Output T2.1

Best practice bicycle safety improvement fact sheets

Output	T2.1
Work package:	T2 Best practice analysis
Activity based on:	A.T2.1 Analysis of collected data from cycle route infrastructure assessments A.T2.2 Desk research on available knowledge on best practices in providing and assessing cycle route safety A.T2.3 Stakeholder consultation
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Status (F – final, D – draft, RD – revised draft):	F
Version:	1.0
File name:	20211216_SABRINA Output T2.1. v1.0
Issue date:	16.12. 2021

Table of Contents

Preamble

This document comprises a set of **30 fact sheets** which summarise the key findings of SABRINA's WP T2 (Best practice analysis) and makes them accessible in an easily accessible format to the target audiences, i.e., stakeholders, experts, and decision-makers from the road safety field, in the whole Danube region. They are divided in three groups as follows:

- Typical cycling **infrastructure risks**
- Cycling infrastructure **countermeasures and development or improvement strategies** ("solutions")
- **Environmental, health, and other not directly safety related aspects** of cycling and the development of infrastructure ("positive effects")

All fact sheets contain an **introductory summary**, a **collection of evidence** such as from international research, EU projects (INTERREG and Horizon programmes) and intermediate SABRINA results, easily accessible **recommendations for application**, representative **pictures** and a list of **references** for further information.

The set of fact sheets is closely aligned with SABRINA's Outputs T2.2 (Recommendation for implementation of best practices) and T2.3 (National Consultations). They inform Output T3.1 (Safe Cycling Routes Toolkit); the findings, measures and recommendations will be integrated in the Safer Cycling Routes Toolkit decision making algorithm.

Risks

RISKS

Network Issues

Overview

Discontinuous bicycle facilities on cycle routes and a **low directness and connectivity** of cycling network routes, i.e., incomplete cycling network, can disfavour bicycling and might lead to conflicts due to **unsafe or uncomfortable conditions**. Sudden endings of bicycle facilities can be dangerous for cyclists in particular, especially at occasions where the cycling facility ends on the left-hand side of the road with a **large distance to crossing intersections** and **high traffic volume** and cyclists have to cross the road. Another example is when such endings encourage **detours in unsafe conditions** or **risky manoeuvres** of cyclists when crossing the road. Accurate numbers of accidents in which cycle network issues have led to accidents are scarce, but studies indicate that an incomplete cycle network is one of the main factors that discourage people from cycling.

What is the problem and where does it occur?

Discontinuous bicycle facilities on cycle routes are problematic for cyclists as they can not only **deter people from cycling** but might also **lead to conflicts** [2]. Such discontinuities in bicycle networks can comprise **sudden endings of cycle paths or on-street bicycle lanes** but also **segments that are not accessible by bicycles** and where cyclists must dismount from the bike to get along the route, i.e., stairs at bridges and underpasses or pedestrian zones with cycling bans. Such route inconsistencies **reduce comfort and directness for cyclists** and can easily **discourage them** [7].

Especially sudden endings of bicycle facilities are **negatively perceived by cyclists** and can be **dangerous**, in particular at instances where **on-street bicycle lanes end and cyclists are forced to merge with motor vehicle traffic** as well as when the cycling facility ends on the **left-hand side** of the road with **a large distance to crossings or intersections** and **high traffic volume**, and cyclists have to cross the road [2, 3, 11].

What causes the problem?

Many studies emphasise the importance of a continuous bicycle infrastructure and a high connectivity of cycling network routes for safe and comfortable cycling [e.g. 1, 2, 6, 10]. Cyclists prefer direct routes with continuous cycling facilities and without segments where they have to dismount from their bicycles to get long the routes [1, 7,11].

Since cyclists prefer to ride on a continuous cycling facility, **interruptions** such as **frequent changes in cycling facility type** and **interruptions in the infrastructure along the cyclist's path**, i.e., a physically separated cycling facility turning into a designated roadway, result in increased mental workload, changes in stress and safety level [4]. In addition, a **low directness and connectivity** of cycling network routes, i.e., incomplete cycling networks, can also disfavour bicycling, as routes without direct connections or which include road segments that are not or only poorly accessible for bicycles, i.e., **stairs or pedestrian zones**, might result in **detours and longer trips or an increased travel time** [1, 9]. This can also lead to **riding in unsafe or uncomfortable conditions**, e.g., detours on roads without bicycle infrastructure to avoid dismounting at pedestrian paths on the route, or to **cyclists doing risky manoeuvres when crossing busy streets**, e.g., to avoid underpasses which are not or only poorly accessible for bicycles due to stairs [9].

What is the size of the problem?

Exact numbers on accidents in which bicycle network issues like discontinuous bicycle facilities or a low connectivity of cycling network routes were a contributory factor are hardly available. However, these issues have **negative impacts on cycling levels**: For Perth, Australia, based on a survey with 2.828 participants, [5] reports that 43% of the participants stated that the sudden end of the bike paths **stopped them from cycling more often –** the second highest share among the aspects mentioned in the survey. In addition, [8] conducted a survey on barriers for cycling in Vienna and indicate that an **incomplete cycle network** was mentioned as the **main barrier for cycling** by the survey participants.

Examples

Sudden end of cycle path at EuroVelo 8, Croatia

Poorly accessible underpass due to stairs at EuroVelo 9, Austria

Related solution fact sheet

- Strategies
- Planning principles
- Overpasses and underpasses
- Organisational measures

References and links

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RISKS

Narrow Infrastructure

Overview

Too narrow bicycle infrastructure and insufficient space between bicycle infrastructures and curb-side parked cars can cause **dooring collisions** and impose **safety risks** for cyclists. Cyclists are at risk of **frontal collisions** with **oncoming cyclists** and collisions with **vehicle doors** as well as collisions with **other vehicles**. This can happen when cyclists **swerve** to avoid a collision with opening vehicle doors and end up in the path of oncoming traffic or when vehicles overtake cyclists with **insufficient safety distance**. These issues are particularly prevalent in **urban areas** as well as at **bridges and underpasses** where there is usually limited space for the implementation of cycling infrastructure. Bicycle crashes due to narrow infrastructure and dooring are a **common phenomenon** and especially in urban areas a significant proportion of bicycle accidents are dooring collisions.

What is the problem and where does it occur?

Many countries' bicycle manuals suggest specific minimum widths for uni- and bidirectional cycle paths as well as specific distances to curb-side parked cars. However, especially **urban areas, bridges and underpasses** provide challenges due to **limitations of space**, resulting in too narrow cycling facilities and insufficient space between the bicycle infrastructure and curb-side parked cars [2]. Bicycle infrastructure that is too narrow or too close to the door zone of parked cars represent **safety risks** for cyclists and can easily dissuade them from their path [5, 10]. Hitting the sharp edge of the vehicle's door or possibly breaking the window glass can result in **cutting injury** and often cause the cyclists to fall which produces injuries due to a **collision with the asphalt** [6]. However, injuries not only result from direct impacts with the vehicle's door, but also by **pushing the cyclists into the path of oncoming traffic** [3]. The latter may also occur if the cyclist swerves suddenly to avoid a collision. These incidents can be **fatal** [6].

Narrow bicycle infrastructure is **particularly problematic** with **high speeds, contra-flow traffic** and a **high volume of cyclists** as it does not allow safe passing and overtaking of cyclists and can cause **frontal crashes** between cyclists because of insufficient space between directional driving and oncoming cyclists [4]. In addition, especially in curves, too narrow bicycle infrastructure also might impose **visibility issues**. Another problem that occurs at narrow bike lanes and advisory lanes in narrow streets in particular, are vehicles overtaking cyclists with **insufficient safety distance**.

What causes the problem?

Narrow bicycle infrastructure or bicycle infrastructure that is located too near to curb-side parked cars is typically caused by **limitations of space**, i.e., road authorities lack space to provide the required widths & distances for bicycle infrastructures. However, too narrow infrastructure can also be a **planning and projecting issue**, when bicycle infrastructure is planned too narrow with regard to the volume of cyclists, even if there would have been enough space, or when in countries with lower volumes of cyclists, unidirectional cycle paths are converted to **bidirectional cycle paths** [4].

What is the size of the problem?

Exact numbers of bicycle accidents that are caused by narrow infrastructure are hardly available. However, for the Netherlands van der [9] – based on data of 148 bicycle-bicycle accidents from hospitalised bicycle victims – report that 18% were accidents in which handlebars of the bicycles hit each other and 11% were collisions with oncoming bicyclists, indicating that **accidents between cyclists** can often be **attributed to limited width of bicycle infrastructure**. Moreover, in particular in urban areas, dooring collisions caused by **insufficient space between the bicycle infrastructure and curb-side parked cars** account for a high share of accidents, and for some cities in North America such collisions are even among the **most common collisions** between bicyclists and motor vehicles [1]. In Vienna, 12% of all cycling accidents in 2015 involving personal injury were dooring collisions [8].

In addition, for Germany, [7] analysed cyclist accidents at mandatory and advisory cycle lanes and indicate that stretches of **road with narrow mandatory** (under 1.85 m) and **advisory** (under 1.5 m) **cycles lanes** had **higher accidents rates** than stretches with wider cycle lanes and that the accident density on stretches of road with advisory cycle lanes **with adjacent parking** was almost **four times as high** as for advisory cycle lanes without.

Examples

Too narrow bicycle infrastructure at an underpass on the EuroVelo 9, Austria

Curb-side parked cars too near to bicycle infrastructure on the EuroVelo 6, Austria

Related solution fact sheet

- Strategies
- Planning principles
- Junctions and crossings
- Roundabouts
- Overpasses and underpasses
- Types of facilities: mixed with motorised traffic and/or pedestrians
- Separated cycling paths

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RISKS

Speed differences in mixed spaces with pedestrians, E-Scooters etc.

Overview

Speed differences between cyclists and pedestrians impose safety risks especially in areas where both **share the same space**, i.e. mixed spaces, and can lead to **serious injuries** in particular for pedestrians. Such conflicts typically occur in mixed spaces in **dense, urban environments** or near **tourist attractions**. Studies indicate that a considerable proportion of accidents and conflicts between pedestrians and cyclists appear on shared pedestrian and bicycle paths.

What is the problem and where does it occur?

Mixed spaces of cyclists and pedestrians are common in **car free zones in historic parts of urban areas**, along **boulevards** and on **promenades** along rivers, lakes or at the seaside [1]. However, the **speed differences** between people walking and cycling often lead to feelings of **discomfort**, **conflicts** or even **collisions** in these zones. Mixed spaces are **problematic** in particular, with **high speeds of cyclists** and **high volumes of pedestrians** [7]. This is typically apparent in **dense, urban environments** or near touristic attractions.

In addition, the increasing different new forms of **micromobility**, e.g. e-scooters, but also **pedelecs** lead to a **further heterogenity in speed differences** between the different transport modes (also in relation to conventional bicycles) and **increase safety risks** in mixed spaces.

What causes the problem?

Conflicts among cyclists and pedestrians in mixed spaces are mainly caused by the speed differential between cyclists and pedestrians. This speed differential translates to **substantial differences in kinetic energy** and could **increase injury risk** in case of a collision [4]. Conflicts and collisions due to these speed differences in particular arise with **excessive speeds by cyclists** (e.g. in downhill direction), **high pedestrian density** and **inattention by both cyclists and pedestrians** [2, 6, 9]. Such collisions can lead to serious injury and even death, with pedestrians usually more seriously injured, especially **when the pedestrian's head strikes the ground** [10].

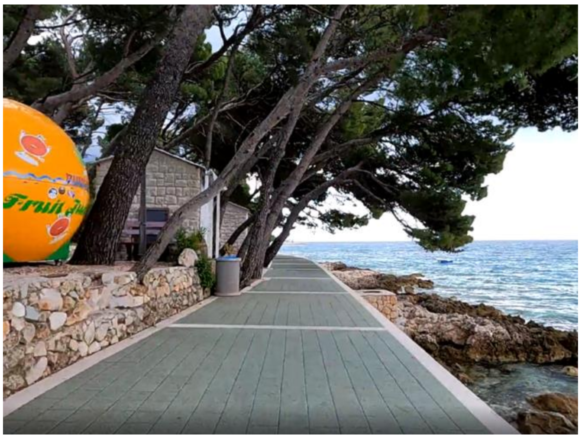
Moreover, **bicycles with electric assistance** increase speed differences to pedestrians, further increasing the kinetic energy that is released in a collision and thus **increasing injury risk** [3]. In the last years, **e-scooters** that are also apparent in mixed spaces and on bicycle infrastructure further increased safety risk because of **increased traffic volumes** and a **further heterogeneity in speeds** [8].

What is the size of the problem?

Specific numbers of conflicts and collisions between cyclists and pedestrians in mixed spaces are hardly available. However, for Australia [5], based on data of 202 injured cyclists from emergency departments report that 36.1% of the cyclists – the **second highest share** – had **crashed on shared pedestrian and bicycle paths**. In addition, based on data from an online survey of 1,046 inhabitants of cities in Finland with regard to experienced conflicts between pedestrians and cyclists, [10] report that **most of the reported** near accidents (40.8%) occurred on **shared pedestrians and bicycle paths**. Both studies indicate that mixed spaces of cyclists and pedestrians and the existing speed differences between both modes in these areas **often lead to conflicts** and **collisions**.

Examples

Conflicts between cyclists and pedestrians at a mixed space on the EuroVelo 14, Austria



Mixed space of cyclists and pedestrians on the EuroVelo 8 in Croatia, typically with conflicts between walking and cycling tourists during summer

Related solution fact sheet

- Strategies
- Planning principles
- Overpasses and underpasses

- Types of facilities: Mixed with motorized traffic and/or pedestrians
- Separated cycling paths
- Organisational measures

References and links

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RISKS

Speed differences in mixed spaces with motorised traffic

Overview

In mixed spaces for bicyclists and motor vehicles the **speed differences** between the two transport modes can lead to **safety risks** especially in **passing manoeuvres**. This is particularly problematic at **rural roads** with **higher posted speed limits** where motor vehicles travel faster, and speed differences are relatively high. Collisions at these occasions often result in **serious injuries** and even **death** for cyclists. It is indicated that a **considerable share** of accidents between bicyclists and motor vehicles **occurs in mixed spaces** and that these accidents can often be attributed to **drivers violating overtaking rules**.

What is the problem and where does it occur?

At roads with no specific bicycle infrastructure cyclists are forced to share the road and interact with motorised vehicles. However, the **speed differentials** between motor vehicles and cyclists but also those in **weight** lead to **safety risks** for cyclists especially in **passing manoeuvres** that can result in serious injuries and **even death of the cyclists** in case of a collision [8]. Moreover, **risk perception** of cyclists is especially high with **dense traffic**, **high speeds of motor vehicles** as well as a **high volume of heavy goods vehicles** present [6]. Higher speed differences are **typically apparent** at **mixed road sections** and **outside built-up areas** where the posted **speed limit is higher,** and drivers of motor vehicles travel considerably faster than cyclists [1].

What causes the problem?

Mixed spaces of cyclists and motor vehicles impose safety risks especially at occasions where the difference between the travelling speed of motor vehicles and cyclists is high, e.g. at **rural roads** when **no adequate bicycle infrastructure** is implemented and cyclists are forced to ride on the driveway. Because of the speed differences (and differences in weight) between motor vehicles and bicyclists that translate to **substantial differences in kinetic energy**, interferences between the two transport modes in the same roads can lead to **serious injuries** if a collision occurs [1]. The **difference between the speed** of motor vehicles and the speed of bicycles is **positively associated** with the **increase of the severity of crashes** and especially at road sections with a **high speed limit** where motor vehicles drive considerably faster than cyclists, the risk of serious injuries and even death for cyclists – as **their vehicles** in contrast to drivers of motor vehicles **do not protect them** – in case of collisions increases [1, 2, 5]. Interactions of motorists and bicyclists at these road sections are problematic especially during passing manoeuvres at curves due to **visibility issues**, with **dense traffic** and at **narrow roads** when motor vehicles often do not pass the cyclists with the **needed safety distance** [3].

What is the size of the problem?

The **interaction of motorists and bicyclists**, particularly **during passing manoeuvres**, is cited as **one of the primary causes** of **bicyclist fatalities** [1], although exact numbers of accidents between cyclists and motor-vehicles at mixed spaces are hardly available. However, [5] investigated 2.934 bicycle-motor vehicle accidents in North Carolina, USA and found that a **considerable high share** of 81.8% of these accidents **occurred in a shared travel lane on a street**, with a roughly **equal split** between **mid-block-areas** and **intersections**. In addition, for Hungary [4] report that of all car-cyclists accidents in Hungary between 2011-2014 (7,920 in total) about **6% of accidents** (341 in built-up areas, 130 outside urban areas) occurred because car drivers **violated overtaking rules**. Both studies indicate that the **speed differences** between cyclists and motor vehicles at mixed spaces where cyclists are forced to share the road with motor vehicles are **problematic**, especially in passing manoeuvres.

Examples

Mixed space of cyclists and motorised traffic on a road outside urban area and posted speed limit of 100 km/h on the EuroVelo 6, Austria

Cyclists and motor vehicles sharing a road section on the EuroVelo 6 in Croatia, with a posted speed limit of 90 km/h

Related solution fact sheet

- Strategies
- Planning principles
- Overpasses and underpasses
- Types of facilities: Mixed with motorized traffic and/or pedestrians
- Separated cycling paths
- Organisational measures

References and links

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RISKS

Junctions and crossings: blind spot

Overview

The blind spot issue imposes safety risks for cyclists and can lead to **conflicts and collisions at junctions**. It typically arises in situations when the cyclist is riding straight ahead and has right of way and a motor vehicle turns right but cannot see the cyclist because he is located in the vehicle blind spot, i.e., not visible through the window or mirrors. This is mostly a phenomenon in **urban areas** at junctions with traffic lights that turn green for cyclists and other traffic simultaneously on roads with cycle tracks or cycle lanes and is especially problematic for **heavy goods vehicles and lorries** leading to serious injuries or even death for the cyclists in case of a collision. Studies indicate that a considerable number of collisions, especially between lorries and cyclists, can be attributed to the blind spot issue.

What is the problem and where does it occur?

At junctions, collisions of bicycles with motor-vehicles can often be attributed to **turning accidents** that are caused by **visibility issues** and **blind spots**. Such accidents happen between straight ahead riding bicyclists and right turning motor vehicles (also known as right-hook accidents), in which the cyclist is located in the blind spot and **cannot be seen or is seen too late** by the driver of the motor vehicle and both vehicles approach the intersection [2, 3, 7]. Especially with **heavy goods vehicles and lorries** this imposes high safety risk with **severe collisions** and even **death** for the cyclists [6]. However, even near misses in such right-turn scenarios are perceived as **very scary** by the cyclists, because they feel that they have **little control of how the situation unravels** [1, 5]. The **majority** of turning accidents at junctions due to blind spots occur in **urban areas, at junctions with traffic lights** that **turn green** for **cyclists** and **other traffic simultaneously** and on **roads with cycle tracks or cycle lanes** [2, 10].

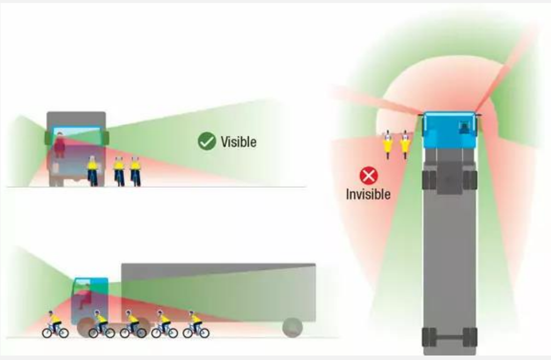
What causes the problem?

Dangerous situations and **accidents** at junctions between right turning motor vehicles and bicyclists – when motor vehicles cross into the cyclist's path – are mainly attributed to the **blind spot issue** [6]. This problem particularly arises with heavy goods vehicles and lorries, whose drivers due to the **size of the vehicles** have **poor vision around the vehicle** [9]. In these cases, often also the bicyclist is **unaware** that the lorry **driver has not seem him/her or that the driver wants to turn right**, which even exacerbates the problem [8]. Turning accidents between motor vehicles and cyclists can lead to serious injuries and death, especially when lorries are involved which due to the **size and weight of the vehicles** increases the severity of injury for the bicyclist in case of a collision [9].

What is the size of the problem?

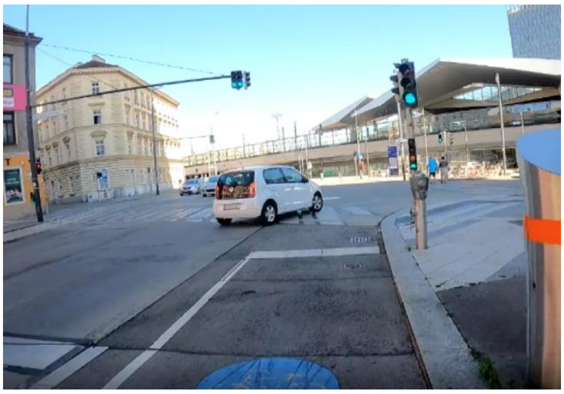
Overall, for Germany, [7] indicate that **turning accidents** make around **one fifth** of all cyclists-involved accidents. With regard to the blind spot issue, for the UK, for the period 2011-2016 [4] reports that 3% of cars involved in collisions with cyclists were **allocated the vehicle blind spot contributory factor**, while this was even **17% for heavy goods vehicles**. For Austria, [11] report that of all accidents between cyclists and heavy goods vehicles between 2015 and 2019, in which the cyclist was killed or seriously injured, **21%** were collisions in which a lorry wanted to turn right and the cyclist wanted to go straight ahead – **the typical blind spot crash**. Similarly, for the Netherlands, [9] reports that between 2005-2013 the number of fatalities among cyclists due to crashes in which a lorry wanted to turn right and the cyclist wanted to go straight ahead **averaged 9 per year**. All of these studies indicate that blind spot issues especially in connection with lorries **impose huge safety risks for cyclists at junctions,** causing **severe injuries and even death** of cyclists in case of collisions.

Examples



Sharing the road with heavy vehicles is especially risky for cyclists

https://www.bicyclenetwork.com.au/tips-resources/know-how/turning-blind/



Potential blind spot problem at junction on EV9, Austria

Related solution fact sheet

- Junctions and crossings
- Roundabouts

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RISKS

Junctions and crossings: left turn issues

Overview

Left turns for cyclists are a demanding task and can impose safety risks because cyclists often have to **weave with traffic from behind** and **identify acceptable gaps** in the traffic flow of oncoming traffic. This can lead to conflicts with motor vehicles. This issue is particularly problematic for cyclists with **high traffic volumes** and **high speed** of motor vehicles as well as at **wide and complex intersections** which make turning difficult and could lead to cyclists doing risky manoeuvres, i.e., turning without a sufficient gap. Studies indicate that at least a small number of cyclist fatalities is related to these left turn issues.

What is the problem and where does it occur?

Turning left at intersections can be **challenging and impose risks for cyclists** as they often have to weave with traffic from behind as well as identify acceptable gaps in the traffic flow of oncoming vehicles which can lead to **conflicts** [2, 7]. Left turns for cyclists are particularly difficult and risky for cyclists with **high traffic volumes** and **high speeds of motor vehicles**, i.e., intersections with higher speed limits, where both weaving with traffic from behind as well as **finding an acceptable gap** for turning is difficult [3, 6, 7, 10]. In addition, **wide and complex intersections** at which bicycle lanes end and the cyclist has to **merge with automobile traffic** or even ride over multiple lanes to arrive on the left-turning lane are especially problematic for cyclists [2, 4].

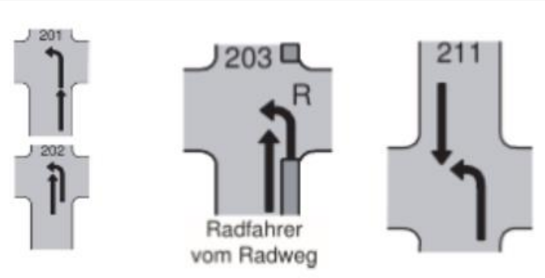
What causes the problem?

Left turns for cyclists typically take more planning and require moving into active traffic lanes. Left turn makeovers are a demanding task for cyclists as they typically have to position themselves from the right edge of the road to the middle of the roadway, to cross and turn left [7]. Thus, turning left is a **difficult, oblique weaving movement** at junctions [8]. Cyclists need to **look over their left shoulder and take up sufficient space on the road as well as clearly gesture their intention to turn left**, i.e., signalling with left hand at shoulder height [1 ,7]. In addition, left-turning bicycles – unless at a signalized intersection with a specific left-turn phase – have to wait and find acceptable gaps in the traffic flow of oncoming motor vehicles which, especially with high traffic volumes of motor vehicles, becomes difficult and can lead to **cyclists doing risky manoeuvres**, i.e., **turning without a sufficient gap**, leading to **collisions with oncoming motor vehicles** that can result in **serious injuries or even death of the cyclists** [10].

What is the size of the problem?

[9] – based on an analysis of cyclist fatalities in Germany between 2013 and 2019 – indicates that a total of **125 of 2761 cyclist fatalities (4.5%)** occurred in **left-turn collisions** (where a cyclist or another vehicle turned left). **38 cyclist fatalities** occurred in **accidents between bicyclists turning left and vehicles from behind** and **14 cyclist fatalities** occurred in **accidents between bicyclists turning left and oncoming motor vehicles**. Similarly, for Berlin, [5] – analysing fatal bicycle accidents between 2011 and 2016 – reports that **two fatal bicycle accidents** involved a left turning bicyclist and an oncoming vehicle and **one fatal bicycle accident** involved a left turning bicyclist and a motor vehicle coming from behind. Both studies indicate that turning left at intersections for bicyclists imposes safety risks and that at least **a small share of cyclist fatalities is related to these issues**.

Examples



Various crash constellations with regard to left-turning cyclists: cyclist turning left collides with vehicle from behind (cyclist on main carriageway or leaving cycle lane); cyclist turning left collides with oncoming motor vehicle. [9]

Related solution fact sheets

- Junctions and crossings
- Roundabouts

References and links

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RISKS

Junctions and crossings: roundabout issues

Overview

Roundabouts can be problematic for cyclists as passing through roundabouts is a challenging **orientation task**, **physically demanding** and it involves **bicycle-motorised vehicle interactions**. Conflicts particularly arise when motorists entering the roundabout **do not give way** to the cyclist on the edge of the roundabout or motorists leaving the roundabout **overtake the cyclist** at the edge of the roundabout. Roundabouts are especially problematic for cyclists when there is **no bicycle facility**, when there is a **marked cycle lane** next to the circulation lane(carriageway?), when there are **multiple lanes**, and when there are **high speeds and high traffic volumes**. Studies indicate that a considerable percentage of especially bicycle-motor-vehicle accidents occur at roundabouts.

What is the problem and where does it occur?

In general, roundabouts have a favourable effect for road safety and improve the safety of intersections for motor vehicles, however several studies suggest poor results for bicyclist accidents [3, 9]. In fact, roundabouts can impose **safety risks for cyclists,** as passing through roundabouts is a **challenging orientation task**, **physically demanding** and it involves **bicycle - motor vehicle interactions** which can result in potential conflicts and accidents [7, 13, 15]. Roundabouts are especially problematic for cyclists when there is **no bicycle facility** present, i.e., mixed traffic, a **marked cycle lane next to the circulation lane**, **extremely low or high central island diameters**, or more than one travel lane, i.e. **multi-lane roundabouts** [1, 4, 10, 14]. Beside these design elements, also **high speeds** and **high traffic volumes increase the risk** of cyclists at roundabouts [7].

What causes the problem?

Roundabouts can be problematic for cyclists as they represent a challenging orientating task because of the **circular design** which can trigger **orientation failure** and increase crash **risk**. Furthermore, because passing through a roundabout is physically more demanding due to the **circular deflection of the road,** the number and **proportion of single-bicycle accidents** may be increased [7]. Especially situations that involve a **circulating bicycle** and an **exiting or entering car** are perceived with a **high level of risk** from cyclists [11]. In this regard conflicts particularly arise when **motorists entering the roundabout do not give way to a cyclist** in the circle, or **motorists leaving the roundabout pull out in front of the cyclist** towards an exit. This is mostly an issue on **multi-lane roundabouts** because motorists are focusing more towards the centre of the roundabout, as well at **large roundabouts**, when a cycle lane forces the cyclists to remain close to the edge. In addition, conflicts also arise when a **cyclist entering the roundabout** cuts across a motorized vehicle entering the roundabout at the same entry, because the cyclist wants to cross in a straight line [13, 14].

Furthermore, perceived risk from cyclists is particularly high when cyclists are exiting the roundabout and cars are coming from behind, and the cyclists feel **less able to control and predict the interaction** with the exiting cars [11]. These potential conflicts can result in accidents which often lead to **serious injury or even death** of the cyclists [10].

What is the size of the problem?

[6] reports that around **2% of cyclist fatalities** in the EU in 2018 occurred at roundabouts. For Switzerland, [2] reports that 2% of serious single-bicycle accidents in the period 2012-2016 occurred at roundabouts, but for **collisions with motor vehicles** this share is even **10%**. In addition, [8] – also for Switzerland – indicate that almost **one-third of the accidents at roundabouts involve cyclists** and that **bicycle accident accumulations often are located at roundabouts**. [5] indicate that in the Netherlands **50% of the victims at roundabouts** in the period 2015-2018 are **cyclists**. For North Rhine-Westphalia in Germany, [12] report that the share of accidents involving cyclists in all accidents with personal injury in built-up areas at roundabouts in the period 2004-2009 was 38%. In conclusion, studies indicate that **considerable share** of especially **bicycle-motor-vehicle accidents** occurs at roundabouts.

Examples

This roundabout in Tulcea, Romania, is lacking any markings (central, cycle path, lanes) and makes it very difficult to navigate by cyclists and drivers together.

This roundabout in Pula, Croatia, has recently been built, and even though cyclists can be frequently seen along this road section, no infrastructure has been dedicated to them (EuroVelo 8).

Related solution fact sheets

- Roundabouts

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RISKS

Poor driving conditions

Overview

Poor driving and road surface conditions are a major risk factor for cycling safety. Uneven road surface conditions due to **potholes or damage from tree roots**, the presence of **sand and gravel** as well as **slippery road surfaces** caused by water and snow can cause cyclists to **lose control or skid** and fall, often resulting in **serious injuries**. Poor riding conditions are typically observed on **unpaved roads**, but also on old, **not properly maintained** bicycle infrastructure whose paved surface has cracked and worn over time, or on bicycle infrastructure that is often affected by water and snow but is not subject to (winter) maintenance services. Studies indicate that a high share of especially single bicycle accidents can be attributed to poor driving conditions or road surface conditions.

What is the problem and where does it occur?

Good road surface and driving conditions are important factors for comfortable and safe bicycle infrastructure [9]. **Poor driving and road surface conditions** impose **major risks** for cyclists because they may **lose control** on uneven road surfaces, e.g. when riding over potholes or bumps, or **skid** on slippery road surfaces and **fall**, which can result in **serious injuries** [10]. An **uneven road surface**, e.g. a pothole or damage from tree roots, a loose object on the road, or bumps or paving block types of surfaces that often become uneven over time can lead to a **loss of control** of cyclists, resulting in **falling, swerving over the road** and **crashing with a kerb or object**, or **flying over the handlebars**, e.g. when a branch or piece of wood tangles into the front spokes [2, 7, 8, 10]. The presence of sand, gravel or leaves, but also slippery surfaces caused by water or ice, are problematic and can lead to cyclists **skidding** [8, 4]. Skidding depends on the **coefficient of friction between the tires and the road** surface and is also subject to the condition of the tires and the state of the road surface. With regard to the road surface condition, especially gravel, mud, water, wet leaves, ice and oil can **reduce the friction** [2012]. However, the latter is also apparent at **low friction surfaces like train & tram tracks, cobbles or drain covers** [8]. In these situations, mostly the **front wheel of the bicycle skids** resulting in the **bicyclist falling** and **getting injured** [10].

What causes the problem?

Bicycle infrastructure and roads are often **not well maintained** and **damaged due to potholes or tree roots** leading to **uneven road surface conditions**. In some cases, bicycle routes are covered with **sand and gravel** or affected by **water and snow** leading to **slippery road surfaces** [8]. This is typically apparent at bicycle route sections on **unpaved** or **gravel roads** or road sections with **cobblestone.** Furthermore, this happens at **old, not properly maintained** bicycle infrastructure, whose **paved surface has cracked and worn away over time**, or at bicycle infrastructure that is often affected by water and snow but is **not subject to (winter) maintenance operations** [5]. These issues are **especially problematic at night** or **twilight** when visibility is low, in particular when **no light posts** are present [1, 11].

What is the size of the problem?

[8] analysed 349 single-bicycle crashes in Denmark and report that **poor driving or surface conditions contributed to the majority of accidents**: curb stones were a contributory factor in 13% of the accidents, skidding due to sand, gravel and leaves was a **contributory factor** in 5% of the accidents, potholes (2%), uneven surface (2%), and low friction surface (including tracks and cobbles) was a contributory factor in 3% of the accidents. Furthermore, **slippery surfaces** were also a **major contributory factor**, with those caused by snow/ice being a contributory factor in nearly half (48%) of the accidents and those caused by water being a contributory factor in another 5%. For Sweden, [7] – based on a survey of 947 persons who experienced a bicycle crash – showed that road surface problems (potholes, small stones, uneven surface) were the **main contributory factor** in 6% of bicycle crashes, curb stones were the main contributory factor in 7%, and 19% were related to skidding – on ice/snow (14%) and on gravel (5%). For the Netherlands, [10] conducted a study on cyclists taken to the emergency room after a bicycle crash and found that 12% of the single-bicycle crashes were related to **kerb impact collisions**. [3] used data from a self-reporting survey of cycling collisions in Ireland. Based on 295 single cyclist collisions, they report that **slippery roads** (water, ice, oil etc.) were the **most common factor** for single cyclist collisions: they were a contributing factor in 31% of single cyclist collisions, and kerbs were a contributing factor in 21% of single cyclist collisions. [4] analysed 638 single-vehicle crashes with e-bikes based on survey data in Switzerland and report that **slippery road surface** (51%) and **poor road condition** (23%) were **among the most common factors** respondents believed to have had an (at least slight) **influence on the accident**.

In conclusion, studies indicate that a **high share of especially single bicycle accidents** can be **attributed to poor driving conditions or road surface conditions**.

Examples

Potholes and damage due to tree roots at EuroVelo 8, Croatia

Presence of unpaved / gravel road at EuroVelo 8, Croatia

Related solution fact sheets

- Driving conditions

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RISKS

Poor signing

Overview

Poor signing, i.e., **missing signs**, **signings in a poor state** or **inappropriately placed** cycle signing, imposes risks for cyclists as it is difficult for them to understand where to ride and which traffic rules apply. This **decreases the level of service** on cycling routes and can lead to **conflicts**. This is particularly problematic at complicated **intersection alignments** and **road works,** when detours are not properly signposted, leading cyclists to undertake **risky manoeuvres** or even **break traffic rules**. Studies indicate that poor and missing signing are problematic and amongst the most important factors for the severity of bicycle crashes.

What is the problem and where does it occur?

Proper signing is essential for cyclists to know where to ride, which traffic rules apply and at which locations they must be particularly cautious to avoid existing hazards. Problems on cycle routes occur when signs are **completely missing**, **in a poor state**, **misleading, or inappropriately placed** [8]. At these occasions it is difficult for cyclists to understand where to ride and which traffic rules apply which **decreases the level of service** for cycling and can lead to **conflicts or even accidents.** In addition, this is **one of the main concerns expressed by cyclists** [7]. Poor signing is particularly problematic at **dangerous occasions**, when a warning of cyclists or motorists is needed but missing, e.g., **low headroom** in an underpass or spots with high risk of conflict between cyclists and motor vehicles, at **complicated intersection alignments** (where guiding of vehicle positioning and direction signing is essential for a safe way through the intersection) as well as at **roadworks** when **detours are not properly signed** and signs do not clearly indicate how cyclists should react which could lead to cyclists doing **risky manoeuvres or even break traffic rules** [5, 8].

What causes the problem?

Signing is particularly important for the wayfinding of cyclists but also with regard to their safety, i.e., signings that warn of hazards, raise motorists' awareness of the likely presence of cyclists ahead, or guide vehicle positioning, and contributes to the level of service for cycling [1, 3, 8].

If signs are completely missing, in a poor state or inappropriately placed, the risk of confusion for cyclists increases, i.e., the **difficulty to understand where to ride and which traffic rules apply**, which also leads to a **decrease of their ability to follow the route** [6, 8]. Problems also arise when **signs are not clearly visible and legible** to approaching cyclists, e.g., obstruction by foliage or other vegetation or large parked vehicles, who have then **not enough time to make the appropriate manoeuvre** [7].

What is the size of the problem?

Numbers on accidents in which poor signing was a contributory factor are hardly available. However, [4] investigated factors contributing to the severity of bicycle crashes based on crash characteristics of 49,621 road accidents with injured or killed cyclists in Italy between 2011 and 2013 and report that road signage was the **fourth most important** predictor of the severity of bicycle crashes. For Alabama, USA, [2] analysed 1,311 bicycle-vehicle crashes that occurred between 2011 and 2015. They state that **crash severity of bicycle-vehicles crashes** was 42.7% **lower when bicycle signs were present** and mention that the presence of bicycle signage helps reducing severity and increases driver's and bicyclists' awareness. Overall, both studies indicate that **poor and missing signing are important factors for the severity of bicycle crashes** and impose risks for cyclists.

Examples

Incomprehensible traffic sign at road section at the EuroVelo 6 in Austria

Problematic traffic signs at construction site, with unsafe detour route at EuroVelo 14 in Austria

Related solution fact

- Signing

References and links

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RISKS

Objects on or aside infrastructure

Overview

Objects on or aside the bicycle infrastructure and roadway, e.g., **bollards, railings, traffic signs, trees, bushes or parked cars**, often impose safety risks for cyclists as they either represent **obstacles** that cyclists could possibly **collide** with or **limit visibility**. Cyclists get injured when hitting such objects and falling, or the limited visibility caused by these objects lead to collisions. This is particularly problematic on **narrow roads** and bicycle infrastructure, **in curves or at junctions**. Studies indicate that a considerable share of cyclists' accidents are collisions with a stationary object.

What is the problem and where does it occur?

Objects like bollards, railings, traffic signs, trees, bushes or parked cars which are often apparent on or aside the bicycle infrastructure and roadway can lead to safety risks for cyclists [3, 6]. On the one hand, such objects represent obstacles that cyclists can collide with. This is particularly problematic at **narrow roads and bicycle infrastructure**, in **curves** with a **limited sight distance** and with **high volumes of cyclists**, when **other cyclists restrict the view on objects** located on the bicycle tracks, as well as with a high density of obstacles within two meters of the bicycle track pavement [1, 3, 10]. On the other hand, especially objects aside the bicycle infrastructure and roadway can **limit visibility**, which can lead to collisions with other road users and motor vehicles in particular. This issue typically arises at **junctions** or in **curves** where objects like trees, bushes or other vegetation but also parked cars **limit sight distances** [9].

What causes the problem?

Safety risks for cyclists due to objects on or aside the bicycle infrastructure and roadway mainly arise because objects on the infrastructure represent obstacles that cyclists can possibly collide with and because objects aside the infrastructure can limit visibility, in particular at junctions and in curves.

Bollards, poles or other road equipment are often put on the road to prevent cars from entering a cycle track, but as they are **often put in the middle of the track**, they also present obstacles for cyclists and **decrease the width of the facility** at these locations [7]. Such objects but also parked cars or garbage cans that are unintentionally placed on the cycle track are **problematic** because of the risk of the cyclists hitting the objects and falling [6, 7]. In addition, sometimes bicycles, but especially cargo bikes or bicycles with trailers, are **not able to pass** (e.g. bollards) or must **enter the path of oncoming traffic** in order to be able to pass (e.g. parked cars) which can lead to **conflicts and collisions**. These issues are especially problematic at narrow bicycle facilities and a high volume of cyclists, e.g. when objects on the infrastructure are **occluded by cyclists** in front and are **not or too late visible** [1, 8]. Moreover, problems can also arise at **road works** due to objects and devices put out to warn and protect road users, e.g. when cyclists get stuck in fences with their handlebars [5].

In addition, safety risks also arise from objects aside the infrastructure as they can **restrict the field of vision and limit sight distances** for cyclists and other road users. This is in particular the case for **fixed objects at the corners of junctions** or for **trees**, bushes or other vegetation **in curves** [9].

What is the size of the problem?

[2] conducted an in-depth study of 100 cyclists injured in on-road crashes resulting in hospitalisation in Western Australia and report that **18% of crashes** involved **hitting an object**. In a national survey on bicyclists' attitudes and behaviours with 7,509 participants, [4] – for the USA – indicates that a crash or collision with a fixed object was the **fifth most frequent reported source of injury** by respondents that experienced a bicycling injury: 7% of the participants who had experienced a bicycling injury reported that this was because of a collision with a fixed object. For Denmark, [6] analysed 349 single-bicycle crashes and report that **objects on the road** were a **contributory factor** in 3% of the accidents and **objects next to the road** (including road equipment) were a contributory factor in 4% of the accidents. Overall, studies show that a **considerable share of cyclists' accidents** can be attributed to **objects on or aside the bicycle infrastructure** and roadway.

Examples

Bollard in the middle of the cycle path at Eurovelo 6 in Austria

Railing as obstacle at EuroVelo 14 in Austria

Related solution fact sheets

- Planning principles

References and links

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Solutions

SOLUTION

Cycling strategies

Overview

The purpose of a Cycling Strategy document is to **promote cycling** in a given region/nation, which will, if incorporated, contribute to **sustainable livelihoods**, **better environment**, **improved health and safety**, **greater social inclusion** and **economic prosperity** as well as overall improvement in the **quality of life**. Below, some examples of strategies on a global, EU and national level are provided.

Global/UN-level policies such as the Paris Agreement on Climate Change [1], the SDG's (Sustainable Development Goals) [2] and the New Urban Agenda [3] – carry a strong obligation to encourage active modes of transport, cycling included. Implementing Cycling measures on a local level is part of the realization of the global-level documents.

The **EU's strategy documents** are fundamental for the additional growth of internal and external policies. Therefore, highlights of the cross-sectoral benefits of sustainable mobility and cycling in order to fulfil the Paris Agreement and the SDGs is of utmost importance. A good example of an EU level strategy is the **EU Cycling Strategy** [4], which serves as a guiding document and has provided recommendations on an EU, national, regional and local level. Recommendations within the document have a high potential to improve the status of cycling in the EU and will motivate more people to cycle if they are incorporated.

A growing number of European nations have developed and implemented national cycling programmes. Commonly, these national strategies and/or action plans establish specific tasks and targets for the growth of cycling on a national level. **National cycling strategies** enable national governments to provide defined support for the growth of cycling in their respective nations. The strategies need to convey a message to regional and municipal governments that cycling is important and should be considered in public initiatives under their authorities. National cycling strategies should ideally refer to the **coordination of cycling policies** (across vertical and horizontal levels), the **exchange of best practices**, **capacity building** for local and regional governments, **co-funding** for cycling infrastructure investments, and funding for **pilot projects, research** and **public awareness campaigns** [4].

Types of problems that the solution can solve

A good strategic foundation is a prerequisite for **treating bicycle traffic on an equal footing with other transport forms**, and for helping transport decision makers **set priorities**. It is proven that developing cycling infrastructure can bring about significant **modal shift changes** leaning towards the increase in cycling (between 11% and 48%, as stated by [6]), a change for which proper strategic planning is critical.

However, the growing popularity of cycling in many cities around the world demonstrates that behavioural change is possible, even where investment in **infrastructure is minimal or less than optimal,** as stated within [5]. Soliciting commitment is critically important in motivating people to move from intention to action and “Foot-in-the-door” strategies which require small initial commitment **have been proven successful at encouraging new and occasional cyclists to ‘‘give it a try”**.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Cycling strategy	€	🕓🕓	🚲🚲🚲

Implementation benefits

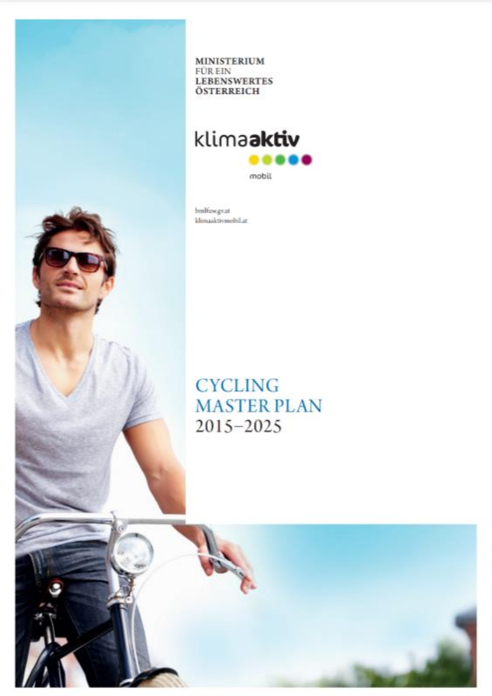
	Contributing to a **health and activity of community** if measures are well conceptualised and implemented
	A **reduction in greenhouse gas emissions** if measures are well conceptualised and implemented
	Improving bicycle and pedestrian infrastructure if measures are well conceptualised and implemented
	Increase of **representation for VRU’s** and raising mobility awareness
	Defining **clear goals** the community can work towards

Implementation Issues

Goals set in strategies can be **too ambitious**

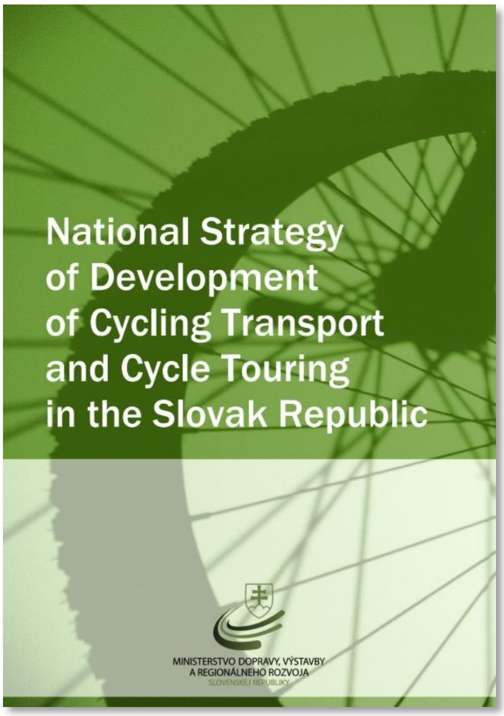
Switch in governmental policies (i.e., post elections) might **invalidate the document policies** entirely or in part

Examples



Austria - Cycling Master Plan 2015-2025

"The Cycling Masterplan published in May 2015 by the Austrian Ministry of Agriculture, Forestry, Environment and Water Management sets as its broad objective an **increase of the cycling modal share**, which should be realized through new **investments in quality cycling infrastructure** and by raising awareness of cycling on a daily basis. The priorities of the plan are: push for **investments** at all levels for the promotion of cycling; more **cycle-friendly conditions** such as the consolidation of infrastructure; information campaigns and awareness raising; optimization of coordination with other modes of transport; bike as a healthy mode of transport." [10], [11]



Slovak Republic - National Strategy of Development of Cycling Transport and Cycle Touring in the Slovak Republic

“The National Strategy of Development of Cycling Transport and Cycle Touring in the Slovak Republic sets clear **guidelines and measures** for the development of cycling in Slovakia. The strategy focuses on several topics including the development of **infrastructure**, cycling **tourism**, **financial strategy** or **research**. Thanks to this general strategy, the Ministry of Transport, Construction and Regional Development wants to make the cycling modal share rise from 1.5%-2% in 2012 to 10% by 2020. The Government's Manifesto for the years 2012-2016 calls for development and emancipation of the cycling transport which should become a regular part of urban and regional transportation systems.” [10], [11]

Related issues fact sheets

- Network issues
- Narrow infrastructure
- Speed differences in mixed spaces with pedestrians, E-Scooters etc.
- Speed differences in mixed spaces with motorised traffic

References and links

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SOLUTION

Planning principles

Overview

Cycling infrastructure, ideally, should be planned according to **regional master plans**, plans which are developed **on a local level**, and **traffic safety guidelines**. For each plan, clearly defined **targets**, **timeline** and a **financial plan** should be defined. It is generally a good idea to apply for external financing from regional, national or EU level funds which are available. Commonly, regional master plans contain a **road network** and the plan for a **bicycle network**, and, if not, this should be a good starting point for planning, so the cycling network can be incorporated in the future documentation. Usually, the principles for road network, elaborations and solutions are written down within **local-level plans**, and are generally connected with road classification, street function and road designs. The cycling infrastructure which needs to be elaborated and planned for includes cycle tracks, cycle lanes, separated cycling paths, intersection solutions, mixed traffic areas where special attention will be given for cyclists (Sharrow zones, Shared Spaces, 30 km/h traffic calming zones), signage, bicycle parking solutions, and other infrastructure measures for cycling.

Types of problems that the solution can solve

According to [1], in Denmark, cycling infrastructure planning is based on:

- a survey of **cyclist issues and wishes**;
- collected knowledge about **existing bicycle traffic**;
- identification of **key traffic corridors**;
- access to **major cyclist destinations** (workplaces, schools, service, shops,)
- and **connections** between collective transport, recreation, etc.

In addition, cycling plans for infrastructure will often include **safety objectives**. The main priority of traffic safety objectives is to prevent accidents and their severity, and not to improve the modal share for cyclists. However, the two are interlinked, and most often the cyclist's **subjective safety** (feeling safe/unsafe) is the **crucial factor for deciding whether/when to cycle**.

A bicycle traffic plan is usually based on the prevailing local situation and varies from location to location based on cycling infrastructure level of development. The existing situation and circumstances (reflected e.g., by cycling traffic volumes, **share of commuter and recreational cycling, urban** vs. **rural** setting) usually require **different approaches**. For example, planners need to ask themselves what should be the main objective for a rural cycling route: ensuring that **locals have adequate facilities for their daily commuting** or **placing the focus on cycling tourists**, ensuring that their needs are satisfied?

An initial **starting point** regarding analysing the current situation for developing a bike plan can be an **investigation of existing cycling traffic volumes**, which can be taken by traffic counts, either automatic or manual.

In addition, the **potential for cycling** can also be assessed and utilised for prioritising cycling infrastructure development. For example: the potential of **workplace commuting by bicycle** if appropriate safe cycling facilities are provided, or the potential of children switching from being driven by parents to cycling on their way to school. **Traffic modelling** can also play a part in determining cycling potential by forecasting the number of trips generated for certain establishment/facility developments.

Sections with high AADT and operative speeds should have **dedicated cycle tracks or lanes**, assuming that the density of cyclists is appropriate. If cyclists on the sections are scarce, the potential for future increases of cyclist flows should be the deciding factor when assessing appropriate measures.

In addition, knowing the **destinations** which need to be linked is important, as well as feasibility options for cycling infrastructure implementation. Taking the **destination attributes** instead of bicycle volumes as the starting point for planning is important in order to identify where the **missing links** in the cycling infrastructure are, and to consider **other solutions** than the conventional cycle lanes along road sections.

Vehicle AADT, **operating speed** and in some cases also the **age distribution** of cyclists can (and should) affect the choice between cycle track, cycle lane and mixed traffic lanes. A high standard for principles of **intersection design** is crucial. [1]

Regarding **cyclotourism**, it is imperative to **connect strategic cycling infrastructure** in urban areas with cycle **routes along rural road** sections and **planned cycle infrastructure**, which includes separated cycle tracks. While **attractiveness** of the route is an essential element for tourist experience, tourists also cycle in urban areas for recreational purposes and to carry out activities like shopping or eating and drinking in restaurants, cafés and bars. In this regard, it is recommended to also respect and consider the **ECS daily route standards** [2] within the development of the bicycle traffic plan, e.g., allow cyclists to reach accommodation such as campsites, hostels and hotels over a span of a daily cycling section, while avoiding road sections with high AADT and vehicle speeds.

Implementation benefits

Demonstrates the cycling infrastructure benefits to the community

Enables **prioritisation** of the infrastructure interventions

Promotes and stimulates cycling within an area

Promotes **safety awareness**

Implementation Issues

A poorly thought-out plan might miss the potential for implementing adequate cycling infrastructure improvements

The greatest part of the **budget** for planning and implementation must be **financed locally**, which might deter smaller municipalities from attempting implementation

Considerable **uncertainty during the planning stage** regarding financing. If it turns out that funding is insufficient, the project may be adjusted for cheaper solutions

Examples

Action plan for improving and upgrading of existing cycling within Medvednica National Park, Croatia.

The **action plan** envisages the upgrading and improvement of 9 existing bicycle routes in the Medvednica Nature Park by 2029 based on the results of the analysis (which incorporated existing initial state of the route system and the current needs of cyclists). The changes are being introduced so that the best parts of the existing route system are **retained and gradually upgraded** towards the future network of routes in the Medvednica Nature Park. In accordance with the recommendations of the Medvednica National Park strategy, the document recommends that development of routes needs to be accompanied by **periodic checks of user reactions** to these changes and, if necessary, adjusting the plan to possible new circumstances. [5]

Cycling action plan, Making London the world's best big city for cycling

London's action plan is aimed at borough officers, local decision-makers, community groups, the business sector, planning and delivery authorities and everyone else who is interested in how cycling can help make London a more successful city. It sets out **actions for the next five years** with the **goal of enabling more Londoners to cycle**. According to the document, presented actions will provide the foundation for London to become a city where cycling is accessible for all, regardless of age, gender or ability. [6]

Related issues fact sheets

- Network issues
- Narrow infrastructure
- Speed differences in mixed spaces with pedestrians, E-Scooters etc.
- Speed differences in mixed spaces with motorised traffic
- Objects on/aside infrastructure

References and links

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SOLUTION

Junctions and crossings

Overview

When assessing road infrastructure safety, special attention is given to junctions and crossings, as those are the **most common spots** where **conflicts between different (and same) modes of transport** occur. Not only that **most of the conflicts occur on junctions**, but also the ones that are known to occur have **more severe consequences** compared to conflicts occurred on straight sections of the road.

Cycling accidents predominantly occur at junctions between cycling facilities and facilities for other – mostly motorised – road users. The following principles can help ensuring the safety and comfort of cyclists at junctions:

- Good **visibility and physical proximity** (or adequate distance, >5 m) between road and parallel cycling facility, at least for the last 20 metres before the junction
- **Straight trajectories** should be ensured for cyclists to avoid ambiguities on their further route choice and/or changes of direction
- **Right-of-way regulations** should be self-evident for all users
- **Directional arrows** (road markings) increase clarity of dedicated use and trajectories
- conflict areas should be **colour-coded** (including those with pedestrians)

Studies show that, even when it is expected for motorised vehicles to yield to cyclists, drivers may **fail to give way**. Various reasons can cause such behaviour, such as drivers not being aware of the presence of a cyclist due to **limited vision** or **lack of attention** [1]. Crossings can be divided into minor and major crossings, with minor crossings involving the intersection of two residential or local streets with low motor vehicle volumes and speeds. Major crossings are those locations where a bicycle boulevard crosses a major street with right-of-way priority [2].

Curb radius reduction

There are numerous countermeasures which can be applied to junctions and crossings in order to increase safety levels for cyclists [3]. One of the proposed improvement measures is the **curb radius reduction**. Curb radius has a significant **influence on motorised vehicle speed**, as larger radiuses allow for greater turning speeds, while smaller radiuses force turning vehicles to negotiate the turn with lower speeds, thus **increasing** the drivers' **probability to spot the cyclist**. While reducing the curb radius, it is important to consider turning needs of design vehicles.

Intersection pavement markings

Intersection pavement markings, another junction improvement measure, also help in the reduction of cyclist injuries as they provide better visibility and guidance for cyclists approaching junctions. Pavement markings per se, include a range of improvements such as **painted bike lanes, dashed lines** or even **bike boxes** (also known as advanced stop bar). For bike boxes at signalized intersections for example, several studies [e.g. 4,5] indicate a reduction in the number of conflicts between bicyclists and motor vehicles after their installation.

Sight distance improvement

Depending on junction condition, one of the simpler (or more complex) improvements is the **sight distance improvement**. In order to increase the cycling safety level, an adequate sight distance should be provided. In some cases, this could be only a simple **vegetation trimming** or **increasing the height of a traffic sign** while, on the other hand, it could also be a more substantial intervention, such as the **relocation of parking spaces** near the crossing or providing a **curb extension**. A simple alternative to curb extension could be the **vertical delineator installation** [3]. To improve the visibility and cyclist detectability, a rule, similar to the one used in motorised vehicle infrastructure design, can be applied, namely the **angle** at which cycling infrastructure and motorised vehicles infrastructure meet should be designed as close to 90º as possible.

Traffic lights

In particular at unsignalized junctions with a high amount of motor traffic and bicyclists at different traffic streams, also the installation of **traffic lights** can improve cyclist safety: By **separating cross traffic streams** by time intervals, the likelihood of crossing collisions is reduced. [6] However, traffic-light intersections are always a second-best solution for cyclists in terms of safety and a **cycle-friendly design** (see measures below) is needed to improve safety, speed and comfort. [7]

Advanced stop lines (bike boxes)

At **traffic light-controlled junctions**, stop lines for cyclists should be placed 3-5 metres in front of the stop lines for motor vehicle traffic. Thereby it can be ensured that cyclists have had the chance to position themselves in front of motorists and be **visible** for them when the traffic light turns green. This can be crucial in avoiding blind-spot collisions with (right-turning) HGVs.

Protected intersections

Protected intersection aims to **improve the safety situation** at intersections for VRU's by means of **physical separation between transport modes**, providing **clear guidance**, **adequate visibility** as well as **encouraging predictable user behaviour**. Protected intersections come as a seamless continuance to protected cycle lanes and offer protection on those parts of the network where vulnerable road users are more exposed.

Unlike at conventional intersections, cyclists at protected intersections are not forced to merge into mixed traffic, instead they are given a dedicated path through the intersection [2]. Some of the features a protected intersection can be equipped with are **painted cycle lanes**, **corner refuge island**, **curb extensions**, and **cycle friendly signal phasing** [1].

Some of the features a protected intersection can be equipped with are **painted cycle lanes**, **corner refuge island**, **curb extensions**, **cycle friendly signal phasing** and other [11]. In addition, one can find corner islands, bike queue areas and waiting zones for turning cars. Protected intersections also provide more safety for pedestrians through shorter and safer crossings and pedestrian islands. [11]

Characteristics

Measure	Costs	Treatment life	Effectiveness
Curb radius reduction	€€	🕒🕒🕒	🚲🚲
Intersection pavement markings	€	🕒🕒	🚲🚲
Sight distance improvements	€-€€	🕒🕒	🚲🚲
Protected intersections	€€€	🕒🕒🕒	🚲🚲
Traffic lights	€€	🕒🕒🕒	🚲🚲
Advanced stop lines	€	🕒🕒🕒	🚲🚲
Protected intersections	€€€	🕒🕒🕒	🚲🚲🚲

Implementation benefits

Improved **visibility** of cyclists

Increased cyclist **safety** at crossings and junctions

Specific implementation measures are quite **inexpensive**

Implementation Issues

Specific improvement measures are quite **expensive**

Some improvement measures require **additional space**

Poorly planned measures can **deteriorate safety levels** for all involved road users

Implementation benefits

Decrease in vehicle – bicycle **conflict points**

Increase in VRU **crossing safety**

Improved **visibility** of all road users

Implementation Issues

Intersection **capacity implications** of added bicycle signal phases

Truck turning requirements for freight movement

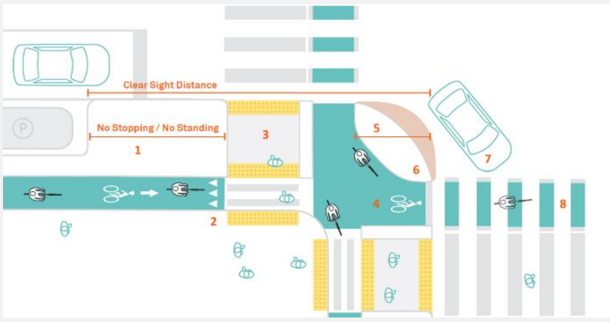
Interaction between bicyclists and pedestrians

Examples

The figure shows an aerial view of a **protected intersection** on Zagreb Avenue in Zagreb. The infrastructure provides **clear guidance** for cyclists by means of a painted red cycle path around the intersection as well as guidance across the intersection. Given that cyclists and pedestrians have to cross multiple lanes, **refuge islands** are provided in between lanes of opposing directions of travel. The whole intersection is regulated by **traffic lights**.

[Google Earth, screenshot taken on 19.11.2021, base layer map from 2016]

Advanced stop line (bike box) for cyclists (Source: KFV)



Example of a protected intersections design

Related issues fact sheets

- Narrow infrastructure
- Junctions and crossings: blind spot
- Junctions and crossings: left turn issues

References and links

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SOLUTION

Roundabouts

Overview

Roundabouts have a favourable effect on **traffic safety**, at least for crashes causing injuries, when considering all road users. However, roundabouts can be an unsafe type of facility for cycling. It is therefore imperative to understand cyclists desire lines and manoeuvres which will need to be considered, in order to provide an adequate level of safety. As a rule of thumb, **the larger the roundabout, the greater are the challenges for cyclists**. [1] If large, multi-lane roundabouts are present at cycle routes, they should be designed with additional provision for cycling safety and comfort. [2] In addition, **speed reduction** is highly recommended. [1]

In numerous nations, various **design standards** have been established for cycling infrastructure at roundabouts. Even though a large gap between procedures continue to exist, some basic design categories of cycle facilities at roundabouts can be recognized. They are aggregated into four categories: **mixed traffic**, **cycle lanes**, **separate cycle paths** and **grade-separated cycle paths**. [3,4]

Types of problems that the solution can solve

Multi-lane roundabouts are more likely to have **higher traffic speeds** due to their position on roads with multiple lanes and have the potential to create more **tension** as well as **high-risk conditions** between bicycles, pedestrians and motor vehicles. This type of a roundabout can present a **significant issue to cyclists**, given these higher speeds and AADT volumes. In this sort of situation, cycle lanes need to be **discontinued** when leading to roundabouts, in order for bicycles to merge with the flow of traffic. [6] Moreover, larger and multi-lane roundabouts can be made cycle-friendly by adding **physically separated cycle tracks**. [2]

At small roundabouts, it is also better not to continue cycle lanes. Instead, it is more advised to **bring cyclists and vehicles** together into a **narrow lane** when they approach the roundabout in order to have them before or after each other rather than approaching parallel to each other and risking side swipe and right hook crashes when exiting/entering the roundabout. [7]

According to research made in Great Britain, the involvement of bicyclists in crashes on roundabouts was discovered to be **10 to 15 times higher** than the involvement of vehicle occupants, when accounting for rates of exposure. Research states that it is **not recommended** to build roundabouts with cycle lanes, as they are more unsafe for bicyclist when compared with other 3 design types (mixed traffic, separate cycle paths, grade-separated cycle paths). [3]

Roundabouts **are safer for cyclists** when they [5]:

- have a **low volume of motor vehicle traffic**;
- encourage **low traffic speeds**;
- only have **one lane**;
- are **smaller** in total size, with larger and higher central islands.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Bicycle friendly design	€€€		

Implementation benefits

More **efficient** traffic flow

Reduced vehicle speeds

Implementation Issues

Costs may be high depending on size and site conditions

Choosing the **right type of bicyclist treatment**

Roundabouts with bicycle tracks are safer than roundabouts with bicycle lanes or without any bicycle facility [8]

Examples

Dutch styled roundabouts where the geometry is arranged such that motor vehicles leaving the roundabout approach the crossings at an angle close to 90 degrees to maximise inter-visibility. [1].

Separated cycling path intersecting vehicle flow on a roundabout, Slovenia [Google maps, 46.563218,15.6274552]

Related issues fact sheets

- Narrow infrastructure
- Junctions and crossings: blind spot
- Junctions and crossings: left turn issues
- Junctions and crossings: roundabout issues

References and links

1. Cycling design Standard (2016): London Cycling Design Standard-Junctions and Crossings London
2. PRESTO - Promoting cycling for everyone as a daily transport mode (2012): Roundabout Intersections. http://www.rupprecht-consult.eu/uploads/tx_rupprecht/09_PRESTO_Infrastructure_Fact_Sheet_on_Roundabout_Intersections.pdf

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SOLUTION

Overpasses and underpasses

Overview

Where cycling routes intersect with roads that have high AADT, crossings should be grade-separated to provide **maximum level of both safety and mobility**. Overpasses and underpasses can also be used to **cross other barriers –** railroads, rivers or canals, cliffs etc. This type of infrastructure provides **continuity of access** for bicyclists and **prevents significant detours**. Over- and underpasses encompass different types of structures, including bridges, and are usually very **expensive**, though some cost savings can be achieved depending on the materials used.

Types of problems that the solution can solve

Effectively planned and designed over- and underpasses can **support safe pedestrian and cyclist movements**, provide **a cost-effective crossing option** to meet identified desire lines, **reduce delays** to traffic, and **provide network connectivity**.

One research [3] states that installation of grade separated intersections (bicycle bridges or tunnels) to cross distributor roads was found to be related to **strong reductions in the fatality crash rate**. A score that was developed to measure network level separation for Dutch municipalities corresponded to a **24% decrease** in the likelihood of **fatal bicycle** crashes. The score combines the share of bicycle kilometres through traffic-calmed areas and the number of bicycle tunnels and bridges to cross distributor roads per bicycle kilometre.

However, it is important that over- and underpass are accessible for cyclists (e.g. no stairs), have a reduced slope and sufficiently comfortable dimensions with regard to the existing volume of cyclists. [4]

Characteristics

Measure	Costs	Treatment life	Effectiveness
Overpass	€€€	◷◷◷	🚲🚲🚲🚲
Underpass	€€€	◷◷◷	🚲🚲🚲🚲

Implementation benefits

Separation from motorised traffic significantly **increases safety**

May offer some **shelter** from wind and rain

Can be spectacular landmarks that help to create **awareness and promote the route**

Implementation Issues

Possible **conflict points** at entrances and exits

Costs are relatively high

Extra **buffers** may be needed for "shy distance" from railings or from traffic to protect bicyclists from sudden wind blasts or gusts.

Examples

Eisenhower **tunnel** on the F325 cycle highway, the Netherlands. Straight approach, good visibility and smooth curves at the tunnel entrance, sunlight windows further in the picture

https://cyclehighways.eu/design-and-build/infrastructure/tunnels-and-bridges.html#gallery-466-1

Cycling bridge in Slovakia

http://www.interreg-danube.eu/approved-projects/danubeparksconnected/section/cycling-the-danube-in-slovakia

Related issues fact sheets

- Network issues
- Narrow infrastructure
- Speed differences in mixed spaces with pedestrians, E-Scooters etc.
- Speed differences in mixed spaces with motorised traffic

References and links

1. The State of Queensland (2020): Bicycle rider and pedestrian underpasses
2. Max A. Bushell, Bryan W. Poole, Charles V. Zegeer, Daniel A. Rodriguez (2013): Costs for Pedestrian and Bicyclist Infrastructure Improvements
3. Elliot & Fyhri, Aslak & Jensen, Anne (2015): The Dutch road to a high level of cycling safety
4. PRESTO - Promoting cycling for everyone as a daily transport mode (2015): Grade Separation. Implementation Fact Sheet. http://www.rupprecht-consult.eu/uploads/tx_rupprecht/11_PRESTO_Infrastructure_Fact_Sheet_on_Grade_Separation.pdf

SOLUTION

Types of facilities: mixed with motorised traffic and/or pedestrians

Overview

Mixed traffic of cyclists and **motor vehicles** can only be recommended on roads with **low volumes of traffic** operating at **low speeds**. To avoid collisions with opening car doors and discouraging dangerous overtaking manoeuvres by motor vehicles **bicycle or sharrow pictograms** to indicate the shared use of a street and imply a safe trajectory choice for cyclists can be used (see also Factsheet “Signs and Markings”). Likewise, mixing cyclists and **pedestrians** on a shared facility can only be recommended in case of low volumes of pedestrians and cyclists, when road space does not allow for separated facilities, and cycling in mixed traffic on the carriageway is not an option.

Cycle streets

Cycle streets are a fairly recent type of cycling infrastructure where **priority is given to cyclists**. The implementation of a cycle street is recommendable along major cycling routes if a **high volume of cyclist traffic** (i.e., more than 50% cycling share, at least in summer) and **relatively low motor traffic loads and speeds** are to be expected. The concepts implies that **entry restrictions**, **one-way regulations and speed limits for motor vehicles** may apply, and cars must **give way** to cyclists, whereas **cycling** is usually **allowed in both directions**, using the full width of the road. For homogenous cycling speeds and safety, it is advisable to give priority to cycle streets. They are usually marked with road signs and large bicycle road pictograms on the carriageway.

Cycle lanes

Cycle lanes are facilities **marked on main carriageways**, **without level changes**, usually adjacent to the first driving lane for motor vehicles, and next to a pedestrian sidewalk or a parking lane. They are usually marked with **solid edge lines** and can be reinforced e.g., by painted cycling pictograms and directional arrows. The regular minimum width of cycle lanes should be around 1,5 metres. Higher widths are required for main bicycle routes, or if permitted speed for motor vehicles is higher than 50 km/h, or for cycling lanes alongside kerbside, perpendicular or angle parking lanes. As for cycle tracks, **collision rates** are usually **higher at junctions than on stretches**. Cycle lanes will only unfold their positive impact on **safety and comfort** if they are always kept free **of flowing and parked motor vehicles**. It is advisable to **paint**, e.g., in red, the surfaces of cycle lanes **on potential conflict points**, such as with turning or joining motor vehicles or pedestrians.

Edge lanes/advisory lanes

Edge lane roads (also depicted as “2 minus 1 roads”) are road configurations which usually allow **two-way traffic, for both for motor vehicles and bicycles**. They are typically applied on **low volume roads**, and where the provision of other cycling facilities (cycle paths or cycle lanes) is not affordable or unfeasible for other reasons. They are used in **urban areas** in several countries, but have successfully been applied also in **rural settings**, e.g., in Denmark and the Netherlands. The **core lane for motor vehicles** can be **narrower** than normal driving lanes. **Passing motor vehicles** are **allowed to use (parts of) the edge lane** in case no cyclists are endangered. When applied in rural areas, typical speed limits for motor vehicles are 60 or 70 km/h, and the *2 minus 1* configuration itself can be seen as a measure of speed management for motor vehicles. Edge lanes should have a minimum width of 1 metre. For more information see e.g., https://cyclingsolutions.info/edge-lane-roads/ [23. 1. 2021]

Shared space with pedestrians, E-Scooters etc.

Shared (cycle and pedestrian) paths should only be foreseen for facilities where **low volumes of pedestrians and cyclists** can be expected, when **road space does not allow for separated facilities**, and **cycling in mixed traffic** on the carriageway is **not an option**. They are **not recommended in densely populated urban areas**. On shared paths, it is advisable to assign separate space for the two modes, however not only by classical edge lane markings but by a tactile separation which can be sensed by persons with handicaps, e.g., a level change of ~3 cm, or a strip of cobblestone.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Cycle Street	€€	🕒🕒	🚲🚲🚲
Cycle Lane	€	🕒🕒	🚲🚲
Edge-Lane / Advisory Lane	€	🕒🕒	🚲
Shared space	€	🕒🕒	🚲🚲

Implementation benefits

Increase in the overall cyclist **safety**

Decrease in vehicle **conflict points**

Implementation Issues

High cost of certain countermeasures

Possible issues with additional **space availability** for certain countermeasures

Possible **increase in motorised traffic congestions**

Examples

Cycle Street in Austria

Cycle lane in Slovakia

Advisory lane in Hungary (Danube Cycle Plans. Picture by jozsanet.hu)

Pedestrian and bicycle lane along the roadway in Ruse, Bulgaria: The lanes are wide enough and do not cross with pedestrians

Related issues fact sheets

- Narrow infrastructure
- Speed differences in mixed spaces with pedestrians, E-Scooters etc.
- Speed differences in mixed spaces with motorised traffic

References and links

1. KFV (2020): Dooring-Unfälle: https://www.kfv.at/download/20-dooring-unfaelle
2. DiGiola, J., Watkins, K.E., Xu, Y., Rodgers, M., Guensler, R. (2017): Safety impacts of bicycle infrastructure: A critical review. Journal of Safety Research, Vol. 61, pp. 105-119
3. PRESTO (2012): Cyclists and Pedestrians. http://www.rupprecht-consult.eu/uploads/tx_rupprecht/07_PRESTO_Infrastructure_Fact_Sheet_on_Cyclists_and_Pedestrians.pdf
4. BIKESAFE Available at: http://www.pedbikesafe.org/BIKESAFE
5. DeRobertis, M., Rae, R. (2001): Buses and Bicycles: Design Alternatives for Sharing the Road
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SOLUTION

Separated cycling paths

Overview

Research on land use and network effects on cycling accidents [1] reports that cycling facilities where cyclists are separated from motorists create **safer situations** as well as better **safety perception** among cyclists. When using infrastructure which is separated from other traffic modes, the number of **road user conflicts** and **stress levels** are significantly **diminished**.

Separated cycle paths are the **most common type** of separated bicycle facilities and are defined by [2] as: **Exclusive facility for bicyclists** that is located within or directly adjacent to the roadway which is **physically separated from motor vehicle traffic** with a vertical element. Separated cycle paths are also called "**cycle tracks**" or "**protected bike lanes**". [2]

Separated cycle paths can be **one-way or two-way facilities**. Their designs can integrate with turning automobile traffic at intersections or can be fully separated. They can be designed at roadway grade or at sidewalk grade. They can also be separated from the adjacent roadway or sidewalk with a variety of treatments, including, but not limited to: on-street parking, raised curbs or medians, bollards, landscaping, or vegetation. [2]

Separated cycle paths have the potential to **improve traffic safety** for all road users, especially when implemented as part of other traffic calming designs. Separated cycle paths have the potential to **attract more cyclists and increase their share in modal split**, since the design can be **attractive to less skilled cyclists** which might ultimately lead to more diversity in cyclist representation across age, gender, and ability. Shifting a greater share of commute, errand, or social trips to the bicycle also offers one potential solution for relieving traffic congestion and contributing to other public policy goals. [2]

Types of problems that the solution can solve

Separated cycle paths are physically divided from vehicle traffic and most cyclists **feel safer**, which can help **attract new cyclists**. [3]

Separated cycling facilities are known to have **multiple benefits**. This type of facilities **dedicates and protects space** for cyclists and **improve perceived comfort and safety**. Regarding safety effect, separated cycle paths or lanes can provide **28% lower injury rate**. [4]

Distance and physical barriers eliminate risk and fear of collisions with vehicles. **Reduced risk of 'dooring'** is also obvious for this type of facilities when compared to an unseparated bike facilities. The construction of raised cycle tracks has caused a slight drop in the total number of cycling accidents and injuries on the road sections between junctions of **4%** and **10%** respectively. [5]

Separated cycle paths are particularly recommended along roads where **traffic volume** and **speed of motor vehicles** make it unsafe to allow cyclists on the carriageway and one-way facilities should at have a minimum width of two meters. [6]

Characteristics

Measure	Costs	Treatment life	Effectiveness
Separated cycle path	€€	🕒🕒🕒	🚲🚲🚲

Implementation benefits

Improved **safety** for cyclists

Lower risk of injury if accidents occur

More potential users because of higher safety and comfort levels

Implementation Issues

High implementation **costs** in some cases

Lack of space in urban areas

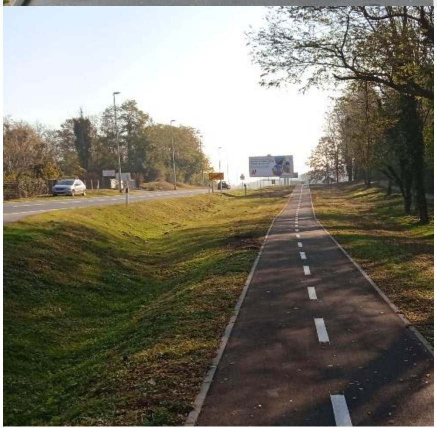
Reduction of on-street parking spaces

Maintenance planning (sweeping and ploughing)

Examples

Separated cycling path in Vienna, Austria

http://cyclingchristchurch.co.nz/wp-content/uploads/2015/07/Vienna%20(111).JPG



Separated cycling path on Eurovelo 6 route, Croatia, near Vukovar. [Vukovar municipality photograph, available upon request]

Related issues fact sheets

- Narrow infrastructure
- Speed differences in mixed spaces with pedestrians, E-Scooters etc.
- Speed differences in mixed spaces with motorised traffic

References and links

1. Kaplan, S., & Prato, C. G. (2015): A Spatial Analysis of Land Use and Network Effects on Frequency and Severity of Cyclist–Motorist Crashes in the Copenhagen Region
2. Federal Highway Administration (2015): Separated Bike Lane Design and Planning Guide
3. Pucher J., Buehler R. (2016): Safer Cycling Through Improved Infrastructure
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5. Jensen U.S., Rosenkilde C., Jensen N. (2006): Road Safety and Percieved Risk of Cycle Facilities in Copenhagen
6. PRESTO - Promoting cycling for everyone as a daily transport mode (2012): Cycle Tracks. Implementation Fact Sheet. http://www.rupprecht-consult.eu/uploads/tx_rupprecht/02_PRESTO_Infrastructure_Fact_Sheet_on_Cycle_Tracks.pdf
7. Bushell M.A., Poole B.W., Zegeer C. V., Rodriguez D.A. (2013): Costs for Pedestrian and Bicycle Infrastructure Improvements
8. NACTO (2011): Urban Bikeway Design Guide

SOLUTION

Driving conditions

Overview

Poor driving and road surface conditions, e.g. uneven or slippery road surfaces can lead to cyclists losing control, or skidding and falling which often results in injuries. Such driving and **surface condition hazards** can be **minimized** by several measures and solutions, e.g. **maintaining drainage openings in-level with the surrounding pavement**, installation of **drainage curb inlets**, improved **road maintenance** and implementation of **road lighting**.

Types of problems that the solutions can solve

Driving condition hazards may be minimized by instituting **good design and maintenance practices**. In accordance with this, **drainage openings** should be maintained **in-level with the surrounding pavement**, which may require raising them after repaving. A bicycle-friendly design should be used so that bicycle tires will **not be trapped** by opening slots which are parallel to the roadway. [1]

Particularly with new infrastructure or reconstruction, **drainage curb inlets** can be installed. Utility covers and other potential hazards should be removed out of the predominant bicycling infrastructure and should be **in-level with the surrounding pavement**, in addition to having **non-skid surfaces**. Pavement quality should be kept in good condition, particularly near the edges where bicyclists tend to ride most often. [1]

Pavement seams should be placed where they **minimally conflict** with the bicycle right-of-way. Excessively wide gutters may unnecessarily reduce bicyclists' space. **Paving** over the gutter pan is a temporary solution, as seams usually reappear in the pavement within five years. **Reflective raised pavement markers** also create hazards for bicyclists and should only be used with appropriate consideration of bicyclists, since they can deflect a bicycle wheel, causing the cyclist to lose control. [1]

Driving in poor-lighting conditions can present a hazard. A study by [2] conducted in the Netherlands found that the implementation of road lighting reduced cycling injury and fatality risk, especially in rural areas. In addition to traffic safety, **adequate lighting** provides clear benefits in terms of personal security. Roadway lighting often serves the purpose of **safeguarding personal safety for pedestrians and bicyclists** as they move along/across roads. Darkness reduces **personal feeling of security**, and bicycling may therefore become uncomfortable and difficult, which reduces safety. Consequentially, ensuring that the lighting provides minimum acceptable levels of illumination is of great importance to all users of a roadway environment. [3]

Research conducted in [4] states that **prioritizing walking and cycling areas** in **winter road maintenance** seems to be beneficial both with regard to injury reductions and with regard to costs for healthcare and sick leave due to injuries from slip accidents. Furthermore, research states that important **countermeasures for slippery surfaces, ice and snow** include improved **winter maintenance**, **removal of loose gravel** and **adjustment of curbs**, followed by **separated cycle tracks** and **removal of fixed objects** on and adjacent to the cycle tracks.

In the case of using shoulder rumble strips for vehicle users, a narrower design **placed close to the lane edge line** allows for more bicycle-friendly space. If textured elements are used, care should be taken that these do not compromise bicyclist safety or comfort. [1]

Several issues which can impact driving condition should be looked at very closely, as described within [1]:

- Initial **design** and **materials selection** can significantly help to prevent driving condition issues which arise due to poor drainage, slippery surfaces, gaps in pavement, and others. Once design standards are determined, inspectors and project contractors should ensure that standards are met.
- Having a plan for regular sweeping and identifying risky elements as well as for making spot repairs is key to **keep cycling infrastructure in good condition**. It is important that bicyclist considerations are incorporated into **long-term maintenance and upgrades**.
- Good design, hazard identification, and maintenance practices should be **institutionalized**. Identification of bicyclist priorities and a system for **regular inclusion** of best bicyclist facilities practices within a regular maintenance framework can help to improve conditions for bicyclists **without substantially increasing costs**.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Drainage	€€	🕒🕒	🚲
Road maintenance	€ - €€	🕒	🚲🚲🚲
Lighting	€€	🕒🕒🕒	🚲🚲🚲

Implementation benefits

Institutionalizing good design, sweeping, and maintenance practices with respect to bicyclists can help to **reduce liability**

Hazard identification programs can **facilitate identification and repair of potential surface hazards**

Implementation Issues

Lack of know-how might be problematic for authorities when it comes to identifying priorities.

Lack of funding might could cause cycling related maintenance to be overlooked in favour of other transport modes.

Examples

Winter maintenance, Denmark

In Denmark, roads and paths are divided into different winter classes. The categories are defined by the road or path's importance for traffic flows, and service objectives are prioritized accordingly. This optimizes the use of resources and achieves a good mutual balance between traffic concerns, the environment, and funding. [6]

Energy-efficient LED lighting system, powered by solar energy, Belgium

From sunset to sunrise, the luminaires are dimmed by 80%. When a pedestrian or a cyclist is detected, the lighting goes back up to 100% for 100 metres and then lights up the users' path as they move along thanks to the detectors. After 11 p.m., only the luminaires at the start of the path are switched on at 20% of the light intensity to guide people in complete safety. The other luminaires are switched off and only come on when someone is detected. This lighting system guarantees the security of people using the path while protecting the flora and fauna along the section. [7]

Related issues fact sheets

- Poor driving conditions

References and links

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2. Wanvik, P.O. (2009). Effects of road lighting: an analysis based on Dutch accident statistics 1987-2006. Accident Analysis and Prevention, Vol. 41, p. 123-128. https://doi.org/10.1016/j.aap.2008.10.003
3. FHWA (2009): Transportation Planning Handbook, Chapter 16: Bicycle and Pedestrian Facilities
4. Koglin, T., Varhelyi, A. (2018): What does maintenance of infrastructure mean for pedestrians and cyclists – A knowledge summary
5. https://cyclingsolutions.info/winter-maintenance-and-cleaning-of-roads-and-cycle-tracks/#prettyPhoto
6. https://www.schreder.com/en/projects/sustainable-self-supporting-lighting-mandel-bike-path

SOLUTION

Organisational measures

Overview

While exact definitions of organisational measures to foster cycling and cyclist safety can vary depending on the source, it can be summarised that organisational measures are those for which no significant infrastructure project investment is required in order to implement them. [1] defines following examples for legal and organisational measures:

- **Time windows** for trucks and delivery vans in city centre areas
- Possibility to **take bicycles on trains, trams or buses**
- **Lowered speed limits** throughout the city (e.g., Graz), 30 km/h zones
- **Parking regulations** for different areas (residential, commercial, city centre, etc.)
- **Enforcement** of parking regulations
- **Mobility management plans**

Organizational measures such as this can be applied to **improve cycling conditions**, and consequentially, **safety**. In the following chapters, some examples of organisational measures which can help solve issues related to cycling are provided: **30 km/h zones** in combination with changes in the street environment and other traffic calming measures, **public transport access**, and **vehicle parking measures**.

30 km/h-Zones

When several road user types use the same traffic space, more work is necessary to ensure that safety level is adequate. One popular measure is introducing zones with speed limits which are set at 30 km/h or lower (20 km/h or walking pace). The major benefits coming from introducing 30 km/h zones are **more pleasant street environment** and **positive social perception**. [1]

A well-designed 30 km/h zone generally **has a positive road safety effect**. At the speed of 30 km/h the risk of a fatal crash is very small. Actions which aim to improve safety by introducing 30 km/h zones and 30 km/h roads need to focus specifically on reducing speeds. This can be achieved by providing the zones with **suitable layouts**, which will make 30 km/h limit more **credible** and, where still necessary, **traffic enforcement** can be utilised. [3]

Characteristics

Measure	Costs	Treatment life	Effectiveness
30 km/h zone	€-€€	🕒🕒	🚲🚲

Implementation benefits

Positive effect on **road safety**

Better **street environment**

Positive **social perception**

Related issues fact sheets

- Network issues
- Speed differences in mixed spaces with pedestrians, E-Scooters etc.
- Speed differences in mixed spaces with motorised traffic

References and links

1. Institute for Social-Ecological Research (2021): Handbook On Cycling Inclusive Planning And Promotion
2. H.P. Lindenmann (2005): The effects on road safety of 30 kilometer-per-hour zone signposting in residential districts
3. SWOV (2018): 30 km/h zones. SWOV Fact sheet
4. Bassani M., Rossetti L., Catani L. (2020): Traffic accident pattern modification as a result of a 30 km/h zone implementation. A case study in Turin (Italy)

Public Transport Access

Bicyclists can expand the length of their journeys by merging cycling with train or bus service. The **catchment area** of a bus stop or train station is **expanded to around 4 to 5 kilometres** for cyclists. **Bike carrier racks** installed on buses are the most common way for public transport service to carry bicycles. Depending on the design, train wagons can hold dozens of bikes, which is especially important along heavily populated commute corridors. [2]

Successful integration of public transport and cycling networks carries **significant benefits** for both cycling and public transport. Public transport and cycling are generally

complementary modes. They can easily be combined as links in a **door-to-door trip chain**. In the Netherlands, about 40% of train passengers arrive by bicycle, and 10% of train passengers continue their trip by bicycle. In addition, 14 % of bus passengers use the bicycle as access mode. [1]

Characteristics

Measure	Costs	Treatment life	Effectiveness
Public transport access	€ - €€	🕒🕒	🚲

Implementation benefits

Promotes bicycling by greatly expanding the range of accessible destination

Implementation Issues

Bicycling portion of the trip becomes less feasible if there is no place to safely park the bicycle before transit/if there is no space in transit

Bicycle access is often prohibited during peak travel times

Examples

Train in Croatia - **folding seat area** near entrance/exit door serves as a place for placing bicycles

https://www.tportal.hr/pedaliranje/clanak/konacno-vlak-koji-voli-bicikle-uzitak-na-liniji-zagreb-sisak-20150424

Ship transits for islands in Croatia often support bicycle transfers

https://www.rogjoma.hr/hr/blog/bicikl-trajekt-najjeftinija-opcija/

Related issues fact sheets

- Network issues

References and links

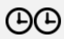
1. Institute for Social-Ecological Research (2021): Handbook On Cycling Inclusive Planning And Promotion
2. https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1630597001.pdf

Vehicle parking measures

Safer bicycling conditions can be facilitated by certain policy, design, and configuration practices for on-street parking for motor vehicles. **Reducing parking spaces** for vehicles is one of several viable options for **reducing conflicts between bicyclists and vehicles** driving into and out of parking, or with vehicle occupants entering or exiting parked cars. Completely eliminating or limiting a parking lane on one or both sides of the road is also an option for **obtaining functional room for cycling infrastructure**, for example, to build a cycling lane. In addition, eliminating or reducing parking will **improve sight distance** along a corridor and may be **particularly useful for segments with numerous busy driveways or conflict areas**. [2]

Analysis performed in [3] displays that there was an **association between the presence of on-street parking and the risk of injury**. However, the results of the adjusted odds ratio analysis were significant only in the case of major street routes without parked cars and bike infrastructure. It was concluded that riding on a major street route without parked cars and bicycle infrastructure is associated with a statistically significant **37%** decrease in the risk of experiencing an injury **when compared to the same type of road, but with on-street parking**.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Reducing vehicle parking	€		

Implementation benefits

Reduces conflicts between bicyclists and parking-related incidents (pulling into and out of parking spaces, dooring)

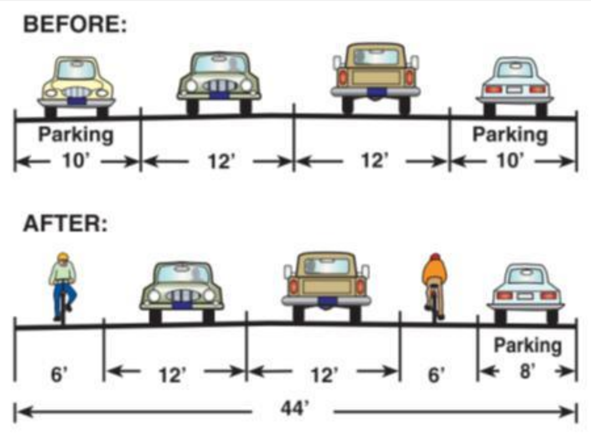
Provides **more space or facilities** for bicyclists

Improves sight distance along a roadway

Implementation Issues

Removing parking might result in an **increase in vehicle travel speeds**

Examples



Example of a **cross section** where parking is removed from one side in order to add bike lanes. [4]

Example of **back-in angle parking with shared-lane markings** - USA [2]

Related issues fact sheets

- Narrow Infrastructure

References and links

1. Institute for Social-Ecological Research (2021): Handbook On Cycling Inclusive Planning And Promotion
2. http://www.pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=5
3. Teschke, K., M. A. Harris, C. O. O. Reynolds, M. Winters, S. Babul, M. Chipman, M.D. Cusimano, J. R. Brubacher, G. Hunte, S. M. Friedman, M. Monro, H. Shen, L. Vernich, and P. A. Cripton (2012): Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study
4. Oregon Department of Transportation (2011): Oregon Bicycle And Pedestrian Design Guide

SOLUTION

Signs and Markings

Overview

Signs communicate **critical information** with the potential to **improve road safety**. The purpose of cyclist-related signage is to provide them (and other road users) with adequate **information,** allowing them to **anticipate certain situations**, which can significantly enhance reaction times. There are multiple sign solutions which can improve cycling safety [5]:

- **Rectangular Rapid Flashing Beacon**

  Used at pedestrian and bicycle crossings and activated by pushbuttons or automatic detection, the RRFB is a type of beacon that makes use of high-intensity light-emitting diodes (LEDs) that blink in a rapid and irregular pattern, similar to what is seen on many modern emergency vehicles.

- **Supporting cyclist signs**

  This group includes all signs which are used to indicate that cyclists are present on the route: cyclists in mixed traffic signs, yield/stop for cyclists, or signs which are indicating the dangers for cyclists such as dooring.

- **Pavement Markings**

  A range of pavement markings can be used at sections and intersections in order to indicate the presence of bicyclists and/or bike facilities and to provide information about upcoming manoeuvres which will need to be undertaken, as well as a guidance for bicyclists on the through an intersection.

All signs should be periodically checked to make sure that they are in **good working condition**, free from graffiti, reflective at night, and continue to serve a purpose.

Rectangular Rapid Flashing Beacon

While the majority of studies to evaluate rectangular rapid flashing beacons (RRFBs) focus on their pedestrian safety benefits, the beacons' ability to **increase vehicle yielding** at midblock crossings **benefits bicyclists** crossing at RRFB locations as well. As stated within a 2009 report [1], when the flasher was activated, the vehicle yielding rate was **54%**. In the before period, **82%** of the trail users were able to cross all the way across the intersection, while **18%** stopped in the middle. In the after period, **94%** of the trail users were able to cross all the way across the intersection, while **6%** stopped in the middle. The same report concluded that there also was **an increase in safety at the intersection** as a result of installing the RRFB.

An FHA report [2] has concluded that, on average across all sites, **4%** percent of vehicles yielded pre-treatment, while at the two-year follow-up, an average of **84%** of vehicles yielded at all sites, demonstrating the measure's effectiveness.

Another research [3] suggested that that RRFBs should be considered for facilities where posted speeds exceed 56 km/h (35 miles per hour) if pedestrians and bicyclists use the facilities.

The installation of RRFBs can reduce pedestrian crashes by **47%** [4]. While cyclists were not the main topic of the study, as mentioned before, it can be assumed that similar numbers can be deducted for this group as well.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Rectangular Rapid Flashing Beacon	€		

Implementation benefits

Yield rates to cyclists are high even after a couple of years

Speeds are lowered on sections where RRFS is installed

Increase in **safety** at the intersection

Solar-power panels can be used to **eliminate** the **need for a power source**.

Implementation Issues

Should **not be used in conjunction** with YIELD, STOP, or traffic signal.

Should be reserved for locations with significant pedestrian & cycle safety issues, as **over-use** of RRFB treatments may diminish their effectiveness.

Examples

Rectangular rapid-flashing beacon installed on a pedestrian crossing, USA.

https://www.youtube.com/watch?v=tT6E3scnXWA

Related issues fact sheets

- Poor signing

References and links

1. Hunter, Srinivasan, and Martell (2009): EVALUATION OF THE RECTANGULAR RAPID FLASH BEACON AT A PINELLAS TRAIL CROSSING IN ST. PETERSBURG, FLORIDA
2. Shurbutt, J., and R. Van Houten (2010): Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks
3. Ross, J., D. Serpico, and R. Lewis (2011): Assessment of Driver Yielding Rates Pre- and Post-RRFB Installation
4. NCHRP (2014): Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments
5. http://www.pedbikesafe.org/

Supporting cyclist signs

Support cycling signs provide **alerting and guiding information** as well as helpful **information** aimed towards all road users with the purpose of assisting cyclists. Road sharing signs can cause vehicle drivers to be **more aware** of bicyclists on sections with inadequate cycling facilities, and wayfinding signs provide **directional information** about routes connecting destinations or circumventing barriers, while indicating to vehicle users that bicyclists may be present. [2]

One research [1] shows that there was a significant increase in average bicyclist distance from the curb after installing “Bikes May Use Full Lane” supporting sign. Likewise, **motorist passing distance increased significantly**. The researchers concluded that the “Bikes May Use Full Lane” sign can be an effective method of **improving bicyclist safety** and have recommended further research into the subject.

[2] makes a mention that **no right-turn on red signal signs** can improve safety for bicyclists, however no specific reference to the research is given. However, it is elaborated that issues might often occur where right turns on red signal are allowed, especially if bicyclists are approaching the crossing from the right or are cycling the wrong way either in the street, sidewalk or a path, as vehicle users **tend to look to the left for a gap in traffic**.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Various sings (metal or electronic sign)	€ - €€	🕒🕒	🚲🚲

Implementation benefits

Regulatory signs, such as STOP, YIELD, or turn restrictions require **driver actions** and are **enforceable**

Prohibiting right turn on red (RTOR) is a **simple, low-cost** measure

Implementation Issues

Overuse often results in **non-compliance and/or disrespect**

Part-time Right Turn on Red prohibitions during peak hours may be sufficient to address the cycling safety problem, but the **impact on traffic flow** should be studied

Examples

Yield to crossing bikes from both directions. Different signs but the same meaning. Left Netherlands, right Australia

https://bicycledutch.wordpress.com/2012/06/04/road-signs-for-cycling-in-the-netherlands/

Cycling crossing sign in Croatia

https://www.signal.hr/hr/proizvodi-usluge/turisticka-rjesenja-22/biciklisticke-oznake-46

Related issues fact sheets

- Poor signing

References and links

1. Brady, J., J. Loskorn, A. Mills, J. Duthie, and R. Machemehl (2011): Operational and Safety Implications of Three Experimental Bicycle Safety Devices in Austin, Texas
2. www.pedbikesafe.org

Pavement Markings

Some examples for pavement markings include **striping and painting symbols** associated with bike lanes, striping for paved shoulders, turning lanes at intersections, shared lane markings, railroad crossings, and drainage grates or other pavement hazards or irregularities. [1]

The **overall principle** for optimising cycling safety is ensuring that all pavement markings are **durable**, **visible**, and **non-skid**. The amount of skid resistance varies with each product and material. If thermoplastic is used for bicycle markings, a thin, non-skid type is recommended. In some instances, glass beads, crushed glass, and aggregate can be included during marking installation in order to increase skid resistance. [1]

A **bike box** is a pavement marking pattern which is intended to provide priority for bicyclists over vehicles at signalized intersections, while also serving as a measure to improve visibility between vehicles and bicyclists. This treatment is used at signalized intersections on roads with a marked bike lane and, according to [2], **reduces conflicts between bicyclists and turning motor vehicles** by making the cyclists easier to see. One research [3] found the use of the bike box to be promising and encourages more studies into its effectiveness. Following the installation of the bike boxes, bicyclist volumes at study intersections increased by **94%**, while the number of conflicts between bicyclists and vehicles **have been reduced by 9%**. Another study [4] also indicates a reduction in the number of conflicts after the installation of bike boxes. However, it should be taken into account that bike box markings are an effective measure only for cyclists arriving at the intersection at red light. [5] (see also Fact Sheet Junctions and Crossings)

Shared lane markings, also known as **sharrows**, are bike-and-chevron pavement markings that provide information to bicyclists about the safe space to ride within the road and encourage them to use more of the travel lane to avoid unsafe spacing between bicycles and the side of the road. A number of studies validated that when utilising sharrows, a **significant shift in the percentage of bicyclists cycling on a road** instead on a sidewalk occurs [6] [7], and **the distance between bicyclists and parked cars is increased** [7]. Another study [8] found that the number of **near-doorings was decreased** after installing sharrow markings.

Characteristics

Measure	Costs	Treatment life	Effectiveness
Pavement marking	€€		

Implementation benefits

Can be used at intersections to **indicate the presence of bicyclists and bike facilities**

Increases cycling usage when compared with no facilities

Reduces conflict between vehicles and cyclists

Implementation Issues

Long-term **maintenance costs** should be taken into consideration as durability and cost are generally inversely related.

Local **weather conditions** and how pavement markings are applied will impact pavement **marking durability**

Examples

Street with **sharrow** pavement marking, Croatia

https://www.index.hr/vijesti/clanak/biciklisti-oprez-evo-kako-odsad-mozete-voziti-gajevom-ulicom/935503.aspx

Bike Box in Croatia

https://www.index.hr/vijesti/clanak/biciklisti-oprez-evo-kako-odsad-mozete-voziti-gajevom-ulicom/935503.aspx

Related issues fact sheets

- Network Issues
- Poor signing

References and links

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2. Hunter, W. W., J. R. Stewart, J. C. Stutts, H. H. Huang, and W. E. Pein (1999): A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes
3. Hunter, W. W. (2000): Evaluation of Innovative Bike-Box Application in Eugene
4. Dill, J., Monsere, C. M., McNeil, N. (2012): Evaluation of bike boxes at signalized intersections. Accident Analysis and Prevention, 44, pp. 126–134.
5. Horn, B., Menge, J., Spiegelberg, I. (2015): Sicher geradeaus! Leitfaden zur Sicherung des Radverkehrs vor abbiegenden Kfz. Berlin. https://repository.difu.de/jspui/bitstream/difu/232443/1/DS1410.pdf
6. Pein, W. E., W. W. Hunter, and J. R. Stewart (1999): Evaluation of the Shared-Use Arrow
7. Alta Planning + Design (2004) San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety
8. Hunter, W. W., R. Srinivasan, and C. A. Martell. (2012): Evaluation of Shared Lane Markings in Miami Beach, Florida
9. Weigand, McNeil, Dill (2013): Cost Analysis of Bicycle Facilities

Positive Effects

Energy and resources

Overview

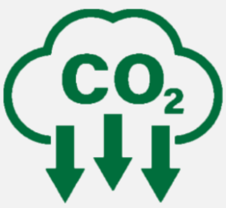
Cycling is a **cheap mode of transport**. The annual personal costs of cycling range from 175 to 300 euros. By comparison: the costs involved in driving a car range from 2500 to 8500 euros a year, based on an average annual mileage. Cycling also scores well in terms of the **social impact** of a kilometre of urban travel by bicycle compared to such costs involved in a kilometre of travel by car or by bus: each kilometre of bicycle use yields a **social benefit of 0.68 euros per kilometre**, whereas **cars and buses cost society 0.37 euros and 0.29 euros per kilometre**, respectively. The annual **infrastructure costs** per traveller kilometre are 0.03 euros for bicycles, 0.10 euros for cars, 0.14 euros for buses, and 0.18 euros for trains. As well as economic benefits, cycling provides **ecological benefits related to energy consumption and gas emissions**.[1]

Positive effects

Increased bicycle use can result in **lower greenhouse gas emissions**. Switching from a car to a bicycle saves 150 g of CO_2 per kilometre. Each 7 km by bicycle rather than by car will save an emission of 1 kilogram of CO_2. Cars are used for 3.6 billion short trips (< 7.5 km) annually. Replacing all these short car trips by cycling would save roughly 2.0 megatons of CO_2 per annum. Increased bicycle use also contributes to **cleaner air**. Switching from a car to a bicycle saves 0.2 g of NOx per kilometre and 0.01 g of particulate matter per kilometre. Each 7 km by bicycle rather than by car will save an emission of 1.5 g of nitrogen oxides and 7 mg of particulate matter. By replacing 3.6 billion short car trips with cycling would save roughly 2.6 kilotons of NOx and 0.13 kilotons of particulate matter per year.[1]

The current levels of cycling in the EU correspond to fuel savings of more than **3 billion litres per year**, which **corresponds to the fuel consumption for road transport of a country like Ireland**. The value of these fuel savings is almost **4 billion euros**. The average weight of a car in the EU in 2017 was almost 1400 kg, a bike rarely weighs more than 20 kg, or **1.5% of the weight of a car**. This means that much **less resources are needed for its construction**. Some of the resources are the same, but used in much less quantities (e.g. steel, aluminium, different polymers), others, like platinum or palladium for catalytic converters which cause significant emissions and environmental damage during their extraction, are not used at all for the manufacturing of bicycles. [2].

Benefits



Lower greenhouse gas emissions

Cleaner air

Low annual infrastructure costs per traveller kilometre

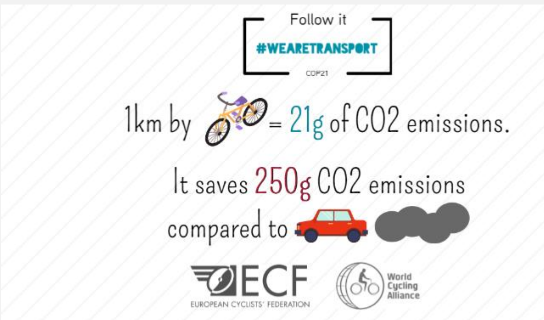
Issues

To provide appropriate bicycle infrastructure

Necessary **costs** to form an accessible, well connected and quality cycling infrastructure

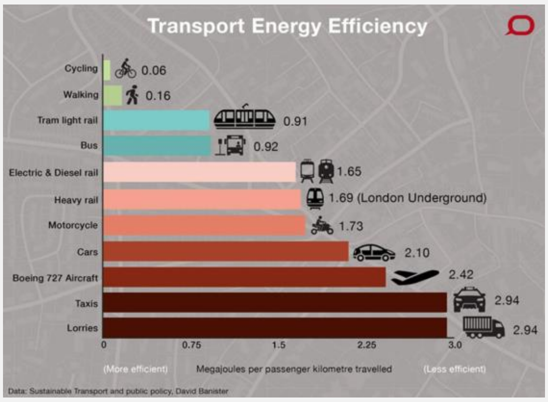
Bicyclists' safety remains a point for attention

Examples



According to the ECF, driving one kilometre by bicycle instead of a car can save up to 250 grams of CO_2 emissions. Furthermore, per every kilometre driven by bicycle, a person produces only 21 grams of CO_2 if we take in consideration materials and energy used during bicycle production.

https://twitter.com/eucyclistsfed/status/669797905113460736



According to many studies, cycling is a very efficient and energy-saving mode of transport, while some even state that cycling is currently the most efficient transport mode, consuming only 0.06 Megajoules per passenger per kilometre travelled.

http://www.gci.org.uk/Documents/E6-40-04-021.pdf

References and links

1. Lucas Harms, Maarten Kansen (2018): Cycling Facts-Netherlands Institute for Transport Policy Analysis
2. https://ecf.com/sites/ecf.com/files/TheBenefitsOfCycling2018.pdf

Time, space and noise

Overview

Studies from London, Montreal, the US and Colombia show that cyclist commuters are the most or among the **most satisfied** with their trips to work which shows the level of quality of time spent cycling [1]. The bicycle is very **space-efficient**: During 1 hour, 7 times more bikes than cars can cross a 3.5m wide space in an urban environment. The **space** that is needed for a **single car-parking spot can fit up to 15 bicycles** [1]. By using the **public space** more **efficiently**, it is possible to move more people through the same infrastructure (more people can cross the section of the road on bicycles than in cars in given time) **without harmful emissions and gases for the environment**.

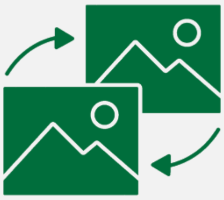
Positive effects

Moving car takes up **28 times more space** than a moving bicycle. A **parked car** takes up **10-15 times more space than a parked bicycle** [1, 2]. In metropolitan and urban areas, parking a bicycle in the vicinity of one's destination is far **easier than parking a car**. In metropolitan and urban areas, a **time of arrival** can be estimated **more accurately** and **more reli**ably when travelling by bicycle rather than travelling by car (or public transport). **Traffic noise** is a serious nuisance to roughly 30% of the population. An increase in the number of bicycles will **reduce** such **nuisance**, but the effects will be limited. For example: depending on the type of road, traffic composition, and construction density, a halving of the number of motor vehicles will locally result in a **3 dB noise abatement**, a difference which is discernible to the human ear. [2]

Benefits

	More efficient use of space
	Noise reduction
	Moving more people through existing infrastructure

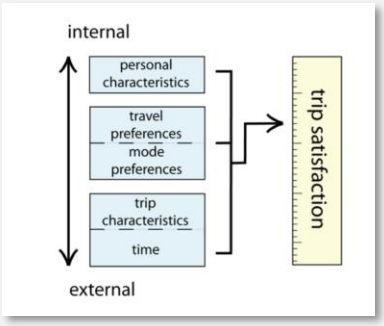
Issues



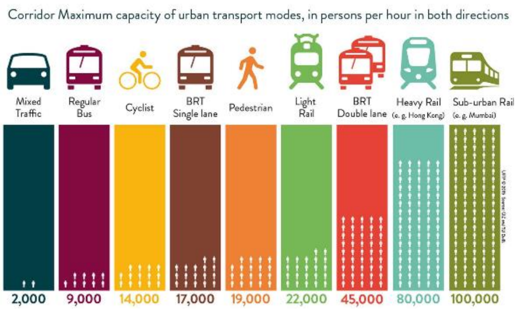
Conversion of space is needed which will result in less car purposed space

It is necessary to **provide parking facilities** for bicycles

Examples



“The happy commuter: A comparison of commuter satisfaction across modes” research shows that personal characteristics, travel and mode preferences, as well as trip and travel time characteristics can be placed on a continuum from internal to external, and all have influences on trip satisfaction. [3]



A 3.5m motor traffic lane can carry around 2,000 people per hour, assuming typical urban car occupancy rates. That same 3.5m, allocated to cycling, can carry at least four times as many people per hour, perhaps even seven times as many - 14,000 people per hour.

https://www.cycling-embassy.org.uk/dictionary/capacity

https://twitter.com/GusTransporte/status/854727543521288192/photo/1

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2. Lucas Harms, Maarten Kansen (2018): Cycling Facts-Netherlands Institute for Transport Policy Analysis
3. St Louis, E., Manaugh, K., van Lierop, D., & El Geneidy, A. (2014). The happy commuter: A comparison of commuter satisfaction across modes.
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5. Sutton, Mark (2018): Cyclists are the happiest commuters, says new YouGov poll
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8. Bruun and Vuchic.1995. The Time-Area Concept: Development, Meaning and Applications. Transportation Research Record 1499

POSITIVE EFFECTS

Multimodality

Overview

Multimodality or multimodal travel is the **combination of different modes of transport in a single journey**. It is important for achieving less car dependent lifestyles and more sustainable transport behaviours in which **cycling** plays an **important role**. In Europe in general, people are increasingly looking to **combine bicycles and trains** for leisure, tourism and mobility trips. [4] All **railway companies** in the European Union (EU) are obliged to provide **at least four dedicated spots for bicycles** on all new and refurbished trains.

Research from the Netherlands, which focuses on cycling substituting motorised transport, shows cycling is **embedded in a multimodal behaviour**. The study also demonstrates cycling serves **many purposes** that overcomes the division of utility and recreational cycling, and that cycling takes place in both dense urban settings and small towns. [2] Another Dutch research show that **83%** of all train journeys are **multimodal trips**, where 44% of train commuters in the Netherlands use the bicycle to reach the train station from their home. Besides, people that combine train and bicycle trips often, use their car less. People using bicycle and a train in a single journey, most often use a **private bike** which is parked in a bicycle **parking facility** at the train station, a **shared bike** which is retrieved from and returned to a facility at the train station, or a **folding bike** which can easily be taken on board the train. Train passengers who cycle to and/or from stations give high importance to **bicycle storage facilities**, as well as to the walking and cycling routes involved in the entire trip chain. [1, 5]

Positive effects

Multimodality that includes cycling usually makes our travel **more efficient**. The combination of different modes of transport results in high environmental **sustainability** since multimodal travel **reduces the environmental footprint** of transportation as long as it includes active modes. It can support the shift to a low carbon economy by taking advantage of the **benefits of different transport types** to ease pressure on Europe's congested roads. At the same time multimodality contributes to **safer and cheaper transportation**. [3] Cycling to and from train stations also saves us time since it is one of the most **reliable journey options** which also contributes to our mental and physical health. [6]

Benefits

Sustainable way of traveling

Time reliable transport option

Cheaper than traveling with car

Challenges

Limited space for bikes on trains

The **lack of safe parking facilities** and **bike share systems** at train stations

Spatial plan changes to provide more cycle friendly streets connecting different locations with train stations

Examples

Train station bicycle parking in Groningen, the Netherlands.

Photo: David Hembrow, http://www.aviewfromthecyclepath.com/2010/05/groningen-railway-station-cycle-parking.html

Bike share station in London.

Photo: Julietta, https://www.jullietta.com/planning-stuff/bike-parking-and-bike-share-at-london-train-stations

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POSITIVE EFFECTS

Technology and design: electric bicycles

Overview

In 2017, more than 10% of the bikes sold in Europe were **electric**, compared to only 1.5% of cars. Since 2006, sales of electric bikes have multiplied by 20, with an average **annual growth rate of almost 30%**. When France introduced a national purchase incentive scheme in 2017, 61% of beneficiaries stated in a survey that they used the electric bicycles to replace car journeys.

Bike-sharing makes **work commutes and in-work trips more efficient** and **increases connectivity** in a city by providing **easy and fast first-mile/last-mile access**, **enhancing productivity** in the urban economy. For the Dublin bike-sharing system, every 1 euro invested created 12.3 euros of **time benefits**, wider **economic benefits** and **health benefits**. The **value of the time savings alone is in a range of 6 – 10.4 million euros**. [1]

Positive effects

With introduction of **electric bikes** many advantages appear: pedal assist gives cyclist a **boost** which helps mastering hills, inclines, and rough terrain, allowing for a **smoother ride** thus **reducing body stress**. It also provides a ride with **greater power and precision** than a regular bicycle. It **gets people cycling who may not otherwise ride a traditional bike** because of physical condition or age. It is easier to take **longer rides** without physical exhaustion. Electric bikes are great for commuting to work on short distances or running quick errands. With alternative ways to travel to your destination, the commute can be faster than a car stuck in traffic, especially in the city centres. When people ride their e-bike instead of driving, they cut down on fuel and pollution, helping to **improve air quality and the environment**.

One study [2] found that people who ride electric bikes experience **nearly as much exercise as those who ride conventional bikes** without feeling as if they've had a difficult workout. The truth is that even with pedal assist, riders still have to pedal which results in burning calories.

Benefits

More efficient commuting

Time **savings**, economic and health **benefits**

Modal split in favour of bicycle transport since more people will get attracted to cycling

Issues

Costs of building appropriate bicycle infrastructure for supporting new technology

Inexperienced elderly riders of e-bikes have an **increased risk of severe crashes or falls**

Examples


RICARDO-AEA

Cycling as a new technology

Final Report

Photos: ECF

Report for European Cyclists' Federation

Ricardo-AEA/R/ED60365
Issue Number 1
Date 09/01/2015

"Cycling as a new technology" aims to help shape a 'new technologies' strategy by offering a high-level assessment of the potential for new cycling technologies, e.g. e-bikes, public bike-sharing, and cargo bikes. With this strategy, ECF was able to better engage in EU level policy in order to support the continued deployment and uptake of cycling in Europe.

https://ecf.com/sites/ecf.com/files/FINAL-REPORT-150116_New-tech.pdf

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2. Pedal-Assist Mountain Bikes: A Pilot Study Comparison of the Exercise Response, Perceptions, and Beliefs of Experienced Mountain Bikers, 2019, Cougar Hall, Taylor H Hoj, Clark Julian, Geoff Wright, Robert A Chaney, Benjamin Crookston, Joshua West
3. https://www.markelinsurance.com/resources/bicycle/benefits-of-e-bikes

POSITIVE EFFECTS

Business

Overview

The value of the bicycle market in Europe was estimated at 13.2 bn EUR in 2016. It is expected to grow with an annual rate of 5.5% until 2022. In comparison, the European car market is expected to grow by only 1.7% until 2024.

There is an estimated number of **2.3 billion cycle tourism trips per year** in the EU, which stand for **a total economic value of 44 bn EUR.** Cycle tourism is linked to ca. **525 000 jobs in the EU.** In France, cycle tourists spend **almost 20% more** than the average for all tourists. In comparison, the cruise tourism industry stood for an **economic value of 38 bn EUR and 326 000 jobs** in 2012. [1]

Positive effects

Cargo bikes have the potential to replace the following share of motorised trips in urban areas:

+ 23-25 % of the **commercial deliveries** in cities

+ 50 % of the **commercial service and maintenance trips**

+ 77% of **private logistics trips** (shopping, leisure, child transport)

Customers using their bike to go shopping account for **a total volume of consumption of 111 bn EUR** in the EU. Clients **coming by bike spend more than those coming by car,** be it during a certain time period or related to the parking space that has to be provided for them: Per square metre, **cycle parking delivers 5 times higher retail spend** than the same area of car parking. Cyclists do their **shopping locally** and are more **loyal customers.** Retailers **often under-estimate the share of clients that go shopping by bike,** and over-estimate the share of car users among their customers. If a street is transformed in a way that gives more space to cyclists and pedestrians and less to cars, the absence of clients that came by car before is **more than compensated for by the clients that come by foot or by bike** afterwards. In London, **retail vacancy was 17% lower and retail rental values 7.5% higher** after active mobility improvements in shopping streets and town centres. [1]

Benefits

Higher retail **spending**

Reduced use of commercial vehicles in favour of cargo bikes

Higher **economic value** linked to cycling tourism

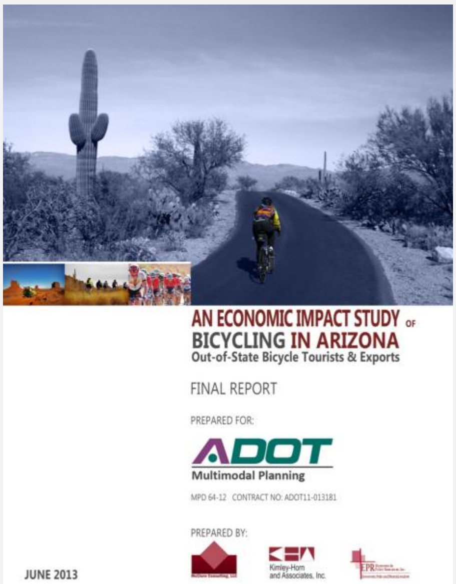
Issues

Company and business awareness to switch from cars and vans to bicycles

Strong transport policy towards bicycle use needs to be implemented

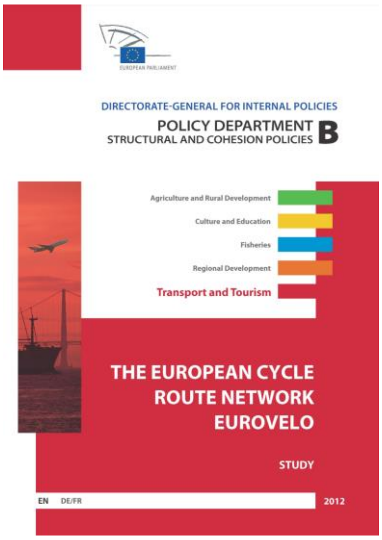
Issues may arise regarding spatial plan changes to provide **more pedestrian zones and cycle friendly streets**

Examples



An Economic Impact Study of Bicycling in Arizona: Out of State Bicycle Tourists and Exports, which focused on the impacts from out-of-state cyclists traveling to Arizona for events, guided tours, races, and training camps. The study documented $57 million in retail sales and 721 jobs created across the state.

https://apps.azdot.gov/files/ADOTLibrary/Multimodal_Planning_Division/Bicycle-Pedestrian/Economic_Impact_Study_of_Bicycling-Final_Report-1306.pdf



THE EUROPEAN CYCLE ROUTE NETWORK EUROVELO document states that there are an estimated 2.295 billion cycle tourism trips in Europe with a value in excess of €44 billion per annum. The same study also says that ECF's EuroVelo network will generate €7 billion of direct revenue when completed

https://ecf.com/files/wp-content/uploads/studiesdownload.pdf

References and links

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Tourism

Overview

Data from the World Tourism Organization show tourism is **one of the world's major economic sectors**. It is the third-largest export category (after fuels and chemicals), in 2019 accounted for 7% of global trade, supports **one in 10 jobs** and provides livelihoods for many millions more in both developing and developed economies. For some countries, it represents over 20% of their gross domestic product (GDP). [1] According to the Global Wellness Institute (GWI) a market which was growing twice as fast as general tourism from 2015–2017 was so called **wellness tourism** defined "as travel associated with the pursuit of maintaining or enhancing one's personal wellbeing". [2] Wellness tourism was valued at more than $641 billion global market in 2019 and it is estimated it will grow by $315 bn during 2020–2024. [3, 12] Recently, the notion of wellness tourism has started to include also **active travel**, including cycling. [4] Hectic work schedules and sedentary lifestyles have resulted in a decline in physical activities among people, leading to a rise in lifestyle-related problems, therefore many wishes to be active while traveling. [3]

With the Covid-19 pandemic, with tourism being one of the most affected sectors, **cycling**, on the other hand, is **gaining popularity**. **Cycling tourism**, defined by the European Parliament as an activity that attributes to travel between destinations by bicycle for **leisure purposes** and where cycling is an **integral part of the tourist experience**, could represent an **important factor in tourism recovery**. In Europe, cycling tourism has set some **records** despite the Covid-19 pandemic. [9]

Positive effects of Cycling tourism

Prior to 2020, the worth of cycling to the European Union (EU) economy was €63 bn. Cycling tourism with its €44 bn represented the biggest share. [5] This **economic impact** was estimated based on more than 2.2 billion cycle tourism trips and 20-million-over-night cycle trips made every year in Europe. [10] Moreover, cycling tourism was linked to 525,000 jobs in the EU, which is more than the steel and cruise industries. [5, 6] According to European Cyclists' Federation's CEO Jill Warren, cycling tourism "helps **combat the over-tourism** of certain hotspots by taking people off the beaten path and spreading tourism around to less-visited areas. It **benefits small and medium-sized businesses**, and the **infrastructure** also **benefits local residents** and **improves rural connectivity**". [7]

In the absence of international travel in 2020, people in Europe took to bicycles, with many trips done locally. [5, 8] In the time of a pandemic, cycling is seen as a **safe way to travel**, which is slow paced and offers a range of possibilities for different ages and abilities. Cycling tourism can be enjoyed in different **natural environments** and in a form of road cycling, mountain biking, e-biking, or bikepacking. [8] The results of the EuroVelo Barometer, which tracks the use of ten long-distance **EuroVelo** routes, show a general **growth of 2%** on the EuroVelo Network during the first eight months of 2021 compared to the same period in 2019. This includes a **12% increase at weekends** suggesting that much of this growth can be connected to **tourism and leisure** use. [11] As part of the surge it was noted that **development of new routes** prompted a **wave of tourism**, which was the case for example in Hungary and in France. [5, 11]

Cycling tourism represents a **sustainable way of travelling** which doesn't benefit only the economy but also environment and people's health. Cycling outdoors connects us with the nature and contributes to our physical and mental health. When traveling by bicycle is combined with public transport, cycling tourism can also **reduce the carbon footprint** of the tourism sector and can therefore bring us closer to a decarbonised future. [13]

How to boost cycling tourism

Many **infrastructural changes** which were adopted by governments and city authorities during the pandemic, have come about as alternatives for **daily commuters**, who for example exchanged public transport for a bicycle. However, the permanent investments will have a **positive impact** also for the **domestic cycling tourism**. [8] To boost cycling tourism even further, the creation and updates of **high-quality, safe and scenic cycle routes** are needed – in a form of further development of EuroVelo and national cycling networks. Besides, attention & promotion needs to be directed also towards **cycle-friendly services and amenities**, such as bike hotels and inclusion of small local business.

Benefits

Sustainable way of traveling

Reduces carbon footprint

Boosts local economy, brings people to less visited areas, improved rural connectivity.

Contributes to our physical and mental health.

Challenges

To provide appropriate **bicycle infrastructure**

Costs for planning, building and maintaining cycling networks

Ensuring **cyclists' safety**

Examples

Cyclists in front of the oldest vine in the world in Maribor, Slovenia.

Photo: Aleš Fevžer, www.slovenia.info

A cyclist on the Slovenian coast.

Photo: Tomo Jeseničnik, www.slovenia.info

Underground biking in Peca, Slovenia.

Photo: Tomo Jeseničnik, Podzemlje Pece d.o.o., www.slovenia.info

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POSITIVE EFFECTS

Physical Health

Overview

According to the World Health Organization (WHO), physical activity is “any bodily movement produced by skeletal muscles that requires energy expenditure”. [1] The WHO figures show one in four adults don’t exercise enough. Globally, women are less active than men (23% vs. 32%), people in high-income countries (63% of active population) are less active than people in middle (74%) and low-income countries (84%). If the global population was **more active**, up to five million premature **deaths** per year **could be prevented**. [2] Worrying is the fact that society, including children, adolescents, is becoming more and more sedentary. The data from the European Union (EU) show only about one in four 11-year-olds and only one in seven 15-year-old reported they undertook moderate to vigorous exercise (an activity that increases the heartbeat) at least one hour daily in 2018, which is a recommended amount by the WHO. In all EU countries, girls are less physically active than boys at both ages. Besides, physical activity also falls sharply between ages 11 to 15 in most EU countries for both genders. [3]

Cycling, besides walking, is a physical activity that is most often listed as a great and very common example of physical activity that can **benefit a person’s health and fitness**. Cycling is a **low impact type of aerobic activity** that many people can **incorporate into their daily lives** as a **mode of transport**, **casual activity**, or **competitive sport**. It is a very **popular** physical activity that is relatively **easy to start** and is **suitable for most fitness levels**. [4] The challenge, however, is many people don’t have **access to spaces** where they would be able to cycle safely or engage in other physical activities. [2]

Positive effects of cycling

Cycling is a very **convenient physical activity** because it offers **different levels of intensity**, for example with adapting the length of the activity or with choosing harder terrain for cycling.

- Cycling improves **cardiovascular health**:
  - Studies show that people who cycle to work experience notable health benefits, including improved cardiovascular functioning.
  - Cycling commuters have 46% lower risk of developing cardiovascular disease, and a 52% lower risk of dying from the condition. [4, 5]
- Cycling improves **high blood pressure** (hypertension) issues:
  - After 3 months of regular cycling blood pressure may reduce by 4.3%. After 6 months the reduction can be by 11.8%.
  - Cycling is an effective method to lower blood pressure in people with type 2 diabetes. [4]
- Cycling helps with the **weight management**:
  - Cycling increases metabolic rate, builds muscle and burns body fat. In a combination with a good diet, cycling helps people to reduce body fat and body mass. [4]
- Cycling improves **cardiorespiratory health**:

- Cycling for about 170–250 minutes per week can greatly improve lung health. [6]
- Physical activity like cycling can help the immune system protect a person from respiratory infections. [4]

- Cycling helps to prevent different **site-specific cancers**, for example, of bladder, breast, colon, gastric, and renal. [1]

Benefits

Improves **cardiovascular health.**

Helps to regulate **high blood pressure.**

Helps to regulate **body fat and body mass.**

Helps to improve **lung health.**

Challenges

To provide appropriate **bicycle infrastructure.**

Costs for planning, building and maintaining safe cycling networks.

Proper and effective **promotion** of cycling in connection to physical health.

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POSITIVE EFFECTS

Mental Health

Overview

In the definition of mental health by the World Health Organization (WHO) the positive dimension is emphasized: “mental health is a **state of well-being** in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community” [1]. The 2020 edition of *Health at a Glance: Europe* highlights good mental health as vital for people to be able to lead healthy and productive lives. Living with a mental health problem can have a significant **impact on daily life**, contributing to worse educational outcomes, higher rates of unemployment, as well as poorer physical health. A new challenge for mental health has come with the Covid-19 pandemic which is also having a negative impact on mental wellbeing, especially amongst young people and people with lower socio-economic status. [2]

According to the Institute for Health Metrics and Evaluation, more than one in six people across EU-28 countries (17.3%) had a mental health problem, such as depression, anxiety disorders and alcohol and drug use disorders, in 2016. Besides the impact on people’s well-being, the estimated **costs** of mental ill-health are over €600 bn or more than 4% of GDP in EU-28 countries. [1] Without effective treatment and support, mental health problems can have a devastating **effect on people’s lives**, and significantly increase the risk of dying from suicide. In 2017, there were on average 11 deaths by suicide per 100,000 population across EU-27 countries. [2]

One of the effective approaches towards good mental health is **physical activity** which gives us **structure, purpose, energy, and motivation**. [3] Cycling offers an affordable and safe way of exercising.

Positive effects of cycling

WHO recommends at least 150–300 minutes of moderate-intensity aerobic **physical activity**; or at least 75–150 minutes of vigorous intensity aerobic physical activity; or an equivalent combination of moderate- and vigorous-intensity activity throughout the week, for substantial health benefits amongst adults aged 18 and above. Physical activity has many **health benefits**, including for our mental health – reducing symptoms of anxiety and depression. [4] Besides, it is effective at altering the way we process and respond to our emotions, reduces how much we overthink, and builds up an emotional resilience to stress. This helps making us behave differently, boosting our self-esteem, and reducing our feelings of loneliness by becoming more social. [3]

- Physical activity like cycling **reduces stress**:
    - Cycling can **lower** the levels of our body’s **stress hormone**, cortisol. [5]
    - Research shows that those who **commute by bicycle** regularly have significantly **lower risk of being stressed** than non-bicycle commuters. [6]
- Physical activity like cycling **reduces anxiety**:

   - Cycling causes our body to **release endorphins**, also called happiness hormones. Amongst other things, they trigger a **positive feeling** in the body, which can be accompanied by a positive and energizing outlook on life. [7]
- Physical activity like cycling **wards-off feeling of depression**:
   - Regular cycling can **boost our mood**. It is especially useful for people with mild to moderate depression. [5]
- Physical activity like cycling can **improve our sleep** and **boost self-esteem**:
   - Cycling helps us getting a **better night sleep**, which can put us in a good mood.
   - Cycling can make us feel **more positive** and better about ourselves, especially as we improve and meet our goals, which helps boosting our self-esteem. [5]
- Physical activity like cycling helps us **socialize**:
   - Cycling can be a great activity if we want some time alone as well as sharing our active time with others.
   - Socializing can **reduce the feeling of loneliness**, helps to reduce stress and anxiety. [5]

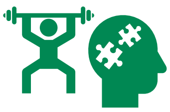
Cycling is usually performed **outdoors**, which also contributes to our **mental well-being**. The studies show that compared with exercising indoors, exercising in natural environments is associated with greater **feelings of revitalisation**, increased **energy** and **positive engagement**, together with decreases in tension, confusion, anger and depression. [8]

Benefits

Cycling **reduces stress**

Reduces anxiety and **boosts our mood**

Improves our **sleep** and **boosts self-esteem**



Contributes to our **physical** and **mental health**

Challenges

To provide appropriate **bicycle infrastructure**

Costs for planning, building and maintaining safe cycling networks

Proper and effective **promotion** of cycling in connection to mental health

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POSITIVE EFFECTS

Social inclusion

Overview

The bicycle can be key to **reducing social inequalities**. It provides an aff**ordable transport option**, brings about additional opportunity for **social interaction**, contributes to the quest towards full **gender equality**, and helps creating additional **jobs**.

Positive Effects

The yearly costs for owning and using a bike only amount to around 5% or 10% (for electric bicycles) to the costs for owning and using a car. By providing a **cheap transport option**, cycling can help to **create jobs** and make **participation in social life** better accessible to disadvantaged population groups. In the United States, the lowest-income households — Americans making less than $20,000 per year – are twice as likely as the rest of the population to rely on bikes for basic transportation needs like getting to work. [2]

Research shows that **women tend to benefit more from higher cycling levels.** For example, since they are still taking care of most of children's' and older adults' mobility in families, they gain more free time if the children and elderly can undertake journeys by bike **independently** and do not need a lift by car. More people cycling and walking in streets increases social control, which can help to deter criminals and **create a higher level of perceived security**. [2]

As stated by [3], cycling provides following social benefits:

- Bike riding provides **affordable and independent travel** for those who might otherwise have restricted travel options.
- Bicycles offer **increased mobility** to many groups of the population with **low rates of car ownership**, such as low-income earners, unemployed people, seniors and those under 18 years of age.
- Construction of shared bicycle riding and pedestrian facilities also creates **benefits for pedestrians and people with disabilities** by providing an increased network of paths and improved road crossings.
- More people riding and walking provides additional **opportunity for social interaction** on the streets which can greatly enhance a **sense of community and connection**, improving mental wellbeing.

Cycling has the capacity to **reduce economic inequalities** between different parts of a city. It does this, in part, by mobilizing people who suffer from transportation disadvantages. The bicycle **empowers those who previously could not move effectively** throughout their communities by foot or other transit means, allowing them to contribute to the economy in their own local neighbourhood or those surrounding it. By serving as either consumers or employees, these enfranchised individuals are better able to stimulate money flows that eventually can lead to economic equity on a larger scale. [7]

Benefits

Lower yearly costs for people using a bicycle instead of a car

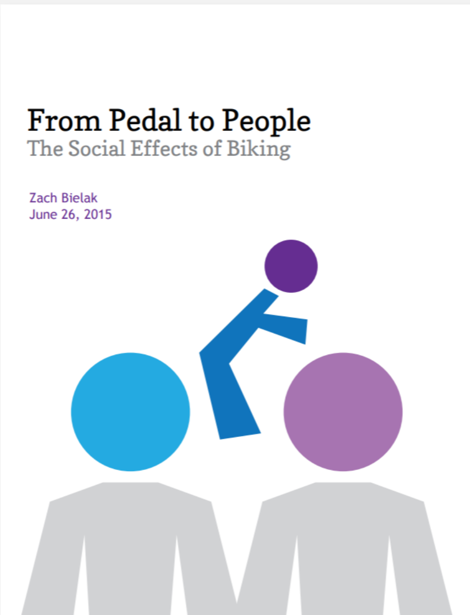
Improved gender equality and **health benefits**

Higher level of perceived security on the streets

Issues

Cycling measures aiming to tackle social issues might not be highly transferable and might depend on instance specific factors, even on a city level.

Examples



From Pedal to People - The Social Effects of Biking [7] concluded that the best social impact of cycling occurs when people stop considering themselves “cyclists,” but rather just people trying to get from Point A to Point B who happen to be using a bike. Only a few societies on this Earth have achieved such a state, but most other societies are not terribly far behind.

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POSITIVE EFFECTS

Diversity of cultures

Overview

Cycling is a **social activity**. By bringing people together and connecting neighbourhoods, it provides the potential for more exchange between them. It can connect people from different backgrounds and social classes, thus improving the cohesion of society [1]. Cycling encourages **social interaction**: *“Cyclists continuously, (un)consciously negotiate with others and with their surroundings to prevent collisions or mediate traffic flows. In doing so, they* ***interact with a large number of other road users and objects in physical space****. Cyclists also have a high degree of* ***freedom to traverse and interact*** *with their surrounding environment, given the infrastructure, traffic laws and cultural acceptance.”* [2]

Positive effects

Cycling, including cycle logistics, makes cultures more resilient by providing transport options also in cases of emergency like natural catastrophes or terrorist attacks.

Cycling increases **accessibility**, not only to employment, but also **to places of social and cultural exchange**. During the last years, **cycling classes for refugees** have been a success story in a number of EU countries, including Sweden, Germany, the Netherlands, or Finland. Often managed by ECF member organisations, these initiatives **give refugees, and in particular women, the possibility to participate more actively in society** by giving them **easy access to relevant facilities**.[2]

Benefits

Better mobility in case of an emergency

Connectivity between people

Accessibility to places of social and cultural exchange

Issues

Change in the people's **mindset**, to give a new look at a bicycle as a mode of transport

Institutions and places of social interest need to **provide bicycle facilities**

Examples

In Portland (USA), cargo bikes are used by members of **Neighbourhood Emergency Teams** (NET) in case of a disaster in order to deliver necessities to those in need. NETs are formed by local community inhabitants, some of which undergo trainings organized by firefighters or paramedics, and actively help other community members during disasters. Cargo bikes offer the possibility to transport cargo combined with the mobility capabilities of a bicycle.

https://bikeportland.org/2012/03/28/the-next-frontier-for-cargo-bikes-disaster-response-69571

In London, The Bike Project offers **cycling lessons to refugees**, and they also provide specific cycling lessons focused on women in a safe, supportive and empowering environment. Women from other countries often do not have the possibility to learn to how ride a bicycle, so once they do learn it, their experience is positive and useful as they significantly improve their mobility.

https://thebikeproject.co.uk/pages/pedal-power

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