RED LIGHT RUNNING CAMERA ASSESSMENT

Final Report

SPR 304-521

RESEARCH

Oregon Department of Transportation

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by

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16. Abstract

In the 2004-2007 period, the Mission Street SE and 25th Street SE intersection in Salem, Oregon showed relatively few crashes attributable to red light running (RLR) but, since a high number of RLR violations were observed, the intersection was identified as having a high crash potential. ODOT approved the installation of RLR cameras for a trial period to study the results of RLR cameras. Cameras were installed in February 2008 in the westbound and northbound directions.

A before and after study of the crashes involving westbound and northbound drivers at the Mission and 25th intersection was completed. In the 50 months prior to the camera installation crashes averaged 0.62 per month. In the 21 months after installation, the average increased by 77.4% to 1.10 per month.

Crash cost estimates for different types of crashes make it possible to account for the expectation that RLR cameras are likely to result in fewer angle crashes, which are often severe, and more rear end crashes, for which injuries tend to be less severe. The estimated average monthly crash costs increased from $16,296 before the cameras were installed to $27,738 after the cameras were installed.

Crashes increased only slightly or not at all at two comparison intersections, whereas the crashes increased substantially at the Mission at 25th intersection. Since traffic volumes declined slightly from the pre- to post-installation periods, the crash data were not normalized.

After camera installation, violations decreased by 43 percent in the westbound direction and 23 percent in the northbound direction. At both the westbound and northbound approaches, left turning vehicles accounted for the overwhelming majority of the violations.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
	NOTE: Volumes greater than 1000 L shall be shown in m^3.			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit	(F-32)/1.8	Celsius	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
m^2	meters squared	1.196	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

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DISCLAIMER

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1.0 BACKGROUND

1.1 OREGON RED LIGHT RUNNING CAMERA PROGRAM

Oregon law (ORS 811.260) establishes the basis for determining when a driver fails to obey traffic control devices. A steady circular yellow signal light is displayed to warn drivers that the right of way is being terminated and that a red or flashing red light will be shown immediately. The driver should stop at the stop line or before entering the marked crosswalk on the near side of the intersection, or if there is no marked crosswalk, then before entering the intersection. If the driver cannot stop in safety, the driver may drive cautiously through the intersection. A driver facing a steady circular red signal light alone shall stop at the stop line, the crosswalk before entering the intersection, or if there is no marked crosswalk, then before entering the intersection. After coming to a full stop, and under circumstances established by law, the driver can make a right turn when the signal light displays red. Failure to obey a traffic control device is a Class B traffic violation. The Institute of Transportation Engineers (ITE) refers to the way Oregon defines the meaning of the yellow indication as the "permissive yellow rule." Other jurisdictions use a different meaning known as the "restrictive yellow rule," where drivers may not enter on yellow unless they can clear the intersection before the end of the yellow *(ITE 1994*).

In response to what appeared to be a growing disrespect for traffic laws in general and disobeying red traffic signal indications in particular, the Oregon Legislature enacted a law in 1999 to help Oregon communities enforce and reduce red light running. The law allowed Beaverton, Bend, Medford, and Portland to install, at their own expense, red light running (RLR) enforcement cameras, provided that certain guidelines were met. RLR cameras monitor both the flow of traffic at the stop location and the condition (or color) of the traffic signal indication on the approach. Special detectors – commonly loops cut into the pavement – check for the passage of vehicles into the intersection and, if the traffic signal phase condition is red, trigger pole-mounted cameras to record pictures of the vehicle position, license plate and driver. Upon verification by a police officer, the vehicle owner is issued a citation through the mail.

Initially the program was to sunset on December 31, 2001. In 2001 legislation was passed that continued the program and allowed more cities to operate cameras and also set limitations for the number of intersections that could operate cameras. The program was further expanded in 2003, 2005, and 2007. Changes in 2007 allowed all cities to operate cameras, and limitations regarding the number of intersections were removed.

According to ORS 810.634 and 810.636, cities operating cameras to photograph drivers must:

- Provide a public information campaign to inform local drivers about the use of cameras before citations are actually issued.

- Once a biennium, conduct a process and outcome evaluation that addresses the effect of the use of cameras on traffic safety, the degree of public acceptance, and the administration of the cameras.
- Post signs on all major routes entering the jurisdiction, indicating that traffic control devices are enforced through cameras.
- Post signs at the location where cameras are installed, indicating that a camera may be operating.
- Set the yellow clearance time for at least as long as recommended by the standard set by the Institute of Transportation Engineers.
- Meet established guidelines for the issuance of citations.

ORS 810.634 and 810.636 are included in this report as Appendix A.

The Oregon Department of Transportation (ODOT) and the Oregon Traffic Control Devices Committee have established *Red Light Running (RLR) Camera Guidelines* for the approval of cameras to be installed by a city on a state highway (*ODOT 2004*). The *Guidelines* state that if the location is a state highway intersection, approval of the Department of Transportation is required. In this case, a Safety and Operations Report is required. The *Guidelines* were revised in April 2010, and revisions were made in response to initial findings of this research project (*ODOT 2010*).

The elements required at the time the Safety and Operations Report was prepared for the Mission Street SE and 25th Street SE intersection in Salem were:

- Crash history. Target crashes for reduction are angle crashes where the driver of one of the vehicles disregarded the traffic control device.
- Crash potential. This includes data on traffic citations issued, complaints received, speeds, and traffic volumes.
- Design, operations, maintenance issues including signal plans, proposed camera location, and operations and maintenance plans.
- Public information campaign.
- Budget.

1.2 SALEM RED LIGHT RUNNING CAMERA PROGRAM

In August 2006 the Salem City Council adopted a resolution to pursue the use of red light cameras in Salem. The city evaluated red light running-related crash and violation data and identified intersections where the installation of red light cameras could be the most effective. Two locations – Mission Street SE (ORE 22) and 25th Street SE and Commercial Street NE and Marion Street NE – had one or more state highway approaches and required the approval of ODOT. Consistent with the *Red Light Running (RLR) Camera Guidelines, 2004* (*ODOT 2004*), the city submitted a Safety and Operations Report for both intersections (*Salem 2007*).

The information provided in the Safety and Operations Report for the Commercial at Marion Street intersection provided substantial support for the camera installation, and installation of cameras was approved by the State Traffic Engineer. This intersection had the highest rate of red light running crashes in the city (*Salem 2007*).

The information provided in the Safety and Operations Report for the Mission Street SE and 25th Street SE intersection (Mission and 25th intersection) showed relatively few crashes attributable to red light running but, due to a high number of citations written and violations observed, was identified as having a high crash potential (*Salem 2007*). After thorough consideration, ODOT agreed to approve the installation of RLR cameras at this intersection, as long as the city would agree to cooperate in studying the effects of the red light camera installation at this location.

1.2.1 Memorandum of Agreement between the City of Salem and Oregon Department of Transportation

In October 2007 ODOT and the City of Salem entered into a Memorandum of Agreement regarding camera installation and evaluation. The Memorandum is in Appendix B. The highlights are as follows:

- An 18-month trial period, during which the red light running cameras may be installed and violations issued. (Note: the trial period started April 1, 2008 and was to have ended September 30, 2009. However, since crash data for this period was not available until the data for the entire 2009 calendar year was published, the researchers reviewed the crash and violation data for the entire 2009 calendar year. This was the first 21 months of camera operation.)
- The city and ODOT will agree on a method to use in studying the effects of the red light running camera (RLRC) installations at the Mission and 25th intersection in Salem.
- The city agreed that the following data would be reviewed:
    - Number of angle and rear-end crashes that occur compared to the number occurring prior to camera installation.
    - The number of red light violations that occur compared to the number that occurred during the initial study period. (Note: March 2008 is considered the initial study period, during which the cameras were installed, signs were posted, but violators were issued warnings rather than citations.)
    - Similar data for two or three other intersections along Mission Street near the 25th and Mission intersection, so that it can be determined if RLRCs at 25th and Mission appear to reduce red light running violations at other intersections that do not have cameras.
- Review of the data using a method or criteria agreed to and, as a result of such analysis, the cameras at the 25th and Mission intersection may be removed.

1.2.2 Program Implementation

Following approval from ODOT, the city entered into an agreement with Redflex, Inc. to install the cameras. The plan for camera installation was submitted and approved by ODOT. ODOT regional staff reviewed timing at the intersection and provided a letter to the city confirming the adequacy of the yellow change intervals.

Signs were installed at the city limits, alerting drivers that photo enforcement was being used in the city. A sign was installed on each approach where a camera would operate, alerting drivers that photo enforcement was in place. Figure 1.1 is an example of a sign installed at the city limits. Figure 1.2 is a photograph of the sign installed at the Mission and 25th intersection in the westbound direction.

Figure 1.1: Photograph of photo enforcement sign installed at Salem city limits

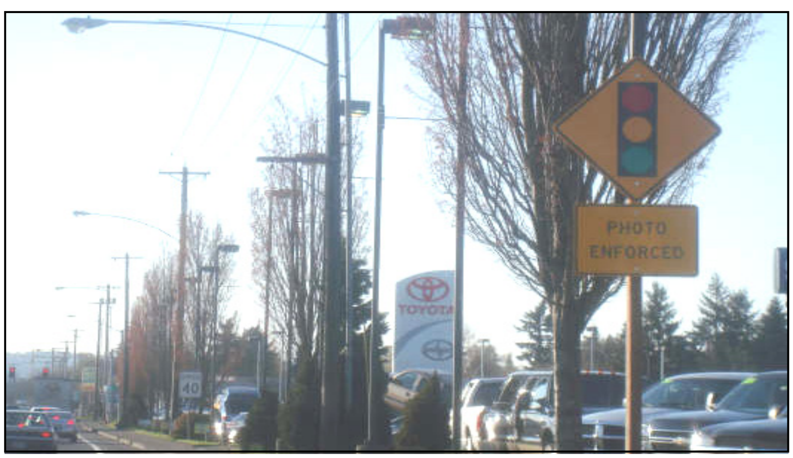


Figure 1.2: Photograph of photo enforcement sign installed on westbound approach of Mission Street SE and 25th Street SE intersection in Salem

Prior to camera installation the City of Salem had initiated a public information program, which continued after the cameras were installed. Cameras were installed on February 29, 2008, with warnings issued during the first month. Starting April 1, 2008, citations were issued.

1.3 EVALUATION

A research project was designed to conduct the study that was described in the Memorandum of Agreement between the City of Salem and ODOT. This study assessed the impact of red light cameras at the Mission and 25th intersection on red light running-related crashes at this intersection and two nearby intersections as well as on red light running violations at the Mission and 25th intersection.

The purpose of the evaluation was to:

- determine the effectiveness of the red light running cameras;
- recommend modifications to the placement and operation of the cameras;
- recommend continued operation or removal of the cameras; and
- recommend revisions to the *Red Light Running (RLR) Camera Guidelines*.

2.0 LITERATURE REVIEW

The purpose of this literature review is to identify previous research that can provide background information on red light running camera programs and can provide insight into the current assessment. It contributes in determining:

- Red light running countermeasures;
- Expected outcomes of red light cameras in terms of changes in crash and violation incidence;
- Methodological considerations in the design of the assessment; and
- The criteria to be used to review camera operation after the trial period.

2.1 RED LIGHT RUNNING

While much of the research on red light running has evaluated the impact of the installation of red light running cameras as an enforcement countermeasure, other research has looked more comprehensively at the issue of red light running. This includes documenting factors that seem to encourage this behavior and identifying engineering countermeasures (in addition to cameras) that can be used to reduce the frequency of red light running and reduce the severity of crashes that may occur.

2.1.1 Exposure Factors

Engineering Countermeasures to Reduce Red-Light Running (*Bonneson et al. 2002*) provides the following summary of exposure factors that contribute to the behavior of red light running.

The number of drivers running the red each signal cycle is likely to increase when:

- the traffic volume increases;
- the number of signal cycles increases; or
- the number of times a green phase "maxes out" increases (i.e., a signal terminates even though a vehicle occupies the approach).

Other factors that have been found to relate to drivers' responses include the following:

- Drivers traveling at higher speeds tend to underestimate the amount of time it takes to stop.

- Drivers are less likely to stop if traveling within a platoon through a series of interconnected signals. They believe they should be able to travel without interruption through successive intersections.
- Drivers on downgrades are less likely to stop than those on a level or upgrade.
- Overly long yellow intervals tend to discourage stopping. If drivers stop and the yellow phase does not terminate almost immediately, they are more likely not to stop the next time.
- Drivers who are closely following another vehicle are more likely to proceed through a yellow or red indication. Drivers who are being closely followed are likely to continue through the intersection to avoid a rear end collision.
- Drivers are more likely to run the red indication when the cross street has a low volume.
- As the threat of receiving a citation increases, drivers are more likely to stop on yellow and red indications.
- Drivers are less likely to stop as the expected delay increases.

2.1.2 Engineering Countermeasures

The research completed by Bonneson et al. (*2002*) included a survey of traffic engineers to identify engineering countermeasures that seemed to be the most promising. The counter-measures which related to signal operation or motorist information were implemented at 10 intersections in five cities in Texas. The results of the evaluation are presented in Table 2.1.

Table 2.1 Summary of RLR countermeasures (*Bonneson et al. 2002*)

Countermeasure Category	Specific Countermeasure	Reported RLR Effectiveness [1]	
		Frequency	Related Crashes
Signal Operation (modify signal phasing, cycle length, or change interval)	Increase the yellow interval duration	-50 to -70 %	--
	Provide green-extension (advance detection)	-45 to -65 %	--
	Improve signal coordination	Varies [2]	--
	Improve signal operation (increase cycle length 20 s)	-15 to -25 % [3]	--
Motorist Information (provide advance information or improved notification)	Improve sight distance	--	--
	Improve visibility of signal (12" lens, add heads)	--	-33 to -47 %
	Improve visibility of signal with yellow LEDs	-13 %	--
	Increase conspicuity of signal with back plates	-25 %	-32 %
	Add advance warning signs without flashers	--	-44 %
	Add advance warning signs with active flashers	-29 to -67 %	--
Physical Improvement (implement safety or operational improvements)	Remove unneeded signals	--	-24 %
	Add capacity with additional traffic lanes	--	--
	Flatten sharp curves	--	--

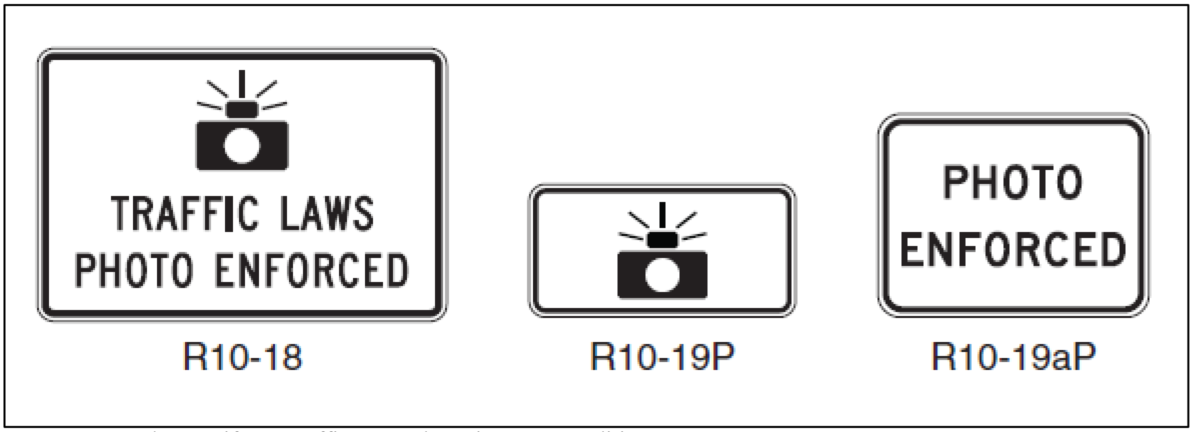
Note:
1 - Negative values indicate a reduction. "--": data not available.
2 - Red-light-running frequency is likely to increase with improved coordination; however, this increase may be offset by the larger cycle length typically required for good progression.
3 - Reductions associated with an increase in cycle length may not be realized if motorist delay increases significantly.

P.J. Carlson and R.A. Retting (*2001*) completed an evaluation of signs used to inform drivers of red light camera enforcement. According to the report, at the time the study was done there were no standards or guidelines established. The purpose of the evaluation was to test the various signs being used by different jurisdictions and identify the designs that were the best understood.

To maximize the impact of red light camera enforcement, drivers must be aware of the enforcement, and signs must convey their message clearly. The survey conducted for the 2001 study indicated that there were 13 different types of signs being used by 15 jurisdictions. These were tested using a panel of experts and drivers in Texas. Based on the results, recommendations were made for a jurisdictional boundary sign, advance warning sign, and regulatory sign. The advance warning sign and regulatory sign were included in the 2003 edition of the *Manual on Uniform Traffic Control Devices (MUTCD)* as options. The *Oregon Supplements to the MUTCD, 2003 edition* (p.7), made placement of the signs standard practice: (*ODOT 2005*)

> "Where photographic equipment is being used to enforce traffic regulations, a TRAFFIC LAWS PHOTO ENFORCED (R10-18) sign (see Figure 2B-1) shall be installed on all major routes entering a jurisdiction to advise road users that some of the traffic regulations within that jurisdiction are being enforced by photographic equipment.
>
> Where photographic equipment is being used to enforce traffic regulations, a PHOTO ENFORCED (R10-19) sign (see Figure 2B-1) shall be installed near the associated traffic control device to advise road users that the regulation is being enforced by photographic equipment.
>
> Option:
>
> If a temporary photo radar unit is used, a SPEED PHOTO ENFORCED (OR22-21) sign (see ODOT Sign Policy) may be used instead of the PHOTO ENFORCED (R10-19) sign.
>
> If the regulations being enforced by photographic equipment are associated with a warning sign advising road users of the condition being warned about (such as a traffic control signal or a toll plaza), a PHOTO ENFORCED (W16-1) plaque (see Section 2C.53) may be used instead of the PHOTO ENFORCED (R10-19) sign.
>
> Standard:
>
> If used below a regulatory sign, the PHOTO ENFORCED (R10-19) and SPEED PHOTO ENFORCED (OR22-11) signs shall be a rectangle with a black legend and border on a white background.
>
> For speed enforcement, the PHOTO ENFORCED or SPEED PHOTO ENFORCED sign assembly shall be located between 100 and 400 yards in advance of the photo radar unit, in accordance with ORS 810.438."

The 2009 edition of the *MUTCD* has revised photo enforcement signs. These are shown in Figure 2.1. Sign R10-18 is to be installed at the jurisdictional boundary; sign R10-19P or R10-19aP should be used at the intersection.



Source: Manual on Uniform Traffic Control Devices, 2009 Edition

Figure 2.1: Photo enforcement signs and plaques

2.2 EFFECTIVENESS OF RED LIGHT RUNNING CAMERAS

In addition to traditional enforcement activity, red light running cameras are the primary enforcement countermeasure used to reduce red light running. Their use is designed to both reduce crashes and violations.

2.2.1 Crash Reduction

Red light running cameras have been used extensively in many jurisdictions in the United States as well as in other countries. For this reason there have been many studies completed to quantify their effectiveness. Several recent studies have summarized findings from other studies. One such study is *Safety Evaluation of Red-Light Cameras* completed by the Battelle Memorial Institute for the Federal Highway Administration (*Council et al. 2005a*). Table 2.2 is taken from this report.

Table 2.2: Summary of findings from past studies (*Council et al. 2005a)*

Reference	City	Camera sites	Comparison/ reference group	Crash type studied and estimated effects (negative indicates reduction)		Comment
Hillier, et al. (1993)[8]	Sydney, Australia	Installed at 16 intersections	16 signalized intersections	Right-angle and left-turn opposed	-50%	RTM* possible; spillover may have affected comparison sites; results confounded by adjustment to signal timing in middle of study period
				Rear end	+25% to 60%	
South, et al. (1988)[9]	Melbourne, Australia	Installed at 46 intersections	50 signalized intersections	No significant results. Looked at right angle, right-angle (turn), right against thru, rear end, rear end (turn), other, all crashes, number of casualties, no significant results		RTM* possible, no accounting for changes in traffic volumes; comparison sites possibly affected by spillover and other treatments
Andreassen (1995)[10]	Victoria, Australia			No significant results		Lack of an effect could be that the sites studied tended to have few red-light-running related accidents; comparison sites may have been affected by spillover
Kent, et al. (1995)[11]	Melbourne, Australia	3 intersection approaches at different intersections	Noncamera approaches	No significant relationship between the frequency of crashes at RLC and non-RLC sites and differences in red-light-running behavior		Cross-sectional design is problematic; likely spillover effects to the noncamera approaches at the same intersections
Mann, et al. (1994)[12]	Adelaide, Australia	Installed at 13 intersections	14 signalized intersections	Reductions at the camera sites were not statistically different from the reductions at the comparison sites		RTM* and spillover to comparison sites are issues not addressed
London Accident Analysis Unit (1997)[13]	London, U.K.	RLC at 12 intersections and 21 speed cameras	Citywide effects examined	No significant results		The results are confounded because two programs are evaluated

Table 2.2: Summary of findings from past studies *continued* (*Council et al. 2005a*)

Reference	City	Camera sites	Comparison/ reference group	Crash type studied and estimated effects (negative indicates reduction)		Comment
Hooke, et al. (1996)(14)	Various cities in England and Wales	Installed at 78 intersections		All injury	-18%	A simple before-and-after comparison not controlling for effects of other factors, RTM* and traffic volume changes; therefore there is limited confidence in the results.
Ng, et al. (1997)(15)	Singapore	Installed at 42 intersections	42 signalized intersections	All	-7%	RTM* and spillover effects at comparison sites are issues
				Right angle	-8%	
Retting and Kyrychenko (2001)(16)	Oxnard, CA	Installed at 11 intersections	Unsignalized intersections in Oxnard and signalized intersections in 3 similarly sized cities	All	-7%	Looked at citywide effects, not just at RLC sites 29 months of before-and-after data used
				All injury	-29%	
				Right angle	-32%	
				Right-angle injury	-69%	
				Rear end	+3% (nonsignificant)	
SafeLight, Charlotte(17)	Charlotte, NC	Installed at 17 intersections	no comparison group	Angle—all approaches	-37%	Probable RTM in site selection
				Angle—camera approaches	-60%	
				All—camera approaches	-19%	
				Rear end—camera approaches	+4%	
				All	< -1%	
Maryland House of Delegates (2001)(18)	Howard County, MD	Installed at 25 intersections		Rear end	-32%	Probable RTM in site selection
				Right angle	-42%	
				Other	-22%	

Table 2.2: Summary of findings from past studies *continued* (*Council et al. 2005a*)

Reference	City	Camera sites	Comparison/ reference group	Crash type studied and estimated effects (negative indicates reduction)		Comment
Fleck and Smith (1998)[19]	San Francisco, CA	Installed at 6 intersections	Citywide effects examined	Citywide injury collisions caused by red-light violators; unclear how these were defined	- 9%	Question on definition of RLC crashes; did not examine specific effects at treated sites
Vinzant and Tatro (1999)[20]	Mesa, AZ	6 intersections with RLC only, 6 intersections with RLC plus photo speed enforcement	6 signalized intersections	Total crash rates—crashes per million entering vehicles at each intersection		It is unclear if the assignment of treatment/no treatment to the four quadrants was random
				Combined-treatment quadrant	- 15.9%	
				Photo-radar quadrant	- 7.5%	
				RLC quadrant	- 9.7%	
				Control quadrant	- 10.7%	
Fox (1996)[21]	Glasgow, Scotland	Installed at 8 intersections and 3 "pelican" crossings	Area wide effects on injury crashes examined	Crossing carelessly	- 54.0%	RTM effects likely because the decreases in non-RLR crashes are greater than the RLR decreases at times, it is difficult to say what citywide effect the cameras have.
				Unsafe right turn	- 29.0%	
				Failure to keep distance	+ 8.0%	
				Other	- 29.0%	
				All per month	- 32.0%	
Winn (1995)[22]	Glasgow, Scotland	6 locations on 1 approach	Various	Injury crashes related to RLR violations	- 62.0%	Probable RTM effects

* RTM = Regression to the mean, also called "bias by selection."

Safety Impacts of Photo-Red Enforcement at Suburban Signalized Intersections (*Miller et al. 2006*) examined 13 signalized intersections in Fairfax County, Virginia that were equipped with cameras. This study focused on the safety impacts of camera enforcement and differentiated between angle crashes and rear end crashes. Empirical Bayes was used to estimate the number of crashes that would be expected if there were no treatment, and these results were compared to the actual number of crashes that did occur. The results, in contrast to the results of other studies, showed an increase in total crashes of 12% and an increase in injury crashes of 14%. Most previous studies had showed small to moderate decreases in right-angle crashes and small to moderate increases in rear end crashes. If these were balanced, the outcome could be judged positive, especially since it is generally thought that angle crashes are somewhat more severe than rear end crashes. The Fairfax County data, however, revealed a substantial (47.3%) increase in rear end crashes compared to an 11.9% decrease in angle crashes. The study suggested that the RLR cameras can have a negative safety impact.

2.2.2 Reducing Violations

Engineering and enforcement countermeasures can be combined for greater impact. The Insurance Institute for Highway Safety conducted a study of longer yellow signal timing combined with red light camera enforcement (*Retting et al. 2007*). The study looked at six approaches at two intersections where the yellow change interval was increased by about one second for a period of time before red light cameras were installed. (On average, initial yellow times on the side streets were slightly less (.2 seconds) than the ITE recommendation, and the modified yellow times were greater (4.1 seconds compared to 3.2 seconds). On the mainline the initial yellow times were about the same as the ITE recommendation, and the modified times were 4.9 seconds, or one second greater than the ITE recommendation of 3.9 seconds.) The results showed that yellow timing changes reduced red light running violations by 36%, and the introduction of cameras led to a further 96% reduction in red light running violations. This result affirmed findings of an earlier study by Bonneson and Zimmerman (*2004*) where yellow times were increased to be consistent with ITE guidelines. Increases of one second of yellow time led to a 50% decrease in red light running violations.

2.3 CRASH COST COMPARISON

In the Council et al. study for FHWA (*2005b*), researchers chose seven jurisdictions (Howard County, Baltimore, Charlotte, San Diego, San Francisco, Montgomery County, and El Cajon City) for which there was sufficient data available on intersections equipped with cameras and a reference group of intersections not equipped with cameras. The data collected on changes in crashes at the treatment and no treatment sites was analyzed using the Empirical Bayes approach and further analyzed using cost comparisons for different types of crashes.

Empirical Bayes (EB) uses historical crash data to predict the number of crashes that would have occurred if there were no treatment and compares that to the number of crashes that actually did occur. Table 2.3 presents a summary of predicted and actual crashes occurring at the 132 RLRC intersections in the seven jurisdictions included in the study. The analysis is based on an average of six years of pre-RLRC installation data for each site (ranging from four to nine years) and an average of 2.76 years of after-RLRC installation. "Right-angle" crashes are those crashes involving two vehicles approaching the intersection from perpendicular directions or two vehicles making opposite direction left-turns.

Table 2.3: Expected and actual crashes occurring in seven jurisdictions studied

	Right-angle		Rear end	
	Total crashes	**(Definite) injury**	**Total crashes**	**(Definite) injury**
EB estimate of crashes expected in the after period without RLC	1,542	351	2,521	131
Count of crashes observed in the After-period	1,163	296	2,896	163
Estimate of percentage change (standard error)	-24.6 (2.9)	-15.7 (5.9)	14.9 (3.0)	24.0 (11.6)
Estimate of the change in crash frequency	-379	-55	375	32

Source: Council et al. 2005a

As expected, right-angle crashes decreased and rear end crashes increased. The study recognized that right-angle crashes tended to be more severe than rear end crashes. Using crash cost estimates for different types of crashes allows for more accurate comparisons of crashes occurring before and after implementation of a RLR camera at an intersection. FHWA contracted with the Pacific Institute for Research and Evaluation (PIRE) to develop cost estimates for different severity levels for the both the right-angle and rear end crashes. The results were published in the report *Crash Cost Estimates by Maximum Police-Reported Injury Severity within Selected Crash Geometries* (*Council et al. 2005b*).

While cost figures were generated for all crash levels, ultimately only two severity categories were used in the analyses (injury and non-injury). Table 2.4 presents the figures by crash level. Crashes are classified as severity level K if one or more persons were killed; level A if one or more persons received a disabling injury; level B if one or more persons received a moderate injury; and level C if one or more persons received a possible injury. The cost estimates in the bottom two rows were used in the analysis. The analysis showed an average crash reduction benefit of approximately $38,000 per site per year where RLR cameras were installed.

Table 2.4: Comprehensive crash cost estimates for urban signalized intersections, by specific severity level (2001 dollars, unadjusted)

Crash severity level	Right-angle crash cost	Rear end crash cost
K	$4,090,042	$3,781,989
A	120,810	84,820
B	103,468	27,043
C	34,690	49,746
O (standard deviation)	8,673 (1,285)	11,463 (3,338)
K+A+B+C "injury crash" (standard deviation)	$64,468 (11,919)	$53,659 (9,276)

Source: Council et al. 2005a

The Council et al. study (*2005b*) provides the basis for the analysis required for the current study. Table 2.5 is generated from information presented in the report. The report presents data in 2001 dollars. Estimates are for multiple vehicles involved in each type of crash.

Table 2.5: Comprehensive crash cost estimates for urban signalized intersections, by severity level (2001 dollars, unadjusted)

Severity of Crash	Type of Crash			
	Vehicles cross paths	**Rear-end**	**Sideswipe**	**Opposite Direction**
Killed or A injury	$213,113	$84,820	$222,564	$239,933
B or C injury	$46,660	$39,398	$51,211	$119,622
No injury	$8,673	$11,463	$6,007	$5,101

Source: Council et al. 2005b

2.4 CHANGES IN VIOLATIONS

A recent study, *Evaluation of Edmonton's Intersection Safety Camera Program* (*Sayed and de Leur 2007*), included a summary of the literature regarding changes in violations when red light cameras were installed as an enforcement tool. The summary included four studies that compared changes in violations at intersections with cameras to changes in violations at intersections without cameras. The findings of these studies indicated that in three cases the violations decreased more at intersections with cameras (range of 40% to 78%) than those without cameras (range of 27% to 67%). In one study, violations were reduced by 50% at the non-camera sites and 40% at the camera sites.

2.5 SUMMARY OBSERVATIONS

The literature review provided guidance helpful in identifying issues to be considered in developing the evaluation design for the RLR camera installation at Mission and 25th. Studies show that when red light running cameras are installed, angle crashes are likely to decrease, and rear end crashes are likely to increase. The use of crash cost estimates, which provide different values for these crash types for different crash severities, can be adapted for use in the present study. Results of research on changes in violations suggest that violations are likely to decline significantly at intersections after red light cameras are installed.

3.0 STUDY DESIGN

This chapter describes the design for the assessment of the red light running camera installation at the Mission and 25th intersection. It was based on the guidance provided by the literature review and the requirements established in the Memorandum of Agreement.

3.1 FACTORS TO CONSIDER IN DEVELOPING THE STUDY DESIGN

The literature review identified the following specific issues that were pertinent to the development of the study design:

- why the incidence of red light running is high at the Mission and 25th intersection,
- the extent to which engineering countermeasures have been implemented,
- the expected outcome of the installation of red light running cameras,
- methodological issues to be considered in developing the study design, and
- the criteria to be used to review camera operation after the trial period.

3.1.1 Incidence of Red Light Running

The following characteristics of red light running identified in Section 2.1.1 were present at the Mission and 25th intersection:

- The traffic volumes are above capacity.
- The phases monitored by the red light cameras often max out so the green terminates even though a vehicle occupies the approach.
- Drivers are less likely to stop if traveling within a platoon through a series of interconnected signals. They believe they should be able to travel without interruption through successive intersections.
- Drivers who are closely following another vehicle are more likely to proceed through a yellow or red indication.
- Drivers who are being closely followed are likely to continue through the intersection to avoid a rear end collision.
- Drivers are less likely to stop as the expected delay increases. The cycle length is 130 seconds during most of the day.

3.1.2 Engineering Countermeasures

Many of the engineering countermeasures identified in Table 2.1 were implemented at the Mission and 25th intersection. The following list provides an examination of the extent of implementation and possible additional modifications.

The signal operation and motorist information countermeasures from Table 2.1 appear in **boldfaced type.** The status of implementation at the Mission and 25th intersection is given.

Increase yellow interval duration. The yellow clearance times meet or exceed the standards established by ITE. The westbound left turn phase has one second of all red.

Provide green-extension. Advance detection provides for green extension; however, when the signal is operating in coordination and the intersection is congested, the green ends at a pre-established time without consideration of vehicles approaching.

Improve signal coordination. This signal is part of a coordinated signal system that is frequently monitored and adjusted as needed. The system includes five intersections on Mission Street SE from Interstate 5 to 25th Street SE. The system begins operating at 6:30 a.m. with a 130-second phasing plan that favors westbound traffic going into the city center. It stops operating at 6:15 p.m. with a phasing plan (also 130 seconds long) that favors eastbound traffic. In the mid-morning and on weekends, the coordinated system does not operate; the signals are traffic actuated.

- **Improve signal operation**. Signal operation is monitored closely and modified as appropriate.
- **Improve sight distance**. There are no sight distance problems at this intersection.
- **Improve visibility of signal (12" heads, add heads)**. All signal heads are 12 inches. To improve visibility, an advance signal head was added for the westbound left turn shortly before the red light cameras were installed.
- **Improve visibility of signal with yellow LEDs**. Yellow LEDs have been installed at this intersection.
- **Increase conspicuity of signal with back plates**. All signal heads at this intersection are equipped with back plates.
- **Advance warning signs**. Warning signs have been posted. An example appears in Figure 1.2. The signs posted are consistent with the 2003 edition of the *Manual on Uniform Traffic Control Devices (MUTCD)*. An advance traffic control sign (W3-3), which is a yellow sign with black lettering, is used with a rider that says "Photo Enforced," It is standard practice that signs displayed together are the same color. The sign posted at the city limit (Figure 1.1) is white with black lettering, which is the standard used for regulatory signs.
- **Add flashers to advance warning signs**. No flasher, flag, or other devices have been used to improve motorist notification that red light running is being enforced using cameras.

3.1.3 Expected Outcome of the Installation of Red Light Running Cameras

Previous study results have indicated that a reduction in right-angle crashes can be expected. While rear-end crashes also may increase, they are not normally as serious as angle crashes; so there is normally a reduction in crash cost estimates following the implementation of RLR cameras. Review of the literature has also showed that installation of cameras can be expected to lead to a reduction in RLR violations as long as the public is aware that the cameras are operating. This is done through signage at the intersection and public information activities.

3.1.4 Methodological Issues

Methodological issues identified in other studies that were potentially relevant to this study included:

- Spillover to other locations is sometimes not quantified which leads to an underestimate of effect.
- An effect cannot be documented due to comparatively few red light running related crashes.
- Signal timing adjusted in the middle of the study period makes the impact difficult to interpret.
- The study does not control for effects of other factors such as traffic volume changes.
- The number of treatment sites limits significance of the results.
- Types of crashes and their severity should be assessed; determination of the economic cost of crashes is suggested.
- Public education should be identified, tracked, and measured.

3.2 THE STUDY DESIGN

3.2.1 Questions to be Answered

The following questions were considered in the study design:

- Was there a change in crashes of different types at the Mission and 25th intersection due to the installation of RLR cameras? What does a cost-benefit analysis, which considers accident type and severity, reveal?
- Were there changes in crashes at nearby intersections – the Mission and Airport and Mission and Hawthorne intersections?
- Was there a change in red light running violations at the Mission and 25th intersection? What approaches were affected?

3.2.2 Data Collection

Crash data were obtained from the ODOT Crash Analysis and Reporting (CAR) Unit, which performed crash queries of the Statewide Crash Data System for the calendar years 2004 to 2009. Because the RLR cameras were installed at the Mission and 25th intersection on February 29, 2008, the period from January 2004 to February 2008 was considered as the pre-camera period, while April 2008 to December 2009 was considered as the post-camera period. The 50-month pre-camera period was chosen for several reasons. Utilization of as much data as possible provided a stable statistical base for analysis. Since January 2004 the crash reporting requirements have been consistent; utilization of data from an earlier period would have introduced inconsistencies. A review of the crash data for the 2004 through 2007 time period indicated fairly consistent crash levels, avoiding the necessity to account for an existing crash trend. The month after camera installation, March 2008, was not included in the study, as only warnings were being issued during this period. It is referred to in some of the tables as "buffer."

The layout and traffic patterns at the Mission and 25th intersection were evaluated to determine the intersection influence area, e.g., the number of feet on each approach within which drivers are influenced by the operation of the traffic signal. Both the location of the Red Light Camera enforcement signs and the approach queue lengths were measured, and the shorter of the two distances was selected and used as the basis for the crash data queries. In the westbound direction a distance of 800 feet east to 50 feet west of the intersection was used for the queries. In the northbound direction a distance of 600 feet south to 50 feet north of the intersection was used. For comparisons of crashes occurring at the three intersections on Mission (25th, Airport, and Hawthorne) a consistent area of influence of 300 feet upstream and 50 feet downstream was used.

In the state of Oregon, only drivers are required to report non-injury crashes; thus if there is no injury, often no police report is filed. If the crash information is based only on a driver's report (or reports filed by multiple drivers) the accuracy and completeness is often affected. Given these data limitations, it was not feasible to analyze whether the crashes occurring at the intersection were related to the signal operation.

Additional data collected included:

- Media coverage;
- Traffic volumes; and
- Violation information.

Inquiries were made to determine if there were changes in signal timing or in signage during the study period. It was found that no such changes were made.

3.2.3 Data Analysis Design

The following comparisons were made:

- Crashes at the Mission and 25th intersection and the two nearby intersections, Mission and Airport Road and Mission and Hawthorne Avenue.
- Crashes involving one or more vehicles traveling in the south-to-north or south-to-west directions at the Mission and 25th intersection. Only crashes where the at-fault driver was traveling in one of these directions were included. Crashes occurring in an alley (driveway) were eliminated.
- Crashes involving one or more vehicles traveling in the east-to-west or east-to-south directions at the Mission and 25th intersection. Only crashes where the at-fault driver was traveling in one of these directions were included. Crashes occurring in an alley (driveway) were eliminated.
- Red light running violation data for the Mission and 25th intersection for both the east-to-west or -south directions and the south-to-north or -west directions.

3.2.4 Criteria for Determining RLRC Effectiveness

The Memorandum of Agreement called for the establishment of a method or criteria to be used to determine the effectiveness of the RLR cameras at the end of the 18-month test period, which would have been September 2009. Since crash data for the January through September 2009 period were not available until the data for the entire 2009 calendar year were published, the researchers reviewed the crash and violation data for the entire 2009 calendar year. This was the first 21 months of camera operation. Based on the review of the literature, the following criteria were used to measure RLR camera effectiveness:

1. No increase in crashes at the Mission and 25th intersection. A comparison would also be made to crashes occurring at the two nearby intersections. The analysis would take into consideration any significant changes in volumes at the three intersections.
2. No net increase in the economic cost of crashes associated with the relevant signal operations. (This analysis would be based on the cost data given in Table 2.6.)
3. An approximately 25% reduction in red light running violations from March 2008 to March 2009 (and sustained through calendar year 2009) for both the northbound and westbound approaches to the Mission and 25th intersection.

3.3 SUMMARY

The time period selected for the analysis of crash history and violations issued was the 50 months prior to the camera installation through the first 21 months that citations were issued for red light running. This was January 1, 2004 through February 29, 2008 for the pre-implementation period and April 1, 2008 through December 31, 2009 for the post-implementation period. Additionally, press releases about the camera installation were compiled for this same time period.

4.0 FINDINGS

Chapter 4.0 presents the data collected before and during the study and discusses the findings. Section 4.1 focuses specifically on the Mission and 25th intersection westbound and northbound directions subject to the RLR camera's influence. Analyses of crash rates, location of crashes within the influence area, and crash costs based on type and severity of crash are presented. Section 4.2 provides a comparison of the Mission and 25th intersection with two nearby intersections with the objective of providing context for the previous analysis by examining general crash trends at nearby intersections in the corridor. Violation rates and press releases are addressed in Sections 4.3 and 4.4 respectively.

4.1 MISSION AND 25TH INTERSECTION CRASH ANALYSIS

The crashes occurring in the westbound and northbound directions of the Mission and 25th intersection before and after the installation of the red light running camera were compared.

4.1.1 Crashes

There were 21 months of crash data available following the installation of the camera; 50 months of crash data were used for the period prior to the camera installation. In order to best utilize all of the crash data available, a monthly average of crashes was used to make the comparison (Table 4.1). March 2008 was not included in the analysis, as it was the month after installation and was considered a buffer between the pre- and post-installation periods. It was found that in

Table 4.1: Monthly crashes before and after RLRCs installed northbound and westbound directions, Mission Street SE and 25th Street SE

	Before RLRC						**After RLRC**	
	2004	2005	2006	2007	2008		2008	2009
January	1	1	0	0	2			1
February	1	0	0	1	1			1
March	0	0	3	0			(Buffer)	2
April	0	1	0	2			1	2
May	1	2	0	0			2	0
June	1	1	0	0			0	0
July	0	1	0	0			0	0
August	2	0	1	2			0	0
September	0	0	2	0			3	4
October	0	0	0	1			1	2
November	0	1	1	0			0	1
December	0	1	1	0			1	2
			Total "before"		31		Total "after"	23
			Monthly Avg.		0.62		Monthly Avg.	1.10

the 50 months prior to the camera installation there was an average crash rate of 0.62 crashes per month. In the 21 months after installation, this rate increased to an average of 1.10 per month. This was a 77.4% increase.

The number of crashes following the installation of the red light running cameras showed a marked increase. Comparing the pre-RLRC period from January 2004 through February 2007 (31 crashes in 50 months) to the post-RLRC period from April 2008 through December 2009 (23 crashes in 21 months) by the rate-quality control method (*Stokes and Mutabazi 1996*) revealed that the increase in crashes was statistically significant ($p < 0.05$). The rate-quality control method was appropriate for the comparison of crash rates within the two periods (crashes per million vehicles) and provided a direct comparison of post-RLRC condition to the pre-RLRC baseline crash data. Testing for seasonal variance was negative, which assured that the seasonally shifted period comparison was valid.

An additional analysis was performed to look independently at each direction of travel directly affected by the camera installations. The average crashes per month for the 50 months prior to the camera installation were compared to the average crashes per month for the 21 months after the camera installation (Table 4.2). Again in this analysis, March 2008 was not included. It was found that average monthly crashes in the westbound direction increased by 116 percent, from .44 crashes per month to .95 crashes per month, while average monthly crashes in the northbound direction were reduced by 22 percent.

Table 4.2: Monthly crashes by direction, Mission St. SE and 25th St. SE intersection

	Average Monthly Crashes Occurring Pre-Installation (January 2004-February 2008)	Average Monthly Crashes Occurring Post Installation (April 2008-December 2009)	Percentage Change
Westbound	.44	.95	116%
Northbound	.18	.14	-22%

4.1.2 Crash Location

A crash location in the form of a milepoint is included in the crash data for crashes occurring on the statewide highway system. Given the coded milepoint for the intersection, 7.54 in 2004 and 2005 and 7.52 in 2006 to the present, it was possible to examine the crashes occurring on Mission Street SE and determine the distance from the intersection. Crashes occurring on city streets do not include a milepoint; therefore the crashes occurring on 25th Street SE were not included in the crash location analysis.

While the area of influence of the intersection on Mission Street SE was determined to be 800 ft west to 50 ft east for drivers traveling westbound, the crash that was the farthest from the intersection occurred at 528 ft. Locations of crashes occurring before and after the cameras were installed were compared, and it was found that the increase in crash rate in the post-camera installation period tended to be greater at distances closer to the intersection. Figure 4.1 presents a visual representation of this data with the milepoint being converted to feet and the crash rates converted into average yearly crashes.

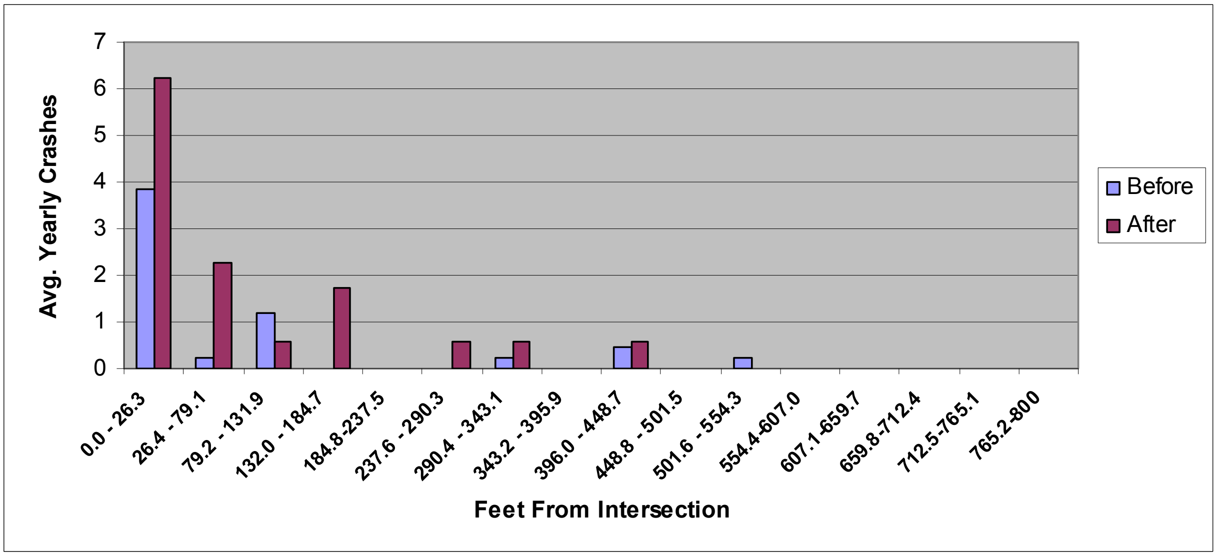


Figure 4.1: Distribution of crashes on Mission Street SE within the area of intersection influence for the pre- and post-camera installation periods

4.1.3 Crash Costs

The overall cost of the crashes occurring in the westbound and northbound directions of the Mission and 25th intersection was analyzed before and after the red light camera installation. The analysis employed the estimated cost per crash figures presented in Table 2.6. Crashes in which more than one injury occurred were counted only once, classified by the most severe injury. No fatal crashes or injury severity “A” crashes occurred at the intersection at any time during the study. It was found that the average monthly cost of the crashes in the 21-month post-installation period (Table 4.4) was approximately 70% higher than the average monthly cost of crashes prior to installation (Table 4.3). The crashes prior to the installation did have a higher percentage of injury crashes and included turn and angle crashes. Despite the fact that the post-installation period contained primarily rear end crashes, the increase in average monthly crashes led to an overall greater cost after installation.

Table 4.3: Average monthly crash costs by type of crash and injury prior to RLRC installation (50 months)

Before Installation	No Injury			Injury B or C			Total	
	Number Crashes	Estimated Cost ($) per Crash	Average Monthly Cost ($)	Number Crashes	Estimated Cost ($) per Crash	Average Monthly Cost ($)	Number Crashes	Average Monthly Cost ($)
Rear End	11	$11,463	$2,522	13	$39,398	$10,243	24	$12,765
Sideswipe	1	$6,007	$120	1	$51,211	$1,024	2	$1,144
Turn/Angle	3	$8,673	$520	2	$46,660	$1,866	5	$2,387
Total	15		$3,162	16		$13,134	31	$16,296

Table 4.4: Average monthly crash costs by type of crash and injury after RLRC installation (21 Months)

After Installation	No Injury			Injury B or C			Total	
	Number Crashes	Estimated Cost ($) per Crash	Average Monthly Cost ($)	Number Crashes	Estimated Cost ($) per Crash	Average Monthly Cost ($)	Number Crashes	Average Monthly Cost ($)
Rear End	8	$11,463	$4,367	12	$39,398	$22,513	20	$26,880
Sideswipe	3	$6,007	$858	0	$51,211	$0	3	$858
Turn/Angle	0	$8,673	$0	0	$46,660	$0	0	$0
Total	11		$5,225	12		$22,513	23	$27,738

4.2 CRASH DATA COMPARISON: THREE INTERSECTIONS

In order to better understand whether the increase in crashes occurring at the Mission and 25th intersection was typical, crash rates were examined at two nearby intersections on the Mission St. corridor. A map of the intersections is displayed in Figure 4.2 below, with the red marker located at Mission and 25th Street SE, the blue marker at Mission and Airport Road SE, and the green marker located at Mission and Hawthorne Avenue SE.

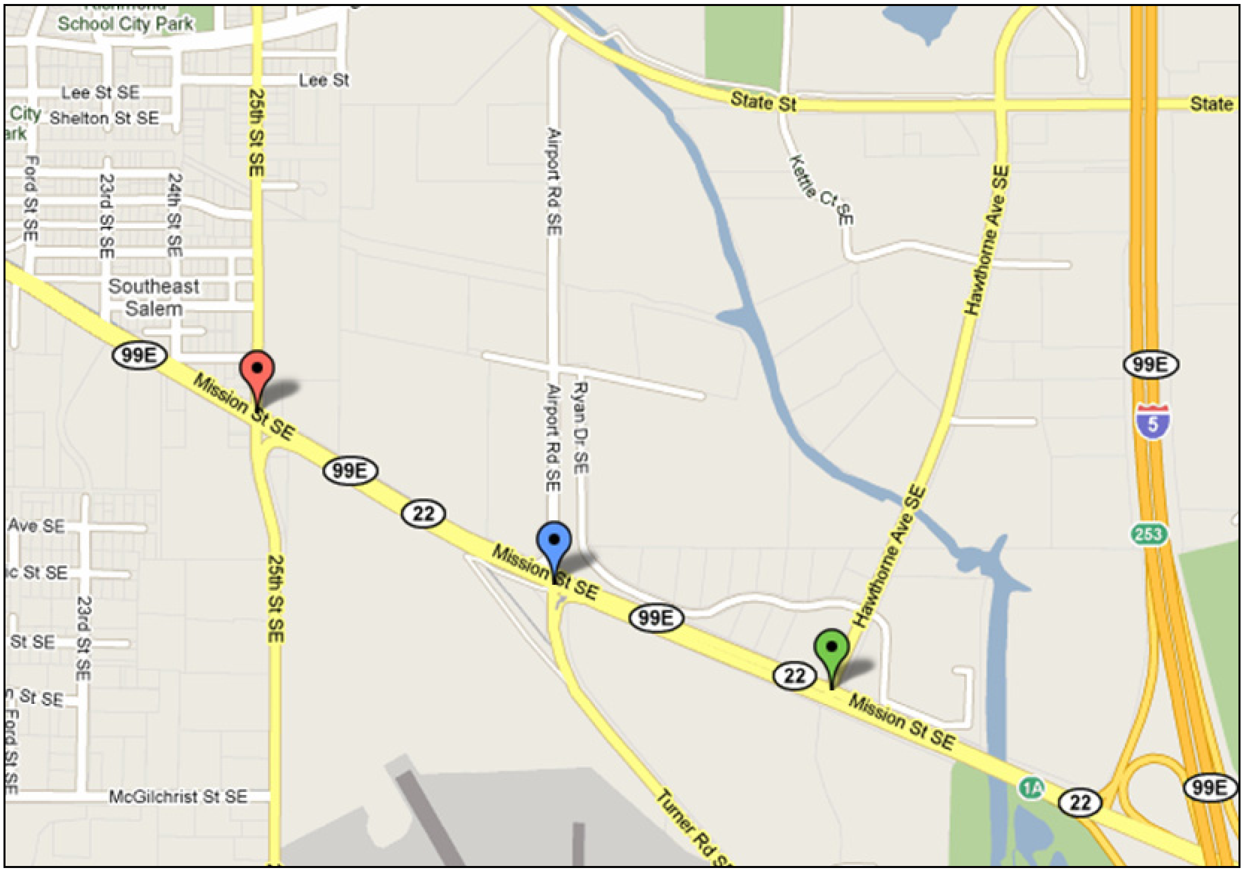


Figure 4.2: Map of Mission Street intersection locations

While the analysis presented in Section 4.1 of the red light camera at Mission and 25th targeted the specific area of influence of the intersection in the westbound and northbound directions, using the same distances was not appropriate for all three intersections, as the different intersections had varying areas of influence (length of queues etc.). Therefore a constant distance of 300 feet for all approaches for all three intersections was selected. It is important to note that because this analysis used a different distance from the intersection than in Section 4.1, the data relating to the Mission and 25th intersection will be slightly different.

Table 4.5 presents monthly averages for all crashes during the 50 months prior to red light running camera installation and the 21 months following installation. The month of March 2008 was excluded from the analysis. Crashes where the at-fault driver was westbound on Mission or northbound on the side street are also shown for the three intersections.

Table 4.5: Average monthly crashes pre- and post-RLRC installation

Intersection	Average Monthly Crashes		
All crashes	**Pre-RLR Camera Installation**		**Post-RLR Camera Installation**
Mission Street SE and 25th Street SE	1.54		1.90
Mission Street SE and Airport Road SE	1.00		1.05
MissionStreet SE and Hawthorne Avenue SE	0.86		0.86
Crashes where at fault driver was traveling westbound			
Mission Street SE and 25th Street SE	0.40		0.95
Mission Street SE and Airport Road SE	0.54		0.33
Mission Street SE and Hawthorne Avenue SE	0.38		0.29
Crashes where at fault driver was traveling northbound			
Mission Street SE and 25th Street SE	0.16		0.14
Mission Street SE and Airport Road SE	0.06		0.14
Mission Street SE and Hawthorne Avenue SE	not applicable		not applicable

Source: Statewide Crash Data System

Average monthly traffic crashes increased at two of the three intersections. At the Mission and 25th intersection, crashes increased from 1.54 per month before the cameras were installed to 1.90 after the cameras began to operate. This was a 23.4% increase. The increase in crashes at the Airport Road intersection was 5%. There was no change in the monthly crash rate at Mission Street SE and Hawthorne Avenue SE. The rate of crashes involving vehicles traveling westbound decreased at the Airport Road (39%) and Hawthorne Avenue (24%) intersections but more than doubled at 25th Street. The rate of crashes involving vehicles traveling northbound decreased by 12.5% at 25th Street SE; at Airport Road the rate more than doubled what it had been before the cameras were installed. In short, the crash rate increased substantially more at the Mission and 25th Street intersection than at the nearby intersections, specifically due to the increase in crashes in the westbound direction.

Average daily traffic (AADT) recorded at two count locations on Mission Street was evaluated to determine if the crash data should be normalized to account for a change in volume. The counts at both locations were averaged for the years 2004 to 2007 (the pre-installation period) and compared to the average for 2008 and 2009 (the post-installation period). It was found that traffic volumes declined by 7.0% at the count location west of 25th Street and by 7.6% at the location east of 25th. Based on this evaluation, the data were not normalized.

4.3 VIOLATIONS

Violation data from Redflex, Inc. for the Mission and 25th intersection are shown in Table 4.6. Violations recorded by RLR cameras do not always lead to the issuance of a citation. Citations are determined by taking the total number of violations and subtracting controlled (rejects) and uncontrolled factors. Rejects are factors that are within the control of the police or vendor, e.g., camera out of focus, or red lights not visible. Uncontrolled factors are those that are beyond the control of the police or Redflex, e.g., license plate or face blocked by traffic, inaccurate DMV information, or gender mismatch. To make the data easier to view, Figure 4.3 presents the same violation data graphically, showing changes in violations issued over the 21-month study period.

Table 4.6: Red light running violations for the Mission St. SE and 25th St. SE intersection

Month	Westbound Direction	Percent change from March 2008	Northbound Direction	Percent change from March 2008
Mar-08	240		63	
Apr-08	201	-16.3%	41	-34.9%
May-08	221	-7.9%	64	1.6%
Jun-08	161	-32.9%	45	-28.6%
Jul-08	152	-36.7%	41	-34.9%
Aug-08	130	-45.8%	64	1.6%
Sep-08	157	-34.6%	52	-17.5%
Oct-08	130	-45.8%	44	-30.2%
Nov-08	122	-49.2%	37	-41.3%
Dec-08	140	-41.7%	23	-63.5%
Jan-09	98	-59.2%	40	-36.5%
Feb-09	94	-60.8%	37	-41.3%
Mar-09	96	-60.0%	36	-42.9%
Apr-09	113	-52.9%	46	-27.0%
May-09	140	-41.7%	30	-52.4%
Jun-09	132	-45.0%	60	-4.8%
Jul-09	158	-34.2%	71	12.7%
Aug-09	174	-27.5%	72	14.3%
Sep-09	121	-49.6%	69	9.5%
Oct-09	126	-47.5%	61	-3.2%
Nov-09	102	-57.5%	50	-20.6%
Dec-09	89	-62.9%	41	-34.9%
Average Change from March 2008		-43.3%		-22.6%

Source: Redflex, Inc.

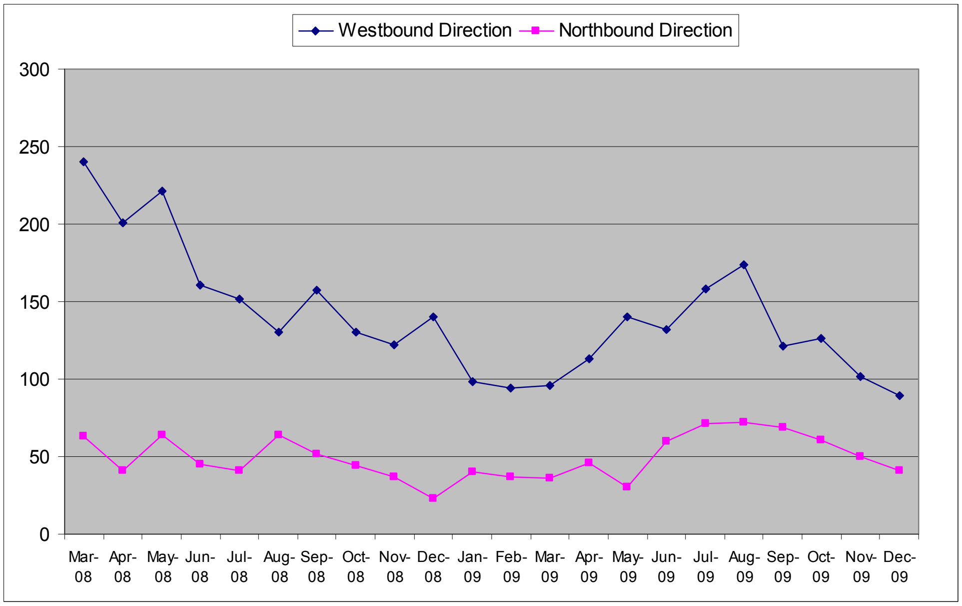


Figure 4.3: Red light running violations, Mission Street SE and 25th Street SE intersection

At the outset of the research project it was expected that the RLR camera program would result in a 25% reduction in red light running violations from March 2008 to March 2009 for both the westbound and northbound approaches to the Mission and 25th intersection. It was also thought that this could be sustained through the end of the review period.

The following observations may be made from the data:

- The data in Table 4.6 show that violations in the westbound direction declined from 240 in March 2008 to 96 in March 2009. This is a 60 percent reduction by the end of one year of camera operation. The average monthly reduction over the entire 21 months of the study period was 43 percent.
- The data in Table 4.6 show that the violations in the northbound direction declined from 63 in March 2008 to 36 in March 2009. This is a 43 percent reduction. The average monthly reduction over the entire 21 months of the study period was 23%.

Table 4.7 presents violation data by direction of travel. At this intersection, in both the westbound and northbound approaches, left-turning vehicles accounted for the overwhelming majority of the violations. This may be explained by the fact that there was proportionately less green time per vehicle being provided for left-turning traffic than for through traffic.

Table 4.7 Red light running violations, by direction of travel, April 2008-December 2009

Direction of Travel	Left Turn	Percent	Through	Percent	Total
Westbound Mission St. SE	2177	76.0%	688	24.0%	2865
Northbound 25th St. SE	794	77.5%	230	22.5%	1024

4.4 PRESS RELEASES

The City of Salem and the Statesman Journal cooperated in providing the public with information about the red light running camera program. Articles provided background information initially on the potential for the program and later on the selection of locations and agreements reached with ODOT regarding review requirements for the Mission and 25th intersection. After the end of the one-year review period there were articles about the results of the program and possibilities of expanding the program to additional locations. Table 4.8 summarizes the articles that appeared in the Statesman Journal regarding red light running.

Table 4.8: Summary of articles appearing in the Statesman Journal, 2003-2009

Date	Title	Topics included
8/4/2003	Salem may get photo radar	Proposed state law to allow photo radar
		Explanation of how photo radar works
		Could implement along with RLR cameras which were approved in 2001.
11/20/2005	Red light camera results are mixed	Salem considering installing RLR camera
		Results from Portland and national studies are mixed: right angle/T-bone collisions down, but rear-end crashes up
8/20/2006	Council to address parking, cameras	City council to vote on RLR cameras
		Cameras make intersections safer without hiring personnel
10/1/2007	State green-lights Salem's preferred site for red light camera	Salem received final approval from ODOT for cameras at Commercial/ Marion St. intersection
		ODOT balking at proposal for cameras at Mission and 25th Sts SE due to low crash volume
		Salem will pay Redflex $200,000 per year to install and monitor cameras at 2 intersections
		Mission and 25th intersection selected due to highest number of RLR violations
		ODOT suggested other locations with more crashes
		Drivers receive ticket for $237 in the mail
10/22/2007	City, ODOT OK red light camera plans	Agreement between city and ODOT allows cameras to operate for 18-month trial period
		ODOT will look at whether cameras influence red light running behavior at other intersections
		Explanation on how cameras work
11/27/2007	Municipal Court docket soon will get more crowded	Red light enforcement program expected to add 25,000 citations per year
2/18/2008	Salem expects to activate red light camera system within days	Red light camera system should be operating within a few days
		Warnings will be issued by the end of the month
		Explanation of how the citation is issued and how the public should respond
		A sworn officer must review each potential violation
2/26/2008	Salem installs first red light cameras	Photo red light program will begin February 29 at 25th St SE and Mission St. SE
		How system works
		Once program is operational there will be 30 day period in which only warnings will be issued
7/5/2008	Red light cameras catch drivers red-handed	Salem police release two videos of violators
		1223 citations issued since April 1
		112 were issued to northbound traffic on 25th at Mission
		379 were to westbound traffic on Mission
		732 were to southbound traffic on Commercial at Marion St.
5/6/2009 5/20/2009 5/27/2009	City may add two cameras	Crashes at sites that have red light cameras are down by 14 percent
		Cameras may be installed at Lancaster and Center and Silverton and Fisher
		Net income to city after one year is $266,000
		Supporters say cameras improve safety and free-up police
		Critics say the system is simply about boosting revenue
		4 other intersections considered for cameras but data did not support need
July 2009	Salem Police Department recognizes "National Stop On Red Light" week	August 2-8 is National Stop on Red Light week
		1000 Americans die in crashes due to red light running
		First year of red light cameras resulted in 14 % reduction in crashes and 45% reduction in violations
		Video clips show drivers running the red light

5.0 CONCLUSIONS AND RECOMMENDATIONS

Red light running cameras were installed on a trial basis to determine if the presence of cameras would reduce red light running violations and the potential of these violations to cause serious traffic crashes. This section summarizes the results of the trial period for red light running (RLR) cameras installed at the Mission and 25th intersection in Salem. Based on the results, recommendations are made about what this study suggests for the continued use of RLR cameras at the Mission Street SE location. Suggested revisions to the *Red Light Running (RLR) Camera Guideline*s are also discussed.

5.1 CONCLUSIONS

The literature review indicated that red light running is a widespread problem and that, in response, many jurisdictions have implemented engineering improvements and installed red light running cameras. Engineering countermeasures made to address red light running include changes in signal timing, additional signing, and advance signal heads. Supplementing these improvements with red light running cameras can be effective if there continues to be a large number of crashes (often angle crashes) due to red light running. The results of various research studies on the effects of red light running cameras indicate that, when cameras are installed, angle crashes are likely to decline; whereas rear end crashes are likely to increase.

The Mission and 25th intersection has good sight distance and good visibility, and signal timing has been adjusted to include an all-red signal phase. These conditions may explain why the pre-camera crash history at this intersection indicated that there were very few angle crashes, which are often the result of red light running.

A before and after study of the crashes occurring at the Mission and 25th intersection was completed. The analysis considered crashes occurring in the direction of the cameras, westbound and northbound, within the intersection's area of influence. It was found that in the 50 months prior to the camera installation there was an average of 0.62 crashes per month. In the 21 months after installation, this number increased by 77.4% to an average of 1.10 per month. When the crash rate was analyzed by direction of travel, it was found that average monthly crashes in the westbound direction increased by 116 percent, while average monthly crashes in the northbound direction were reduced by 22 percent. Crash location within the established intersection area of influence was examined, and it was found that not only were a majority of the crashes located close to the intersection, but the increase in crashes also was greater closer to the intersection.

Crash cost estimates for different types of crashes make it possible to compare crashes occurring before and after cameras are installed and account for the expectation that RLR cameras are likely to result in fewer angle crashes, which are often severe, and more rear end crashes, for which injuries tend to be less severe. Using data from a 2005 Federal Highway Administration study, it was possible to estimate crash costs at the Mission and 25th intersection (*Council et al. 2005b*). The estimated average monthly crash costs increased from $16,296 before the cameras were installed to $27,738 after the cameras were installed. There was a higher percentage of injury crashes (including turn and angle) prior to the cameras being installed, but, despite the post-installation period containing primarily rear end crashes, the overall increase in crash rate led to an overall greater cost after installation.

Crash data from two nearby intersections were compared with corresponding data at Mission St. and 25th to evaluate whether the trend at the intersection was occurring throughout the corridor. It was found that the crashes increased substantially at the Mission at 25th intersection, whereas they increased only slightly or not at all at the Airport Rd. SE and Hawthorne Avenue SE intersections. It was found that traffic volumes declined slightly (7% at the count location west of the intersection and 7.6% at the count location east of the intersection) from the pre- to post-camera installation periods; thus the crash data was not normalized.

Violation data from Redflex for the Mission and 25th intersection was reviewed. Violations in the westbound direction declined in the first year from 240 in March 2008 to 96 in March 2009, a 60% reduction. The average monthly reduction from March 2008 for the period from April 2008 through December 2009 (the end of the study period) was 43 percent. Violations in the northbound direction declined from 63 in March 2008 to 36 in March 2009, a 43% reduction. The average monthly reduction from March 2008 for the period from April 2008 through December 2009 was 23%. At both the westbound and northbound approaches, left-turning vehicles accounted for the overwhelming majority of the violations. This may be due to proportionately less green time for left-turning traffic than for through traffic.

5.2 RECOMMENDATIONS REGARDING RLR CAMERAS AT THE STUDY LOCATION

Red light running cameras were installed on a trial basis to determine if the presence of cameras would reduce red light running violations and the potential of these violations to cause serious traffic crashes.

Due to a significant increase in crashes at the Mission and 25th Street intersection during the trial period of red light running camera operation, ODOT and the City of Salem should work together on a process for removal of the cameras that would consider the terms of the Memorandum of Agreement.

Signal timing revisions to allow for more green time for the left-turning vehicles on both the east and south approaches should be considered. Currently green time for the vehicles traveling from south to west can be as low as five seconds if a pedestrian activates the “WALK” signal to cross Mission Street SE. Drivers who are the third or fourth in line and have waited for nearly two minutes for the signal to turn green expect to be serviced, but may not be if the left turn phase is shortened.

Reinforcement of the seriousness of RLR through a public awareness program should be considered.

5.3 RECOMMENDED REVISIONS TO RLR CAMERA GUIDELINES

The *Red Light Running (RLR) Camera Guidelines, 2004* (*ODOT 2004*) provide guidance on implementing legislation regarding RLR cameras. The *Guidelines* state that "RLR Cameras should be installed only where a safety problem with red light running has been documented and then only after other means have failed to solve the problem." Other means include assuring proper sight distance, assuring that speed zones are consistent with engineering practice, assuring that the number, size, and location of vehicle heads are consistent with the MUTCD and Oregon traffic signal policies, and assuring that the signal timing is consistent with traffic volumes, speed, and specific intersection design elements. The 2004 *Guidelines* also require jurisdictions wanting to install red light cameras on a state highway to submit a Safety and Operations Report to ODOT. The report was to address crash history; crash potential; design, operations and maintenance issues; a public information campaign; and budget.

The Mission and 25th intersection represents a good example of the effective use of engineering countermeasures to reduce the impact of red light running. There are a large number of red light running violations, but the use of all-red clearance times, advance signal heads, and other measures to improve visibility have both prior to and since the installation of RLR cameras minimized the impact of red light running.

An interim report for this research project suggested that revisions be made in the *RLR Camera Guidelines*. In April 2010 the *Guidelines* were revised to strengthen the requirement that engineering countermeasures appropriate for the intersection be exhausted prior to installation of red light running cameras (*ODOT 2010*). The interim report also suggested that use of "crash potential" to support the installation of red light running cameras be deemphasized. The interim report stated, "Crash potential should only be used to reinforce that the problem is likely to continue or get worse due to changes in traffic patterns, volumes, and other considerations."

The revised *Guidelines* allow jurisdictions to include "Safety Concerns" in the required Safety and Operations Report. Safety concerns include traffic citation data, complaints, enforcement observations, speeds, traffic volumes, grades, traffic signal spacing, and proximity to freeway or expressway ramp terminals. "Crash potential" is no longer specifically mentioned.

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APPENDIX A:

OREGON REVISED STATUTES 810.434 AND 810.436 RELATING TO PHOTO RED LIGHT

Appendix A: Oregon Revised Statutes 810.434 and 810.436 relating to photo red light

810.434 Photo red light; operation; evaluation.

(1) Any city may, at its own cost, operate cameras designed to photograph drivers who violate ORS 811.265 by failing to obey a traffic control device.

(2) Cameras operated under this section may be mounted on street lights or put in other suitable places.

(3) A city that chooses to operate a camera shall:

(a) Provide a public information campaign to inform local drivers about the use of cameras before citations are actually issued; and

(b) Once each biennium, conduct a process and outcome evaluation for the purposes of subsection (4) of this section that includes:

(A) The effect of the use of cameras on traffic safety;

(B) The degree of public acceptance of the use of cameras; and

(C) The process of administration of the use of cameras.

(4) By March 1 of the year of each regular session of the Legislative Assembly, each city that operates a camera under this section shall present to the Legislative Assembly the process and outcome evaluation conducted by the city under subsection (3) of this section. [1999 c.851 §1; 1999 c.1051 §327; 2001 c.474 §1; subsection (5) of 2001 Edition enacted as 2001 c.474 §3; 2003 c.14 §491; 2003 c.339 §1; 2005 c.686 §1; 2007 c.640 §1]

810.436 Citations based on photo red light; response to citation.

(1) Notwithstanding any other provision of law, if a city chooses to operate a camera that complies with this section and ORS 810.434, a citation for violation of ORS 811.265 may be issued on the basis of photographs from a camera taken without the presence of a police officer if the following conditions are met:

(a) Signs are posted, so far as is practicable, on all major routes entering the jurisdiction indicating that compliance with traffic control devices is enforced through cameras.

(b) For each traffic control device at which a camera is installed, signs indicating that a camera may be in operation at the device are posted before the device at a location near the device.

(c) If the traffic control device is a traffic light, the yellow light shows for at least the length of time recommended by the standard set by the Institute of Transportation Engineers.

(d) The citation is mailed to the registered owner of the vehicle, or to the driver if identifiable, within 10 business days of the alleged violation.

(e) The registered owner is given 30 days from the date the citation is mailed to respond to the citation.

(f) A police officer who has reviewed the photograph signs the citation. The citation may be prepared on a digital medium, and the signature may be electronic in accordance with the provisions of ORS 84.001 to 84.061.

(2) If the person named as the registered owner of a vehicle in the current records of the Department of Transportation fails to respond to a citation issued under subsection (1) of this section, a default judgment under ORS 153.102 may be entered for failure to appear after notice has been given that the judgment will be entered.

(3) A rebuttable presumption exists that the registered owner of the vehicle was the driver of the vehicle when the citation was issued and delivered as provided in this section.

(4) A person issued a citation under subsection (1) of this section may respond to the citation by submitting a certificate of innocence or a certificate of nonliability under subsection (6) of this section or any other response allowed by law.

(5) A citation for violation of ORS 811.265 issued on the basis of photographs from a camera installed as provided in this section and ORS 810.434 may be delivered by mail or otherwise to the registered owner of the vehicle or to the driver if the driver is identifiable from the photograph.

(6)(a) A registered owner of a vehicle may respond by mail to a citation issued under subsection (1) of this section by submitting, within 30 days from the mailing of the citation, a certificate of innocence swearing or affirming that the owner was not the driver of the vehicle and by providing a photocopy of the owner's driver license. A jurisdiction that receives a certificate of innocence under this paragraph shall dismiss the citation without requiring a court appearance by the registered owner or any other information from the registered owner other than the swearing or affirmation and the photocopy. The citation may be reissued only once, only to the registered owner and only if the jurisdiction verifies that the registered owner appears to have been the driver at the time of the violation. A registered owner may not submit a certificate of innocence in response to a reissued citation.

(b) If a business or public agency responds to a citation issued under subsection (1) of this section by submitting, within 30 days from the mailing of the citation, a certificate of nonliability stating that at the time of the alleged violation the vehicle was in the custody and control of an employee or was in the custody and control of a renter or lessee under the terms of a motor vehicle rental agreement or lease, and if the business or public agency provides the driver license number, name and address of the employee, renter or lessee, the citation shall be dismissed with respect to the business or public agency. The citation may then be reissued and delivered by mail or otherwise to the employee, renter or lessee identified in the certificate of nonliability.

(7) The penalties for and all consequences of a violation of ORS 811.265 initiated by the use of a camera installed as provided in this section and ORS 810.434 are the same as for a violation initiated by any other means.

(8) A registered owner or an employee, renter or lessee against whom a judgment for failure to appear is entered may move the court to relieve the owner or the employee, renter or lessee from the judgment as provided in ORS 153.105 if the failure to appear was due to mistake, inadvertence, surprise or excusable neglect. [1999 c.851 §2; 2001 c.104 §305; 2001 c.474 §2; 2001 c.535 §30a; 2003 c.14 §493; 2003 c.339 §3; 2005 c.686 §2; 2007 c.640 §2]

APPENDIX B:

MEMORANDUM OF AGREEMENT BETWEEN THE CITY OF SALEM AND ODOT

Appendix B:

MEMORANDUM of AGREEMENT
Between the City of Salem and the Oregon Department of Transportation

Subject to review by the Oregon Department of Transportation (ODOT) and the City of Salem after an eighteen-month trial period as provided in this MOU, ODOT has agreed to the installation of Red Light Running Camera (RLRC) equipment by the City of Salem at the intersection of Mission Street (Oregon State Highway OR-22) and SE 25th Street (a City of Salem street).

Based on ODOT policy, ODOT considers both history of crashes and potential for crashes when making decisions about the placement of RLRC at intersections on state highways. As a practice, ODOT has made decisions about placement of RLRC relying primarily on crash data. ODOT's crash data for the Mission and 25th Street intersection shows that there were 77 crashes at this intersection between 2002 and 2006; 4 were angle crashes, normally associated with red light running. However, the intersection of Mission and 25th has one of the highest incidences of red light violations in the City of Salem, as shown in a recent study conducted by the City's RLRC contractor. There were 74 red-light running violations in a twelve-hour period at this intersection. The City of Salem has requested approval for the installation of a RLRC at this intersection because the City feels that the significant number of red light running violations present a real and present safety hazard that create the potential of serious crashes that would result in serious injury or the loss of life. ODOT has agreed to allow the installation of a RLRC at the intersection of Mission and 25th on a trial basis.

During the initial months of the trial period, the City will work with ODOT's Traffic-Roadway Section and its Research Unit to agree on a method to use in studying the effects of the RLRC program in Salem. The decision to conduct the study will be based on mutual agreement between ODOT and the City regarding funding or resources required. At the end of the trial period, the City agrees that the following data will be reviewed with ODOT:

1. The number of angle and rear-end crashes that occur during the trial period compared to the number that occurred during the initial study period of the intersection, as well as the trend – i.e., the increase or decrease over time – of such crashes during the initial study period and trial period, and

2. The number of red-light violations that occur at this intersection during the trial period compared to the number that occurred during the initial study period, as well as the trend – i.e., the increase or decrease over time – of such red-light violations during the initial study period and trial period, and

3. Whether this RLRC appears to reduce the number of red light running violations in a selected geographical area. During the 45 to 60 days after the effective date of this Agreement, and based on resource availability, ODOT agrees to conduct a red light running analysis of two to three additional intersections along Mission Street near the 25th and Mission intersection. ODOT agrees that this analysis will not delay the installation of the RLRC at the 25th and Mission intersection and that the City may request its RLRC contractor to proceed with the process to install the RLRC at this intersection once this Agreement is signed.

The City and ODOT agree that the data compiled during the trial period will be reviewed using a method or criteria mutually agreed upon by the City and ODOT, and as a result of such analysis, the RLRC at the 25th and Mission intersection may be removed. The method and timing of the removal of the RLRC will be done in accordance with the provisions of the City's contract with its RLRC contractor and will not be done in a way that results in any increased cost to the City unless the City initiates the removal of the RLRC. The City agrees that in any future renewal of the contract with the City's RLRC contractor, it will include a provision regarding the timing, method, and cost of moving or removing a RLRC.

The City of Salem views RLRC as an additional important tool in its comprehensive approach to improving the safety of Salem streets and appreciates ODOT's agreement to install a RLRC at the 25th and Mission intersection during this trial period.

City of Salem

Linda Norris Date 10/24/07

Title: Asst. City Manager

Oregon Department of Transportation

Edward G. Fischer Date 10/29/07

Title: