



Capacity and Behaviour on One-way Cycle Tracks of Different Widths

Poul Greibe¹ and Thomas Skallebæk Buch¹

¹Trafitec, Copenhagen, Denmark.
pgr@trafitec.dk, tsb@trafitec.dk

Abstract

The main objective of this study is to examine how widths of cycle tracks influence the behaviour, flow and capacity of bicycle traffic. Empirical data has been collected by video observations at 8 different one-way cycle tracks of varying widths (1.85 m-2.85 m excl. kerb between cycle track and carriageway). The locations are characterised by high bicycle traffic volumes on the track, no traffic lights / junctions / bus stops / zebra crossing nearby, and no dividing verge between cycle track and carriageway. Speed and lateral positions has been measured for 8,925 cyclists. The average speed is 21.6 km/h but differs slightly between locations. Women ride 2-3 km/h slower than men but also with a smaller dispersion. The traffic volume does not affect average speed, but dispersion decrease with increasing bicycle traffic volumes. At narrow cycle tracks cyclists are riding closer to the footpath and closer to each other during overtaking compared to cycle tracks of a larger width. Car parking in the road side next to the cycle track reduces “the effective width” of cycle track with about 10-15 cm. High bicycle traffic volumes are only observed in short time spans and it seems like the capacity limit is not reached. Flows as high as 20 bicycles per 10 sec are observed at a 2-lane cycle track (width: 2.35 m) and still with an average speed of about 21 km/h. Controlling factors are used when calculating capacity from short time spans, and the hourly capacity of a 2-lane cycle track has been estimated to about 3,000 bicycles/h. The width does not affect the capacity much unless the number of lanes are reduced or increased. A cargo bike has an average speed of 16.3 km/h and its headway is 1.3 times as big as the headway of a traditional bicycle. Due to the speed and the size of a cargo bike it reduces capacity equally to 3-4 traditional bicycles. Based on the data recommended widths of bicycle tracks are found in order to ensure a safe and efficient traffic operation for cyclists.

Keywords: cycle track, path design, speed, capacity, bicycles

1 Introduction

Bicycle traffic has increased in the large cities in Denmark over the last 10-15 years. Moreover, politicians wish to continue the growth making bicycling account for an even larger share of the urban

area transportation. Similar objectives are found in many other countries, which also invest in a better cycling infrastructure. One of the measures taken in Denmark and elsewhere is the construction of cycle tracks in urban areas, which provide the necessary space for bicycle traffic and decrease perceived risk among cyclists.

At the same time, in Denmark the national objective is to reduce deaths and injuries in traffic, where cyclists currently account for approximately 20% of the total number of injuries reported by the police.

To achieve these objectives on increased safe cycling, a well-functioning and well-developed infrastructure for bicycle traffic is required.

In urban areas, junctions very often constitute a bottleneck in relation to cyclist passability. At the same time, the vast majority of accidents involving cyclists in urban areas occur in junctions. However, it should be noted that accidents on cycle tracks are underreported, because these accidents often are single accidents or accidents between cyclists and typically less severe than accidents between cyclists and vehicles.

Nevertheless, cycle tracks between junctions are also important in relation to cyclist safety and passability. An increase in the bicycle traffic volume will put a larger pressure on the most busy cycle tracks during rush hours, which may require an increase in the capacity of some of these cycle tracks. Meanwhile, the number of cargo bikes is growing, and these are characterised by other dimensions and driving behaviour, which may affect the capacity and safety of the cycle tracks.

Supported by the Ministry of Transport, Trafitec has conducted a study (Buch and Greibe, 2014) to examine the issue. The main results are presented in this paper.

1.1 Objective

The main objective of this study is to examine how widths of one-way cycle tracks in urban areas influence the behaviour, flow and capacity of bicycle traffic. Traffic safety has not been a part of the project but is of course a direct offshoot of the subject. Sections with one-way tracks along a road are the primary focus. Based on new empirical studies, we wish to assess the width of the cycle track in relation to cyclist behaviour (lateral position and speed) and capacity in order to provide guidance on widths of cycle tracks allowing safe and efficient bicycle traffic. To illustrate this, cyclist behaviour at different flow volumes and during overtaking has been studied. Furthermore, it has been examined how cargo bikes affect bicycle traffic.

1.2 Current knowledge

Existing studies from Denmark and other countries have been reviewed in order to examine recommended widths of one-way cycle tracks, cyclists' speed and one-way cycle track capacities (Buch and Greibe, 2014). One literature study (Allen et al., 1998) from 1998 found a capacity of 1,500-5,000 cyclists per hour and traveling speed around 12-20 km/h. Another literature study (Navin, 1994) found a capacity of 2,000-10,000 cyclists per hour for a 2.5 m wide cycle track depending on the level of service. A Chinese study based on behaviour models for passing manoeuvres estimated a capacity of 5,500 cyclists per hour for 2-3 m wide tracks (Li et al., 2013).

A recent Danish study based in micro simulation (Rambøll, 2012) suggests a capacity of 5,900 cyclists per hour for a 2.2 m wide track. The study uses a width of 0.8 m per cyclist. The capacity at a higher level of service is estimated to 3,200 cyclists per hour. The Danish Capacity Manual (Danish Road Standard Committee, 2010) indicates a capacity of 2,000 cyclists per hour for a 2 lane cycle track. However, the recommendation is based on data from the 1940s.

The width of regular cyclists is around 0.70-0.75 m (CROW, 2007), and 0.8-0.9 m for cargo bikes (Buch and Greibe, 2014). The Dutch Road Standards suggest 1.0 m per cyclists/lane and in Denmark the recommended widths of one way cycle tracks is 2.2 m (Danish Road Standard Committee, 2000) leaving space for safe overtaking.

Very different results are found regarding capacity, which is linked to the fact that different methods have been applied and that clear methodological challenges occur (Buch and Greibe, 2014). When determining the capacity of bicycle tracks and cyclist behaviour at high traffic volumes, the fact that large traffic flows can only be observed in very short time spans pose a challenge.

Another challenge is the definition of the physical dimensions of a cyclist and how much space a cyclist needs. Very often, a service level will be defined, which – dependent on the chosen definition – may have a large impact on the calculated capacity. Further to this, the type and condition of the bicycle also affect the average speed and needed space, and the differences between countries can be significant depending on the bicycle culture.

Below the results from existing studies are indicated as most frequently detected span, while numbers in brackets indicate the full span as found in various studies and different country standards, (Buch and Greibe, 2014).

- Recommended width for a 2-lane cycle track: 2.0-2.2 m (1.7-2.5 m)
- Width of an extra lane: 1.0 m (0.8-1.2 m)
- Average speed of cyclists: 17-20 km/h (10-25 km/h)
- Capacity 2-lane cycle track: 4,000-7,000 bicycles/h (2,000-10,000 bicycles/h)

2 Data Collection and Methods

The present study is based on empirical data collected through video recordings at 8 different locations in Denmark.

Two synchronised cameras covering the observational area on the cycle track are used for the video recordings. Two measuring points (MS1 and MS2) by about 25 m distance are defined, see Figure 1. The time of each cyclist's crossing MS1 and MS2 is registered, and based on this, the speed is calculated. In MS2, the cyclist's lateral position is measured. In addition, it is being recorded whether individual cyclists are overlapping each other when crossing MS2, and in the affirmative, these are numbered according to their position.



Figure 1: Example of video observation. At MS2, the cyclist in position 2 has an overlap with two cyclists

For each cyclist, the following information is recorded:

- Speed
- Lateral position
- Type of bicycle (regular bicycle, cargo bike, moped)
- Gender (male/female)
- Age (child/adult/elderly)
- Position in case of overlap

Regular bicycle means all common two-wheeled bicycles such as city bikes, racing bikes, mountain bikes and the like, see examples at the top of Figure 2. Cargo bikes means three-wheeled bicycles or bicycles with bicycle trailers – see examples at the bottom of Figure 2.



Figure 2: Definition of regular bicycles and cargo bicycles

The cycle tracks included in the study are tracks only with curbs (and level difference) against sidewalk and carriageway, see Figure 3. The width of the cycle track varies between 1.85 m and 2.85 m. To obtain a set of data based on high traffic volume periods, recordings were made during rush hours on selected Copenhagen cycle tracks, at which bicycle traffic volume is generally high. Recordings were primarily conducted on days of only little wind and no rain to prevent the weather from affecting cyclists' lateral position and speed. Locations included cycle tracks both with and without parked vehicles in the roadside. Thus, the effect of parallel car parking in the roadside in relation to such cyclists' lateral position can be studied.

Table 1 shows an overview of the studied cycle tracks indicating width of the track as well as use of space to the left of the cycle track (parking or carriageway).

Location (name of street)	Width of track (excl. 0.15 m curb against carriageway)	Adjacent road space
Tagensvej	2.85 m	Carriageway
Amager Boulevard	2.50 m	Bus lane
Gammel Kongevej	2.50 m	Parked vehicles
Rosenørns Allé	2.35 m	Carriageway
Bredgade	1.85 m	Carriageway
H.C. Ørsteds Vej	1.85 m	Parked vehicles
Jagtvej	1.85 m	Carriageway
Tietgensgade	1.85 m	Parked vehicles

Table 1: Studied cycle tracks with indication of width and whether roadside car parking is present or not

Figure 3 shows an example of two of the cycle tracks included in the study. Here is an example of a narrow track (1.85 m) with car parking in the roadside, and a wide track (2.85 m) with no parking.



Narrow cycle track (1.85m) with parking

Wide cycle track (2.85m) without parking

Figure 3: Example of two of the cycle tracks included in the study

In total, observations of 8,925 cycle track users with a distribution between 900 and 1,300 per location have been conducted.

3 Results

The following section presents the main findings of the study. Results related to lateral positions and speeds are subsequently used to provide indicative cycle track widths allowing a safe and well-functioning traffic.

The majority of cycle track users ride on regular bicycles. In the study, cyclists on regular bicycles account for 97.8% of the 8,925 track users. Cargo bikes account for 1.5% and mopeds for 0.3%. There are only small variations between the studied locations.

Cycle track users are evenly distributed by gender, but at most locations, there is a slight predominance of women (52% on average). The vast majority of the track users are adults, which is to be expected in relation to the group's share of the population as a whole as well as the selected locations and time of data collection. In rush hours commuting traffic between home and work/education are the dominating trip purpose on the busiest cycle tracks in Copenhagen. Children (<16 years old) account for only 0.8% of the track users in the study, but none of the locations are close to schools. Elderly cyclists (>65 years old) account for 1.0%.

3.1 Lateral Position

The following presents the main findings in relation to the lateral position of the cyclists. These results provide an insight into how cyclists use the tracks, and may be utilised to define the required track width.

By comparing tracks of the same width, but with/without parked cars in the road side, the study shows that on cycle tracks with car parking in the roadside, overtaking cyclists place themselves further to the right (towards the sidewalk) than on cycle tracks with no car parking in the roadside. Only overtaking between cyclists on regular bicycles are taken into account. Lateral positions of

cyclists in position 2 during overlap are compared at the four locations with narrow cycle tracks (1.85 m). Based on this comparison car parking in the roadside reduces the effective track width by between 10 and 15 cm (12 cm on average). Figure 4 illustrates this.

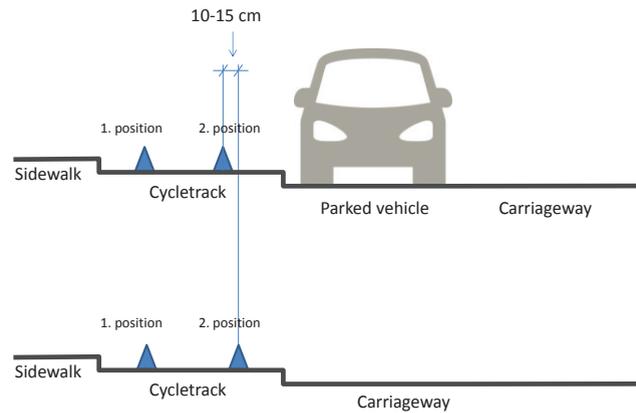


Figure 4: Car parking in the roadside reduces the effective cycle track width

Hence, the subsequent conclusions are using the effective track width, where tracks with car parking are reduced by 0.12 m. It is not possible to conclude whether cyclists in position 1 are affected by car parking or not.

Figure 5 shows another example of cyclist lateral position, in this case on a narrow and a wide cycle track at different traffic volumes.

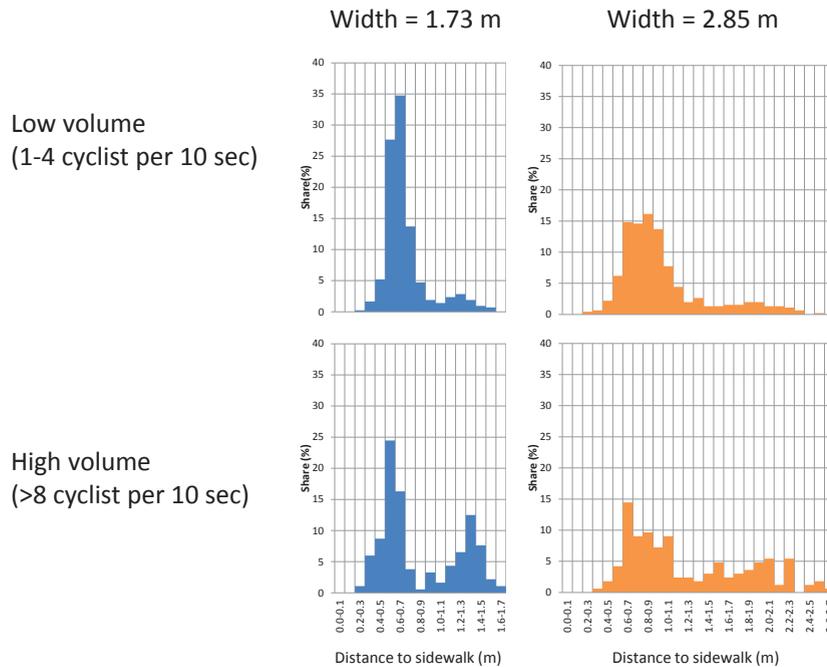


Figure 5: Example of lateral position of regular bicycles at low and high traffic volume at two locations with different cycle track widths (Location: Tietgensgade and Tagensvej)

At low traffic volume, cyclists place themselves to the right on the tracks, where about 90% ride in a well-defined area (lane 1). The lane is best defined on narrow tracks. At high traffic volumes, the track width is exploited substantially more. On the narrow tracks, two lanes are well defined, while the lanes on the wide tracks are not as clearly defined. In this study, about half the cyclists place themselves in lane 1 at high traffic volumes.

Figure 6 shows the distance to the sidewalk of regular bicycles, when riding unhindered (free flow) or when riding in position 1 or 2 respectively with overlap. Solid lines indicate linear best fit of average values. The average values are calculated for each location respectively. Dotted lines indicate the dispersion (std.dev).

In both situations, it is clear that cyclists keep a larger distance to the curb, riding in less well-defined lanes (larger dispersion) on the wide cycle tracks compared to the narrow ones. When overlapping, the study also suggests that cyclists in position 1 and 2 increase the lateral distance to each other when the width of the cycle track is increased. On the most narrow cycle tracks, there is very little free space for the cyclists. The lateral position of the unhindered cyclists is between position 1 and position 2, but closer to position 1.

In a few cases, cyclists are observed in position 3, however only on wide cycle tracks (>2.30 m). At none of the cycle tracks, cyclists have ever placed themselves side by side in three well-defined lanes.

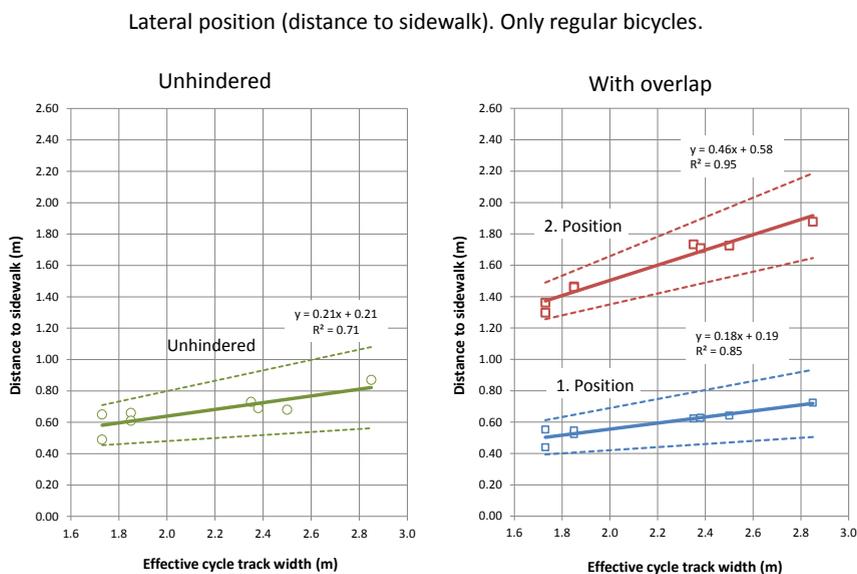


Figure 6: Lateral position (distance to sidewalk) relative to effective cycle track width (only regular bicycles). Cyclists riding unhindered are shown to the left. In case of overlap, placing of position 1 and 2 can be seen to the right

The speed difference between cyclists in position 1 and position 2 also seems to have an impact on the lateral distance. This can be seen from Figure 7 for pairs of regular bicycles in position 1 and 2 respectively during overlap. Solid lines indicate linear best fit of average values. The average values are calculated for each location respectively.

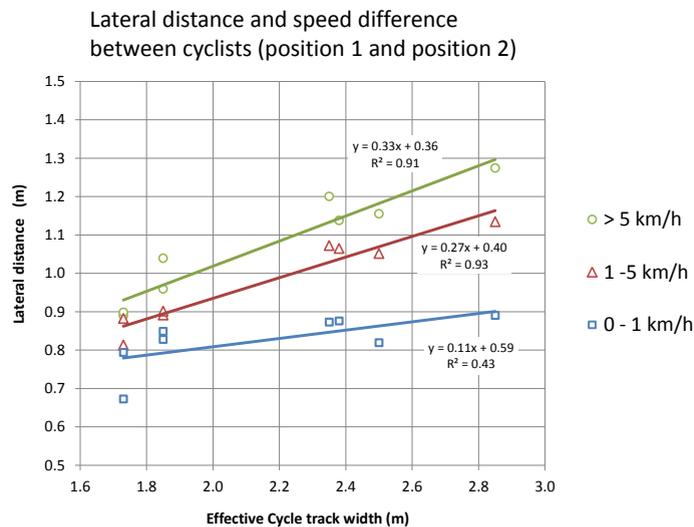


Figure 7: Distance between cyclists in position 1 and position 2 in relation to effective track width and speed difference between the two cyclists (only regular bicycles)

Cyclists riding together (at almost the same speed), in general ride closer together than two cyclists during overtaking, and the lateral distance varies less dependent on the width of the track. At overtaking (speed difference >1 km/h), the lateral distance increases more as the widths of the tracks increase. At a width of 2.8 m, the distance between cyclists in position 1 and 2 is approximately 1.2 m, while only about 0.9 m on narrow tracks.

In a few cases, cyclists were observed using the carriageway instead of the cycle track when overtaking. These scenarios are not systematically recorded, but were most frequently observed on the narrow tracks or under high traffic volumes. Please refer to Figure 8, where a cargo bike takes up so much space on the cycle track, that the overtaking cyclist chooses to continue on the space between the parked vehicles. Cyclists overtaking by driving into the carriageway may pose a risk of accidents.



Figure 8: Example of cyclist using the space outside the cycle track when overtaking

The study of the lateral positioning shows that the distance from cyclist to sidewalk or to other cyclists, increases as the width of the track increases. Therefore, increased track width is expected to provide an added level of comfort for cyclists, but also a safer traffic flow due to the reduced risk of hitting the curb or other cyclists. The study also documents a few number of incidents where cyclists are overtaking by riding on the carriageway in situations of very narrow cycle tracks or high traffic volumes, hence posing a safety risk.

3.2 Speed

Figure 9 provides a breakdown of the measured speeds distributed by type of bicycle, gender and age.

Cyclists on regular bicycles ride with an average speed of 21.7 km/h (std. dev. 3.9 km/h and an 85% percentile of 25.9 km/h). The measured average speed covers a span of between 20.2 km/h and 23.7 km/h for the various cycle tracks.

Cyclists on cargo bikes have an average speed of 16.3 km/h. On an average, men ride slightly faster than women do, and children/elderlies ride slightly slower than adults do. The average speed among women is 20.4 km/h, and among men 22.9 km/h. The dispersion is larger for men, suggesting that men make up the majority among the fastest cyclists, while women tend to maintain a uniform speed.

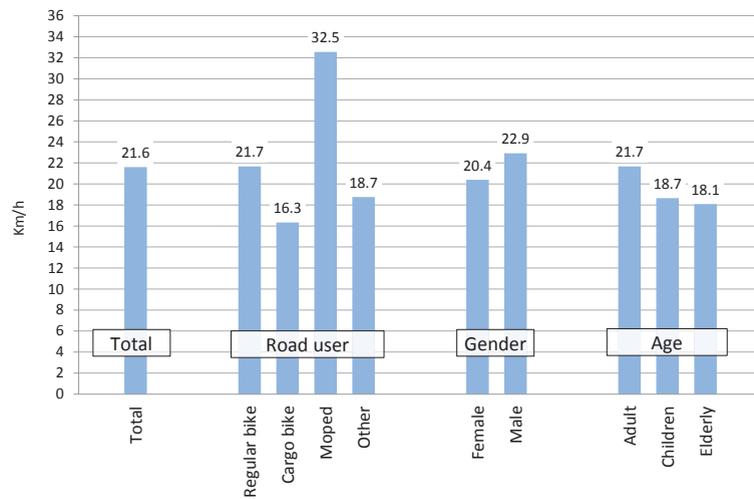


Figure 9: Average speeds distributed by type of bicycle, gender and age (all locations)

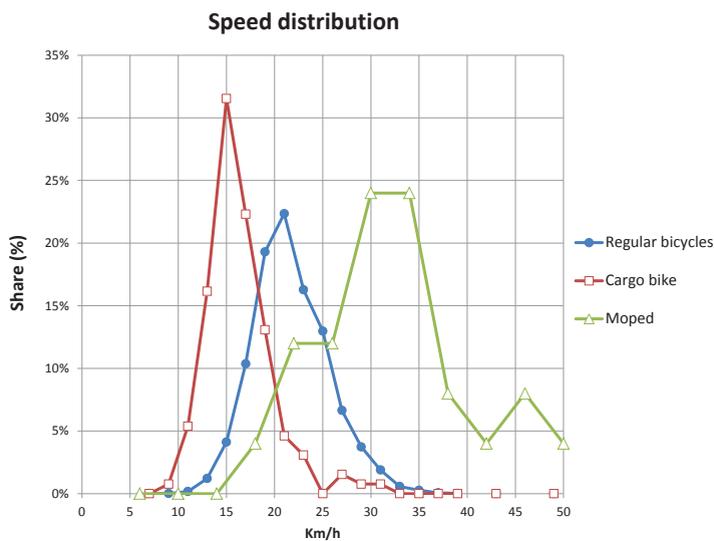


Figure 10: Speed distribution of regular bicycles, cargo bikes and mopeds

Figure 10 shows the dispersion of speed of regular bicycles, cargo bikes and mopeds. Obviously, mopeds ride somewhat faster and have a larger dispersion. Cycle tracks servicing road users with such different speed patterns, may pose a problem for safety and traffic operation, - especially if the space does not allow unrestricted passages. It should be recalled though, that mopeds and cargo bikes only represent a small share of the total traffic on the studied cycle tracks.

Another phenomenon is cyclists phoning or texting while riding. These are not recorded systematically in the study, but in connection with the data processing, a note was made on 1-2% of the cyclists stating that these were using a hand-held mobile phone while riding. Cyclists phoning or texting have an average speed of about 18 km/h compared with about 22 km/h for other cyclists. A larger proportion of these ride without overlap, suggesting that they often ride more isolated than other cyclists, perhaps exactly due to the speed. Inattention and distraction among road users is a well-known problem in relation to traffic safety, specifically related to the use of smartphones and the like. This study suggests that cyclists using mobile phones to talk or text, compensate for the increased workload by reducing speed. Despite the reduced speed, however, these still pose a risk, because they ride with one hand only and gazing away from the remainder traffic.

Figure 11 shows regular cyclists' speed in positions 1 and 2 as a function of the effective track width. Solid lines indicate linear best fit of average values. The average values are calculated for each location respectively. The speed is slightly increased as the width of the track increases, but the relation does not appear to be strong. For cyclists in position 3, only very limited data exists (and only for track widths of >2.3 m). Typically, the speed in this position is at the same level as that of the position 2 cyclists or slightly higher.

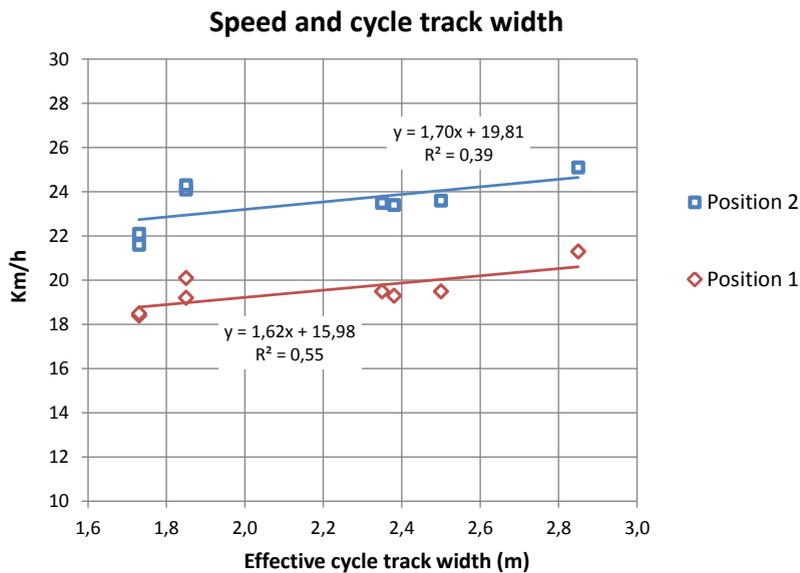


Figure 11: Speed of cyclists on regular bicycles in position 1 and 2 during overlap as a function of the effective track width

In addition to the fact, that speed increases as the width of a track increases, the dispersion of speed also tends to increase. Figure 12 shows an example of the speed distribution of regular cyclists on 3 cycle tracks with different widths, measured at the same traffic volume. Clearly, both speed and dispersion increase as the width of track increases.

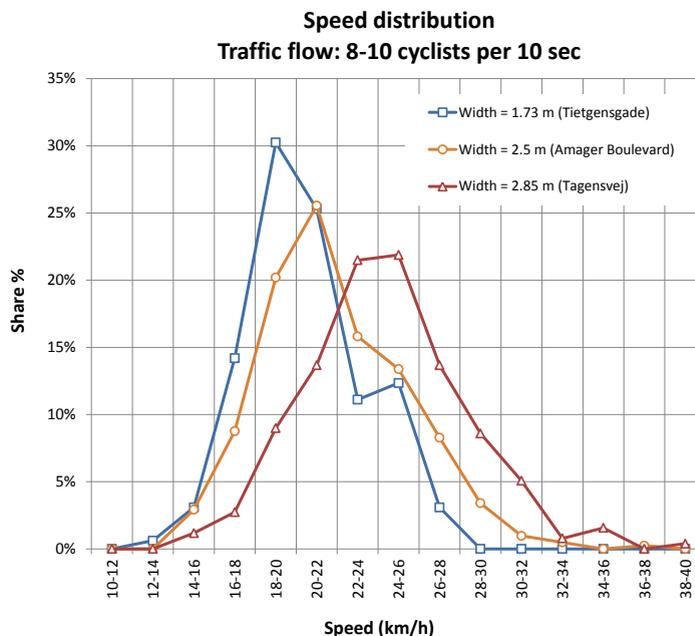


Figure 12: Example of speed distribution on three cycle tracks with different widths. Measured during the same traffic volume

Data from the study also shows that the average speed is almost the same irrespective of whether the traffic intensity on the cycle track is low or high. There is a tendency to a slight decrease in speed when traffic intensity increases, - though only a small change. By contrast, dispersion is reduced when traffic increases. At high traffic volume, the dispersion is relatively small meaning that most cyclists ride with the same speed.

Overall, the study shows that users of the cycle track maintain a speed of approximately 22 km/h but this varies depending on type of track user. Especially mopeds stand out by running significantly faster than other track users, but in turn, these only make up a small share of the total traffic. Cargo bikes are distinguished by a lower speed. A very wide dispersion in speed amongst the track users can increase the risk of accidents due to more overtaking, hence increasing the risk of sudden and unexpected events. Danish authorities have previously discussed, whether mopeds in fact should be running on the carriageway instead (among motor vehicles upholding the same speed), but so far regulations have not been changed.

Data also suggests that speed and speed dispersion increase the wider the cycle track, and that the speed (in situations with overlap) is approximately 4 km/h higher for cyclists in position 2 than for cyclist in position 1.

3.3 Capacity of 2-lane Cycle Tracks

In order to estimate the capacity of cycle tracks, the maximum observed traffic volume during short time spans have been measured and then converted to hourly traffic volumes. Three of the observed locations were excluded since the observed traffic volume seemed to be far from the capacity limit.

The calculation uses a correction factor taking into account, that during short time spans, traffic volume may be significantly higher than the volume measured over the longer time. Normally, the capacity of a road section is based on 15 minute intervals with high traffic intensity. In this study, the

maximum flow on the cycle tracks is measured during 10 and 20 second intervals. Due to lack of suitable cyclist volume data, the correction factors is based on motor vehicle traffic for a 4-lane freeway (one direction) by comparing maximum observed traffic volumes in 15 minute intervals and maximum volumes in 10 and 20 sec intervals. Compared to other road types traffic operation on freeways is expected to be most equivalent to a 2 lane cycle track. The estimated correction factors was found to be 0.63 (varies from 0.61-0.65) for 10 sec intervals and 0.69 (varies from 0.64-0.74) for 20 sec intervals. Thereby a flow of 25 cyclists per 20 sec will correspond to $25 \cdot 3 \cdot 60 \cdot 0.69 = 3,105$ cyclists per hour.

Using this method, the estimated capacity for a 2 m wide cycle track is found to be about 3,000 cyclists per hour. The identified capacity is somewhat uncertain due to variation in observed maximum cycle traffic volumes and due to the correction factors. Figure 13 shows the estimated relation between capacity and track width. Increase of track width provides a slightly higher capacity but the relation is weak. The solid line indicates best fit and the red area indicates the uncertainty. The cycle tracks included in the capacity study are between 1.73 and 2.50 m wide (efficient track width). Possibly, there is a jump in capacity at a width larger than 2.5 m, when a cycle track is wide enough to perform as a 3-lane track, but it cannot be verified by this study.

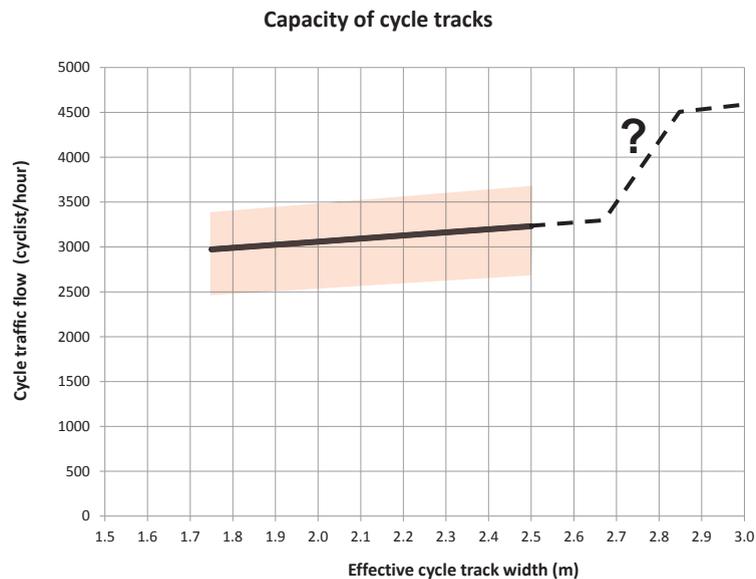


Figure 13: Capacity as a function of effective cycle track width based on the largest traffic volumes observed

3.4 The Effect of Cargo Bikes

Cargo bikes represent a limited share of the total traffic volume on tracks during rush hours. Hence, data is limited, which is why the following statements about the effect of cargo bikes are somewhat uncertain:

- Cyclists on cargo bikes ride slower (16.3 km/h compared to 21.7 km/h for regular bicycles).
- Cargo bikes utilise 10-20 cm more space on the track compared to regular bicycles (width of bicycle and distance to sidewalk). The lateral position of a regular bicycle overtaking a cargo bike, is 10-20 cm further to the left compared to a regular bicycle overtaking another regular bicycle.

- Looking at the flow in lane 1, a cargo bike takes up about 1.3 times a regular bicycle lengthwise (measured as headway).
- Together, this means that one cargo bike reduces capacity by about 3-4 regular bicycles, especially because the cargo bikes reduce the flow in lane 2 of the tracks – in particular on narrow tracks. As such, the average speed of the remainder cycle track users decreases as well.
- Measurements of flow (10 sec. data) confirm lower speeds and less flow when cargo bikes are appearing.

3.5 Recommended Widths of One-way Cycle Tracks

Based on the results of this study, some recommended minimum widths of one-way 2-lane cycle tracks in urban areas are provided. The recommendations are based on the lateral position of the cyclists on the track during overtaking. Thus, distance to curb as well as lateral distance between the cyclists have been taken into account. Consequently, the recommended widths ensure that bicycle traffic can be run in a safe and appropriate manner. Table 2 provides an overview of the recommended widths, distinguishing between cycle tracks with/without car parking in the roadside.

Type of one-way bicycle tracks	Without car parking in the roadside	With car parking in the roadside
Min. width of 2-lane cycle track for regular bicycles	1.80 m	1.90 m
Min. width of 2-lane cycle track with room for cargo bikes	1.95 m	2.05 m
Preferred min. width of 2-lane cycle track (improved service level)	2.25 m	2.35 m
Min. width of 3-lane cycle track	3.05 m	3.15 m

Table 2: Recommended widths of one-way cycle tracks with and without car parking in the roadside (incl. 0.15 m curb)

Table 2 suggests a minimum width depending on whether there are only a few or many cargo bikes. Cyclists on cargo bikes are frequent users of cycle tracks in urban areas with a heavy cycling traffic volume, and hence such tracks should not be designed for regular bicycles only.

In addition, the preferred minimum width of 2-lane cycle tracks is suggested, leaving the cyclists more space to manoeuvre, hence experiencing a higher level of service, but only a slightly higher capacity. Consequently, the preferred width of a cycle track is 2.25 m without car parking in the roadside and 2.35 m on locations with car parking in the roadside. On such locations, the level of service will seem higher because conditions are more safe and the need to ride up close to the curb when overtaking is not necessary.

Finally, a minimum width of a 3-lane cycle track has been identified. On a slightly narrower cycle track, three bicycles will be able to ride side by side. However, the track cannot be expected to serve as a real 3-lane cycle track. The width is based on lateral positions on 2-lane cycle tracks. Furthermore, it is assumed that cyclists wish to have the same amount of space around them provided by the 2-lane cycle track with preferred minimum width before allowing occurrence of a new lane. Further studies are needed for verification.

4 Conclusion

The main findings and conclusions can be summarised as follows:

- Parked vehicles in the road side (along the cycle track) reduce effective width of a cycle track by 0.10-0.15 m.

- Lateral distance between cyclists in position 1 and 2 increases when width of the cycle track is increased. The lateral distance between position 1 and 2 ranges from 0.9 m (at narrow 2-lane tracks) to 1.2 m (at wide 2-lane tracks). Also the distance to sidewalk increases when track width is increased.
- Lateral distance between cyclists in position 1 and 2 increases when speed differences between position 1 and 2 increases.
- Traffic volume and track width influences lane usage.
- Average speed among regular bicycles are found to be 21.7 km/h, cargo bikes 16.3 km/h and mopeds 32.5 km/h.
- Cyclist speed increases as width of cycle track increases.
- Bicycle traffic volume does not affect speed within the observed volumes (no flow break down observed). However, speed dispersion is reduced considerably at high volumes.
- The maximum observed flow volumes are found to be around 20-25 cyclists per 20 sec – equals approx. 3,000 cyclist/h when converted to hourly volumes at 2-lane cycle tracks.
- Increased track width produce slightly higher capacity (within the observed range of width 1.8 -2.5 m)
- Cargo bikes take up more space compared to regular bicycles. The lateral position of a regular bicycle overtaking a cargo bike is 10-20 cm further to the left compared to a regular bicycle overtaking another regular bicycle.
- A cargo bike roughly equals 3-4 regular bicycles in terms of capacity and accessibility
- Based on the results from this study, the recommended minimum width for 2-lane cycle track (without parked vehicles in road side) is 2.25 m in order to provide safe conditions and high level of service for the cyclists.

Further research regarding wide cycle tracks (>2.85 m) is needed in order to investigate the recommended width of a 3-lane cycle track. Until then, the recommended width of a 3-lane track has been set to 3.05 m (without parked vehicles in road side). Better estimates on the capacity should also be considered. Especially methods to convert short time span volumes to hourly volumes need more attention. Another issue that need to be discussed is whether hourly cyclist volumes satisfy traffic engineers need when planning for bicycle infrastructure. A more useful way to measure cyclist volumes might be e.g. cyclist per 20 sec since bicycle traffic volumes in this way better can be related to traffic signal phasing etc. When measuring bicycle traffic volumes in order to determining capacity limits it should be considered to look at locations with a “true bottleneck” (e.g. at narrowing) in order to observe potential traffic break downs.

References

- Allen, P., Roupail, N., Hummer, J. E., and Milazzo, J. S. (1998). Operational Analysis of Uninterrupted Bicycle Facilities. *Transportation Research Record* 1636 pp. 29-36, USA: TRB
- Buch, T. S., and Greibe, P. (2014). *Bredde af cykelstier: Analyse af adfærd og kapacitet. Baggrundsrapport*. Denmark: Trafitec
- CROW (2007). *Design manual for bicycle traffic*. Record 25. The Netherlands: CROW
- Danish Road Standard Committee (2000). *Byernes trafikarealer – Hæfte 3 – Tværprofiler*. Denmark: Danish Guidelines for planning and design, Danish Road Directorate
- Danish Road Standard Committee (2010). *Capacity and Service Level*. Denmark: Danish Road Standard Committee
- Li, Z., Wang, W., Liu, P., Bigham, J., and Ragland, D. R. (2013). Modeling Bicycle Passing Maneuvers on Multilane Separated Bicycle Paths. *Journal of Transportation Engineering* 139(1), pp. 57-64. USA: American Society of Civil Engineers

- Navin, F. P. D. (1994). Bicycle Traffic Flow Characteristics: Experimental Results and Comparisons. *ITE Journal* 64, pp. 31-36. USA: Institute of Transportation Engineers
- Rambøll (2012). *Vurdering af kapacitet af cykelstier*. Denmark: Rambøll