# Quality parameters for cycle infrastructure: interruptions and delays

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# 1. Introduction

Stops and interruptions are critical quality aspects of a cycle route. On a typical bicycle, cycling stably without excessive effort requires maintaining a speed of 15 km/h or higher. The need to slow down below this speed or stop completely and put the feet on the ground is an inconvenience and reduces the efficiency and competitiveness of a cycle trip. It takes time and wastes energy. Up to 85% of the time lost by a cyclist in a built-up area is caused by traffic lights.[1] A single stop takes up as much energy as cycling an additional 75-100 m.[2] Frequent stops and/or long waits reduce the credibility and usability of dedicated cycling infrastructure.[3]

Interruptions are also a safety hazard. A cyclist losing balance while slowing down or completely stopping to give right of way to another road user is one of the typical scenarios of single-vehicle crashes for older cyclists.[4] Another study estimated that 16% of single-bicycle accidents happen while mounting or dismounting the bike. The chances of losing control at low speeds are strongly elevated among older cyclists. Women, cyclists with physical problems and inexperienced cyclists (cycling less than one day per week) have an increased likelihood of these crashes too.[5]

This factsheet gives an overview of how different national or regional guidelines quantify this aspect of the quality of cycle routes and compares the specific thresholds used for the two most common parameters: number of interruptions per kilometre and time loss per kilometre. The final section summarises the quality requirements and provides a few recommendations on how to achieve them in urban settings.

Only several standards and guidelines have been included in this comparison, much less than in the factsheets on for example geometric design parameters. Many other documents note the need to minimise stopping and delays but do not provide any specific thresholds or even metrics that would allow us to compare different variants of a route or a solution.

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[1] Design manual for bicycle traffic. CROW 2017. https://www.crow.nl/publicaties/design-manual-for-bicycle-traffic
[2] Ibidem.
[3] See for example "Cycling and Kinetic Energy – why riders are reluctant to stop", https://www.cyclingnorthwales.uk/campaigning/cycling-kinetic-energy-riders-reluctant-stop/
[4] Boele-Vos, M J et al. “Crashes involving cyclists aged 50 and over in the Netherlands: An in-depth study.” *Accident analysis and prevention* vol. 105 (2017): 4-10. https://doi.org/10.1016/j.aap.2016.07.016
[5] Schepers, Paul & Klein Wolt, Karin. Single-Bicycle Crash Types and Characteristics. Cycling Research International. Vol. 2. (2012). 119 – 135. https://www.researchgate.net/publication/230867692_Single-Bicycle_Crash_Types_and_Characteristics

Figure 1. Priority uncontrolled cycle crossing on the cycle highway Nijmegen - Cuijk, Netherlands.

# 2. Analysed standards and guidelines

## 2.1. Germany

Documents:

- **Empfehlungen für Radverkehrsanlagen** (Recommendations for cycling facilities), 2010[6]
- **Radnetz Hessen. Qualitätsstandards und Musterlösungen** (Cycle network Hesse. Quality standards and sample solutions), 2020[7]

German federal recommendations for cycling facilities discuss the maximum delay times because of stopping and waiting in section 1.2.4. Table 2 on page 10 presents the maximum value of the parameter for six different route categories, between 15 and 60 s/km, and one additional category with no requirements at all (IR V). For the comparison, we selected AR II (15 s/km) as cycle highways, IR II (30 s/km) as main cycle routes, and IR IV (60 s/km) as other cycle routes.

In addition to maximum time loss per kilometre, the recommendations include target average travel speed for each route category. It is a parameter that takes into account the design speed[8] but is also affected both by the number and length of stops. Therefore, it can also be considered a way to quantify the interruptions. In practice, however, such a compound parameter might be more difficult to measure and analyse.

Regional quality standards for the state of Hesse are provided in section 3.1.3. “Rechnerische Verlustzeiten für typische Knotenpunktformen und Streckenabschnitte”, a simplified way to calculate expected time loss depending on the category of the road, traffic volumes and crossing solution. The values vary from 0 seconds (crossings with right of way for cyclists, grade-separated crossings) to 40 seconds (traffic lights with detectors, no green wave for cyclists).

For cycle highways, the summarised time losses should not exceed 30 seconds per kilometre in urban areas and 15 seconds per kilometre outside urban areas (section 3.1.1).

## 2.2. Netherlands

Documents:

- **Design Manual for Bicycle Traffic**, 2016[9]
- **Sign up for the bike – design manual for a cycle-friendly infrastructure,** 1993[10]

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[6] https://www.fgsv-verlag.de/era

[7] https://www.nahmobil-hessen.de/wp-content/uploads/2021/01/Qualitaetsstandards_und_Musterloesungen_2te_Auflage_web.pdf

[8] Compare: Geometric design parameters for cycling infrastructure, https://ecf.com/files/reports/geometric-design-parameters-cycling-infrastructure

[9] https://www.crow.nl/publicaties/design-manual-for-bicycle-traffic

[10] Earlier version of the Design Manual on Bicycle Traffic.

In the most recent version of the CROW manual, section 4.3.2 describes the concept of "directness in terms of time", explaining the need to reduce the number of interruptions and waiting times. Table 4.1 presents ambitions and requirements, but only for cycle highways. In terms of waiting time, specific criteria and design requirements for traffic lights on all categories of routes are explained in section 6.3.3.2. The parameters extracted from different chapters are summarised in Table 1.

**Table 1. Relevant quality parameters in the CROW Design Manual for Bicycle Traffic, 2016 edition.**

| Parameter | Unit | Level | Value |
|---|---|---|---|
| Number of stops on a cycle highway | stops/km | ambition | 0.0 |
| | | maximum | 0.4 |
| Average waiting time at traffic lights | seconds | good | 15 |
| | | moderate | 20 |
| Maximum waiting time at traffic lights | seconds | outside built-up areas | 90 |
| | | inside built-up areas | 100 |

The first (1993) edition of the design manual provided two quantifiable parameters and threshold values in a uniform manner for different categories of cycle routes. Table 2.3 in section 2.3 presents the maximum average waiting times, expressed in seconds per kilometre. Table 2.6 in the same section presents maximum values for the probability of stopping, quantified as an average number of stops per kilometre. Table 2 summarises the maximum values of the parameters.

**Table 2. Relevant quality parameters in the CROW manual, 1993 edition.**

| Parameter | Unit | Main cycle routes | Secondary cycle routes | Other cycle routes |
|---|---|---|---|---|
| Average waiting time | s/km | 15 | 20 | 20 |
| The average number of stops | stops/km | 0.5 | 1.0 | 1.5 |

## 2.3. Poland

Documents:

- **WR-D-42 Wytyczne projektowania infrastruktury dla rowerów (Design guideline for cycle infrastructure),** 2022[11]
- **Standardy techniczne i wykonawcze dla infrastruktury rowerowej Miasta Poznania (Technical and executive standards for cycle infrastructure of the City of Poznań)**, 2019[12]

The national guidelines mention several times the necessity to minimise the number of stops and length of delays on cycle routes (part 1: pages 17, 19, 23, 39; part 2: page 19). They do not, however, quantify this requirement.

[11] https://www.gov.pl/web/infrastruktura/wr-d
[12] https://www.poznan.pl/mim/rowery/-,p,35473,35475,37915.html

Concrete requirements can be found in standards adopted on the regional or municipal level. For example, cycling infrastructure standards for Poznań use the concept of a delay factor: time lost on stopping (at traffic lights, yielding) per kilometre of the route. Section 3 includes the maximum values of the factor for main and other cycle routes:

- 20 s/km for main cycle routes,
- 40 s/km for other cycle routes.

The cycle highway category is not used in the standard.

## 2.4. Spain (Catalonia)

Document: **Manual for the design of cycle paths in Catalonia**, 2008[13]

Section 2.9 of the manual introduces a requirement of having as few stop points as possible. The maximum number of stops is not depending on the category of the route, but on the type of area the route crosses:

- 1 stop/km in built-up areas,
- 0.5 stops/km outside built-up areas.

## 2.5. UK

Document: **Cycle infrastructure design (LTN 1/20)**, 2020[14]

The Local Transport Note 1/20 on Cycle infrastructure design, issued by the UK Department of Transport and applicable in England and Northern Ireland, does not include a hierarchy of cycle routes but defines parameters for two different levels of service (LOS): amber (LOS1) and green (LOS2). Routes not meeting the amber criteria fall into the red category (LOS0). For further comparisons, LOS2 was assumed to be equivalent to main cycle routes, and LOS1 to basic cycle routes.

Parameters for different levels of service are defined in Appendix A: Cycling Level of Service Tool, with requirements for "Stopping and give way frequency" and "Delay at junctions" listed under the key requirement "Directness". Table 3 presents the extracted values.

**Table 3. Relevant quality parameters in LTN 1/20.**

| | Unit | Level of service 1 (Amber) | Level of service 2 (Green) |
|---|---|---|---|
| Stopping and giving way frequency | stops/km | 4.0 | 2.0 |
| Delay at junctions | about motor vehicles | similar to delays for motor vehicles | shorter than for motor vehicles or no stop at all |

[13] https://llibreria.gencat.cat/product_info.php?products_id=2283
[14] https://www.gov.uk/government/publications/cycle-infrastructure-design-ltn-120

# 3. Comparison of key quality parameters

## 3.1. Number of interruptions per kilometre

Interruptions counted in this parameter should include:

a. The need to yield to other traffic.
b. The need to stop on traffic lights; if a crossing is divided into several sections with separate traffic lights and the traffic lights are not synchronised for cycle traffic, each of them should be counted as a separate interruption.
c. Other situations that might require a full stop, for example, because of a railway level crossing, a moveable bridge, or the need to use a lift to continue the journey along the route.

Table 4 compares the maximum number of interruptions in different guidelines. The UK Local Transport Note 1/20 provides thresholds notably higher than the other guidelines. One possible explanation is that in the UK cycle routes are often planned along main roads, which makes it difficult to avoid signalised crossings (see recommendations below).

**Table 4. Maximum number of interruptions per kilometre in the analysed guidelines.**

| | Basic cycle routes | Main cycle routes | Cycle highways |
|---|---|---|---|
| Germany | - | | |
| Netherlands | 1.5[15] | 0.5[16] | 0.4<br>(0.0 aspiration) |
| Poland | - | | |
| Spain | 1.0 inside built-up areas, 0.5 outside built-up areas | | |
| UK | 4.0[17] | 2.0[18] | - |
| **Recommendation** | **1.5** | **1** | **0.4** |

## 3.2. Delay per kilometre

The delay should take into account both the probability of stopping and the average waiting time in case of a stop. For example, if cyclists have 12 seconds of green light and 48 seconds of red light in a 60-second traffic light cycle, the probability of stopping is 80% and the average waiting time is 24 s (half of the maximum of 48 s). This translates to an expected delay on the crossing of:
24 s * 80% = 19.2 s.

Table 5 compares the maximum delay per kilometre in different guidelines. Dutch guidelines present consistently the most ambitious requirements. The recommendation includes

[15] 1993 edition.
[16] Ibidem.
[17] Level of service 1 (amber).
[18] Level of service 2 (green).

adopting the German and Dutch values for cycle highways, and somewhat less strict standards from Poznań for lower categories of cycle routes.

**Table 5. Maximum delay in seconds per kilometre in the analysed guidelines.**

| | Basic cycle routes | Main cycle routes | Cycle highways |
|---|---|---|---|
| **Germany** | 60 | 30 | 15<br>Hesse: 30 in urban areas |
| **Netherlands** | 20 | 15 | 15 |
| **Poland** | 40 | 20 | - |
| **Spain** | - | | |
| **UK** | similar to delays for motor vehicles | shorter than for motor vehicles or no stop at all | - |
| **Recommendation** | **40** | **20** | **15** |

## 3.3. Delay per intersection

Dutch manual provides also quality parameters applicable per single signal-controlled intersection: average and maximum waiting time. As this was the only such case in the analysed guidelines, these parameters were not included in the recommendations.

**Figure 2. Following railway lines reduces the number of crossings and makes it easier to provide grade separation on them. Cycle highway F3 Brussels – Leuven, Belgium.**

# 4. Recommendations

Main cycle routes and cycle highways should be planned in a way that minimises the number of intersections which require stopping or giving right of way. If a stop is necessary, then the maximum and average waiting time should be minimised. Table 6 summarises recommended thresholds for different categories of cycle routes.

**Table 6. Recommended quality parameters for different categories of cycle routes.**

| | | Maximum value | | |
|---|---|---|---|---|
| **Parameter** | **Unit** | **Basic cycle route** | **Main cycle route** | **Cycle highway** |
| **Interruptions per kilometre** | Stops/km | 1.5 | 1 | 0.4 |
| **Delay per kilometre** | Seconds/km | 40 | 20 | 15 |

Minimalization of interruptions, especially in urban areas, is mostly decided on the planning stage, by choosing the right itineraries for main cycle routes. Depending on the local context, the optimal corridor may be the following:

1. Local streets: local streets have less need for traffic lights than distributor roads and they can be arranged in a way that gives priority to intersections to cycle traffic moving along a selected corridor while making it impossible to use the same corridor through motorised traffic.
2. A railway line: there is usually a limited number of roads crossing the line, and the main roads usually cross the railways by bridge or tunnel, making it easy to also provide a grade-separated solution for cyclists.[19]
3. A river or a canal – as with railway lines, the number of crossings is limited, and in many cases their design facilitates grade-separated solutions for cyclists.
4. A primary (trunk) road that has a very limited number of intersections.[20]

On crossings with local roads, the right of way for the cycle route should be established.

On intersections with main roads, grade-separated crossings are preferable.[21]

[19] For example, https://ecf.com/news-and-events/news/f3-cycle-highway-%E2%80%93-along-and-across-ten-t-corridors
[20] For example, https://ecf.com/news-and-events/news/cycling-along-motorway-safe-comfortable-practical
[21] For example, https://ecf.com/news-and-events/news/bicycle-tunnels-rijnwaalpad-cycle-highway, https://ecf.com/news-and-events/news/small-green-bridge-saves-time-all-users


Figure 3. Signalised and non-signalised intersections in two parallel corridors in Brussels: Chaussée de Louvain (distributor road) and F203 cycle highway. Background credit: OpenStreetMap.

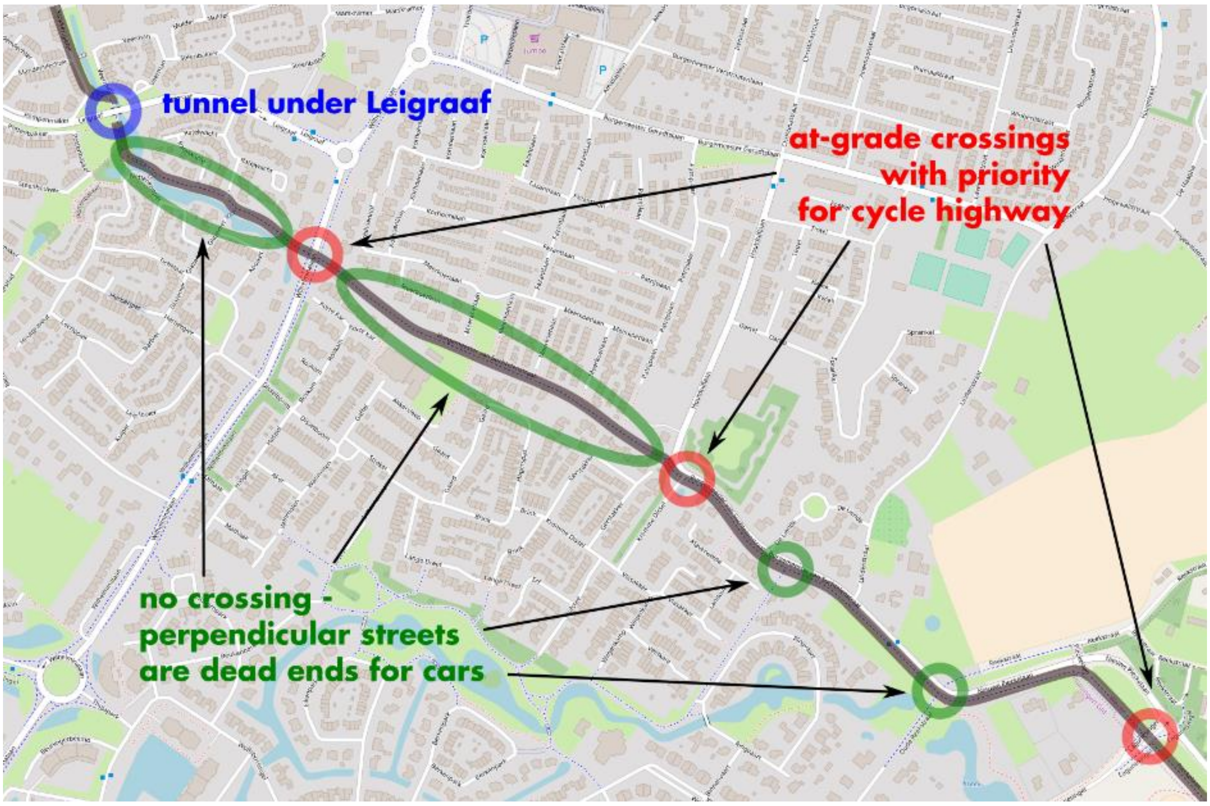


Figure 4. To reduce the number of interruptions on the cycle highway Batavierenpad Zuid in the Netherlands some street sections were closed for cars, with the few remaining crossings rebuilt to safe standard with priority for cyclists. Background credit: OpenStreetMap.

In case a signalled intersection is necessary:

- Fixed traffic light cycles are usually the most cycle-friendly. If that is not feasible, advanced detection of cyclists or automatically awarding green light to cyclists together with a parallel stream of motorised traffic can reduce the probability of stopping and expected waiting times.
- Requesting cyclists to push a button to obtain a green light is the worst possible option. It drastically lowers the quality of the cycle route by raising the probability of stopping to 100% and usually also significantly increasing the expected waiting times.
- Minimising the size of the intersection allows to improve the efficiency of traffic lights, and shorten their cycle.
- Further recommendations and case studies for the cycle-friendly design of signalised intersections can be found in the Cycle Highway Manual.[22]


**Figure 5. "Green wave" for cyclists, with traffic lights synchronised for 20 km/h in the direction of the city centre in the morning. Copenhagen, Denmark.**

[22] https://cyclehighways.eu/design-and-build/infrastructure/signalised-crossings.html

**Quality parameters for cycle infrastructure: longitudinal gradients**

Selected quality parameters for cycling infrastructure in national and regional guidelines were compared in the frame of the REALLOCATE project, with additional contributions from the UNECE Group of Experts on Cycling Infrastructure and ECF member organisations.

A considerable effort has been made to ensure that the information presented is current and accurate. If outdated or incorrect information is brought to our attention, ECF will correct or remove it.  Please also let us know if you would like to see other standards or guidelines added to the comparison or if you know about other relevant research that should be mentioned in the document.

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