Mobile Marked and Unmarked Speed Cameras: Their time and distance halos and relative effectiveness in reducing speeds

Bill Frith and Tiffany Lester

Opus Research, Wellington

Abstract

Mobile speed cameras were deployed at an urban 50 km/hr speed limit site, an urban 70 km/hr speed limit site and a site on a rural two lane, two way road with a 100 km/hr speed limit. Both unmarked vans and marked camera vehicles were used. Speeds were measured in the vicinity of the sites with and without the presence of camera vans. The extent of time and distance halo effects was investigated as was the effectiveness of marked and unmarked camera vans in reducing speeds. Both marked and unmarked cameras, as they were used at the locations surveyed are effective in reducing speeds in their immediate vicinities with evidence that marked cameras were more effective at the urban (50km/hr and 70km/hr limits) sites. There was little difference in effectiveness between marked and unmarked deployments at the rural (100 km/hr location).The study indicated a time halo of around an hour in the urban sites while speeds began to increase when the camera deployment terminated at the rural site. The best estimates of a distance halo are around 500 metres for the urban sites and 1 kilometre for the rural site. There was no strong evidence that halo effects differed between marked and unmarked vehicles.

Keywords

Speed, camera, halo, vehicle, marked, unmarked

Introduction

This work stems from a desire from New Zealand Road Policing to investigate the halo effects of mobile, radar equipped, speed cameras in an urban area and on a two lane two way rural state highway. In particular the Police wished to see if camera vehicles marked in official Police livery had any different impact from those which were unmarked.

The use of mobile speed cameras has the ability to be an effective means of reducing speeds, and consequently road injury (e.g. Mara et al, 1996), Mobile speed cameras impact upon the speeds of motorists both at their sites and way from their sites, and both in time and distance. These phenomena are called time and distance halos. Time and distance halos depend on the specific circumstances in which the enforcement is being carried out.

Barnes (1984) conducted surveys at three State Highway 1 sites to determine the effectiveness of roadside radar enforcement carried out by an officer in a patrol car without a camera. Reduced speeds began more than two kilometres before the site (due to headlight flashing, radar detectors, and so on). The surveys showed that in the immediate vicinity of the Officer, vehicle speeds were dramatically reduced, but quickly increased again to return to normal within a distance of about 5 kilometres.

Wright and Matthews (1988) measured speeds at a State Highway location downstream of an enforcement officer in a vehicle with radar. The average speeds of drivers exceeding 115km/hr at the enforcement vehicle position were 122km/hr at the enforcement vehicle, 102 km/hr 2.4 km downstream, and 105 km/hr 5.7 km downstream.

A number of studies of time and distance halo effects are mentioned in ACC and LTSA (2000). Brackett and Edwards (1977), cited in Ostvik & Elvik, 1990 evaluated the impact of an American study in which a stationary police car was randomly moved from place to place along a long stretch of road. The aim was to create the impression that there was a massive concentration of enforcement along that road. They found that speeds were reduced up to 20 kilometres from the stationary car.

Hauer, Ahlin, and Bowser (1982) examined both distance and time halo effects at enforcement sites. They found that mean speeds at the enforcement sites were reduced, but that the impact of the enforcement – measured by the reduction in mean speeds – reduced by half every 900 metres downstream from the enforcement site. The time halo effect was examined by observing individual vehicles over several days during and after enforcement. They found that vehicles exposed to enforcement at a site only once reduced their speeds at the site for up to three days following the enforcement. Vehicles that encountered enforcement at a site over five days reduced their speeds at the site for at least six days after the last day of the enforcement.

More recently, Vaa (1997) examined the time halo effects of six weeks of very high enforcement levels in uninterrupted 60 and 80 km/hr zones between 18 to 30 kilometres in length In the 60-km/hr zone, “speeding” was defined as exceeding 70 km/hr; while, in the 80-km/hr zone, it was defined as exceeding 80 km/hr. During the enforcement period, there was a reduction in the proportion of drivers who were speeding in both of the speed zones. In the 60 km/hr zone, this reduction lasted up to eight weeks after the enforcement period. In the 80-km/hr zone, the reduction in the proportion of speeding drivers lasted up to six weeks.

The above research therefore indicates that halo effects tend to be greater when the enforcement action is part of a larger scale campaign

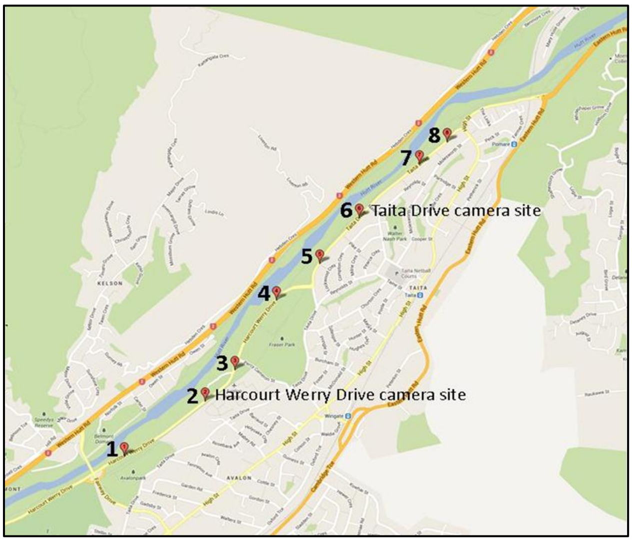
Methodology

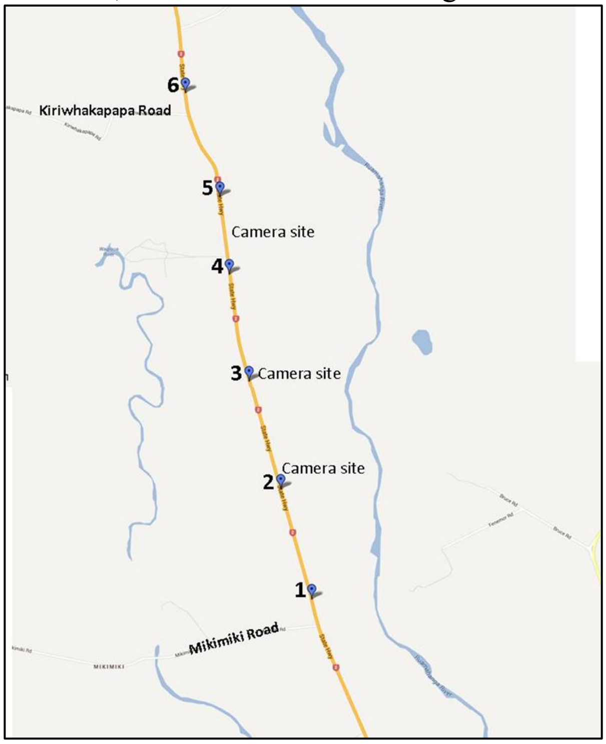
The study used three study sections, all at places where the New Zealand Police had previously deployed mobile speed cameras. These were

- A flat 1.7 kilometre stretch with a speed limit of 70 km/hr.
- A flat 1.8 kilometres long stretch with a speed limit of 50 km/hr.
- A flat 4.2 kilometre stretch of rural state highway with a speed limit of 100 km/hr.

Speeds were measured using rubber tubes strung across the road attached to a device which measured speed, as well as providing traffic counts. One camera deployment position was used at each of the urban sites and three camera deployment positions at the rural site. Marked and unmarked camera vans were deployed for various shifts at each site over two, three day periods; one three day period for each type of camera van. There were also days on which speed was measured with no cameras operating, in order to provide a baseline comparison. There were no occasions when cameras were simultaneously deployed at both the urban sites as the same camera vehicle covered both sites. Figure1 shows the two urban sites (which were adjacent to each other) and the rural site. The numbers represent the positions of speed measurement devices and the approximate positions used by the camera vehicles (there was some Police discretion) are marked. Thus the approximate distances between the speed measurement positions may be ascertained from inspection of figure 1.

Figure 1: Site maps Urban 50km/hr and 70km/hr to the left, Rural 100km/hr to the right





To assess the impact of the cameras on the speeds at which drivers choose to travel analyses were performed using speed data from unimpeded or “free” vehicles. These were defined as vehicles with headway of at least 4 seconds from the nearest vehicle in front. The main speed-related variables used were the median speed (a measure relating to the centre of the speed distribution) and the 85^{th} percentile speed (a measure relating to the upper end of the speed distribution). The median was used instead of the mean to minimise the impact of outliers (possibly due to equipment malfunction) on the analysis. The analysis for time halos uses CUSUM charts related to median and 85^{th} percentile speeds. The Cumulative Sum Control Chart (CUSUM), (British Standards Institution, 1980) is a tool to highlight changes, by making their appearance in the chart more striking. The charts detect changes in a process over time (such as changes in speeds) by looking at changes in the cumulative sum of the variable of the process over time, related to a reference value. In this case, the mean level of the speed variable (in this case the speed variable is either the median or 85^{th} percentile speed) over any series of time periods is simply the slope of the CUSUM chart over that period added to the reference value k. A change to the mean will show up as a change in the slope. The CUSUM is horizontal when the mean is equal to k, of positive slope when greater than k, and of negative slope when less than k. The interpretation for the chart is to regard any consistent slope, either upward or downward, as an indication of a consistent deviation from the reference value. In all the CUSUM charts in this paper, the reference values are the respective medians and 85 percentiles of the speeds of the unimpeded vehicles in the traffic flow, with no speed camera operating. The time halos are analysed by looking at speeds during camera deployment and after camera deployment using CUSUM Charts. A concerted rise in the CUSUM indicates an increase in speed marking the end of the time halo. As a large amount of speed data was collected, it was possible to carry out a large number of analyses. The analyses shown in this paper are illustrative examples.

Time halos[1]

For the ***urban 70 km/hr site*** figures 2 and 3 shows speeds and CUSUMs of speeds for the last 40 minutes of unmarked and marked camera deployment and then the following 2 hours.

Figure 2: Speeds and CUSUMs of speeds at unmarked camera van site

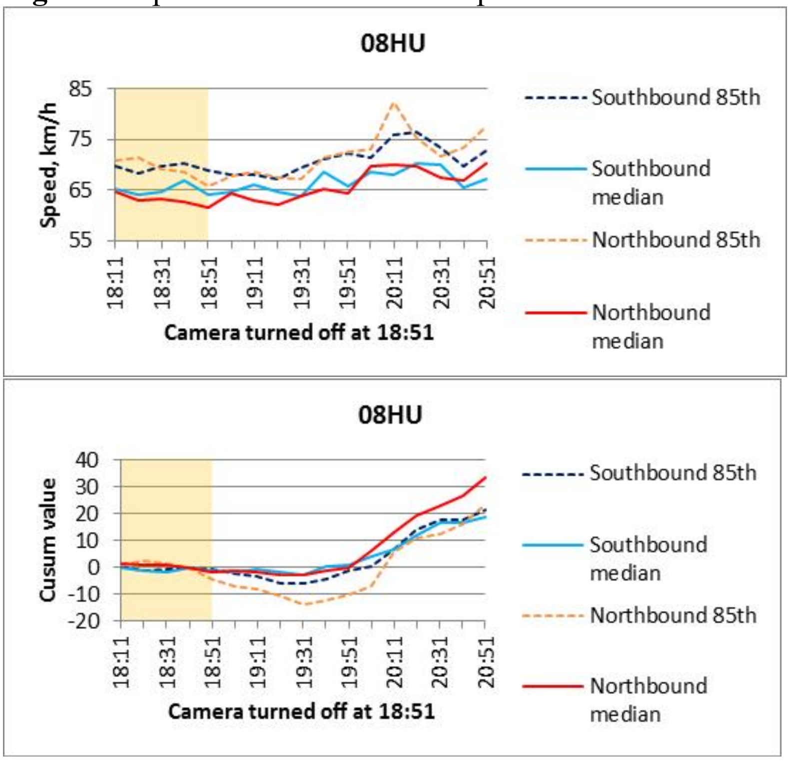
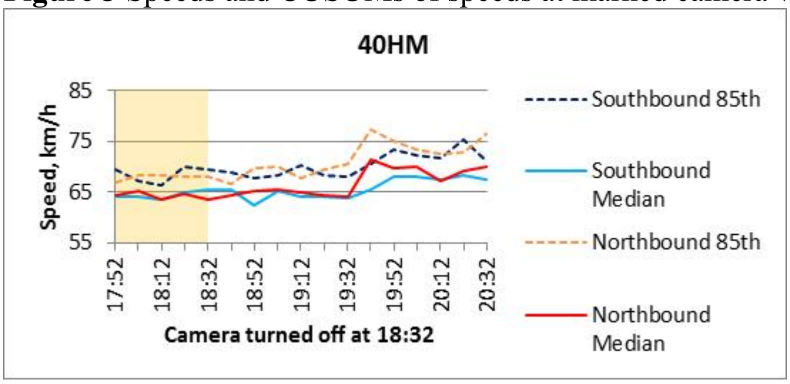


Figure 3 Speeds and CUSUMs of speeds at marked camera van site



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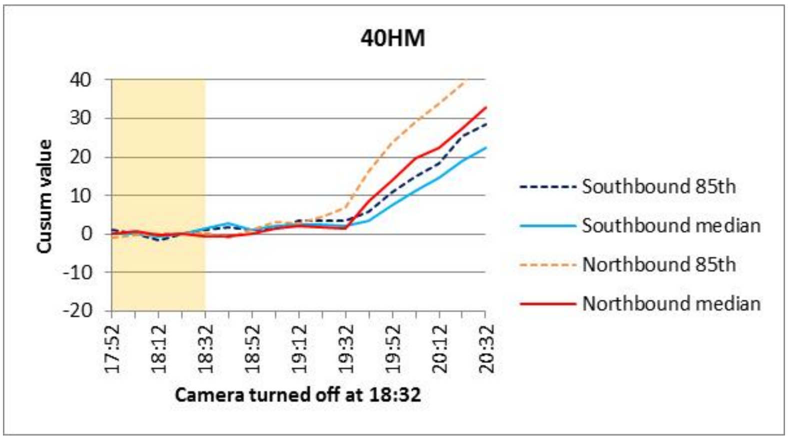
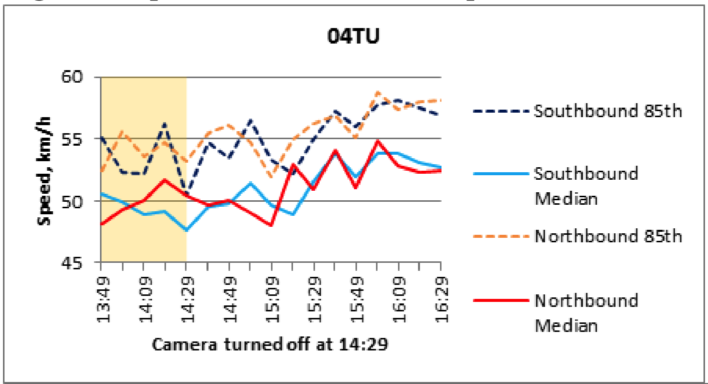
[1] The phrase "camera turned off" refers to the end of a camera deployment.



In both figure 2 (unmarked van) and figure 3 (marked van) the CUSUM curves begin to slope upwards about an hour after the camera van leaves, for both medians and 85 percentiles indicating a time halo of around one hour.

For the ***urban 50 km/hr site*** figures 4 and 5 show speeds and CUSUMs of speeds for the last 40 minutes of unmarked and marked camera deployment and then the following 2 hours.

Figure 4: Speeds and CUSUMs of speeds at the unmarked camera van site.



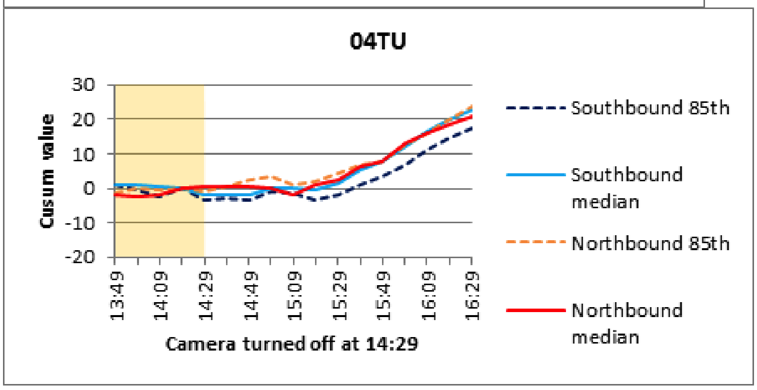
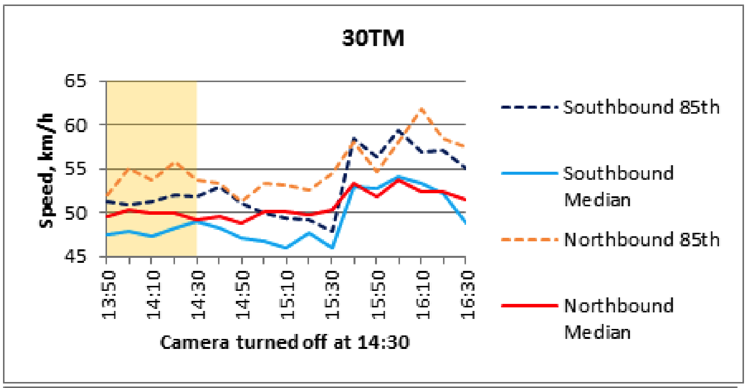
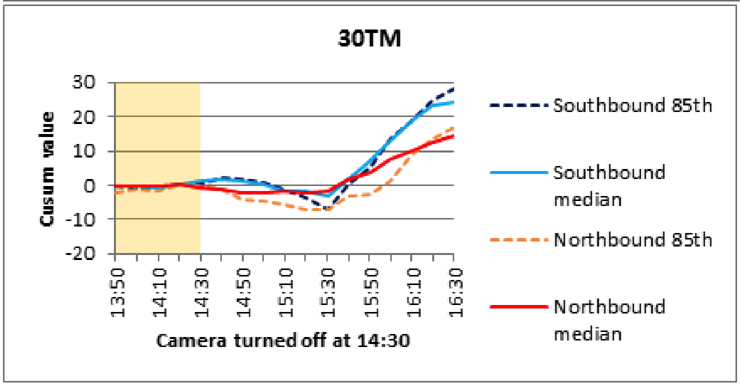


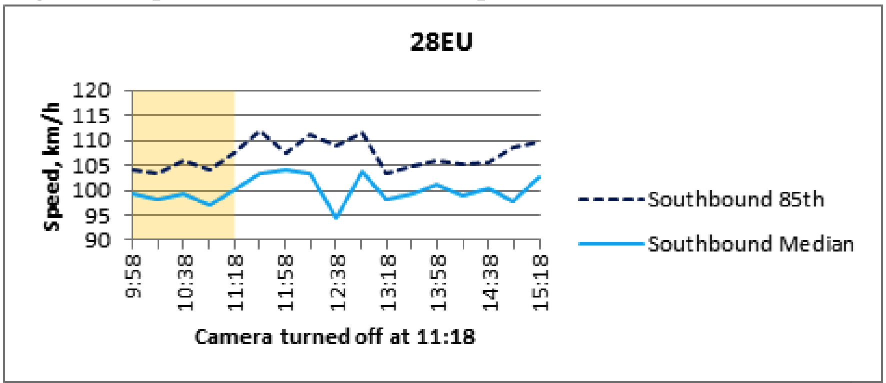
Figure 5: Speeds and CUSUMs of speeds at marked camera van site





For the ***rural 100 km/hr site***, figure 6 and figure 7 depict southbound traffic with unmarked and marked camera vehicles to the north of area. The speeds are measured at site 4 as shown in figure 1. The analysis repeats that done previously, except that the final 80 minutes of camera deployment is used instead of the final 40 minutes as lower traffic flow meant a longer data gathering period.

Figure 6: Speeds and CUSUMs of speeds near unmarked camera van site



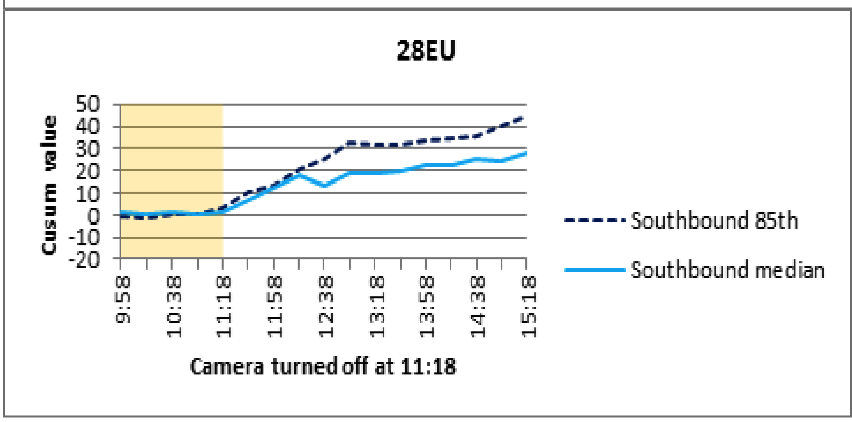
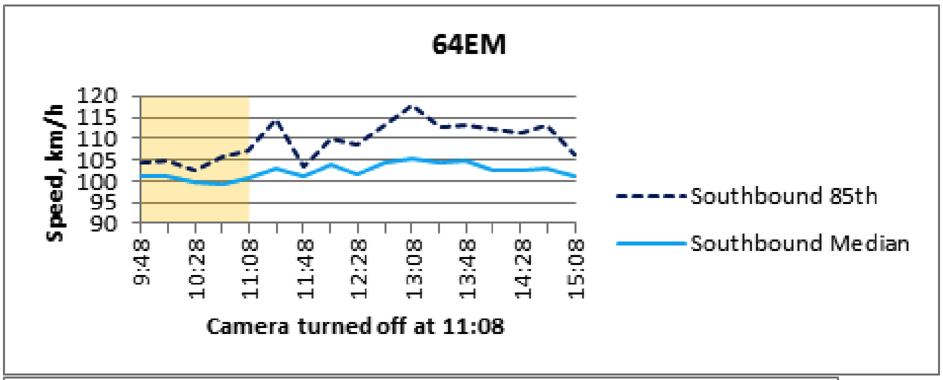
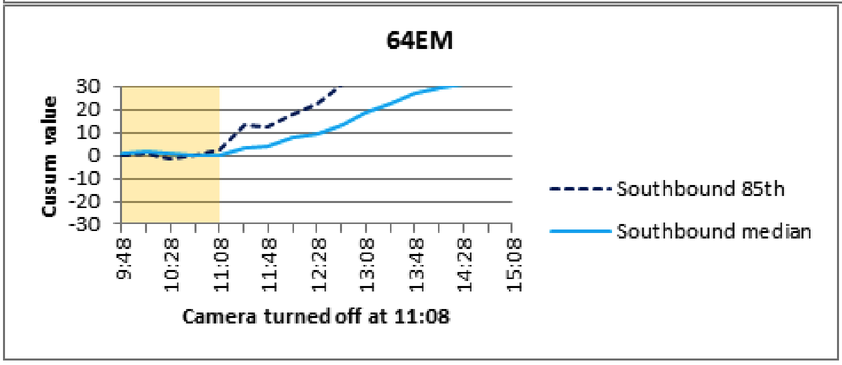


Figure 7: Speeds and CUSUMs of speeds near unmarked camera van site





In neither case is there any evidence of a time halo as the CUSUM slopes up immediately the deployment ends.

Distance Halos

For the ***urban 70 km/hr*** speed limit site, figure 8 and figure 99 show the median and 85th percentile speeds as vehicles proceed in both directions along the site.

The northward progression takes vehicles through one speed measurement before the camera site, through the camera site, and then through two further measurements. The approximate distances between the measurement points are shown in figure 1. For both the unmarked vehicle and the marked vehicle there is no effect at the position south of the camera. At the camera site and 350 metres north of the camera site, both types of vehicle have well discernible impacts on speed for both directions, but less so for southbound traffic. By the second northern position (1 km from the camera) the impact on northbound traffic no longer apparent.

There quite a strong halo effect in the southbound direction, notwithstanding the fact that the vehicles have not yet reached the camera. This may be related to northbound vehicles warning southbound vehicles that a camera is present by flashing their lights.

Figure 8: Speeds at speed measurement sites for traffic moving in a northerly direction north

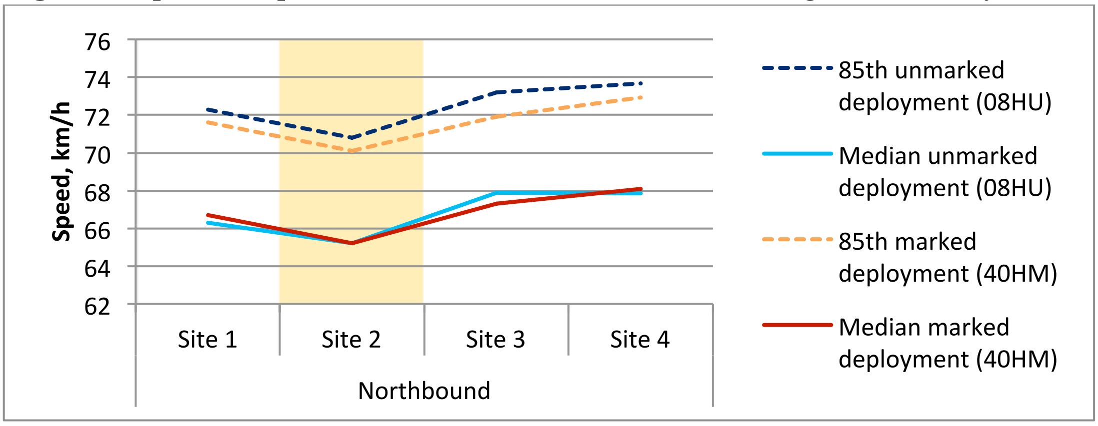
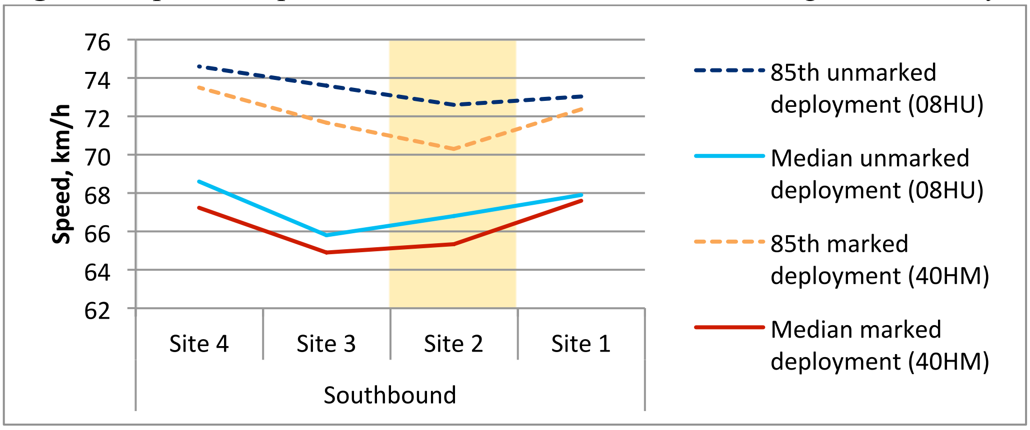


Figure 9: Speeds at speed measurement sites for traffic moving in a southerly direction



The location of the camera is near measurement site 2. It is apparent that for northerly movement, the impact of the camera on speeds has substantively dissipated by site 3, only 350 metres from the camera. In the other direction there is substantial slowing before the camera site and this partially dissipated by the time measurement site 1 is reached, some 760 metres south of the camera.

For the ***urban 50 km/hr*** speed limit site, with intersections at both ends, the camera vehicle is near speed measurement site 6. Figure 10 and figure 11 show the median and 85th percentile speeds as vehicles proceed in both directions along the site. For vehicles moving north the impact of the marked vehicle is greater than the effect of the unmarked vehicle, particularly at the camera site itself.

Figure 10: Speeds at speed measurement sites for traffic moving in a northerly direction

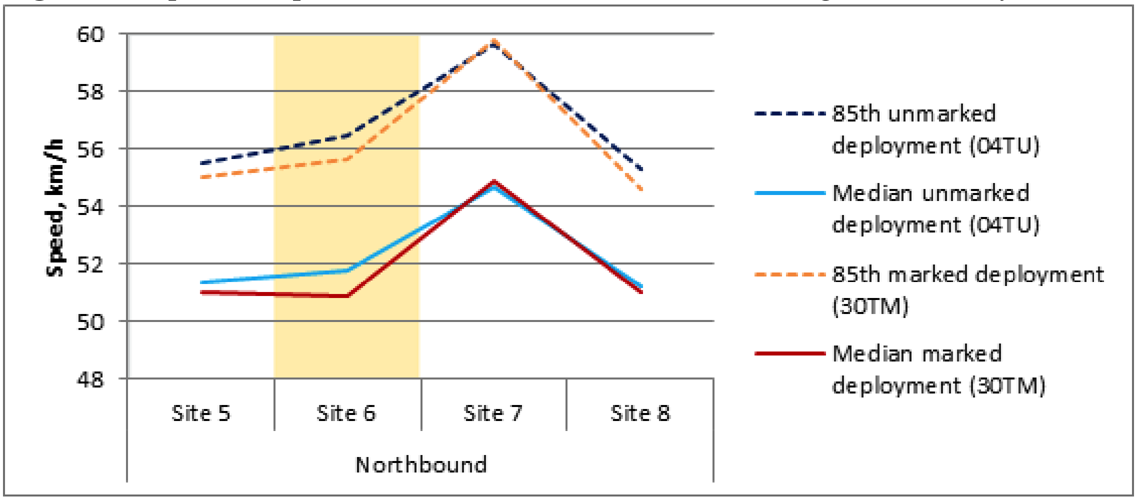
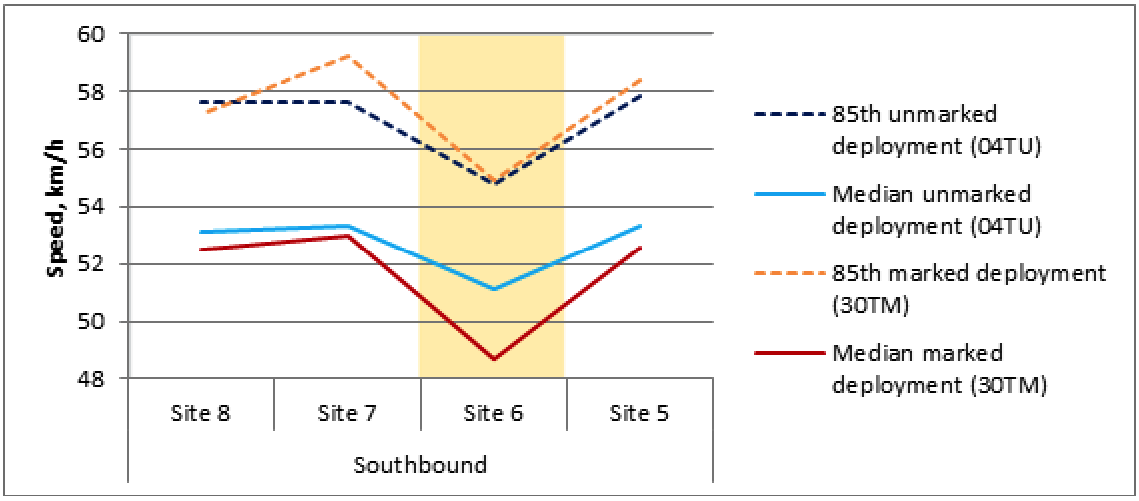


Figure 11: Speeds at speed measurement sites for traffic moving in a southerly direction



It is apparent that for northbound traffic, the reduction of speed associated with the camera has dissipated by the time site 7 (730 metres to the north) is reached, irrespective of whether the camera is the more effective marked camera, or the less effective site unmarked camera. The vehicles then slow again before the intersection. In the southerly direction the story is similar with the speed back to prior values by site 5, 470 metres away from the camera..

For both the 70 km/hr and 50km/hr sites, the results indicate a distance halo of between approximately 300 to 700 metres. Taking the middle ground 500 metres could be a realistic estimate to use for its length.

At the ***rural 100 km/hr*** site figure 12 and figure 13 examine how the impact of the camera dissipates as vehicles travel through the stretch of road with the camera in the northern position. The stretch has intersections at both ends. For northbound vehicles (figure 12) which are approaching the camera, there is some evidence of anticipation, but a very prompt increase of 85^{th} percentile speeds as they leave the stretch of road, It suggests a good knowledge of the area of operation of the cameras by faster drivers. Southbound vehicles (figure 13) have a relatively large distance to cover within the measured road section after encountering the camera. It is apparent from figure 13 both types of camera vehicles had good impacts at the northern sites 6 and 5. There is little evidence of an impact of the northern camera after site 4, indicating a distance halo of around 1000 metres, depending on the exact position of the camera vehicles, about which there was some uncertainty owing to police discretion.

Figure 12: Speeds at speed measurement sites for traffic moving in a northerly direction

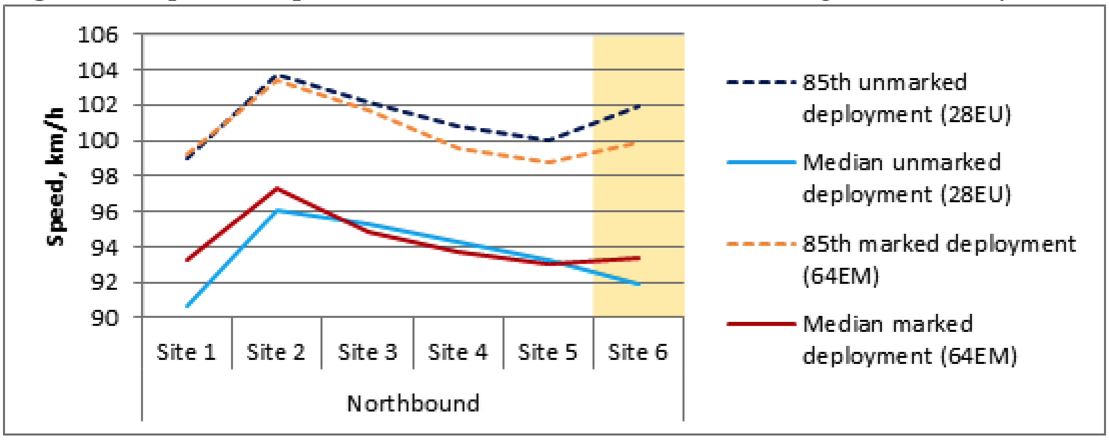
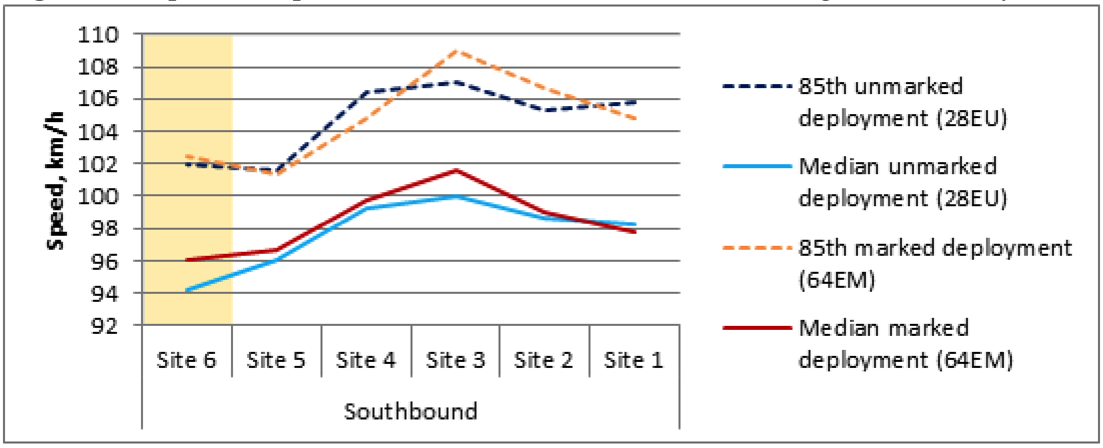


Figure 13: Speeds at speed measurement sites for traffic moving in a southerly direction



At this site, as shown in the charts, the cameras succeeded in reducing speeds appreciably, but unlike in some of the urban cases there was very little difference in performance between the marked and unmarked cameras. This is illustrated further in paragraph 2.3.

Overall speeds

This paragraph compares the cumulative distributions of speeds at the camera sites during daytime hours, with marked vehicles present, unmarked vehicles present, or no camera vehicle present. In all the figures presented, the horizontal axis represents the proportion of the vehicles travelling at speeds lower than the plotted value.

For the ***70 km/hr urban*** site figures 14 and 15 show the distributions for north and southbound traffic.

Figure 14: Northbound speeds at the 70 km/hr camera site for periods of marked/unmarked/no camera-vehicle present at that camera site, in daylight (07:00 to 17:30)

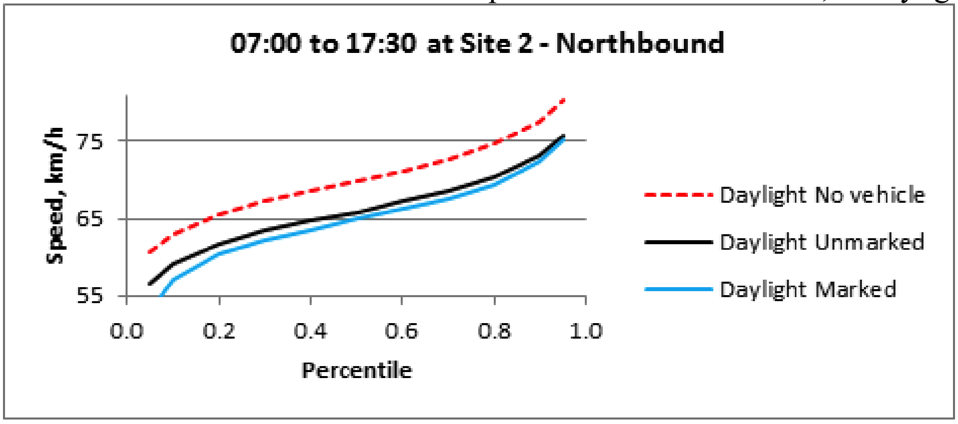
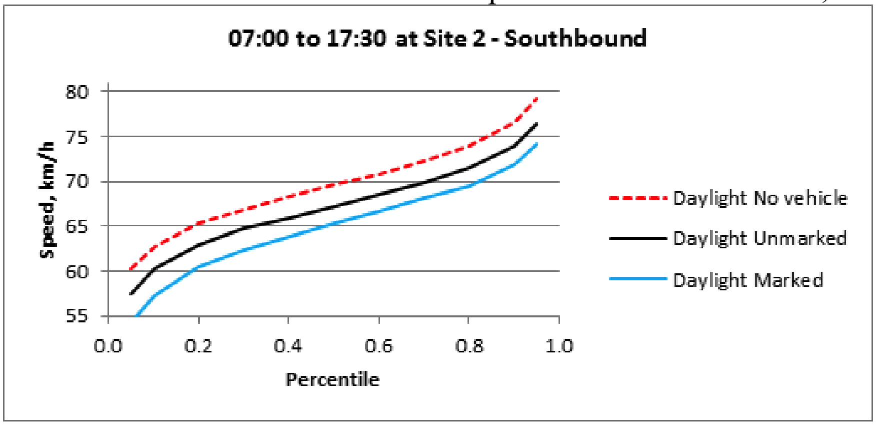


Figure 15: Southbound speeds at the 70 km/hr camera site for periods of marked/unmarked/no camera-vehicle present at that camera site, in daylight (07:00 to 17:30)



.For the ***50 km/hr urban*** site figures 16 and 17 show the distributions for north and southbound traffic.

Figure 16: Northbound speeds at the 50 km/hr camera site for periods of marked/unmarked/no camera-vehicle present at that camera site, in daylight (07:00 to 17:30)

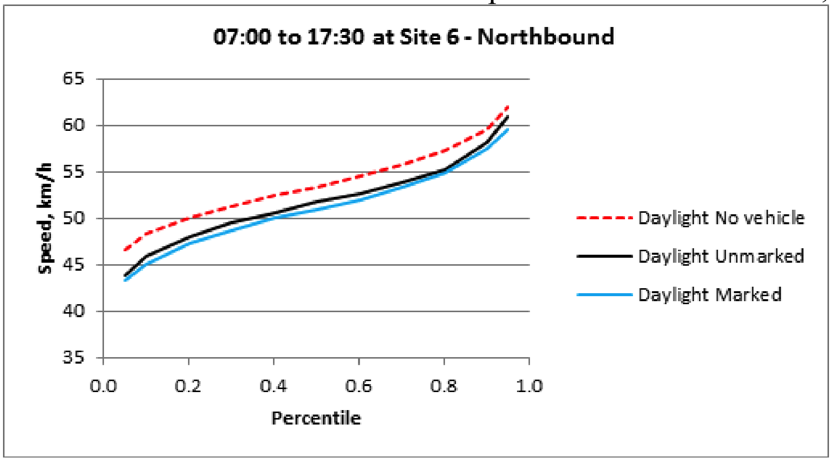
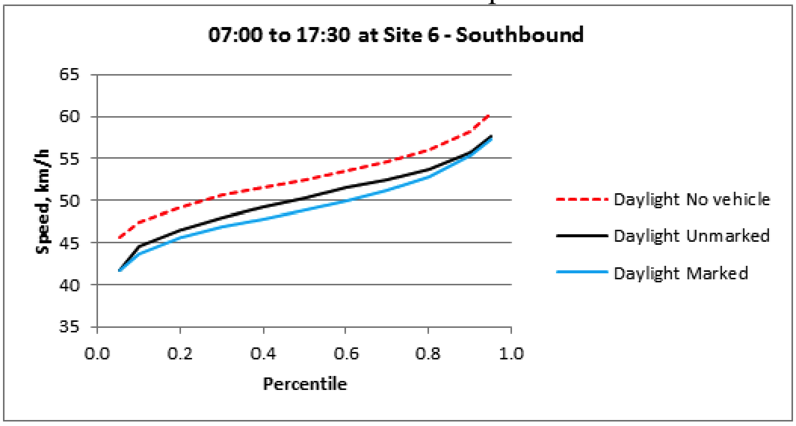


Figure 17: Southbound speeds at the 50 km/hr camera site for periods of marked/unmarked/no camera-vehicle present at that camera site, in daylight (07:00 to 17:30)



For the ***rural 100 km/hr*** site figures 18 and 19 show the distributions for north and southbound traffic.

Figure 18: Northbound speeds at the rural 100 km/hr site for periods of marked/unmarked/no camera-vehicle present at the southern camera site, in daylight (07:30 to 17:00)

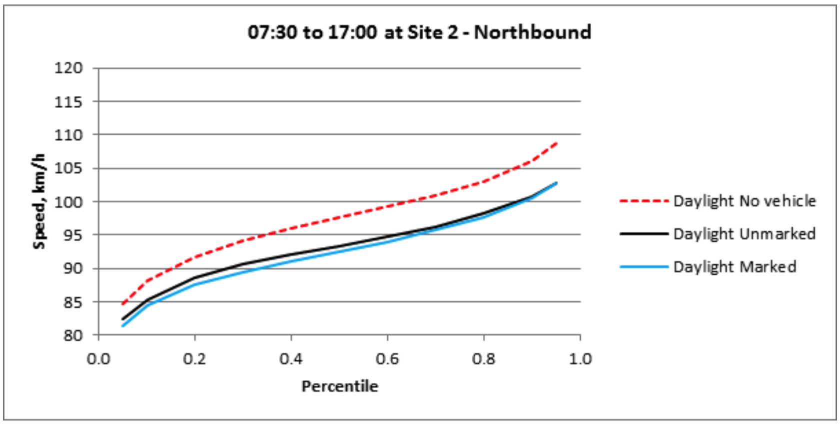
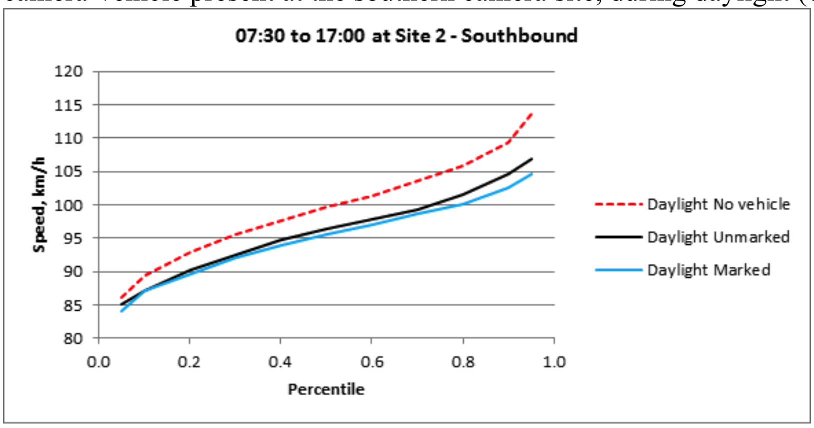


Figure 19: Southbound speeds at the rural 100 km/hr site for periods of marked/unmarked/no camera-vehicle present at the southern camera site, during daylight (07:30 to 17:00)



These results show that in all cases the speeds were lower in the presence of cameras than without cameras, and that the marked cameras were the more effective cameras at reducing speeds at the urban sites. There was much less difference between the performance of unmarked and marked cameras at the rural 100 km/hr site although the marked camera vehicles performed slightly better than the unmarked.

Conclusions

At the locations surveyed, both marked and unmarked cameras were effective in reducing speeds in their immediate vicinities with evidence that marked cameras were more effective. The difference was small at the rural 100 km/hr site.

There were indications of a time halo of around an hour in the urban locations, while speeds began to increase immediately the camera deployment terminated at the rural location. These halo effects applied for both marked and unmarked vehicles.

The best estimates of a distance halo based on this study are around 500 metres for the urban sites and 1 kilometre for the rural site. These distances apply for both marked and unmarked camera vehicles. Both distances would take 36 seconds to travel at the appropriate speed limit.

The distance halos are small compared to some reported elsewhere, and in New Zealand in the past where the enforcement method was a mobile officer with a radar. However, New Zealand has few speed cameras for its size and the perceived likelihood of a motorist coming upon a second camera after passing one must be relatively low. Thus, in this case the relatively small distance halos are not a surprise.

Acknowledgements

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