English

Promoting Cycling for Everyone
as a Daily Transport Mode

Cycling: a daily transport mode for everyone

GIVE CYCLING A PUSH

PRESTO Cycling Policy Guide

Cycling Infrastructure

INTELLIGENT ENERGY EUROPE




The Project

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Other PRESTO publications (available at www.presto-cycling.eu)
PRESTO Cycling Policy Guide: **Promotion of Cycling**
PRESTO Cycling Policy Guide: **Pedelecs**
25 PRESTO Implementation Fact Sheets on **Cycling Infrastructure**, **Promotion of Cycling** and **Legislation on Pedelecs**

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1 Give Cycling a Push: PRESTO policy guides and fact sheets

Cycling policy is on the agenda in European cities. In recent years and decades, many local authorities have been undertaking a range of activities to stimulate cycling as a daily transport mode, because they are increasingly convinced that cycling is good for cities (also see the next chapter).

But decisions makers and those involved in implementation are faced with a lot of questions. How to develop an effective cycling policy? What will be the best approach in my city? How to provide high-quality infrastructure? How to promote cycling use and foster a cycling culture? The increasing success of the Velocity conference series testifies to the need for cycling policy knowledge and exchange of experiences. Success stories have become well-known as inspirational good practice. National and local design guides and cycling research and documentation centers are proliferating. BYPAD has become a key tool to assess and monitor cycling policy. Knowledge is becoming more abundant, but remains largely scattered and adapting it in a specific urban context is still quite a challenge for local authorities.

The PRESTO guidelines and fact sheets are the first effort to bundle **state-of-the-art European knowledge and experience on urban cycling policy** in an easily accessible format. They were developed not only to support the PRESTO cities in their cycling policy activities, but also to serve as **European reference guides**.

The PRESTO project: promoting cycling for everyone as a daily transport mode:

Five cities and a range of experts unite in developing strategies to tap the potential of cycling in cities. The cities represent a range of diverse size, location, culture and cycling tradition. All will deploy actions in three fields: cycling infrastructure, cycling promotion and pedelecs. In the course of the project, they will benefit from training sessions and expert advice. The trainings will further be developed into a set of e-learning virtual classes on cycling policy that will later be open to any interested participants.
www.presto-cycling.eu

The **4 Policy Guides** offer a clear and systematic framework to help decision makers develop a **cycling policy strategy**.

One policy guide presents a **general framework**, outlining the fundamentals of an integrated cycling policy. There are of course no one-size-fits-all answers. This is why the guide proposes to distinguish cities according their level of cycling development as **Starter, Climber and Champion cities**, and suggests approaches and packages of measures that are likely to be most effective at each stage.

Three further policy guides develop one policy area each: cycling **infrastructure**, cycling **promotion** and **pedelecs**. The first two of these outline overall principles, critical issues and decision making factors, without going into technical details. The third on focuses on the role pedelecs can play in urban transport and how their use can be promoted by local authorities and bicycle retailers.

The policy guides are accompanied by **25 implementation Fact Sheets** giving more detailed and practical (technical) information on how to implement a selection of cycling policy measures. They are meant as a working instrument for those involved in **implementing cycling policy**.

The policy guidance offered here is meant to be of real practical use to local authorities in defining their own cycling policy strategy. At the same time, it should be considered as a work in progress and will hopefully stimulate debate, feedback and further revisions and refinement over the coming years.

PRESTO CYCLING POLICY GUIDE: GENERAL FRAMEWORK	
PRESTO CYCLING POLICY GUIDE: INFRASTRUCTURE	**PRESTO CYCLING POLICY GUIDE: PROMOTION**
IMPLEMENTATION FACT SHEETS: INFRASTRUCTURE *Network links* • **Traffic calming and cycling** • **Cycle tracks** • **Cycle lanes** • **Cycle streets** • **Contra-flow cycling** • **Bicycles and buses** • **Cycling and walking** *Intersections and crossings* • **Right-of-way intersections** • **Roundabouts intersections** • **Traffic-light intersections** • **Grade separation** *Parking* • **Bicycle parking and storage solutions** • **Bicycle parking in the city centre** • **Bicycle parking in residential areas** *Public transport* • **Cycling facilities at interchanges**	**IMPLEMENTATION FACT SHEETS: PROMOTION** *Awareness raising* • **Broad promotional campaigns** • **Bike events and festivals** • **Bicycle/ bike counters** • **Targeted cycling programmes – schools** • **Safe cycling campaigns** *Information* • **Bicycle maps** • **Cycling information centres / mobility centres** *Training and programmes* • **Targeted adult cycling training programmes** • **Bike testing events**
	PRESTO CYCLING POLICY GUIDE: PEDELECS
	IMPLEMENTATION FACT SHEET: PEDELECS • Legislation on pedelecs

Figure 1: PRESTO Fact Sheets and Policy Guides

This is the PRESTO Cycling Policy Guide on Infrastructure.

2 The riding bicycle

If we want to develop cycling as a daily urban transport mode, then our cities need to be fit for cycling. CHAMPION CYCLE CITIES have modal shares of upwards of 30%. Tapping this potential will only work if riding a bicycle is physically possible, safe and attractive. Only then will cycling be able to compete against the car in cities.

- For this, an integrated cycling infrastructure policy is needed.(2.1)
- Infrastructure and street and road design must be adapted to cyclist's needs. (2.2)
- A well-organized cycle network must allow cyclists to reach any destination easily, safely and conveniently. (2.3)
- Careful design choices need to be made in each specific situation.(2.4)

In the following parts we will consider cycling parking policy (3) and the intermodal linkage between cycling and public transport (4).

2.1 The need for an integrated cycling infrastructure

Why is cycling infrastructure needed? Because to a large extent our cities have become unfit for cycling. This in turn is because of the intensity and speed of motorized traffic, and because of the way streets have for a long time been designed for motorized traffic. Safety for pedestrians has been managed by separating them from traffic and organizing crossings. Cyclists were largely forgotten in the process. To facilitate the use of cycling as a sustainable daily transport mode, adaptations in infrastructure will be needed.

In planning and designing cycling infrastructure in cities, we are faced with two often contradictory needs.

- **Taking cyclists seriously** as a specific road user. This implies creating room for cyclists and their specific needs.
- **Integrating cycling infrastructure** into an often restricted public space. This means accommodating competing claims for space from various users, as well as guaranteeing the quality of urban design.

In dealing with this, over the years two seemingly opposed planning philosophies have developed[1]:

- **The network/segregation approach**. In this view, cycling infrastructure is to be considered as an additional network in its own right. It consists of separate, dedicated infrastructure, with its own technical design norms. The basic assumption is that cycling and road traffic are incompatible, so separate networks are needed for safety and to serve the needs of both. This is a strongly technical, engineering approach.
- **The holistic/mixing approach**. In this view, the entire existing street and road network needs to be reclaimed for cyclists (and pedestrians), through traffic-calming and sharing space with motorized traffic. The assumption here is that road traffic needs to adapt itself to low-speed users and be slowed down to increase safety. This fits in with an increasing concern for high-quality urban public space, shared by all and open to various social uses.

[1] Adapted from Arantxa Julien, 2000 - Comparaison des principaux manuels européens d'aménagements cyclables, CERTU

Over the years, experience has made it clear that neither approach is a full solution and that a mix will be needed. On the one hand, the network/segregation approach is clearly not feasible on all streets and cycle routes, since it is constrained by available space and budgets. On the other hand, mixing is clearly not justified at high traffic intensities or speeds.

So what is needed is to combine both options in a **hierarchical network approach**. The guiding principle should be: mixing if possible and segregating if necessary. In all of this, **safety is the overriding concern**.

- **Mixing where this is safe or can be made safe**. Mixing cyclists with general traffic is the default option. Local, fine-meshed cycle links should run through quiet, traffic-calmed areas without any special physical provision for cyclists, except occasional markings or signage. In many cases, the impact of motor traffic can be reduced by various ways of traffic reduction and traffic calming. Such **invisible infrastructure** is likely to have a greater impact on cycling levels than cycling-specific measures. The basic justification is that reducing the volume of motor traffic and its actual speed to max. 30 km/h is the overall safest option. Traffic-calmed streets are still accessible to cars, but all users, including cyclists and pedestrians can safely and freely move about. In this way, all local streets become part of the cycle network.
- **Segregating where safety requires it, because of high traffic volumes and speeds.** A cycle network cannot cover a city on quiet traffic calmed streets only. Some roads or bridges with major traffic flows are often fast and direct links between major urban destinations. These have a high cycling potential as major routes and often there is no acceptable alternative. Main arteries are also often historic lines connecting landmark areas that make orientation and navigation easy for all, including cyclists. Because of high traffic intensities and speeds (50 km/h or more), segregated cycle tracks will be needed, especially when large numbers of cyclists can be expected to use them. These high-quality routes can become the **backbone of the cycling network**, interconnecting quieter local areas. Cycling tunnels and bridges can be built to cross barriers such as busy roads, railroads or rivers: these can create high-profile segregated links, often direct routes away from traffic. Major routes used by great flows of cyclists can receive preferential treatment at traffic lights or have priority over motor traffic.

2.2 Cycle friendly infrastructure: basic requirements

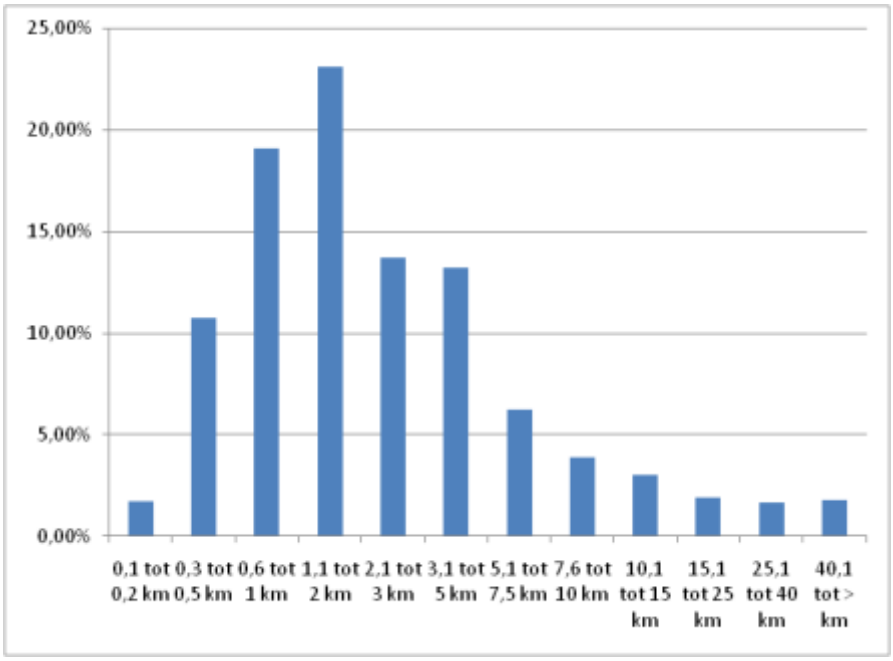
When investing in cycling infrastructure, we need to make the right choices. What is needed to really improve cycling conditions, to make cycling safe and to attract as many cyclists as possible? Starting from cyclists' needs five key requirements can be defined.

2.2.1 Cyclists' needs

First we need to be aware of the essential user needs of cyclists and the characteristics of bicycles.

It is vital to keep in mind that the bicycle is mainly used for **short distances**. More than 80% of all bicycle trips are less than 5 km long. The table below shows the share of bicycle trips per distance category for the Flemish region in Belgium. In other countries or regions a similar division of cycle distances will be found. Cycling is essentially a local transport mode.

Figure 2: Share of bicycle trips per distance

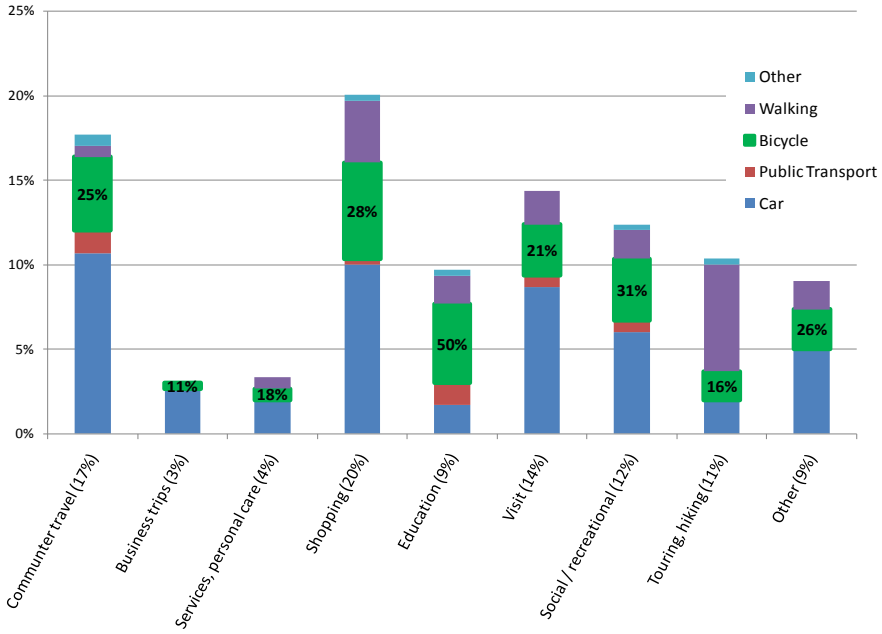


Source: OVG Flanders 2001 (Travel behavior survey)

Looking at the travel purpose, the bicycle is useful for **all kinds of trips and all ages**. The diagram below shows the range of purposes cycling is used for in the Netherlands, with its high rate of cycling. In More than 50 % of trips to school are made by bicycle but, of course, school travel only represents a small share (9%) of all trips. For the other travel purposes such as work, shopping and leisure the bicycle has a 20% to 30% share, meaning that overall 26% of trips in the Netherlands are made by bicycle.

In many cycling policies there is a strong emphasis on school travel. This makes sense: making children experience cycling as a normal daily means of traveling is the first step towards keeping them on their bicycle in their adult lives. However, we need to be well aware that school travel trips only represent this small share of trips. If we want to have a significant impact on towards cycling, we need to focus on the promoting cycling across the entire range of travel purposes, especially commuter travel and shopping.

Figure 3: Travel motives and share of bicycle trips in The Netherlands



Source: Mobility Study Nederland, 2007

Apart from daily utility trips, the bicycle also plays a major role in recreational trips. In the last decade recreational cycling has increased systematically in all European countries. Besides the qualities of the surrounding landscape, attractive cycle facilities are a key element in promoting recreational cycle trips. When these cycle facilities are also run through more urban areas, they also have a potential for supporting daily functional cycle trips at the same time. While the needs of functional and recreational cyclists differ, facilities should be closely integrated in urban environments so that double use is promoted.

2.2.2 Cycle infrastructure works

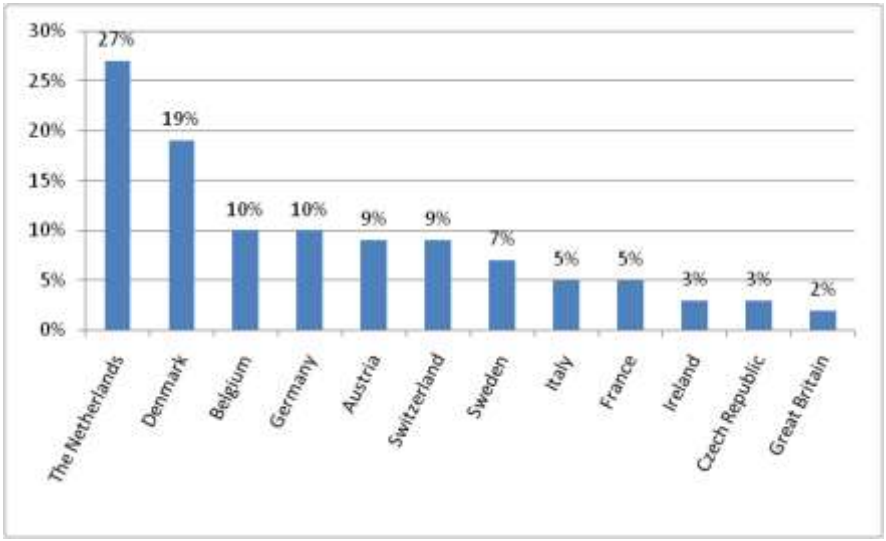
There are clearly large differences in cycle use among the various European countries and cities. It may be a bit too simple to state that countries with high-quality cycling infrastructure have a higher modal share of cycling, but there is undeniably a relation between good cycling infrastructure and cycle use.

We need to be careful, because there is a lack of reliable international and European-wide statistics, comparing bicycle use per country. The following figures have been culled from different sources via internet research. Although they are fragmentary and calculated in different ways, they do give a rough indication of varying cycle use in European countries and cities. The highest shares do correspond with higher qualities of cycling infrastructure.

Table 1: Bicycle share in all journeys in some European countries and cities

	National figures (1999 - 2008)	Bicycle share at the municipal level
The Netherlands	26%	The top municipalities score between 35% and 40%; cities with the lowest bicycle use rate between 15% and 20%
Denmark	19%	The differences among the larger cities are relatively small: in general at the level of 20% of all trips
Belgium	10%	Quite a difference between Flanders (14%) and Wallonia (3%) Many cities in Flanders approach 15%. Top: Bruges - almost 20%
Germany	10%	The western federal states have a higher average bicycle use, especially Nordrhein-Westfalen. Several cities with bicycle shares between 20% and 30%
Austria	9%	Top: Graz (14%) and Salzburg (19%)
Switzerland	9%	Several cities at a higher level, such as Bern (15%), Basel (17%), Zurich (15%) and especially Winterthur (approx. 20%)
Sweden	7%	Cities: 10%. Extremes: Lund and Malmö 20%. The small city of Västerås: 33%
Italy	5%	A few striking exceptions, especially in the Po Plains, with places like Parma (over 15%) and Ferrara (around 30%). Another top city: Florence (over 20%)
France	5%	Top: Strasbourg 12% and Avignon 10%
Ireland	3%	Virtually no upward extremes (Dublin 5% at most)
Czech Republic	3%	A few cities with some degree of bicycle use (Ostrava, Olomouc and Ceské Budejovice, between 5% and 10%) and some with an even higher bicycle use (Prostejov 20%)
Great Britain	2%	Some isolated cities with a much higher degree of bicycle use (York and Hull 11%, Oxford and especially Cambridge nearing 20%)

Figure 4: Bicycle share in all journeys in some European countries



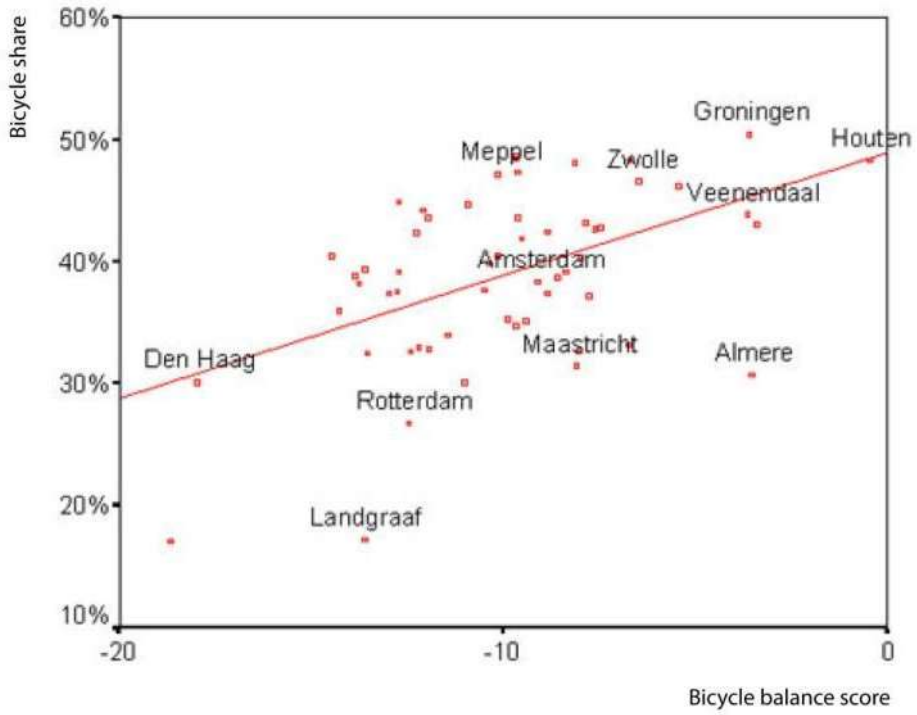
Source: European Commission, quoted in Cycling in the Netherlands, 2009.

More specific research projects have shown that good cycle infrastructure indeed leads to a higher cycling share. The benchmarking 'Fietsbalans' project, conducted by the Fietsersbond (Dutch cycling association), has revealed a clear link between levels of cycling in a

municipality and the quality of the cycling infrastructure. The quality of the infrastructure was recorded objectively using measuring equipment and is expressed in the so called bicycle Balance Score. In Dutch municipalities with a high bicycle Balance Score, bicycle use is on average 14% higher than in municipalities with a low bicycle Balance Score.

Once again, it needs to be underlined that cycle-friendly infrastructure is not the same as dedicated lanes and tracks. The bicycle balance score is partly based on 'route testing': a route may partially run through a 30 km/h area with traffic calming measures but without cycle lanes or tracks: this raises the quality score.

Figure 5: Relation bicycle use and quality of cycle infrastructure



Source: Fietsberaad (NL)

2.2.3 Quality requirements for cycling infrastructure

What is it that makes cyclists want to get on their bikes? Starting from user needs, it is possible to define five main requirements for cycle-friendly infrastructure. These were developed in the Netherlands, but have been internationally recognize as valid policy guidelines.

It will not always or everywhere be possible to fulfill each requirement, not even in CHAMPION CYCLING CITIES. But the point is that the more of them are fulfilled, the more people will be attracted to get on their bikes. These requirements must always be kept in mind as objectives to strive for. And they can also be used as criteria to assess the quality and shortcomings of existing infrastructure.

1. **SAFE.** Safety is undeniably the basic requirement and must be the overriding concern. Cyclists cause no significant danger, but they themselves are and feel vulnerable when moving in the same space as motorized traffic. Risk results from the major differences in mass and speed. Safety can be provided in three main ways. Reducing traffic intensities

and lowering speeds below 30 km/h makes mixing safe. Separating cyclists in space and in time from fast and heavy motorized traffic reduces the number of dangerous encounters. Where conflict points between motorized traffic and cyclists cannot be avoided (at intersections and crossings), these should be presented as clearly as possible, so that all users are aware of the risk and can adapt their behavior.

2. **DIRECT.** Directness means that the cyclist can as direct a route as possible to his destination. Detours must be kept small and overall travel time for cyclists needs to be minimized. This makes cycling highly competitive over short distances, since travel time will mostly be lower than when travelling by car. All factors with an impact on travel time influence directness: detours, number of stops at crossings, traffic light regulation, slopes etc. Cycling can then be promoted as a smart choice and a fast means of transport into a city center or to local schools, to work or other amenities.
3. **COHESIVE.** Cohesion is about the extent to which cyclists can go from any origin to any destination without interruption. This basically means that cyclists will strongly appreciate an area-wide or city-wide network. Black spots and barriers, cycling provision that suddenly stops are strong disincentives to cycling. Cyclists need to be confident that wherever they go, they will easily find a route with a consistently good quality of provision. Every home, every company, every amenity must be accessible by bike and connected to the overall network. Cohesion also means good connections to other networks, mainly public transport stops and hubs.
4. **ATTRACTIVE.** Attractiveness means that bicycle infrastructure is well integrated into agreeable surroundings. This is a matter of perception and image, which can strongly encourage or discourage cyclists. Since perceptions are highly variable and personal, general rules are hard to give. But perception should receive full attention in planning and when analyzing usage levels and complaints. Apart from design and landscape qualities and the image of an area, this also includes the factor of actual and perceived 'personal security'. This is particularly crucial in the evenings and at night.
5. **COMFORTABLE.** Comfort is about creating an enjoyable, smooth and relaxed cycling experience. Physical and mental effort should be minimized as much as possible. For smooth driving irregular efforts should be avoided: having to stop and start repeatedly is tiresome and stressing. Bad material design or maintenance cause annoying vibrations, shocks and obstacles: this makes cycling a more complex task, requiring more concentration and effort to control your balance and spot nuisances in advance.

In practice these requirements may sometimes conflict. Then it becomes a matter of striking the right balance. Consider the following common situations.

- The most direct route often runs along a busy road and is therefore less safe or attractive than required. Building segregated cycle lanes can guarantee safety. An alternative route away from traffic may be safer and attractive, but probably longer and less direct.
- For safety reasons, cyclists are sometimes required to make a detour via a tunnel or bridge, or to stop frequently at traffic lights. Both reduce directness (detour, waiting time) and comfort (climbing slopes, stopping and starting).
- The most direct route runs through green parks or outside built-up areas. This may be visually attractive, but is often insecure at night or felt to be so.

There are no hard and fast rules for solving all of these contradictions. But there are some rules of thumb:

- Safety must always be the top priority.
- Utility routes and recreational routes have a different set of priorities, as shown in the table below. Fast and easy routes are crucial for daily functional cycling trips, even running through less than attractive surroundings. For recreational routes, attractiveness is a major concern and detours are much less of an issue. More on the distinction between utility routes and recreational routes.

Utility cycle network	Recreational cycle network
Safety	Safety
Directness	Attractiveness
Cohesion	Cohesion
Comfort	Comfort
Attractiveness	Directness

2.2.4 Design requirements: stability, zigzagging and section of free space

The physical design of cycling infrastructure needs to take into account the physical space needs of cycling. This is includes the dimensions of the cyclist and the bicycle, but also the physical characteristics of the activity of riding a bicycle.

Stability. Bicycles are unstable vehicles. Crosswinds, lorry slipstreams, bumps and holes in the road surface and involuntary low speeds determine the stability and hence the room required for maneuvering. To maintain balance, a speed of at least 12 km/h is required. At speeds below that, the bicycle starts to wobble. This happens when pulling away from a stationary position, slowing down in tight bends and riding uphill.

Zigzagging. When riding, cyclists constantly have to maintain their balance. That is why they always move slightly from side to side, even when riding fast. This is called zigzagging. Apart from the speed, zigzagging also depends on age, experience, physical capacity, disruptions in the road surface and cross winds. At normal cycling speeds in normal conditions, the zigzagging movement is about 0.20 m. In situations where cyclists are forced to travel at less than 12 km/h, more free space is required. This is the case at traffic lights, for example, where cyclists have to pull away from stationary position and when cycling uphill. In that kind of situation, zigzagging may require a track width of up to 0.80 m.

Fear distances from obstacles. Designers also have to take the fear of obstacles into account: cyclists will want to keep their distance from kerbs, edges and walls. The Dutch Design Manual indicates the following obstacle distances[2]: for green verges and low kerbstones, the obstacle distance is 0.25 m; for higher kerbstones 0.50 m, for closed walls 0.625 m.

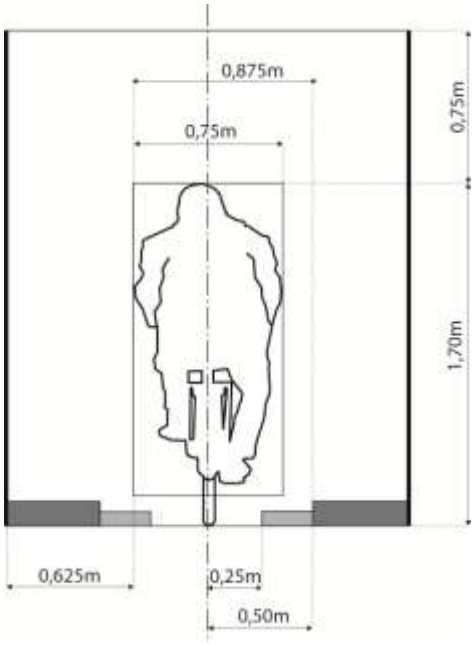
[2] CROW-record 25 – Design Manual for Bicycle Traffic

Section of free space. Now we can calculate the pavement width required for one cyclist: take the width required by the bicycle and its rider (0.75 m) and add to that the zigzagging margin and fear distances from obstacles (these margins may overlap). The most common situation is that of a cyclist riding along a high kerb on one side: an **absolute minimum pavement width of 0.9 m** is required.

Whenever possible, we should provide room for side-by-side riding: this makes cycling a more enjoyable social activity, allows adults to drive next to children and allows faster cyclists to overtake slower ones. This means we should go for a **recommended minimum width of 1.5 m**.

For comfortable driving in tunnels, provide **minimum 0.75 m headroom**.

Figure 6: Section of free space



Source: adapted from CROW – 2006: Design Manual For Bicycle Traffic. CROW-record 25

2.3 Planning cycle networks

With these general quality requirements of cycle infrastructure in mind, the next step is to apply them in developing a cycle network. This chapter offers some planning principles for an effective cycle network.

The development of a cycle network must start from the cyclists' travel needs of, independent from other transport modes. A correctly developed cycle network starts from this principle and targets cycle facilities on these locations where high cycle flows are present or expected.

2.3.1 Routes (not tracks or lanes), structure (not design)

But what exactly is a cycle network? Here is a working definition: **a cycle network is an interconnected set of safe and direct cycling routes covering a given area or city**.

It is worth stressing once again that a network consists of **routes, not tracks or lanes**. The quality of a route or a network does not depend on one particular type of infrastructure, such as segregated tracks.

A quality cycling route is an **uninterrupted itinerary** fitting as closely as possible the criteria outlined above: safe, direct, cohesive, comfortable and attractive. The physical shape this takes may vary from route to route and even within one route. A route may start in a residential 30km/h area mixed with light traffic, move onto a cycle lane where traffic is slightly heavier, run through a dedicated cycling tunnel under a ring road, continue as a segregated track along a main road, cut through a park as a short-cut and through a pedestrianized shopping area reach to the railway station.

The quality of the network as such depends on its structure: how well does it fit together; how easily does it make urban destinations accessible; how well does it avoid or manage risky situations? This is a different issue from the quality of the design (more on design below).

2.3.2 Selective and progressive (not a master plan or blueprint)

At some stage it is worth actively developing a desired cycling network as a planning tool. Basically this means drawing coloured lines on a map to connect urban destinations. As such it becomes a guide for designers in the field: if the designer has a clear view of the function of a link or an intersection within the network he will be able to come up with the most appropriate design solution. If a link is a top level cycling route, carrying many cyclists from one urban area to another, the design must be very different from that of a local route connecting a residential neighbourhood to a main route or a local train stop.

This does not mean, however, that a STARTER CYCLING CITY needs to start by developing a detailed master plan of a complete city-wide network and then implement it in a short time span. However refined the research and analysis of potential travel patterns, this kind of prediction of the needs of not-yet-existing cyclists is inherently abstract and risky. Implementing it in one-go may turn out to be a costly mistake, providing a large share of underused facilities.

At the start, it is recommended to make a rough outline of the most likely city-wide connections, just to have an overview. But then it makes more sense to build a network selectively and progressively. An option would be to start with the city center and one adjacent residential district, make those cycle-friendly, and create a high-potential main route to connect both. Progressively other districts can follow and more routes be developed, gradually interconnecting. Such an approach has several advantages.

- We can start in areas with the highest potential, where people already cycle to some extent, where traffic is already quiet or calmed etc. This increases the initial chances of success.
- In addition, the use of the network can be monitored and constantly improved. Counting flows and feedback from cyclists on missing links will give valuable input. With careful monitoring a network can be built and adjusted that closely fits users' needs and is thus highly effective as well as cost-effective.

2.3.3 Main requirements of a cycle network

For a cycle network, three of the five main requirements (see above) are essential: safety, directness and cohesion. The other two, comfort and attractiveness, are less relevant at the network level but more on the level of specific design of routes and road sections (see below).

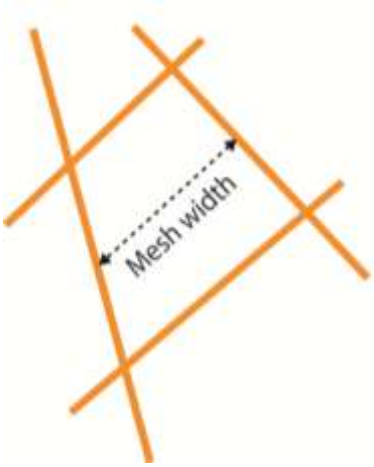
The most elementary network requirement is **network cohesion**. Without cohesion there is no network, only a bunch of single routes. This is a matter of degree: the more routes interconnect and allow cyclists to freely choose their itinerary, the stronger the network is. For cyclists, cohesion is a very real quality: it is the extent to which they can reach their destination via the route of their choice.

To make a network cohesive, a clear understanding of major origins and destinations is important. By drawing in lines of desire between those, we can get an idea of potential travel flows. Using computer models to calculate travelling patterns is only feasible for CHAMPION CITIES with sufficiently large numbers of cyclists to provide meaningful data.

Apart from major connections, the mesh width and density are important factors of cohesion: the smaller the distance between routes, the more the cyclist has the choice, for instance between a fast route along a busy road or a slower but quieter one, or between a direct uphill route and a longer one avoiding steep hills.

Apart from the internal cohesion of a cycle network, the cohesion with other networks also plays a role. Especially the intermodal connection for the cycle network to public transport points is very relevant as cycle trips are an import means of transport to and from public transport.

Mesh width. A mesh is the smallest, closed element in a network. The mesh width is the distance between parallel routes. The larger the mesh width, the lower the network density (the total link length per surface unit) and the lower the level of cohesion.



The mesh width is only relevant in built-up areas, where there is a demand for cycle trips. For cycle networks a maximum mesh width of 250 meters is recommended.

Outside the built-up area, it is only relevant that there are bicycle connections between villages, centers and amenities that attract cyclist.

The **network directness** concerns the distance or time you need to cycle between points of departure and destination. In terms of policy, the bicycle should have more direct routes than the car in the built-up area. This way cycling is quicker than taking the car.

Directness in distance can be determined by calculating the detour factor. The more a route from A to B approaches a straight line, the better for the cyclist.

Detour factor. The detour factor is the relationship between the shortest distance over the network and the distance as the crow flies. The lower the detour factor the higher the directness of the network. The detour factor must of course be related to distance: the same detour factor over a longer distance implies a longer absolute detour. For a dense cycle network a maximum detour factor of 1.4 applies as a guide value. To make cycling attractive over short distances (in the built-up area) the detour factor of the cycle network should be less than the detour factor for cars.

Directness in time concerns the provision of connections that optimize the flow of traffic. The number of intersections per kilometer at which a cyclist does not have right of way applies as a criterion. For main cycle routes, this number should be zero or as close to zero as possible. The stopping frequency per kilometer could also serve as an indicator for the directness in time. A survey of cycle networks in different Dutch cities (Fietsbalans, 2000) gave a stop frequency of 0.40 to 1.56 stops per kilometer.

The basic requirement of safety is more than a matter of physical design. Much can be done to ensure safety on the network level. Here are some guidelines to ensure **network safety**.

- *Avoid conflicts with crossing traffic.* Especially in the built-up area this is not obvious to accomplish without reducing the quality of traffic flows. In theory grade-separated crossings (bridge, tunnel) with car roads would be perfect with regard to safety, but in practice traffic lights and traffic calming facilities are often more appropriate to avoid conflicts with crossing traffic.
- *Separate different types of road users.* When speed differences between motorized traffic and cyclists are too high these road users should be separated from each other and have their 'own' network of connections. A basic rule of thumb is always to separate cyclists from motorized traffic at speeds over 50 km/h.
- *Reduce speed at points of conflict.* When separating vehicle types is not possible, the speed differences between motorized traffic and cyclists should be minimized. The speed of the slowest means of transport (the bicycle) is used as the basis. The maximum recommended speed for mixing is 50 km/h but 30 km/h is much more preferable, if only because injuries in case of accidents are significantly less severe.
- *Ensure recognizable road categories.* Creating recognizable and comprehensible traffic situations is essential for safety. Consistent design solutions on roads with similar functions (in terms of road hierarchy) makes potential conflict situations more predictable for cyclists and other users, while also inciting everyone to behave more predictably.

2.3.4 Developing a utility cycle network

If we focus on cycling as a daily transport mode, we need to set up a utility network, as opposed to a recreational network. The goal of a utility or functional cycle network is to connect destinations for functional trip purposes such as shopping, working, education, socio-cultural visits etc. The connections should be as direct as possible.

Developing a utility cycle network for a city or a wider area usually takes three main steps.

Step 1: determining major origin and destination areas and links

Origins and destination depend on the size of the study area. At the level of the urban region, a city centre can be regarded as a single point of origin, while for the network inside the centre the various neighborhoods and districts will be regarded as separate points of origin.

Typical main cycling destinations are:

- Residential neighbourhoods and districts;
- schools and universities;
- shopping areas;
- sports amenities
- employment concentrations, such as large companies and business parks;
- major public transport hubs and interchanges (railway, bus, tram, metro)

All these destinations can now be connected on a map with simple straight lines. The result is called the preferential (theoretical) network, a set of high-potential links that the network must contain.

Step 2: detailing preference lines into routes

Next, the origin-destination links should be detailed into preferential routes. This means they should be drawn in on a map, along existing roads and cycle infrastructure, possibly indicating missing links and cycling shortcuts to be created. The shortest most direct route should be considered first and checked against the other criteria.

Defining the routes and their required design qualities will depend on the importance of the link, in other words the numbers of current or expected cyclists. If numbers of current cyclists between areas are available, these can be allocated to the route to be created. Data on travel behavior or numbers of cycle flows at different points in a city can also help in determining the main cycle routes. Only in cities or areas with high rates of cycling is traffic modeling an option, for instance to determine the potential of building a cycling bridge as a shortcut.

Step 3: Creating a hierarchy in the network

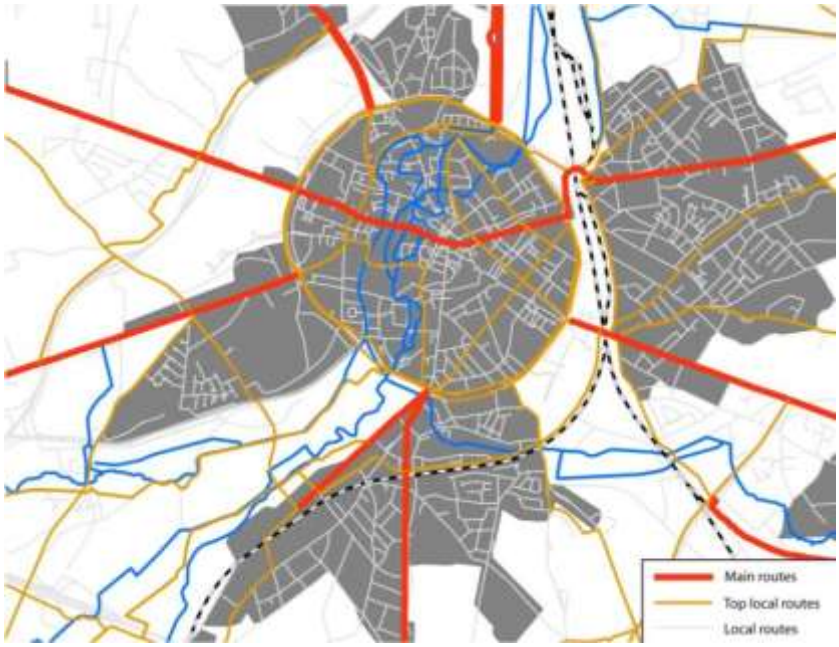
An extensive cycling network is most effective when it has a clear hierarchy. We are all familiar with this from the road network, from motorways to district roads and local roads. Similarly, across an urban area cycle network users have different priorities at different times: short trips or long trips, utility or recreational purposes, speed or safety. In some CLIMBER CITIES and certainly in CHAMPION CITIES, some routes will be heavily used by important flows of cyclists, needing sufficient space and sufficiently smooth flow management. To respond to these different needs, cycle routes can be classified into three levels (more details on design implications below):

- MAIN ROUTES have a connecting function at city or intercity level. They connect centres, villages, towns and cities with each other, outside the built-up area.
- TOP LOCAL ROUTES have a distributor function at the district level of the built-up area. They provide the main cycling connections between urban districts and major urban areas.

- LOCAL ROUTES have an access function at the neighbourhood level. They include basically every street or track that can be used by cyclists, connecting all buildings and other origins and destinations to higher level routes.

In actual practice road authorities often use the two highest levels of cycle connections. The lowest level (neighborhood level) is often not represented in the cycle network. This is not because it has no relevance, but because it is far too detailed and dedicated cycling infrastructure is often not necessary. Cycling will be possible or made possible by non-cycle-specific measures (or 'invisible infrastructure') such as traffic calming, speed reduction and traffic deviation.

Figure 7: Example of a hierarchical cycle network



2.3.5 Integrating utility and recreational cycle networks

The focus of this guide is on daily urban cycling, in other words utility networks. Nevertheless, in and around urban areas there is growing user demand for recreational networks. For these, the attractiveness and experience offered by the cycle route and its surroundings is more important than direct connections.

The traditional concepts are the signaled long distance routes and the signaled touristic theme route, which are still attractive. But more recently, **recreational cycle networks** have been developing. They are structured as a number of nodes connected with links, offering cyclists the freedom to determine their own trip on a network. Exploring a region by bicycle is the goal of these networks. Many of these recreational routes pass trough urban areas and centres.

Image source: T. Asperges

Figure 8: Types of recreational routes

	Long distance routes	Round trips	Recreational network
Properties	A national or international (e.g. EuroVelo) network of through routes; allows long round trips	Circular, mainly local/regional routes representing a specific theme (e.g. Route of the Black Gold in a mining area in Limburg). Many of these loops have been created in the last decades. Average length 30-40 km.	Fine-meshed regional network, along attractive routes to explore a region. Mostly signposted via junction numbers (and additionally via destinations)
Use	Flexible use, trips can be planned by individual cyclists. But only one route possible (follow the signs)	Less flexible use. Necessary to finish the whole route to get back to your departure. Always the same route. After having seen this route, you have less interest to do it once again.	Very flexible use, local or regional trips can be planned by individual cyclists and can be changed during the trip (based on a map with the junction numbers). Suitable for touring trips.
Responsible organizations	(inter)national cycle associations / tourist associations	Municipal, regional or provincial councils or private initiatives by local associations	Municipal, regional or provincial council. Co-operation between different policy levels to get a uniform network

Source: Design Guide for bicycle infrastructure, CROW-record 25

Figure 9: Touristic long distance cycle routes

Long distance routes in Germany

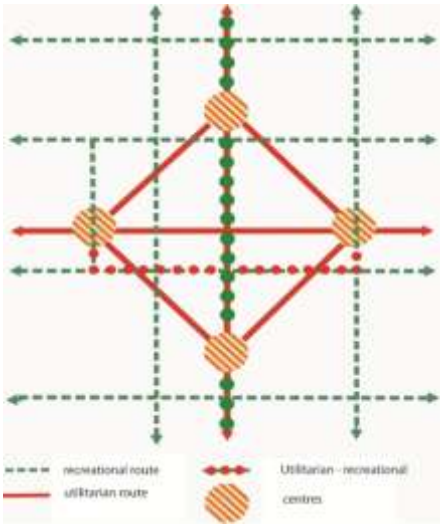
EuroVelo cycle network - ECF

As shown above explained utility and recreational cycle networks definitely respond to widely different user needs: utility cyclists want to get as quickly as possible from A to B whereas the recreational cyclist is looking for a leisurely attractive ride while exploring a region.

In practice, however, **utility and recreational networks tend to overlap and should be integrated**. Many recreational departure points and destinations are in or near a (city) centre or a (railway) station. At the same time there is also a demand for utility trips along alternative quiet and attractive routes, parallel with busy roads but at a distance from them.

In designing cycle networks, it makes sense to take both uses into account. This makes it possible to combine efforts and means of the touristic sector and the road authorities. This allows for a more solidly funding basis to realize more consistently high-quality facilities. Integrating major transport hubs is vital, both for utility and recreational trips, because of the potential of combining public transport and cycling in one trip chain.

Figure 10: Integrated utility and recreational network



An example of an integrated cycle network is *Suisse à Vélo*, the Swiss network of cycle, hiking, skating, canoeing and mountain bike routes. The entire network is signalized uniformly and there are also connections with bus, train and boat at different routes to avoid for instance the steepest routes. More info on www.schweizmobil.ch

Image source: Shweizmobil

2.4 Designing cycling facilities

Planning a network is one thing; physically designing facilities on the ground is another. How to make the right design decisions? In this chapter we first consider the importance of the route hierarchy and the common design solutions available, we present a decision matrix for links and we outline specific options and issues at intersections.

2.4.1 Designing facilities according to route function

Above we defined three levels of cycling route within a cycle network: main routes, top local routes and local routes. Since routes on each level have specific functions, logically this leads to specific design requirements. These are not hard and fast rules and the local context always needs to be taken into account. Nevertheless, it is useful to keep them in mind as recommended quality standards: these design characteristics will allow each route to fully perform its designated function. In addition, consistent design within each level clarifies the network for cyclists. In addition, it makes situations and behaviour more predictable for cyclists and other road users, which increases safety and comfort.

Main routes

- High level fast long distance cycle routes (tending to cycle 'highways')
- Mostly complementary in use:
  - Utility use – connecting centers over 5 to 15 km;
  - Recreational use – long distance routes between city centers (10 to 50 km)
- High quality design standards:
  - Maximum separation between pedestrians and motorized traffic
  - Car free routes
  - Minimum number of crossings:
    - Crossings with busy roads: preferable multilevel - conflict free (tunnel, bridge)
    - Crossings with quiet roads: priority for the cyclists
  - Material: asphalt or concrete
  - Minimum 3 meters width
  - Double direction of cycle flow
  - Limited slope
- Outside urban areas these routes are often towpaths along canals, old railway tracks or cycle tracks parallel to existing railways
- Inside urban areas these main routes are "bicycle corridors" with a high concentration of bicycle flows because of a high density of attraction poles (schools, dense living areas, office districts, …)
- The main routes are integrated into the overall cycle network; they do not make up a coherent network on their own.

main cycle routes – image source: T. Asperges

Top local routes

- The most logical (quick) connection between (sub)centers and districts
- Mostly along (busy) roads
- In most cases need for separated cycle lanes because of intensity and speed of motorized traffic
- If possible conflict free crossings with busy roads (traffic lights)
- When separation of conflicts is not possible, a lot of attention given to conflict presentation and speed reduction (speed tables, roundabouts…)
- The top local routes form a coherent cycle network on the regional or urban level

top local cycle routes - image source: T. Asperges

Local routes

- Routes to provide access to destination in districts and neighborhoods
- Refining the top local cycle network (minimizing the mesh width and detour factor)
- Mostly in traffic calming zones where separation of car traffic and cyclists is not always necessary and mixing is safe and convenient
- Emphasis on creating direct routes on local level: shortcuts, contra-flow cycling, cycling through pedestrianized areas…

local cycle routes – image source: T. Asperges

2.4.2 Common dedicated cycle facilities

Before going into detail on the decision of what cycling facilities are necessary in which conditions, we briefly present the most common cycling-specific facilities. This is not as straightforward as it may seem, especially since legal definitions vary among countries and terminology can be confusing.[3] Here we present a brief overview, but more detailed discussions can be found in the PRESTO fact sheets.

Cycle track

A cycle track is a dedicated facility for cyclists physically separated from motorized traffic, either by a gap (distance) or by being raised to a higher level (height).[4]

Legally, a cycle track is a part of the public road exclusively reserved for cyclists, indicated with a road sign. Riding or parking of motor vehicles on them is not allowed. Usually, they are mandatory: when a cycle track is available, cyclist are obliged to use it.

Cycle tracks are provided along connecting busy roads where the intensity and speed (over 50KM/h) of motorized traffic is too high to mix safely with cyclists. Cycle tracks are then the safest solution (safer than cycle lanes), because of the physical separation.

A disadvantage of cycle tracks is that cyclists are outside the direct field of vision of motorists. This becomes a problem where the car and bicycle encounter each other at intersections. At these points it is important to establish eye contact (conflict presentation) and in most cases it is advisable to bend in the cycle track towards the road before the intersection.

→ *more in the fact sheet on CYCLE TRACKS*

[3] Especially the notion 'cycle path' is used in various senses, and is thus avoided in the PRESTO guides and fact sheets.
[4] In UK usage they are called off-carriageway lanes


Cycle tracks – image source: T. Asperges

Cycle lane

A cycle lane is a space reserved for cyclists on the road, indicated by road markings and possibly colour or bicycle logos.

Legally, a cycle lane is a part of the public road exclusively reserved for cyclists. Riding or parking of motor vehicles on them is usually not allowed.

Cycle lanes are used along connecting roads where the intensity of motorized traffic is fairly low, but speed is still too high for mixing cyclists and cars. Cycle lanes are also used along urban busy roads, where space is lacking to build cycle tracks, although this is less safe. In these cases the speed of motorized traffic needs to be reduced to max 50 km/h. Attention should be paid to sufficient width and safety buffer distances from traffic and parked cars.

Cycle lanes are always marked with a double lane on the road, dashed or continuous according to national regulations. To make the cycle lane stand out more strongly, their surface is often colored in a striking hue such as red (NL), blue (DK) or green (F).

→ more in the fact sheet on CYCLE LANES


Cycle lanes – image source: T. Asperges

Advisory cycle lane

An advisory lane is a suggested space for cyclists on the road, created with road markings, surface such as bicycle symbols, arrows and chevrons (in some countries also called suggestion lane). Legally it is part of the carriageway which means that motorized traffic is obliged to ride on it and is allowed to park on it.

Actually, this is a form of mixing motorized traffic with cyclists. The advisory lane merely serves as an eye catcher to draw the attention of car drivers to the potential presence of cyclists and potential conflict points. It also serves to visually narrow the carriageway. In this way they are meant to influence drivers' behavior and induce more respect for cyclists.

Cycle suggestion lanes are used on (urban) streets where the intensity of motorized traffic is too high to completely mix road users. It can be an alternative in narrow streets where space for a cycle lane is lacking.

→ more in the fact sheet on CYCLE LANES

Advisory cycle lanes – image source: T. Asperges

Cycle street

A cycle street is a road so designed that cyclists dominate physically and visually, expressing visually that motorized traffic is tolerated as a guest. In practice they generally look like street-wide cycle tracks on which cars are allowed.

Actually, cycle streets are a form of mixed traffic without a specific legal status. Legally, cars are allowed as in an ordinary street, but the design strongly favours cyclists. Only in Germany do cycle streets have a legal status in the traffic code, as a street dedicated for cyclists on which cars are allowed.

Cycle streets are used in urban areas on routes with high intensities of cyclists and where motorized traffic still needs to have access. They should have a 30km/h speed limit and be used in residential streets with only local traffic. To improve speed and comfort cycle streets should have right of way at intersections.

→ more in the fact sheet on CYCLE STREETS

cycle streets – image source: Fietsberaad / German cycle street signage

2.4.3 Choosing design solutions

How to decide on the best design solution at a given location? Often, there will be different views and indeed no single ideal solution. Still, the decision should be based as much as possible on a number of clear criteria and guiding principles.

The decision depends on the following key factors.

- The function of the route, from main cycling route to local route
- The spatial environment, basically inside or outside the built-up area
- The overall traffic situation, essentially the intensity and speed of motorized traffic, related to the road function (connector road, distributor road, access road) and physical characteristics (available width, number of lanes etc.).

Basic principles

The following generally recognized basic guiding principles should be used a rule of thumb. [5]

OUTSIDE THE BUILT-UP AREA	INSIDE THE BUILT-UP AREA
ALWAYS strict **separation** of cyclists and motorized traffic.	**Mixing** as the default option **Separation** where necessary, because of high speed (> 50 km/h) and high intensity of motorized traffic
CONFLICT AVOIDANCE	**CONFLICT PRESENTATION**

[5] This is based on extensive Dutch experience and research, among other analysis of accident statistics. See CROW Record 85 - Design Manual fo bicycle traffic.

Outside the built-up area

Because of the speed differences between cyclists and motorized traffic the risk of conflicts and serious injury are too high for allowing them to share the same space. The starting point is then **conflict avoidance through separation**. Separated cycling facilities are always necessary to ensure safety. The specific type of cycling facility is closely linked to the road's function in the hierarchy and the speed restrictions.

The design manual for bicycle traffic in The Netherlands recommends to use separated facilities (cycle tracks) above 80 km/h. Up to 60 km/h the intensity of road traffic on a local cycle link may make mixing or cycle lanes an acceptable option.

The decision matrix below offers more detailed guidance[6].

				Cycle route function	
		Speed (km/h)	**Intensity (cars/day)**	**Basic network**	**Main cycle route (I_{cycle} > 2000 bikes/day)**
		n/a	0	Solitary track	
Road function	**Distributor road**	60	1-2.500	Mixed traffic or cycle suggestion lane	Cycle street, if I_{car} < 500 cars/day
			2.000 – 3.500	Advisory cycle lane or cycle lane	Cycle track
			> 3.000	Cycle track	
	Connector road	80	irrelevant	Separated cycle track	

[6] Adapted from CROW Record 85 – Design Manual for Bicycle Traffic. Speed limit values vary from country to country.

Inside the built-up area

Inside the more complex built-up area, it is clearly impossible always to separate users and to avoid conflict situations. Therefore the starting point in the built-up area is **conflict presentation**. Design the road and cycling facilities in such a way that all road users are visually alerted to potential conflict situations between different types of users. In practice this starting point means that cycling facilities are mixed where possible and separated where necessary.

Most links on the basic cycle network should run through quiet streets with a 30km/h speed limit. This is the safest situation all-round and requires no cycle-specific infrastructure. Mixing should be the default option. On busier roads and complex intersections, especially at high speeds and intensities separation must be preferred.

The decision matrix below offers more detailed guidance[7].

<table>
<tr><td colspan="4"></td><td colspan="3">Cycle route function</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Speed (km/h)</td><td rowspan="2">intensity (cars/day)</td><td colspan="2">Basic network</td><td>Main cycle route</td></tr>
<tr><td>($I_{bicycle}$ < 750/day)</td><td>($I_{bicycle}$ 500-2500/day)</td><td>($I_{bicycle}$> 2000/day)</td></tr>
<tr><td colspan="3"></td><td>Not applicable</td><td>0</td><td colspan="3">Solitary track</td></tr>
<tr><td rowspan="4">Function traffic road</td><td rowspan="2">Local access road</td><td colspan="2" rowspan="2">Walking space or 30 km/h</td><td>1 – 2.500</td><td colspan="2" rowspan="2">Mixed traffic (with or without advisory cycle lane)</td><td rowspan="3">Cycle street or cycle lane (with right of way)</td></tr>
<tr><td>2.000 - 5.000</td></tr>
<tr><td rowspan="2">Distributor road</td><td colspan="2">> 4.000</td><td colspan="2">Cycle track or cycle lane</td></tr>
<tr><td rowspan="2">50 km/h</td><td>2x1 lanes</td><td rowspan="3">not applicable</td><td colspan="3" rowspan="3">Cycle track (adjacent or separated)</td></tr>
<tr><td>2x2 lanes</td></tr>
<tr><td colspan="2">70 km/h</td></tr>
</table>

More ways of giving the advantage to cyclists

Inside built-up areas the cycle network should be as dense as possible with direct routes between departures and destinations. Going for a maximum mesh width of 200 to 250 m makes the bicycle strongly competitive on short distances. As space is scarce in built-up

[7] Adapted from CROW Record 85 – Design Manual for Bicycle Traffic. Speed limit values vary from country to country.

areas combining cycle traffic with other traffic modes is often the only option. Three solutions to benefits cyclist have become widely used in recent years and incorporated in many traffic codes. They can be rolled out quickly, easily and at low cost. Their effect will be multiplied when generalized, although safety conditions must be respected.

Contra-flow cycling in one-way streets. Allowing cyclists to use one-way streets in both directions is a very powerful way to increase the directness of cycle routes. One-way-routes create significant detours for cyclists and a contra-flow street is in effect a shortcut. The measure is widely used, and in some cases systematically applied. In Belgium it has legally become the default option, except when the road profile is too narrow.

→ more in the fact sheet on CONTRA-FLOW CYCLING

Bus/bike lanes. Below 30 km/h, cyclists and buses can mix. At higher speeds, however, they should be separated: the differences in mass, speed and braking distance make mixing unsafe. Ideally, cycle routes should be created away from bus routes. However, in cities with dense bus networks, this is not always possible. Moreover, buses are often stuck in traffic and to increase their flow and reduce their trip time, special bus lanes have become widespread. In recent years, bus/bike lanes are becoming more widespread. They are attractive for cyclists, because they also create the same shortcuts for cyclists and also allow them to jump the car queue. Safety, however, must be guaranteed. Buses should drive at less than 30 km/h and the lane should be wide enough for buses to overtake the cyclist. On longer stretches, buses will simply drive too fast for the cyclist's safety and comfort.
Bus/bike lanes should not be used as a way to avoid tough choices: a cycle lane or track are always safer and more comfortable, and can often be provided by taking out a traffic lane or a parking lane.

→ more in the fact sheet on BICYCLES AND BUSES

Advanced stop lines for cyclists. At traffic light intersections, an advanced stop line for cyclists creates a box space for them to wait in front of cars during the red phase. This way, cyclists are highly visible and they can safely turn left at the green light ahead of traffic. In addition, a lead-in cycle lane towards the advanced stop line allows them to jump the queue. This measure is useful where the speed difference between cars and cyclists is not too high (< 50 km/h). At complex and busy intersections, it is safer to separate cyclists from road traffic and to do the left turn in two steps.

→ more in the fact sheet on TRAFFIC LIGHT INTERSECTIONS

advisory lane, bus/bike lane, advanced stop line – image source: T. Asperges, D. Dufour

2.4.4 Cycle facilities at intersections

Over 70% of all cycle accidents resulting in lethal or serious injuries occur at intersections. Many of these accidents are caused by turning motor vehicles hitting bicycles going straight

ahead. At the same time, intersections have a strong impact on comfort and directness of cycle routes. This is why intersections and crossings in the cycle network need to be designed with special care: cyclists must be able to cross them or turn left and right safely, speedily and comfortably.

Once again, the design choice will depend on the function of the cycle route, the spatial context (inside our outside the built-up area) and speed and intensities of motorized traffic.

Safety is the overriding cycling requirement here. A general design rule for intersections is **presenting conflicts** clearly through simple, **self-explanatory design**.

- Visibility is crucial: cyclists should be as much as possible in the motorist's field of vision. A key recommendation for physically separated cycling tracks is to **bend in the cycle track** (closer to the carriageway) well in advance of the intersection.
- Also for safety reasons, **minimize speed difference**: speeds should be brought down as close as possible to cycling speeds of 20-30km/h.
- In addition **specific cycling provisions** can be applied, such as traffic islands, cycle stocking lanes, advanced stop-lines and cycle bypasses.

Directness is another key cycling issue at intersections. Delay caused at intersections strongly increases cycling journey time. The design and regulation should aim to **minimize waiting time**. Measures to be considered are: right of way for cyclists, central traffic islands, remote cyclist detection at traffic lights, short cycles or green waves at traffic lights, right-turning bypasses, and in general logical and direct routes across the intersection (avoid crossing in steps).

Finally, **comfort** is also at stake. This is mainly matter of respecting **curve radii** allowing cyclists to take turns easily, without having to slow down or being forced out of their path.

The table offers an overview of the three basic design solutions. Some key principles to keep in mind.

- A simple **right-of-way intersection** is the basic option on 30 km/h roads with mixed traffic.
- A **single-lane roundabout** is the safest solution when traffic is busier, because cyclists are inserted between slowed down cars. Multiple-lane roundabouts are much riskier and should be designed with a separate cycle track around it.
- **Traffic light intersections** are inherently risky and imply waiting time. However, they are indispensable on major roads with heavy traffic flows. Design should make cyclists clearly visible, allow short and easy maneuvers and reduce waiting time.
- **Grade-separated solutions** such as tunnels or bridges should be used to cross the busiest roads and bypass complex and dangerous intersections.

→ more in the fact sheet on RIGHT-OF-WAY INTERSECTIONS

→ more in the fact sheet on ROUNDABOUT INTERSECTIONS

→ more in the fact sheet on TRAFFIC-LIGHT INTERSECTIONS

→ more in the fact sheet on GRADE SEPARATION

Figure 11: Intersection types and issues for cyclists

Recommended intersection lay-outs	Scope / field of application	Cycling design criteria	Key design issues for cycling
RIGHT OF WAY INTERSECTION	Quiet roads, below 30 km/h or quiet 50 km/h roads All cycling routes Inside built-up area	Road intensities and cycling crossability Equivalent roads or roads with different levels of priority (corresponding signage and markings)	Cycle route has right of way, yields right of way, or is equivalent (priority-from-the-right default rule) Bending in or out Traffic island
ROUNDABOUT INTERSECTION	Moderately busy roads, at 50 km/h or more Moderately busy main routes, top local routes, local routes Inside and outside built-up area	Road hierarchy, intensities and capacity required Cycle track, cycle lane or mixed traffic	Single-lane or two-lane Size of roundabout Cycling bypass tracks Cycling tunnel
TRAFFIC LIGHT INTERSECTION **tcs (traffic control system)**	Busy roads at 50 km/h or more Busy main routes and top local routes Inside and outside built-up area	Cyclist flow capacity needed and desired waiting time	Signal regulation Cycle detection Advanced stop lines Turning lanes

Image sources: T. Asperges, Fietsberaad,

3 The standing bicycle

Bicycle parking has long been a neglected issue. We now realize that parking and storing are just as crucial as a cycle network to get and keep people on their bikes. Here we first look at the reasons for a bicycle parking policy and the need to distinguish between short-term parking and long-term storage. Then we consider the demand for parking at destination but also the demand for storage at or near homes. Finally, we give some brief indications of available products for parking and storage.

3.1 Why a bicycle parking policy?

One of the attractions of a bicycle is that it is a small and light vehicle, convenient to hop on and hop off and easy to dispose of. You can just lean it against a wall or stand it on its kickstand, and if you are worried about theft just attach it to a railing, a lamppost or a traffic sign. So do we really need bicycle parking facilities?

- The first issue involved is the risk of **bicycle theft**. Bicycle theft or the fear of theft and vandalism is one of the main obstacles for cycling. It reduces bicycle possession, bicycle use and bicycle quality. If you are too afraid that your bicycle may be stolen or vandalized, you will tend not to use it or not even buy one. Or you will use a cheap, old bicycle which is uncomfortable and possibly less safe. If, on the other hand, you can store your bicycle safely at night and if you are sure to find a comfortable and secure parking or storage space at any destination, this will encourage you to buy and use your own bike, or use that luxury tourist bike also for daily trips.
- The second issue is **managing large numbers of bicycles in public space, especially in the city center.** If there is not enough well-organised and secure parking provision, bicycles will stand or lie around anywhere, cluttering space, blocking pavements. They become a hazard for pedestrians and the mobility-impaired, and degrade the quality of public space. Such a situation ends up annoying cyclists themselves: if it is too difficult to park properly near the destination, potential cyclists will be discouraged. In any case, large numbers of bicycles are a sign of a healthy demand, an opportunity to be seized by providing quality parking and storage.

Basically, **a bicycle parking policy must be proportional to the number of current cyclists and the level of our ambitions.** When the number of cyclists is still low, not much is needed. But if we are serious about making cycling a major urban transport mode, we need to be able to satisfy rising demand. Cycle parking should be **integrated into overall parking policy and in planning processes**, in the same way as car parking.

An effective parking policy needs to address the following issues, developed below.

- The various needs of different users, basically the distinction between short-term parking and long-term storage.
- The level of demand generated by various urban destinations
- The specific challenges of storing bicycles at home in cramped urban dwellings
- The choice among types of available products.

3.2 Short-term parking and long-term storage

Cyclists are all individuals, and they may have different user demands and priorities. But, basically, they have two demands when leaving their bike behind.

- **Convenience**. When they arrive, cyclists like to leave their bike as near as possible to their destination. One of the strengths of cycling is its use as a door-to-door means of transport.
- **Security and protection**. When they return, cyclists like to get back their bike, preferably in mint condition: undamaged, clean, dry.

In practice, these demands soon turn out to be contradictory, difficult so satisfy both. Secure and protected parking and storage needs some level of concentration, which means a longer walking distance and a loss of time for the cyclist.

Also, the same cyclist will have different priorities at different moments. Much depends on the trip purpose and especially the **parking duration**. This is a fundamental of bicycle parking policy.

- **Short-term parking.** Proximity and speed are more important than a high level of security. Cyclists parking briefly, just to hop in and out of a shop or a post office, will want to park in front of their destination or as close as possible. Since their activity is so short, they will also want to minimize the time needed for parking. They will be happy with a basic level of security, since they are not prepared to lose time using a locker or walking to a guarded facility. Often they can keep an eye on the bicycle themselves.
- **Long-term storage.** A high level of security is more important than proximity and speed. Cyclists may leave their bicycles behind for hours, a day or a night. They may use their bike to drive to or from public transport, possibly for daily commuting. Or they simply need to have a secure place for it at or near their home or work. Since they cannot check their bicycles for a long time, they demand a high level of security and protection: sheltered or indoor storage, preferably locked, supervised or controlled. And compared to their long period of absence, those extra minutes to walk to storage facilities or to operate a locker are worth it.

We can easily link this to types of origins and destination, their various users and their trip motives to assess the type of parking provision needed, as summed up in the table below.

Figure 12: Function, duration and type of bicycle parking

			PARKING DURATION			
			Short / daytime (< 1 hour)	Between short and long	Long / daytime (> 6 hours)	Long overnight
		Type of parking provision	***reserved space in public area***	***stands or racks in public area***	***sheltered secured or supervised storage***	***indoor secured or guarded storage***
ORIGIN – DESTINATION	Residence					
	Public transport hub (railway, bus)	Pre trip				
		After trip				
	School	Students and teachers				
		Visitors				
	Companies	Employees				
		Visitors				
	Shopping	Employees				
		Visitors				
	Entertainment / leisure	Employees				
		Visitors				
	Visits (at home)					

Clearly, city centers will need a mix of provision to satisfy the need for short-term parking as well as long-term storage. By way of indication, city centers of mid-sized Dutch cities average a balance of around **40 % bicycle parking space without stands or racks, around 40% unguarded bicycle stands and racks and around 20% guarded bicycle parking and storage**[8].

Of course, the choice of provision will also depend on policy priorities. Some examples.

- A city council may want to have bicycle-free shopping streets. In that case, they want to have as few individually parked bicycles on the street as possible and incite cyclists to use properly organized parking provision. They will need to provide large numbers of bicycle stands at short distances from each, since shoppers will not walk far. A centralized cycling storage facility some distance from the shops is unlikely to work.
- A city council first of all wants to cope with bicycle theft and vandalism. In that case, the key will be to provide enough guarded parking provision, either individual lockers or supervised collective storage.

→ *more in the fact sheet on BICYCLE PARKING IN THE CITY CENTRE*

[8] Leidraad fietsparkeren, CROW-158

3.3 Parking demand levels

Once we know the type of cycle parking required, we need to quantify the demand and to estimate the capacity needed and at which locations: how many bicycles must we provide room for and where exactly?

Public space: mapping supply and demand

In STARTER CLIMBING CITIES, as long as the number of cyclists is low, they will find a way of securing their bicycles to urban furniture. Reserved spaces, stands or racks can be put in near major destinations and in the busiest areas. As soon as the number of cyclists begins to rise, we can observe what provision is well-used, over-used or underused and that in some places loose bicycles are piling up. We can try and adjust things with a trial-and-error approach, but **systematic planning and monitoring** will become more effective.

The techniques to assess car parking demand are well-tried and they can easily be adapted to cycling. The basic approach is **mapping the supply-and-demand balance.** In a well-defined area in a typical period current supply is weighed against current and potential future demand. The exact location is crucial: you may well provide the right type and number of parking facilities, but if they are too far from where they are needed, they will simply not be used.

This typically involves four steps.

- Step 1: count the current supply of bicycle parking facilities, indicating them on a map, subdivided in meaningful subareas or street sections.
- Step 2: count the current demand of bicycle parking. How many bicycles are parked now and what is the occupancy rate? A simple rule of thumb: as soon as the occupancy rate in bicycle racks and guarded bicycle parking is over 80% there is a lack of bicycle parking facilities.
- Step 3: detect and count the number of stray bicycles (abandoned) that uselessly block parking capacity
- Step 4: estimate future demand for bicycle parking, based on new development, knowledge on travel behavior in the city centre and the cyclists' profile.

A **survey among cyclists** is useful to assess future demand. Especially the demand for supervised storage strongly depends on the user profile: their age, the frequency of their visits, the duration of their stay and the quality of their bicycles. We know that supervised storage will be more used by owners of new and expensive bicycles, by elderly people, by occasional visitors and by long-term visitors. A survey can also access willingness to pay.

Experience indicates that **free supervised storage** can have a strong magnet effect. Secure storage free of cost attracts a lot of people who did not cycle before. Also, because it saves time checking in and out and paying, it attracts more short-term parking cyclists.

New developments: minimum targets

Cities and especially city centers have a mix of urban functions. If we want to incite inhabitants, workers and visitors to use the bicycle, we must provide sufficient parking opportunities **inside, on private ground or near entrances of buildings and functions**. New developments should take the bicycle parking needs into account. **Minimum target figures** for bicycle parking and storage should be included in building regulations as mandatory provision. The figures should be related to the potential modal share of cycling

for each specific function. The table below shows typical figures, in this case from the building code of the city of Antwerp[9].

Figure 13: Minimum targets of number of bicycle parking in new developments and renovations

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="4">New construction and renovation</td></tr>
<tr><td colspan="2">Dwellers:
Indoor / secured (space for 1 bicycle parking facility > 1,5 m²)</td><td colspan="2">Employees and students: Secured, lockable racks on private grounds.</td><td>Short-stay visitors:
Bicycle stand or rack</td></tr>
<tr><td colspan="2">Housing</td><td colspan="2">Min 1 + 1 per bedroom</td><td colspan="2">-</td><td>- (in exceptional cases)</td></tr>
<tr><td colspan="2">Offices, companies, hotels</td><td colspan="2" rowspan="4">-</td><td colspan="2" rowspan="4">1 per (extra) 75m² or 1 per 3 employees</td><td>- (in exceptional cases)</td></tr>
<tr><td colspan="2">Shopping areas (stores, restaurants, retail)</td><td rowspan="2">30 per 100 visitors</td></tr>
<tr><td colspan="2">Sport centers, leisure / entertainment</td></tr>
<tr><td colspan="2">Care institutions</td><td>15 per 100 visitors</td></tr>
<tr><td rowspan="4">Educational institutions</td><td>Childhood /Kindergarten</td><td rowspan="4">-</td><td rowspan="4">1 per 3 employees</td><td>20 per 100 children</td><td>-</td></tr>
<tr><td>Primary school</td><td>30 per 100 students</td><td>-</td></tr>
<tr><td>Secondary school</td><td>50 per 100 students</td><td>-</td></tr>
<tr><td>Higher education</td><td>50 per 100 students</td><td>-</td></tr>
</table>

The Vienna Bike City project demonstrates that a lot more than minimum provision is possible. This housing estate especially targets the special needs of cyclists. Specific features are e.g. extra-large elevators, a bike-service-centre as well as secured bicycle parking spaces. But also limited parking spaces for private cars are characteristic for the Bike-City.

Image source: Fietsberaad (NL)

[9] Source: Bicycle parking plan city of Antwerp, February 2009

3.4 Storing in residential areas

Fairly recently, it has become clear that storing bicycles at or near the home is a crucial issue. In many older urban areas and often also in new developments family houses and apartments simply do not have the storage room to accommodate one or more bicycles. This may be an important factor explaining low bicycle ownership rates. Leaving a bicycle parked outside all night is obviously not very reassuring, while storing it in a hallway or a cellar is far from convenient.

Providing secure and comfortable residential storage in these areas is vital to develop the cycling potential. Data on available storage facilities or surveys can help to determine latent demand. An alternative is a demand-led approach: make an offer available to neighbourhoods and invite residents to claim provision in their area.

Here are two common solutions.

- **Neighbourhood storage facilities**. Space can be found inside buildings or enclosed areas where a number of residents can store their bicycles collectively. Generally, they will be attractive within a 150 m radius, and access should be restricted to users.
- **On-street bicycle drums**. Small collective lockers for 5 to 8 bicycles can be provided in various places. Bicycle drums are the size of a car, so they can simply be installed on a car-parking space.

For both, users generally pay a yearly rent, but local authorities can decide on the level of public funding. The facility can be run on a community basis, by the authorities, the public parking agency, or a commercial service provider or a mix of those.

Image source: T. Asperges, groenerik.files.wordpress.com

In Europe, **public bicycle schemes** are becoming increasingly popular. They are another answer to the lack of parking space at homes or at destinations, and an incentive to bicycle use. But this is fundamentally different from neighbourhood storage. Public bicycles are fee-based (although often the first half hour is free) and are not door-to-door but station-to-station. To be really attractive and flexible, a sufficient density and coverage of bicycle stations is needed: then you can pick up a bike near any place and be sure to find a place to drop it off at any destination. However, regular daily cyclists will want and need their own bicycle to fit all their various transport needs at any time and any place. Public bicycles can be a useful complement to a bicycle parking policy but not a substitute.

→ more in the fact sheet on BICYCLE PARKING IN RESIDENTIAL AREAS

3.5 Bicycle parking and storage solutions

The market offers a wide range of products for bicycle parking and storage. There are broadly two groups:

- **Bicycle parking systems** are structures that you can lean a bicycle against or in and most often attach to. This includes various types of stands and racks, for a single bicycle or for several, with a bolt locking system or not.
- **Bicycle storage facilities** are protected spaces for storing a bicycle. This includes individual and collective lockers, as well as cycle centers. They may be supervised or not, automated or not, free or paying. In the larger ones, bicycles will be stored in parking systems.

The most common and effective bicycle parking systems are those to lean the bike against and allowing to secure it with a lock. The universal **inverted U-shaped bar** has proven its qualities: it is stable, compatible with all types of bikes, compatible with all kinds of locks, easy to use, robust, easy to maintain and easily integrated in public space (on squares, on pavement extensions, on a car parking space). To be avoided at all cost are the so-called paperclip racks that only squeeze the front wheel and risk damaging the bicycle.

Pictures – recommended U-shaped bars and to be avoided paper-clip racks – T. Asperges

Cyclists request bicycle storage facilities when they park their bicycle for a longer time (> 1 hour). We can distinguish three main types, each with its own specific uses.

- **Individual bicycle lockers** are used in situations calling for individual protection against bicycle theft and vandalism, but where the demand is too low to create a supervised storage facility (e.g. small railway stations, park & bikes near city centers). The cost of an individual locker lies somewhere around 1.000 €.
- A **collective bicycle locker** can contain a number of bicycles. Each user has a key. The most important advantage of the collective locker is that it takes up considerably less space for the same number of bicycles than individual lockers. A specific type is the bicycle drum used in urban neighbourhoods (mentioned above).
- **Supervised storage** is worthwhile at destinations with large number of cyclists (e.g. main railway stations), a high rate of long-term parking and a high risk of bicycle theft. Railway stations are typical examples, but also large events, which may require temporary or mobile supervised storage.

individual locker (city of Brugge)

'Bicycle point' at railway station Leuven, Belgium – T. Asperges

Supervised bicycle storage facility at Amsterdam-South – NS fiets

Recently there has been a trend away from manned to **unmanned automated storage facilities**. Automation is used in manned facilities for checking in and out and in the form of surveillance cameras. But fully automated facilities are becoming more frequent. Saving on personnel cost is an obvious reason. But in the absence of a human presence, special care needs to be given to personal security in terms of visibility and lighting.

Even more innovative are the **fully-automated on-street storage systems**, such as BikeTree, Bicycle Mill and Biceberg. Cyclists can feed their bike into a rotating elevator system that stores bikes underground. These take up limited room in public squares, but the time for handling the bikes may be rather long.

unmanned supervised storage facilities at Dutch railway stations – NS fiets

→ more in the fact sheet on BICYCLE PARKING AND STORAGE SOLUTIONS

4 Cycling and public transport

Cycling is first of all a transport mode for short distances. But it can play a significant part in longer trips as well, as a feeder mode for public transport. Here we will consider the intermodal connections between cycling and public transport, the infrastructure to facilitate this and the issue of carrying bicycles on public transport.

4.1 Cycling as public-transport feeder

A key aim of any sustainable transport policy is to shift trips away from cars to public transport. A key obstacle to using public transport is that it is not a door-to-door-mode. A long-distance train journey implies walking or extra bus or tram journeys at the start and the end of the trip chain. Even within urban areas, walking, waiting and changing one or more times can be quite discouraging.

Combining the bicycle and public transport in one journey is a **high-potential intermodal trip chain**. Using the bicycle to drive from home to the station or from the station to your destination can greatly simplify the trip and often save time. You can use your own bicycle to start from home and park it near the station. Perhaps you can take it along on public transport, ready for use at the other end. Or else, you may have a bicycle waiting for you at your arrival, either your own, a rented one or one provided by your employer. This s also a benefit for public transport operators: compared to walking, cycling multiplies the catchment area of public transport stops or stations.

Data on the use of feeder modes are hard to find, but some numbers illustrate the potential of the bicycle-public-transport intermodal trip chain. In the Flemish region of Belgium 22% of all trips to the station are made by bicycle. In the Netherlands the bicycle is used for as much as 39% of all trips to the station.

4.2 Cycling facilities at public transport interchanges

To make this combination attractive, public transport operators are increasingly investing in high-quality bicycle parking facilities at major public transport hubs.

Essential is the provision of high-quality parking and storage facilities. As bicycles are parked for a long time (> 2 hours) at public transport stops the user demands are high with regard to safety and protection.

The mix of parking provision should be adapted to each public transport location.

- A basic provision of stands and racks is recommended, ideally covered and protected from the weather.
- As numbers increase, some rented lockers can be offered as a premium service.
- At even larger numbers, collective storage should be considered on a subscription basis.
- At the largest hubs, free indoor and supervised parking storage becomes feasible.

Cycle parking should be **standard equipment for all urban train stations**. The provision should be designed for **smooth bicycle-train interchange**: located on a logical access route, at a short walking distance from platforms, wide opening times, easy to access.

A recent evolution is the creation of **bicycle stations**, which originated in the Netherlands and Germany. A bicycle station is a major railway station, equipped with a large-scale high-quality bicycle storage facility, combined with a range of bicycle services. Services can

include anything from bicycle repair and rental of accessories to showers and cycling information. By combining these services the supervising personnel can do additional tasks and at the same time offer a higher service level to cyclists.

Bicycle station Basel – Switzerland – city of Basel - B. Auer.

Bicycle repair shop at bicycle station Leuven – T. Asperges

Cycle parking provision also makes sense at **stops of major urban public transport routes**, such as metro and light-rail stations, fast tram or bus routes or BRT. Cycling may also be a feeder mode for regional coach services and terminal buses at the edge of the urban area. For local bus lines and in smaller cities, cycling will be more of a substitute for public transport than a complement, since there are more frequent stops and distances are shorter.

Having a **bicycle for the last lap**, to go from the station to your final destination, is also quite attractive. For regular trips, you can have a bicycle at destination. Commuters, for instance, can easily come in by train, pick up a bicycle (their own or a company bicycle) from storage and put it back for the night when they go home. For occasional trips, rental or public bikes offer possibilities.

Quite unique is the Dutch OV-fiets service. This is a nationwide bike rental service available to train season-ticket holders. At 185 locations all over the Netherlands, they can pick up a bike using their train smart card. They pay a yearly subscription (€ 9.50) and a fee for each single trip (€ 2.85 for 20 hours).

OV-Fiets - The Netherlands, NS-fie

→ more in the fact sheet on CYCLING FACILITIES AT INTERCHANGES

4.3 Carrying bicycles on public transport

Another option is to allow cyclists to carry their bicycles with them on public transport. The obvious advantage is that cyclists have their bicycle with them from door-to-door. But there is an **inherently limited potential** since this is only feasible with small numbers of cyclists.

- Bicycles take up space and may cause overcrowding
- Loading and unloading the bicycle takes time for all passengers.
- Bicycles on-board can be a safety hazard, if they are not securely attached.

For these reasons, carrying bicycles on public transport is best restricted to situations where demand is low and spare space available: off-peak hours, recreational trips and trips outside urban areas.

- In most European countries, bicycles are usually allowed at **off-peak hours** only, roughly from 9 a.m. until 4 p.m. and then again from 6 or 7 p.m. onwards. Sometimes, bikes are allowed only during the evening rush hour, when traffic is less dense than in the morning. (Check the table below.) Even then, there is a 'self-regulating' effect: people will not take their bicycle into overcrowded buses and metros.

Table 2: Time restrictions for taking bicycle on public transport at some PT operators

	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brussels, Belgium														
Lille, France														
NordRheinWestfalen: AVV, Germany														
NordRheinWestfalen: VRS, Germany														
NordRheinWestfalen: VRR, Germany														
Rotterdam (metro), the Netherlands														
London metro, UK														

Source: Paper bikes on public transport, Velo-city 2009 conference

- Some public transport operators actively support carrying bicycles along on **recreational trips or tourist tours** at weekends or in the holiday season.

- Carrying bicycles has an interest on **long distance travel outside urban areas**. Stops are few and far between and halting times are longer. There is, however, no cross-border harmonization on long-distance coaches.

Folding bicycles are increasingly carried on public transport. Since they only take up the space of a small suitcase, they should generally be allowed. Still, on some crowded railway connections they have been banned: too many folded bicycles were compromising the comfort of travellers.

There are several systems and mechanisms for carrying bikes on public transport. With some, there is a space for bicycles but no specific system to attach them and the bike has to be held by hand. Inside vehicles, bicycles can either be attached horizontally or vertically, with hooks or belts. In still other systems, the bicycle is attached on the outside of the vehicle, be it at the front or at the back, or there can be a separate trailer.

Free-standing bicycle

Bicycle rack in front of bus in the United States – not allowed in Europe

Bicycle rack in the bus - Chambéry

Bicycle rack at the back of the bus – The Loire - France

Bicycle rack at the back + bicycle trailer - Switzerland

5 The PRESTO fact sheets on infrastructure

This Policy Guide is accompanied by 15 fact sheets on cycling infrastructure.

Status: state of the art recommendations

- The fact sheets offer practical guidelines on how to select appropriate cycling infrastructure measures and how to implement them successfully.
- The recommendations represent a digest of state-of-the-art practice and knowledge. They are based on the most internationally renowned design guides, derived from best practice experience and research (see bibliography below).
- The fact sheets offer broadly recognized basic principles, rules of thumb and quantitative indications (intensities, dimensions etc.). They should not be considered as final normative truths, but be handled with care and intelligently applied to specific situations and constraints.
- A special effort has been made to assure the internal coherence of the fact sheets (including cross-references) and to the general framework developed in this policy guide.

Contents: selection criteria, technical design, wider context

- For each measure, the fact sheet address selection criteria such as its function within a network (what is it meant to do), its scope (when and where can it be applied), its uses and abuses, its strengths and weaknesses, its alternatives.
- The fact sheets offer extensive guidelines on technical design and implementation.
- The fact sheets also mention relevant wider issues of traffic management, urban design and land-use planning.
- The fact sheets are illustrated by means of photographs, diagrams and practices from various European cities.

Perspective: for starters, climbers and champions.

- The state-of-the art design guidance does not compromise on quality. The recommendations correspond to best practice in champion cities and countries, with high levels of cycling and long traditions in cycling policy.
- However, the recommendations also take into account the perspective of starter and climber cities, where cycling is still limited and needs to be stimulated by emerging cycling policy. In particular, the specific needs involved in retrofitting existing urban street networks for cycling have been duly considered.

Caveats

- Underlying principles are more important than numbers. Quantitative indications (intensity thresholds, speed limits, dimensions) are cited from the authoritative CROW design guide (unless mentioned otherwise) and have been cross-checked with the other sources.
- Take into account that legal design requirements vary between countries. This has been pointed out wherever possible.
- Take into account that road categories and speed limits vary between countries. Mentions here are based on Dutch practice and the reader needs to transpose them to

local practice. Within the built-up area, the 50/30 km/h speed limits are fairly standard; outside the built-up area speeds vary between (60/80, 70/90 km/h etc.).

- Speed limits can be unreliable. If actual speeds do not correspond with legal limits, design should be guided by actual speeds, for safety reasons. The 85th speed percentile (V85) is a widely accepted guideline.
- Cycling intensities are an important criterion for design. These can be current intensities (existing demand). They may also be used as predicted intensities on links within the planned network, based on estimates of potential demand.
- Photographs are meant to illustrate best practice on one specific topic. They may include other elements that may not always be good practice.

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