Quantifying Europe's Cycling Infrastructure using OSM (QECIO 2.02): Our Methodology

Contents

Abstract

There is a great demand for data on cycling infrastructure, but as for now, no official source provides this kind of information on a European scale. Therefore, this project aims to quantify the amount of cycle infrastructure using OpenStreetMap (OSM). The first version of the project collected data about three basic infrastructure types (cycle tracks, cycle lanes, cycle and pedestrian paths) for 500+ European cities, including all planned urban nodes of the trans-European transport network (TEN-T).

The second edition expanded the methodology to cover peri-urban and rural areas and to consider three additional infrastructure types (bus and cycle lanes, cycle streets, and limited access roads). We researched 37 European countries, including all 27 EU member states, and the information was gathered at NUTS 3 level (Nomenclature of territorial units for statistics). The information collected from OSM was processed to obtain the information needed. We calculated the length of the cycling infrastructure, taking into account the directionality and also explored the availability of some additional data for cycling infrastructure (surface, smoothness, width). Lastly, we calculated five measures that are displayed on interactive maps.

Changelog

Version 2.00, 2023/07/24:

- Launch of the new dashboard.

Version 2.01, 2023/08/07:

- Added cycleway=opposite as an additional criterion for contraflow detection. Mostly used in Germany.
- Fixed an error, where a cycleway tag was sometimes not considered.
- Added access checks for cycle infrastructure, to avoid counting cycle infrastructure not publicly accessible.

Version 2.02, 2023/09/05:

- Logic for distinguishing cycle tracks from cycle and pedestrian tracks rewritten to take into account the values of the “foot” and “segregated” keys (if present). The change significantly affected the numbers for Finland.
- Added cycleway=opposite_lane|opposite_track (not recommended tagging, but used in a few places) to criteria for contraflow detection.
- Added “surface” check if “tracktype” is not set for highway=track.
- Fixed direction check for cycle streets with contraflow cycling.
- Added recognition of unhewn_cobblestone as surface value.

- Split surface category “blocks/slabs/cobbles” into two subcategories (acceptable and not acceptable as cycling surface). As for now, the subcategories are not displayed on the maps, only used to determine acceptability of some highway = track features.

Background

Last year, our first project collecting bike infrastructure across the TEN-T urban nodes was launched. The Trans-European Transport Network (TEN-T) is the EU’s flagship transport policy to support the construction and renovation of transport infrastructure across the EU. The European Commission’s proposal for revision of the TEN-T guidelines expanded the number and role of so-called urban nodes on the TEN-T network. An increase in the modal share of active modes, such as cycling, is listed as one of the priorities for urban nodes. We decided to investigate how well these urban nodes are currently equipped with cycling infrastructure. More information on the TEN-T revision and the amendments proposed by ECF (European Cyclists Federation) can be found here.

Nevertheless, some infrastructure was not considered, such as agricultural roads or cycle streets. Likewise, only the urban nodes were included, without including information on other areas. Working outside urban areas brings a degree of complexity as we must homogenize the data. Therefore, in this project, we aimed to implement additional information about cycle infrastructure, and additional information available in the map, and extrapolate the analysis to rural areas of Europe.

Methodology

Theoretical framework

OpenStreetMap is a free, world-wide, crowdsourced geographic dataset. In certain contexts, OSM data has been found to be more detailed and up to date than municipal data and to be useful in accessible urban planning (Ferster et al., 2019, Timaite et al, 2022). Information about appropriate cycle infrastructure is crucial to enhancing safe cycling and encouraging cycling as a sustainable mode of transport. Therefore, information on current infrastructure is needed for continued development and optimisation (Hardinghaus & Panagiotis, 2020, Ferster, 2020). OSM datasets provide information that can be used for evidence-based transport planning. Previous research projects have acknowledged OSM open database as a source of data that could enhance accessible travel planning. Previous projects have made use of the tool to describe cycling infrastructure in different places, such as CicloMapa, the Bicycle Network Analysis, and GrowBike.

To extract the data, we did a review of the available information on OSM, and the tags used for cycling infrastructure. More information on OSM bicycle-related tags can be found on wiki.openstreetmap.org/wiki/Bicycle and taginfo.openstreetmap.org. After analysing the tags, we extracted the following types of infrastructure and measures following the logic outlined in Annex I.

Geographic scope

The analysis includes 37 countries covered by the European NUTS (Nomenclature of territorial units for statistics) classification. This includes the 27 EU member states, candidate countries awaiting accession to the EU, potential candidates, and countries belonging to the European Free Trade Association (EFTA).

Certain more remote EU territories outside of the European continent were not included (French territories in America or Africa, Canary Islands).

Technical details

In this edition we used Protobuf (PBF) files from European countries available from the Geofabrik website (http://download.geofabrik.de/europe.html). Highways and a subset of their parameters were extracted per country using the PyOsmium package (https://osmcode.org/pyosmium/).

The cleaning and processing of the data were performed in several steps.

1) The analysis was performed at NUTS-3 level, clipping the highway per NUTS-3 administrative boundary.
2) The main road network and the local road network were calculated from the extracted highways. We assume that on the main road network segregation of cycle and motorised traffic is necessary, on the local road network both types of traffic can safely share the carriageway.
3) We analysed OSM ways, which are linear features representing segments that connect two points in the space. We estimated which ways from the highway network contain cycle infrastructure. Based on the OSM tags, we assigned each way to a specific cycling infrastructure type. See Table 2.
4) Later, we defined the directionality of the way, aiming to identify contraflow and scale the length of the way. In some cases, we translated a single highway feature into two cycling infrastructure features (for example when cycleway:both is used or cycleway:left and cycleway:right on the same highway). For the length calculations, we divided the length of the unidirectional cycling infrastructure by two. Finally, we

calculated the total lengths and the road network coverage of the cycling infrastructure.

5) In this edition we have added information on the surface type and quality, grouping the information available in OSM in line with the EuroVelo European Certification Standard.

Explanation of the indicators in the dashboard

Ratio of segregated cycling infrastructure to the main road network

The ratio of segregated cycling infrastructure to main roads is an indicator of road coverage by cycling infrastructure. The segregated cycling infrastructures considered are cycle tracks, cycle and pedestrian tracks and cycle lanes. While the road network was calculated by adding highways labelled as motorway, trunk, primary, secondary, tertiary, motorway link, trunk link, primary link, secondary link, and tertiary link in OSM.

$$segregated\ infrastructure = cycle\ tracks + cycle\ lanes + shared\ pedestrians \quad (1)$$

$$ratio = \frac{total\ length\ segregated\ infrastructure\ (km)}{total\ length\ main\ roads\ (km)} \quad (2)$$

About the interpretation of the ratios: ratio of 100 can be roughly interpreted as 100% of main roads having bidirectional cycling infrastructure. The ratio can exceed 100% for various reasons:

1. At least some streets in the main road network have bidirectional cycling infrastructure on both sides of the road.
2. The city has cycle tracks (tagged as highway=cycleway) or cycle and pedestrian tracks outside the road network (for example crossing green areas, alongside a river etc.); these are included in the numerator but not denominator of the ratio.
3. The city has segregated cycling infrastructure located also alongside residential roads (which are excluded from the main road network).

As mentioned, these numbers on cycling infrastructure do not directly reflect the quality of infrastructure or cyclability. Similarly, there may be roads that are of high quality and regularly used for cycling, such as residential roads, that do not have explicit infrastructure. This may negatively bias the ratios.

Ratio of extended cycling infrastructure to public roads.

The ratio of cycling infrastructure to public roads is an indicator of road coverage by cycling infrastructure. The extended cycling infrastructure used in the numerator included: cycle tracks, cycle and pedestrian tracks, cycle lanes, limited access roads, bus lanes and cycle streets. The length of the road network used in the denominator was calculated by adding main roads and local roads. The local roads were selected using the following tags: residential, living street, unclassified.

$$extended\ infrastructure = cycle\ tracks + cycle\ and\ pedestrian\ tracks + cycle\ lanes + limited\ access\ roads + bus\ lanes + cycle\ streets \quad (3)$$

$$ratio = \frac{total\ length\ extended\ infrastructure\ (km)}{total\ length\ public\ roads\ (km)} \quad (4)$$

Ratio of cycle tracks to main roads (plus information on surfaces)

The ratio of cycle tracks to main roads is an indicator of road coverage by cycle infrastructure. Only cycle track length was used in the numerator. The length of the road network used in the denominator was calculated by adding main roads. The different types of surfaces were grouped according to EuroVelo European Certification Standard (ECS) criteria. *See Table 4.*

$$ratio = \frac{total\ length\ cycle\ tracks\ (km)}{total\ length\ main\ roads\ (km)} \quad (5)$$

Availability of additional data

The percentage of additional data is an indicator of the completeness of OSM tags. The numerator represents the average amount of information on cycling infrastructure available for that area, taking into account surface, smoothness and width tags. The cycling infrastructure considered for these statistics includes cycle tracks, cycle lanes, cycle and pedestrian tracks and limited access roads, because these are the types of infrastructure where the parameters are most likely to affect usability. We explored which percentage of each one of the different infrastructures were labelled over the total.

$$infrastructure\ analysed = cycle\ tracks + cycle\ lanes + cycle\ and\ pedestrian\ tracks + limited\ access\ roads \quad (6)$$

$$x\ tag\ (\%) = \frac{total\ length\ cycle\ infrastructure\ tagged\ with\ x\ tag\ (km)}{Lenght\ of\ infrastructure\ analysed\ (km)}$$

(7)

Where x could be surface, smoothness or width.

$$available\ data\ (\%) = \frac{surface\ tag\ (\%) + smoothness\ tag\ (\%) + width\ tag\ (\%)}{3}$$

(8)

Ratio of contraflow cycling

The contraflow cycling is a ratio of local one-way streets with contraflow cycling allowed to the total length of local one-way streets.

$$ratio = \frac{total\ length\ of\ local\ ways\ with\ contraflow\ (km)}{total\ length\ for\ local\ roads\ oneway + contraflow\ (km)}$$

(9)

Disclaimer

The data featured in this dashboard only represents OSM contributions. The lower numbers may therefore reflect missing OSM data rather than the actual absence of cycling infrastructure in each area. Besides missing data, these numbers may not be fully representative in cases where OSM's thorough universal tagging guidelines do not account for certain local or informal cycling infrastructure types.

Lastly, the data does not imply that the cycling infrastructure is necessarily high quality. To infer the cyclability of a given city's network, one needs to consider additional factors beyond the OSM tags that are currently extracted and analysed. - **we aim to explore this in the future.**

Since OSM is an open dataset, anyone can improve the accuracy of the database, and thus this dashboard, by adding and updating OSM data. Also, if there any differences between official databases and our results, please do not hesitate to contact us back. Lastly, we point out that other way to incentive the completeness of OSM database is to incentive people to add information through policies or citizen science campaigns as stated by Hardinghaus & Panagioties, (2020).

Authors

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Annex I. Cycle infrastructure types

Infrastructure type	Description	Example
Cycle track	An independent road or part of a road designated for cycles, signposted as such. Cyclists are physically separated from motorised traffic, for example by a dividing verge, a kerb or a safety barrier.	
Cycle and pedestrian track	As above, but the same space is shared with pedestrians.	

Infrastructure type	Description	Example
Cycle lane	A part of a carriageway designated for cycles. Distinguished from the rest of the carriageway by paint only.	
Bus and cycle lane	A lane reserved for (public transport) buses and cycles.	

Infrastructure type	Description	Example
Cycle street	A road where (some) motorised traffic is allowed, but cycle traffic is prioritised on the carriageway. Signage and exact rules vary across countries.	
Limited access road	A road where motorised traffic is limited (for example, only agricultural vehicles or vehicles of the residents are allowed), but fully open to cycles (but, contrary to cycle street, cyclists are not indicated as priority users).	

Infrastructure type	Description	Example
Pedestrian track with cycling allowed	A road or a part of the road originally designed for pedestrians, where cycling has been (conditionally) authorised, either by general rules or through a cycle panel under the pedestrian track sign. *Not included in the dashboard as for now.*	

Annex II. OSM tags considered

List of tags that are kept when extracting the highways:

'highway', 'tracktype', 'maxspeed',

'cycleway', 'cycleway:right', 'cycleway:left', 'cycleway:both',

'oneway', 'oneway:bicycle',

'surface', 'smoothness', 'width',

'cycleway:oneway', 'cycleway:surface', 'cycleway:smoothness','cycleway:width',

'cycleway:left:oneway', 'cycleway:left:surface', 'cycleway:left:smoothness', 'cycleway:left:width',

'cycleway:right:oneway', 'cycleway:right:surface', 'cycleway:right:smoothness', 'cycleway:right:width',

'cycleway:both:oneway', 'cycleway:both:surface', 'cycleway:both:smoothness', 'cycleway:both:width',

'cyclestreet', 'bicycle_road',

'bicycle', 'foot', 'segregated',

'access', 'vehicle', 'motorcar', 'motor_vehicle', 'agricultural',

Table 1. Explanation of logical operators used.

Explanation of symbols	
|	or
&	and
=	equals
!=	does not equal
*	cycleway* includes cycleway, cycleway:left, cycleway:right and cycleway:both

Table 2. Summary of the tags employed, and the definition of the variables used.

Analysis type	Dashboard column name	OSM tags	Definition
Infrastructure types	Cycle tracks	(highway = cycleway) & ((foot != designated) | (segregated = yes))	Cycle infrastructure that is separated from motorised traffic by physical infrastructure (curbs, grass, etc.) and reserved for exclusive use for cycles.
		(highway = footway | path | pedestrian) & (bicycle = designated) & (segregated = yes)	
		cycleway* = track | opposite_track	
	Cycle lanes	cycleway* = lane | opposite_lane	Cycle infrastructure that is an inherent part of the carriageway, set aside for the use of bicycles by paint or other markings but without a physical separation from motorised traffic.
	Cycle and pedestrian tracks	(highway = footway | path | pedestrian) & (bicycle = designated) & (segregated != yes)	Track designated (signed) for use by pedestrian and cyclists.
	Pedestrian track with cycling allowed	(highway = footway | path | pedestrian) & (bicycle = yes)	Pedestrians track that cyclists are allowed to use, but not formally designated for cyclists (for example, a path in a park). As for now, included in the GPKGs but not displayed in the dashboard, because the category includes many tracks without practical added value for the cycle network.
	Limited access roads	(highway = unclassified | tertiary | service | residential) & (access = no | agricultural | forestry | destination) & (bicycle = yes | designated)	Roads where motorised traffic is restricted (for example, only to residents or agricultural vehicles), but fully open to cycle

Analysis type	Dashboard column name	OSM tags	Definition
		highway = track & ((tracktype = grade1 | grade2) | (surface =))	traffic. In case a limited access road is signed as cycle street, the later takes precedence.
		Classified as cycle track, cycle and pedestrian track or pedestrian track with cycling allowed in first approach & (access | motorcar | motor_vehicle | agricultural | vehicle) = (yes | designated | agricultural | forestry | destination | delivery | permissive | private)	
	Cycle streets	cycle_street = yes	Cycle streets – road where (some) motorised traffic is allowed, but cyclists are somehow prioritised ("cars are guests"). Must be signed as such, only exists in selected countries.
		bicycle_road = yes	
	Bus and cycle lanes	cycleway*= (share_busway| opposite_share_busway)	Bus lane with designated use for cyclists.
Road network	Main roads	highway = (motorway | trunk | primary | secondary | tertiary | motorway_link | trunk_link | primary_link | secondary_link | tertiary_link)	Main arteries for motor traffic, where we assume that the cycle traffic should be somehow segregated.
	Local roads	highway = (living_street | residential | unclassified)	Local roads, where we assume it is safe to mix cyclists and motorised traffic on the carriageway.
	Active roads	highway = (cycleway | footway | path | pedestrian | track | service)	Other types of highways that are not a part of the public road network but might potentially

Analysis type	Dashboard column name	OSM tags	Definition
			contribute to the active mode network (sometimes depending on additional tags).
Local roads directionality	Two-way streets	oneway != yes	Street is bidirectional both for cars and for bicycles.
	One-way streets with contraflow cycling	(oneway = yes) & ((oneway:bicycle = no) | (cycleway = opposite | opposite_lane | opposite_track))	Street is unidirectional for cars and bidirectional for bicycles.
	One-way streets without contraflow cycling	(oneway = yes) & (oneway:bicycle != no) & (cycleway != opposite | opposite_lane | opposite_track)	Street is unidirectional both for cars and for bicycles.

Table 3. Determination of whether cycling infrastructure is bidirectional.

Cycling infrastructure type	Is bidirectional if...
Cycle track, cycle and pedestrian track, cycle street or limited access road represented as a standalone highway feature.	oneway != yes & oneway:bicycle != yes
Cycle track, cycle lane or cycle and bus lane represented as a “cycleway” tag of a highway feature (cycleway* = *).	cycleway*:oneway= no

Table 4 Definition of surface and quality criteria based on the ECS.

ECS criteria	OSM tags related		Acceptable as track surface?
ECS surface material	**OSM surface tag**		
asphalt/concrete	asphalt | concrete | metal | chipseal		yes
blocks/slabs/cobbles	paved | paving stones | bricks | wood		yes
	cobblestone | grass_paver | sett | unhewn_cobblestone		no
stabilised gravel	compacted | fine_gravel		yes

gravel/dirt	unpaved | ground | gravel | pebblestone | dirt | earth | mud | sand		no

ECS surface quality	**OSM tracktype tag**	**OSM smoothness tag**	
perfectly rideable		excellent	yes
well rideable	grade1	good	yes
moderately rideable	grade2	intermediate	yes
	grade3		no
badly rideable	grade4 | grade5	bad	no
not rideable		very_bad | horrible | very_horrible	no

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