A MATSim model for a low carbon future mobility in the UK context

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UKRI EPSRC Supervisory team

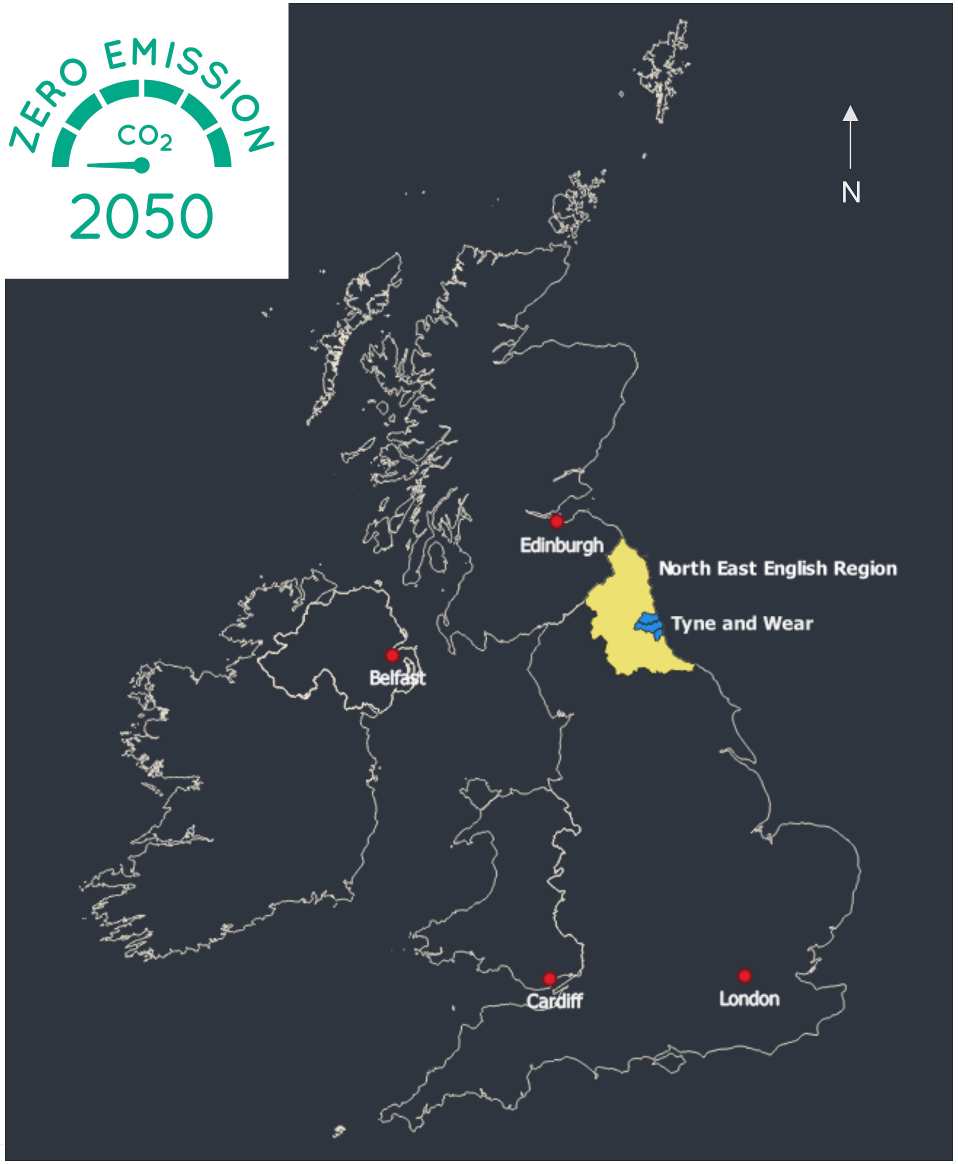
Alistair Ford
Philip James
Roberto Palacín
Dominik Ziemke

1. PhD project aims

To **identify**

- infrastructure interventions
- changing human behaviour

to **reduce GHG emissions** in urban areas in the Tyne and Wear region of England (blue area on the map) and enable the agents the use of **active modes**.



Transport icons have been designed using resources from Flaticon.com

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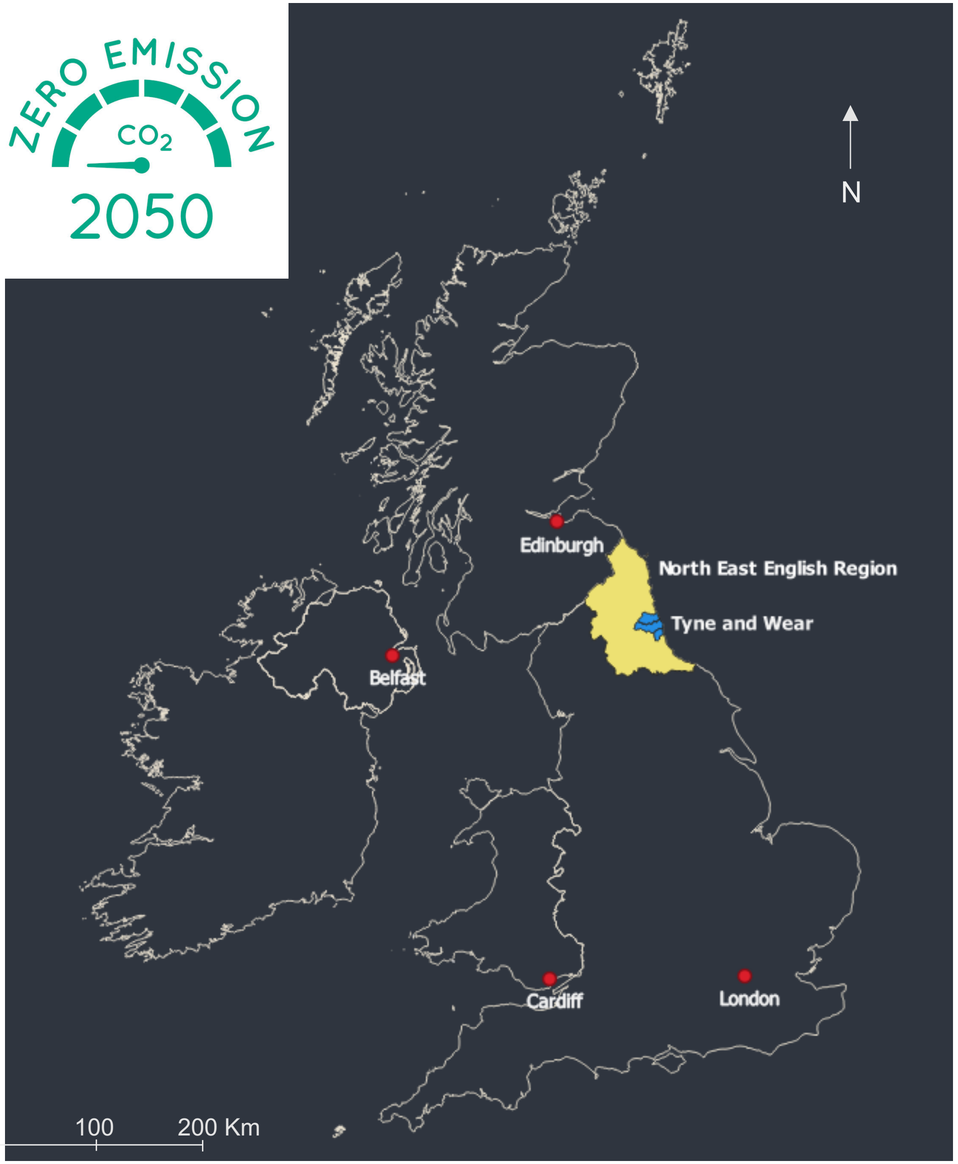

Four innovations to simulate transport scenarios with MATSim in the UK context:

1) a new, open-access and very detailed synthetic population methodology for any region in the UK;
2) an additional network attribute (“quietness”)
3) a bicycle contribution code update
4) tailored “stick” and “carrot” scenarios

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Engineering and Physical Sciences Research Council

2. Synthetic population

Demand

Synthetic population

Socio-demographic

Activity plan

Tools:
SPENSER platform (UoL)
Own developed codes (NU)
PAM (Arup)
OSMOX (Arup)

Datasets:
Census 2011
ONS 2019
National Travel Survey
OpenStreetMap

A simplified digital twin of the actual population (**2019**).

2.6 million inhabitants in area of study

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Individual characteristics	Family dependencies	Mobility access	Spending power
Person ID	Marital status	Driving licence	Economic activity
Household ID	Children dependency	Car access	Occupation
Age		Bike access	Annual Gross Income
Sex			

SPENSER (UoL). Link: https://lida.leeds.ac.uk/research-projects/spenser-synthetic-population-estimation-and-scenario-projection-model/

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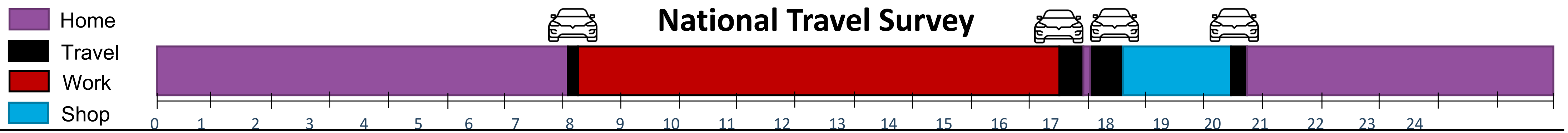

National Travel Survey (NTS). Link: https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=7553

2. Synthetic population

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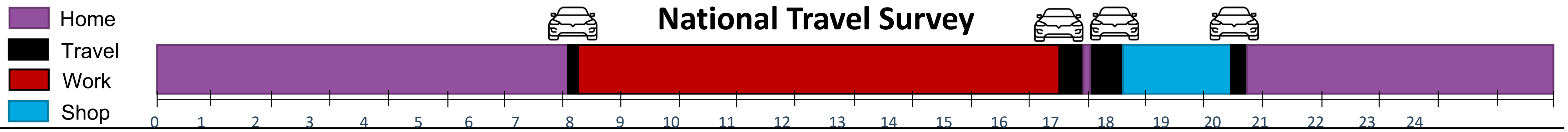
Similar socio-demographic attributes



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2. Synthetic population

Demand

- **Synthetic population**
- Socio-demographic
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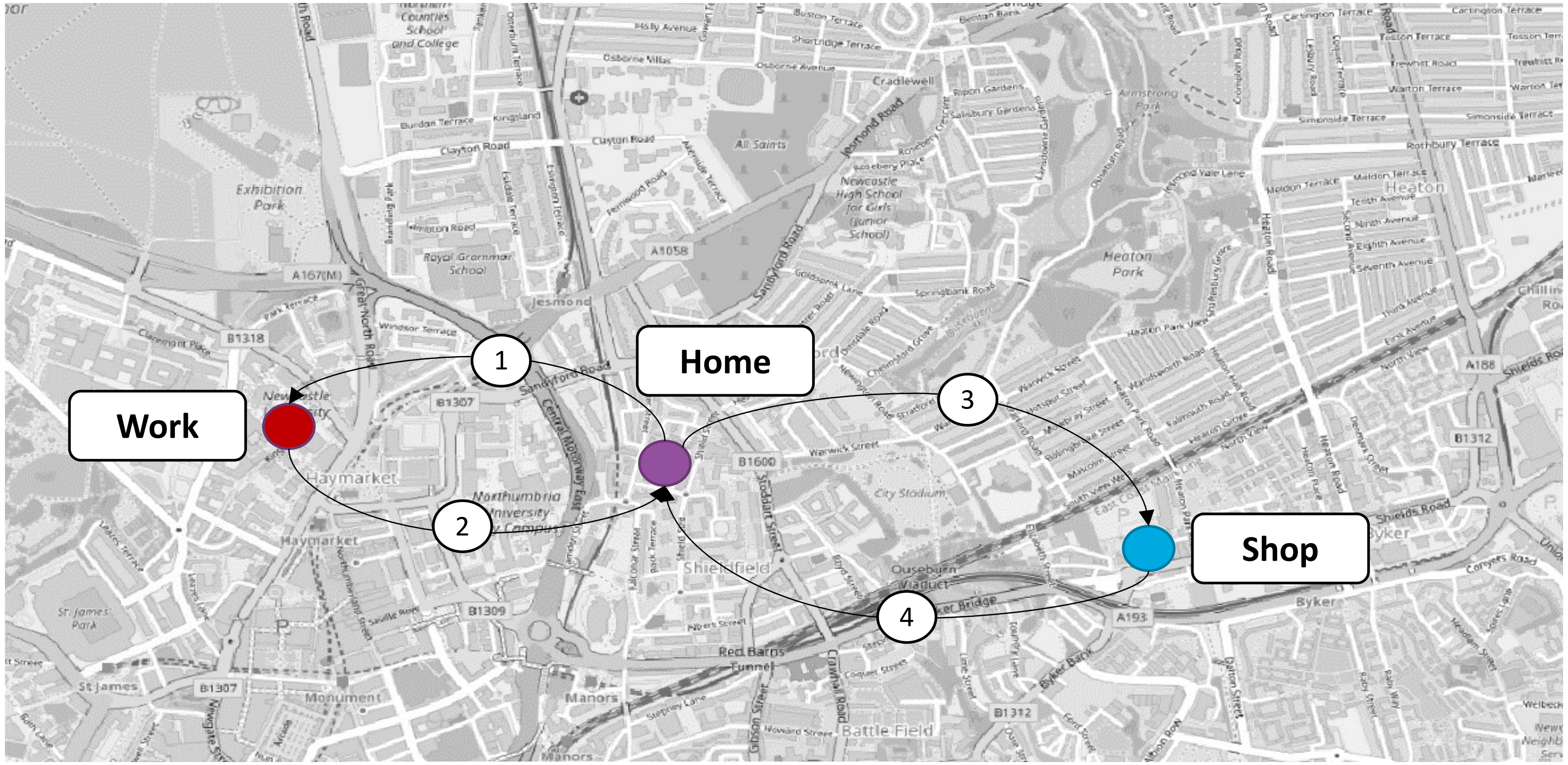
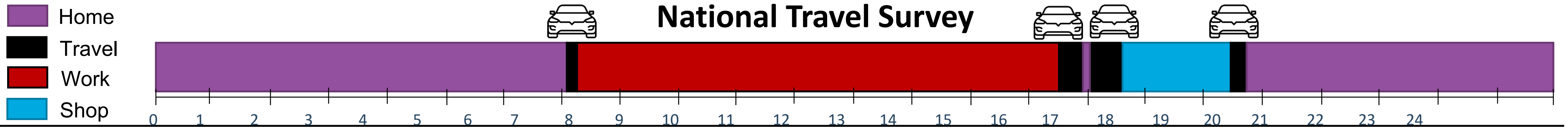
Individual characteristics | **Family dependencies** | **Mobility access** | **Spending power**





PAM (Arup). Link: https://github.com/arup-group/pam
OSMOX (Arup). Link: https://github.com/arup-group/osmox
OpenStreetMap. Link: https://download.geofabrik.de/

3. Network

Supply

Network

Tools:
Osmium,
UK2GTFS,
PUMA (Arup),
GeNet (Arup)

Datasets:
OpenStreetMap
UK GTFS
Defra DEM
Cyclestreet

A simplified digital representation of the road and public transport network

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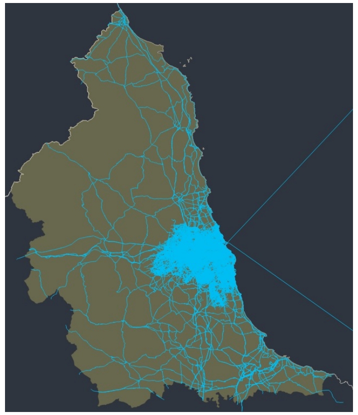
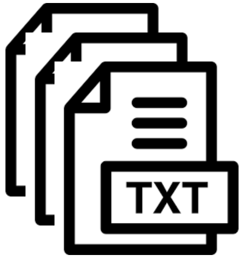


Roads



GTFS

Osmium: Link: https://osmcode.org/osmium-tool/
UK2GTFS Link: https://itsleeds.github.io/UK2GTFS/

OpenStreetMap. Link: https://download.geofabrik.de/
UK GTFS: Links: https://data.atoc.org/rail-industry-data
https://www.travelinedata.org.uk/

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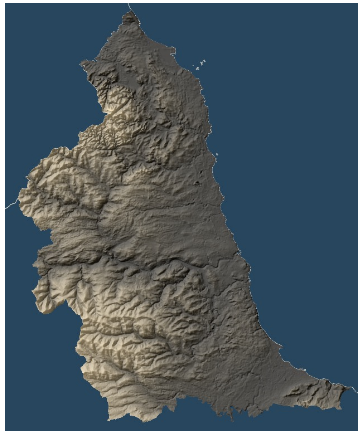

Altitude and gradient

GeNet (Arup). Link:: https://github.com/arup-group/genet
Defra DEM: Link: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

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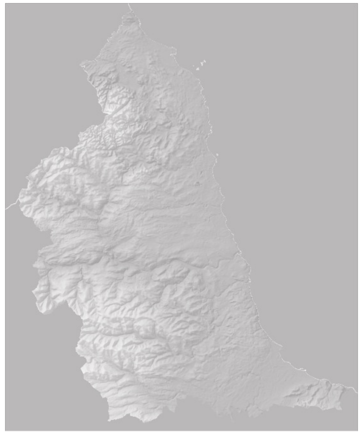

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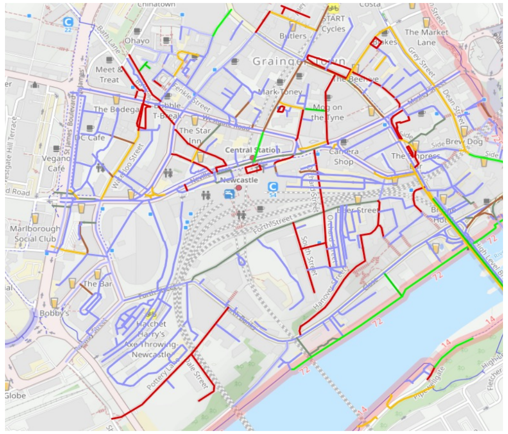
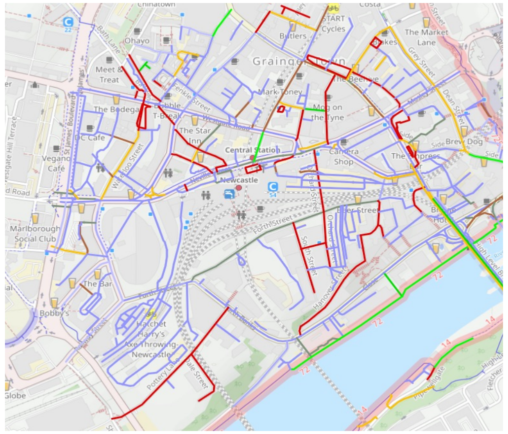


Cycleability rating

3. 1. Cycleability rating



Cycleability rating

Factors included:

- Road type
- Cycle infrastructure
- Path widths/quality
- Barriers, obstructions
- Land ownership
- Surface type and quality
- Kerbs


```
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        <attribute name="geometry" class="java.lang.String">ibc}eroAooina}gB{ncpE_o|[cjqwCow~Z</attribute>
        <attribute name="osm:way:highway" class="java.lang.String">residential</attribute>
        <attribute name="osm:way:maxspeed" class="java.lang.String">20 mph</attribute>
        <attribute name="osm:way:osmid" class="java.lang.String">67624770</attribute>
        <attribute name="quietness" class="java.lang.String">0.6</attribute>
        <attribute name="slope" class="java.lang.String">-0.018093156425236068</attribute>
    </attributes>
</link>
```

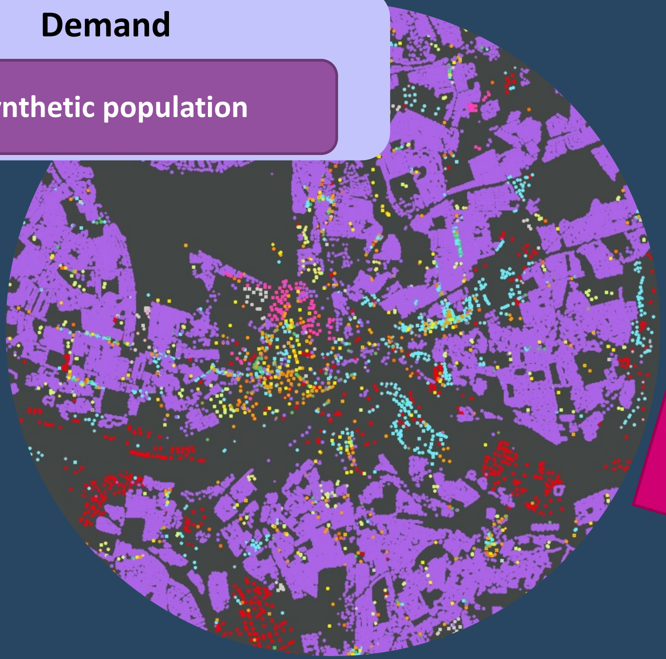

Values between 0.0 and 1.0

0.0: very poor
1.0: excellent

Cyclestreets. Cycleability ratings https://bikedata.cyclestreets.net/cycleability/

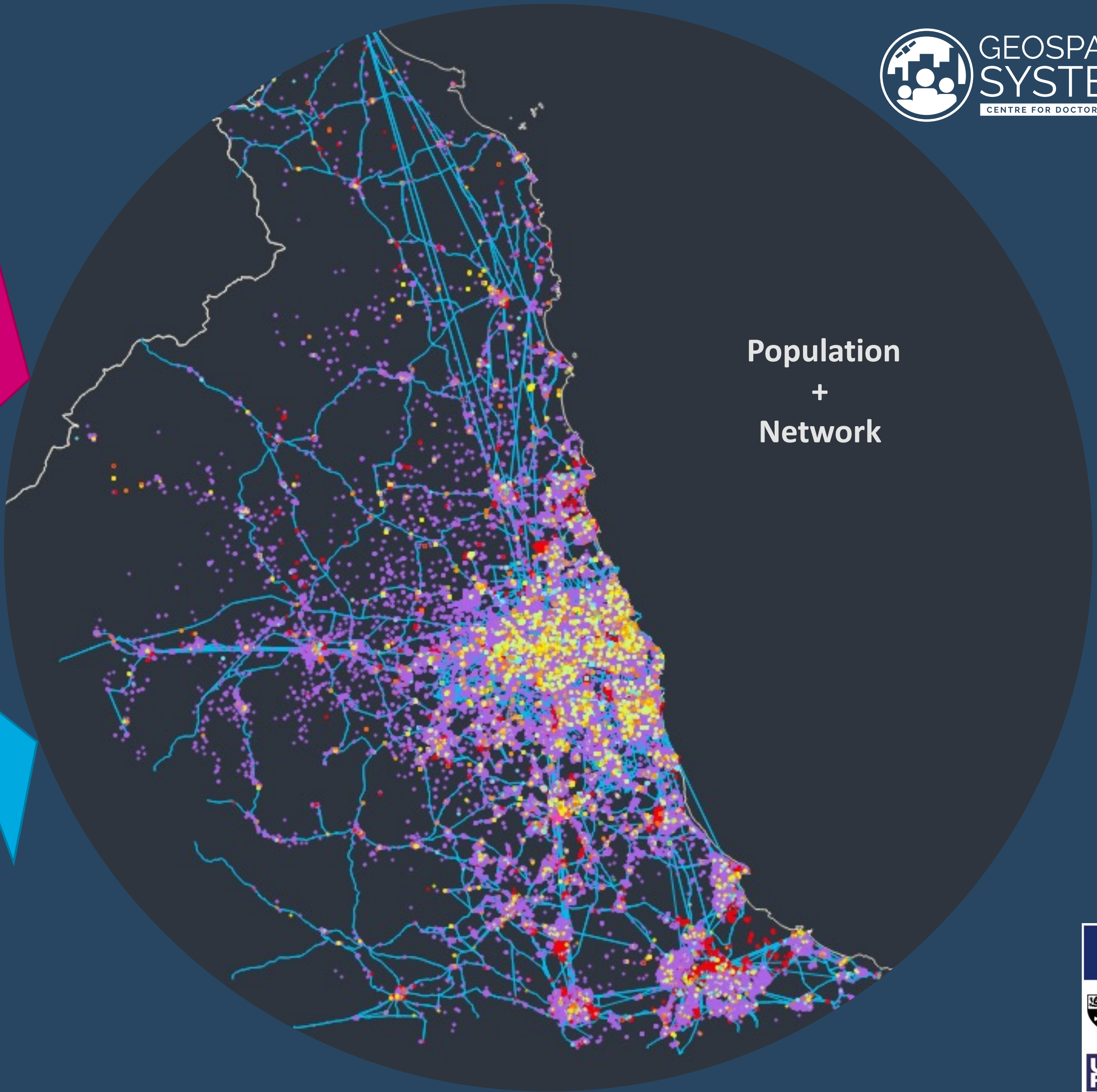
Demand

Synthetic population



Supply

Network



Population
+
Network

4. Bicycle contribution extension update

Bicycle contribution (Ziemke et al, (2019))

Extension of the agent-based transport simulation framework MATSim for bicycle traffic.

- Road comfort (OSM tags: surface, highway, smoothness)
- Road infrastructure type (OSM tag: highway)
- Road gradient (DEM)

Ziemke, Dominik, Simon Metzler, and Kai Nagel. "Bicycle traffic and its interaction with motorized traffic in an agent-based transport simulation framework." Future Generation Computer Systems 97 (2019): 30-40. https://doi.org/10.1016/j.future.2018.11.005

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- ~~Road comfort (OSM) (surface, highway, smoothness)~~
- ~~Road infrastructure type (OSM) (highway)~~
- Road gradient (DEM)
- Road quietness (Cyclestreets)

Marginal utility of quietness

$$\beta_{\text{quietness}(a)} = \beta^{\text{max quietness}(a)} \cdot (1 - \text{quietness}(a))$$

Ziemke, Dominik, Simon Metzler, and Kai Nagel. "Bicycle traffic and its interaction with motorized traffic in an agent-based transport simulation framework." Future Generation Computer Systems 97 (2019): 30-40. https://doi.org/10.1016/j.future.2018.11.005

5. MATSim simulation

Bicycle extension updated

Tool:
MATSim bicycle contribution

MATSim
Multi-Agent Transport Simulation

Demand

Synthetic population

Socio-demographic

Activity plan

Tools:
SPENSER platform (UoL)
Own developed codes (NU)
PAM (Arup)
OSMOX (Arup)
Catapult Connected Places

Supply

Network

Tools:
Osmium, UK2GTFS,
PUMA, GeNet (Arup)

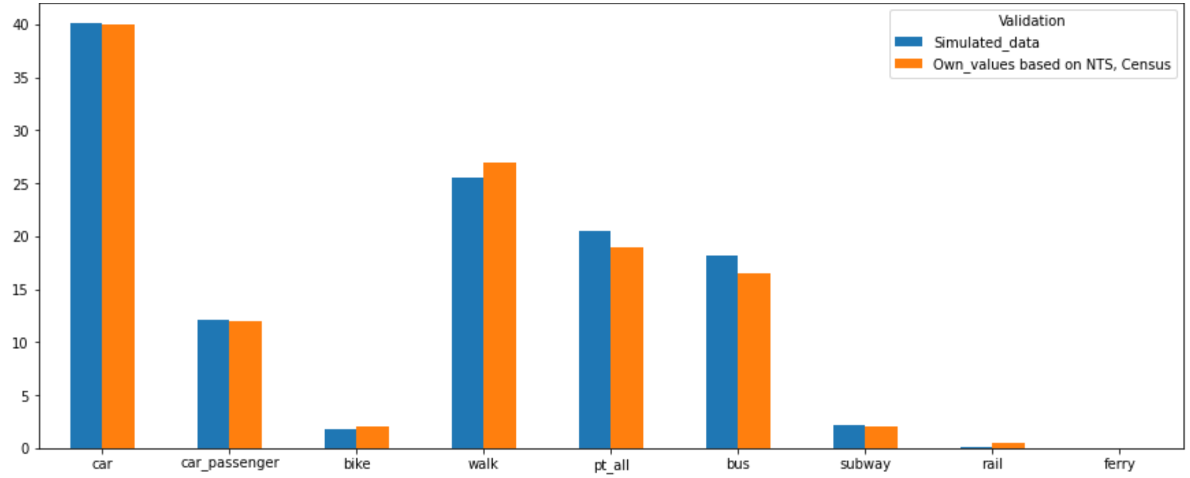
Datasets:
OpenStreetMap
GTFS
Defra DEM
Cyclestreet

5. MATSim simulation. Calibration

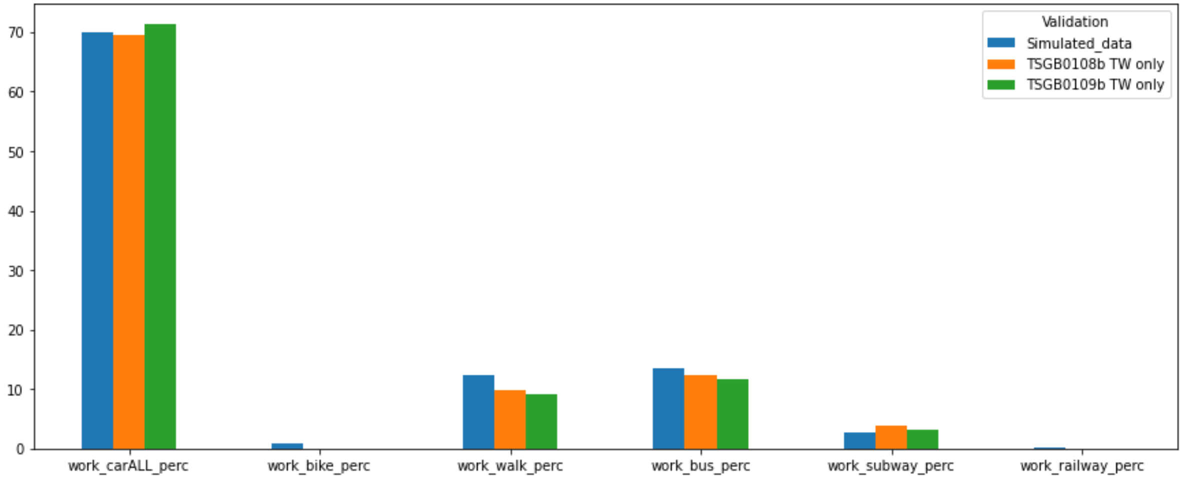
Parameter	Values
Population sample	20%
Number of iterations	1,500
Controler	Qsim
Modes	car, car passenger, bike, walk, PT (bus. rail, metro, ferry)
Car use	Only by those with access to car: considerCarAvailability (true)
PT	Deterministic, SwissRailRaptor, SBBPt, useCapacityConstraints (false), access and egress (walk)
Bicycle extension	Marginal utility of comfort (0.0), infrastructure (0.0), gradient (-0.02), quietness (-0.035)
Strategies	80%, ReRoute (0.1), TimeAllocationMutator (0.1), SubtourModeChoice (0.1), ChangeExpBeta (0.7)
ASC	Car: -0.37 Car_passenger: -1.7 Bike: -1.1 Walk: 0.0 Bus: -7.2 Rail: -0.001 Subway: -0.001 Ferry: -0.001

5. MATSim simulation. Validation results

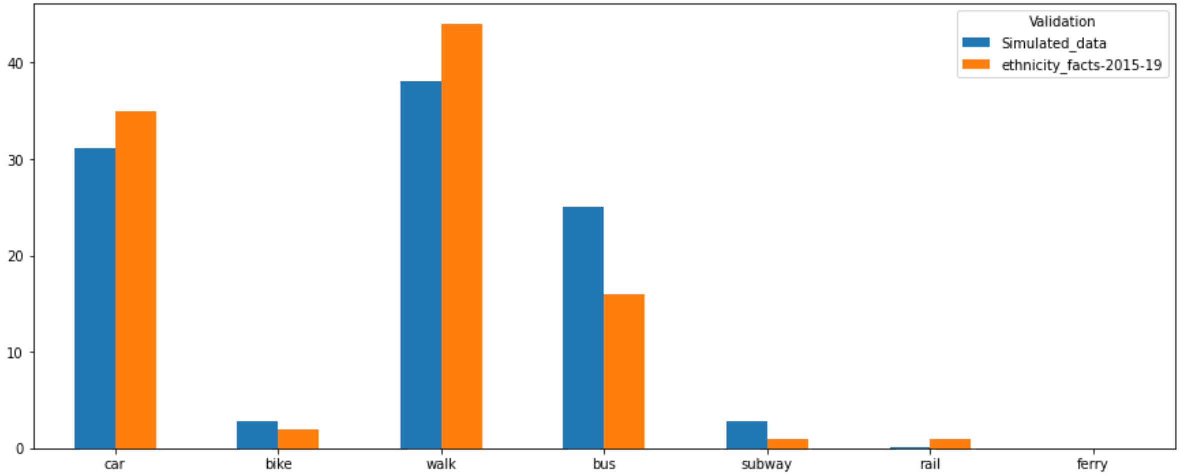
% of transport modes used



% of transport modes used (commuting only)



% of transport modes used (school trip only)



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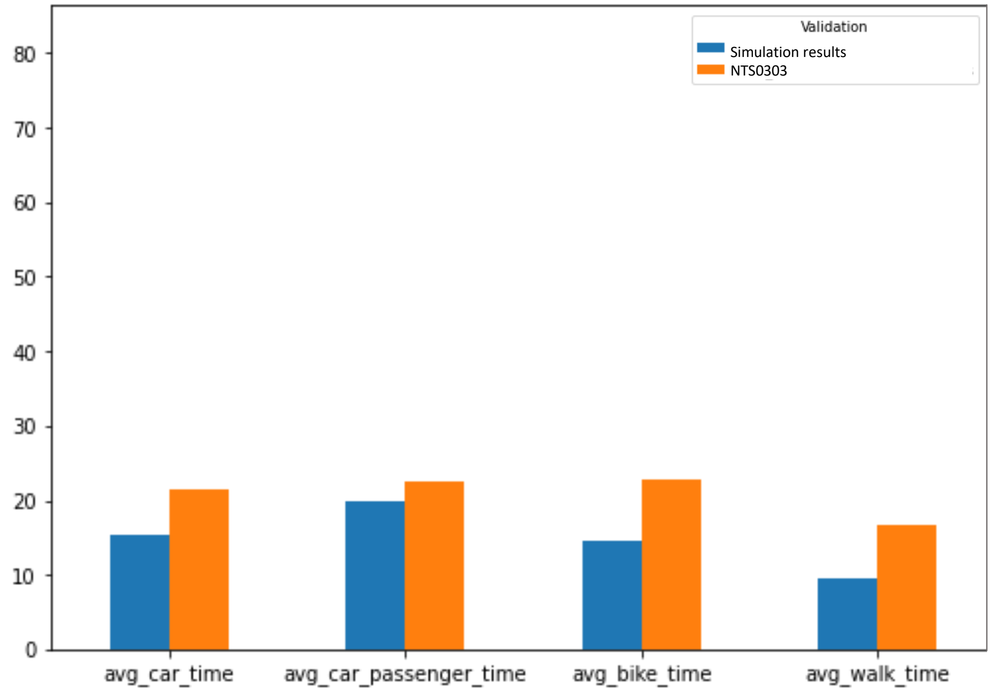
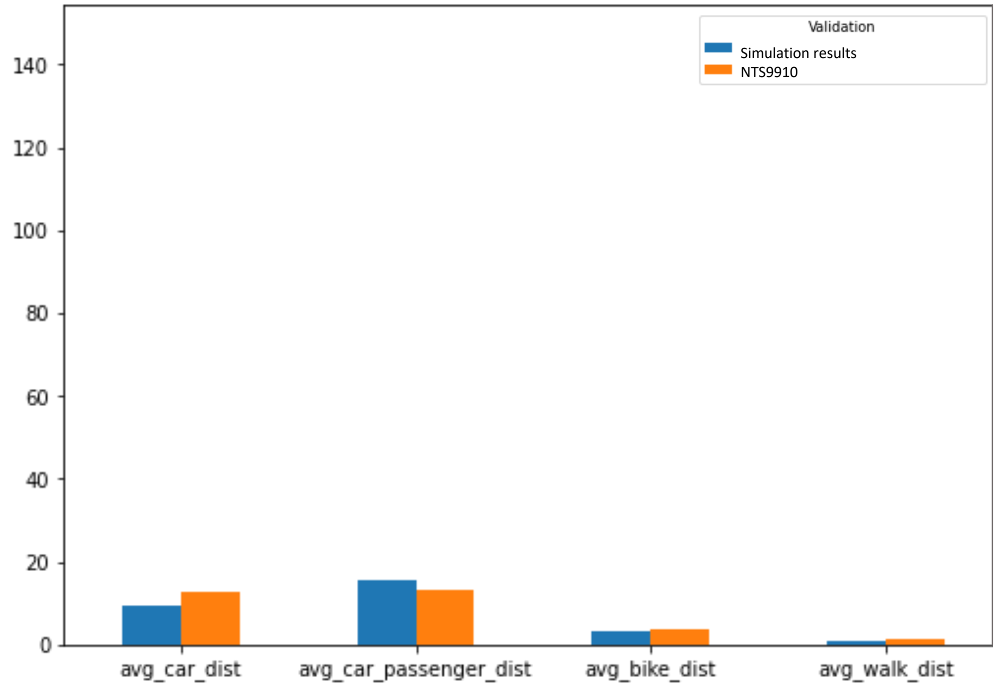
5. MATSim simulation. Validation results

Average trip time (min) per transport mode



Average trip distance (km) per transport mode



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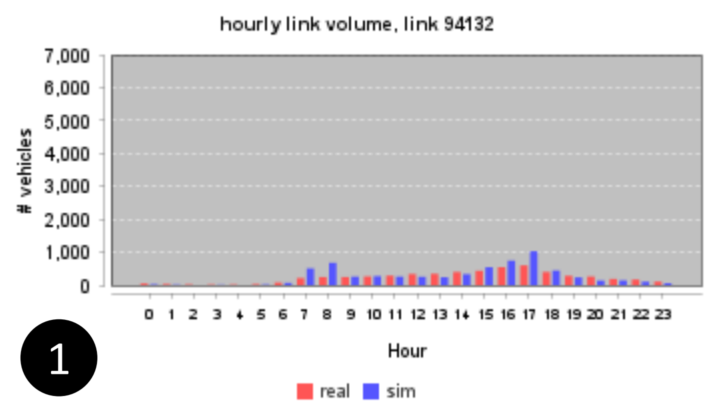
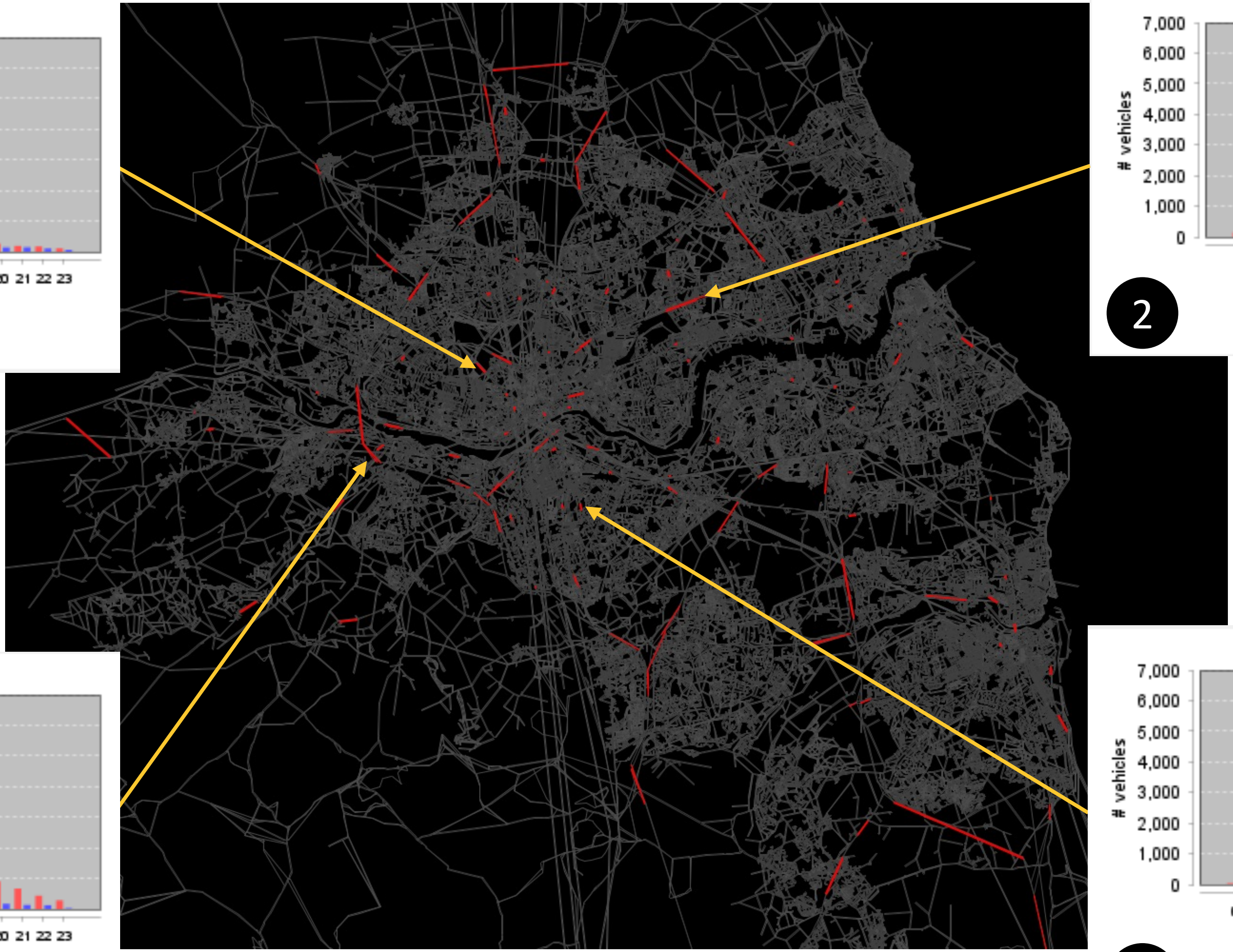
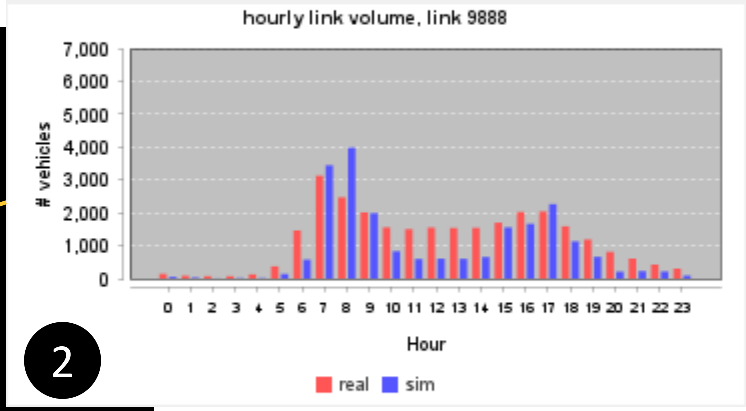


1





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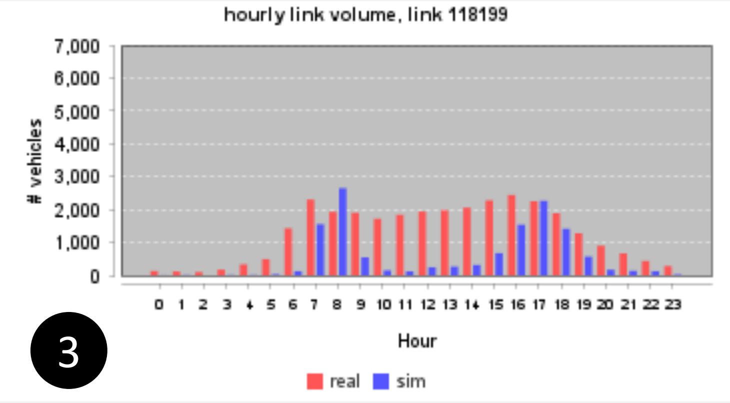

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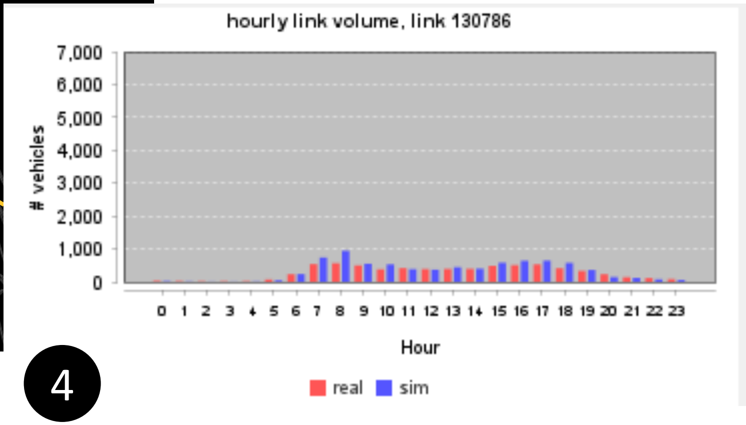

4

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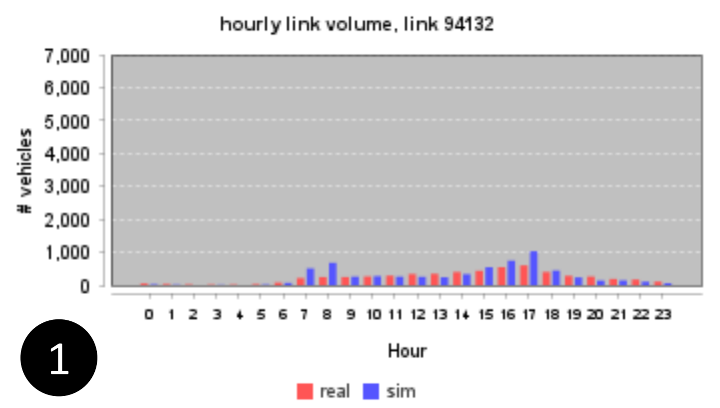

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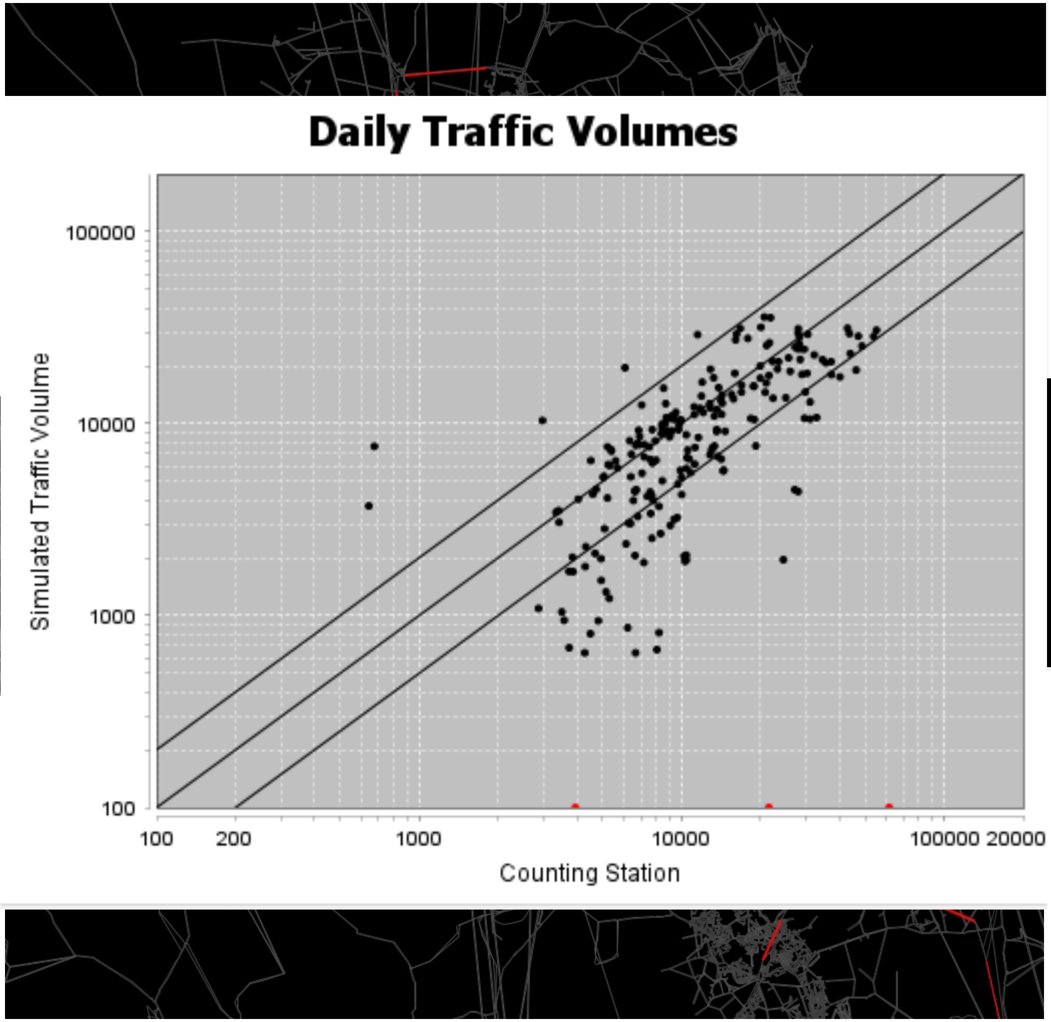

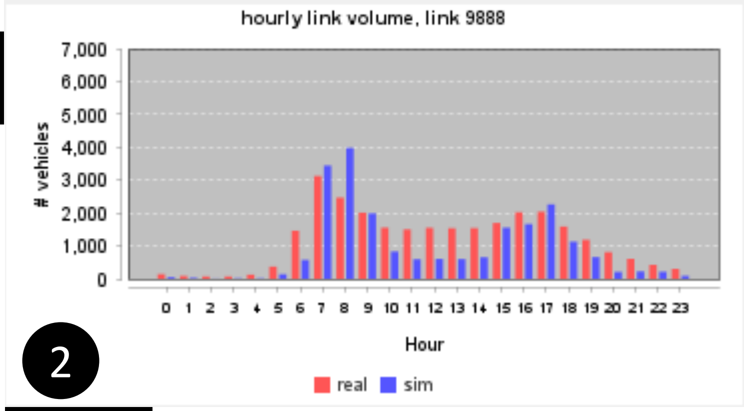

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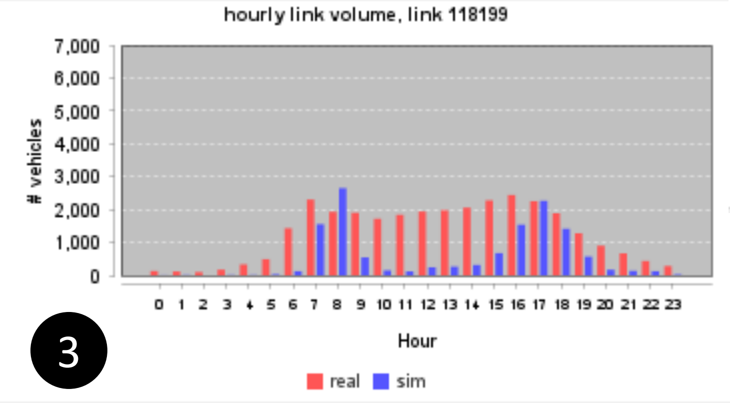

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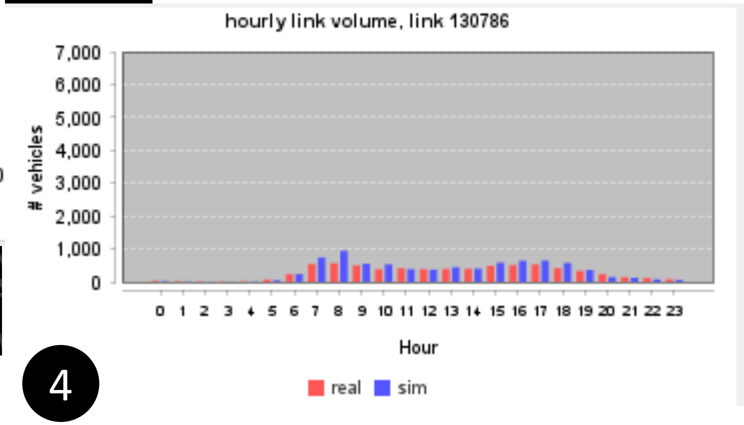

4

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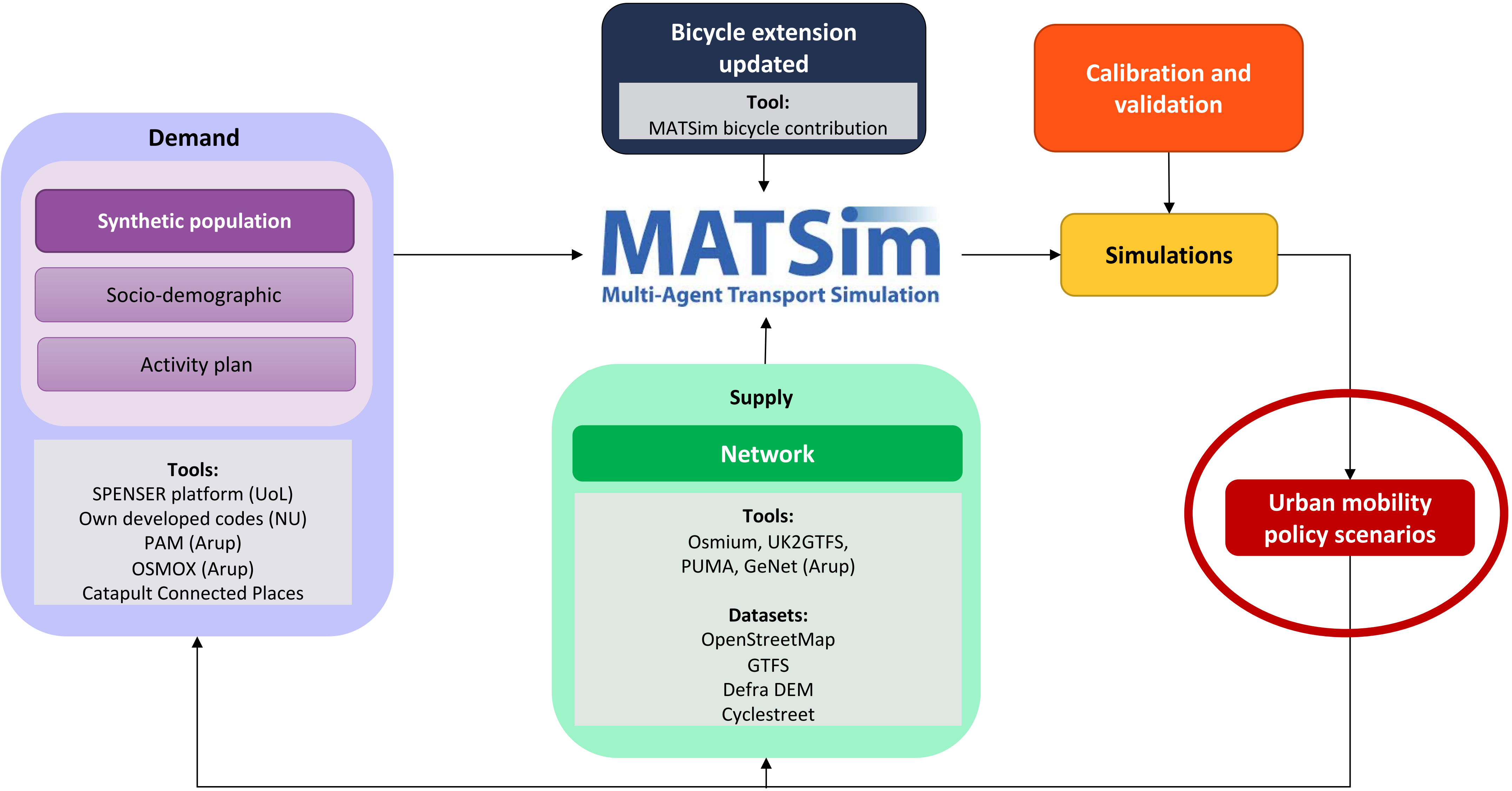
6. Full PhD project methodology



7. Tailored “stick” and “carrot” scenarios

The phrase “**stick and carrot**" is a metaphor for the use of a combination of <u>reward</u> and <u>punishment</u> to induce a desired behaviour (Wikipedia).

Image taken from Wikipedia https://en.wikipedia.org/wiki/Carrot_and_stick

7. Tailored “stick” and “carrot” scenarios

Preliminarily results

1. Ultimate cycle network scenario

Carrot scenario:

Duplicated network only allowed for bikes

Quietness = 1.0 (fully safe and segregated cycle paths)

Transport mode	Change
Car (all)	- 0.52 %
PT	+ 0.37%
Walk	- 0.59%
Bike	+ 0.74%

7. Tailored “stick” and “carrot” scenarios

Preliminarily results

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Stick + carrot scenario:

Carrot scenario

+

Flow capacity reduced proportionally (no. of lanes) to transfer road car space to cycle paths

Transport mode	Change
Car (all)	- 1.94%
PT	+ 1.21%
Walk	- 0.32%
Bike	+ 1.06%

7. Tailored “stick” and “carrot” scenarios

Preliminarily results

2. Low Traffic Neighbourhoods scenario

Stick scenario:

Cars only allowed in motorway, trunk, primary, secondary and tertiary links (red links in the image)

Quietness = 1.0 (fully safe and segregated cycle paths) in the other links

Transport mode	Change
Car (all)	- 3.24%
PT	+ 2.95%
Walk	+ 0.98%
Bike	- 0.7%

7. Tailored "stick" and "carrot" scenarios

Preliminarily results

3. Pay as you drive scenario

Stick scenario:

Car users (drivers and passengers) **pay a daily penalty**

£10

Transport mode	Change
Car (all)	- 8.9%
PT	+ 5.5%
Walk	+ 1.89%
Bike	+ 1.51%

7. Tailored “stick” and “carrot” scenarios

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Preliminarily results

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Transport mode	Change
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Stick scenario:

Car users (drivers and passengers) **receive a monetary penalty per km driven.**

£0.50 per km

Transport mode	Change
Car (all)	- 6.43%
PT	+ 4.72%
Walk	+ 0.6%
Bike	+ 1.0%

7. Tailored “stick” and “carrot” scenarios

Work in progress

4. Active travel reward scenario

Carrot scenario:

Active travel users receive a **monetary reward** per km walked/cycled

£0.50 per km
£0.20 per km

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Work in progress

5. Cycle Hubs scenario (PT + AT)

Carrot scenario:

Cyclist are allowed to access and egress metro stations.

New cycle hubs set up next to metro stations.

Agents can leave the bicycles in a secure and safety place

Work in progress

Global stick and carrot scenario:

Combination of previous single policies to enable the agents to use more active travel modes instead of private motor vehicles

Suggestions and comments
to improve the model and scenarios are
very welcome!

Thank you
for your attention

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