The Effectiveness of Average Speed Enforcement Systems in Taiwan

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ABSTRACT: In recent years, several countries have installed average speed enforcement (ASE) systems to improve road traffic safety through speed management. In Taiwan, 50 ASE systems have been installed since January 2022 on various highways or city roads with speed limits ranging between 30 and 90 km/h. This study uses microscopic vehicle speed data from 15 ASE systems to explore the effect of reducing average speeds. It also uses average speeds, speeding enforcement, and accident numbers from the National Police Administration. A macroscopic speeding enforcement and accident data analysis was conducted using 50 ASE systems compared to 2023 and 2024. In conclusion, according to microscopic vehicle speed or macroscopic road accident data, accident prevention was not entirely achieved in all locations where the ASE systems were installed. Nevertheless, most ASE systems reduced vehicle speed and improved road safety, particularly in tunnels.

Keywords: Average speed enforcement, Sectional speed control, Speed control, Technology enforcement, Accident prevention.

1. INTRODUCTION

From a theoretical and practical viewpoint, traffic speed management on highways is essential for controlling the incidence and severity of accidents. Many countries prioritize highway speed management strategies to achieve this goal, such as setting speed limits and enforcing speeding regulations. Among the traditional methods of speeding regulation enforcement are police-operated radar or laser guns for fixed-point enforcement of vehicle speeds. The fixed-point speed enforcement method has a disadvantage. When a vehicle passes a fixed speed measurement location, if the driver deliberately avoids enforcement, he or she will often reduce the speed to within the speed limit before the speed measurement location and then resume the original driving speed after passing the detection equipment. In addition, there are many detection and point-to-point speed enforcement devices on the market, which drivers can use to reduce their speed. Therefore, in order to manage the speed over a longer section, an enforcement system using average speed enforcement began to emerge (Soole *et al.*, 2013, Borsati *et al.*, 2019, Liu *et al.*, 2019). In 1997, the Netherlands started using average speed enforcement (ASE) systems (Soole *et al.*, 2013).

In April 2018, Taiwan installed its first ASE system for traffic law enforcement in the Wanli Tunnel on Highway No. 2 in New Taipei City. Automated vehicle identification cameras were installed at the beginning and end of a specific road section. The system records the entry and exit times of each vehicle passing through this road section and automatically calculates the difference between these times to determine the vehicle's speed. Vehicles exceeding the speed limit receive a fine. The system differs from traditional fixed-point or moving-point speed control systems. ASE systems enhance the speed control of passing vehicles on a road section by extending the speed control range from points to lines while mitigating the difference between vehicle speeds. This approach facilitates uniform and stable traffic flow. ASE systems effectively reduce average speeds, standard deviations of speed, and vehicle speed ratios. ASE systems also positively affect the number of accidents and casualties. Therefore, several ASE systems have been installed across Taiwan, particularly in locations such as tunnels (urban or suburban), urban roads (two-lane or multilane), suburban highways (two-lane or multilane), and intercity expressways (Tseng & Tsai, 2021; Tseng & Shi, 2024).

After that, Taiwan continued to build ASE systems, and by the end of 2023, 50 ASE systems had been built. In this study, we examined the effectiveness of these systems in terms of speed and safety.

2. LITERATURE REVIEW

Vehicle speed affects traffic safety, with higher speeds exhibiting a more significant effect on the incidence and severity of road traffic accidents. Many studies indicate that speeding is a critical factor associated with traffic safety hazards. Higher speeds are typically associated with a longer vehicle stopping distance and a higher risk of accidents. Higher speeds are also associated with higher kinetic energy generated by collision, which increases the probability of casualties (Howard *et al*., 2008). Differences in vehicle speeds and traffic flow affect road safety. According to Mohammed (2013), variations in vehicle speed positively correlate with the rate of accidents. If the variation in vehicle speed increases by 1%, the rate of accidents increases by 0.3%.

Taylor *et al*. (2002) studied the relationship between speed and accident rate on four road sections and found that the average speed and accident rate positively correlated (Figure 1). In other words, the higher the average speed, the greater the risk of an accident.

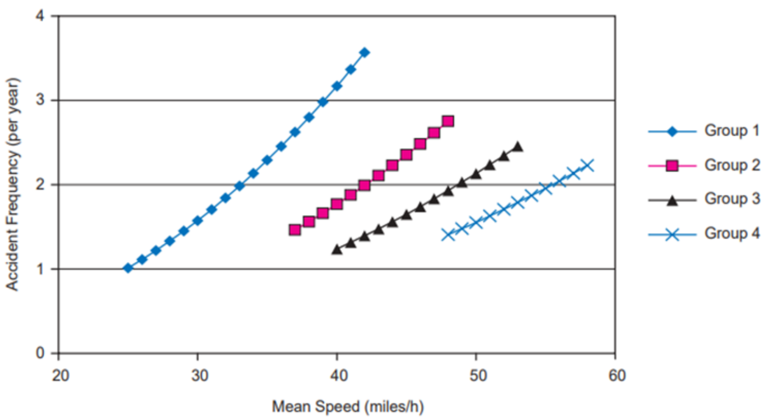


Figure 1 Relationship between average vehicle speed and accident rate (Taylor, 2002)

Speeding directly influences not only the incidence but also the severity of accidents. According to Nilsson (2004), changes in average speed positively correlate with the probability of death, injury, or severe injury in an accident, indicating that higher speeds are associated with greater accident severity. When the average speed increases by 10%, the probability of death, injury, or severe injury increases by 20% to 40% (Figure 2).

In ASE systems, cameras are installed at the beginning and end of a road section to identify license plates. When a vehicle passes through this road section, the system records the entry and exit times of the vehicle and calculates the vehicle's speed by dividing the distance by the time. Figure 3 illustrates the operation principle of an ASE system. ASE systems control the average speeds of vehicles on the road, force drivers to comply with speed regulations, and mitigate the burden placed on traffic law enforcement. In addition, their rate of reporting traffic violations is close to 100% (Aarts *et al*., 2009; Montella *et al*., 2011).

The Netherlands installed the world's first ASE system in 1997 (Soole *et al.*, 2013). After this system was installed, vehicle speeds, accident rates, and travel times decreased, increasing traffic safety. Despite being more expensive than other speed control measures, this ASE system proved more cost-effective in scenarios involving large road sections. Therefore, countries such as Norway, the United Kingdom, Finland, Lithuania, Switzerland, and Italy decided to install their own ASE systems.

Figure 2 Relationship between rate change and accident severity rate
(Nilsson, 2004)

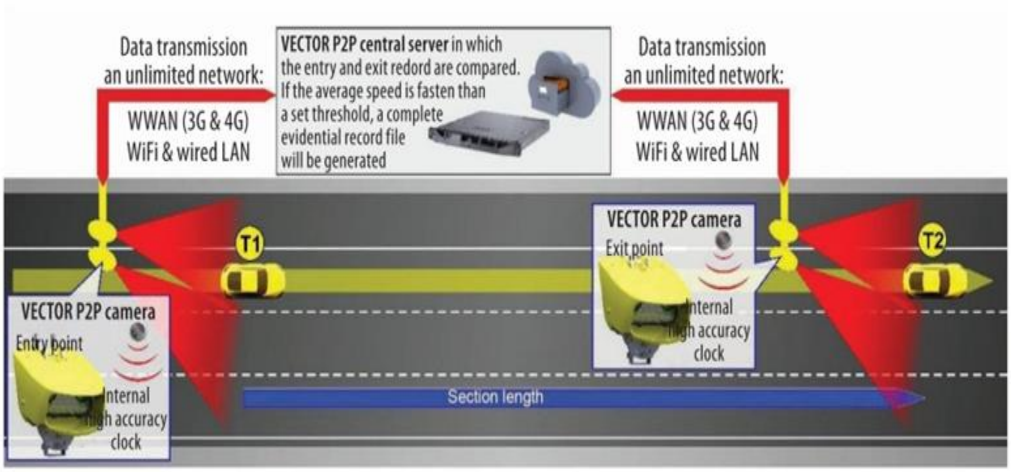


Figure 3. ASE system operating principles
(Gaveniene *et al.*, 2020)

In Italy, after an ASE system was installed on the A56 urban expressway, the speed difference between vehicles and the speeding behavior of drivers decreased (Alfonso *et al.*, 2015). The standard deviation of vehicle speed also decreased by 26%, and a 20% reduction in speeding patterns was observed. In addition, the percentages of speeding small and heavy vehicles decreased by 84% and 77%, respectively, and the frequency of traffic accidents decreased by 32%. Mattia et al. (2019) argued that increasing the coverage of sectional speed enforcement effectively increases road safety. In Italy, increasing the coverage of sectional average speed enforcement by 30% reduced the frequency of accidents by an average of 3%.

Montella *et al*. (2012) reported that after an ASE system was installed on the A1 Milan-

Naples highway in Italy in 2007, accidents and casualties decreased by 31.2% to 55.6%. ASE systems considerably influence the crash rate caused by accidents. Vanlommel *et al.* (2015) examined the effect of an ASE system installed in a road section on the Belgian E40 highway on the driving speed of vehicles. They reported that the system reduced the average speed of vehicles by 15 km/h, making the flow of traffic more uniform. Gaveniene *et al.* (2020) compared the speed data of 25 road sections over 16 months in Lithuania. They reported that after an ASE system was installed, accidents decreased by 16.67%. In addition, the number of vehicles exceeding the speed limit by 20 km/h decreased from 20.84% to 9.91%, representing a reduction of 10.93%. Similarly, the number of vehicles exceeding the speed limit by more than 20 km/h decreased from 2.10% to 0.20%, representing a reduction of 1.9%. These findings confirm the efficacy of ASE systems in controlling vehicle speeds.

Liu *et al.* (2019) examined the effects of an ASE system installed in Wanli Tunnel in New Taipei City, Taiwan. They reported that the system effectively reduced the speeds of vehicles while stabilizing the differences in speed in traffic flow. Specifically, the average speed of traffic flow decreased from 57.89 to 46.57 km/h, and the difference in speed decreased from 11.92 to 5.74 km/h (Figure 4). Before the system was activated, the maximum traffic flow in the tunnel was approximately 1,800 pcu/h. However, after the system was activated, the maximum traffic flow in the tunnel reached approximately 2,100 pcu/h, indicating an increase of 17%. In addition, after the system was activated, the number of speeding tickets considerably decreased from nearly 1,800 in July 2018 to nearly 600 in February 2019. The percentage of violations also substantially decreased from 10.56% to 0.56%, and the number of traffic accidents decreased from 7 to 1.

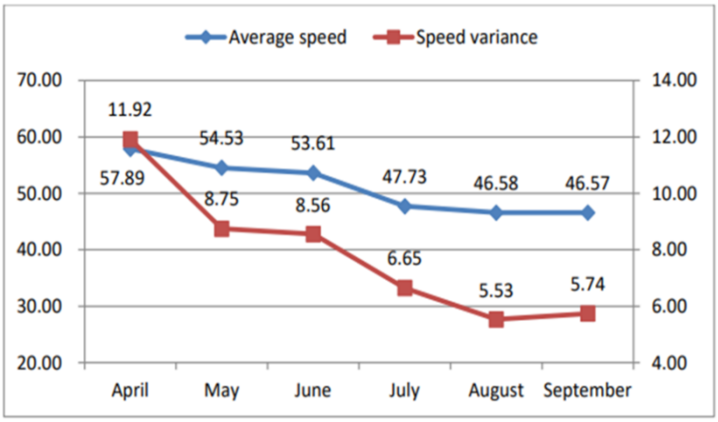


Figure 4. Change in vehicle speeds after installation of ASE system in Wanli Tunnel (Liu *et al.*, 2019)

Hu *et al.* (2020) explored the same ASE system in the Wanli Tunnel. They examined the effects of the system on vehicle speeds and speed conditions in the east-west direction of the tunnel. Their results indicated that, after 6 months of its installation, the system considerably reduced the average speed, standard deviation of speed, and 85th percentile speed of all vehicles. Specifically, the average speed decreased by 9.2% and 25.6%, the standard deviation decreased by 41.7% and 36.7%, and the 85th percentile speed decreased by 28.2% and 22.7%. In addition, the probability of speeding decreased by more than 90%.

Overall, reviewing the literature revealed the following:

1. Many countries consider speed management an essential strategy for preventing road traffic accidents. In Taiwan, speed management is included as a countermeasure in the Road Traffic Order and Traffic Safety Improvement Plan enacted by the government. According to experience and academic theories, the primary purpose of speed

management is to ensure road safety and efficiency, indicating the importance of speed management as a countermeasure for preventing road traffic accidents.

2. Many countries have invested significant resources in determining how to control the speed of vehicles on the road. ASE systems are a practical approach for reducing vehicle speeds and road accidents and mitigating accident severity. Many countries have gradually implemented these systems to control traffic flow.
3. In Taiwan and other countries, various performance indicators have been identified, and multiple comparisons before and after implementation have been conducted to determine the effectiveness of ASE systems. These performance indicators include average speed, speed variation or standard deviation, 85th percentile speed, speeding proportion, and number of accidents or severe accidents. A literature review indicates that almost all studies employ the change in average rate before and after an ASE system is activated as their main evaluation index.

3. DATA COLLECTION AND CLEANING

In this study, data were collected from two primary sources. The first data source was vehicle speeds recorded at controlled road sections, as identified by the ASE system of each police unit. These data were collected before the system was activated and in the first, second, third, and fourth quarters, represented by Q1, Q2, Q3, and Q4 after its activation. The second data source was speeding enforcement and accident data. 15 sets of microscopic speed data were obtained (Table 1), and all macroscopic enforcement and accident data was obtained from the accident database of the Police Department, Ministry of the Interior.

Table 1. 15 ASE systems examined in this study.

No.	location of the ASE system	classification	activation date	speed limit (kph)	number of one-way lanes
A1	Guanyin Shan Tunnel, New Taipei City	tunnel	2022.5.1.	80	2
A2	Caopu Senyong Tunnel, Pingtung County	tunnel	2022.3.1.	70	2
B1	Huanhe Road, New Taipei City	urban road	2022.1.24.	60	3
B2	Xiwan Road, New Taipei City	urban road	2022.5.1.	40	1
B3	Shang Xiang Road, Taichung City	urban road	2022.2.16.	50	4
B4	Songyi Road, Kaohsiung City	urban road	2022.2.25.	50	2
C1	Provincial Highway No.7B, Taoyuan City	suburban highway	2022.2.28.	40	1
C2	County Highway 182, Tainan City	suburban highway	2022.1.28.	50	2
C3	Provincial Highway No.3, Kaohsiung City	suburban highway	2022.2.25.	60	2
C4	Provincial Highway No.21, Nantou County	suburban highway	2022.4.25.	60	2
C5	Provincial Highway No.9E, Taitung County	suburban highway	2022.1.29.	40	2
D1	Provincial Highway No.61, Taoyuan City	expressway	2022.2.24.	90	2
D2	Provincial Highway No.61, Changhua County	expressway	2022.3.1.	90	2
D3	Provincial Highway No.62, Keelung City	expressway	2022.4.1.	80	2
D4	Provincial Highway No.62A, Keelung City	expressway	2022.4.1.	40	2

3.1 Collection and cleaning of speed data

Daily individual vehicle speed data were obtained from 15 ASE systems over 13 months, starting from 1 month before system activation until 12 months after system activation. Specific difficulties or limitations were observed during the process of data collection:

1) The management unit refused to provide information to protect personal data.

2) The data provided by the property management unit differed from those available on all vehicles except speeding vehicles. Therefore, these data were discarded.
3) Some systems were suspended for specific reasons, resulting in a lack of data.
4) A high discrepancy was observed in the number of daily data samples. Therefore, these data were discarded.

Various performance measures, including average vehicle speed and standard deviation over a day, average free-flow speed (FFS) and standard deviation, and 85th percentile speed, were used to evaluate the effectiveness of individual ASE systems. Regarding the speed data of free-traveling vehicles, we conservatively selected vehicles whose headway from the previous vehicle exceeded 10 seconds while passing through the starting point of the speed-controlled road section as our sample.

Speed data were analyzed as follows:

1) To enable an objective comparison and analysis, complete 24-hour weekday data were uniformly selected for analysis.
2) During the speed data cleaning process, average values ± three standard deviations were used to detect outliers and mitigate the effect of extreme values on average speed.
3) The speed data recorded during the month before the ASE system was activated and in the first to fourth quarters after its activation were selected as performance indicators for comparison.

3.2 Collection of accident data

Traffic accident data were collected from the records of the Police Department and Ministry of the Interior on each road section where an ASE system was installed for 1 year before and after its activation. These data included the number of accidents, casualties on the scene and within 24 hours of the accident, and the number of individuals injured.

After the accident data were examined, data on the equivalent number of accidents were obtained from the Institute of Transportation, Ministry of Transportation and Communications (1993) to determine the differences in the number of accidents before and after each ASE system was activated:

$$\mathrm{ETAN} = (9.5 \times F) + (3.5 \times J) + \mathrm{TAN} \tag{1}$$

where *ETAN* is the equivalent number of accidents, *F* is the number of fatalities, *J* is the number of injured persons, and *TAN* is the total number of accidents.

4. RESULTS

In this section, this study first discusses the effects of 15 ASE systems from a microscopic point of view on the speeds of vehicles and the frequency of accidents.

4.1 Impact on Speed

For brevity, only one ASE system within four patterns (Table 1) for tunnels (Type A), urban roads (Type B), suburban highways (Type C), and expressways (Type D) was selected in this study to determine its effect on vehicle speed (Table 2).

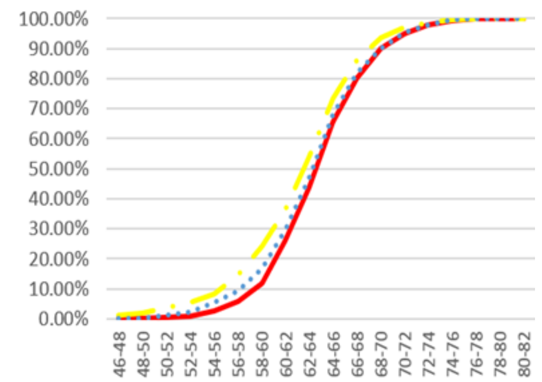
A comparison of the effects of various ASE systems on vehicle speed in each quarter (Q1 to Q4) before and after system activation revealed that most systems reduced the average speed or speed difference in general or free traffic flow. After 1 year of their activation, these ASE systems controlled the average speed of traffic flow within the speed limit. Varying speed reductions were achieved depending on the location and traffic conditions. If the 85th percentile speed exceeded the speed limit, data were submitted to the relevant authorities to review the speed limit. Overall, most of the ASE systems reduced the number of speeding vehicles. In summary, the ASE systems effectively reduced the driving speed and speed difference of vehicles, thereby increasing the uniformity of traffic flow.

Table 2. Examples of effects of various ASE systems on vehicle speed.

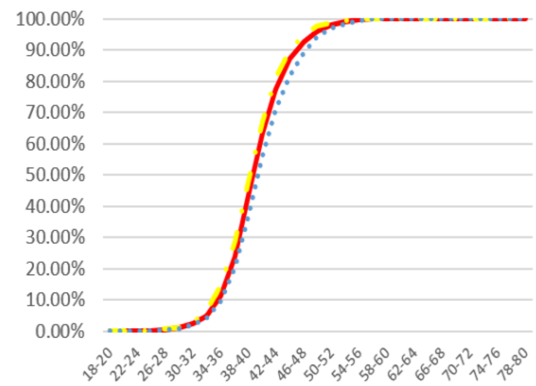
Measure of effectiveness	before	Q1	Q2	Q3	Q4
A2：Caopu Senyong Tunnel, Pingtung County (S.L. = 80 kph)					
average speed (kph)	65.1	64.5	63.5	65.2	64.6
standard deviation (kph)	4.3	4.5	5.1	4.3	4.7
average FFS (kph)	65.6	64.9	64.0	65.4	65.1
the standard deviation of FFS (kph)	4.7	4.7	5.1	4.5	4.9
85th percentile speed (kph)	69	69	68	69	69
speeding vehicle ratio (%)	9.8	8.4	6.4	9.9	9.9
B4：Songyi Road, Kaohsiung City (S.L. = 50 kph)					
average speed (kph)	41.5	41.0	40.8	41.4	42.3
standard deviation (kph)	4.6	4.3	4.5	4.5	4.9
average FFS (kph)	41.8	41.4	41.1	42.2	43.2
the standard deviation of FFS (kph)	5.0	4.8	4.8	5.0	5.5
85th percentile speed (kph)	46	45	45	46	47
speeding vehicle ratio (%)	3.9	2.5	2.5	3.5	5.8
C3：Provincial Highway No.3, Kaohsiung City (S.L. = 60 kph)					
average speed (kph)	58.9	58.4	56.0	59.6	55.7
standard deviation (kph)	7.3	7.4	6.7	7.1	6.9
average FFS (kph)	58.8	58.6	55.9	59.6	55.6
the standard deviation of FFS (kph)	7.6	7.3	6.7	8.5	7.2
85th percentile speed (kph)	66	65	62	68	62
speeding vehicle ratio (%)	7.3	7.4	6.7	7.1	6.8
D3：Provincial Highway No.62, Keelung City (S.L. = 80 kph)					
average speed (kph)	80.7	75.1	75.6	73.6	75.5
standard deviation (kph)	7.9	5.5	5.7	6.7	5.6
average FFS (kph)	82.2	76.3	76.9	74.8	76.4
the standard deviation of FFS (kph)	8.6	5.8	5.7	6.2	5.8
85th percentile speed (kph)	88	80	81	80	81
speeding vehicle ratio (%)	49.6	14.5	17.5	11.5	16.8

The purpose of traffic law enforcement should be traffic efficiency and safety, and punishment or penalties are not the purpose. That is, although the violation rate is a primary concern, this article still lists the average speed as the research focus. At location A2 (suburban two-lane tunnel section), the average speed and 85th percentile speed were significantly lower than the speed limit (80km/h). The speeding rates in Q1 and Q2 decreased, while those in Q3 and Q4 slightly increased. At location B4 (a two-lane section of an urban road), the average speed and the 85th percentile speed were both below the speed limit, but the speeding rate at Q1 and Q2 decreased, while that at Q3 and Q4 increased. At location C4 (suburban multi-lane highway), the average speed and the 85th percentile speed were both below the speed limit, and the speeding rate was maintained at a certain level. Location D3 is a high-speed expressway section near a metropolitan area with heavy traffic and many large vehicles. The average speed and 85th percentile speed can be reduced below the speed limit after setting ASE, which has a significant effect, and the overspeed can also be steadily reduced. Although the speed limit at each location may vary due to factors such as ASE location, road type, and traffic volume. However, the overall average speed and 85th percentile speed were all within an acceptable range.

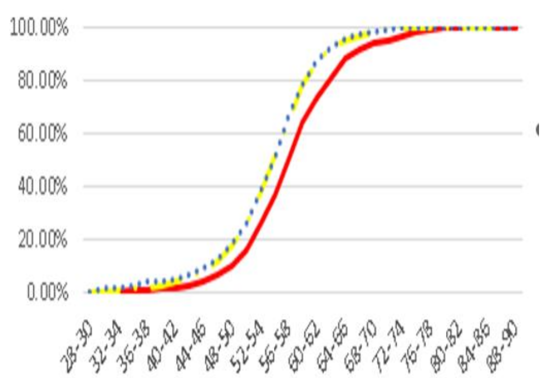
This study further counted and produced the cumulative distribution diagram of the speed for the four road types in Table 2, as shown in Figure 5. Among them, in the tunnel part, Caopu Senyong Tunnel (A2) before opening and the second and fourth quarters are compared. The cumulative distribution percentage curve shows that the speed distribution before opening is on the far right, which means that the rate before opening is the highest. The distribution after activation is biased to the left, indicating that the speed distribution has decreased after the system is activated (Figure 5(a)). In the urban road part, Songyi Road in Kaohsiung City (B4) is not much different from Q2 and Q4 before the ASE system was installed, but the percentage of speeding vehicles is not high. This is probably because there is only one lane in one direction, and drivers know that with the enforcement system, the driving speed can be appropriately reduced (Figure 5(b)). For suburban highways, the Q2 and Q4 curves of Kaohsiung Provincial Highway 3 (C3) and the curves before ASE installation show a decreasing trend in the speed distribution, indicating that the system has a significant effect in reducing speed after activation (Figure 5(c)). The speed distribution of Keelung Highway No.62 (D3) for the expressway has shown a clear downward trend since the ASE system was used (Figure 5(d)).



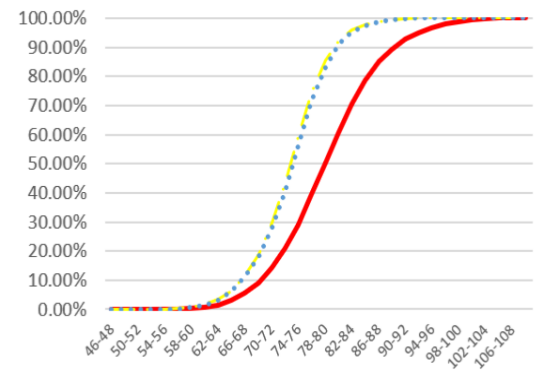
(a) A2：Caopu Senyong Tunnel



(b) B4：Songyi Road



(c) C3：Provincial Highway No.3



(d) D3：Provincial Highway No.62

Note: Before Q2 Q4

Figure 5. The cumulative percentage of the speed distribution of the four types of roads

4.2 Impact on Accident

Police data were analyzed to determine the number of accidents and identify severity indicators 1 year before and after the activation of each ASE system (Table 3). If the value of ETAN after system activation was lower than before, a positive ETAN difference was obtained, indicating improved road safety. The standard errors of ETAN (in Table 3) before and after setting up the ASE system are 2.88 and 2.81, respectively.

Table 3 lists the locations of 15 ASE systems installed in Taiwan. At three locations, the number of accidents in the year before system activation was less than or equal to five. The ASE systems installed at these three locations were presumably not installed to prevent traffic accidents. We discarded the data obtained from these three locations (B2, C5, and D4). Among the remaining 12 locations, 9 experienced fewer accidents after the ACS systems had been installed (Table 3), and 3 (A2, C4, and D3) experienced more accidents after the ASE systems had been installed. Among the three locations that experienced more accidents, two experienced decreased accident severity (A2 and C4). In summary, most of the ASE systems effectively reduced the number of accidents and mitigated their severity (Table 3). Taken together, these findings underscore the importance of installing ASE systems.

Table 3. Effectiveness of various ASE systems in preventing accidents

Sites	Number of accidents and ETAN in one year								
	Before (number)			After (ETAN and number)				Comparison (ETAN)	
	all accidents	fatal accidents	injury accidents	(1) ETAN	all accidents	fatal accidents	injury accidents	(2) ETAN	(3) = (1) – (2)
A1	36	0	5	53.5	14	0	5	31.5	22.0
A2	18	0	9	49.5	23	0	4	37.0	12.5
B1	22	0	9	53.5	15	0	1	18.5	35.0
B2*	5	0	5	22.5	1	0	1	4.5	18.0
B3	63	1	49	244.0	58	0	37	187.5	56.5
B4	36	1	30	150.5	15	0	12	57.0	93.5
C1	142	0	93	467.5	92	2	93	436.5	31.0
C2	49	2	56	264.0	45	3	50	248.5	15.5
C3	21	0	24	105.0	5	0	6	26.0	79.0
C4	19	1	9	60.0	23	0	10	58.0	2.0
C5*	3	0	4	17.0	4	0	4	18.0	-1.0*
D1	29	0	20	99.0	10	1	5	37.0	62.0
D2	42	1	14	100.5	40	1	7	74.0	26.5
D3	24	0	2	31.0	27	0	5	44.5	-13.5
D4*	2	0	1	5.5	1	0	2	8.0	-2.5*

4.3 Comprehensive analysis

Given the effectiveness of these 15 ASE systems in controlling vehicle speed, we expected the speeds of vehicles to decrease and the degree of road safety to increase after ASE systems had been installed. We collected and analyzed vehicle speed and accident data and converted these data into equivalent values. Figure 6 depicts the effects of various ASE systems on different road categories.

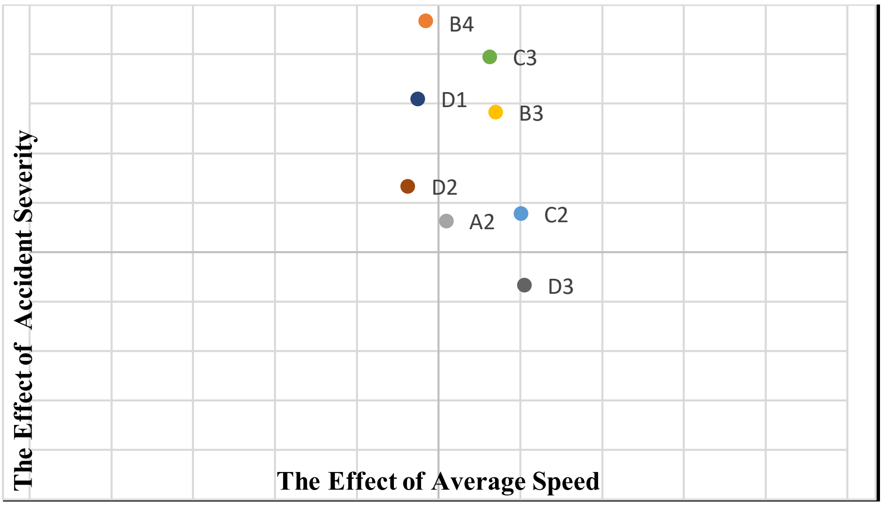


Figure 6. Effectiveness of ASE systems in Taiwan.

Figure 6 depicts the effects of each ASE system on vehicle speed and road safety through an importance-and-performance comparison in management instead of an average speed index or an accident data index. The *x*-axis in Figure 6 illustrates the effect on average speed after the ASE system was activated, with positive values indicating that the ASE system reduced vehicle speed and vice versa. The *y*-axis in Figure 6 illustrates the effect of accident severity after the ASE system was activated, with positive values indicating that the ASE system mitigated accident severity and vice versa. Figure 6 shows the effects of various ASE systems on vehicle speed and accident severity in four road patterns (Types A1 to D4).

In Figure 6, the first quadrant illustrates a decrease in average speed and accident severity after installing ASE systems, representing the optimal scenario for the ASE system. The second quadrant illustrates an increase in average speed but a decrease in accident severity after installing the ASE systems. The third quadrant illustrates an increase in average speed and accident severity after installing the ASE systems. The fourth quadrant illustrates a decrease in average speed but an increase in accident severity after installing the ASE systems.

Figure 6 depicts the results of each ASE system. These results can be summarized as follows:

1) Most ASE systems fell within the first quadrant, indicating that significant average speed and accident severity reductions were achieved in most locations after the ASE system was activated.
2) Although three ASE systems fell within the second quadrant, a slight increase in average speed was observed, with an amplitude of approximately 2 km/h. Nevertheless, a significant reduction was observed in the severity of accidents.
3) None of the ASE systems fell within the third quadrant.
4) Only one ASE system (D3) fell within the fourth quadrant. Despite the significant effect on vehicle speed, an increase was observed in the severity of accidents. After further analysis, D3 was installed on Expressway No. 62 in Keelung City. This expressway has several curved sections and is characterized by high traffic volumes, high proportions of large vehicles, and rainy weather, suggesting that vehicle speed may not be the leading cause of accidents on this expressway. These findings suggest that strategies other than ASE systems may be more effective in preventing accidents.

5. CONCLUSIONS

This study used vehicle speed data to determine the effectiveness of ASE systems in reducing vehicle speed and accident severity on various highways or road types in Taiwan. Our findings can be used as a reference in the transportation field:

1) Most ASE systems installed in Taiwan reduce vehicle speed and increase road safety. Regarding vehicle speed, 93% of the systems effectively reduced the average traffic speed to less than the speed limit, 67% of the systems reduced the average speed, and 60% reduced the standard deviation of vehicle speed. Regarding safety, 67% of the systems reduced the number of accidents, and 91% of the systems mitigated the severity of accidents.
2) Given the diversity and randomness of accidents, not all can be prevented through speed management in all locations. Both driver-related factors (e.g., fatigue and driving under the influence) and vehicle-related factors (e.g., tire tread wear, low road visibility, and insufficient turning radius) play a role in the occurrence of accidents. In this study, although the ASE systems reduced the number of traffic accidents in most road sections, the number of accidents increased in three sections. These findings indicate that ASE systems may not be effective in all road sections.
3) After the ASE systems were activated, their effectiveness in reducing vehicle speed gradually decreased. According to our analysis, the most significant reduction in average vehicle speed was observed in the first quarter after an ASE system was activated. However, the average speed of 11 out of 16 systems was higher in the third or fourth quarter than in the first quarter. As indicated by the systems' pre-activation values, the effectiveness of the ASE systems presumably decreased over time after their activation.
4) We recommend extending the adaptation period and conducting a professional and objective evaluation before installing an ASE system. In this study, challenges were experienced during data collection. Challenges included insufficient data collection instances, a small number of vehicles monitored, and other unstable conditions that hindered comparisons before and after system activation. Consequently, determining whether to implement ASE systems in the future is recommended. When a speed control system is installed, a comprehensive assessment of road geometric conditions, traffic characteristics, road types, and accident causes should be conducted. In addition, an objective and professional evaluation should be conducted to determine whether the target area is suitable for installing an ASE system.
5) Generally, we recommend monitoring the effectiveness of ASE systems regularly. According to our findings, certain systems achieve significant effects during the first 3 months of use. However, after 6 months, their effectiveness in reducing average vehicle speed or its standard deviation decreases, even below the values observed before their activation. To our knowledge, no inspection mechanism has yet been established for the currently available systems. This lack of data suggests that certain systems are presumably still used, although they are no longer effective. Hence, relevant units should establish performance indicators (average rate, standard deviation, etc.) and regularly monitor the effectiveness of ASE systems to ensure that these indicators meet their expected requirements.

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