

INFRASTRUCTURE/ **INTERSECTIONS AND CROSSINGS****RIGHT-OF-WAY INTERSECTIONS**

Overview

Right-of-way mixed traffic is the simplest, most agreeable approach for cyclists on quiet intersections. Cyclists mix with motorized traffic to cross and turn left or right. If a priority road is concerned, special provisions can assist cyclists: traffic islands, bending in or out, turn lanes. When cyclists are on the priority road, design and signage should underline their status. Main network links should have priority at intersections.

Background and Objectives

Function

Right-of-way intersections (without a roundabout or traffic lights) allow cyclists to cross, turn left and turn right where quiet roads intersect. Right-of-way control and additional physical provision can improve cycling conditions when a priority road is involved.

Scope

Right-of way intersections are recommended in two situations.

- **Two local access roads intersect** (30 km/h inside the built-up area, 60 km/h outside the built-up area). Local access roads are generally fairly narrow and quiet, and cyclists mixed with motorized traffic. Therefore, little extra provision is needed on the intersection which will be of fairly limited dimensions.
- **A local access road intersects with a fairly quiet distributor road** (50 km/h). When a distributor road is involved, this will normally have a priority status. Right of way will be controlled by signage and markings. Intensities may not justify a roundabout or traffic signals, but special provisions for cyclists may be needed, especially when major cycling routes are involved.

Implementation

Definition

A right-of-way intersection is a road exchange where traffic flows freely interchange. If it is **uncontrolled**, basic right-of-way rules apply, generally the priority-from-the-right rule. Alternatively, right of way can be **controlled** by signage and markings to give a major road priority over a side road. Possible cycling-friendly provisions include traffic islands, speed tables, tracks bending in or out, and right of way for main cycle routes.

General design issues for cyclists

At right-of-way intersections, traffic freely **interweaves**. Vehicles' paths crisscross at a number of potential conflict points. Cyclists are more at risk than motorists: they are less well-protected and slower. Therefore, a fundamental recommendation is to reduce overall speed to that of a cyclist. **A design speed of 20 to 30 km/h is recommended.**

- The risk for the cyclist of serious injury on impact is reduced.
- The cyclist can more easily and correctly assess the distance and speed of traffic before crossing. To cross a two-lane road with traffic at 30 km/h, the cyclist needs a clear view of traffic over at least 45 m in both directions. With traffic at 50 km/h, the viewing distance needed is 100 m, and at 70 km/h at least 180 m.



Design requirements must take into account the **cycling network hierarchy**. Basic local links, top local links and main routes need to be implemented with appropriate quality requirements. Top local links and certainly main routes are meant to accommodate larger flows of cyclists, usually as cycle tracks or wide cycle lanes, to allow for important cycling flows, comfortable cycling and attractive speeds. Any intersection should be designed to accommodate the same flows of cyclists with good comfort and minimum waiting times. If not, the function and attractiveness of the route will be undermined.

Design requirements also depend on the **intensity** of traffic, which determines the **crossability** of the road for cyclists. Crossability can be calculated as average waiting time, depending on the crossing distance, the speed of the cyclist and the gap distribution (how frequently there is a gap in traffic through which a cyclist can cross). The lower the crossability, the greater the need for improved design and special cycling provision. Dutch guidance suggests the following rule of thumb.

Approx. traffic intensity (1x2 lanes, built-up area)	Crossability for cyclist at 1 m/s (3.6 km/h starting from standstill)
Below 800 pcu/h	Reasonable without central traffic island
From 800 pcu/h – 1.600 pcu/h	Reasonable in two stages
From 1.600 pcu/h – 2.000 pcu/h	Moderate to poor
Above 2.000 pcu/h	(very) poor

Since they are on the carriageway, **cyclists are subject to the general road priority regulations**. In starter cities, where cyclists are uncommon, motorists may be reluctant to give way to cyclists. Design that clarifies the cyclist's rights as well as awareness campaigns are recommended. The design approach varies according to the road hierarchy of intersection branches.

- At an uncontrolled intersection of equivalent roads, a **default right of way** principle is applied. In most of Europe, road-users coming from the right have right-of-way (priority-from-the-right principle).¹ This is also valid for cyclists.
- When a major road crosses a less important road, priority is controlled by traffic signs and road markings. **Cyclists share the priority status of the road they are on**. Design should clearly express the different status of main road and side road. As intensities on the main road increase additional safety measures are needed.
- **Priority for main cycle routes** can be considered, whether on tracks along roads, on solitary tracks, in cycle streets or as mixed traffic on local access roads (see below).

There are also two **critical comfort design issues**:

- All **curve radii** for cyclists should be 5 m at least. Below this, the cyclist needs to slow down to 12 km/h and has difficulty to maintain stability. On link bends, 10 m allows for a speed of 20 km/h, 20 m for 30 km/h.
- All transitions between different materials should be smooth. Especially the transition from a track to a carriageway should be designed with **flush kerbs** (without any difference in level).

Cycling on an intersection of two quiet roads

When two local access roads intersect, **both roads are equivalent**. No special provision for cyclists is needed. Traffic on all branches is mixed, not very intense and fairly slow, and this situation also applies on the intersection.

- Cyclists can easily cross when the default right-of-way rules apply.

¹ In the UK and Ireland, the principle holds that drivers have right-of-way unless signaled otherwise, and at T-intersections the continuing road has priority over the ending road.

- A design speed of 30 km/h is recommended for safety, even outside the built-up area, where speed limits on local access roads are higher.
- If there is a cycle lane or a suggestion lane, this should not be continued across the intersection. Otherwise, this might create the misleading impression of a right of way for cyclists.

Cycling on a quiet road crossing a priority road

At some right-of-way intersections, **one road has the priority**. This occurs when a quiet local access road crosses a busier distributor road with a higher speed limit (50 km/h in built-up area, 80 km/h outside the built-up area). Right of way is regulated by means of **traffic signs and markings**, so that traffic on the main road has the priority. Cyclists on the quiet road also have to give way.

For a basic, quiet cycle link crossing a fairly quiet priority road no special provision is needed. If there is a speeding tendency on the priority road, general traffic calming measures can be considered, such as narrowing the carriageway before the intersection or elevating the intersection (speed table).

When the priority road is rather busy, a central **traffic island for cyclists** is recommended.

- With traffic intensities over 800 pcu/h inside the built-up area and 350 pcu/h outside the built-up area, crossing becomes difficult, time-consuming and unsafe.
- A traffic island of at least 2.5 m across allows the cyclist to cross one lane, wait in the middle and then cross the second lane. On top local routes and main routes, with constant flows of cyclists at peak times, a width of up to 3.5 m should be considered, to accommodate several waiting cyclists at the same time.
- Ideally the traffic island is placed symmetrically in the centre of the carriageway. It should remain level in the middle where cyclists cross, but physically elevated at both ends.
- An additional benefit is that the traffic island will also slow down passing traffic: the traffic lanes will need to be narrowed or bent out to go around the traffic island.



Two-way cycle lane crossing with traffic island with right of way (image source: P. Kroeze)

Cycling on a priority road crossing side roads

Many cycle links run along priority roads, crossing side roads. Cyclists will be on a special facility, such as a cycle track, a cycle lane or a cycle suggestion lane. In this case, **the cyclist shares the priority status**. Moreover, the motorist turning off has to give way to the cyclist riding straight ahead, according to general traffic code principles.

Legally, the priority signs and road markings are sufficient, but car drivers may not be aware of cyclists' presence and priority status. Therefore, **the cycle track paving or the cycle lane markings should continue across the side road**. This clarifies the right-of-way situation, and attracts motorists' attention to the presence of cyclists. This is useful for motorists approaching from the side road, but also for motorists on the priority road turning off when the cyclist is continuing straight ahead.

- Continue the cycle facility in a **straight line**, offering a direct route for cyclists. This improves the cyclist's comfort and strengthens the visual continuity of the priority road.
- Apply additional **give-way road markings** on the side of the carriageway. These draw the attention of motorists turning into the side road.
- **Continue a segregated cycle track by road markings**. If the separation from the carriageway is sufficiently wide, the interruption may create safe stacking space for cars turning into the side road.
- **Continue an elevated cycle track on the same level** across the side road. The difference in level will function as a speed table and slow down vehicles entering and exiting the side road. Cyclists will also enter and leave the track via the side road, so the gradients should be comfortable for them and kerbs should be flush.
- **Alert motorists to a two-way cycle track** with additional signaling. Motorists tend to be surprised by cyclists arriving against the flow. Vertical signs, cycle symbols and arrow markings on the road and a centre line help to alert drivers to the two-way cyclist flow.
- **Use similar approaches at private entrances** to drives and car parks, similar solutions should be devised to stress the visual continuity and the priority right of way of the cyclist.



*Cycle lane on priority road crossing a side road
(image source: Vademecum fietsvoorzieningen, Vlaanderen)*



*Cycle track crossing side road
(image source: Fietsberaad)*

Cycle tracks or lanes on a priority road approaching an intersection

On priority roads, it is recommended to **bend in or bend out a segregated cycle track 20 to 30 m before the intersection**. The physical separation makes the cyclist less visible to motorists, so that a car turning off may not notice the cyclist going straight ahead.

At **low speeds**, up to 60 km/h, it is recommended to **bend in the cycle track** before a side road. Cyclists are brought closer to motorized traffic and become more visible to motorists. They are more clearly on the same road which clarifies their priority status. Also, vehicles turning off need to slow down for cyclists, which is safer and makes it easier for traffic from the side road to cross or enter the main road.

- Narrow down the separation progressively, to not less than 0.35 m wide
- Allow a bend radius of at least 12 m. for comfort.
- Allow a final straight track stretch of min. 10 m., where cyclists travel parallel and close to the road, giving motorists the time to see them.

An alternative is to make a **transition from cycle track to cycle lane**, which means eliminating the separation. Cyclists are then returned to sharing the motorway on a marked lane. They become more visible and can also more easily prepare for left turns.

At **higher speeds**, over 60 km/h, it is safer to **bend out the track**. The speed difference between motorized vehicles turning off and the cyclists moving straight ahead is too large, and cars need more time to slow down. Bending out is also a safe solution for a two-way track.

- Widen the separation progressively, so that the track crosses the side road at 5 to 7 m from the main road. This way, a vehicle turning off has room to slow down and stack before the cycle track.
- Apply vertical signage and give-way road markings on both sides of the track crossing the side road.
- The bend radius should be at least 12 m. for comfort.
- The track has a final straight stretch of min. 5 m.



Cycle crossing with a bent-out track (image source: P. Kroeze)

Turning right and left at intersections

At a right-of-way intersection, vehicles must weave to change direction. **Such weaving creates potential conflict points**. The general principle applies that any vehicle changing direction has to give way to vehicles going straight ahead.

Cyclists are, of course, less visible, slower and more vulnerable.

- **Less experienced cyclists** will prefer not to weave at all and to step down or change direction in two steps. They are willing to compromise on speed and directness for safety's sake.
- **Experienced cyclists**, however, feel more confident and like to move speedily and directly across an intersection. They will cross and turn left in the middle of traffic. To be



safe, they adopt behavior to make themselves as visible and predictable as possible. They will take up sufficient space on the road and clearly gesture their intentions. Teaching this behavior is a key role for cycling education.

It is important to **allow cyclists to weave** with the general flow of traffic whenever feasible. Mandatory two-step movements separated from traffic should only be used when really justified. Otherwise, experienced cyclists will be frustrated by these indirect and time-consuming paths.

Generally speaking, cyclists can safely cross a relatively **quiet and simple right-of-way intersection**, with no more than **a single traffic lane** in each direction. The overall design should provide a clear and simple lay-out for maximum visibility of all movements and intentions. Cyclists can mostly be allowed to interchange without any special provision.

On distributor roads, the cyclist will be mostly on a cycle lane. At the same time, the traffic intensity makes weaving more difficult and risky. In this case, **a cycle stacking lane** can be included in stacking lanes for motorized traffic. This will greatly improve the cyclist's comfort and safety.

- If there is a left-turning stacking space on the intersections, a **left turning cycle lane** can be integrated. This creates a separate waiting space for the cyclist, away from traffic from behind and from facing traffic. The lane should be no less than 15 m long. This does not remove all conflicts. When intensities are too high, the left-turn lane may be difficult to reach and there is still the potential conflict with traffic from behind.
- Many conflicts occur between motorized vehicles turning right and cyclists crossing in-line. It is safer to insert the **right-turning traffic lane to the right of a cycle lane or cycle track**. The cycle lane or track continues straight ahead. Right-turning traffic must then cross the lane or track before actually turning right. A crossable in-line speed hump between the cycle track and the turning lane can be considered.
- When large numbers of cyclists turn right, a **right-turning cycle lane** can be considered. This way, cyclists weave into their separate turning space away from traffic.

Right of way for main links inside built-up areas

Main links, in the cycling network are fast and comfortable routes, sometimes called cycle highways, mostly on separated tracks and with a minimum of intersections and crossings. They are the backbone of the network and should be designed to carry important flows of cyclists' at peak hours. Every stop to yield priority reduces speed, raises stress, increases risk and makes the route less attractive.

It is recommended to **give main cycling links right-of-way when crossing streets**, to maximize travel speed for cyclists and make the link as strong as possible. The route may be on a distributor road or a local access road, or it may be an off-road solitary cycle track. The right-of-way should be **strongly underlined by the design**.

- Install the legally required priority signage requiring traffic to stop and give way.
- Add give-way road markings on both sides of the cycling route.
- Continue the main cycle route paving across the intersection.
- Take additional speed control measures narrowing before the intersection, speed table on the intersection.
- Add traffic lights when speed of the crossed road is over 50 km/h and intensity over 5000 pcu/day.

The measure is strongly recommended in CHAMPION CYCLING CITIES. The right-of-way will be more easily accepted if there is **an intense flow of cyclists**. Even there, it is generally not recommended outside the built-up area, since it goes too much against the expectation patterns of motorists and is therefore unsafe.

In STARTER AND CLIMBER CYCLING CITIES the numbers of cyclists will be much lower and intermittent. If busy traffic on a distributor road is asked to stop for an occasional cyclist on a crossing solitary track, the measure will seem unacceptable, motorists may not respect it and the cyclist will be endangered. However, creating such a main priority route may be **a powerful**

incentive, especially if the route is used by for instance school children. Before introducing right-of-way for cyclists, the following issues should be considered.

- If the link is on a main road, it will share priority.
- If the link is on a relatively busy side road, and the difference of intensity with the main road is limited (for instance half the intensity of the main road), right-of-way will be more easily accepted.
- If the surrounding landscape makes it clear that the cycle route connects urban destinations, right-of-way will be more easily accepted.
- Design should strongly underline the right-of-way.

An alternative is to add traffic lights, with an on-demand button (waiting time) or with cycle detection (no waiting time).



Right-of-way crossing for cyclists (image source: T. Asperges)

Considerations

Strengths

- On local access roads, intersections without special provision continue the logic of mixed traffic and traffic calming.
- Cycle-friendly design at intersections generally has the effect of slowing down traffic and thus increasing overall safety.
- Right of way for main links strongly increases the attractiveness of a network, especially for less experienced cyclists.

Weaknesses

- Some safety measures may provoke small detours for cyclists, such as tracks bending in and out.
- Some measures may be space-consuming, such as bent-out cycle paths.
- Right-of-way for cyclists is more difficult to apply in starter cities, with low cycling levels. Additional visibility and safety features will be needed. Special care is needed when cycle routes receive right of way when crossing a more important road.

Alternative options

Roundabout, traffic lights, or grade-separated crossings (tunnels, bridges) for more important cycling routes and higher traffic intensities.