Evaluating the effects of a vehicle activated ITS device at a pedestrian crossing

Gábor Pauer[2], Nóra Krizsik[1,2], Szilárd Szigeti[1,2]*

[1] Budapest University of Technology and Economics, Department of Transport Technology and Economics, H-1111 Budapest, Műegyetem rakpart 3., Hungary

[2] Road Safety Research Centre, KTI Institute for Transport Sciences Non-profit Ltd., H-1119, Budapest Thán Károly street. 3-5., Hungary

** Corresponding author: pauer.gabor@kti.hu*

Abstract

Since inappropriate speed is one of the most common cause of road accidents, several speed management tools have been invented and applied on the road network of the European Union. According to our results, vehicle activated, digital road signs are effective in reducing the vehicle speeds at the local level. In accordance with these findings, taking into account the safety of pedestrians, we have tested a new vehicle activated ITS device at a pedestrian crossing measuring its effects. The device proved to be effective in terms of reducing the average and v85 speeds, and the ratio of speeders. An interesting observation was that the effects were greater under daylight visual condition than after sunset. The potential road safety benefits of the proposed ITS device were then assessed based on the connections between the speed and accident risks/injury severity.

Keywords

road safety; ITS; speed management; pedestrian crossing.

Introduction

Speed is one of the major contributors to road accidents. According to the latest research, the COVID 19 pandemic made it even more important to address safety issues arising from higher vehicle speeds due to the reduction of traffic volume (Katrakazas et al., 2020). One of the Thematic Reports (Report on Thematic Area 5 (TA5): Transport Safety and COVID-19) of project RADAR (Risk Assessment on Danube Area Roads – DTP2-046-3.1) pointed ot that:

- a comparatively higher share of vulnerable road user travel was noted on the urban and suburban system, and the number of cyclist fatalities partly increased;
- average driving speeds increased slightly – whereas the share of extensive speed violations increased more substantially;
- the share of inadequate speed as prime causal crash factor increased, especially for fatal crashes.

To solve the speeding issues at local level, several traffic management tools can be used at specific sites. Authors previous research focused on the evaluation of the effects of vehicle activated, digital speed warning signs (Pauer, Krizsik and Szigeti, 2022). According to our results and in line with the reviewed literature (Walter and Broughton, 2011; Gehlert et al., 2012; Jooma et al., 2017; Malin and Luoma, 2020), vehicle activated signs on road sides proved to be effective in reducing the operational speed of the traffic and the number of speed violators. Based on these findings and focusing on the safety of pedestrians, we have tested a new vehicle activated device at a pedestrian crossing within the framework of project RADAR The effects of the device were assessed by measurements. The potential road safety related benefits of the proposed ITS solution were then assessed based on the connections between the speed and accident risks/injury severity.

Methodology

The research and measurements were carried out during a Pilot Action in the August of 2021 in the framework of project RADAR. Details of the methodology are described below.

Introduction of the investigated ITS device

The referred ITS device consisted of a pedestrian crossing warning sign with interior lighting and a LED text (Lassíts! – "Slow down!") placed 50 meters in front of the pedestrian crossing, and a yellow blinker placed directly at the pedestrian crossing (Fig. 1). As part of the device, a speed measuring radar and a WiFi transmitter complemented both elements.

Figure 1. Main parts of the introduced ITS device

The device operated based on the presence and speed of arriving vehicles, while it was also able to collect the speed data. The radar detected incoming vehicles and measured their speed. When an incoming vehicle was detected, the interior lighting of the pedestrian crossing warning sign was turned on (regardless of the vehicle speed). If the vehicle arrived at a speed higher than the speed limit, the text "Lassíts" (Slow down) was also displayed. If no new vehicle has arrived, the lights turned off after 5 seconds. When detecting an incoming vehicle, the radar also activated the yellow blinker located on the column of the designated pedestrian crossing sign (regardless of speed). It switched off after 10 seconds without a new vehicle arriving.

Details of the speed measurements

Location

In our Pilot Action, the speed measurements were carried out at a pedestrian crossing designated in urban area, close to the border of the city of Martonvásár in Hungary (2462 Martonvásár, road 6204, 11+150 km section; GPS: 47.311269, 18.794216). The measured direction was the one that leads out from the city. Approaching the pedestrian crossing in the measured direction, there is a speed limit of 40 km/h, however, the speed limit sign is placed 350 meters in front of the crossing, so the effect of this restriction can be assumed to be quite low at the pedestrian crossing. The operational speed is also negatively affected by the fact that after passing the pedestrian crossing, the drivers reach a road section with rural nature (with only bushes and trees near the road).

The pedestrian crossing sign is placed right near the pedestrian crossing. The distance between the pedestrian crossing, and the pedestrian crossing warning sign is exactly 50 meters[1].

The location of the measurement was recommended by the road operator company. According to their observations, the attention of the drivers is not increased appropriately at this pedestrian crossing, especially at night or under poor visibility conditions. A street lighting column can be found only on the one side of the crossing, while the pedestrian crossing warning sign is shaded by a tree.

AADT at the road section is 5193 vehicle units/day, but according to our observations during the measurements, the pedestrian traffic is not high. In the afternoon, 5-10 pedestrians cross here per hour, this number is even lower at night. In November 2020, a pedestrian was hit (serious injury) at the pedestrian crossing at night, while in July 2019, a single vehicle accident occurred in the junction (a drunk moped driver fell because of the choice of inappropriate speed).

Method of the measurements

The measuring equipment was part of the introduced ITS device. It was located on the column of the designated pedestrian crossing sign and recorded speed data continuously on the 50-meter-long section in front of the pedestrian crossing.

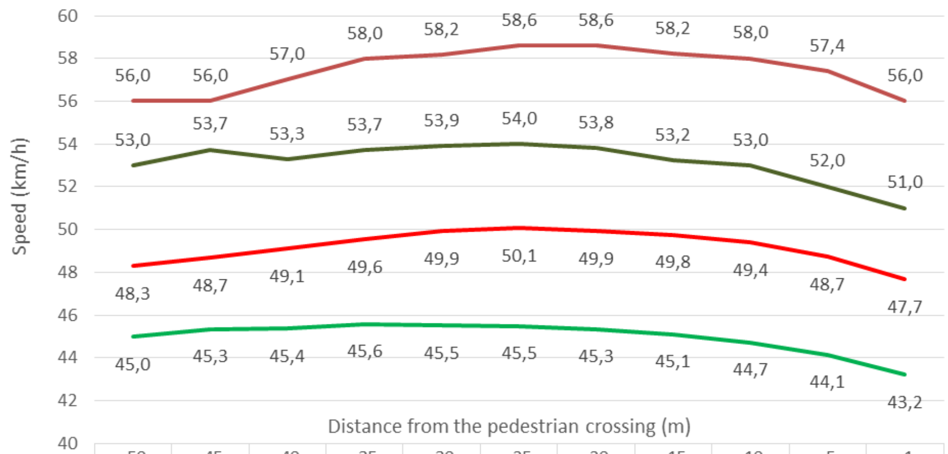
Before and after measurements were performed, meaning that the measurements were done in the first week (2021.08.23-08.27) in the original condition of the environment of the pedestrian crossing. Then in the following week (2021.08.30-09.03), the ITS devices were installed and their effects were measured according to the same methodology as before. The measurements were carried out each day between 17:00 and 23:59, considering also the time of sunset to be able to separately analyse the effects under different visual conditions (daylight/nighttime).

Raw data were cleaned and transformed to consider only the incoming vehicles arriving to the pedestrian crossing at free-flow.

Results

To evaluate the effects of the ITS device, weekly aggregated data were used. In Fig. 2, the average and the v85 speeds are presented separately for the period when the ITS device was non-operating (first week – red colours), and operating (second week – green colours).

[1] The distance is in line with the Hungarian regulations (83/2004. (VI. 4.) GKM order)



	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	-1
avg.speed (first week)	48,3	48,7	49,1	49,6	49,9	50,1	49,9	49,8	49,4	48,7	47,7
v85 speed (first week)	56,0	56,0	57,0	58,0	58,2	58,6	58,6	58,2	58,0	57,4	56,0
num of vehicles (first week)	649	772	981	1392	1811	2031	2099	2099	2099	2099	2099
avg.speed (second week)	45,0	45,3	45,4	45,6	45,5	45,5	45,3	45,1	44,7	44,1	43,2
v85 speed (second week)	53,0	53,7	53,3	53,7	53,9	54,0	53,8	53,2	53,0	52,0	51,0
num of vehicles (second week)	751	918	1158	1549	1847	1956	1986	1986	1986	1986	1986

Figure 2. Average and v85 speeds in the different scenarios

First of all, it should be noted that in spite of the 40 km/h speed limit at the measured location, the average speeds were around 47-50 km/h, and the v85 speeds were around 56-59 km/h. This was presumably the consequence of the previously introduced characteristics of the location. This implies that dealing with speed management is highly justified at the area of the selected pedestrian crossing.

Based on the presented data, the deployed ITS device had a substantial positive effect on vehicle speeds. In the line of the pedestrian crossing warning sign (50 meters from the crossing), the average speed decreased by 6.9%, and the v85 speed decreased by 5.4% with the operating ITS device. The difference got even higher as the vehicles approached the pedestrian crossing. In the line of the pedestrian crossing, the average speed was 9.3% and the v85 speed was 8.9% lower. However, even in this case, the average speed was slightly above the allowed speed limit.

The shape of the curves shows that the drivers accelerated on the measured section by default (in the first week) since they were traveling out from the town and started to decrease their speed only about 20 meters from the pedestrian crossing. Contrary to this, the ITS device was able to achieve that the speed did not, or just very slightly increased from the line of the pedestrian crossing warning sign.

Besides the speed curves, several further parameters have been calculated as follows in Table 1.

Table 1: Value of indicators in the different scenarios

		First week (without scenario)	Second week (with ITS device)	Difference
Ratio of vehicles exceeding the speed limit	at -50 meter	88.0%	69.8%	-18.2%
	at -25 meter	89.4%	71.0%	-18.4%
	at -1 meter	79.1%	56.8%	-22.3%
Ratio of vehicles reducing speed (from first measured point to -1m):		78.4%	79.0%	+0.6%
Ratio of vehicles reducing speed by at least 4km/h (from first measured point to -1m)		28.3%	36.1%	+7.8%

In line with the lower average speeds, the share of vehicles exceeding the speed limit decreased significantly as a result of the presence of the ITS device. The difference was about 18% on the road section in front of the pedestrian crossing and 22% in the line of the crossing. However, even in the second week, the values were still high: more than half of the drivers were driving above the speed limit. The ratio of vehicles reducing speed was high due to the presence of the pedestrian crossing. However, the speed reduction mainly took place only right before the pedestrian crossing, as it has been shown by the previous figure. This ratio did not change significantly with the operation of the ITS device, but the accelerations were less typical in the second week. There was a 7.8% increase in the proportion of those who reduced their speed by at least 10% of the speed limit.

Analysis of the different periods (before/after sunset)

Due to the operating principle of the device (interior lighting, light signals), it seemed to be reasonable to examine the effects separately under different visibility conditions. In Fig. 3, the v85 and average speeds have been indicated with the same colours as in Fig. 2 (red: first week, green: second week; darker: v85, lighter: average speed). The dotted lines show the periods before, and the dashed lines show the periods after sunset.

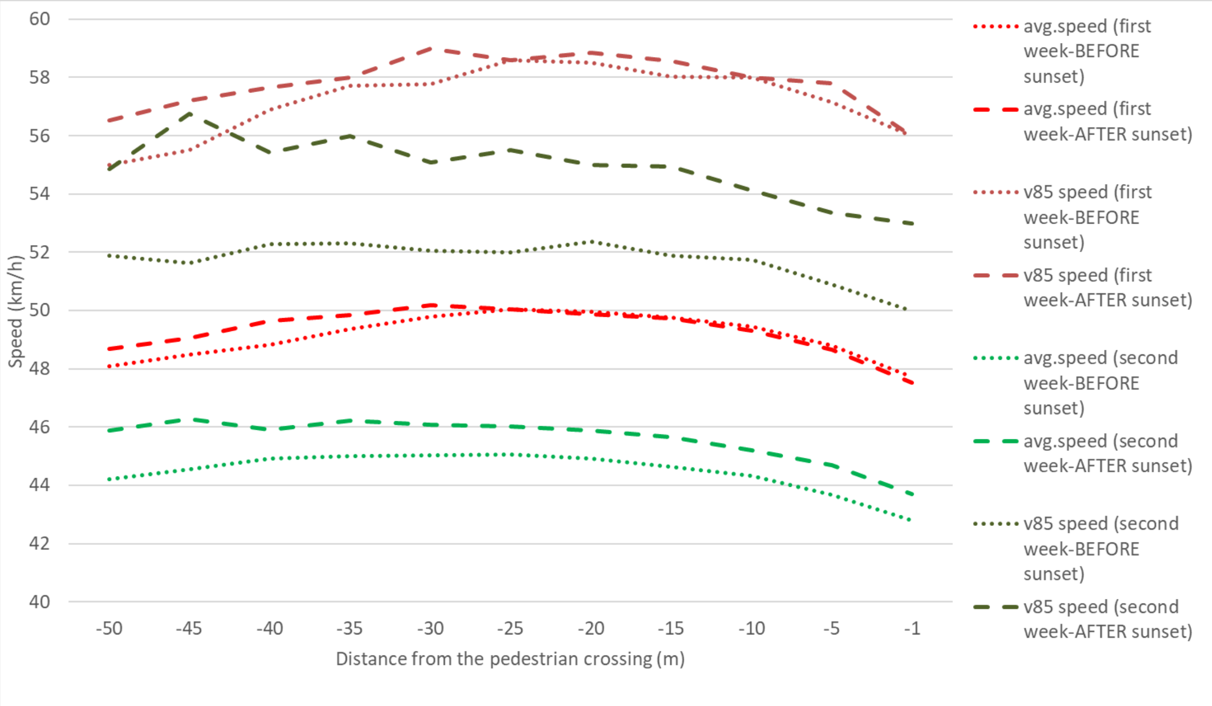


Figure 3. Average and v85 speeds of different periods in the different scenarios

According to the data from the first week (without the ITS device), there was no significant difference in the average speed, nor in the v85 speed in the periods before and after sunset. Typically, the speed values were only slightly lower, and only at the beginning of the measured section under daylight visual condition.

However, greater differences were observed in the second week. Contrary to the expectations, there was a higher decrease in speed before sunset. Thus, the ITS device achieved greater effects under daylight visual condition than after sunset. A possible explanation for this phenomenon can be that the drivers are less likely to expect pedestrians at the crossing at night. So, the warning by the pedestrian crossing warning sign seems to be given less importance in this period. However, a similar prediction of another hazard (e.g., a dangerous curve) might have the opposite effect. Investigating different type of locations and scenarios in this regard would be an interesting area for future research.

Conclusion

According to our speed measurements, the investigated ITS device had a positive effect on traffic speed. In the line of the pedestrian crossing warning sign (50 meters from the crossing), the average speed decreased by 6.9%, and the v85 speed decreased by 5.4%, if the ITS device was operating. In the line of the pedestrian crossing, these reductions were 9.3% and 8.9%, respectively. To calculate the potential effects on accident risk/injury severity, international results based on the connection between speed and these factors were applied as follows.

Driving at a high speed increases the odds of getting involved in an accident, and it also increases the severity of the injuries (EC, 2018). The connection was studied in many research works (Taylor et al., 2002; Nilsson, 2004; Aarts and van Schagen, 2006; Richards, 2010). The results verified that there is a strong correlation between speed and accident risk. Also, the relation between the speed and the injury severity is more direct and less complicated than between speed and accident risk (Elvik, 2009).

To calculate the potential effects regarding the accident risk, we have applied Nilssons' Power Model (Nilsson, 2008) with the use of its empirically updated exponents proposed by Elvik (2009).

In our example, the investigated ITS device was able to decrease the average speed at the pedestrian crossing from 47.7 km/h to 43.2 km/h. Thus, using the Power Model's formula with the proposed exponents, the number of fatal accidents could be reduced by 22.7%, while the number of serious and slight injury accidents could be reduced by 13.8% and 9.4%, respectively, as a consequence of reduced speed.

To quantify the effects of our Pilot Action on possible injury severity, the diagram published by Tefft (2013) was used. In the diagram, the risk of severe injury (left) and death (right) was determined in relation to impact speed (by averaging data from 422 pedestrian hits). As a result of the reduced speed due to the proposed ITS solution, the risk of severe injury decreases to 37% from 47%, and the risk of death decreases to 15% from 20%, as shown by Fig. 4.

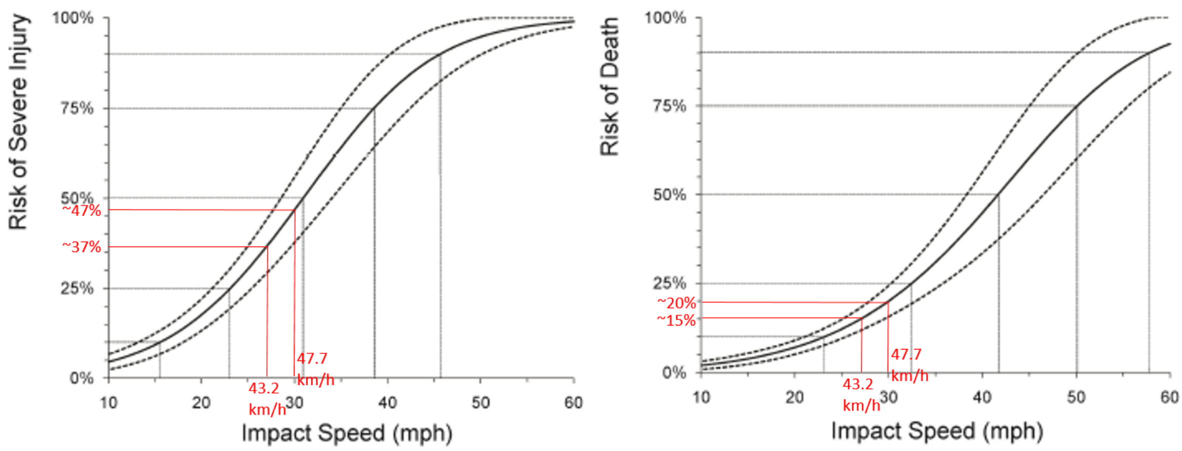


Figure 4. Change of the risks of severe injury and death (Tefft, 2013)

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