

Cyclists' speed – field observations and measurements

J. Eriksson¹, A. Niska², S. Gustafsson³, G. Sörensen⁴

¹ Swedish National Road and Transport Research
Institute, VTI, SE-581 95 Linköping, Sweden,
jenny.eriksson@vti.se

² Swedish National Road and Transport Research
Institute, VTI, SE-581 95 Linköping, Sweden,
anna.niska@vti.se

³ The National Society for Road Safety, NTF, SE-
171 44 Solna, Sweden,
susanne.gustafsson@ntf.se

⁴ Swedish National Road and Transport Research
Institute, VTI, SE-581 95 Linköping, Sweden,
gunilla.sorensen@vti.se

ABSTRACT

Many different road users share the space on pedestrian and cycle paths, and their speeds may differ greatly. Differences in speed can complicate the interactions between road users which, in turn, may cause incidents and accidents. The purpose of this paper is to enhance the understanding of cyclists' speed on pedestrian and cycle paths and to understand how cyclists adapt their speed to other road users and the surrounding environment. The paper is based on a study [1] where three different data sources were used: existing measurements of cycle speed and flow in three different Swedish municipalities, Eskilstuna, Linköping and Stockholm (19 sites); new measurements of cycle speed and flow in Linköping (4 sites) and Stockholm (1 site); and road side observations of bicycle types at these five sites.

The average speed of cyclists on the paths varied between 15 and 25 kilometres per hour. As expected, the lower average speeds were found in uphill directions, near intersections and on paths with high pedestrian flows. The higher speeds were found in downhill directions and on commuter routes. In all, 70–95 percent of the road users observed on pedestrian and cycle paths were cyclists while 5–30 percent were pedestrians. The most common type of bicycle used was a comfort bike, followed by a trekking bike. Electric assisted bicycles and racer bikes occurred at all sites, with a proportion of 1–10 percent and 1–15 percent, respectively. The relationship between bicycle type and measured speed was not entirely clear, but the paths with higher proportions of electric and racer bikes generally had higher speeds. There also appears to be a connection between average speed and the width of the distribution – the higher the average speed, the wider the speed distribution. More research is needed on how this affects the accident risk.

Keywords: cyclist, speed, type of bicycle, cycle traffic, cycle path.

1. INTRODUCTION

In Sweden, many different road users with different desired speeds co-exist on pedestrian and cycle paths. Conflicts and incidents occur and sometimes they lead to collisions between road users. Accidents between vulnerable road users may not be a major traffic safety problem but can cause a feeling of insecurity. In Sweden, about one percent of pedestrians who need emergency care have been injured in a collision with a cyclist [2]. Of all injured cyclists who seek emergency care in Sweden, seven percent have been injured in a collision with another cyclist and one percent in a collision with mopeds or pedestrians [3]. However, in about ten percent of the single bicycle crashes, the cyclist crashed while avoiding a collision with another road user [3, 4]. The analysis of single bicycle crashes [3] is based on emergency hospital data registered in STRADA, the national road accident database in Sweden, and included 4000 randomly selected injured cyclists. Each cyclist had at least one classified injury from a single bicycle crash. All accident descriptions were classified by cause of accident. Commonly occurring causes of single bicycle crashes, declared by the cyclists, showed that "high speed" occurred in four percent and "downhill slope" occurred in seven percent of the crashes. In downhill crashes, high speed may have contributed to the cause and the severity of the crash. In a literature review conducted in this study [1], there was a lack of research on the relationship between cyclists' speed and accident risk. Instead of actually studying the relationship, it seems to be assumed that a higher bicycle speed also means a higher accident risk, referring to studies with motor vehicles [5]. However, one study [6] found a relationship between injury severity and the speed of the cyclist. In that study, information about speed and other background variables was collected through surveys among injured cyclists. The result showed an increased risk when comparing speeds above 25 km/h with speeds of 15-25 km/h.

A study [7] of cycling behaviour, based on naturalistic cycling data from Gothenburg, identified and quantified factors that increase the risk of critical events. In the study, 20 cyclists were riding in real traffic for two weeks each, on a bicycle equipped with GPS, video camera and kinematic sensors. During the rides cyclists themselves pushed a button when they experienced a critical event. In total, 63 critical events were identified and 16 percent of these occurred due to another cyclist and 29 percent due to a pedestrian. The study showed that the average speed was higher during critical conditions than in baseline events, which could indicate that cyclists' speed do affect the accident risk.

Differences in speed between the road user categories occurring on various types of cycle paths could be a cause of failure in interaction. Knowledge of the road users' composition on pedestrian and cycle paths and the resulting speed distribution are not sufficiently known. In addition to having an impact on the interaction with other road users and thus on safety, the speed has a strong correlation to cyclists' accessibility, which in turn might affect cyclists' choice of route as well as the choice of travel mode. In this context, one needs to distinguish between journey speed and spot speed. The journey speed is measured over a distance travelled, considering stops and other speed-setting obstacles, while the spot speed is the speed at a certain cross section (i.e. at the measurement site). In this paper, our analyses focus on spot speed measurements.

1.1. Aim

The purpose of this study is to enhance the understanding of cyclists' speeds at pedestrian and cycle paths and, if possible, to understand how cyclists adapt their speed to other road users and the environment. The focus is to study cyclists' speed from a road safety perspective. The questions we would like to answer are: What is the average cycle speed and speed distribution

on pedestrian and cycle paths? What is the road users' composition on pedestrian and cycle paths? What are the desired speeds of cyclists on cycle paths?

2. MATERIAL AND METHOD

2.1. Measurement sites for bicycle speed and flow data

Bicycle flow measurements are commonly carried out in Swedish municipalities, but most of the measurements do not include information about speeds. Nevertheless, we have been able to assemble spot speeds from three municipalities: from 10 sites in Stockholm, 6 sites in Linköping and 1 site in Eskilstuna. We have also conducted new measurements within the framework of this study: on 4 sites in Linköping and one site in Stockholm. In total, speed and cycle flow data from 20 sites were analysed (Table 1).

Table 1. Measurement sites included in the analyses, E=existing measurements, N= new measurements.

Municipality	Site	Site No.	Type of measurements	Average daily traffic of cyclists*
Stockholm	Brommaplan	1	E	2,250
Stockholm	Nockebybron	2	E	750
Stockholm	Huddinge-Rågsvedsv	3	E	550
Stockholm	Flatenvägen	4	E	400
Stockholm	Huvudstabron Ö	5	E	770
Stockholm	Huvudstabron V	6	E	680
Stockholm	Hägerstensvägen N	7	E	610
Stockholm	Hägerstensvägen S	8	E	610
Stockholm	Kungsholms strandstig 1	9	E	1,520
Stockholm	Kungsholms strandstig 2	10	E	3,440
Stockholm	Danvikstullsbron	11	N	4,020**
Linköping	Vallaskogen	12	N	2,830
Linköping	Haningeleden	13	N	1,120
Linköping	Hunnebergsgatan	14	E+N	3,390
Linköping	Malmslättsvägen, norra	15	E+N	1,780
Linköping	Malmslättsvägen, södra	16	E	2,020
Linköping	Hamngatan	17	E	2,710
Linköping	Underpass, Hamngatan	18	E	2,190
Linköping	Underpass, Lasarettsgatan	19	E	3,080
Eskilstuna	Torshällavägen Ö	20	E	490

*Based on period from existing measurements or, for site 11-13 from new measurements.

**From 2014, 25–29 Aug.

The existing speed and flow data obtained from measurement sites in Stockholm and Linköping have been collected with two different types of equipment that detect axle passages. These two are: Metor (Linköping, measurement sites No 14-20), and MetroCount (Stockholm, measurement sites No 1-10). Detection of axle passages is based on registration of contact pressure from sensors (in this case rubber tubes) for each occurrence of wheel axis passage at the

measurement site. For the existing data from the measurement site in Eskilstuna (site 20) and from the new measurements in Stockholm and Linköping (sites No 11-15), a camera measurement system was used. The camera system is named OTUS3D (www.viscando.se) and has a 3D feature that detects movements/tracks and classifies these into pedestrians, cyclists and motor vehicles.

2.2. Data collection period

From the existing measurements in Stockholm, data of 1-5 days are extracted from the period 31 August to 21 September in 2015. Data are aggregated by hour and direction. From the existing measurements in Linköping, data of about 4 weeks in September and October 2015 are included in the analyses, aggregated by hour but not directionally divided. From Eskilstuna data from the whole year of 2015 are available, on an individual level and directionally divided, but our analysis mainly focuses on weekdays in September. All results are based on weekdays (Monday to Friday) except the monthly and weekly variability of speed and flow (figure 3 and 4) which are based on data from all the days of the week. If missing values exists for at least one hour, the whole day removes.

The new measurements in Stockholm and Linköping were carried out for two weeks, from 30 August to 10 September 2016, for 1-10 days at each site, except for the site in Stockholm where only parts of two days were measured. However, for certain periods of time, data is missing due to poor battery power.

Direction 1 (dir. 1) is always representing the direction towards the city center and direction 2 (dir. 2) is the opposite direction.

2.3. Description of the new measurement sites

All sites where we performed new speed measurements had a bi-directional pedestrian and cycle path separated from the motor vehicle traffic. There was a variation in lane width and in the type of cyclist/ pedestrian separation (Table 2). In appendix there are pictures of the sites (see figure 14 – 17).

Table 2. Design of the selected pedestrian and cycle paths, and width of the paths at the measurement site.

Site No.	Cyclist/pedestrian separation	Width, total [m]	Width, cycle path [m]	Width, pedestrian path [m]
11	Road marking, white line	4,9	2,5	2,4
12	None	3,1	-	-
13	None	2,9	-	-
14	Different road surfacing: Paving/ stones	6,6	2,5	2,0+2,1
15	Road marking, white line	5,1	2,4+0,4	2,3-0,5*

*Lamp posts intruding the pedestrian path and reducing the width.

2.4. Observations of road users on pedestrian and cycle paths

At the sites in Stockholm and Linköping where the new speed measurements took place (Table 1), the traffic composition was also observed for about one hour at a time. A total of 15 occasions of observations were conducted during ongoing speed measurements and video capture with

the camera measurement system, see Table 3 below. During the observations, there were both cloudy and sunny weather (but no rain) and the air temperature was between 10 and 24 degrees Celsius. Depending on the traffic flow, one or two observers were operating at each occasion. In all, three different observers were involved in the observation study.

Table 3. Occasions of observations at the sites during f the new measurements

Site No.	1 st occasion	2 st occasion	3 st occasion	4 st occasion
11	30 Aug. 09:15-10:15	30 Aug. 11:00-11:40	30 Aug. 15:45-16:45	31 Aug. 09:15-10:15
12	1 Sep. 16:10-18:05	7 Sep. 14:45-15:45	9 Sep. 07:30-08:30	
13	6 Sep. 15:00-16:30	7 Sep. 16:30-17:50	8 Sep. 07:15-08:45	
14	2 Sep. 13:00-14:00	4 Sep. 12:50-14:00	6 Sep. 07:30-09:00	
15	8 Sep. 16:30-17:30	12 Sep. 7:30-8:30		

An observation protocol was developed describing the categories observed:

Classic bicycle (CB): foot brake, handlebars higher than the saddle, rarely more than 7 gears, often basket. Includes mini bikes.

Trekking bicycle (TB): rarely foot brake, handlebars and saddle approximately at the same height, often more than 7 gears.

Mountain bicycle (MTB): regardless of type.

Racing bicycle (RB): rarely foot brake, handlebars lower than the saddle. narrow tires, road handlebars.

Electrically assisted bicycle (EB): regardless of type. We presume that all electric bikes had pedal assistant up to 25 km/h, i.e. were pedelecs.

Other bicycles or bicyclists (OB): child together with an adult cyclist: in bicycle seat, in child carrier trailer or on their own bicycle. Children younger than 12 years old who are without adults. Box bikes and other more unusual types of bicycles were also included in this group.

Pedestrians: this group included those who led their bicycle.

Other road users: this group includes electric wheelchairs, E.U. mopeds, class 2 mopeds, cars and wheeled adults/children (e.g. one roller skates or skateboards).

3. RESULTS

3.1. Average speed of cyclists

A first analysis shows that the average speed of cyclists passing the measurement sites varies from 16 km/h to almost 25 km/h during weekdays (Figure 1). This overview shows an aggregation of speeds in both directions (site No. 11 excluded due to incomplete data).

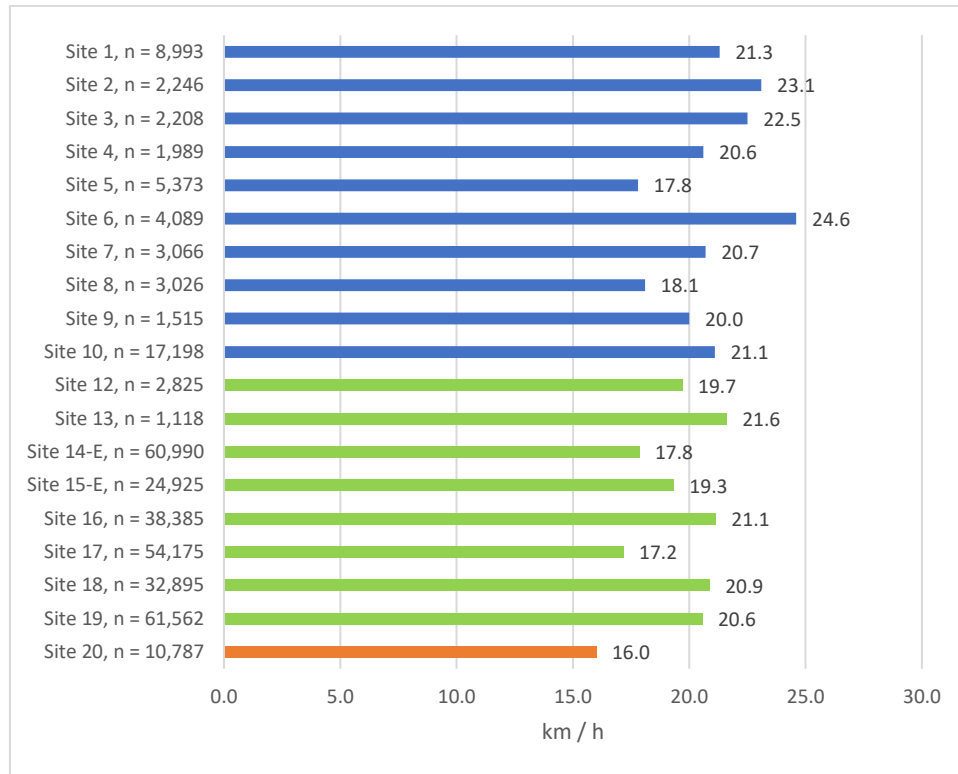


Figure 1. Average speed (km/h) of bicyclists passing the measurement sites. "n" = number of cyclists.

The aggregation of directions might give a false impression, since the average speed depends on the direction. Hence, directional speed is presented (Figure 2). For some of the sites there were major differences in speed between the directions. In total, the differences between directions vary from only 0.4 km/h (site No. 1) to 12.8 km/h (site No. 6). At site No. 5, 6 and 12, the average speed is higher than 25 km/h in one direction, but only about 14 km/h in the other direction. This is explained by the fact that these sites are located at slopes. For the sites where the difference between directions is no more than 2 km/h, average speeds are approximately 15–22 km/h. The sites No. 16–19 have no information of directional average speeds.

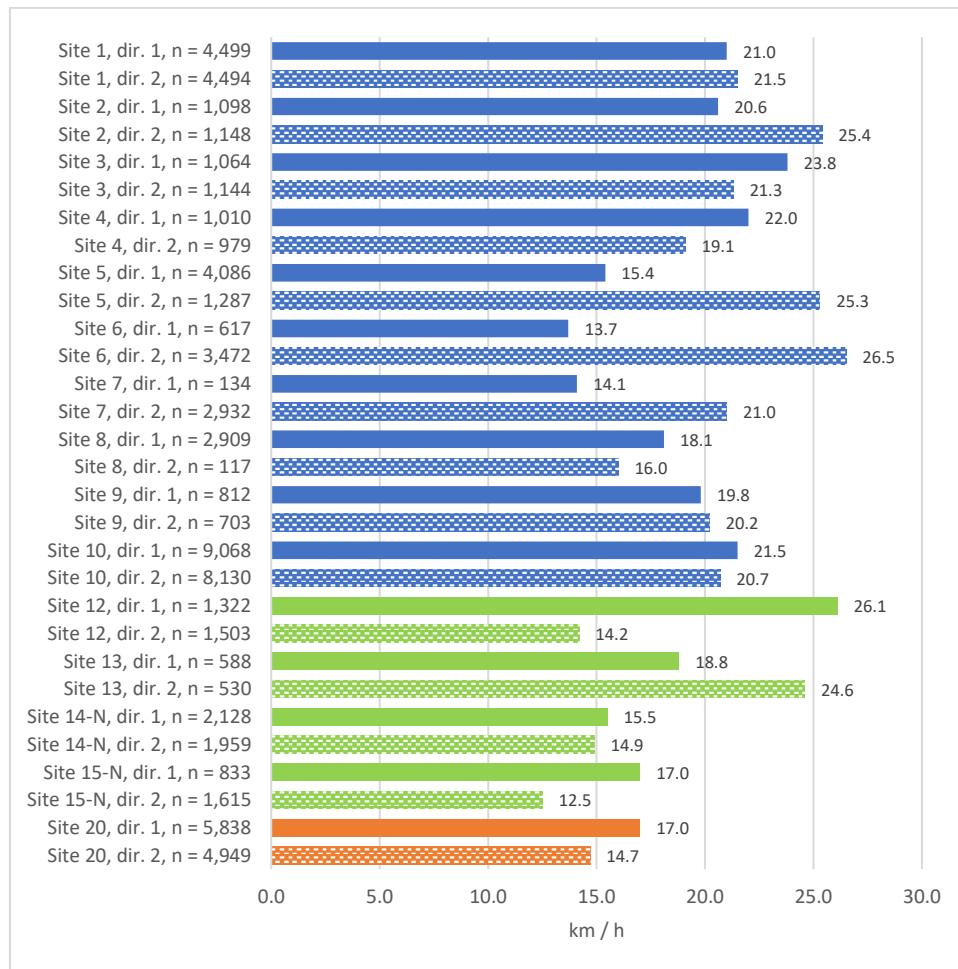


Figure 2. Average directional speed (km/h) of bicyclists passing the measurement sites.

Besides the fact that cycle road gradients obviously affect cyclists speed, the differences in the average speed between the directions can be explained by, for example, differences in distance to intersections or other physical obstacles, visibility conditions and traffic flow. Whatever the reasons, our conclusion is that it is important to have directionally data in further analyses of cyclists' speed.

3.2. The variability of speed and flow over the year, week and day

On site No. 20, bicycle flows and speeds have been collected throughout the year, making it possible to study any seasonal variations (Figure 3). The flow varies, as expected, a lot over the year, with a peak in August and a minimum in January. Except for the snowiest months in 2015 (January and February), there are only small differences in cyclists' average speed over the year. Direction 1 is slightly downhill, while the other direction is slightly uphill and therefore there is a noticeable difference in average speed between the two directions, for a major part of the year. However, in January and February, the average speed is generally similar in the two directions. This is probably explained by the fact that cyclists in the downhill direction choose to cycle slower in the wintertime, considering the risk of slippery conditions due to ice and snow.

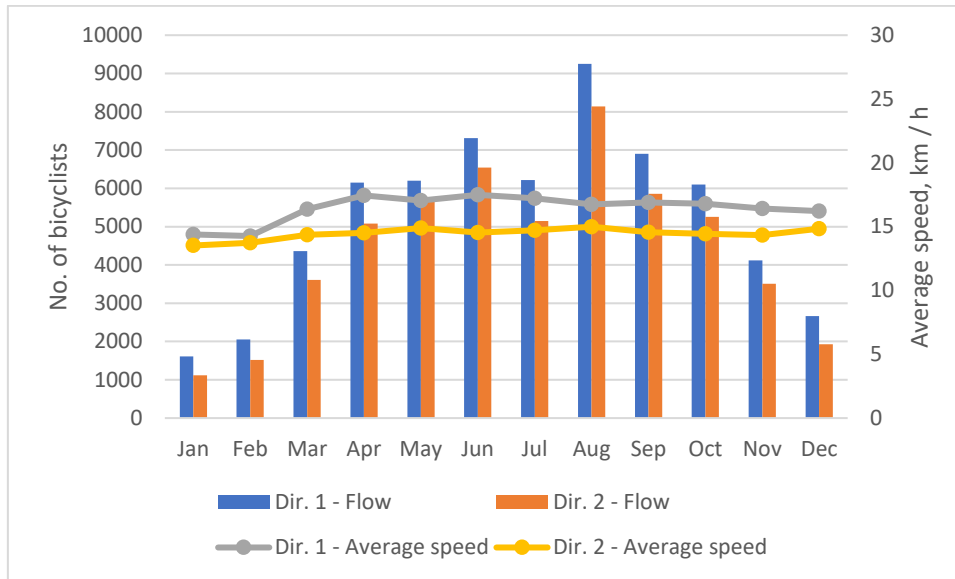


Figure 3. Average speed (km/h) of cyclists (right axis and lines) and total cycle flow (left axis and bars) per month for site 20. Divided by direction, all days of the year 2015 (n=116,373).

For site No. 20, the average speed is slightly lower during the weekends than on weekdays (Figure 4). Other types of errands and other types of cyclists might be possible explanations. Cycle flows are also significantly lower during the weekends, which could explain the somewhat lower speed average rates.

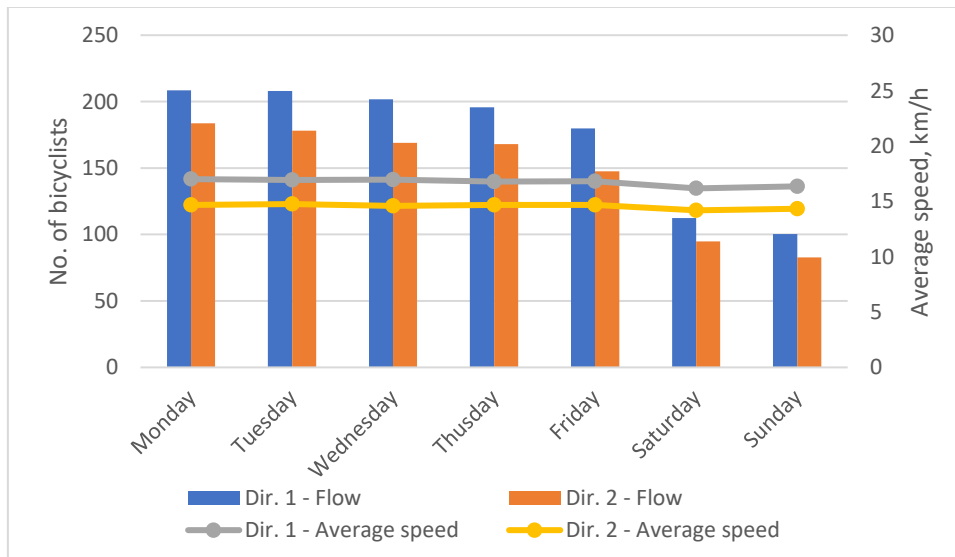


Figure 4. Average speed (km/h) of cyclists (right axis and lines) and total cycle flow (left axis and bars) per day for site 20, in the year 2015 (n=116,373). Divided by direction, all days of the weeks, 2015 (n=116,373).

Previous Swedish studies have shown that there are major differences in cycle flow depending on the time of day, with peak hours in the morning and in the afternoon [8, 9]. This also applies to site No. 20 (Figure 5). This site appears to have commuter traffic with peaks in one direction (Dir. 1) in the morning and in the opposite direction in the afternoon (Dir. 2).

The cycle flow could also affect the average speed, since it might be more difficult for an individual cyclist to choose his/her desired speed at high cycle flows. In this case, however, there were relatively low volumes of cyclists even for peak hours. There was no big difference in average speed over the time of the day. The average speed was, however, somewhat higher in the morning between 06-08 a.m. in direction 1. There were only a few cyclists during the night and hence, the average speed during night hours is strongly dependent on the speed of individual cyclists.

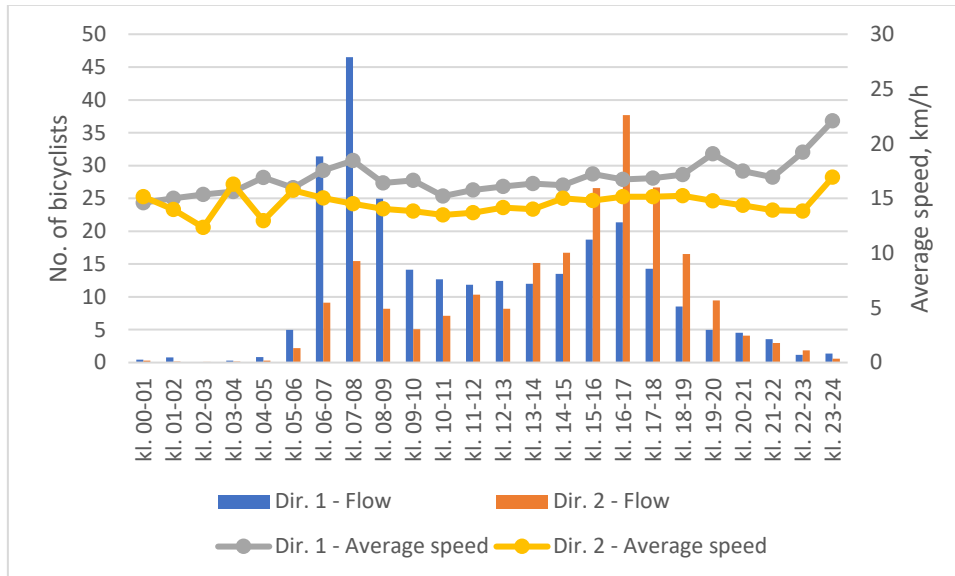


Figure 5. Average speed (km/h) of cyclists (right axis and lines) and total cycle flow (left axis and bars) per hour for site No. 20. Divided by direction, and hours for weekdays, September 2015 (n=10,787).

3.3. Distribution of speed among cyclists

From a traffic safety perspective, it is possible that a widely distributed speed, e.g. expressed by the difference between the slowest and the fastest cyclists on a path is more important than the average speed. The speed distribution among cyclists appears to follow a normal distribution at some sites (e.g. site No. 14) while others have a non-symmetric distribution at higher speeds (e.g. site No 20) as shown in Figure 6. Weibull and lognormal distributions give the best description of the cycle speed distributions [5].

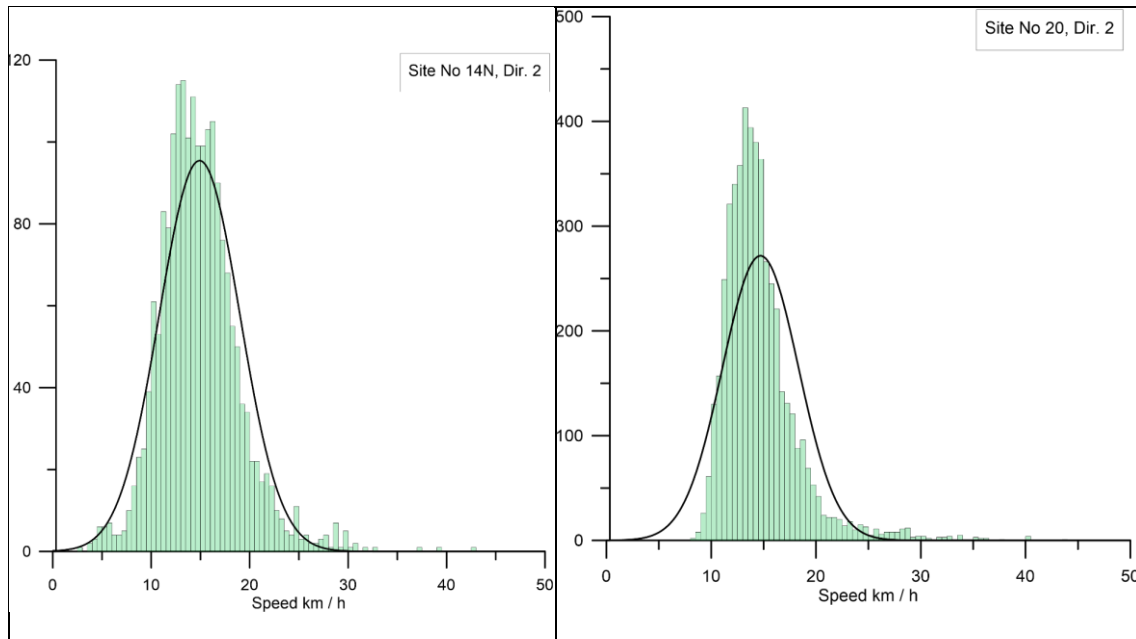


Figure 6. Examples of symmetric and non-symmetric distributions of cycle speeds at site No. 14-N, dir. 2 (left) and site No 20, dir. 2 (right). The black curve illustrates the normal distribution. Observe the differences in the scale at the y-axis.

For two of the sites, two different speed groups appear, one which has a peak of 5 km/h and the other about 17 km/h (Figure 7). The grouping around the lower speed is probably pedestrians being incorrectly registered as cyclists, or maybe cyclists leading their bicycle or cycling slowly in the company of pedestrians. The speed distribution, as the average speed, may differ depending on the cycle direction (see Figure 7 to Figure 9).

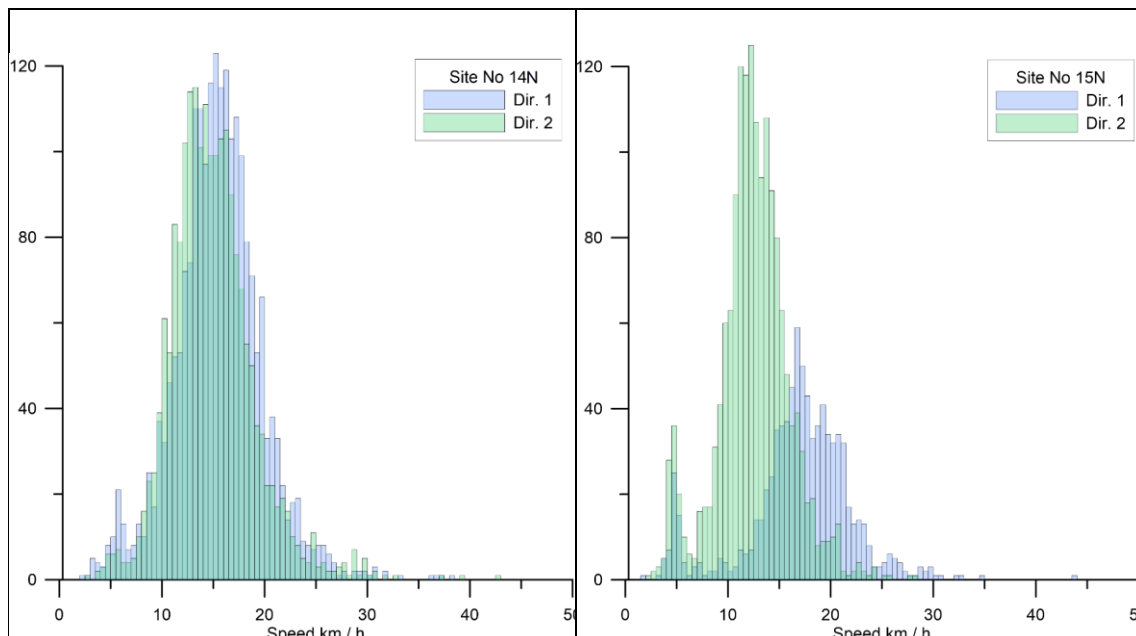


Figure 7. Directional speed distribution of sites No. 14-N (left) and 15-N (right).

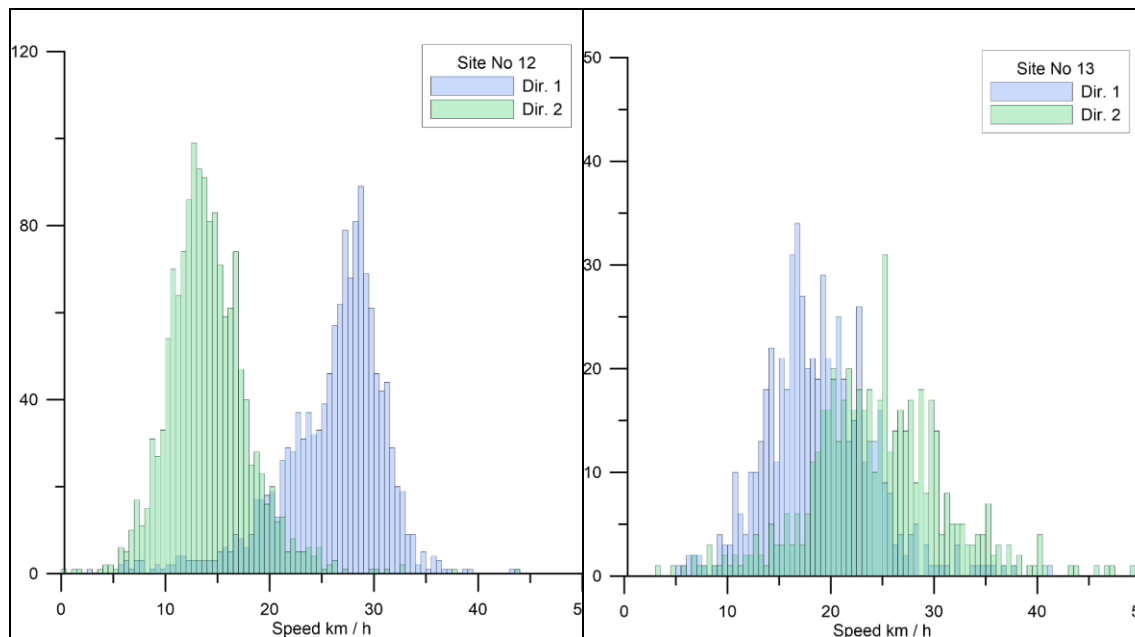


Figure 8. Directional speed distribution of sites No. 12 (left) and 13 (right).

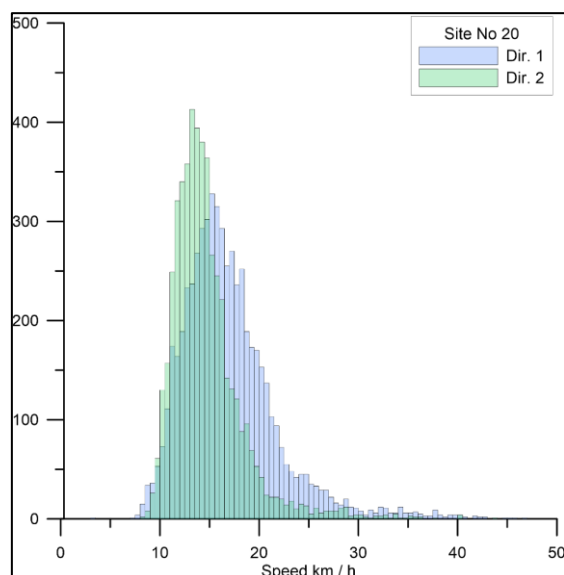


Figure 9. Directional speed distribution of site No. 20.

The difference between the 15th and 85th percentiles of the speed distribution (Figure 10) can be used as a measure of the deviation in speed. The widest speed distributions were found at the one of the commuter routes (site 13) and one of the downhill paths (site 12, direction 1). There also seems to be a correlation between average speed and the width of the distribution – the higher the average speed, the greater the speed distribution. This correlation can also be seen in Figure 11. However, two sites differ slightly from this pattern. Site 12, direction 1, had the highest average speed, but not the widest distribution. This might be due to a downhill slope increasing the speed of slow cyclists while faster cyclists are forced to slow down as the cycle path takes a turn at the end of the hill (see also Figure 10). Site 11 has uphill slopes in both directions. Direction 1, had a wide speed distribution in relation to the moderate average speed rate. The relatively large difference in speeds may be due to a long uphill slope and a road barrier at a bridge opening, which force some cyclists to start from stagnant just before passing the

measurement site. The uphill slope in this direction is longer than in the opposite direction, which could explain the difference between directions.

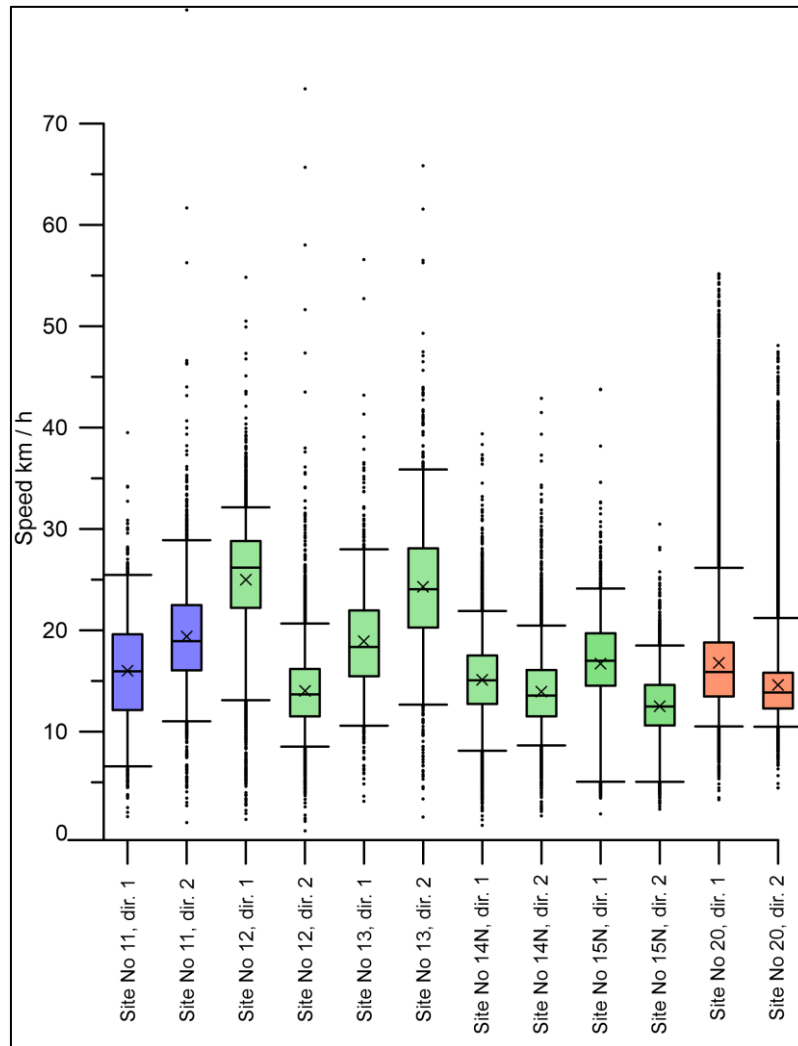


Figure 10. Speed rate distribution in box plot, divided by direction. Box= 15th and 85th percentile, respectively. Line in box= The median speed. Cross in box= Average speed. Whiskers limitations= 5th and 95th percentile, respectively. Dots= Extreme values.

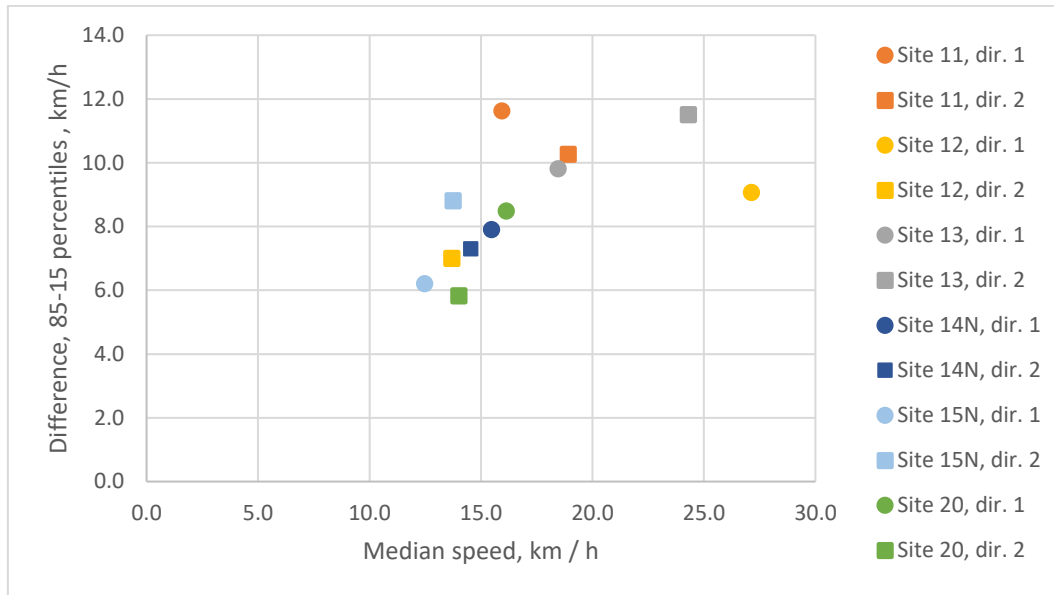


Figure 11. The difference between the 85- and the 15-percentiles in relation to median speed (km/h).

3.4. Road user composition on pedestrian and cycle paths

Both the average speed and the deviation in cyclists' speed can be affected by the road user composition. With a large proportion of pedestrians or other slower road users, the number of interactions increases, which in turn could affect cyclists' ability to maintain their desired speed. It can also increase the risk of conflicts. To study how the road user composition affects cyclists' speeds, roadside observations were also performed at sites where new measurements were conducted. In total 4 604 cyclists, 1 207 pedestrians and 46 other types of road user were observed during the approximately 18 hours of roadside observations. At sites 12, 13 and 15, there were about 90 percent cyclists, compared to less than 70 percent at site 11 and 14 (Figure 12).

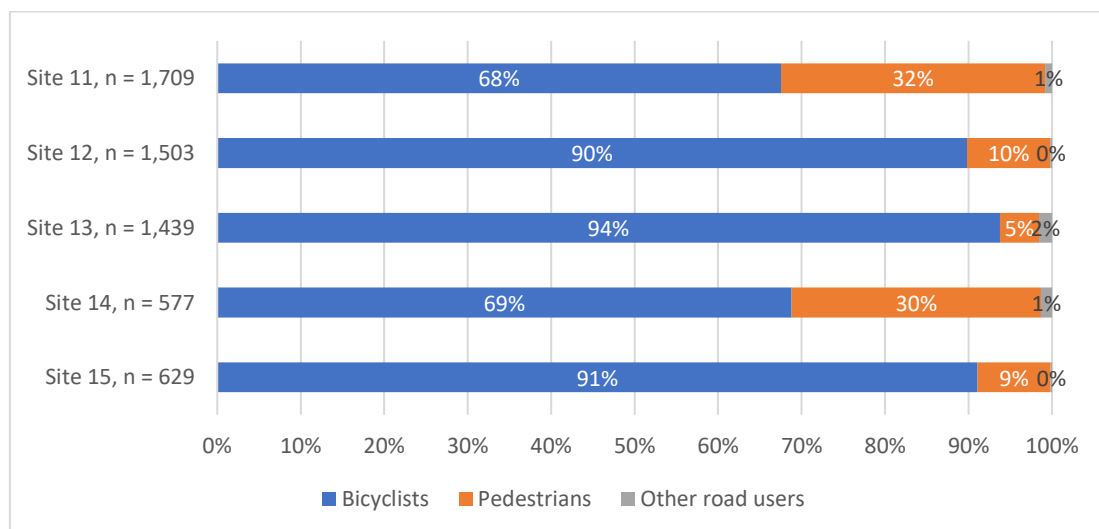


Figure 12. Distribution between cyclists, pedestrians and other road users based on observations at site 11–15.

The composition of the categories of cyclists shows a big difference between the sites (Figure 13). Worth noting is the relatively high percentage of electrically assisted bicycles (EB) and racing bicycles (RB) at sites 11 and 13. Moreover, at site 13 speeds are relatively high (Figure 11). Site 11 we don't show the same correlation, but here the cyclists have just arrived at the top of a hill when passing the measurement site.

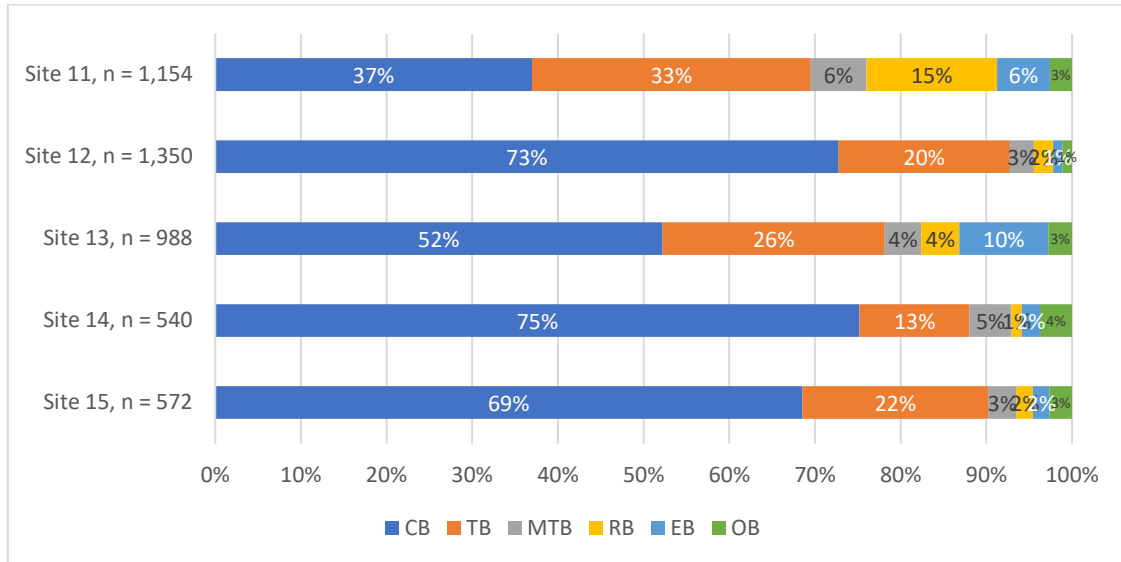


Figure 13. Cyclist category composition based on observations at the five sites No11–15.

4. DISCUSSION

The purpose of municipal cycle measurements is usually to count the number of cyclists and, although technically possible, the collection of data on cyclists' speeds is seldom performed at the same time. At the time of installing the measurement equipment, it is necessary to determine the degree of details that the collected data should have. Most municipalities refrain from saving speed data, while a few save average speed data aggregated per hour. Preferably, individual speed data should be saved, to increase the range of speed analyses possible.

In a separate study [10], the camera measurement system's ability to detect speeds was evaluated. One of the conclusions was that the measurement equipment worked well in detecting speeds and the feature to plot trajectories proved to be useful in the analyses. This suggests that the data obtained in this study is of sufficient quality. In general, however, previous literature tends to focus on how these types of measurement systems (other examples of such systems include Metor and MetroCount) detect flow rather than speed. Therefore, the accuracy and usefulness of such systems is still largely undetermined.

4.1. Average speed of cyclists at pedestrian and cycle paths

The average speed of cyclists passing the measurement sites varies between 16 and 25 km/h. It is important to note that these results are based on speed data at a certain measurement spot, i.e. "spot speed, which differs from the journey speed measured over a distance, taking into account stops and other speed-setting obstacles. However, it should also be noted that we have analysed speeds and flows collected using different measurement methods. No general monthly, weekly or hourly difference in average speed was found, except in snowy months. These results contradict the conclusions from a study [11], based on data from a bike share

system. However, these two studies are not really comparable since bicycles in bike share systems might be used to a greater extent by leisure cyclists and not by fast cycling commuters. In addition, the study [11], describes journey speed, while our study describes spot speed.

4.2. The importance of infrastructure for cyclists' speeds

Cyclists' speed is obviously affected by downhill and uphill slopes. According to Berg (2017), cyclists increase speed from about 20 km/h to 25 km/h for a longer downhill slope with 1 percent gradient and from 20 km/h to 30 km/h at 3 percent gradient using the same power output. At site 12 in our study, it was found that the average speed uphill was significantly lower than in the downhill direction, about 14 km/h compared to 26 km/h. At most, the gradient was 7 percent. Furthermore, there were lower average speeds at places near intersections (14N, direction 2 and 15N direction 2, which was also preceded by minor uphill slopes). The lower and higher measured average speeds from these sites are, of course, affected by the fact that the sites have different conditions. Based on a study by Chalmers and Gothenburg municipality (2016), the median speed can (to more than half) be explained by nine different variables, of which our study supports the following: signal crossings (-), downhill slope (+), bi-directional cycle paths (+), and an interaction term between segment length and uphill slope (-), where “+” indicates an increase and “-” a decrease of the average speed. Our results strengthen this model, although our study did not quantify the importance of these factors.

We identified a relatively high average speed, 25 km/h, on site 13, direction 2. The section of the cycle path at this site is relatively flat and, most cyclists can keep 20–30 km/h on a smooth and horizontal surface [12]. At this site, we identified the widest distribution in speed, taking into account the difference between the 85th and the 15th percentile. However, for this section, we presume that the relatively large distribution in speed is mainly related to the road user composition rather than to the infrastructure.

At site 12, direction 1, there was a relatively large distribution in speeds. In this case, it could probably be explained by the infrastructure where the speed distribution is greater downhill, where some cyclists choose to “let go” while other cyclists are more careful and choose to brake. Overall, there was a clear correlation between the average speed and the speed distribution, with a greater average speed also resulting in a wider distribution. However, in the downhill slope of site 12, the deviation is not as large as the average speed indicates. This could be explained by the fact that the slowest cyclists get a boost downhill while the fastest cyclists might need to slow down due to a curve with quite a poor visibility at the end of the slope, making it risky to ride too fast.

For sites 11-15 (N) information was available about path widths and kind of separation between cyclists and pedestrians, if any. However, the data in this study were not of such an extent that it was possible to analyse the significance of these factors for cyclists' speed.

4.3. The importance of road user composition for cyclists' speed

Something that could affect cyclists' speeds is the road user composition on pedestrian and bicycle paths. Cyclists' speeds decrease up to 30 percent if the cycle path is shared with pedestrians [13]. Where observations were conducted in our study, sites 11 and 14 had the largest pedestrian proportion of about 30 percent. The other three measurement sites had a pedestrian proportion of 10 percent or less. The average speed of site 11 was between 16-19 km/h and site 14 around 15 km/h, which is in the lower part of the measured average speeds. It is difficult to conclude whether the speeds were affected or not by a larger proportion of pedestrians at these

sites, since they also differ in many other perspectives. To draw such conclusions, more detailed studies are needed of how cyclists' behaviour is affected by the number of pedestrians - preferably at one and the same measurement site but at different occasions.

In terms of cyclist categories, there were quite large differences between the sites. For example, site 13 had the largest share of cyclists using electric assisted bicycles (EB) and a large proportion of trekking bicycles (TB) but a lower proportion of classic bicycles (CB). At this site, one of the highest average speeds was also measured. This might be related to the low proportion of CBs and the high proportion of TBs, i.e. cyclists choose their bicycle in accordance with their desired speed. Unfortunately, it was not possible to measure the speed of the respective bicycle type at the occasions of observations within the frame of this study. Instead, to assess whether our assumption is correct, we have considered the results of a study [14], where 41 cyclists assessed their desired speed by choosing one of four groups: comfort cyclists (often overtaken), normal cyclists (keeping the same speed as others), fast cyclist (often overtaking other cyclists) and electrified cyclists (using electric assisted bicycle). Those who indicate that they are comfort cyclists (i.e., lower desired speed) either had a CB or a TB. That also applied to those who stated that they were "normal cyclists", and to one person who had an MTB. The only person who had a RB chose the fast-cycling group, as were several persons using a CB or a TB and one MTB-cyclist. In the study, 10 cyclists used EBs, but the desired speed of this group was not identified. We can therefore conclude that cyclists using a CB are to a greater extent comfort cyclist preferring a lower speed, while those using a TB to a greater extent are "normal cyclists". The relationships between desired speed and the choice of bicycle were not statistically significant [14].

What type of bicycle you choose may be more affected by the purpose of the trip (exercise, commuting, leisure cycling, etc.) or your financial situation, rather than your desired speed. Many students have cheaper old bicycles, and, in many cases, they have been classified as CBs in this study, but students might still have relatively high desired speed. At site 12, for example, 3 out of 4 bicycles were classified as a comfort bicycle and this path was close to a university. Hence, we can assume that there are many students cycling to and from the university at this site. Instead of only classifying the type of bicycle, it would be of great interest to study and categorise different types of cyclist, for example according to clothing. Cyclists wearing exercise clothing probably have a higher desired speed than those dressed in suits

4.4. Cyclists' speeds and the relationship to road safety

Research on bicyclists' speeds and the correlation to road safety is still in the beginning [6]. More studies are needed about the relationship between the safety of cyclists, average cycling speed, and speed distribution on pedestrian and cycle paths. There are only a few studies on this topic and they are based on perceived safety [15] or appearance of critical situations [7]. These two studies do not account for actual outcome in accidents. In addition to the more detailed observation studies, we recommend that accident data from STRADA is used to in combination with speed measurements. Then it would be possible to see if locations with higher average speeds and/or wider speed distribution have higher accident risks. This, however, requires long-term and comprehensive data collection.

5. CONCLUSIONS

The aim of this study was to understand bicyclists' speeds at pedestrian and cycle paths:

- Cyclists' average speed varied between 16 to 25 km/h at the measurement sites. The variation depended on location and road user composition. Lower average speeds occurred at uphill slopes, close to crossings or where the pedestrian flow was high. Higher average speeds occurred at downhill slopes and commuter paths.
- There appears to be a connection between average speed and the width of the distribution – the higher the average speed, the greater the speed distribution.
- Between 70 and 95 percent of the road users observed on the pedestrian and cycle paths were cyclists and about 5-30 percent were pedestrians.
- As for the type of bicycle, classic bikes were the most frequent followed by trekking bikes. Electric assisted bicycles occurred at all sites but varied from 1 to 10 percent. Racer bikes also occurred at all sites, with a proportion of between 1 and 15 percent. The correlation between the type of bicycle and desired speed is not entirely clear, but cyclists on electric assisted bikes and on racer bikes generally have higher desired speeds.

This study is a first step in trying to describe the distribution of cyclists' speeds. The next step, which would require more in-depth data, is to relate the outcome of accidents to the speed distribution, and to investigate how high speeds affect the accident outcomes.

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APPENDIX

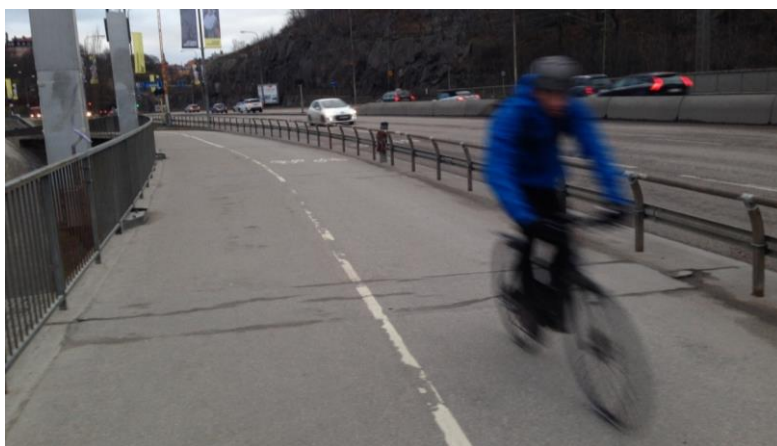


Figure 14. Site 11, direction 1. Photo by Anna Niska, VTI.



Figure 15. Site 12, direction 2. Photo by Jenny Eriksson, VTI.



Figure 16. Site 13, direction 1 (left). Site 14, direction 1 (right). Photo by Gunilla Sörensen, VTI.



Figure 17. Site 15, direction 1. Photo by Gunilla Sörensen, VTI.