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Report in Brief: City of Albuquerque Yellow Light Timing Change and All-Red Clearance Interval Timing Change Effectiveness Study

Specifics & Findings

In this brief: Our review of the Yellow Light Timing Change and All-Red Clearance Interval Timing Change in Albuquerque, NM focused on determining the traffic safety impact measured by changes in crashes and the cost of crashes.

The full report titled *City of Albuquerque Yellow Light Timing Change and All-Red Clearance Interval Timing Change Effectiveness Study Final Report* can be found at: www.cabq.gov/municipaldev

Main Findings

- Separate analyses of all 20 study intersections and the 18 YLI intersections was completed.
- The all intersection analyses showed a 7% reduction in total crashes, a reduction in the million entering vehicle (MEV) crash rate, and a weak statistically significant reduction in PDO crashes.
- There was an overall 8.1% reduction in the count of total crashes, a reduction in the MEV crash rate from the pre-study to the post-study time period for the 18 yellow light interval timing change intersections, and a weak statistically significant reduction in the angle crash rate.
- The all intersection cost analysis found a small 11-month total cost increase of $60,000.
- There was no change in the comparison intersection count of crashes or MEV crash rate from the pre-study period to the post-study time period in the average of the crash rates for total, fatal, injury, PDO, rear-end or angle crashes.

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While several studies have shown that red light camera (RLC) programs reduce the number and rate of red light running violations (Retting et al., 1999) and RLC systems improve safety (Washington & Shin, 2005), including the 2010 Albuquerque RLC study (ISR, 2010), there are other available countermeasures. Two of these other countermeasures are the subject of this study. RLC systems function by monitoring the status of the traffic signal by an electrical connection to the signal controller (Retting, Ferguson, and Hakkert, 2003).

The overall goal of this study is to report on the safety impact of a change in the yellow light interval timings at 18 of the previous RLC intersections and changes in the all-red light clearance timings at 2 of the previous RLC intersections in Albuquerque, New Mexico on traffic safety measured by changes in total crashes, the type and severity of crashes, and the cost of crashes. This Yellow Light Interval Intervention (YLI) and All-Red Light Clearance Timing (ARL) study is a follow up to the October 2010 RLC report.

This study addresses the following questions:

- What is the impact on crashes of increased yellow light time intervals on safety at signalized intersection approaches that were equipped with cameras?
- What is the impact on crashes of a brief all-red light clearance interval on safety at the two signalized intersection approaches that were equipped with cameras?

The design of this study is based on similar methods used to conduct the RLC camera study completed in October 2010. Originally a 12-month before and after-time frame was considered based on the available post 12 month time period from January 2011 through December 2011 and the pre-time period of January 2010 through December 2010. Because complete crash data was not available for December 2011 we used an 11 month pre-study time period (January 2010 – November 2010) and post-study time period (January 2011 – November 2011).

It is important to note that the RLC system was in operation during calendar year 2010 at most of the study intersections and so the RLC system was in effect during most of the pre-study time frame at most of the study intersections that are part of this study. This is important given that pre- post-studies assumes the study group and comparison (or control) group are similar and that changes detected in the study group, but not the control group, were actually a result of the intervention. We are also not able to disentangle the possible safety effects of the RLC system in the post-time period. There is the possibility that the beneficial effect of the RLC system found in the RLC study extended beyond the end of the program. The study intersections and comparison

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- The YLI intersection cost analysis found a small 11-month total cost decrease of $62,800.
- Appropriate yellow light timings are crucial for intersection safety and all red light clearance intervals help reduce the frequency of red-light running and right angle crashes.
- Because the yellow light timing and all-red clearance interval change occurred right at the time the red light camera (RLC) system was discontinued it is not possible to study the change in the yellow light interval timings and all-red clearance interval without including the time period during which the RLC system was operational.
- We were also not able to account for the possible effect of the RLC in the post-time period. There is the possibility that the moderate net cost benefit of the RLC system found in the RLC study extended beyond the end of the program.
- Like RLC systems yellow light time intervals and all-red light clearance intervals are not a complete remedy to address red light running problems that include crashes at intersections. YLI systems and ARL are one of several possible countermeasures that can be utilized to address crash problems at intersections.

Target Audience:

Department of Municipal Development, City of Albuquerque; Albuquerque City Council; Albuquerque citizens; other local and state government policymakers; law enforcement agencies; and traffic safety researchers.

intersections differ in this important way. For this reason it is difficult to attribute any changes in crashes and crash rates solely to the increases in the yellow light time intervals and the all-red light clearance intervals. It is important to separate the effects of different improvements because studies have shown that treatments vary in their effectiveness.

Separate analyses of all 20 study intersections and the 18 YLI intersections was completed.

Literature Review

According to the National Highway Traffic Safety Administration's (NHTSA) (2011), in 2009 approximately 2,210,000 crashes occurred at intersections or were intersection related. Of these crashes an estimated 1,158,000 crashes occurred at signalized intersections. Approximately 2,299 crashes at the signalized intersections resulted in fatalities, an estimated 370,000 crashes resulted in injuries, and approximately 785,000 crashes were deemed property-damage only crashes. According to the National Safety Council (NSC) (2011), in 2009 approximately 699 fatal crashes plus an estimated 87,100 non-fatal injury crashes occurred at intersections or were intersection related due to a red light running violation. A red light violation occurs when a vehicle enters an intersection some time after the signal light has turned red. Vehicles inadvertently in an intersection when the signal changes to red (i.e. waiting to turn left) are not red light runners. A nationwide study of fatal crashes at traffic signals in 1999 and 2000 estimated that 20 percent of drivers fail to obey traffic signals (http://www.iihs.org/research/qanda/rlr.html).

Several studies have shown that yellow light interval timing increases decrease the frequency of red light running (Bonneson and Zimmerman, 2004; Van der Horst and Wilmink, 1986; and Retting et al., 2008). Retting and Green (1997) reported lengthening yellow light intervals provides red light compliance and sustained safety benefits resulting from fewer crashes. Driver habituation to the yellow light interval change did not appear to occur and reduce the effect on lengthening the interval of the yellow light. Retting el al. (2008) revealed a 36%

Methodology

This study uses three methods to study the effectiveness of RLCs. These methods are common in the traffic safety literature (Ozbay et al., 2009). Our study uses these methods with some slight modifications. In the second and third method we calculate crashes per million entering vehicles (MEV).

A simple before and after study. This method focuses on the comparison of the frequency and rate of crashes by total and type of crash (rear-end and right-angle) for a period of time before the installation of the two interventions and for a similar period of time after the installation of interventions.

Before and after study with a correction for traffic flow. This method adjusts the impact of the two interventions safety from the before to after study periods by correcting for traffic volumes. Traffic volume is an important factor that is influential on travel safety.

Before and after study using comparison intersections. This method uses comparison intersections in order to consider the effects of unrecognized factors. Comparison intersections are defined as intersections that are similar in crash rates, traffic volume, and geographic characteristics.

Cost analysis. This method translates the actual changes in the frequency of crashes from the pre-study to post-study time period to a dollar impact.

Paired Samples T-Test. The Paired Samples T-Test compares the means of two variables. This is a "repeated measures" test and requires a sufficient sample size to statistically measure significant differences before and after a treatment. The sample size of 2 ARL intersections is not large enough to conduct a paired samples t-test and so these 2 intersections are combined with the 18 YLI intersections to create a sample of 20 intersections. A separate analysis of the 18 YLI was completed.

overall decrease of red light running at experimental sites where the yellow light interval was increased by 1 second at 6 approaches at two intersections. However, results from 3 comparison sites were inconsistent. Two of the comparison sites also experienced a decrease of red light running by 23% and 27%, while the third comparison intersection had a 60% increase in red light running violations. A study by Bonneson and Zimmerman (2004) found yellow light intervals should be between 3.2 and 5.4 seconds for approaching speeds ranging from 30 to 60 mph. Red light running was shown to increase when yellow light intervals were less than 3.2 seconds and greater than 5.4 seconds.

Habituation to the increased yellow light interval is a potential side effect (ITE, 2003). The time for one signal cycle to complete is lengthened when the yellow light interval is lengthened. This causes drivers and pedestrians to have to wait longer for their turn to go through the intersection. If the cycle is too long, drivers may habituate to the lengthened signal and enter the intersection later in the cycle in order to avoid having to stop at the excessively long light (ITE, 2003). This would decrease the potential benefits increasing the yellow light interval could bring. Bonneson and Zimmerman (2004) reported yellow light intervals should not exceed 5.5 seconds as longer intervals correlate with a decrease in potential benefits as drivers would begin entering the intersection later in the cycle.

Table 1. Albuquerque Intersection Crashes 2000-2008

Variable	Comparison		Study	
Intersection Count	37		20	
Crash Count	1,196		938	
Average Crashes per Intersection	32.3		46.9	
	Count	Percent	Count	Percent
Fatal	1	0.1%	1	0.1%
Injury	370	30.9%	247	26.3%
PDO	825	69.0%	690	73.6%
Angle	421	35.2%	237	25.3%
Rear-end	775	64.8%	701	74.7%

The goal of implementing an all-red light timing clearance interval is to allow vehicles in the intersection when the light turns from green to yellow to red time to clear the intersection by holding all lights red for a limited time. Although this does not affect the act of running red lights, it has been proven to reduce the number of right-angle crashes at intersections, thereby increasing safety for motorists (ITE, 2003).

Albuquerque Crashes

Between January 2010 and November 2011 there was 1,196 crashes at the 37 comparison intersections, and 896 crashes at the 20 study intersections.

Table 1 displays summary statistics for the 37 comparison intersections and the 20 study intersections. There was one fatal injury crash at a study intersection and one fatal injury crash at a comparison intersection. There were more rear-end crashes and property damage only (PDO) crashes at both study and comparison intersection when compared to angle crashes and injury crashes. Injury crashes made up approximately 31% of all comparison intersection crashes and 26.3% of study intersection crashes. Property damage only crashes accounted for the largest number and percent of all crashes at both comparison intersections (69%) and study intersections (73.6%).

Table 2 reports the count and percent changes in crashes at all 20 study intersections from the pre-study time period to the post-study time period. Between the pre- and post-study period there were 34 (7%) fewer total crashes. By crash severity there were 7 (5.8%) more injury crashes and 40 (11%) fewer PDO crashes. There was one fatal crash in the pre-time period and there were no fatal crashes in the post-time period. By crash type there were 17 (4.7%) fewer rear-end crashes and 17 (13.4%) fewer angle crashes.

Table 2. All Study Intersections Crash Counts

Crashes	Pre-Period Crash Count	Post-Period Crash	Increase/ Decrease	Percent Increase/ Decrease
Total Crashes	486	452	-34	-7.0%
Crash Severity				
Fatal	1	0	-1	-100%
Injury	120	127	+7	5.8%
PDO	365	325	-40	-11.0%
Crash Type				
Rear-end	359	342	-17	-4.7%
Angle	127	110	-17	-13.4%

A separate analysis of YLI intersections and ARL intersections found total crashes decreased by 8.1% for the YLI intersections and increased by 4.7% for the two ARL intersections.

Injury crashes and angle crashes increased by 45.5% and 33.3% respectively for the ARL intersections while for the YLI intersections injury crashes increased 1.8% and angle crashes decreased by 18.3%. PDO crashes decreased by 11.1% for YLI intersections and 9.4% for ARL intersections and rear-end crashes decreased by 4.6% for YLI intersections and 6.5% for ARL intersections. Crashes at the two types of intersections varied by type of intervention, with YLI intersections showing a reduction in total crashes and ARL intersections showing an increase in total crashes.

Table 3 reports on the differences in crashes by MEV crash rates for total crashes, by type of injury and type of crash from the before time period to the after time period for study and comparison intersections There were no statistically significant differences between the pre and post average of MEV crash rates for total, fatal, injury, PDO, rear-end or angle crashes for the comparison intersection as opposed to a weak statistically significant difference for PDO crashes for the study intersections.

For the study intersections there was a reduction in the total crash rate per MEV, the rear-end crash rate and angle crash rate and an increase in the injury crash rate.

Table 3. All Study Intersections and Comparison Intersections Difference in Crashes per MEV

Crashes	Pre-Period Crashes per MEV	Post-Period Crashes per MEV	Difference in Crashes per MEV
Study Intersections			
Total	1.15	1.07	-0.08
Injury	0.28	0.30	0.02
PDO	0.86	0.77	*-0.09
Rear-End	0.85	0.81	-0.04
Angle	0.30	0.26	-0.04
Comparison Intersections			
Total	0.99	0.99	0.00
Injury.	0.30	0.31	0.01
PDO	0.69	0.68	-0.01
Rear-End	0.62	0.67	0.05
Angle	0.37	0.32	-0.05

*p< 0.1, **p<0.05, ***p<0.01, ****p<.0001

Table 4 reports differences in crashes per MEV for YLI intersections only. The differences for angle crashes were weakly statistically significant and no statistically significant differences were found for comparison

Table 4. YLI Study Intersections and Comparison Intersections Difference in Crashes per MEV

Crashes	Pre-Period Crashes per MEV	Post-Period Crashes per MEV	Difference in Crashes per MEV
Study Intersections			
Total	1.13	1.04	-0.09
Injury	0.28	0.28	0.01
PDO	0.85	0.76	-0.09
Rear-End	0.84	0.80	-0.04
Angle	0.29	0.24	*-0.05
Comparison Intersections			
Total	0.99	0.99	0.00
Injury.	0.30	0.31	0.01
PDO	0.69	0.68	-0.01
Rear-End	0.62	0.67	0.05
Angle	0.37	0.32	-0.05

*p< 0.1, **p<0.05, ***p<0.01, ****p<.0001

intersection crashes. No other statistically significant differences were found at the study intersections. Like the all intersection analysis (Table 3) there was a reduction in the total crash rate per MEV, the rear-end crash rate, the PDO crash rate, and angle crash rate and an increase in the injury crash rate.

Table 5. All Study Intersections Estimated Costs

Severity	Actual Before Crashes	Actual After Crashes	Change	Cost per Crash	Calculated Cost
Injury (K+A+B+C)	121	127	+6	$26,000	+$156,000
Possible Injury (O)	365	325	-40	$2,400	-$96,000
Total Crashes	486	452	-34	---	+$60,000

Table 5 reports crash cost changes for the study intersections from the pre-study to post-study time period. As indicated in Table 5 there was a cost increase of $156,000 based on an actual increase 6 injury crashes (increase of 7 injury crashes and a reduction of 1 fatal crash) from January 2011 through November 2011 and a decrease of $96,000 based on an actual decrease of 40 possible injury crashes for the same time period. The YLI and ARL system experienced a small aggregate crash

increase of $60,000 (+$260,000 - $96,000) since the implementation of the YLI and ARL system in January 2011 through November 2011.

Table 6 separates the crash costs by intervention. The YLI intersections experienced a small cost decrease of $62,800 which resulted from an increase of one injury crash and a reduction of 37 possible injury crashes. The two ARL intersections experienced a cost increase of $122,800 based on an increase of 5 injury crashes. Four of five of these injury crashes occurred at the Coors and Central intersection.

Table 6. YLI and ARL Intersection Estimated Costs

Severity	Actual Before Crashes	Actual After Crashes	Change	Cost per Crash	Calculated Cost
Yellow Light Interval Intervention Intersections					
Injury (K+A+B+C)	110	111	+1	$26,000	+$26,000
Possible Injury (O)	333	296	-37	$2,400	-$88,800
Total Crashes	443	407	-36	---	-$62,800
All-Red Clearance Interval Intersections					
Injury (K+A+B+C)	11	16	+5	$26,000	+$130,000
Possible Injury (O)	32	29	-3	$2,400	-$7,200
Total Crashes	43	45	+2	---	+$122,800

Conclusion

This study was designed to address two questions:

- What is the impact on crashes of increased yellow light time intervals on safety at signalized intersection approaches that were equipped with cameras?
- What is the impact on crashes of a brief all-red light clearance interval on safety at the two signalized intersection approaches that were equipped with cameras?

All three analyses for the 20 study intersections showed a weak statistically significant reduction in PDO crashes. The three analyses for the 18 YLI intersections showed a weak statistically significant reduction in angle crashes. We were not able to statistically test for differences for the two ARL intersections.

We were not able to separate the safety effects measured as a decrease in crashes and increase in the cost of crashes at the 18 yellow light timing increase intersections and the 2 all-red light clearance timing increase intersections. This occurred because we were not able to separately statistically analyze the effects on the two all-red light clearance intersections.

We were also not able to separately create comparison group intersections for the yellow light timing increase intersections and all-red light clearance intersections.

All three analyses of the YLI intersections found that angle crashes were statistically significantly reduced. In total there was an 8.1% decrease in total crashes, an 18.3% decrease in angle crashes, a 4.6% decrease in rear-end crashes, an 11.1% decrease in PDO crashes, and a 1.8% increase in injury crashes. We also found a .09 reduction in the MEV total crash rate.

While this occurred we found an overall 4.7% increase in the count of total crashes from the pre-study to the post-study time period for the two all-red light clearance intersections and an increase in the total MEV crash rate at both all-red light clearance intersections.

These findings partly support findings in the literature and cited in the literature review that note appropriate yellow light timings is crucial for intersection safety and that all-red light clearance intervals help reduce both right angle crashes and injuries. The purpose of increasing the yellow light interval is to allow drivers greater reaction time to the changing light, allow vehicles more time to clear the intersection, and to decrease the number of red light runners. The practice of enhancing the yellow light interval in an effort to decrease the number of red light runners has shown promising results from a number of studies. Implementations of both all-red clearance intervals and lengthening yellow light intervals have been shown to increase safety at signalized intersections.

As noted before a pre-test post-test study design assumes that the study group and comparison group are similar and the intervention being studied is the only or primary difference between the pre- and post-time period. Since the RLC system was in place and operational during most of the pre-time period at most of the study intersections this assumption is violated.

We were also not able to account for the possible effect of the RLC in the post-time period. There is the possibility that the moderate net cost benefit of the RLC system found in the RLC study extended beyond the end of the program. For this reason it is difficult to attribute any changes in crashes and crash rates solely to the yellow light time intervals and the all-red light clearance intervals.

A longer post-study period would be useful for studying the benefit of the yellow light timing interval intervention and the all-red clearance timing interval and to better understand if the benefit found in the RLC system extended beyond the end of the program.

Like RLC systems yellow light interval interventions and all-red light clearance intervals are not a complete remedy to address red light running problems that include crashes at intersections. YLI systems and ARL are one of several possible countermeasures that can be utilized to address crash problems at intersections. 

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