TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

Camilo Cardona Torres
Cartography M.Sc. student

Thesis

Assessing cyclist safety using infrastructure parameters from OpenStreetMap: The case of Leipzig, Marseille and Edinburgh

Supervisors Mathias Gröbe, M.Sc. – Technical University of Dresden
Dipl.-Ing. Albine Chanove – Fraunhofer Institute for Transportation and Infrastructure Systems

Reviewer Dr. Barend Köbben – University of Twente

Dresden, 26. October 2022

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Introduction → Background → Methods & Implementation → Results → Conclusion

Introduction

Motivation

Road crashes → serious problem worldwide

1.35 million deaths in 2016[a]

1st cause of death in people between 5 and 29 yeas old

23,800 deaths in Europe (2016)[b]

8% cyclist fatalities

2% increase in cyclist fatalities 2016 - 2019

Cycling → attractive and sustainable transport mode

Benefits in Europe: 150 billion euros[c]

- Easing of road congestion
- Pollution reduction
- Healthier lives

Unsafe infrastructure discourage cycling

Road infrastructure influences injury and crash risk

Data availability VGI → OSM

Note: VGI = Volunteered Geographic Information, OSM = OpenStreetMap

a: Global status report on road safety (World Health Organization, 2018)
b: Annual statistical report on road safety in the European Union (European Commission, 2020)
c: The benefits of cycling: Unlocking their potential for Europe (European Cyclists' Federation, 2018)

Research Objectives

Main objective:

Assessing cyclist safety considering official traffic crash data and road infrastructure parameters using OpenStreetMap data in Germany, France and Great Britain.

Research Objectives

Sub-objectives:

Preparing data to make it comparable:

- Defining variables to find comparable cities in each country
- Defining infrastructure characteristics considering OSM
- Defining cyclist safety indicators

Analysis of junctions (intersections) and crashes:

- Building an algorithm to classify all the junctions at a city level
- Matching cyclist crashes with network junctions spatially
- Carrying out a spatial and statistical analysis

Background

Literature review

Without VGI	– Wang & Akar (2018) found that **intersections of five or more arms without traffic signals** are negatively associated with cyclist's safety perception in Ohio. – Shen et al. (2020) identified that speed limit, **traffic control strategies** and urban junctions had significant impact on cyclist injury severity at intersections in United Kingdom.
With VGI	– Using the Strava platform, Saad et al. (2019) concluded that traffic volume, bicycle volume, intersection size, **signal control type**, **number of intersection arms**, **bike lanes**, sidewalk width, median width, and speed limit are the significant factors that affect bicycle crashes at the intersections in Florida. – Using **OSM**, Collins and Graham (2019) observed that multilane roads, bus lanes, speed limit and junction density affected cycle collision counts in London. Additionally, they found that one-way roads had the largest effect on reducing collision risk along with the provision of junctions **without traffic signals**.

Data

OpenStreetMap

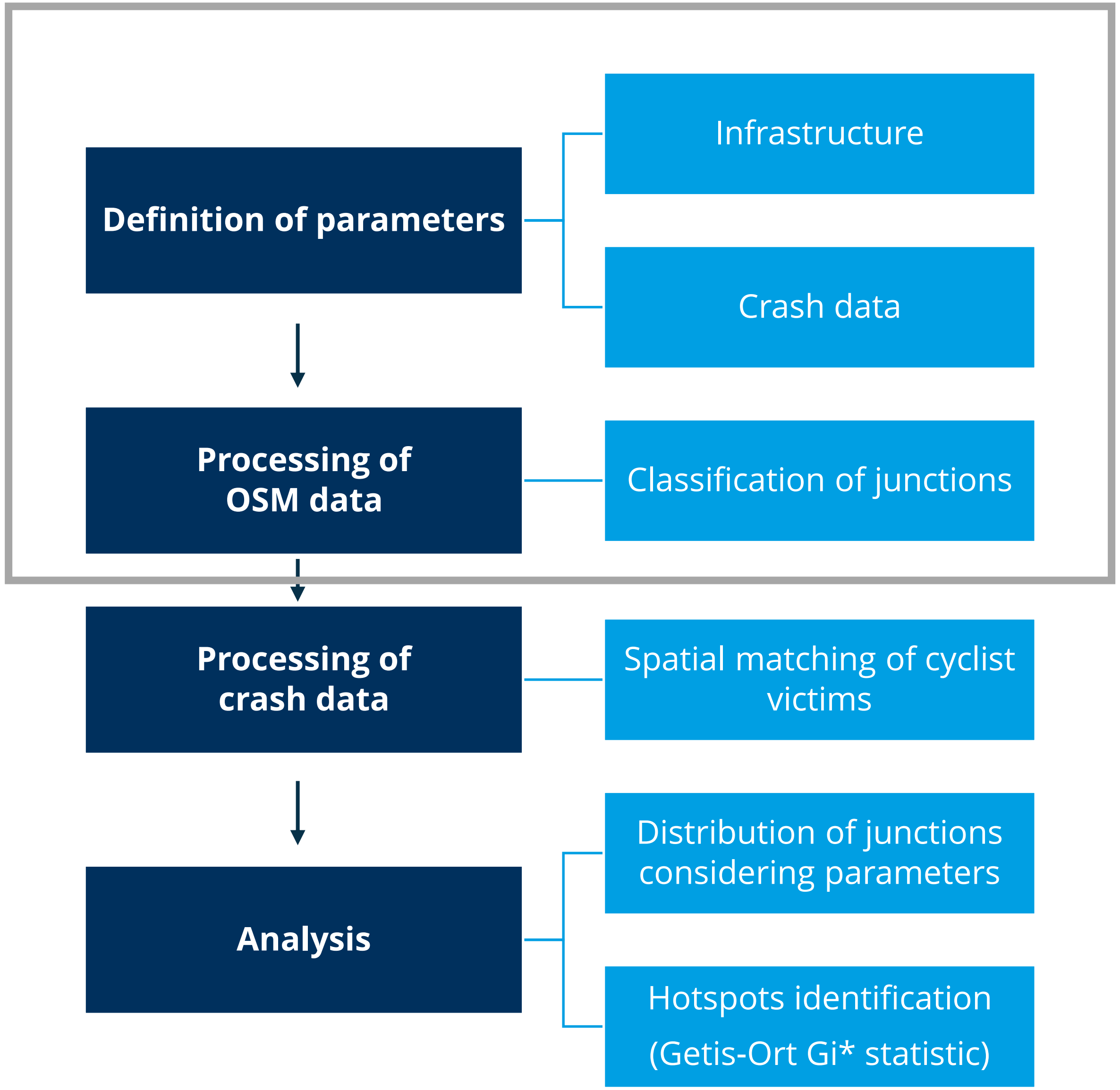
- Project that creates and distributes free geographic crowdsourced data for everybody
- Attributes represented by tags (*key=value*)
  - name
  - highway
  - cycleway

Crash data

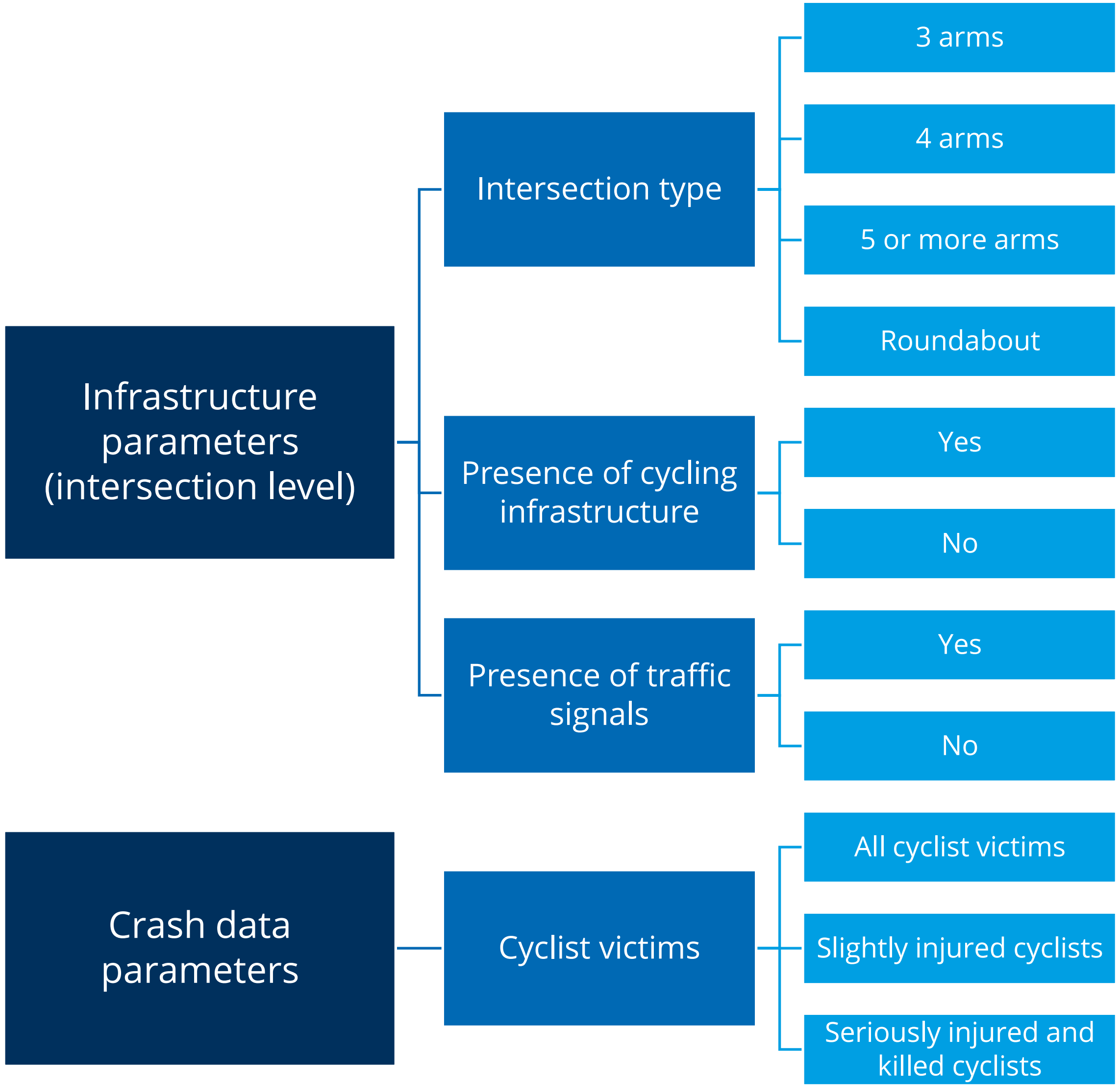
- Police reports in European countries
- Harmonised database (Chanove, 2021):
  - Years: 2015 – 2017
  - Extension:
    - Saxony (Germany)
    - France
    - Great Britain
  - Attributes:
    - Coordinates
    - Vehicle
    - Injury severity

Methods & Implementation

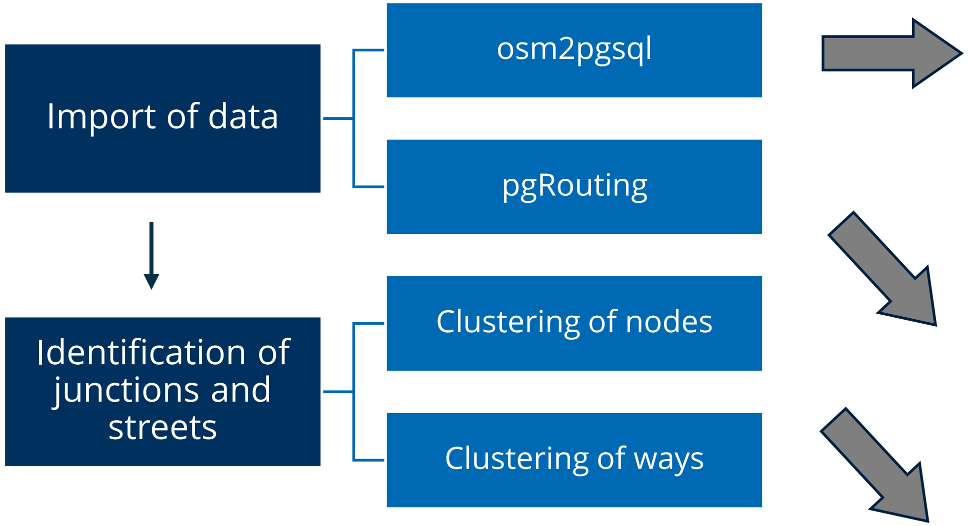
Workflow


Definition of parameters
Infrastructure
Crash data
Processing of OSM data
Classification of junctions
Processing of crash data
Spatial matching of cyclist victims
Analysis
Distribution of junctions considering parameters
Hotspots identification (Getis-Ort Gi* statistic)

Definition of parameters



Processing of OpenStreetMap data



Data	Tag's keys
City boundaries	*admin_level, name*
Road infrastructure	*name, highway, lanes, junction, bicycle, cycleway, cycleway:right, cycleway:left, cycleway:both*
Traffic signals	*highway*

Table 1. Importing parameters of osm2pgsql

Data	Tag's key	Tag's value
Nodes and ways from traffic network	*highway*	*motorway*
		trunk
		primary
		secondary
		tertiary
		residential

Table 2. Importing parameters of pgRouting

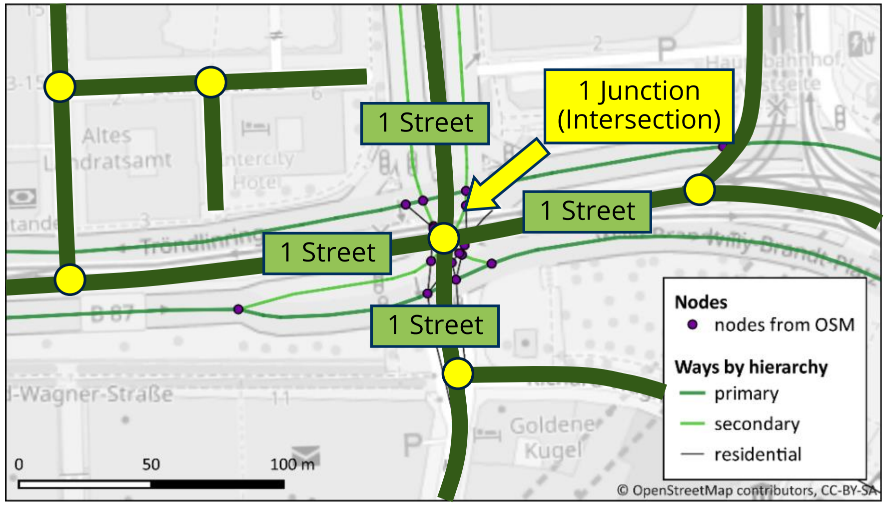
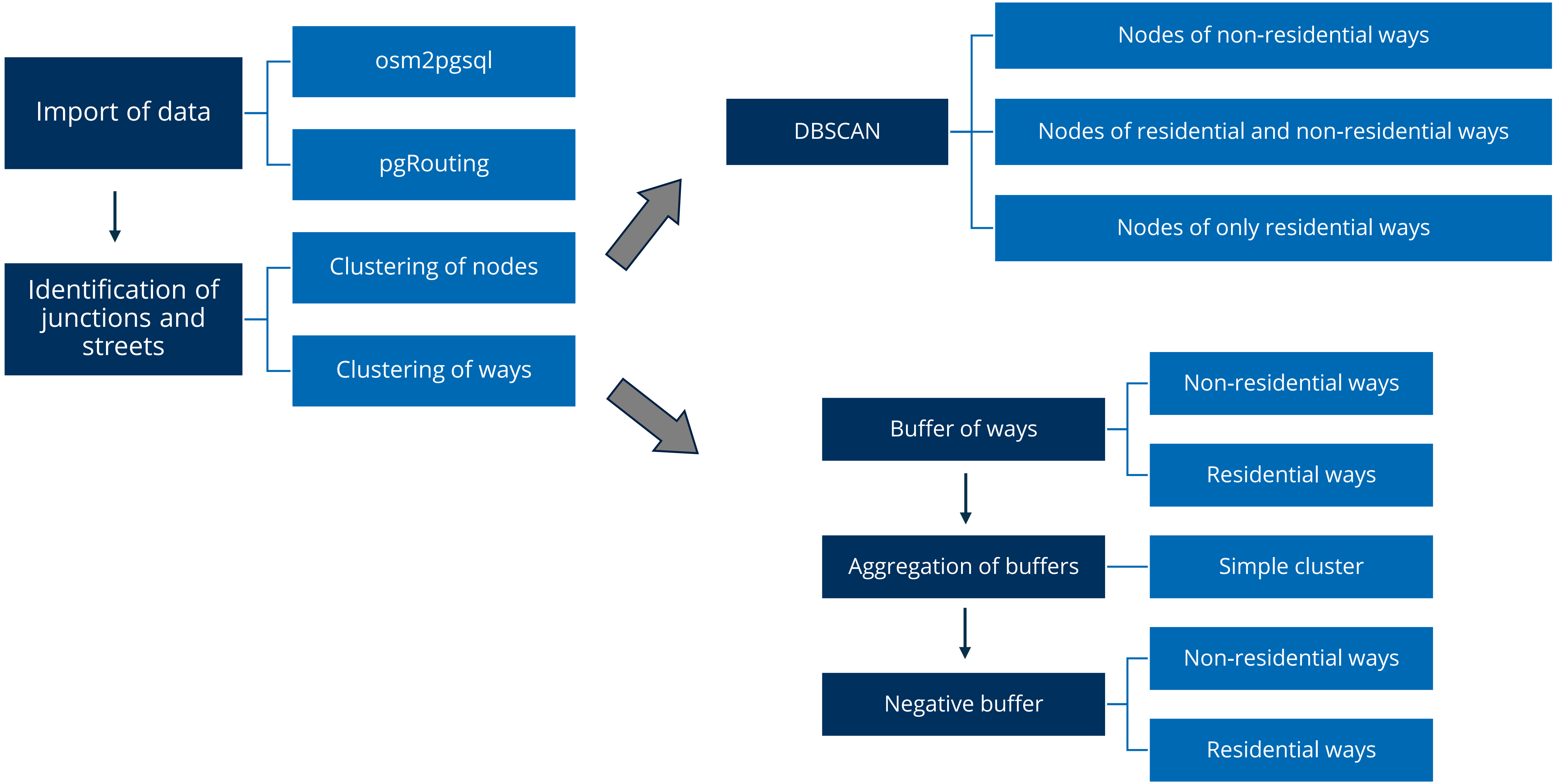
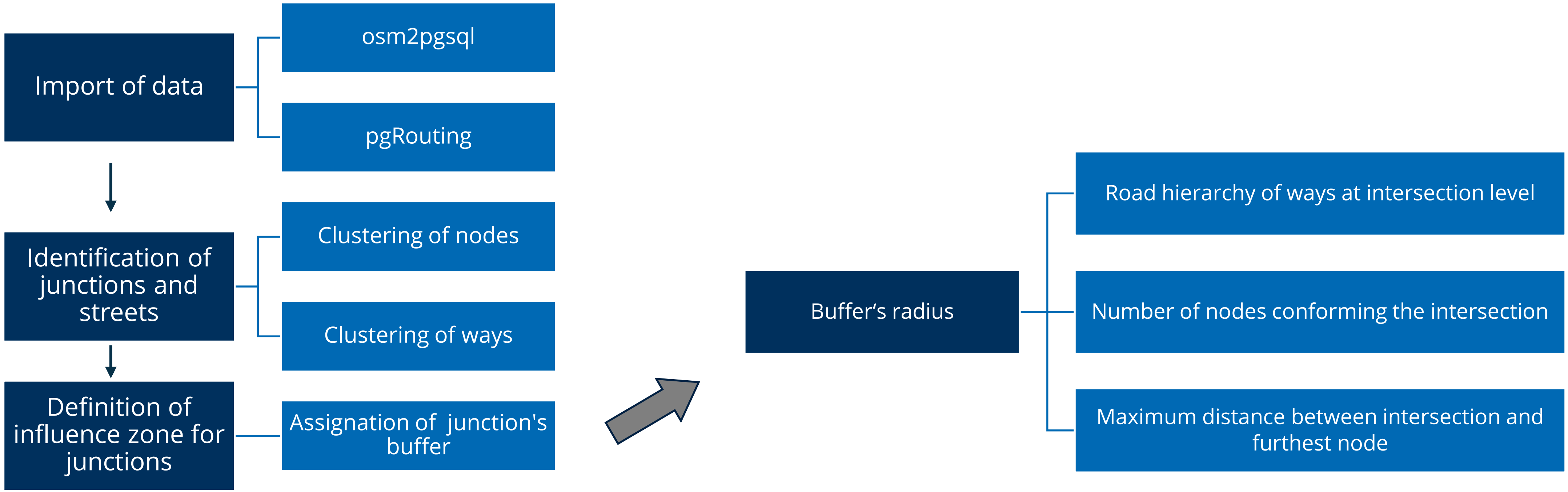


Figure 1. Output of nodes and ways using pgRouting (intersection in Leipzig)

Processing of OpenStreetMap data



Processing of OpenStreetMap data



Processing of OpenStreetMap data

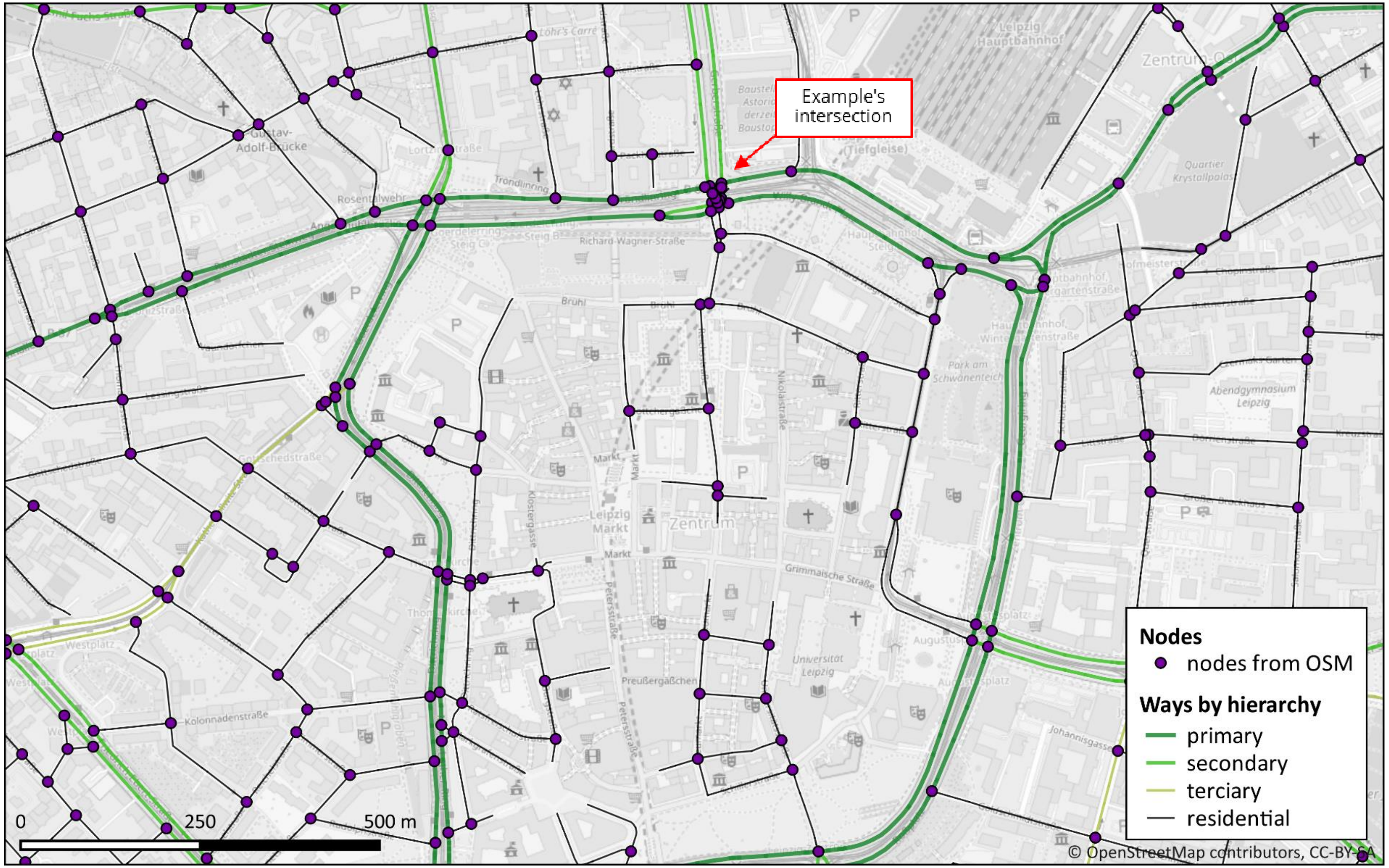


Figure 2. Imported nodes and ways (Leipzig)

Processing of OpenStreetMap data

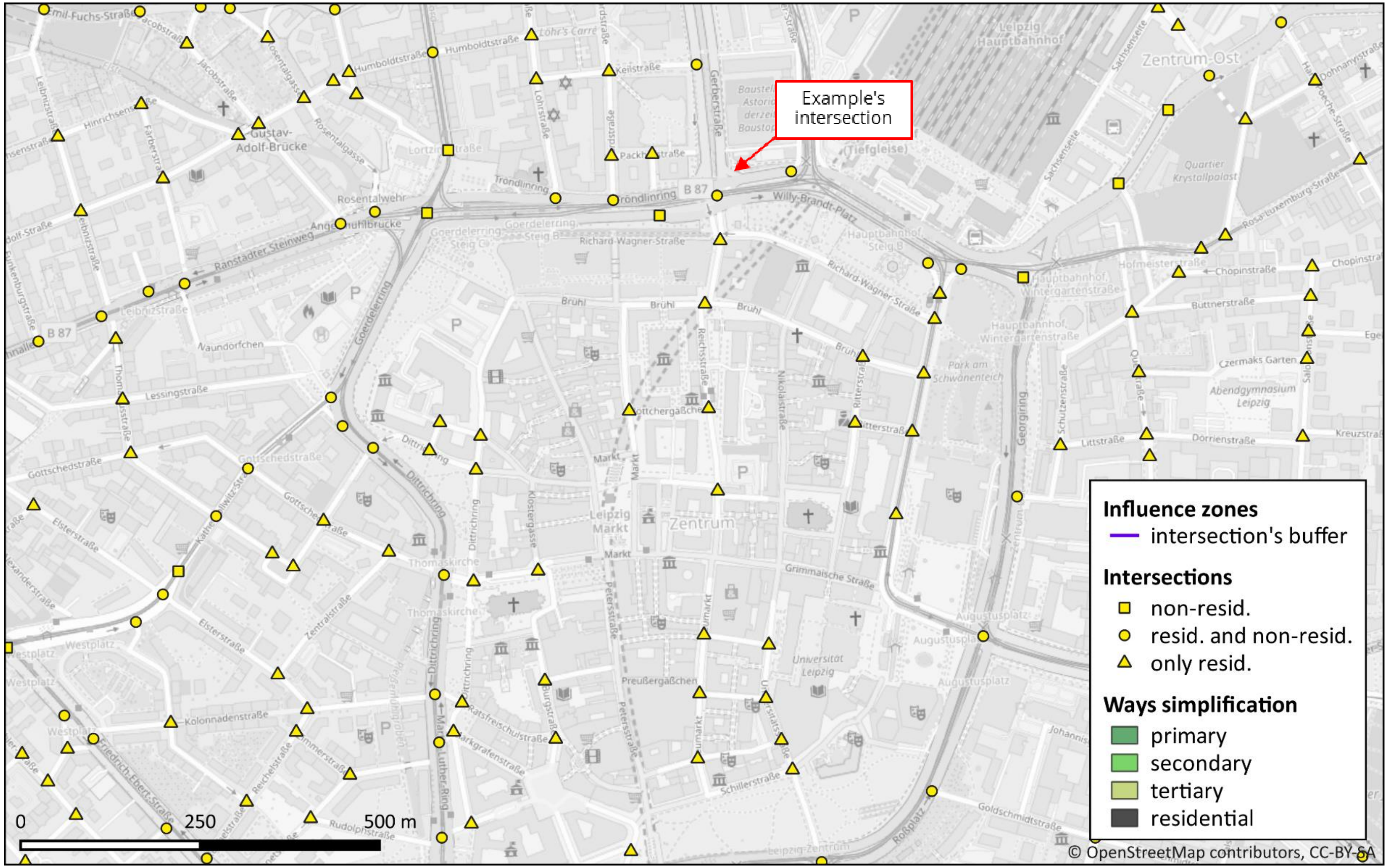


Figure 3. Output of clustering of nodes (Leipzig)

Processing of OpenStreetMap data

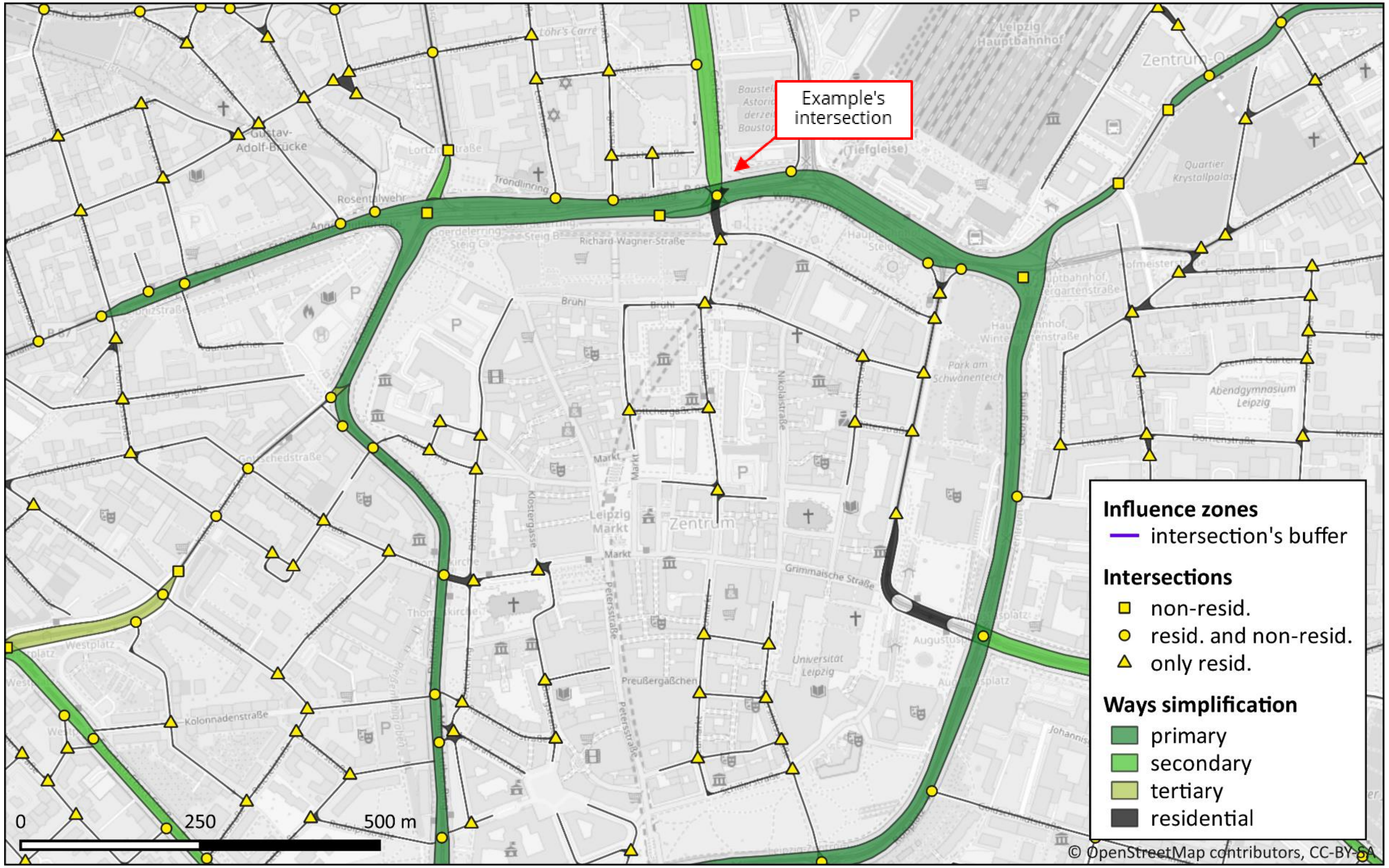


Figure 4. Output of clustering of nodes and ways (Leipzig)

Processing of OpenStreetMap data

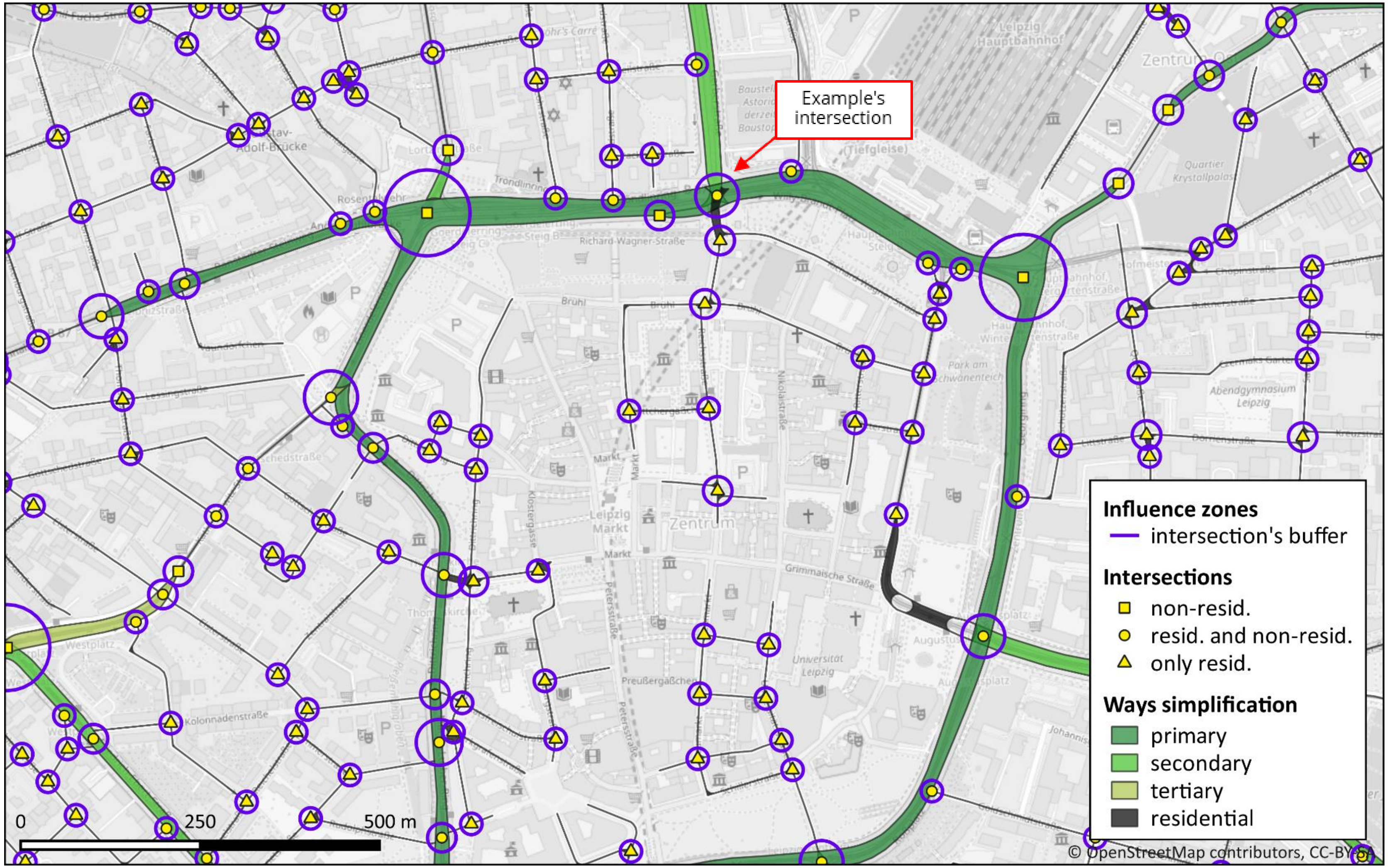
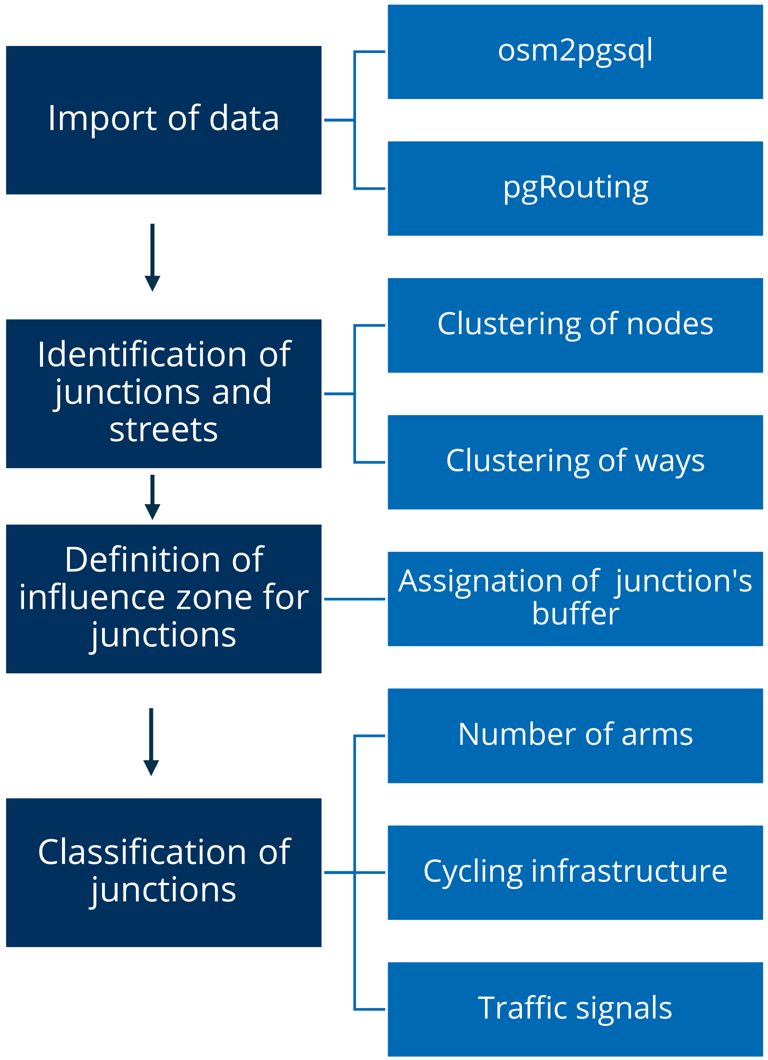


Figure 5. Output of clustering of nodes, ways and influence zones (Leipzig)

Processing of OpenStreetMap data



Study area

Study area

- Selection of one city per region/country:
  - Saxony (GER)
  - France (FRA)
  - Great Britain (GBR)

- Criteria:
  - 500.000 inh. < Population < 1.000.000 inh.
  - Smallest difference in area
  - Smallest difference in population density

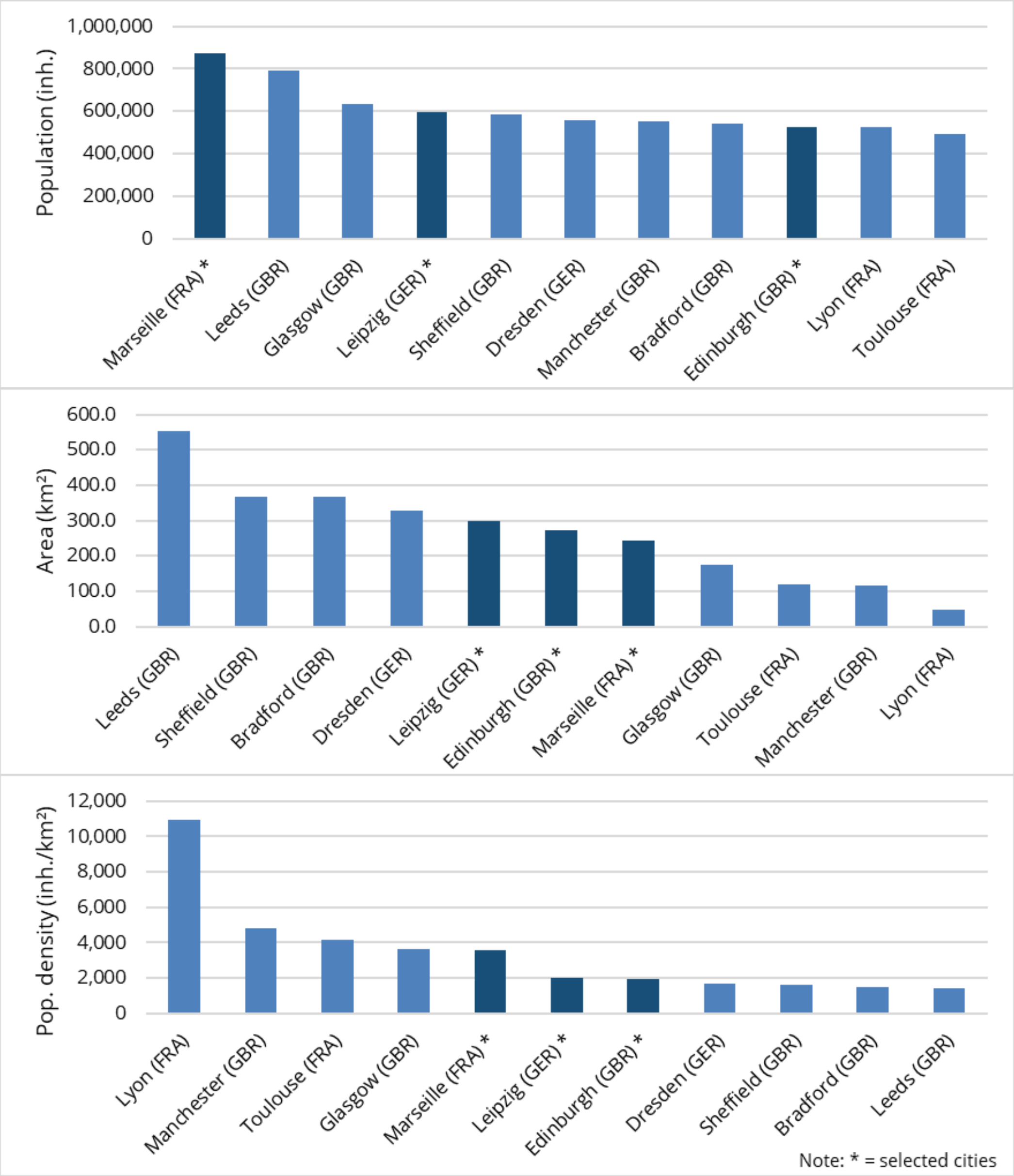


Figure 6. Different variables to choose comparable cities

Study area

- Selection of one city per region/country:
  - Saxony (GER) → **Leipzig**
  - France (FRA) → **Marseille**
  - Great Britain (GBR) → **Edinburgh**

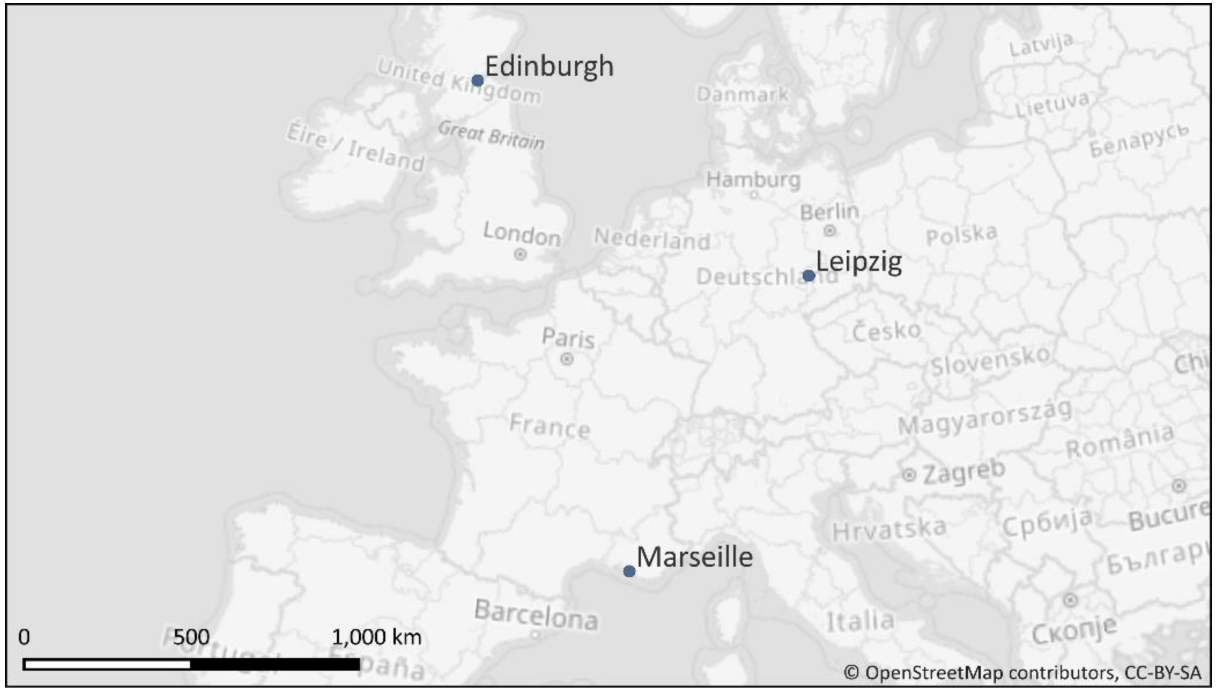


Figure 7. Localisation of chosen cities for the study area

Results

Distribution of intersections with cyclist victims

- 3-arm and 4-arm junctions
  - Highest proportion:
    - With cycling infrastructure (in Leipzig)
    - Without cycling infrastructure and without traffic signal (in Marseille and Edinburgh)
- Roundabouts
  - Highest proportion:
    - With cycling infrastructure (in study area)

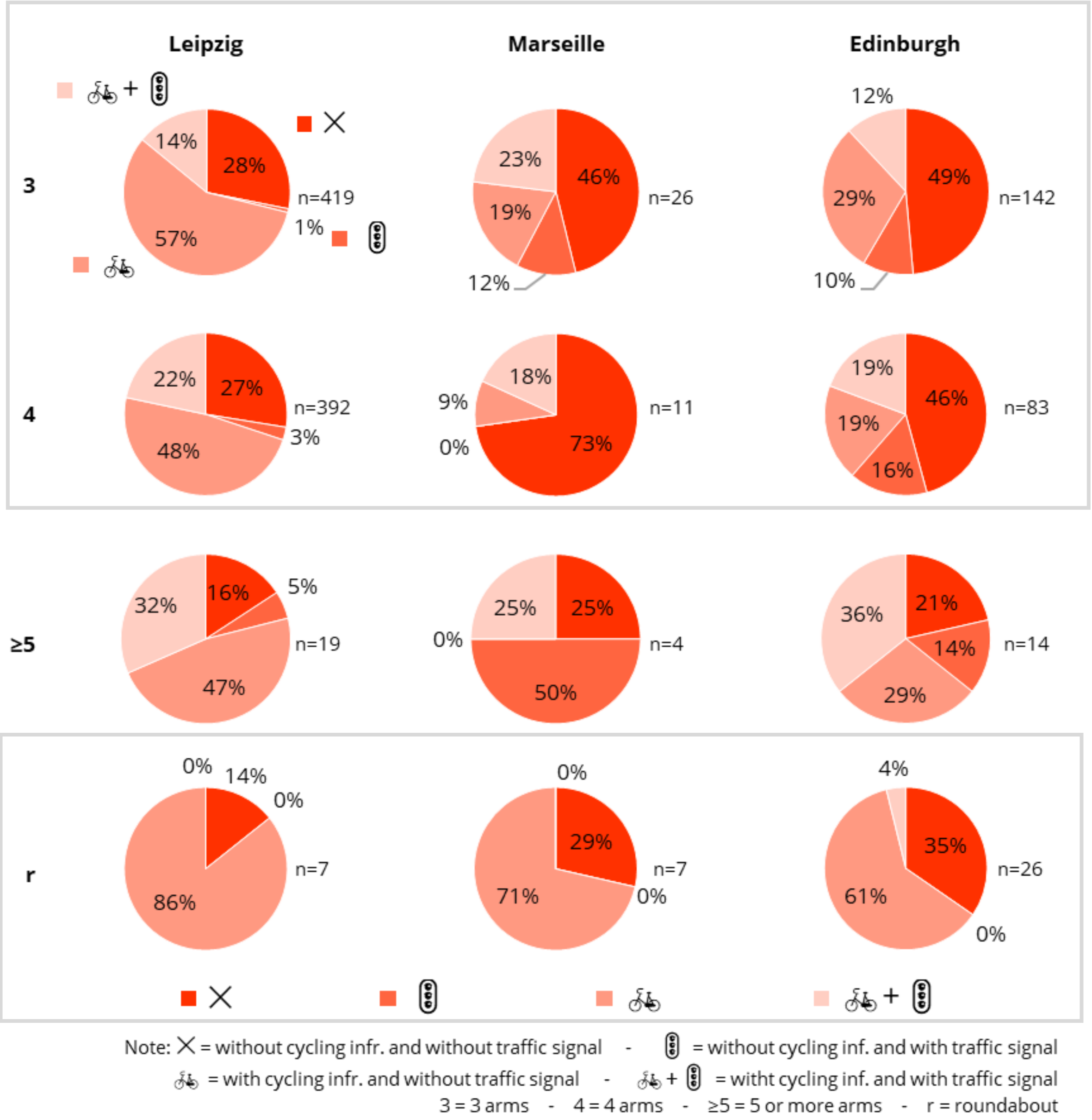


Figure 8. Percentage of intersections with cyclist victims by category based on infrastructure attributes

Hotspots

Figure 9. Hotspots for cyclist victims by injury severity in city centre

Conclusion

Conclusion

- Data availability and accuracy played an important role
  - OSM's traffic network is extensive, dense, diverse and complex

- It was possible to identify patterns regarding cyclist victims and infrastructure parameters
  - Useful insights for mobility planners and decision makers

- An innovative approach of assessing cyclist safety was carried out
  - Use of VGI → OSM (promising source for updated and freely accessible geodata)
  - Multicity analysis
  - Easily replicable

- Future work
  - Improvement of data availability and quality (crash data → police reports, OSM → tags)
  - Better algorithms to simplify nodes and ways from OSM
  - Exploration of complementary data sources and parameters associated with mobility and infrastructure
  - Different cities around the world in the assessment

Thank you…

Questions?

Camilo Cardona Torres
Cartography M.Sc. student

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Annex

Processing of OpenStreetMap data

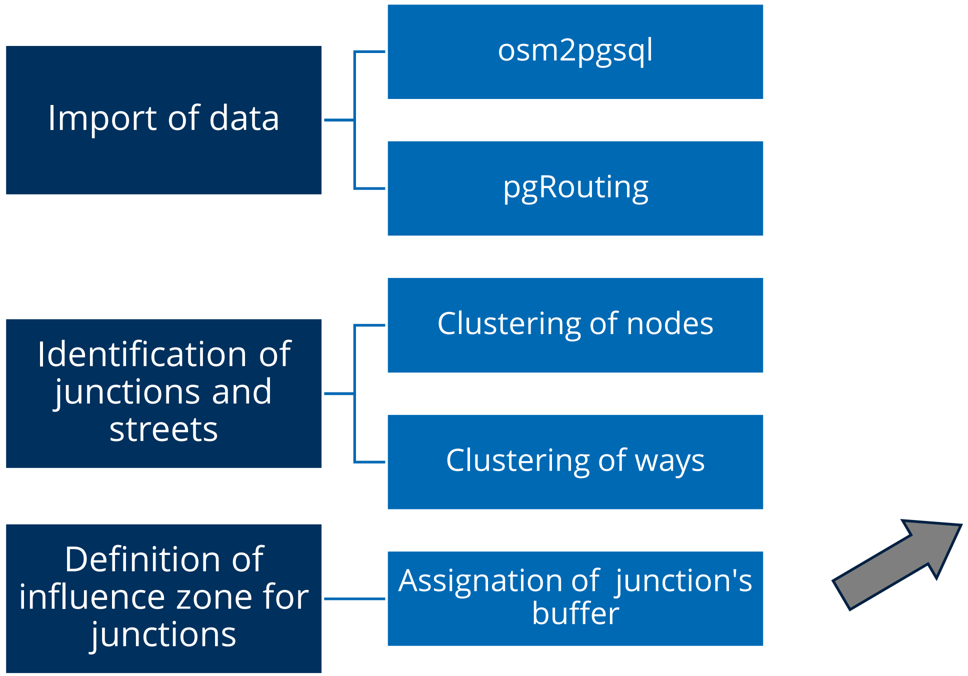
- Import of data
  - osm2pgsql
  - pgRouting
- Identification of junctions and streets
  - Clustering of nodes
  - Clustering of ways

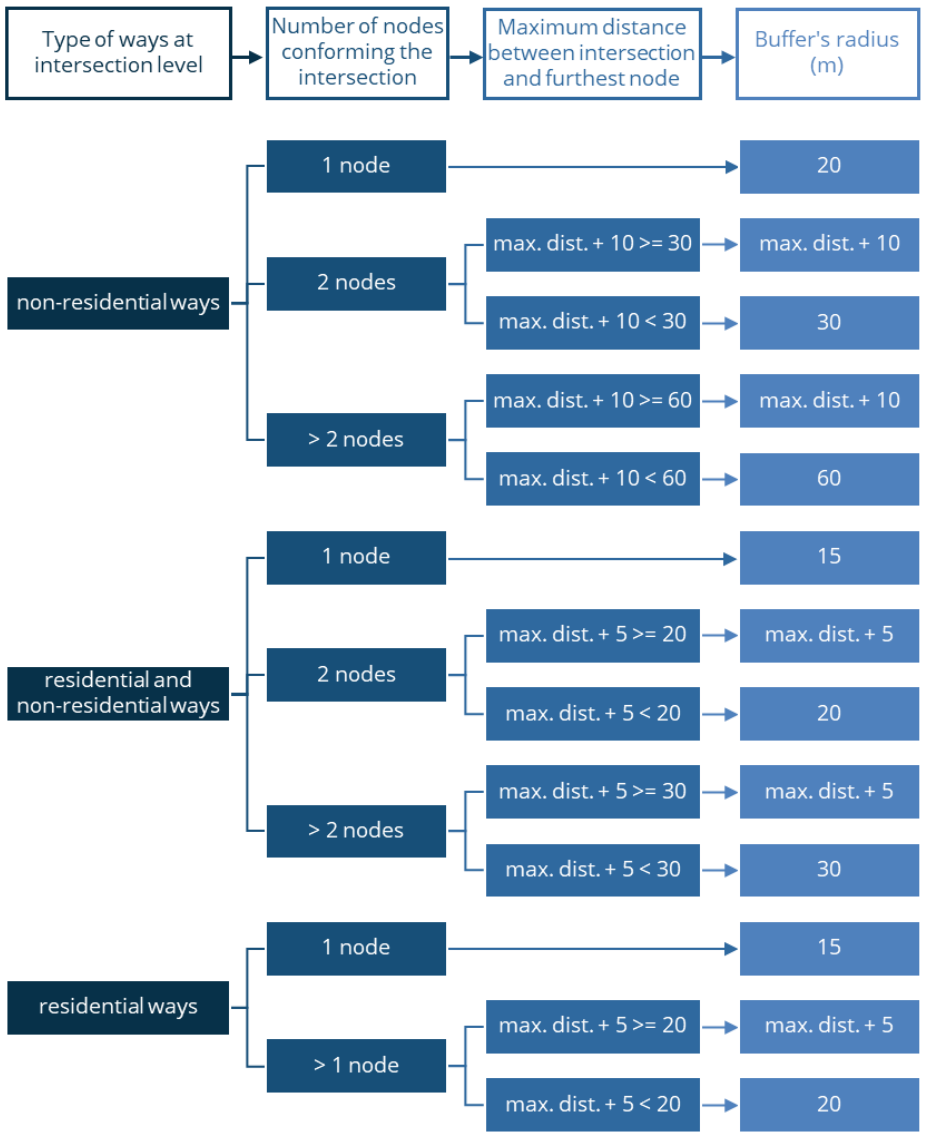
DBSCAN	Category of the nodes	Radius (m)	Min. Points
First	Nodes of non-residential ways	50	2
	Nodes of residential and non-residential ways	35	2
	Nodes of only residential ways	20	2
Second	Nodes resulting from first DBSCAN	20	2
Third	Nodes resulting from second DBSCAN not associated with “nodes of only residential ways”	30	2

Table A1. Parameters for DBSCAN of nodes

- Buffer of ways
  - Non-residential ways — 25 m
  - Residential ways — 10 m
- Aggregation of buffers
  - Simple cluster — 1 m distance
- Negative buffer
  - Non-residential ways — -24.9 m
  - Residential ways — -9.9 m

Processing of OpenStreetMap data





Identification of intersections

- DBSCAN considering road hierarchy:
  - Nodes of non-residential ways
  - Nodes of residential and non-residential ways
  - Nodes of only residential ways

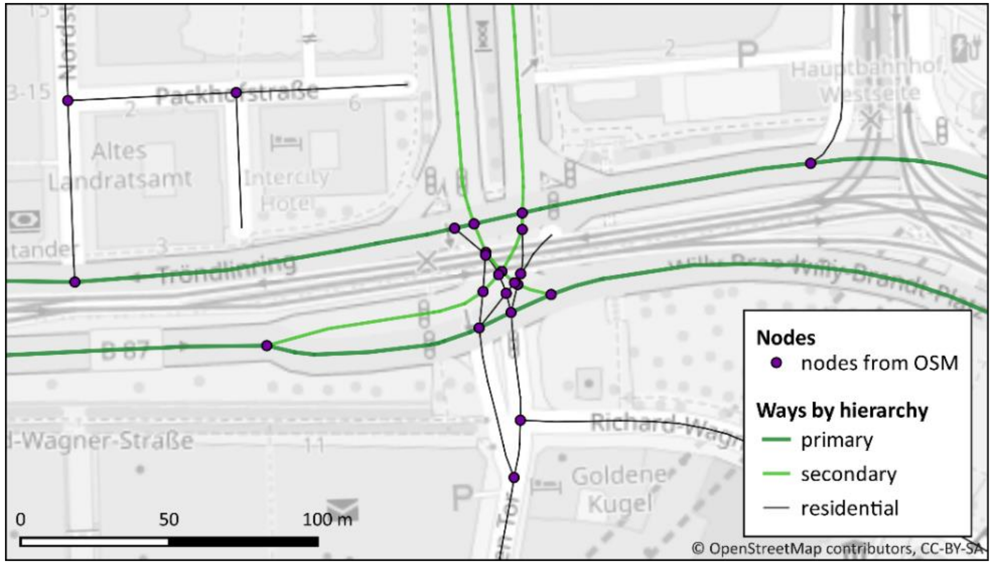


Figure A1. Output of nodes and ways using pgRouting (intersection in Leipzig)

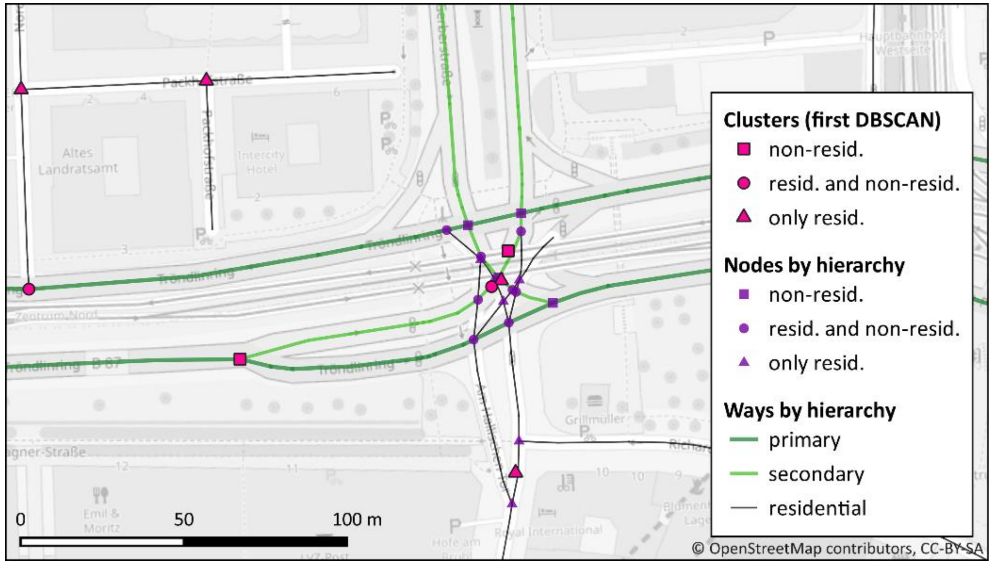


Figure A2. Clusters after first DBSCAN for identifying intersections

Identification of number of arms

Figure A3. Output of intersection's classification by arms counting (Leipzig)

Comparison between chosen cities

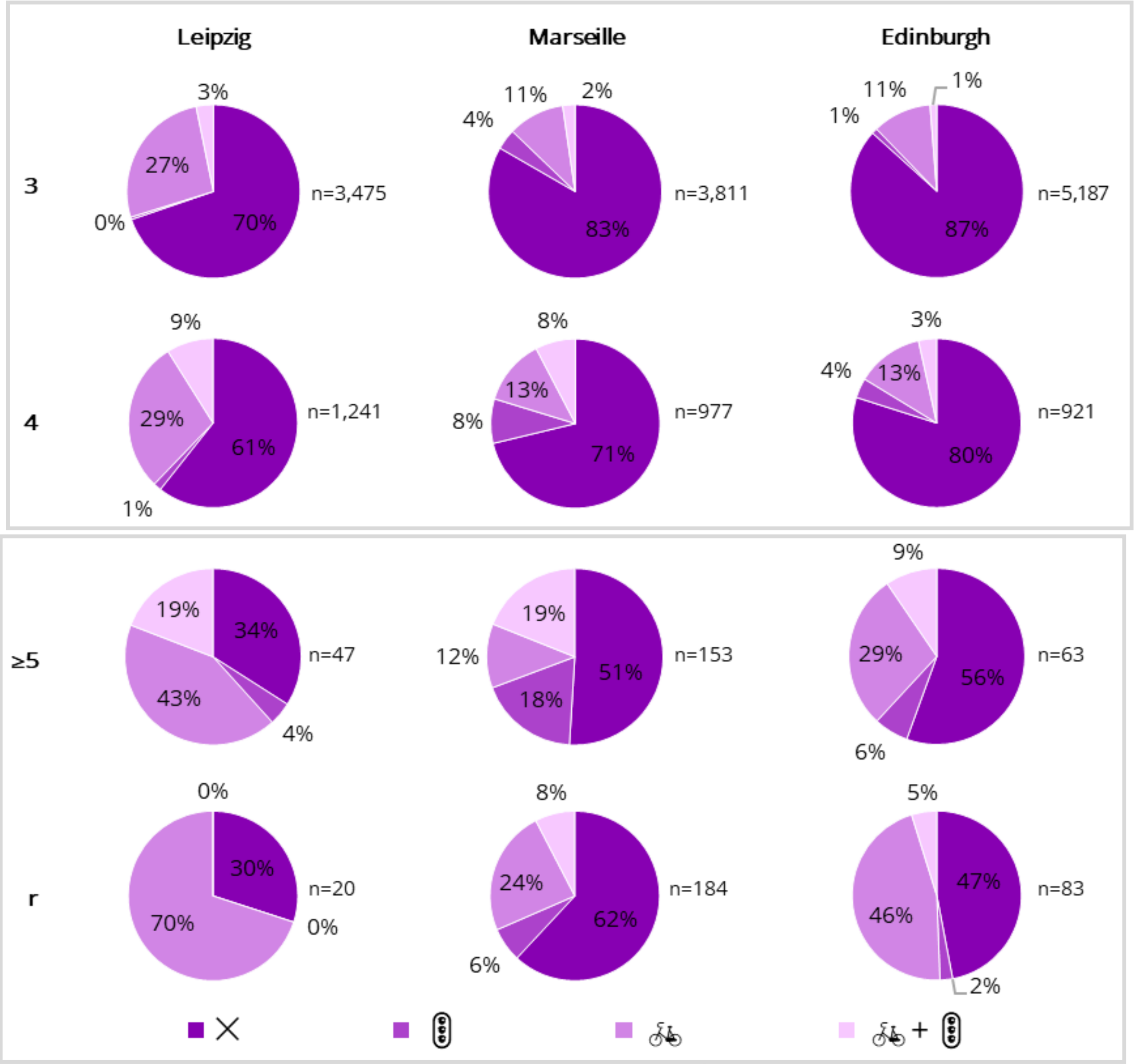
Variables	Leipzig	Marseille	Edinburgh	Mean	Std. Deviation
General					
Population (2019)	593,145	**870,731**	524,930	662,935	183,160
Area (km²)	**297.9**	242.1	273.1	271.1	27.9
Population density (inh./km²)	1,991.2	**3,596.0**	1,921.8	2,503.0	947.2
Minimum elevation (m)	**97**	0	0	32	56
Maximum elevation (m)	178	**652**	251	360	255
Infrastructure and cycling					
Length of cycling infrastructure (km)	**967.1**	241.5	521.5	576.7	365.9
Length of traffic network (km)	**1,572.2**	1,538.7	1,513.5	1,541.4	29.5
Cycling inf. by area (km/km²)	**3.2**	1.0	1.9	2.1	1.1
Traffic network by area (km/km²)	5.3	**6.4**	5.5	5.7	0.6
Cycling modal split (%)	**18.7**	1.0	4.0	7.9	9.5
Crash victims (yearly average)					
Victims	**2,305.3**	2,293.0	978.0	1,858.8	762.8
Cyclist victims	**950.3**	39.3	212.3	400.7	483.8
Seriously injured and killed cyclists	**145.0**	12.7	35.7	64.4	70.7
Total victims / 100,000 inh.	**388.7**	263.3	186.3	279.4	102.1
Cyclist victims / 100,000 inh.	**160.2**	4.5	40.4	68.4	81.5
Seriously injured and killed cyclists / 100,000 inh.	**24.4**	1.5	6.8	10.9	12.0

Note: Highlighted values are the highest per row

Table A2. Comparison of selected cities through road infrastructure and safety variables

Count of intersections

- 3-arm and 4-arm junctions
  - Highest proportion:
    - Without cycling infrastructure and without traffic signal (in study area)
- Other junctions
  - Highest proportion :
    - With cycling infrastructure (in Leipzig)
    - Without cycling infrastructure and without traffic signal (in Marseille and Edinburgh)



Note: X = without cycling infr. and without traffic signal - = without cycling inf. and with traffic signal
= with cycling infr. and without traffic signal - + = witht cycling inf. and with traffic signal
3 = 3 arms - 4 = 4 arms - ≥5 = 5 or more arms - r = roundabout

Figure A4. Percentage of intersections by category based on infrastructure attributes

Intersections with and without cyclist victims

Distribution among junctions of the same type

- 3-arm and 4-arm junctions
  - Highest distribution:
    - With cycling infrastructure and traffic signal (in study area)
- Junctions with 5 or more arms
  - Highest distribution:
    - With cycling infrastructure and traffic signal (in Leipzig and Edinburgh)
    - With traffic signal (in Marseille)

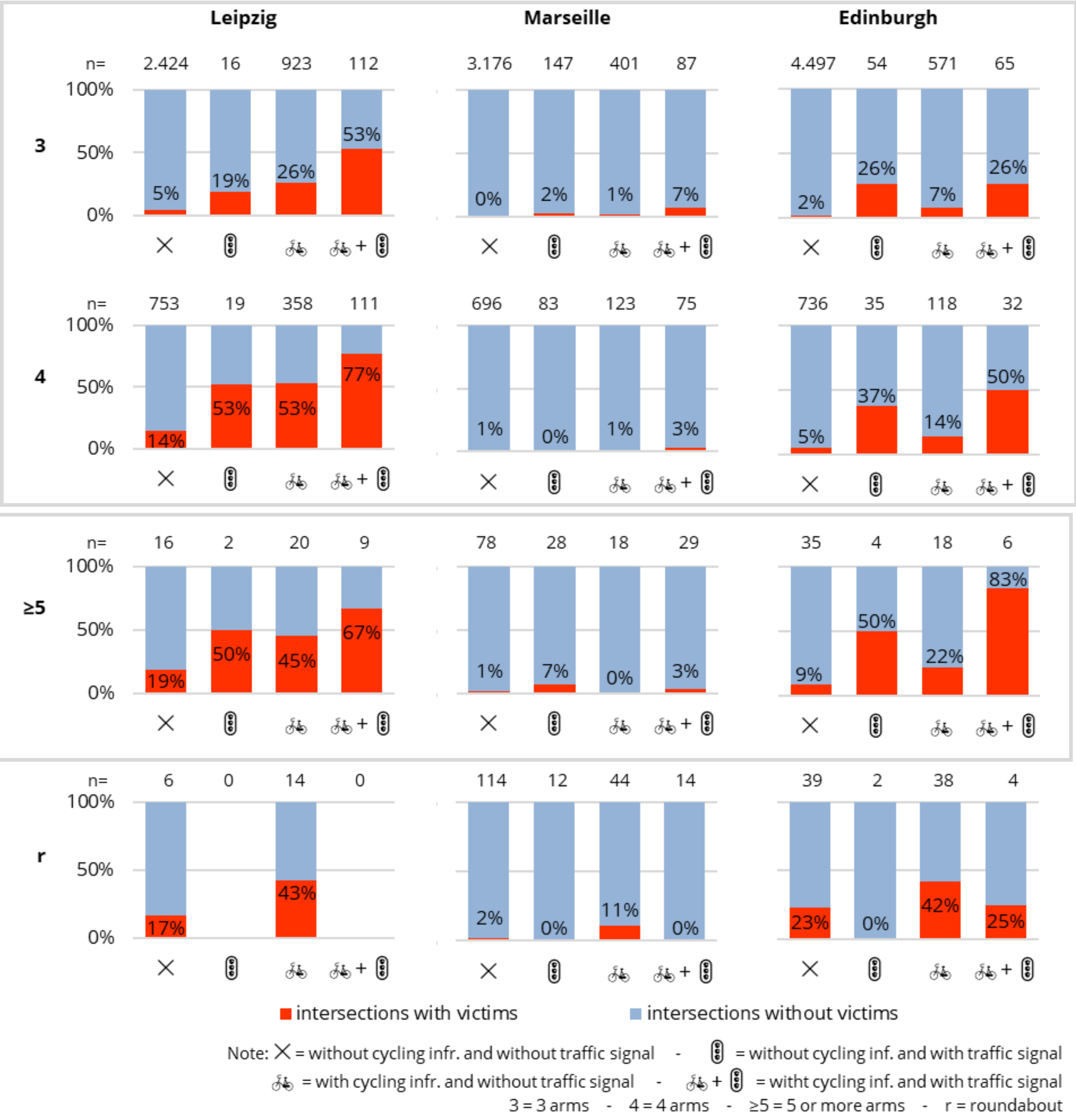


Figure A5. Percentage of intersections with and without cyclist victims

Intersections with slightly injured cyclists

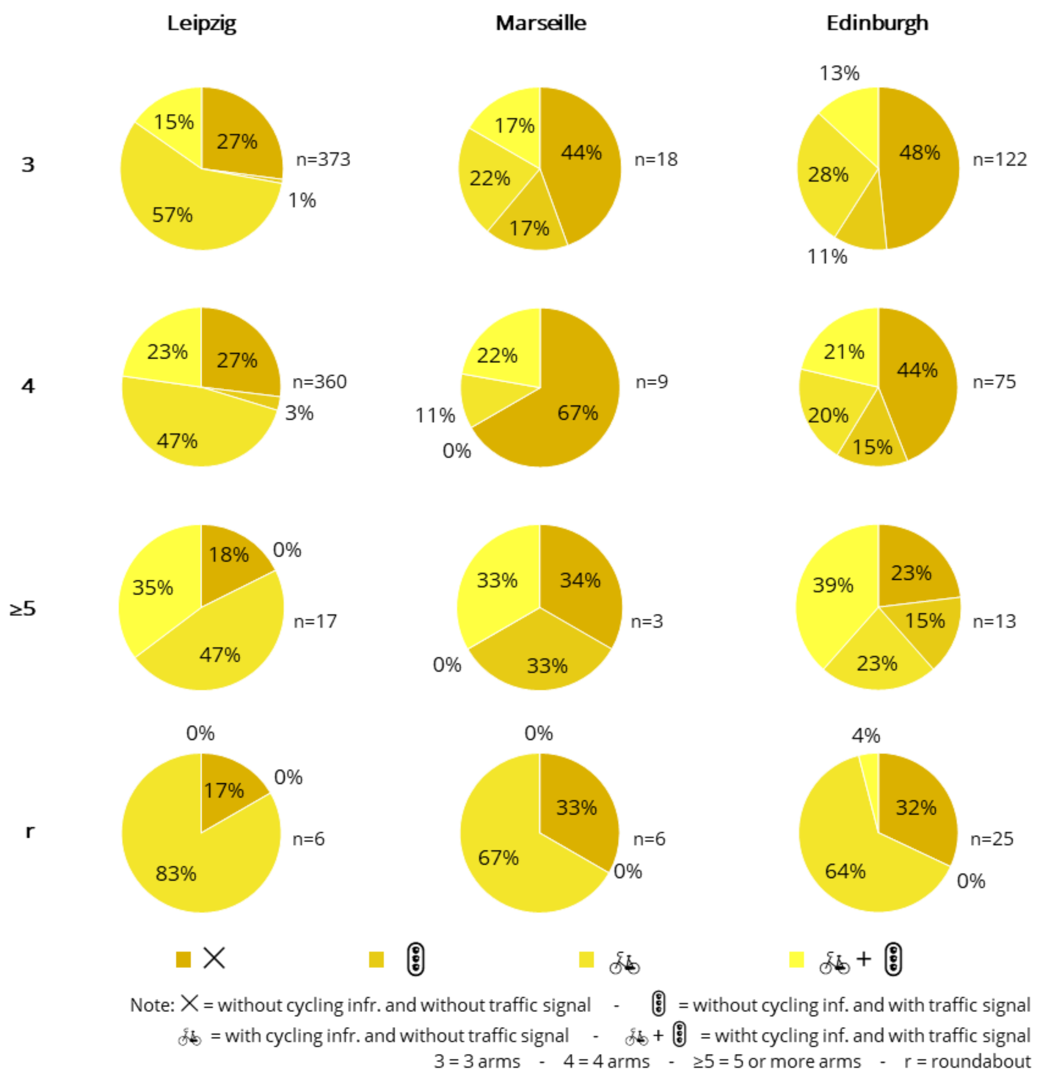


Figure A6. Percentage of intersections with slightly injured cyclists

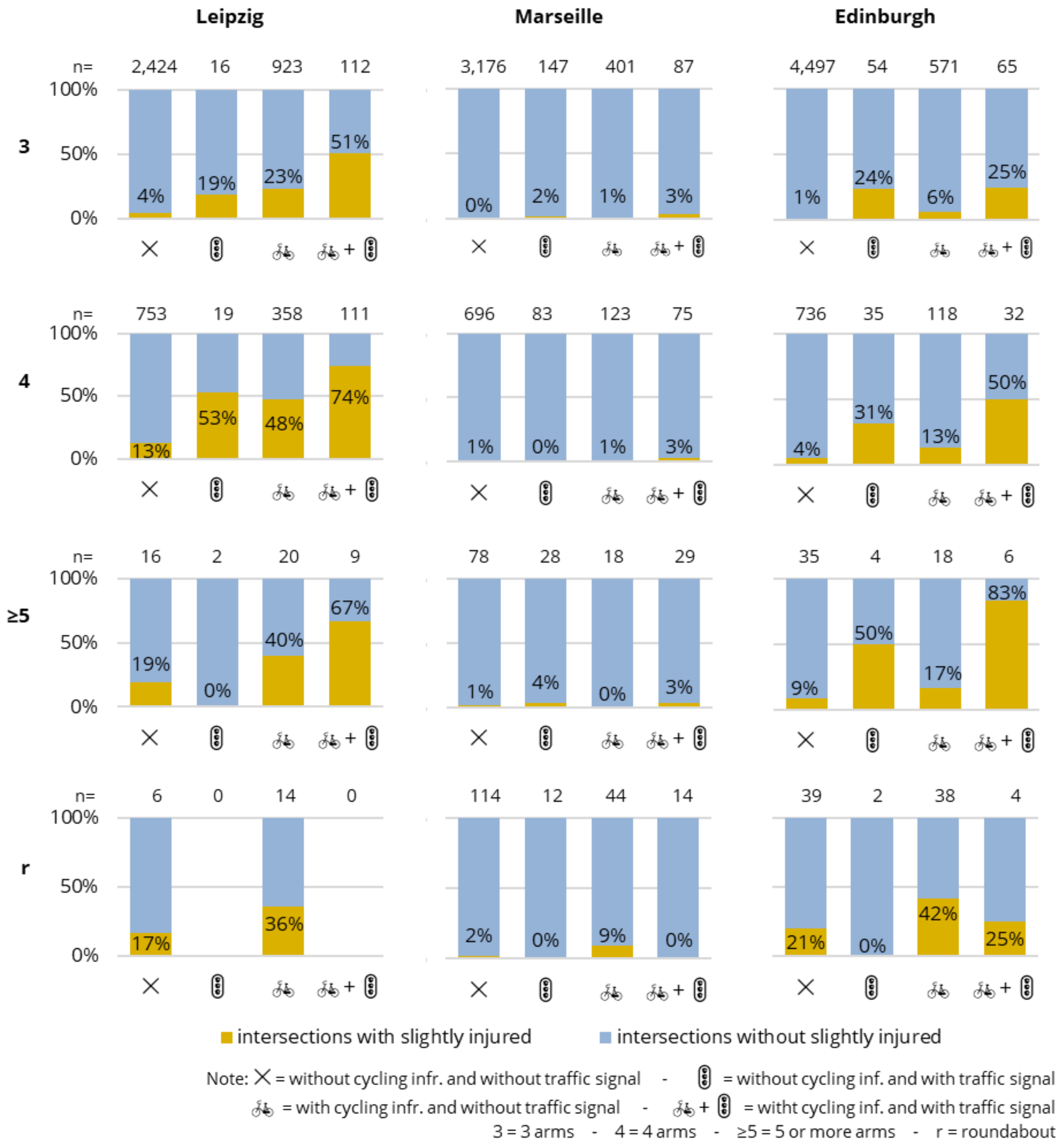
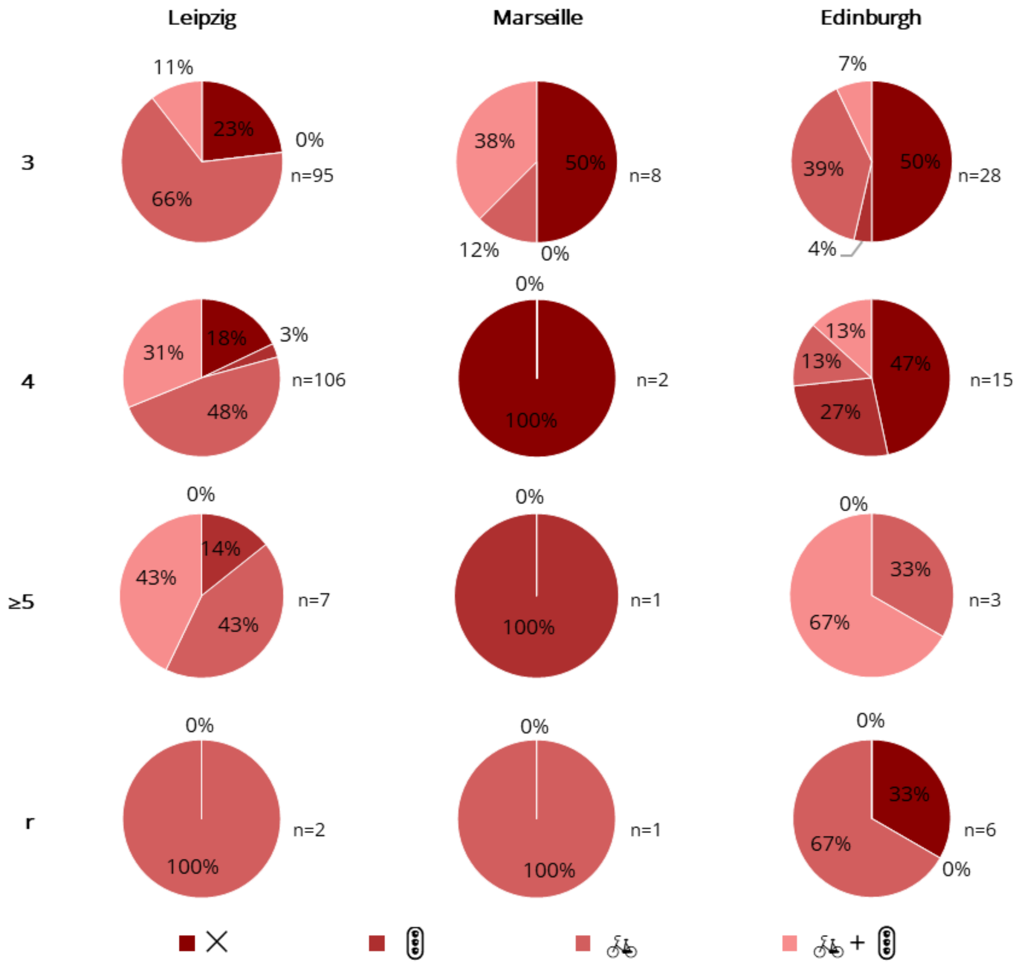


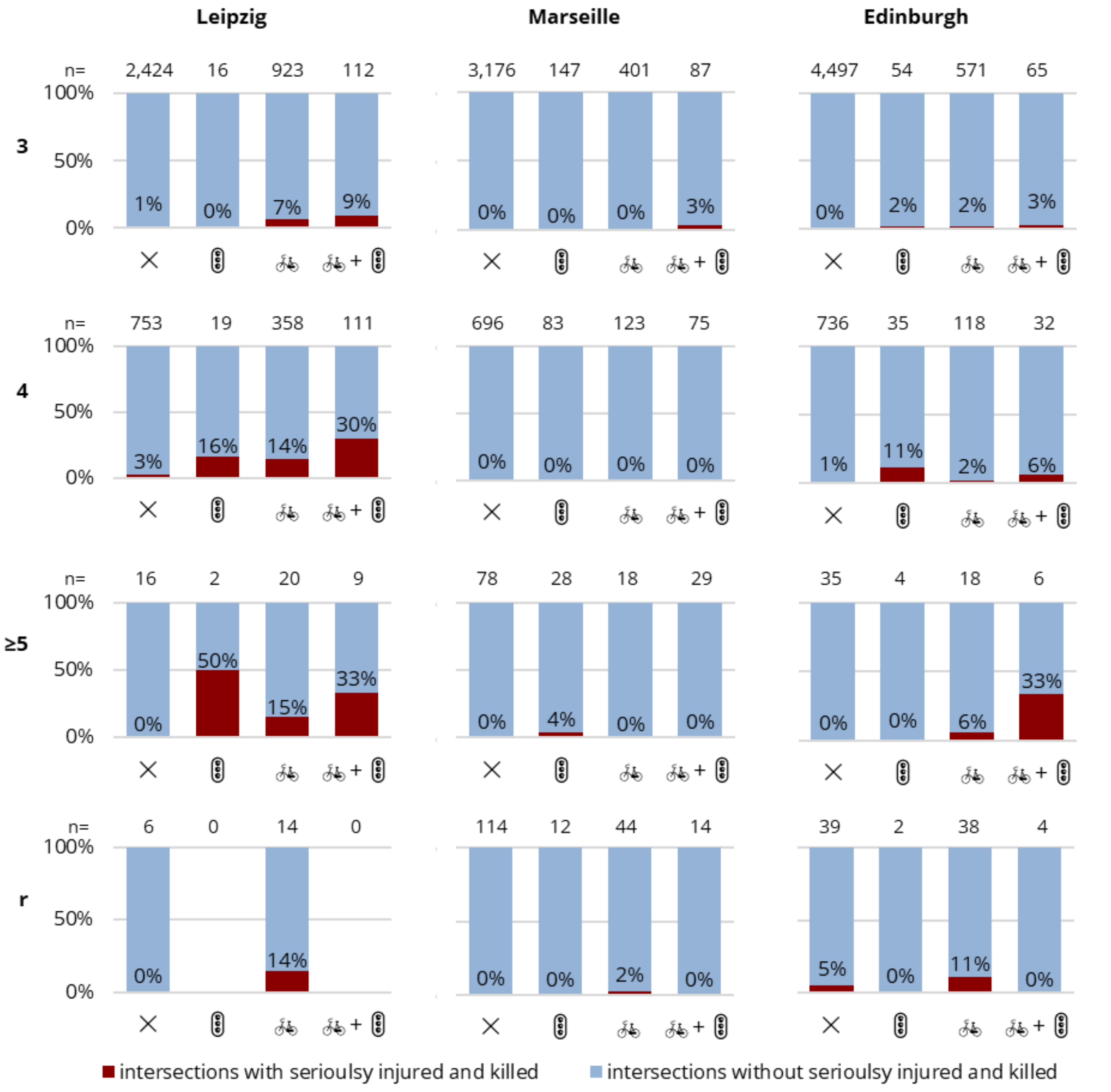
Figure A7. Percentage of intersections with and without slightly injured cyclists

Intersections with seriously injured and killed cyclists



Note: × = without cycling infr. and without traffic signal - 🚦 = without cycling inf. and with traffic signal
🚲 = with cycling infr. and without traffic signal - 🚲 + 🚦 = witht cycling inf. and with traffic signal
3 = 3 arms - 4 = 4 arms - ≥5 = 5 or more arms - r = roundabout

Figure A8. Percentage of intersections with seriously injured and killed cyclists



Note: × = without cycling infr. and without traffic signal - 🚦 = without cycling inf. and with traffic signal
🚲 = with cycling infr. and without traffic signal - 🚲 + 🚦 = witht cycling inf. and with traffic signal
3 = 3 arms - 4 = 4 arms - ≥5 = 5 or more arms - r = roundabout

Figure A9. Percentage of intersections with and without seriously injured and killed cyclists