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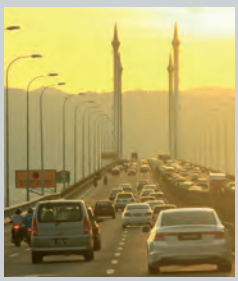

Research Report

The Effectiveness of Automated Enforcement System in Reducing Red Light Running Violations in Malaysia: Pilot Locations

Hawa Mohammed Jamil
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Sharifah Allyana Syed Mohamed Rahim

MIROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH

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Abstract

This report highlights the effectiveness of Red Light Cameras (RLC) as a tool of Automated Enforcement System (AES). Section 1.0 explains the introduction and background of red light cameras (RLC) and AES in Malaysia, the objectives and limitation of the study. The objectives of the study are to determine the number of red light running before and after the installation of the RLC, to analyse the reduction of red light running and to evaluate the impact of installing RLC on red light running violations.

Literature review regarding implementation of the AES system is explained in Section 2.0 with various examples of the effectiveness of the system. There are also several studies that had been carried out to identify factors associated with red light running. Apart from that, A "Stop Red-Light Running" Program carried out by the American Trauma Society and FHWA found that 55.8% of the respondents are red light runners. Attributes of red light runners include drivers without children, those driving alone (the presence of passengers significantly decreases the likelihood to run a red light), those employed in jobs that do not require a high level of education or unemployed, those rushing to work or school in the weekday morning hours, those driving more than two miles from home, drivers that have been summonsed for running the red light, being an ethnic minority and those who have been drinking alcohol prior to the committing violation.

Section 3.0 elaborates on the methodology of the study. The methodology consists of preparation, data collection I, data analysis I, installation of RLC, data collection II, data analysis II, evaluation I, data collection III, data analysis III, evaluation II and reporting.

Results of the study are reported in Section 4.0. There are four sub sections for the results. The results are divided into overall pattern of red light running, pattern of red light running violation as stratified by vehicle type, pattern of red light running violation

as stratified by location, and pattern of red light running violation by time of day and day of week. In general, the study showed an overall reduction in violation rate one year after installation with 1.23% and six months after installation with 2.20% of the RLC, as compared to before installation (4.29%). Motorcycles held the position as the highest contributor in violation rate, followed by cars and other types of vehicles. Comparing in terms of violation rate (violation per volume), motorcycles are the highest violators with 6.04% before installation and 4.30% for six months after installation before further decreasing to 3.63% one year later; followed by cars (before: 3.71%; six months after: 1.54%; one year after: 0.46%) and other types of vehicles (before: 3.69%; six months after: 2.05%; one year after: 0.37%).

Finally, Section 5.0 contains the conclusion and recommendation of the study. It was found out that the installation of AES is indeed timely and it was found to be very beneficial in Malaysia. The AES had been proven in previous studies as an effective tool in reducing the occurrence of red light crashes, but only a few studies have been carried out in Malaysia.

1.0 Introduction

In Malaysia, traffic crashes are one of the major causes of injuries and fatalities. The number of road accidents in 2011 was 449,040 whereas 6,877 persons were involved in road fatalities (RMP 2012). One of the likely reasons for the high number of accidents and fatalities is from running the red light. For the past five years, the numbers of accidents at signalised intersections in Malaysia has seen an upward trend and this resulted in 207 fatalities and 706 injuries in 2011 (RMP 2012). Thus, red light running (RLR) represents a significant safety problem that deserves attention.

The Automated Enforcement System (AES) is an intervention to curb RLR. It is defined as a technical recording device that is triggered automatically when a violation occurs, so that information of the offending driver is recorded, making it easier to identify the vehicle for the purpose of sanctioning the owner or driver.

The primary cause of crashes at signalised intersections normally involves vehicles that enter an intersection when the red light is displayed. Drivers often face a problem when reaching a signalised intersection at the onset of the amber light; whether to apply the brakes or to proceed through the intersection. The drivers are in what is considered an option zone or dilemma zone, in which it is neither possible to clear the stop line nor to stop comfortably at the stop line.

Red light cameras (RLC) can play a significant part in encouraging drivers to stop instead of violating the red light. Studies in two U.S. cities—Oxnard, California and Fairfax City, Virginia carried out by Retting *et al.* in 1999—found out that violation rates have decreased by approximately 40% during the first year of RLC enforcement. It has been reported that automated enforcement is used in 75 countries throughout the world (Bochner 1998). Apparently, there have been reductions of between 5 to 60% in speeding violations, 40 to 90% in red signal violations and 15 to 90% in crashes (Bochner 1998). However, there are a few study overseas show otherwise.

It appears that automated enforcement of stop lights can be an effective safety measure, based on the number of researches conducted about its effectiveness. However, there are very few studies of this nature that have been undertaken in Malaysia. A study done by Universiti Putra Malaysia (UPM) evaluated traffic light violations among motorists in Selangor found out that traffic light violations are influenced by factors such as time of the week (weekday or weekend), type of vehicle (two-wheeled or four-wheeled vehicles), location and type of traffic lights (countdown timer or normal) (Kulanthayan *et al.* 2007). The study has recommended that cameras be installed at traffic light intersections to detect violations. In support of this, this proposed study will tackle the above listed factors with red light violations throughout Malaysia. The hypothesis is that AES RLC can reduce the occurrences of RLR. With the reduction of red light running incidence, the likelihood of crashes at intersections will also decrease.

A before and after study was designed to evaluate the impact of installing RLC on RLR. The violations before camera installation were compared to those obtained after installation (along each individual approach) of RLC (referred to as the camera approach), on a lane-by-lane basis. A recent study about traffic light violations among motorists conducted by UPM showed day, type of vehicle, location and type of traffic to be strong influences on traffic light violations, and that RLC is expected to help reduce traffic light violations (Kulanthayan *et al.* 2007). The data was analysed using SPSS with two indicators determining the effectiveness of AES. Comparison was then made by calculating the rate of violation per junction, in terms of total violations per volume.

1.1 Scope and Objectives of the Study

The main objective of the study was to evaluate the effectiveness of the RLC as a tool for AES.

The specific objectives were:

1) to determine the number of RLR violations before and after installation of the RLC;
2) to analyse the reduction in RLR; and
3) to evaluate the impact of installing RLC on RLR violations.

1.2 Limitation of the Study

The study was conducted at four sites, based on the high numbers of total accidents recorded at the sites prior to the study. Two were in Kuala Lumpur (Jalan Klang Lama and Jalan Ipoh) and the other two were in Perak (KM 26 Jalan Ipoh–Kuala Kangsar and Jalan Pasir Puteh).

2.0 Literature Review

Several studies have been carried out to identify the factors associated with RLR. In a field study done by Retting *et al.* (1999b they used data collected by automated cameras, trained observers and records from the department of motor vehicles to provide a profile of red light violators. Red light runners were found to be at the age of below 30, male, less likely to wear the seatbelt, have poor driving records, drive smaller and older vehicles than drivers who do not run the red light (Retting 1996). These results were found to be parallel with the characteristics of red light running crashes. It was estimated that in United States, 260,000 red light running crashes occur annually, resulting in 750 fatalities (Retting *et al.* 1999a & 1999c).

A "Stop Red-Light Running" Program carried out by the American Trauma Society and FHWA in 1999 found out that 55.8% of the respondents are red light runners. Attributes of red light runners include drivers without children, those driving alone (presence of passengers significantly decreases the likelihood of running a red light), those employed in jobs not requiring a high level of education or unemployed, those rushing to work or school in the weekday morning hours, those driving more than two miles from home, previously summoned for running the red light, ethnic minorities (Romano *et al.* 2005) and those who have been drinking alcohol prior to the violation (Romano *et al.* 2005; Retting 1996).

Other researchers investigated the pressure of engineering factors on RLR. A prior study done by Bonneson (2002) indicated that there is association of RLR with the frequency of yellow phase. The results stated that the more frequent yellow phase appeared, the higher the potential of RLR. In 2000, Porter and England verified that high daily traffic volumes may be associated with red light runners (Porter *et al.* 1999). In another study, Mohamedshah, Chen and Council (2000) explored the relationship between the type of signal and crashes occurring due to running the red light. It was suggested that fully

actuated traffic lights tend to have higher number of crashes as compared to semi-actuated or pre-timed traffic lights.[1]

Studies also have been conducted on the acceptance of RLC programmes. By using postal survey of drivers in Norway, Spain and The Netherlands, good acceptance of RLC was established as an enforcement tool. In the US, a public opinion survey indicated that there is support to use RLC as a supplement to police enforcement in reducing RLR violations, whereas the level of acceptance appears to be correlated with driver attitude towards RLR violations and public awareness of RLC programmes. A focus group in San Francisco spoke of running the red lights because they felt the drivers behind the vehicles were going to run it and they noted that they were in a hurry and would do anything (including running a red light) to get to their destination more quickly (Fleck *et al.* 1999). Most violators did not want to be "taken advantage of" while driving, as opposed to the non-violators who had a more courteous attitude.

[1] ***Fully actuated traffic light:*** *Requires "actuation" by a vehicle or pedestrian in order for certain phases or traffic movements to be serviced. Actuation is achieved by vehicle detection devices and pedestrian push buttons.*
Semi actuated traffic light*: Vehicle loop detectors are installed on the minor street approaches and push buttons are provided for pedestrians wanting to cross the major roadway.*
Pre-timed traffic light: *The signal assigns right-of-way at an intersection according to a predetermined schedule. The sequence of right-of-way (phases or splits) and the length of the time interval for each signal indication in the cycle are fixed based on historic traffic patterns. (Source: http://www.halifax.ca/traffic/documents/fixedvsactuated.pdf)*

3.0 Methodology

The aim of the study was to evaluate the effectiveness of the AES i.e., the RLC in curbing RLR.

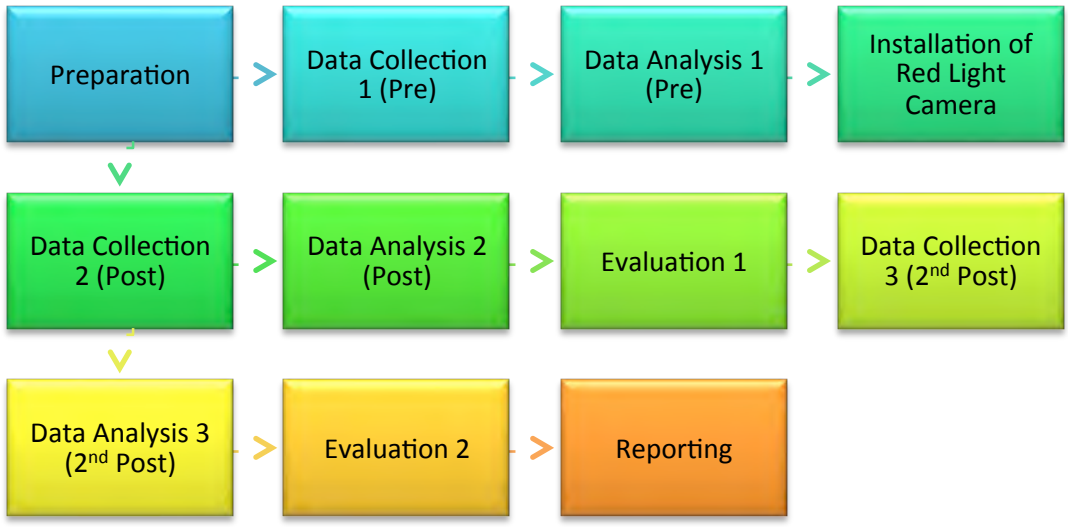

Figure 1 Methodology framework for evaluating RLR study

Figure 1 shows the research framework of the study. The methodology consists of preparation, data collection I, data analysis I, installation of RLC, data collection II, data analysis II, evaluation I, data collection III, data analysis III, evaluation II and reporting. The post and 2nd post are designated respectively as after six months of installation and after one year of installation.

3.1 Preparatory Works

There are two things mentioned under preparatory works. One is site selection and verification. Another one is training for staff.

3.1.1 Site Selection and Verification

MIROS has identified 800 highly accident-prone locations, and 265 of these locations were then identified for RLC installation. Four locations were decided for RLC, namely: Jalan Ipoh, KL, Jalan Klang Lama, Sg. Siput and Jalan Pasir Putih.

These four locations were divided into two zones; Zone A consisted of Sg. Siput (Route F0001) and Jalan Pasir Putih while Zone B consisted of Jalan Ipoh, KL and Jalan Klang Lama (Route Z0089). All the junctions are three legged junctions except for Jalan Pasir Putih (Figure 2).

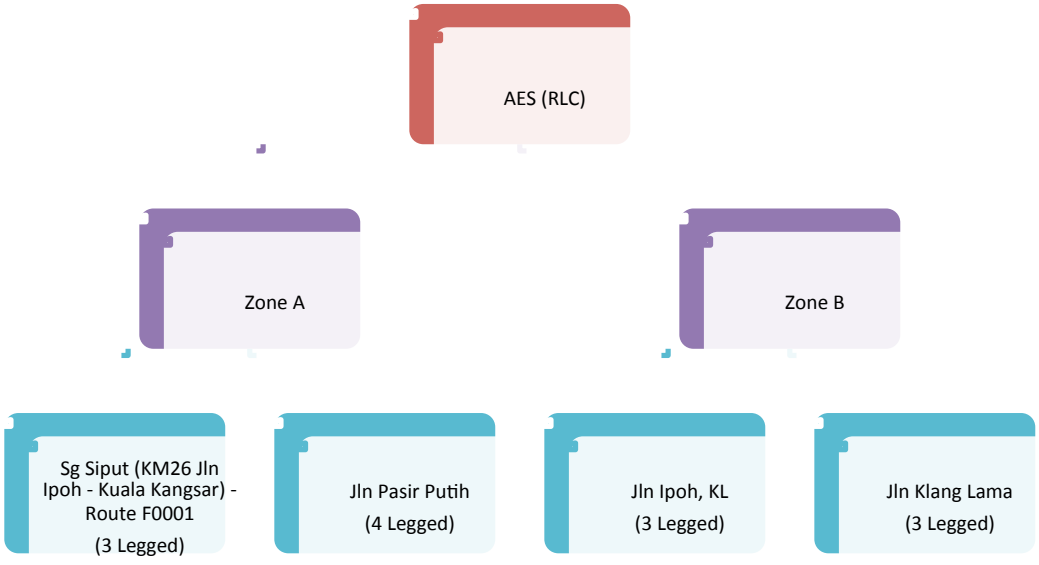

Figure 2 Locations of RLC

3.1.2 Training for Research Assistants

Research Assistants (RA) were given briefings and training on how to collect the data. Training was carried out at Jalan Reko, Kajang to make sure they were familiar with data collection at the site prior to the actual data collection period.

3.2 Data Collection using Video Camera and Manual Counting

Four enumerators were tasked with taking note of any particulars regarding the sites such as landmarks and the weather. The enumerators were placed unobtrusively, so that the drivers were unaware that their driving behaviour was being observed. Data was taken at every leg. An RA and a video camera were placed on each route for ease of data collection (refer Plate 1). The data was collected for two days for each site; differentiating between weekdays and the weekend. Data was recorded for two by two hour periods; peak and off peak; while considering different levels of traffic congestion. Peak hour here means the busiest hour when the traffic volume is at its highest whereas off peak hour describes the exact opposite.

Plate 1 Video camera used to capture volume and violation

The data collected for this study was done in the following manner.

1) Layout of the site; the layout of the site was observed by the RO during site visit. RO also decided on where to place the RA/enumerators.

2) Type of intersection (three-legged, four-legged) and the width of intersection.

3) Particulars of the site; the RA were asked to take note of the date, time, weather and location of the site. Location of the site means Jalan Pasir Putih, Jalan Klang Lama, Sg. Siput or Jalan Ipoh, KL.

4) Signal timing; RAs were instructed to jot down signal timing which consisted of green, amber and red signals.

5) Traffic Volume and violations; both traffic volume and violations were recorded for all directions of the chosen route, which consisted of right/left turn and through traffic. The traffic volume and violation were also separated by vehicle type.

Traffic volume and number of violations were required in order to obtain the violation rate in terms of violation/volume. For all the sites, data was collected for before and after installation of the AES camera.

3.2.1 Location of Observers

Figure 3 shows the placement of the enumerators at each site. Enumerators A would observe drivers coming from Leg A, enumerators B on Leg B and enumerators C on Leg C. They were positioned unobtrusively, so that drivers would not notice that they were being watched. In addition to that, the enumerators were asked to refrain from wearing their corporate shirt as it would have attracted the drivers' attention.

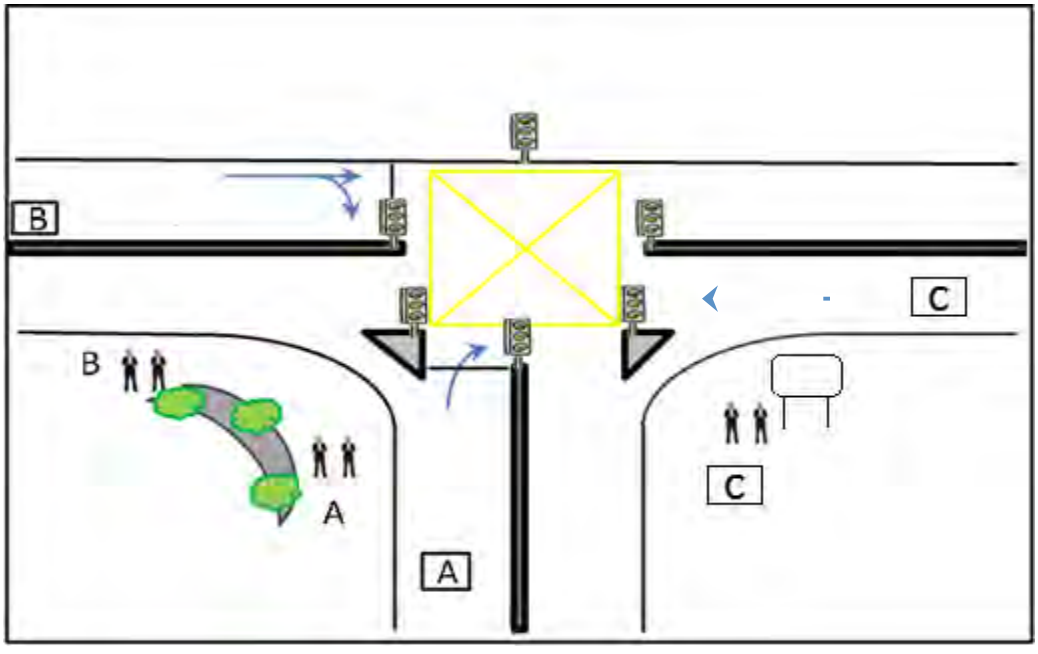

Figure 3 Location of enumerators

Plate 2 Example of enumerator placed unobtrusively

3.3 Data Analysis

The outcome measure of this study was motorist performing red light running violation (yes/no). Violation is defined as when: 1) the front wheels of a vehicle entered the defining boundary of an intersection after traffic signal had changed to red; and 2) the vehicle proceeded through the intersection while the traffic light was red (Kulanthayan *et al.* 2007). Based on this definition, the sample population of the study is vehicles crossing the road junction. Hence, drivers that stopped partially over the stop line were not considered violators. Motorists who entered the intersection on a green or amber light were coded as compliant, even when the lights turn to red during the crossing. However, motorists that stopped before, and crossed the junction before the light they are facing turn to green, were coded as violators (Johnson *et al.* 2010). The data

captured on video was counted by RA and entered into the MS Excel 2010 programme. Descriptive analyses were performed, and percentage of violation for before and after installation of the AES was calculated. To determine the effectiveness of the AES, a before and during data were analysed using Chi Sq. Analysis in SPSS 17. The odds ratio and 95% confidence interval were computed and taken as the final result for assessing the effectiveness of the AES.

4.0 Results and Discussions

A total of 493,782 vehicles were observed for their red light running profile in the study. Data was collected for before installation, six months after installation and one year after installation of RLC.

4.1 Pattern of Overall Red Light Running Profile

The results of RLR violations for before and after installation (six months and one year upon installing RLC) are shown in Table 1. Violation percentage is the number of vehicles violates the red light to the number of total vehicles.

The percentage of RLR violations was found to have significantly decreased ($p<0.01$) at all locations after the installation of the RLC with 4.29% for before and 2.20% for six months after installation and further reduced to 1.23% for one year after installation. Overall, drivers tended to violate 1.991 (95% CI: 1.912, 2.072) times more before installation as compared to six months after installation, and 3.616 (95% CI: 3.438, 3.803) times more before installation to one year after installation.

Table 1 Summary of RLR violation before and after installation

Red light running		Before installation		Six months after installation		OR (95% CI)	One year after installation		OR (95% CI)
	Violation status	N	Violation percentage	N	Violation percentage		N	Violation percentage	
Overall	Violate	6870	4.29%	3778	2.20%	1.991 (1.912, 2.072)	1991	1.23%	3.616 (3.438, 3.803)
	Comply	153106		167600			160437		

4.2 Pattern of Red Light Running Violation by Vehicle Type

When stratified by type of vehicle, results indicated that car drivers (2.17%) showed the highest difference in violation rate as compared to motorcyclists (1.74%) and followed by other types of vehicles (1.64%) for six months after installation. Whereas after one year of installation, other types of vehicles (3.32%) showed the highest difference in violation rate followed by cars (3.25%) and motorcyclists (2.41%). Compared to before installation, car drivers tended to violate 2.460 (95% CI: 2.328, 2.600) times higher after six months of installation and then increased to 8.244 (95% CI: 7.524, 9.034) times more after one year of installation. Compared to six months after installation, car drivers tended to violate 2.460 (95% CI: 2.328, 2.600) times more before installation. The odd ratio then increased to 8.244 (95% CI: 7.524, 9.034) times higher before installation when compared to one year after installation The condition was different for motorcyclists and drivers of other types of vehicles, where motorcyclists tended to violate only 1.431 (95% CI: 1.342, 1.524) times more before installation compared to six months after and 1.705 (95% CI: 1.594, 1.822) times more before than one year after the RLC installation. While drivers of other types of vehicle violated 1.830 (95% CI: 1.528, 2.191) times before installation than six months after, and 10.300 (95% CI: 7.415, 14.306) times higher before than one year after installation. Based on the results, all vehicle types were found to be significant to perform RLR violations for both six months and one year after the RLC were installed.

Table 2 RLR violation and volume for each vehicle type

Vehicle type		Before installation	Six months after installation	One year after installation
Car	Violation	4088	1890	522
	Volume	110250	122651	112282
Motorcycle	Violation	2437	1700	1429
	Volume	40368	39551	39343
Others	Violation	345	188	40
	Volume	9358	9176	10803

Figure 4 shows the violation rate for each type of vehicle, comparing before and after installation (six months and one year after). The trend clearly shows that there is a reduction in violation rate after installation. In terms of absolute number, cars had the highest number of violation with 4088 for before installation, dropped to 1890 after six months and then to 522 one year after (Table 2), followed by motorcycles (before: 2437; six months after: 1700; one year after: 1429) and other types of vehicle (before: 345; six months after: 188; one year after: 40). However, by comparing in terms of violation rate (violation per volume), motorcycles were the highest violators with 6.04% before installation and 4.30% for six months after installation before further decreasing to 3.63% one year later, followed by cars (before: 3.71%; six months after: 1.54%; one year after: 0.46%) and other types of vehicles (before: 3.69%; six months after: 2.05%; one year after: 0.37%).

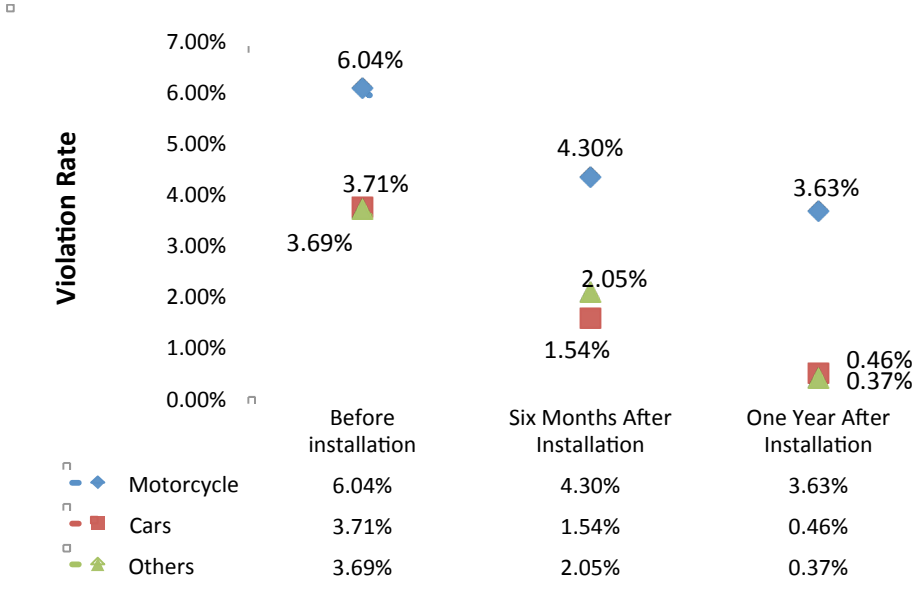

Figure 4 Violation rate before and after installation by vehicle type

Table 3 displays the average number of RLR in one cycle. Cycle is defined as one complete sequence of signal indications (green, yellow, red) for all approaches. By calculating the average for before installation, an average of 14 cars, 8 motorcycles and

1 other type of vehicle violated the red light within a cycle. These figures then dropped to 6 cars, 5 motorcycles and 1 (0.51) other type of vehicle during the next six months. Cars demonstrated the highest reduction in RLR with 7.18 after six months and 4.47 one year after installation. Motorcycles had the second highest reduction in violation followed by other vehicle types.

Table 3 Average number of RLR in a cycle

	Before installation	Six months after installation	(Reduction of six months to before installation)	One year after installation	(Reduction of one year to six months after installation)
Car	13.36	6.18	7.18	1.71	4.47
Motorcycle	7.96	5.56	2.41	4.67	0.89
Others	1.13	0.61	0.51	0.31	0.48

Retting *et al.* (1996) observed red light runners to most likely drove smaller and older vehicles. However, the study classified the vehicles based on the size of wheelbase instead of the number of wheels (i.e., two-wheeler, etc.). Three different sizes were classified namely small (wheelbase ≤99 inches), midsize (wheelbase 100–109 inches), and large (wheelbase >109 inches). In Malaysia, motorcycles comprise more than 50% of vehicles that use the road and contribute the highest number of fatalities each year. Motorcyclists are the most vulnerable group in all types of violation, as they are smaller in comparison, move faster and are harder to notice on the road. Also, a motorcycle that is travelling at a high speed is harder to come to a stop as compared to cars, particularly in short distances at signalised intersections.

4.3 Pattern of Red Light Running Violation by Location

The observation on RLR violation by location revealed that the percentage of violation was reduced generally by 1.95% after six months and 2.72% after one year for Kuala Lumpur, and 2.12% after six months and 3.52% after one year for Perak. These patterns were found to be statistically significant ($p<0.05$) in terms of violation at all locations for before and after RLC installation. Drivers in Kuala Lumpur were found to be prone to

violating 2.150 (95%CI: 2.034, 2.272) more before as compared to six months after installation. This value then increased to 3.848 (95%CI: 3.591, 4.124) times before installation, as compared to one year after installation. Comparing before installation to the first six months, drivers in Perak tended to violate 1.728 times (95% CI: 1.627, 1.828) more. This value increases after a year. After a year, drivers in Perak violated 3.233 times (95% CI: 3.004, 3.480) higher as compared to before installation.

Table 4 RLR violation and volume for each location

Location		Before installation	Six months after installation	One year after installation
KL	Violation	3613	2003	1054
	Volume	97271	113622	106197
Perak	Violation	3257	1775	937
	Volume	62705	57756	55294

In terms of absolute number, it can be seen that in both Kuala Lumpur and Perak, the total violation decreases within time. In Kuala Lumpur, the number of violation is 3613 for before installation, dropped to 2003 after six months and then to 1054 one year after (Table 4). As for Perak, the reduction of violation is more or less the same as Kuala Lumpur (before: 3257; six months after: 1775; one year after: 937). Looking at the violation trend, it can be safely said that the number of violation will reduce with time. In other words, the longer the time after installation, the more reduction can be seen with the violation.

Figure 5 illustrates the violation rate by location, comparing before and after installation. As in the previous stratification, the trend also showed a reduction in violation rate after installation. Perak had a higher violation rate both before and after installation (after six months and one year) with 5.19%, 3.07% and 1.67% as compared to Kuala Lumpur with only 3.71%, 1.76% and 0.99% respectively.

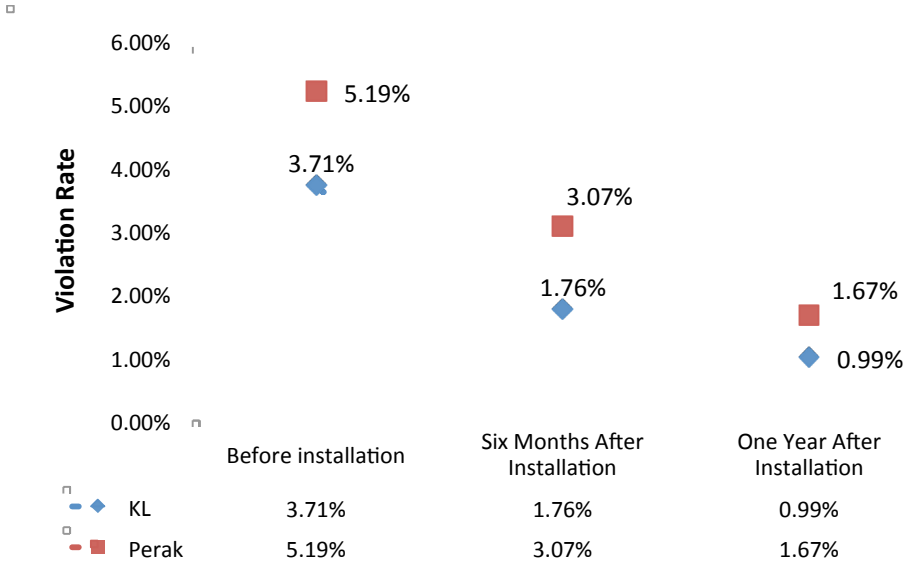

Figure 5 Violation rate before and after installation by location

From this study, it was found that traffic volume in Perak was significantly lower than traffic volume in Kuala Lumpur. Nevertheless, Perak stated higher red light running violations. This could be due to the fact that drivers tend to violate more when there is lesser volume of vehicles. This is concurred by a study done by Green (2003) that suggests drivers feel safe to disobey a traffic signal when there are fewer vehicles on the roads.

4.4 Pattern of Red Light Running Violation by Time of Day and Day of Week

Time is one of many factors affecting RLR. Drivers often beat the red light when they are in a hurry. Green (2003) conducted an extensive analysis using Australian crash data afternoon and on the weekends, suggesting a relation to drinking and driving. Time of day is also concluded by Retting *et al.* (1999) as a factor influencing RLR. They found different characteristics of RLR related crashes during the night as compared to daylight crashes. The involvement of male and younger drivers was higher in the night time

crashes. With regards to day of week, Lum and Wong (2002) observed a higher tendency of stopping at junctions during weekdays.

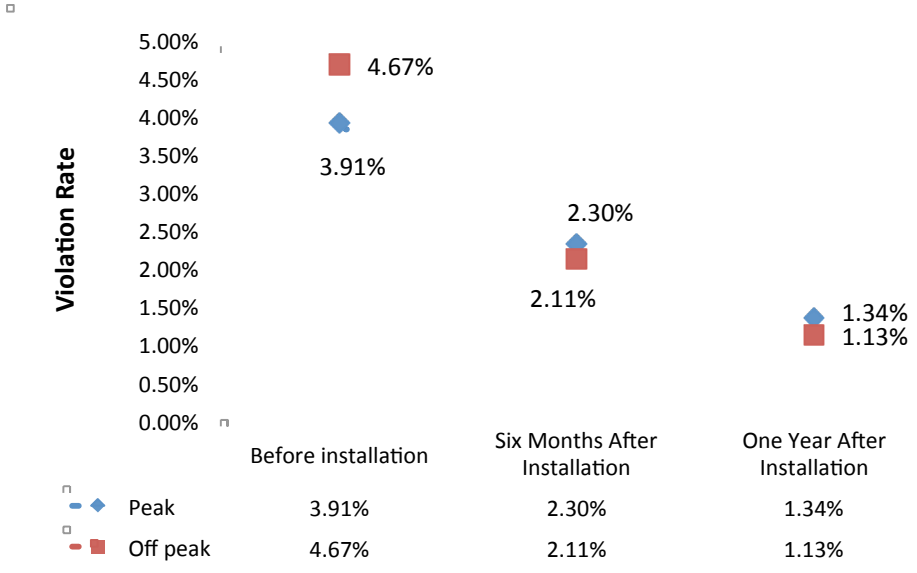

Figure 6 Violation rate before and after installation by time of day

With regards to this study, before installation of the RLC, drivers were more likely to run the red light during off peak hours with 4.67%, as compared to during peak hours with 3.91% (refer Figure 6). This could be due to the volume between peak and off peak before installation is more or less the same but violation during off peak is much higher. It's the opposite situation with six months after installation. Peak hours recorded a higher violation rate of 2.30% than off peak hour with 2.11% (Figure 6). This condition continued after one year of installation where the violation rate during peak hours was 1.34% and off peak hour 1.13%. Comparing the odds, drivers during off peak hours indicated that they have 2.270 (95% CI: 2.146, 2.400) times more likely to run the red light than drivers during peak hours (1.725 times, 95% CI: 1.627, 1.828). These values increased six months after installation to 4.308 (95% CI: 4.013, 4.625) times for off peak hours, than 2.994 (95% CI: 2.787, 3.216) times for peak hours. On the other hand, the RLC was found to be statistically significant in reducing the violation rate, as stratified by time of day and day of week ($p<0.05$).

In terms of absolute number, Table 5 shows the number of red light running violations and volume by time of day. Results show that the number of violation seems to be decreasing after the installation of AES. Off peak period showed a higher reduction in violation with 3757 for before installation, 1915 six months after installation and 978 after a year of installation as compared to peak period.

Table 5 RLR violation and volume by time of day

Time of day		Before installation	Six months after installation	One year after installation
Peak	Violation	3113	1863	1013
	Volume	79602	80825	75524
Off peak	Violation	3757	1915	978
	Volume	80374	90553	86904

Subsequently, another analysis was carried out to compare the significant level of the attributes, in this case time of day and traffic violation. Table 6 shows traffic violation by time of day, in which there is not much difference in percentage of violation can be seen between peak (2.5%) and off peak (2.6%) periods. As such, traffic light violation was found not significant (p=0.592) with time of day. This suggests that time of day does not influence the traffic violation thus explains the irregularity of trend in Figure 6.

Table 6 Traffic violation by time of day

Time of day	Violate	%	Comply	%	Odds
Peak	5989	2.5	229962	97.5	0.0260
Off peak	6650	2.6	251181	97.4	0.0265
Total	12639	2.6	481143	97.4	

Variable	95% Significance	95% Confidence interval	Odds ratio
Time of day	0.592	0.956–1.081	1.017

As for type of day, the attributes considered in it are weekdays and weekends. In general, weekdays stated a much higher violation rate with 4.30% before installation, 2.49% six months after installation and then down to 1.38% (one year after) as compared to weekends (before: 4.29%; six months after: 1.84% and one year after:

1.06%). Nonetheless, violation rate before installation during weekday and weekend are almost similar. This is due to the number of violation and volumes are proportional to each other. Therefore, traffic volume does play a role in determining the violation rate. Apart from that, drivers on weekends tended to violate 2.393 times (95% CI: 2.243, 2.553) six months after installation and 4.164 times (95% CI: 3.857, 4.496) one year after installation higher than drivers on weekdays; six months after installation (1.760 times, 95% CI: 1.671, 1.854) and one year after installation (3.202 times, 95% CI: 2.995, 3.423).

Figure 7 demonstrates the violation rate for type of day, comparing between before and after installation. Based on the graph, it can be concluded that for both weekday and weekend, nearly similar violation rates were seen for before and after installation.

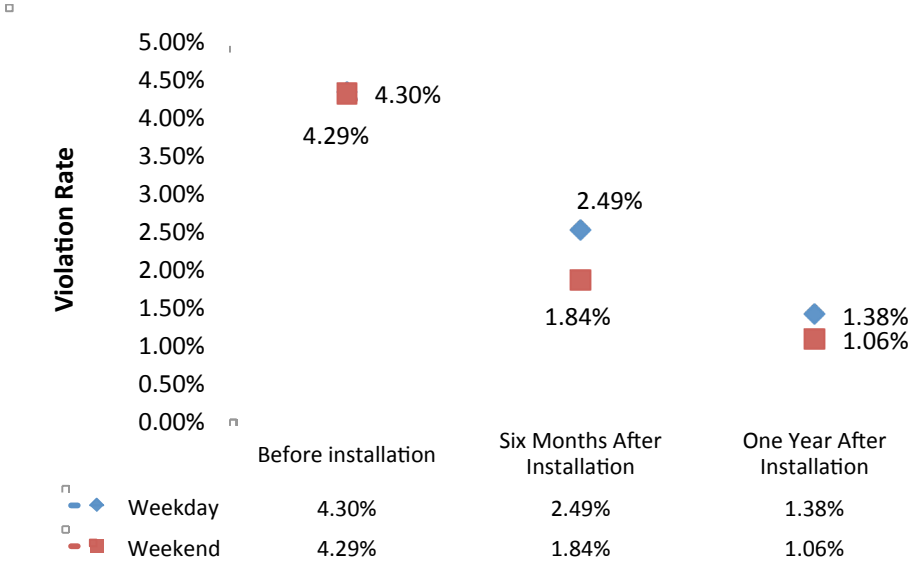

Figure 7 Violation rate before and after installation by day of week

In contrast to the previously mentioned analysis, Table 7 shows RLR violation and volume by type of day. It can be seen that weekend had a higher reduction in violation as compared to weekday for six months with 54.2% to 37.9%. After a year of installation, weekday showed a higher reduction in violation as compared to weekend

(weekend: 37.9%, weekday: 52.7%). In terms of absolute number, the number of violation for weekday is higher than weekend for all duration.

Table 7 RLR violation and volume by type of day

Type of day		Before installation	Six months after installation	One year after installation
Weekday	Violation	3868	2402	1136
	Volume	89928	96464	82059
Weekend	Violation	3002	1376	855
	Volume	70048	74914	80369

Similar with the analysis done in Table 6, an analysis was carried out between traffic violation and day of week. Table 8 shows correlation between traffic light violation and day of week. For a total of 493,782 vehicles observed, only 2.6% of vehicles violated the red light and 97.4% complied. Chi square test done indicates the significant of the above said variables (p=0.000). Apart from that, the odds ratio stated drivers were more likely to violate 1.2 times more during weekdays as compared to during weekends. Based on these results, it can be safely said that day of week seem to be one of the factors affecting red light running. In support to this, a study conducted by Green (2003) also found that incidents of red light running occurred higher during weekdays than during weekends.

Table 8 Traffic violation by day of week

Day of week	Violate	%	Comply	%	Odds
Weekday	7406	2.8	261045	97.2	0.028
Weekend	5233	2.3	220098	97.7	0.024
Total	12639	2.6	481143	97.4	

Variable	95% Significance	95% Confidence interval	Odds ratio
Day of week	0.000	1.151 – 1.237	1.193

5.0 Conclusion and Recommendations

In general, the study showed an overall reduction in violation rate one year after installation with 1.23% and six months after installation with 2.20% of the RLC, as compared to before installation (4.29%). Motorcycles held the position as the highest contributor in violation rate, followed by cars and other types of vehicles. As for location type, Perak was found to have higher violation rates both before and after installation (six months and one year after) with 5.19%, 3.07% and 1.67% respectively as compared to Kuala Lumpur with only 3.71%, 1.76% and 0.99% respectively. On the other hand, violation rates for both time of day and type of day were basically not much different. Drivers ran the red light more often during off peak hours with 4.67% as compared to during peak hours with 3.91% for before installation, which then changed to more violations during peak hours (six months after: 2.30% and one year after: 1.34%) as compared to off peak hours (six months after: 2.11% and one year after: 1.13%). As for type of day, weekdays showed a higher violation rate with 4.30% before, 2.49% six months after and 1.38% one year after than weekends with 4.29% before, 1.84% six months after and 1.06% one year after.

The installation of AES is indeed timely and was found to be very beneficial in Malaysia. AES has been proven in previous studies to be an effective tool in reducing red light crashes, but only a few studies had been carried out in Malaysia. A study performed by UPM by Kulanthayan *et al.* (2007) has recommended that cameras be installed at traffic light intersections to detect violations. It was also reinforced in this study whereby the RLC was found to have significantly reduced RLC violations according to the attributes mentioned above. Apart from that, many studies and remedial programmes should still be continually carried out.

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Research Report

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