Speed feedback signs as a tool to manage demand for lower residential speeds

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Abstract

Citizens frequently express concerns regarding unsafe speed and look for ways to improve speed compliance. Speeding is a subjective term since a vehicle may be driving within the posted speed limit but may still be inappropriate for the road conditions. In an urban environment, speeding in residential areas, schools and playgrounds is a common concern. Although there are number of tools such as: posted speed limits, signage, electronic speed warning signs, enforcement etc. available to deter speeding drivers, addressing these concerns in a long lasting way has always been a great challenge to transportation professionals.

Vehicle activated traffic calming signs have been used in Canada for over a decade. In Calgary, Speed Limit Observation and Warning System (SLOWS) and Interactive Speed Limit Observation and Warning System (iSLOWS) have been used in residential neighbourhoods, school & playground zones, construction zones, and special events such as Calgary Stampede to educate drivers against speeding. Although these two devices look strikingly similar in function, the process to assign these devices is completely different. SLOWS trailers are temporary and rotated on a 2-week/location basis following a citizen request whereas iSLOWS are permanently assigned to a location following a detailed traffic speed study. Amidst the increasing demand and popularity of these devices as tools to address speeding concerns in short term, long lasting impacts of these devices on educating drivers against speeding remain questionable.

The City of Calgary conducted speed study at various locations in 2014 with the objective of evaluating the effectiveness of SLOWS trailers and iSLOWS in reducing speed. Speed display boards mounted on trailers were placed on roadside at various playground and non-playground zone locations for a period of 2 weeks. Speed data were collected before, during and after the installations using rubber road tubes connected to an automatic counter in the immediate vicinity of the speed display board. In case of iSLOWS, the speed data were collected in different trigger speeds to see the impacts of the speed limit warning sign to drivers.

Results indicated that average speed during SLOWS trailer deployment reduced by 1.59 km/h to 5.64 km/h depending on the location, compared to before installation period. These results were significantly different at 95% confidence level at most locations. Results from iSLOWS study indicated that the level of speeding reduced when the trigger speed is lowered from 35 km/h to 30 km/h. However, the positive effect didn't last long as the speed level was back to the before installation level after 4 weeks of iSLOWS installation.

Introduction

Vehicle activated traffic calming signs have been used by many jurisdictions in Canada for over a decade. In Calgary, Speed Limit Observation and Warning System (SLOWS) and Interactive Speed Limit Observation and Warning System (iSLOWS) have been used in residential neighbourhoods, school & playground zones, construction zones, and special events such as Calgary Stampede to educate drivers against speeding. Both of these devices use radar technology to measure speed of an oncoming vehicle and display on the screen to make the speeding drivers aware of their speed relative to the speed limit. Although these two devices look strikingly similar in function, the process to assign these devices is completely different. SLOWS trailers are temporary and rotated on a 2-week/location basis following a citizen request whereas iSLOWS are permanently assigned to a location following a detailed traffic speed study.

Figure 1: Typical example of iSLOWS used in Calgary

As shown in Figure ***1***, iSLOWS is typically placed in a permanent fashion on a pole after a detailed traffic study in coordination with the Community Associations. The City of Calgary started installation of these devices in 2008 and now has over 70 iSLOWS. Although the iSLOWS are meant to be placed permanently, there have been situations where some of them have been relocated because of growing demand. Typically, the iSLOWS have been installed on collector roads where speeding is a common concern. 85th percentile speeds are generally reviewed to determine the location for iSLOWS. As there are no guidelines developed, context sensitive engineering judgement is presently used to select the locations.

As shown in *Figure* ***2***, SLOWS trailer is generally placed on a median or boulevard for a two-week period at each location following a citizen's complaint via 311 about speeding in their neighbourhood. In some cases, the request comes through Councillor's office following a citizen complaint. City of Calgary currently has a fleet of 8 SLOWS trailers that are rotated around the City based on the request. Rotation duration is usually from the first week of April to the end of November depending on weather conditions. Because of the sheer volume of requests, it is not always possible to determine whether the reported speeding concern is real or perception of residents. Hence, the SLOWS trailers are installed in places where requested. However, the impact for long term is not clear. The impact of the temporary SLOWS signs on motor vehicle drivers might fade due to excessive use unless they are supported by police enforcement.

Figure 2: Typical example of SLOWS trailer used in Calgary

This paper discusses the results of a before-after speed study conducted at six locations in Calgary to determine the effectiveness of the SLOWS trailers in reducing speed of vehicles by warning the drivers with the speed display. Results from one of the iSLOWS locations will also be discussed.

Objectives

The main objectives of this study were:

- To evaluate the effectiveness of SLOWS trailers and iSLOWS in reducing speed of vehicles
- To evaluate if there was any lasting effect after the removal of electronic speed warning devices

Literature Review

Speed display boards have been in use since more than a couple of decades and the technologies are changing towards better performance and accuracy. With the increase in use of these devices, many researchers have tried to find a relation between the impacts of speed display boards on driver behaviour in reducing the speed for immediate or long term.

Hildebrand et al. (2014) evaluated the long term effectiveness of speed display boards on speed reduction through school zones; one week, two months, one year and four years after the installation. Before-after study results indicated that sustained and statistically significant reduction in the average speeds ranging from 5-14 km/h were achieved dependent mostly on the degree of excessive speeding prior to installation. Mean speeds were reduced consistently to 36-37 km/h on a 30 km/h zone. It was concluded that speed display boards have a statistically significant long-term effect on reducing motorist speeds through school zones.

Although experts generally agree that law enforcement is most effective at lowering speeds, this measure is often unavailable due to workforce limitations and cost. Where increased law enforcement is not possible, technology is providing other means for reducing vehicle speeds Mattox et al. (2007). In a study conducted on the development and evaluation of a speed activated sign to reduce speed in work zones, Mattox et al. (2007) concluded that the speed-activated sign produced significant reductions in vehicle speed for short term. Speed reductions of 4.8 km/h at some locations and up to 16.1 km/h were achieved at other locations where excess level of speeding was prevalent.

It is hard to argue the fact that a pedestrian struck by a vehicle traveling at a higher speed will have a more catastrophic effect than if the vehicle were traveling at a slower speed. Pasanen (1992), Anderson et al. (1995), Rosen and Sander (2009) etc. have tried to explain relationship between impact speed and likelihood of pedestrian fatality with a wide range of results. Pasanen (1992) estimated that about 6 percent of pedestrians would die if struck by a vehicle travelling at 30 km/h. The pedestrian fatality risk rises to 40 percent if the impact speed was 50 km/h and 94 percent for impact speed of 70 km/h. Anderson et al. (1995) however, estimated that the pedestrian fatality rate increases to 85% when struck by a vehicle at 50 km/h. Contrary to the previous findings, Rosen and Sander (2009) identified far lower fatality risks than generally reported in the traffic safety literature. This discrepancy is primarily explained by sample bias

towards severe injury collisions in earlier studies. Nevertheless, a strong dependence on impact speed is found, with the fatality risk at 50 km/h being more than twice as high as the risk at 40 km/h and more than five times higher than the risk at 30 km/h.

In a work cited by Veneziano et al. (2010); Lee et al. (2006) examined the effectiveness of speed monitoring displays in reducing speed in school zone in South Korea. Speed data were collected before deployment, and again two weeks and 12 months after deployment. Prior to the display installation, 26.5 percent of motorists were observed to be exceeding the 50 km/h speed limit, while only 9.9 percent were speeding two weeks after deployment, and 5.5 percent 12 months after deployment. Additionally, 85th percentile speeds fell from 52.8 km/h before deployment to 44.8 km/h (two weeks) and 43.2 km/h (12 months) afterward. Kolmogorov-Smirnov two-sample tests were performed to determine whether the before-and-after speed distributions were similar, with results indicating that a significant change in speed distributions had occurred.

Chang et al. (2004) conducted a speed study along 108th Avenue NE; King County, United States using radar speed signs. Results indicated that there was a general decrease in volumes and speeds as expected. However, one of the major findings of this study was the achievement of qualitative sentiment from the community indicating a convincing traffic safety balance that has immeasurable value. The community recognized that the occasional speeder will remain, but the solution implemented achieved the overall goal of improving liveability. The neighborhood involvement factor, including outreach, education, input, and development of a mutually acceptable solution, established the framework of a consensus process and resulted in a solution that was acceptable and endorsed by any public agency's loudest critic – its community and tax-paying citizens who demand and expect the best services possible.

Methodology

SLOWS trailers - Before-after speed study:

Speed data was collected using rubber road tubes installed on the roadway in the immediate vicinity of the display board and connected to an automatic counter. Only one direction of travel of the roadway was studied at each of the locations during a weekday. Vehicle speed data was collected for a 24 hour period 1-2 weeks prior to the deployment of SLOWS trailers, during the presence of SLOWS trailers and approximately two weeks after the removal.

Results: Locations with speed limit 50 km/h

Table 1: Summary of results from location 1 – Silver Springs Bv & Silver Ridge Dr NW

Statistic	Before SLOWS	During SLOWS Installation	After SLOWS
Sample size	589	589	589
Average Speed	47.36	43.50	36.54
85th Percentile Speed	53.17	49.15	48.05
Standard Deviation	6.15	5.88	11.10
Percentage of vehicles exceeding speed limit	33.9%	11.37%	10.35%

Table 2: Summary of results from location 2 – Maple Creek Dr & Maple Ridge Cres SE

Statistic	Before SLOWS	During SLOWS Installation	After SLOWS
Sample size	740	740	740
Average Speed	46.78	43.57	45.06
85th Percentile Speed	55.87	51.11	52.60
Standard Deviation	9.97	8.42	7.77
Percentage of vehicles exceeding speed limit	40.40%	21.08%	26.75%

Results: Locations with speed limit 60 km/h

Table 3: Summary of results from location 3 - 34 Av & 85 St SW

Statistic	Before SLOWS	During SLOWS Installation	After SLOWS
Sample size	2400	2400	2400
Average Speed	58.74	53.10	60.38
85th Percentile Speed	66.14	59.57	68.66
Standard Deviation	8.77	7.55	9.12
Percentage of vehicles exceeding speed limit	43.12%	13.50%	54.91%

Upon completion of the speed data collection, two sample t-test was performed to test the significance of the change in average speed before installation, during SLOWS trailers and after the removal of SLOWS trailers.

Significance test: Null Hypothesis (H0): Mean speeds before and during SLOWS trailer installation are equal.

Reject H0: We can say with 95% confidence that the two mean speeds are significantly different (If t Stat lies outside ± t Critical two-tail values). Cannot reject H0: There is not sufficient evidence to reject null hypothesis that the two mean speeds are equal (If t Stat lies within ± t Critical two-tail values). *Table 4* to *Table 6* summarize the results of t-test.

Table 4: Significance test for location 1 - Silver Springs Bv & Silver Ridge Dr NW

	tStat	tCritical two tail	Result: Average speed significantly different at 95% confidence level?
Before vs During SLOWS	10.98	1.96	Yes (Reject H0)
Before vs After removal	20.67	1.96	Yes (Reject H0)

Table 5: Significance test for location 2 - Maple Creek Dr & Maple Ridge Cres SE

	tStat	tCritical two tail	Result: Average speed significantly different at 95% confidence level?
Before vs During SLOWS	6.70	1.96	Yes (Reject H0)
Before vs After removal	3.69	1.96	Yes (Reject H0)

Table 6: Significance test for location 3 - 34 Av & 85 St SW

	tStat	tCritical two tail	Result: Average speed significantly different at 95% confidence level?
Before vs During SLOWS	23.89	1.96	Yes (Reject H0)
Before vs After removal	1.16E-10	1.96	Yes (Reject H0)

Results summarized in *Table 1* to *Table 3* indicated that the average speed was reduced by 3.21 km/h to 5.64 km/h during SLOWS trailer installation compared to before installation period which was significantly different at 95% confidence level for all 3 locations. This indicated the positive impact of SLOWS trailers in reducing speeds of vehicles when it's present. After the removal of the SLOWS trailers, the mean speed increased in two locations and decreased in one. While one location witnessed higher level of decrease in average speed, another location observed increase in mean speed to a level even higher than the before period. This inconsistency in change in speed level indicated that the effect of SLOWS trailers did last after the removal but was not consistent at all locations.

Percentage of vehicles exceeding the speed limit in before installation period was in the range 33% - 43% whereas this number was down to 11% - 21% range during SLOWS trailer installation and slightly increased after the removal of SLOWS trailers except in one case which witnessed sharp change in the percentage of vehicles exceeding speed limit even higher than before period (Before: 43.12%, During: 13.50% and After: 54.91%).

Results: Locations with speed limit 30 km/h

Speed data collected during 24 hour period were separately analyzed for playground zone hours and after hours. *Table **7*** to *Table **9*** summarize the speed data for this location.

Table 7: Summary of results from location 4 - 22 Av & 7 St NE

Statistic	Before		During		After	
	PGZ Hours	Remaining Hours	PGZ Hours	Remaining Hours	PGZ Hours	Remaining Hours
Sample size	238	71	238	71	238	71
Average Speed	32.62	36.45	29.49	34.10	30.69	34.86
85th Percentile Speed	39.37	46.15	34.06	42.62	37.02	42.73
Standard Deviation	6.01	8.63	5.16	7.72	6.17	7.75
Percentage of vehicles exceeding speed limit	64.70%	0.05%	44.11%	0.02	52.94%	0.01%

Table 8: Summary of results from location 5 - Falsby Pl & Falsby Rd NE

Statistic	Before		During		After	
	PGZ Hours	Remaining Hours	PGZ Hours	Remaining Hours	PGZ Hours	Remaining Hours
Sample size	156	72	156	72	156	72
Average Speed	27.78	29.94	26.09	28.54	27.94	31.07
85th Percentile Speed	33.82	36.77	31.70	35.46	34.46	36.87
Standard Deviation	6.04	7.24	4.98	6.87	6.16	6.58
Percentage of vehicles exceeding speed limit	33.33%	0.01%	20.51%	0%	27.56%	0.01%

Table 9: Summary of results from location 6 - 1 Av & Penworth Dr SE

Statistic	Before		During		After	
	PGZ Hours	Remaining Hours	PGZ Hours	Remaining Hours	PGZ Hours	Remaining Hours
Sample size	237	67	237	67	237	67
Average Speed	31.62	34.76	28.76	29.15	31.16	31.60
85th Percentile Speed	38.77	41.66	33.82	35.42	38.44	37.48
Standard Deviation	7.06	7.43	5.45	6.05	6.61	6.76
Percentage of vehicles exceeding speed limit	57.38%	0.02%	39.24%	0%	52.32%	0.01%

Two sample t-test was performed to test the significance of the change in average speed before installation, during SLOWS trailers and after the removal of SLOWS trailers. *Table 10* to *Table 12* summarize the results of significance tests.

Table 10: Significance test for location 4 – 22 Av & 7 St NE

Stats	Average speed significantly different at 95% confidence level?	
	During PGZ Hours	After Hours
Before vs During	Yes (Reject H0)	Yes (Reject H0)
Before vs After	Yes (Reject H0)	Yes (Reject H0)

Table 11: Significance test for location 5 – Falsby Pl & Falsby Rd NE

Stats	Average speed significantly different at 95% confidence level?	
	During PGZ Hours	After Hours
Before vs During	Yes (Reject H0)	No (Cannot reject H0)
Before vs After	No (Cannot reject H0)	No (Cannot reject H0)

Table 12: Significance test for location 6 – 1 Av & Penworth Dr SE

Stats	Average speed significantly different at 95% confidence level?	
	During PGZ Hours	After Hours
Before vs During	Yes (Reject H0)	Yes (Reject H0)
Before vs After	No (Cannot reject H0)	Yes (Reject H0)

The study showed a reduction of average speed by 1.69 km/h to 3.13 km/h during SLOWS trailer installation in the playground zone compared to before installation period which was significantly different at 95% confidence level. The average speed was reduced by 1.59 km/h to 3.16 km/h during non-playground zone hours. This indicated the positive impact of SLOWS trailers in reducing speeds of vehicles when it's present. After the removal of SLOWS trailers, the average speed increased to similar level as before and was not significantly different in most cases indicating that the effect of SLOWS trailers didn't last long.

Percentage of vehicles exceeding the speed limit during installation of SLOWS trailers reduced significantly compared to before installation period and increased close to before period level once the SLOWS trailers were removed. During non-playground hours, the percentage of vehicles exceeding 50 km/h was negligible in before and after periods and none during the SLOWS trailer installation.

iSLOWS speed study:

A temporary iSLOWS was placed along 14A Street south of the intersection with 19 Av SW as a traffic calming measure in the Bankview Community in Calgary on August 2014 for a six week period. The idea was to test how the vehicles react to the "SLOW DOWN" display on iSLOWS.

Before speed data was collected using hoses whereas after iSLOWS installation, the speed data were measured by radar in the same iSLOWS as it has the data collection capability. Because of inconsistent tools, there could be slight discrepancy between before and after speed data. Initially, the trigger speed of the iSLOWS was programmed as 35 km/h and changed to 30 km/h two weeks later. The iSLOWS would show "SLOW DOWN" message when the vehicle operating speed exceeds the trigger speed. Weekly data samples were used to compare the speed difference before and after changing the trigger speed of ISLOWS.

Table 13: Speed data summary before and after iSLOWS installation

Statistic	Before iSLOWS installation	During iSLOWS installation					
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Average Speed	29.3	30.5	31.3	27.8	30.4	29.9	31.7
85th Percentile Speed	37.6	38.0	39.0	35.0	38.0	37.0	40.0
Percentage of vehicles exceeding 30 km/h	51%	52%	56%	35%	51%	49%	56%
Percentage of vehicles exceeding 35 km/h	27%	23%	28%	13%	25%	22%	30%

During iSLOWS installation, the percentage of vehicles exceeding trigger speed was 23% - 28% in the first two weeks under the condition that the trigger speed was set as 35 km/h. This was comparable to 27% in the before period. The percentage of vehicles exceeding 30 km/h was between 52% - 56% slightly higher than the before period level (51%).

When the trigger speed was changed to 30 km/h in the third week, the percentage of vehicles exceeding trigger speed (30 km/h) significantly reduced to 35% compared to before period which was 51%. The percentage of vehicles with speed ≤ 35 km/h decreased dramatically to 13% compared to 27% in the before period and 23% - 28% in week 1 and week 2. Starting 4th week, the percentage of vehicles exceeding both 30 km/h and 35 km/h climbed back to the week 1 level for rest of the test period. This indicated that the impact of iSLOWS remained effective for a short period and faded away as the speed warning device stayed for a longer period.

Conclusions

It was concluded from the before-after speed study that the SLOWS trailers are effective in reducing the speed of vehicles during the rotation period whereas the impact after removal is still inconclusive. The statistical analyses indicated that the positive effect of these devices still remained at some locations even after two weeks of removal.

Results indicated that the average speed was reduced by 3.21 km/h to 5.64 km/h during SLOWS trailer installation compared to before installation period which was significantly different at 95% confidence level for all 3 locations with speed limit 50km/h to 60 km/h. After the removal of the SLOWS trailers, the mean speed increased in two locations and decreased in one. This inconsistency in change in speed level indicated that the effect of SLOWS trailers did last after the removal but was not consistent at all locations.

Percentage of vehicles exceeding the speed limit in before installation period was in the range 33% - 43% whereas this number was down to 11% - 21% range during SLOWS trailer installation and slightly increased after the removal of SLOWS trailers except in one case which witnessed sharp change in the percentage of vehicles exceeding speed limit even higher than before period (Before: 43.12%, During: 13.50% and After: 54.91%).

In the playground zone, average speed was reduced by 1.69 km/h to 3.13 km/h during SLOWS trailer installation compared to before installation period which was significantly different at 95% confidence level. The average speed was reduced by 1.59 km/h to 3.16 km/h during non-playground zone hours. This indicated the positive impact of SLOWS trailers in reducing speeds of vehicles when it's present. After the removal of SLOWS trailers, the average speed increased to similar level as before and was not significantly different in most cases indicating that the effect of SLOWS trailers didn't last long.

Percentage of vehicles exceeding the speed limit during installation of SLOWS trailers reduced significantly compared to before installation period and increased close to before period level once the SLOWS trailers were removed. During non-playground hours, the percentage of vehicles exceeding 50 km/h was negligible in before and after periods and none during the SLOWS trailer installation.

The iSLOWS speed study indicated that the speed reduced when the device was present and the effect faded after a few weeks. The trigger speed also played a major role as the percentage of vehicles exceeding 30 km/h reduces significantly after the trigger speed was reduced from 35 km/h to 30 km/h. In conclusion, the both SLOWS trailer and iSLOWS appear to be effective tools in reducing the speed where speeding problem exists.

Next Steps/Further Research

Although the study revealed positive effects of the SLOWS trailers and iSLOWS in reducing speed for a short period of time, the permanent effect of electronic speed display signs remains questionable and further research is needed in the following area:

1. Optimal rotation period before the effect fades down,
2. Multiple rotations at the same location supported with police enforcement,
3. Technological upgrades: Display, data collection capability/uses/liability of such data
4. Selection of locations. Direct request from 311 – more of PR tool than actual problem solving in some cases as often people request but there is not really a speeding issue.

Lessons Learned from Calgary's SLOWS trailer rotation and iSLOWS

1. Currently, the City of Calgary has a fleet of 8 SLOWS trailers that rotate within 14 wards. As the request for these devices comes directly from citizens and Councillors, it is sometimes overwhelming to accommodate the request in a short period of time as everyone would like to see it installed as soon as they witness a speeding vehicle in their neighbourhood. Despite the level of effort and likely long waiting time, the citizens seem to be aware that there is such a device that can help curb speed in the neighbourhood. Given the popularity of this device and its ability to immediately comfort citizens, The City of Calgary is planning to expand the fleet to accommodate the increasing requests. Ideally, there is desire to have one dedicated SLOWS trailer per ward. This will greatly reduce the efforts in moving the trailers from one location to another and also makes it easier to deal with Councillor inquiries in terms of prioritising the locations.
2. Although longer periods of rotation have been tried at some locations following the request from City Councillors, the optimal rotation period seems to be two weeks as the vehicles get the message and slow down. If it is placed for an extended period of time, there may be increase in non compliance (also supported by literature) as the drivers get used to seeing it every day. This may however be a good topic for further investigation.
3. Current fleet displays the speed of an oncoming vehicle regardless of whether the vehicle has exceeded the speed limit or not and displays "SLOW DOWN" message when the vehicle exceeds the speed limit. We sometimes hear complaints from Calgary Police that the vehicles may have been trying to test their speed against the SLOWS trailer display or see how fast they can go, leading to distraction and often times, increasing the speeding behaviour. A different type of display that doesn't show the actual speed of the vehicles but displays the message "SLOW DOWN" when the radar identifies that the vehicle is going over speed is under consideration for future upgrades.
4. The rotation is labour intensive as it needs to be moved fairly long distance and often hard to find the location that a SLOWS trailer can fit (on median, road side or parking lane). Although there may not be much we could do as it must be rotated manually, keeping the SLOWS trailers within a certain locality e.g. wards would greatly reduce the

efforts to move the trailers from one place to another by shortening the travel distance. This however, depends on whether or how soon we can add the new trailers on the existing fleet.

5. Occasionally, we hear from citizens that the SLOWS trailer is not displaying message. This is mainly due to the lack of adequate sunlight to charge the solar batteries and need a boost. This often keeps one or two SLOWS trailers out of service. Should we decide to purchase new units, one of the items in the wish list would be to have larger solar panels so that the charge will not run out at night or when there is not adequate sun light.
6. Current fleet doesn't have speed data collection capability. We are often asked by citizens what we do with the speed that was collected from the SLOWS trailers? In fact we have not been able to do so because of the lack of such technology in the existing fleet. Once again, this is one of the add-ons that we would be looking for in the new fleet when we decide to expand. This will greatly reduce efforts to have a separate speed study at the locations where the SLOWS trailers have been installed. This data can be collected and utilized for further research. If we identify that the speeding is still a concern after installing the SLOWS, request can be made to the Calgary Police Service to supplement with the speed enforcement.
7. Process to get iSLOWS installed is too long and time consuming as it needs to go through a detailed traffic study. Citizens sometimes get frustrated with the long process and ask if they can purchase and install themselves. The City of Calgary does not allow these installations by citizens because of the risk of overuse where otherwise not required.
8. The City usually gets requests from citizens to install iSLOWS for relatively short period of time (longer than SLOWS) i.e. six months or so. However, because of the delicate nature of these devices, it is challenging to move the iSLOWS while keeping its integrity.
9. Reliability of data collected from iSLOWS is questionable. More research is planned on this topic.

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