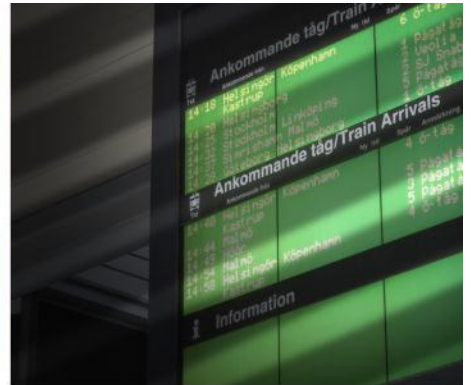
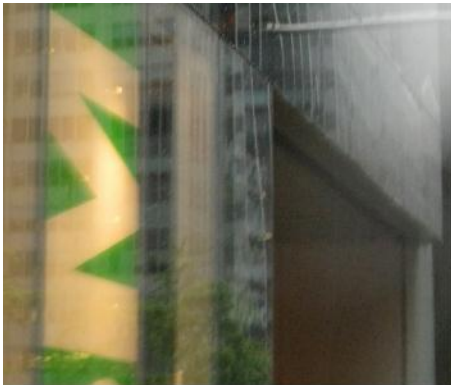


Evaluation of Actibump in Uppsala, Sweden

Effect on speed, yielding behaviour and noise level



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Preface

On behalf of EDEVA, Trivector Traffic has evaluated the dynamic speed bump Actibump and its effect on vehicle speed, drivers' yielding behaviour towards vulnerable road users and noise level. Contact persons at EDEVA were David Eskilsson and Marcus Raninger. The assignment was carried out by Trivector Traffic during July 2014-May 2015 with PhD Eng Annika Nilsson as project manager and PhD Eng Hanna Wennberg as responsible for quality control and translation to English. MSc Eng Alexander Börefelt from Trivector Traffic has also participated. Studies of speed and yielding behaviour have been carried out by Leif Franzén at Franzén Transport & Machine Consultation and studies of noise and vibration levels were done by Veronica Drewsen at Nitro Consult.

Gothenburg, May 2015

Trivector Traffic AB

Table of contents

Preface

1.	Introduction	1
1.1	Background and purpose	1
1.2	Study design and hypotheses	1
1.3	Data collection	1
1.4	Study site	3
1.5	Data analysis	4
2.	Results	5
2.1	Speeds	5
2.2	Yielding behaviour	6
2.3	Noise and vibration levels	6
3.	Conclusions	7

Annex 1: Report from the study of noise and vibration levels before and after Actibump was implemented on Dag Hammarskjölds väg in Uppsala, Sweden.

1. Introduction

1.1 Background and purpose

Trivector Traffic has, on behalf of EDEVA, evaluated Actibump on Dag Hammarskjölds väg in Uppsala, Sweden. Actibump is an active, dynamic speed bump that is activated only by those vehicles exceeding the speed limit.

The purpose of this study is to evaluate whether vehicle speeds and drivers' yielding behaviour are influenced by the implementation of Actibump. Moreover, the purpose is to determine the influence of Actibump on noise and vibration levels.

1.2 Study design and hypotheses

The evaluation has been conducted by studies before and after implementation of Actibump on basis of the following hypotheses:

- 1) The average speed and 85-percentile speed of free vehicles are lower with Actibump than without, comparison before-after study
- 2) After implementation of Actibump, a larger share of drivers yield towards vulnerable road users crossing the street, comparison before-after study
- 3) Noise levels are not higher with Actibump than without, comparison of before-study and study after implementation of Actibump on street without speed bump in before-situation

Hypotheses are tested by comparison of the data collected before and after Actibump is implemented on Dag Hammarskjölds väg in Uppsala, Sweden.

1.3 Data collection

Speeds

Studies of motor vehicle speeds were conducted by measuring speeds of 200 free vehicles before and after implementation, respectively. Speeds were measured in a section located closely in front of the pedestrian crossing.

Free vehicles are vehicles that independently can choose their own speed, which is defined as having 3-5 seconds between vehicles. There is a correlation between the speed of free vehicles and the risk of collisions between motor vehicles and pedestrians. Average speed of free vehicles is higher than for vehicles in general since free vehicles exclude vehicles in a queue.

In order to measure the speed of free vehicles, speeds were measured during off-peak from 10.00-15.00. Information on type of vehicle and direction/lane were also noted.

Yielding behaviour

Studies of yielding behaviour were conducted on more than 100 interactions between drivers of motor vehicles and pedestrians, or between drivers of motor vehicles and cyclists, where the vulnerable road users cross the street at the pedestrian crossing in question. An interaction is defined as a situation when a driver encounters one or more vulnerable road users indicating an intention to cross the street at the pedestrian crossing, either from the pavement or traffic island. It was observed whether:

- ▶ the driver stops and yields
- ▶ the driver slows down and yields
- ▶ the driver slows down but does not yield
- ▶ the driver keeps the same speed and does not yield
- ▶ the driver accelerates and does not yield

It was also observed whether the interaction was with a pedestrian or cyclist (or both) and also the number of pedestrians/cyclists in the interaction (if there were more than one). The studies were conducted in the morning and afternoon when there were an adequate number of vulnerable road users crossing the street.

Noise and vibration levels

Methods for the studies of noise and vibration levels are reported in Annex 1.

Time periods and locations for data collection

Data collection has been carried out during comparable periods before and after implementation of Actibump, in September 2014 (before) and April/May 2015 (after). Actibump was installed during the end of September/beginning of October 2014. Speeds and yielding behaviour were studied on Thursday 4 September 2014 and Tuesday 12 May 2015. For the studies of noise and vibration levels, see Annex 1.

Figure 1-1 shows the exact locations of the studies of speeds, yielding behaviour, and noise/vibration levels on Dag Hammarskjölds väg in Uppsala, Sweden.

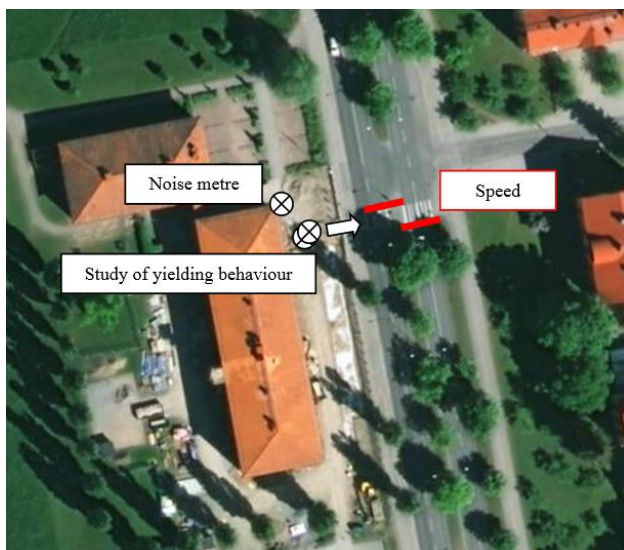


Figure 1-1 Location of the studies of speeds, yielding behaviour and noise/vibration levels.

1.4 Study site

Actibump is implemented on Dag Hammarskjölds väg, a street in Uppsala in Sweden, between the two streets Sjukhusvägen and Husargatan. The study site is located close to the hospital Akademiska sjukhuset and the school Kunskapsskolan.

Dag Hammarskjölds väg has one northbound lane and two southbound lanes, and has an average annual daily traffic (AADT) of 14 000-15 000 vehicles per day. The street is wide with trees as well as grass strips and traffic islands between the two driving directions. The speed limit is 30 km/h on weekdays during 07.00-18.00 and 50 km/h at other times. A pedestrian crossing is situated in the study site. The study site before and after implementation of Actibump is shown in Figure 1-2.



Figure 1-2 Study site before implementation of Actibump (above) and after implementation (below).
Photo: Leif Franzén.

1.5 Data analysis

The data collected on speeds and yielding behaviour has been analysed in Excel and SPSS. The hypothesis of average speed has been tested using T-test for analyses of statistical significances while Chi2-test has been used for testing the hypothesis on the share of drivers yielding for vulnerable road users.

A comparison of noise levels was carried out during two days with comparable weather conditions; one before respectively one after the implementation of Actibump. Noise levels have been compared for different periods during the day, see Annex 1.

2. Results

2.1 Speeds

There has been a statistically significant decrease of average speed after the implementation of Actibump compared to before (Table 2-1). The difference in speed is 5.5 km/h in total and a little less for the left lane in the southbound direction. The range of speed has also decreased.

Table 2-1 Vehicle speeds (km/h) before and after implementation of Actibump. Statistical significances (sign.) at the 95% level.

Directions	Speed parameters (km/h)								
	Number of observations		Average speed		Standard deviation		Difference after-before average speed	Share of heavy traffic	
	before	after	before	after	before	after		before	after
Both directions	200	200	33.0	27.5	7.2	4.8	-5.5 (sign.)	18 %	15 %
South, from city centre	100	100	32.7	27.7	7.7	4.5	-5.0 (sign.)	22 %	13 %
- Lane 1	47	52	32.3	26.0	6.7	3.7	-6.3 (sign.)	40 %	25 %
- Lane 2	53	48	33.1	29.4	8.4	4.7	-3.7 (sign.)	5,7 %	0 %
North, to city centre	100	100	33.7	27.2	6.7	5.1	-6.5 (sign.)	14 %	16 %

For all vehicles, the 85-percentile speed has decreased from 40 m/h to 32 km/h. Figure 2-1 shows speed profiles before and after implementation of Actibump. In general, speeds have been lowered. The share of drivers exceeding the speed limit of 30 km/h was 75 % before implementation and 21 % after. Note that these figures apply only to free vehicles.

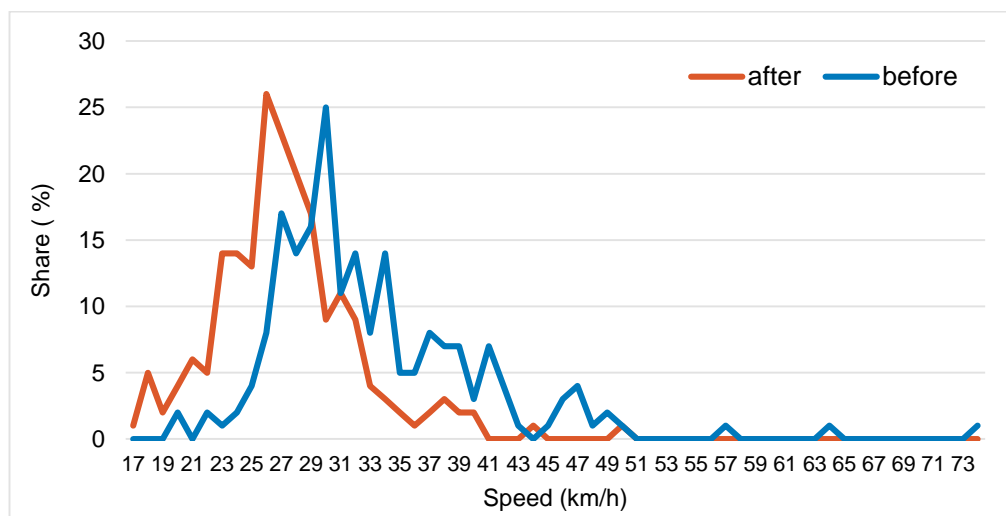


Figure 2-1 Share of motor vehicles with different speeds before and after implementation of Actibump.

2.2 Yielding behaviour

There has been a statistically significant increase of the share of drivers yielding for vulnerable road users at the pedestrian crossing after the implementation of Actibump compared to before (Table 2-2). The share increased with 21 percentage units, from 51 % to 72 %. Around 70 % of the interactions were between drivers and pedestrians (the rest with cyclists). The largest difference was observed for interactions with drivers going from the city centre. For drivers in the opposite direction, the difference was not statistically significant.

Table 2-2 Share of drivers yielding towards vulnerable road users before and after implementation of Actibump. Statistical significances (sign.) at the 95% level.

Directions	Number of observations		Share of drivers yielding		Difference in share of drivers yielding after-before	Share of interactions with pedestrians	
	before	after	before	after		before	after
Both directions	166	186	51 %	72 %	21 %-units (sign.)	71 %	77 %
South, from city centre	93	98	46 %	81 %	34 %-units (sign.)	-	-
North, to city centre	73	88	56 %	61 %	5 %-units (no sign.)	-	-

2.3 Noise and vibration levels

After Actibump has been installed, the noise levels are lower both during the period of 30 km/h speed limit and the period of 50 km/h speed limit. The equivalent noise level during the day has decreased from 69.2 dBA to 65.4 dBA after implementation of Actibump, see Annex 1 and Figure 2-2.

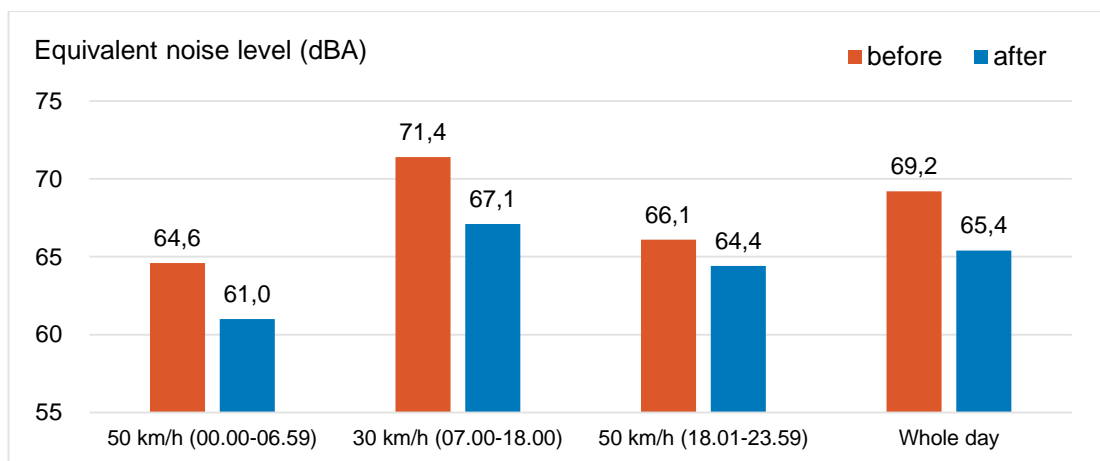


Figure 2-2 Noise levels before and after implementation of Actibump. A-weighted equivalent noise level L_{Aeq} dBA

The number of indications on the vibration metre (at a vibration value over 0.5 mm/s) has increased from 5 times to 10 times after implementation of Actibump. This suggests that vehicles driving over the Actibump result in ground vibrations, but these vibrations are below 1 mm/s and will therefore not affect buildings significantly (see Annex 1). The actual vibrations measured were not higher after the implementation of Actibump compared to before.

3. Conclusions

An evaluation of the active, dynamic speed bump Actibump has been conducted by studies before and after the implementation of Actibump on Dag Hammarskjölds väg in Uppsala, Sweden. The following hypotheses have been tested:

- 1) The average speed and 85-percentile speed of free vehicles are lower with Actibump than without, comparison before-after study
- 2) After implementation of Actibump, a larger share of drivers yield towards vulnerable road users crossing the street, comparison before-after study
- 3) Noise levels are not higher with Actibump than without, comparison of before-study and study after implementation of Actibump on street without speed bump in before-situation

The results show that the average speed and 85-percentile speed of motor vehicles have decreased and that the share of drivers yielding towards vulnerable road users have increased after the implementation of Actibump. The difference in share of drivers yielding, however, was only statistically significant for those driving from the city centre.

Motor vehicle speeds are correlated with the expected traffic safety effects in terms of reducing risks of accidents and injuries. Decreased speed therefore implies an improvement of traffic safety by the implementation of Actibump. A larger share of drivers yielding towards vulnerable road users leads to an increased accessibility for the vulnerable road users as well.

The results also show that noise levels have decreased by the implementation of Actibump, while the number of indications of vibrations has increased. This is compared to the situation without Actibump, i.e. a location without any speed bump. The hypothesis therefore concerns the effect of Actibump in comparison with other types of speed bumps. Noise and vibration levels on sites with other types of speed bumps have not been measured within this evaluation study. Referring to results from previous studies summarised in a Swedish handbook of traffic safety measures¹, noise levels can increase locally around a speed bump, especially if the construction of the speed bump causes vehicles to decelerate strongly before the bump and accelerate after. Other paving than asphalt also causes more noise; for example, cobblestones give 2-4 dBA higher noise level. The handbook also suggests that speed bumps may cause vibrations. Nevertheless, reduced speeds and more even driving patterns generally result in decreased noise levels.

¹ Swedish Association of Local Authorities and Regions (2009). Åtgärds katalog för säker trafik i tätort. Third edition. Stockholm, Sweden: Kommentus förlag.

