLR camera programs in their jurisdictions (as of March 2017)[1]. In the State of Illinois, RLR cameras are currently in operation at intersections located on state and local roads in eight counties in the Metro East (St. Louis) and Chicago area.

Data and Method – A sample of 41 signalized intersections (Figure 1) under IDOT's jurisdiction and equipped with RLR cameras were selected to evaluate the effective of RLR cameras in terms of reduction in traffic crashes. These 41 intersections were located on state routes in Cook, DuPage, Kane and Lake Counties, and outside of the City of Chicago limits, since IDOT does not have jurisdiction over the RLR camera installations in the city. The safety impacts were quantified through an extensive review and analysis of over 8,800 traffic crashes that occurred over a 7-year period, before and after installation of the RLR cameras. Specifically, traffic crash data were analyzed for a 3- year before-installation period, and a 3-year after-installation period. The crash data for the one year in between the before and after periods was excluded to account for the RLR system installation and a period of time for traffic to adjust to changed conditions. An emphasis was placed on right-angle crashes and rear-end crashes since RLR cameras have the greatest impact on these two crash types.

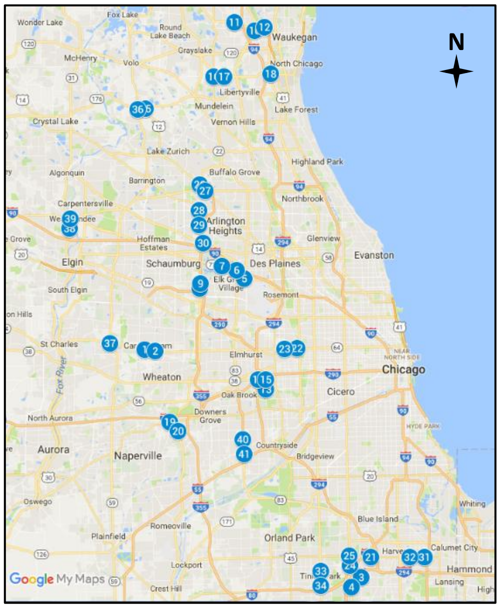

Figure 1. Location of 41 RLR Camera Study Intersections

Results—**Table 1** shows the frequency and percent reductions in total crashes, right-angle crashes, and rear-end crashes before and after RLR installation. As shown in this table, there is an overall 3-year reduction of 1,525 total crashes (36%), including a reduction of 81 right-angle crashes (53%) and 13 rear-end crashes (3.5%) at the 41 study intersections. The percent right-angle crashes decreased from 3.6% before the RLR camera installation to 2.7% after the RLR camera installation, but the percent rear-end crashes increased from 8.8% before the RLR camera installation to 13.3% after the RLR camera installation.

Table 1: Before and after crash comparisons – Aggregated data for 41 study intersections

Crash Type	Crashes (Before-RLR Installation)	Crashes (After- RLR Installation)	Percent Reduction
	3 year total	3 year total	
Total Crashes	4,192	2,667	36.4%*
Right-Angle Crashes	153	72	52.9%*
Rear-End Crashes	367	354	3.5%

* Denotes statistically significant reduction at 95% level of confidence

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[1] Insurance Institute for Highway Safety, Highway Loss Data Institute, http://www.iihs.org

APPENDIX D: AADT FOR THE BEFORE- AND AFTER-INSTALLATION PERIODS AT THE TEST SITES

Intersection No./ Name		**Average Annual Daily Traffic (Vehicles per day)**									
		Before-Installation Period					**After-Installation Period**				
		NB	SB	EB	WB	Total	NB	SB	EB	WB	Total
1	IL-64/North & Kuhn	900	2,775	18,950	18,850	**41,475**	900	2,775	20,700	20,700	**45,075**
2	IL-64/North & Gary	7,550	13,200	18,850	21,250	**60,850**	7,550	13,200	20,700	22,950	**64,400**
3	Crawford/Pulaski & 175th	5,450	4,475	3,050	5,550	**18,525**	5,550	5,450	3,050	5,550	**19,600**
4	IL-50/Cicero & 183rd	8,050	7,400	7,800	4,025	**27,275**	7,000	7,700	4,100	9,350	**28,150**
5	IL-72/ Higgins & Landmeier	16,700	17,900	7,450	7,450	**49,500**	19,900	19,900	7,450	7,450	**54,700**
6	IL-72/ Oakton & Busse	15,600	11,350	14,700	14,700	**56,350**	14,600	14,600	14,700	14,700	**58,600**
7	IL-72/ Higgins & Arlington Hts Rd	12,400	16,650	16,850	17,900	**63,800**	12,400	16,650	16,250	16,250	**61,550**
8	Rohlwing & Nerge	5,050	9,350	7,050	3,950	**25,400**	5,525	7,550	7,050	3,950	**24,075**
9	IL-53/ Biesterfield & IL-53/ Rohlwing	9,350	6,650	7,450	16,950	**40,400**	7,550	6,500	13,600	13,600	**41,250**
10	IL-21 & IL-132	7,000	5,500	12,300	12,300	**37,100**	8,450	5,300	14,350	14,350	**42,450**
11	IL-132 & Hunt Club Rd	10,700	7,600	16,150	18,950	**53,400**	10,650	7,400	20,100	21,700	**59,850**
12	US-41 & Delany Rd	3,300	11,600	18,950	18,950	**52,800**	3,225	13,900	19,750	19,750	**56,625**
13	22nd St/Cermak & Wolf	8,700	7,750	6,275	13,300	**36,025**	8,700	7,750	6,275	13,300	**36,025**
14	IL-38/ Roosevelt & Hamilton/ Harrison	450	450	12,250	12,250	**25,400**	450	450	13,500	13,500	**27,900**
15	IL-38/ Roosevelt & Wolf	7,750	6,500	12,250	14,350	**40,850**	7,750	6,500	13,500	14,200	**41,950**
16	US-45 & Peterson	13,350	14,250	6,600	5,450	**39,650**	12,950	14,750	8,000	7,550	**43,250**
17	Il-137 & Butterfield	8,950	1,500	14,150	14,150	**38,750**	7,700	1,500	16,750	16,750	**42,700**
18	IL-137 & IL-43	12,000	13,050	9,550	16,100	**50,700**	10,800	11,900	13,650	8,000	**44,350**
19	US-34 & Yackley	8,200	6,750	12,300	14,100	**41,350**	8,200	6,750	13,000	14,400	**42,350**
20	IL-53 & Maple	12,800	11,000	11,600	11,600	**47,000**	15,250	12,900	11,600	11,600	**51,350**
21	US-6/ 159th & Kedzie	9,150	6,800	10,450	13,850	**40,250**	9,150	6,800	13,400	12,800	**42,150**
22	IL-64/ North & 5th	2,000	6,550	22,250	18,150	**48,950**	4,100	4,400	28,900	28,900	**66,300**
23	IL-64/ North & 25th	8,900	9,200	25,200	22,250	**65,550**	8,900	9,200	26,500	26,500	**71,100**

Intersection No./ Name		**Average Annual Daily Traffic (Vehicles per day)**									
		Before-Installation Period					**After-Installation Period**				
		NB	SB	EB	WB	Total	NB	SB	EB	WB	Total
24	IL-50/ Cicero & 167th	8,000	12,450	7,600	12,400	**40,450**	8,400	12,750	8,600	14,500	**44,250**
25	US-6/ 159th & IL-50/ Cicero	12,450	15,750	15,850	14,300	**58,350**	12,750	14,900	16,350	12,350	**56,350**
26	US-12/ Rand & IL-53/Hicks	9,700	8,950	13,500	13,650	**45,800**	5,750	5,750	15,150	15,150	**41,800**
27	US-12/IL-53/Rand & IL-53/IL-68/Dundee	14,650	13,650	12,650	12,150	**53,100**	16,650	15,150	12,850	14,400	**59,050**
28	US-14 & Palatine	12,450	12,900	7,050	7,750	**40,150**	13,150	15,300	7,750	9,900	**46,100**
29	Hicks & Euclid	975	5,350	10,400	10,400	**27,125**	5,550	9,050	11,450	11,450	**37,500**
30	IL-53 East Ramp & IL-62/Algonquin	—	11,900	14,850	17,900	**44,650**	—	9,800	17,300	14,450	**41,550**
31	US-6/159th & Woodlawn East	750	750	12,950	12,950	**27,400**	750	750	16,300	16,300	**34,100**
32	US-6/159th& State/ Indiana	7,400	6,400	13,650	13,650	**41,100**	6,650	6,200	12,600	12,600	**38,050**
33	IL-43/Harlem & 171st	15,700	15,600	8,150	11,700	**51,150**	17,600	17,550	8,750	6,000	**49,900**
34	IL-43/ Harlem & 183rd	12,950	15,100	9,650	6,350	**44,050**	17,800	16,200	9,650	4,400	**48,050**
35	IL-176 & Old Rand/Main	8,150	8,150	3,925	2,250	**22,475**	2,575	2,575	7,050	7,050	**19,250**
36	IL-176 & US-12/IL-59/West/Liberty	—	1,650	6,250	9,400	**17,300**	—	1,650	9,750	7,150	**18,550**
37	IL-59 & IL-64	15,050	17,100	19,250	19,550	**70,950**	12,700	15,900	18,100	16,100	**62,800**
38	RT-31 & Boncosky	11,200	15,100	1,950	-	**28,250**	13,200	12,700	2,175	—	**28,075**
39	RT-31 & RT-72	15,100	15,350	12,150	15,350	**57,950**	12,700	13,450	11,400	15,200	**52,750**
40	IL-83 & 63rd	23,650	22,100	13,050	6,150	**64,950**	23,550	29,450	13,050	6,150	**72,200**
41	IL-83 & 75th	23,650	23,650	7,350	7,350	**62,000**	23,550	23,550	7,350	7,350	**61,800**

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