The Automated Speed Enforcement System – A Case Study in Putrajaya

Muhamad Kamil HAMZAH[a], Choy Peng NG[b], Faridah Hanim KHAIRUDDIN[c], Mohammed Alias YUSOF[d]

[a,b,c,d] *Civil Engineering Department, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Kem Sungai Besi, 57000 Kuala Lumpur, Malaysia*

[a] *E-mail: mhmmdkamil567@gmail.com*
[b] *E-mail: cpng@upnm.edu.my*
[c] *E-mail: hanim@upnm.edu.my*
[d] *E-mail: alias@upnm.edu.my*

Abstract: Speeding contributed 60% of road crashes in Malaysia every year. The automated speed enforcement (ASE) system was piloted in 10 blackspots area across the states of Selangor, Perak, Kuala Lumpur and Putrajaya on 22 September 2012. This study was aimed to measure the drivers' speed compliance at Lebuh Sentosa, Putrajaya where ASE camera was installed. Spot-speed studies conducted in October, November 2012 and February 2013, respectively revealed more than 70-90% compliance at the treatment site (ASE camera installed). However, less than 50% of drivers comply with the speed limit at the control site (ASE camera not installed). At treatment site, the 85th percentile speed was less than 70km/h but it was above 70 km/h at the control site. Moreover, we found that the effect of the ASE camera increases over the time. This implies that the ASE system has successfully reduced the speeding incidents at the blackspot area.

Keywords: speed, automated speed enforcement, speed camera, chi-squared

1. INTRODUCTION

Speeding is one of the major contributing factors of road crashes and fatalities around the world. Higher speeds will increase both the probability of crash occurrence and the severity of its consequences (Elvik and Vaa, 2004; Elvik, 2005; NHTSA, 2007). Speed contributed about 50% of road crashes in low-income countries and 30% deaths in high-income countries (WHO, 2004). Finch *et al.* (1994) reported that reduction in mean speed of 1 mph will reduce 5% of road crashes. WHO (2004) indicated that a reduction in speed of 1 km/h could lower down the fatalities and injuries by 5% and 3%, respectively.

In Malaysia, speeding is recognized as one of the risk factors contributing to road crash. The Road Safety Department Malaysia (JKJR) reported that about 60% of the road crash each year was contributed by speeding (MyMetro, 2011). The frequent collision types related to speeding was due to "loss of control" (OECD, 2011). The Royal Malaysia Police (PDRM) reported that 63% of the total summonses of 167,868 issued during the *Ops*[1] enforcement

[1] Every year, the *Ops* enforcement program is conducted during festive seasons (Hari Raya and Chinese New Year) because the crash rates during these periods are the highest in the year. Usually, government agencies, non-government agencies and private sectors were involves in *Ops* enforcement program. The government agencies involved in *Ops* enforcement program is Royal Malaysia Police (PDRM), Road Transport Department (JPJ), Road Safety Department (JKJR), Public Works Department (JKR), Malaysia Highway Authority (LLM) and Malaysian Institute of Road Safety Research (MIROS).

program conducted in January 2011 were for the offense of driving beyond the speed limit (Berita Harian, 2011).

Despite a series of road safety enforcement programs conducted in Malaysia to tackle the speeding problem, many drivers still engage in speeding behavior. The main concern now is that the enforcement program conducted in Malaysia needs a large number of human resources (i.e. police) in the operation and it has restraints such as inclement weather. In addition, the police enforcement program was an active approach that was only effective to stop the deterred and manipulators drivers from speeding but it will not be effective on the defiers[2].

With the emergence of information and communications technology, a new technique of speeding enforcement introduced, it is known as the automated speed enforcement (ASE) system. The ASE system is an enforcement technique with one or more speed cameras[3] to capture the images of motor vehicles traveling beyond the speed limit. Images captured during the speeding offense by the ASE system are processed and reviewed in the ASE control office. A violation notice is then posted to the registered owner of the identified vehicle. This ASE technology was widely deployed in countries such as Australia, Canada, Europe, and the United States (NHTSA, 2007).

The technology of ASE camera was very advanced as it increases the capacity of enforcement by applying technical solutions (Luoma *et al.*, 2012) and this can optimize the resources during the enforcement program. Previous researches had documented that ASE is effective in reducing the speed, crash frequency and injuries (Keall *et al.*, 2001; Keall *et al.*, 2002; Hirst *et al.*, 2005; Thomas *et al.*, 2008; Shin *et al.*, 2009; Cameron, 2010; Luoma *et al.*, 2012; Rudjanakanoknad *et al.*, 2012; He *et al.*, 2013) if installed in strategic locations. However, ASE cameras can also be hazardous because it can increase the chances of rear-end road crashes (Shin *et al.*, 2009) when it was installed in an improper location.

On 22 September 2012, the ASE system was officially launched in 10 locations across the states of Selangor, Perak, Kuala Lumpur and Putrajaya in Malaysia. The ASE cameras were installed at blackspot or road crash prone areas. The warning signs for the ASE cameras were installed and visible 2-3 km before the cameras (The Star, 2012) to alert the drivers.

The cameras installed were those of the fixed type located at a fixed position. According to Cameron (2010), the fixed ASE camera would reduce the fatal and serious casualty crashes by 15.52% and medically-treated injury crashes by 7.76% at the enforcement

[2] Drivers can be categorized into 4 groups comprising the conformers, deterred drivers, manipulators and defiers. The conformers were those law abiding or safety concern drivers that never exceed the speed limit; the deterred drivers were those that will behave with the presence of enforcement; the manipulators were those who slow down only at the enforcement locations and defiers were those speeding regardless of enforcement (Blincoe *et al.*, 2006).

[3] There are two generally types of speed camera for ASE: fixed or mobile. Fixed cameras are those mounted at a fixed location (can be hidden or visible) and can continuously monitor traffic speeds without a human operator. Speeds are measured with a Doppler or laser radar systems. Mobile camera operations may be deployed in police vehicles, marked or unmarked, and are usually tended by enforcement officers or other trained officials. Mobile deployments may be rotated among sites, so enforcement is not typically continuous at any one location (Thomas *et al.*, 2008).

zones. Table 1 shows the location of the fixed ASE cameras in Malaysia.

Table 1: Location of the automated speed enforcement
(Source: Road Transport Department Malaysia, 2012)

Route Number	Location	State	Speed Limit (km/h)
F0058	KM 7, Jalan Maharajalela, Teluk Intan	Perak	90
E0001	KM 376, Lebuh Raya PLUS, Slim River	Perak	110
F0001	KM 91, Jalan Ipoh-Butterworth	Perak	60
F0001	KM 85.5, Jalan Ipoh-Kuala Lumpur	Perak	90
E0001	KM 205.6 Taiping Utara	Perak	90
E0002	KM D7.7, Sungai Besi	Kuala Lumpur	80
Z0002	Jalan Persiaran Timur	Putrajaya	80
E0002	KM 301.9, Kajang	Selangor	90
Z0022	Lebuh Sentosa	Putrajaya	70
E0026	KM 6.6, Jalan Kajang/ Puchong	Kuala Lumpur	80

The following figures show the ASE cameras and warning signs for the ASE system.

Figure 1: The ASE camera at Putrajaya

Figure 2: The warning sign for ASE camera

This study attempted to measure the driver speed compliance at the ASE location due to its installation has brought about concerns from the general public regarding the novelty of its installation. The study location was fixed at Lebuh Sentosa, Putrajaya. The preliminary study was conducted on 31st October and 28th November 2012, respectively. The final data collection was conducted on 20th and 27th February 2013.

The rest of the paper is organized as follows. Section 2 provides an overview of ASE worldwide, whilst Section 3 contains the study location and methodology. Section 4 presents empirical results and discussion, followed by conclusions and recommendations in Section 5.

2. OVERVIEW OF ASE WORLDWIDE

The state of Victoria, Australia was the first innovator that implements a large scale of automated speed enforcement (ASE) in 1989 (Belin *et al.*, 2010). A total of 54 speed cameras was installed between December 1989 and January 1991. An intensive mass media publicity campaign was then conducted to support the ASE system. The publicity was aimed to increase the awareness of the drivers regarding speeding and safety and the camera's legitimacy (Cameron *et al.*, 1992).

The unmarked police vehicles installed with camera mounted on tripod outside the vehicle or inside the vehicle were used in the operation to reduce the visibility. General warning signs were erected at the major road coming into Victoria. The purpose of the warning sign was to alert the drivers. This ASE system was proven effective because it increases the drivers' perceptions of being caught and thus increases the compliance rate.

According to an evaluation conducted by Cameron *et al.* (1992), a significant decrease of casualty due to crashes was observed after the implementation of the ASE program. The largest reduction is about 30% of the arterial roads in Melbourne. Therefore, the introduction of the ASE system was considered as one of the most important interventions in Victoria.

In New Zealand, the visible mobile speed cameras were widely used since 1993. In order to increase the uncertainty about the location of operating cameras, the hidden mobile speed camera was introduced in 1997. Keall *et al.* (2001) tested the effectiveness of the hidden cameras in a 100 km/h speed limit zones to identify any changes in crash rates associated with the use of the hidden speed cameras.

Keall and his team reported that there was a statistically significant net fall of 11% in the crash rate, 19% reduction for injuries, and 8% in the number of injured vehicle occupants per crash in the enforcement zone relative to the control zone during the first year of the hidden camera program. A further study conducted after the first year (between 1997 and 1999) also yielded the same results (Keall *et al.*, 2002). This shows that the hidden camera program was significantly more effective than the visible camera program because it was able to control the speed and modify drivers' behavior.

Speed cameras were employed in the UK in 1992. Jones *et al.* (2008) conducted a study in the rural county and found that the overall crashes decreased by 19% while the fatal and seriously injured crashes decreased by 44%. The effect of speed camera in another area has influenced other location without cameras where the overall crashes were also found to be declined by 1% and crashes involving fatalities or serious injuries declined by 9%. The reduction in total crashes was significantly greater than that expected from the effect of regression to the mean in 12 out of 20 sites tested.

They concluded that the introduction of mobile speed cameras in a rural county appears to have resulted in real and substantial reductions in road traffic crashes, and particularly those involving deaths or serious injuries. They suggested the deployment of mobile speed cameras is an effective tool for organizations wishing to reduce road traffic casualties in areas where high crash rates have been associated with excessive vehicle speeds.

The Korean National Police Agency has implemented the ASE and installed 853 units of fixed speed camera a number of road section and 821 units of mobile-speed cameras in South Korea since 1997. A public survey in South Korea shows that most of the Korean's drivers supported the ASE system. Kang (2002) reported that the introduction of massive ASE systems was very successful in Korea. The ASE system has improved the speed compliance amongst drivers and reduces the fatal road crash. The fixed-type ASE systems were reported as the most effective tools in reducing the road crash when it was installed at the upstream of curves or the downgrade sections and equipped with well-designed advanced warning signs placed at least 500 m or 1 km prior the enforcement zone.

The automated speed enforcement system in Finland was started before 2000 and driving speeds are being monitored by the police. A threshold of 20 km/h was applied by the police on the ASE system to avoid an overload of office work. The speed violation of below 4 km/h was allowed. All speeding incidents more than 4km/h resulted in a speeding offense as follows: a note for excessive speed of 4–10 km/h, a fixed fine of 11–19 km/h and a fine based on the driver's income for speeding of 20 km/h or more. In addition, the driver's license will be confiscated by the police for a specified time if committed a severe speeding offense (Luoma *et al.*, 2012).

ASE implementation in Finland declined the mean speed by 1.5–4.4 km/h. The effectiveness of ASE was justified further by informing the public about the reduction in crash and injury rates due to the reduction in mean speed. The police held press conferences on this improvement and the issue was widely discussed in the media. This has further improved the awareness amongst the community.

ASE was only implemented in 14 states and Washington D.C. in the United States. This is because the journalists and policymakers perceived that the ASE's technology is controversial and unpopular with the general public. A public survey conducted at Minnesota shows that majority of the community support the deployment of ASE but limited to areas such school zones, construction area, crash blackspot and location where many people driving above the speed limit (Douman *et al.*, 2012).

One of the examples of the ASE system in the United States was a limited access urban freeway - the Arizona State Route 101 of 6.5 miles, in the city of Scottsdale was installed with 3 speed detection camera per direction in the enforcement zone. Comprehensive 9-months evaluation study conducted in 2006 demonstrate that the average speed at the enforcement zones was reduced by 9 mph during the enforcement period. Moreover, the automated speed enforcement program successfully reduces all kinds of road crashes and injuries, except the rear-end crashes. In addition, it was also predicted that the local authority can save about $17M per year in a crash related injury costs with the enforcement of the automated speed enforcement program in the city of Scottsdale (Shin *et al.*, 2009).

Amongst the advantages documented by various researchers including

- Increase fairness of enforcement (Kang, 2002)

- Improve the drivers' perceptions of being caught (Cameron *et al.*, 1992; Kang, 2002)
- Provide more efficiency in ticketing and payment process (Cameron *et al.*, 1992; Kang, 2002)
- Allow safer and more efficient enforcement duties by the police (Cameron *et al.*, 1992; Kang, 2002)
- Reduce the travelling speed (Cameron *et al.*, 1992; Keall *et al.*, 2001; Keal *et al.*, 2002; Kang, 2002; Elvik and Vaa, 2004; Shin *et al*., 2009)
- Decrease the fatal crash rates (Keall *et al.*, 2001; Elvik, 2002; Kang, 2002; Keall *et al.*, 2002; Elvik and Vaa, 2004; Cameron, 2010)
- Reduce the fatalities and injuries in a crash due to speeding (Keall *et al.*, 2001; Keall *et al.*, 2002; Hirst *et al.*, 2005; Thomas *et al.*, 2008; Shin *et al.*, 2009; Cameron, 2010; Luoma *et al.*, 2012; Rudjanakanoknad *et al.*, 2012; He *et al.*, 2013)

The disadvantages of the ASE recognized by researchers are,

- Drivers are slowing down suddenly at the enforcement zone causing an increase in rear-end collision (Shin *et al*., 2009)
- The issue of how to handle offenses for which the drivers cannot be identified such as in the case of the owner was summoned but the offense was committed by others (Douma *et al.*, 2012, Luoma *et al.*, 2012)
- ASE camera's influence distance is limited, driver tend to slow down within the enforcement zone but continue speeding beyond the enforcement zone (Mountain et al., 2004)

3. STUDY LOCATION AND METHODOLOGY

Amongst the 10 sites, Lebuh Sentosa at Putrajaya was chosen to collect the spot speed data. Lebuh Sentosa is one of the trunk roads in the federal territory of Putrajaya with a posted speed limit of 70 km/h. The treatment site was fixed at the point where ASE camera was installed while the control site was fixed in the opposite direction of the road. Both the treatment and control site has a wide verge planted with some small trees and bushes that were used to conceal the observer during data collection (Figures 3 and 4).

Only vehicles travelling in the middle and fast lane were observed, the vehicles travelling on the slow lane were omitted by assuming that those vehicles were complying with the speed limit. Figure 5 shows the layout plan of the study location.

The hand held radar meter was used to capture the speed of the vehicles. The first data collection was conducted on 31 October 2012 to obtain only 100 vehicle speed on both the treatment and control site. This data were then used to compute the minimum sample size required. On 28th November 2012, data collection was conducted for 1 hour on both the treatment and control site. The purpose of the second data collection was to verify the minimum sample size required to compute during the first observation.

The actual data collection was then scheduled in February 2013.

(a)

(b)

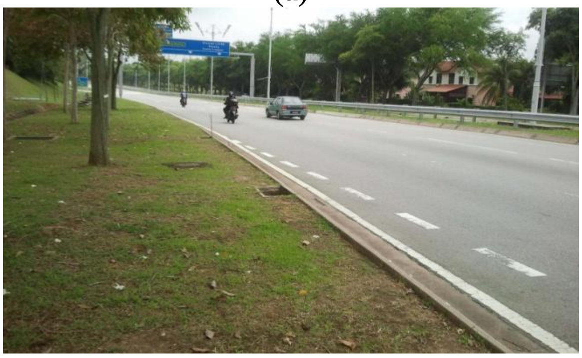
(c)

(d)

Figure 3: The treatment site

(a)

(b)



(c)

(d)

Figure 4: The control site

The required sample size for data collection could be determined using the following formula,

$$n \geq \frac{Z^2 S^2}{e^2}$$

Where n = sample size required
Z = level of confidence (for 95% confidence, Z = 1.96)
S = standard deviation
e = tolerance

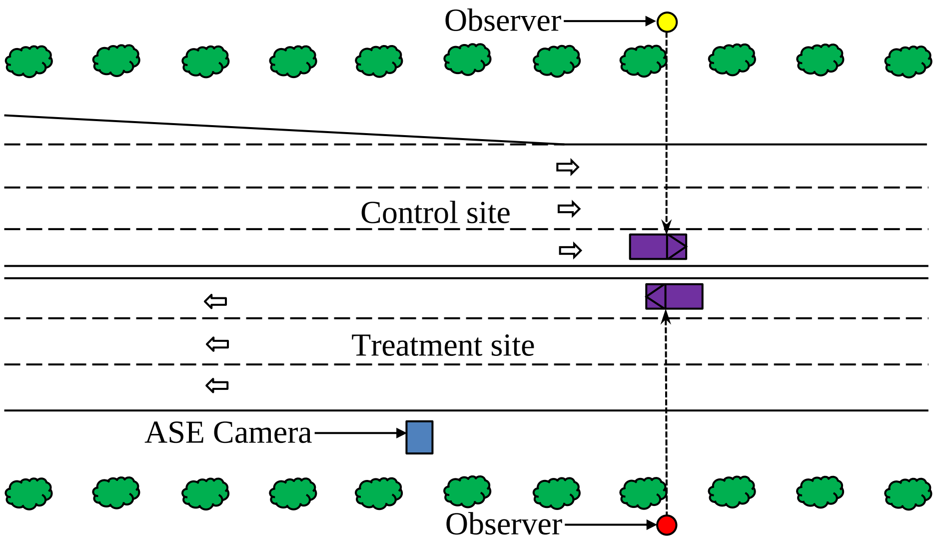


Figure 5: Radar meter spot speed study layout

4. RESULTS AND DISCUSSIONS

A summary of the data collected on 31 October 2012 (Wednesday, Sunny) was tabulated in Table 2. The second data collection was conducted about 1 month later by 28 November 2012 (Wednesday, Sunny) and was tabulated in Table 3.

Table 2: Summary of data collection

Items	Treatment site	Control site
Data collection time	1030 – 1110	1125-1220
Total observation	100	100
Minimum speed (km/h)	35	42
Maximum speed (km/h)	102	112
Mean speed (km/h)	61.63	73.70
Mode speed (km/h)	54	70
Median speed (km/h)	60	71.5
85^{th} percentile speed (km/h)	77.15	86.3
Standard deviation (km/h)	13.39	13.75
No. of vehicles above 70 km/h	28	54
The sample size required, *n*		
(a) If e = 1 km/h	689	727
(b) If e = 1.2 km/h	478	504

Table 3: Summary of data collection

Items	Treatment site	Control site
	28-11-12	28-11-12
Data collection time	1100 – 1200	0930 – 1030
Total observation	140	130
Minimum speed (km/h)	33	48
Maximum speed (km/h)	110	115
Mean speed (km/h)	61.62	72.85
Mode speed (km/h)	57	67
Median speed (km/h)	60	71
85^{th} percentile speed (km/h)	76.15	89
Standard deviation (km/h)	14.24	13.41
No. of vehicles above 70 km/h	34	68
The sample size required, *n*		
(a) If e = 1 km/h	779	691
(b) If e = 1.2 km/h	541	480

The data collection of both sites was conducted during different time due to lack of equipment and manpower. Nevertheless, the traffic flow observed to be similar at all time during the data collection period. From Tables 2 and 3, it was observed that if the speed tolerance of 1 km/h was anticipated, the sample size to be collected at the treatment and control sites should be 689-779 and 691-727, respectively. Subsequently, if a tolerance of 1.2 km/h was expected, then the sample size should be 478-541 and 480-504 for the treatment and control sites, respectively. Regarding the minimum speed, maximum speed, mean speed, mode speed, median speed and 85^{th} percentile speed observed at treatment site were relatively lower than control site.

The results of the speeding behavior for both the treatment and control site are shown in Table 4 and 5. Generally, more than 70% of the drivers were complying with the speed limit at treatment site but at control site, less than 50% of the drivers were complying with the speed limit. Table 4 shows the speeding behavior among drivers at the treatment and control sites. The odds of speeding at the treatment and control sites were 0.39 and 1.17, respectively. The relative odds ratio computed shows that drivers at control site were 3 times more likely to commit violations. We found a significant association between the speeding behavior and location of driving, χ^2 (1) = 13.97, $p < 0.01$. This data also represents the fact that under the ASE, drivers were 3 times more likely to obey the speed limit.

Table 4: Speeding behavior among drivers at the treatment and control sites (31-10-2012)

Site	Speeding			Odds ratio	Relative odds ratio
	No	Yes	Total		
Treatment	72 (59)	28 (41)	100	0.39	3.02
Control	46 (59)	54 (41)	100	1.17	
Total	118	82	200		
Chi-squared	13.97				
p-value	0.0002				

* Note: Value in parenthesis indicates predicted values.

Similar results were also obtained for the second data collection. As indicate in Table 5, the same speeding behavior was observed for drivers travelling at the control site (location without ASE camera), χ^2 (1) = 22.52, p < 0.0001, which represent the fact that the odds of speeding were 3.42 times higher when there is zero speed enforcement effort on the road. Both results show consistent evidence that ASE camera is useful to prevent drivers from speeding at the hazardous road location.

Table 5: Speeding behavior among drivers at the treatment and control sites (28-11-2012)

Site	Speeding			Odds ratio	Relative odds ratio
	No	Yes	Total		
Treatment	106 (87)	34 (53)	140	0.32	3.42
Control	62 (81)	68 (49)	130	1.10	
Total	168	102	270		
Chi-squared p-value	22.52 0.0000				

* Note: Value in parenthesis indicates predicted values.

Based on the two preliminary data collection, the actual data required if a tolerance of 1.2 km/h was anticipated was 541 at the treatment site and 504 at the control site. The actual data collection was conducted on 20th and 27th February 2013 (Wednesday, Sunny), respectively for treatment and control site to act in concert with the Ops enforcement program. A total of 550 data collection was conducted at each treatment and control site. The data obtained was summarized in Tables 6 and 7. The data collection was conducted in different day, however, the weather and traffic flow was observed to be similar during the data collection period.

Table 6: Summary of data collection

Items	Treatment site	Control site
	20-02-13	27-02-13
Data collection time	1015-1340	0950 – 1315
Total observation	550	550
Minimum speed (km/h)	29	45
Maximum speed (km/h)	91	120
Mean speed (km/h)	57.75	75.44
Mode speed (km/h)	54	70
Median speed (km/h)	58	73
85th percentile speed (km/h)	67	93.65
Standard deviation (km/h)	9.64	15.85
No. of vehicles above 70 km/h	48	297

It was observed that with the conjunction of the Ops enforcement, the speeds (minimum, maximum, mean, mode, median and 85th percentile speed) of the treatment site were lower than the preliminary data collection. However, at the control site, the speeds (minimum, maximum, mean, mode, median and 85th percentile speed) were higher than the previous observation. The data collection indicates that 91.3% drivers were complying with the speed limit at the treatment site but only 46% of the drivers comply with the speed limit at the control site.

Table 7: Speeding behavior among drivers at the treatment and control sites (February 2013)

Site	Speeding			Odds ratio	Relative odds ratio
	No	Yes	Total		
Treatment	502 (378)	48 (173)	550	0.10	12.28
Control	253 (378)	297 (173)	550	1.17	
Total	755	345	1100		
Chi-squared	261.83				
p-value	0.0000				

* Note: Value in parenthesis indicates predicted values.

As shown in Table 7, χ^2 (1) = 261.83, $p < 0.0001$, which represent the fact that the relative odds of speeding were 12.28 times greater at the control site. The preliminary and actual data collections also revealed a trend of decreasing in speed violation at the treatment site. Conversely, at the opposite site of the ASE program (the control site), drivers tends to drive recklessly.

The results of the spot speed studies conducted over the period of about 5 months indicate that the establishment of the ASE system in Malaysia is effective in reducing the speeding incidents at the treatment site. The speed trends at both the treatment and control site were useful to assess the effectiveness of national policy about the ASE system. The minimum speed, maximum speed, mean speed, mode speed, median speed and 85th percentile speed demonstrated a reduction at the treatment site over the period of data collection from October 2012 to February 2013. However, the opposite situation was observed at the control site.

During the data collection period, we observed that most of the drivers driving in the fast lane abide the speed limit when approaching the enforcement zones but most of the drivers start to speed beyond the enforcement zones. This may lead to another problem which is the switching of blackspot or accident prone area from the original location where ASE camera was installed to another location beyond the enforcement zones.

It was observed that the implementation of the ASE in most of the countries publicized through mass media. In addition, the authority will usually conduct a public survey to gather the responses from the public regarding the implementation. The location for the installation of a fixed type ASE was also chosen based on criteria such as crash blackspots related to speeding. In Malaysia, the implementations ASE were also publicized through mass media. However, there was no public survey conducted to gather the responses from the public regarding its implementation. A study of ASE using Stated Choice Model (SCM)[4] for public acceptance will be highly appreciated if it was carried out prior to the implementation.

Higgins *et al.* (2011) highlighted that there were some states such as Arizona in the United States where the ASE were banned due to public voting. These were conducted through internet survey and it was found that 40 % of the population are accusing the government that the device is solely revenue generating. Similarly for the ASE in Malaysia,

[4] SCM is a best method to gauge public support or rejection of an enforcement policy as it considers the behavior of individuals.

we should conduct a public survey through internet or other media ensuring the right groups participate in the survey in the respective areas. The government has the obligation to clear the people's perception that the installation of ASE is not just for income generating especially when they allow private companies to operate the ASE not the enforcement agency such as police or the Road Transport Department.

Mountain *et al.* (2005) also concluded in their study that all speed management schemes reduce road crashes but ranked vertical deflection scheme to be the most reliable in reducing road crashes, followed by horizontal scheme and speed cameras. It's simply because the vertical deflection schemes are able to reduce the mean speed of drivers to an average of 8.4 mph and statistics shows the percentage of over speeding drivers also reduced. However, Mountain *et al.* (2005)'s findings still have issues such as to recognize the primary reason for the yearly variation of the number of road crashes in each scheme. In this regard, Hirst *et al.* (2005) suggested that a prediction model need to be developed based on type of schemes, speed changes and site condition. Therefore, prior to the implementation of the ASE in this country, a study should be conducted using similar model in order to please the public regarding the novelty of the ASE system.

In addition to this, the hidden ASE cameras were found to have greater benefits than the fixed type ASE cameras. This is because driving without knowing the exact location of the ASE camera could increase the perception of being caught of the drivers. This can prevent the drivers from speeding beyond the enforcement zone. A new technology such as the intelligent speed adaptation (ISA) could also be useful to remind the drivers to abide the speed limit.

5. CONCLUSIONS AND RECOMMENDATION

The ASE system is proof as one of the most significant tools to reduce the speed. In our case, it was found that the drivers were more likely to obey the speed limit with the presence of the ASE camera in the accident prone area. Our study demonstrated that with the presence of ASE camera, it decreases the likelihood of speeding overtime at the treatment area. Previous research has demonstrated that the ASE system has more advantages over disadvantages. However, some studies also indicated that there are other tools such as the vertical deflection scheme and horizontal schemes that are proven more effective than the speed camera.

With the ASE, it can improve and create a safe driving environment especially in the targeted speed zone. However, previous research and our observations also indicated that drivers will abide the speed limit at the enforcement zones but speeding beyond the enforcement zones. In this case, the ASE system in fact may reduce the crash probability and injury severity related to speeding at the enforcement zones but alternately, this could also create a new road crash blackspot. Therefore, the most critical agenda now is that the drivers must be educated that speeding is dangerous and can cause fatalities. A society that values road safety will value their lives. In view of this, we need to train the society and create a safe driving on the roads.

REFERENCES

Belin, M., Tillgren, P., Vedung, E., Cameron, M., Tingvall, C., (2010). Speed cameras in Sweden and Victoria, Australia – a case study. *Accident Analysis and Prevention*, 42, 2165-2170.

Mutakhir (2011). 70 Peratus saman Ops Sikap berkaitan memandu lebih had laju. *Berita Harian*, 11th February 2011. http://www.bharian.com.my/bharian/articles/70peratussamanOpsSikapberkaitanmemandulebihhadlaju/Article/, accessed on 7th December 2012. (in Malay)

Blincoe, K.M., Jones, A.P., Sauerzapf, V., Haynes, R., (2006). Speeding drivers' attitude and perceptions of speed cameras in rural England. . *Accident Analysis and Prevention*, 38, 371-378.

Cameron, M.H., Cavallo, A., Gilbert, A., (1992). Crash-based evaluation of the speed camera program in Victoria 1990–1991, phase 1, general effects, phase 2, effects of program mechanisms. Monash University, Road crash Research Centre. http://www.monash.edu.au/miri/research/reports/muarc042.pdf, accessed on 7th December 2012.

Cameron, M., (2010). Policy advice to guide the placement of fixed and speed/red-light cameras in Western Australia. Office of Road Safety, Government of Western Australia.http://www.ors.wa.gov.au/Documents/speed-report-placementofcameras.aspx, accessed on 17th December 2012.

Douma, F., Munnich, L., Garry, T., (2012). Identifying issues related to deployment of automated speed enforcement. Centre for Transport Studies, University of Minnesota.

Editor, (2012). Automated **e**nforcement **s**ystem to begin operations midnight **S**aturday**.** *The Star*, 22nd September 2012. http://thestar.com.my/news/story.asp?file=/2012/9/22/nation/20120922141615&sec=nation, accessed on 19th December 2012.

Elvik, R, Vaa, T., (2004). The Handbook of Road Safety Measures. Elsevier, Amsterdam/ New York.

Elvik, R., (2005). Speed and road safety: synthesis of evidence from evaluation studies. Annual Meeting of the Transportation Research Board, Washington, DC.

Finch, D.J., Kompfner, P., Lockwood, C.R., Maycock, G., (1994). Speed, speed limits and road crashs. Project Report PR58. Transport Research Laboratory, Crowthorne.

Hanif, A. (2011). Aspek perundangan perlu diteliti. *Mymetro*, 8th February 2011.http://www.hmetro.com.my/articles/Aspekperundanganperluditeliti/Article, accessed on 7th December 2012. (in Malay)

He, J., King, M., Watson, B., Rakotonirainy, A., Fleiter, J., (2013). Speed enforcement in China: national, provincial and city initiatives and their success. *Accident Analysis and Prevention*, 50, 282-288.

Hirst, W.M., Mountain, L.J., Maher, M.J., (2005). Are speed enforcement cameras more effective than other speed management measures? An evaluation of the relationship between speed and road crash reductions. *Accident Analysis and Prevention*, 37, 731-741.

Higgins, L.M., Shaw, W.D., Edbendewe-Mondzozo, A., (2011). Attributes affecting preference for traffic safety camera programs. *Accident Analysis and Prevention*, 43, 1042-1048.

Jones, A.P., Sauerzapf, V., Haynes, R., (2008). The effects of mobile speed camera introduction on road traffic crashes and casualties in a rural county of England.

Journal of Safety Research, 39, 101-110.

Kang, J., 2002. Changes of speed and safety by automated speed enforcement system. *IATSS Research*, 26(2), 38-44.

Keall, M.D., Povey, L.J., Frith, W.J., (2001). The relative effectiveness of a hidden versus a visible speed camera programme. *Accident Analysis and Prevention*, 33, 277-284.

Keall, M. D., Povey, L. J., Frith, W. J. 2002.Further results from a trial comparing a hidden speed camera programme with visible camera operation. *Accident Analysis and Prevention*, 34, 773-777.

Luoma, J., Rajamäki, R., Malmivuo, M., (2012).Effects of reduced threshold of automated speed enforcement on speed and safety. *Transportation Research Part F*, 15, 243-248.

Mountain, L.J., Hirst, W.M., Maher, M.J., (2005). Are speed enforcement cameras more effective than other speed management measures? The impact of spee management schems on 30mph roads. *Accident Analysis and Prevention*, 37, 742-754.

National Highway Traffic Safety Administration (NHTSA), 2007. Automated enforcement: a compendium of worldwide evaluations of results.

Organisation for Economic Co-operation and Development (OECD), (2011). International transport forum: IRTAD road safety 2010 annual report. http://www.internationaltransportforum.org/irtadpublic/pdf/10IrtadReport.pdf, accessed on 7th December 2012.

Road Transport Department Malaysia (JPJ), (2012). Pengesahan lokasi projek Automated Enforcement System (AES) bagi fasa percubaan. http://www.jpj.gov.my/web/guest/carian?p_auth=J22Y4n4D&p_p_auth=EDap9O47&p_p_id=20&p_p_lifecycle=1&p_p_state=exclusive&p_p_mode=view&p_p_col_id=column-1&p_p_col_pos=2&p_p_col_count=3&_20_struts_action=%2Fdocument_library%2Fget_file&_20_groupId=10157&_20_folderId=58912&_20_name=2001, accessed 14th December 2012.

Rudjanakanoknad, J., Prarom, P., Pamwai, S., (2012). Attitudes of drivers towards speed enforcement measures on Bangkok expressways. *Procedia – Social and Behavioural Sciences*, 48, 222-233.

Shin, K., Washington, S.P., van Schalkwyk, I., (2009). Evaluation of the Scottsdale Loop 101 automated speed enforcement demonstration program. *Accident Analysis and Prevention*, 41, 393–403.

Thomas, L.J., Srinivasan, R., Decina, L.E., Staplin, L., (2008). Safety effects of automated speed enforcement programs – critical review of international literature. *Journal of the Transportation Research Board*, No. 2078, 117-126.

World Helath Organisation (WHO), (2004). Road safety – speed. http://www.who.int/violence_injury_prevention/publications/road_traffic/world_report/speed_en.pdf, accessed on 14th December 2012.