Making cities better with human-centric urban data science

Michael Szell

NEtwoRks, Data, and Society (NERDS)

with:
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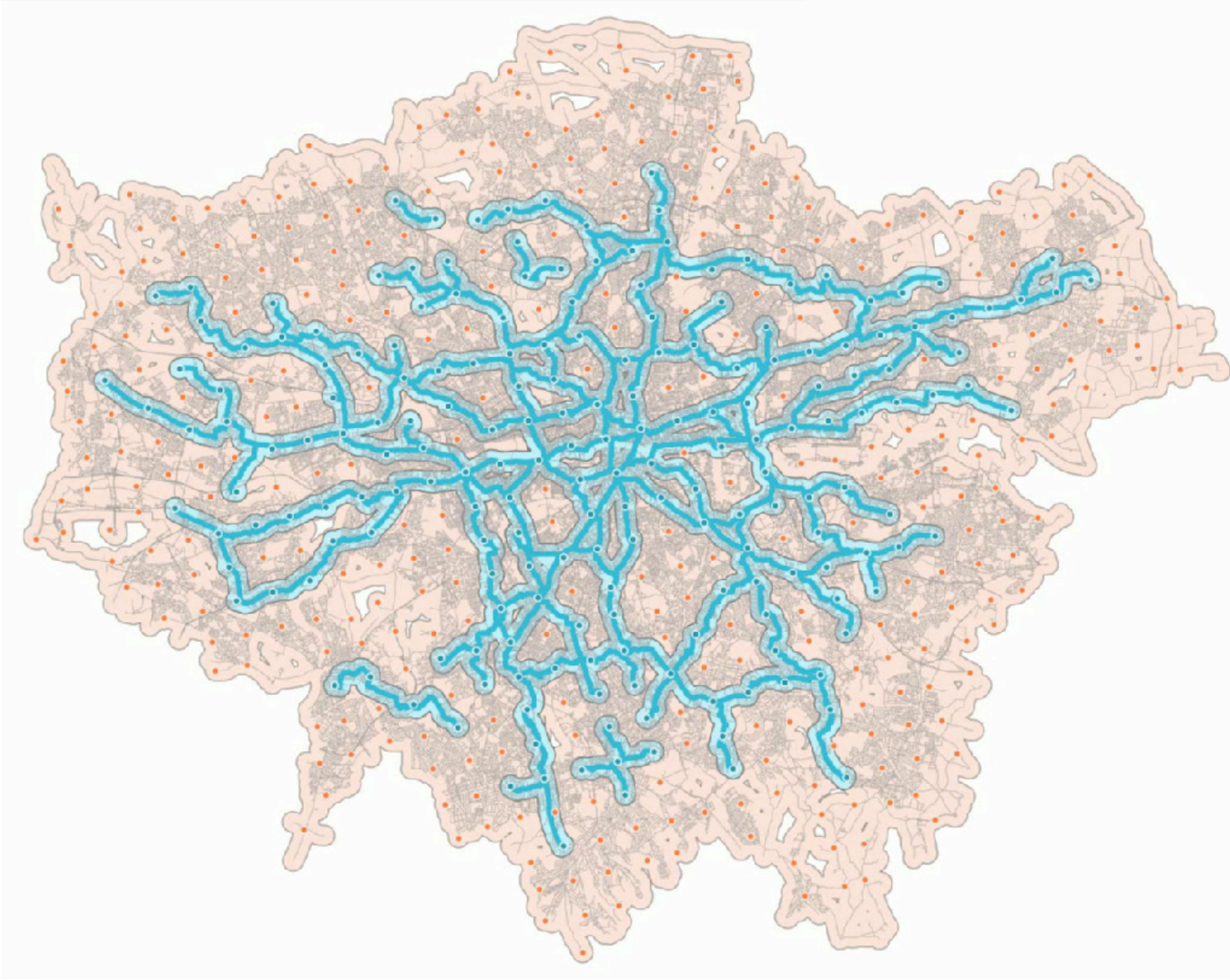
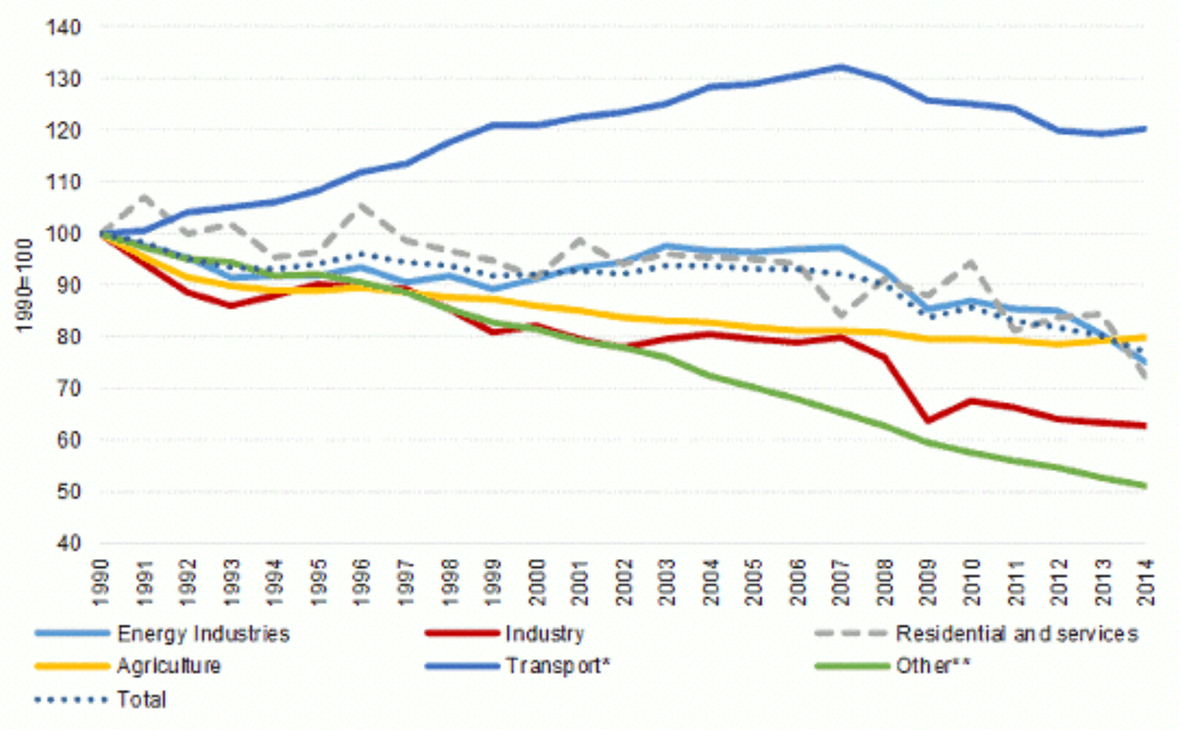
M. Lynghede, C.L. Kolding Andersen,
M. Klanjčić, L. Gauvin, M. Tizzoni



IT UNIVERSITY OF COPENHAGEN

Urban Complex Systems, Lyon, Oct 27, 2021

Transport plays a key role in the climate crisis



Transport represents almost a quarter of Europe's greenhouse gas emissions and is the main cause of air pollution in cities.

https://ec.europa.eu/clima/policies/transport_en

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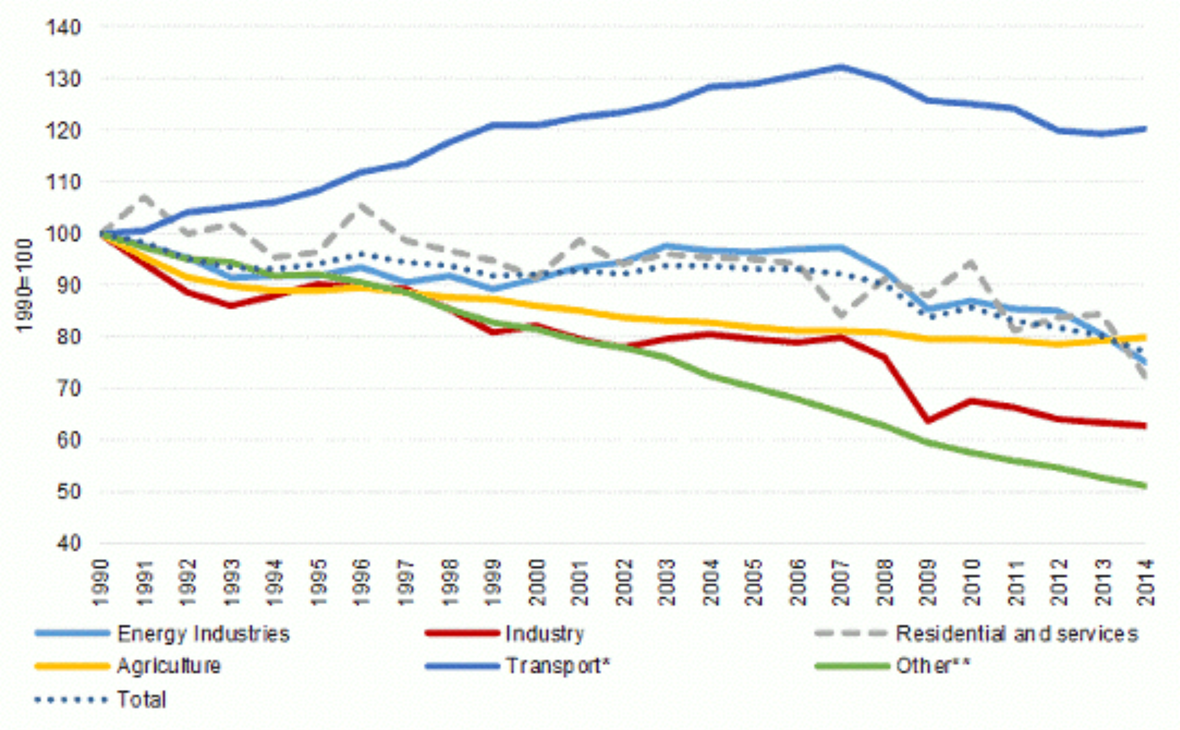

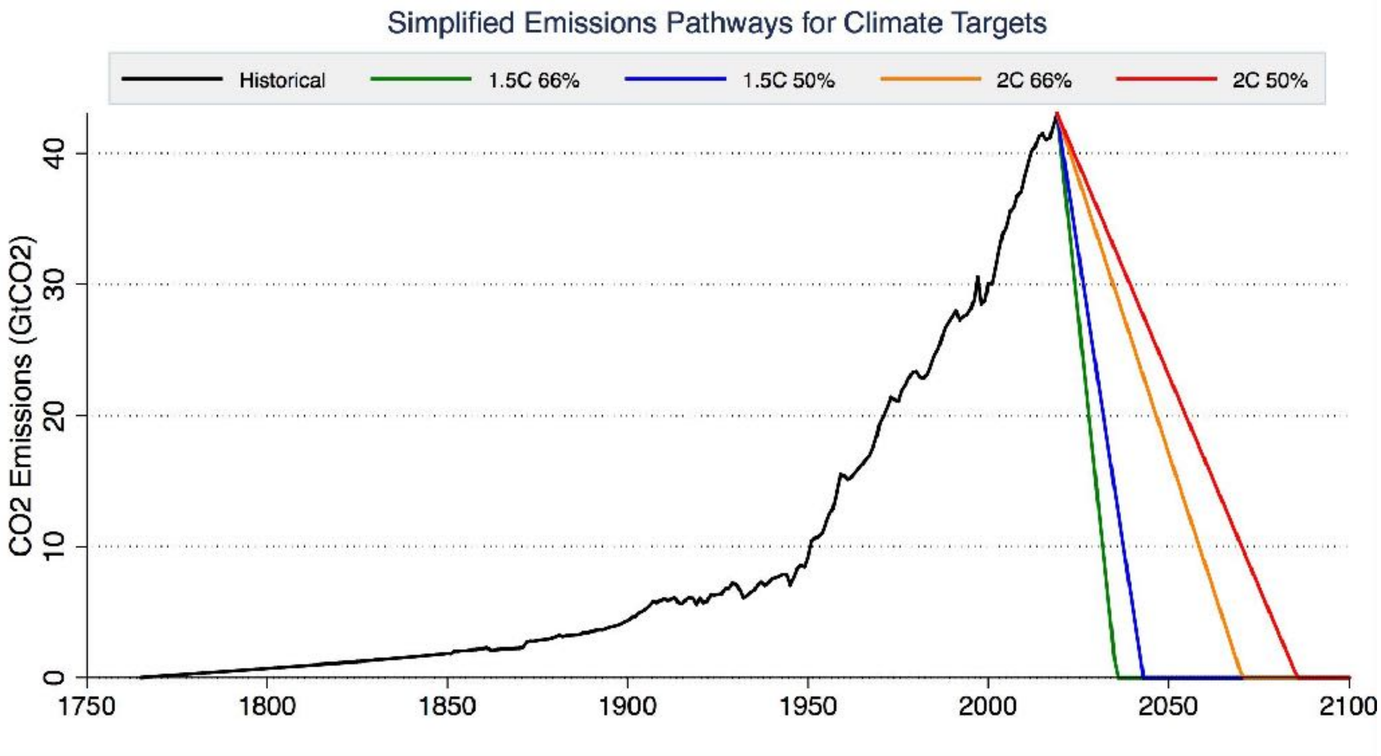

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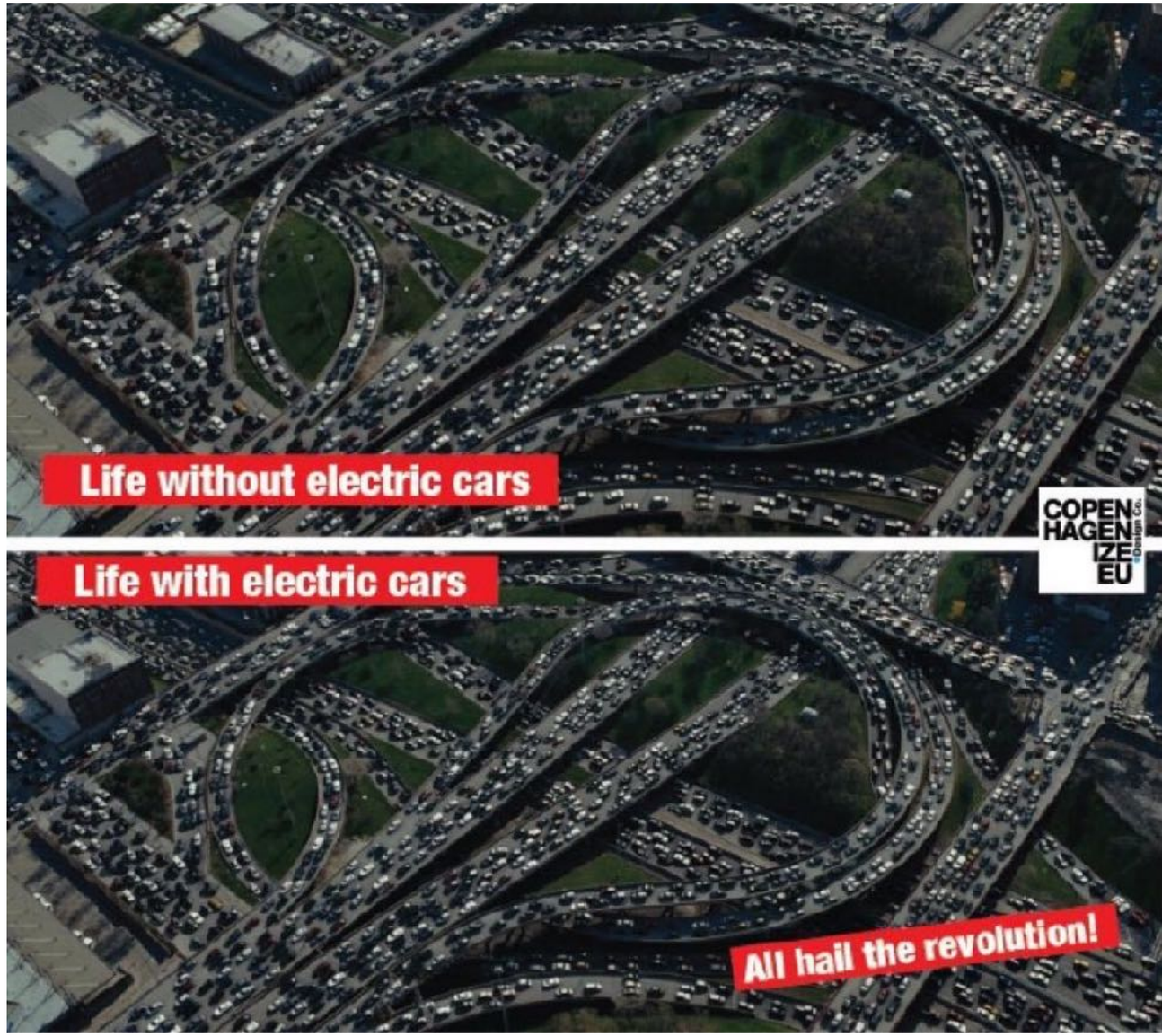
Zeke Hausfather

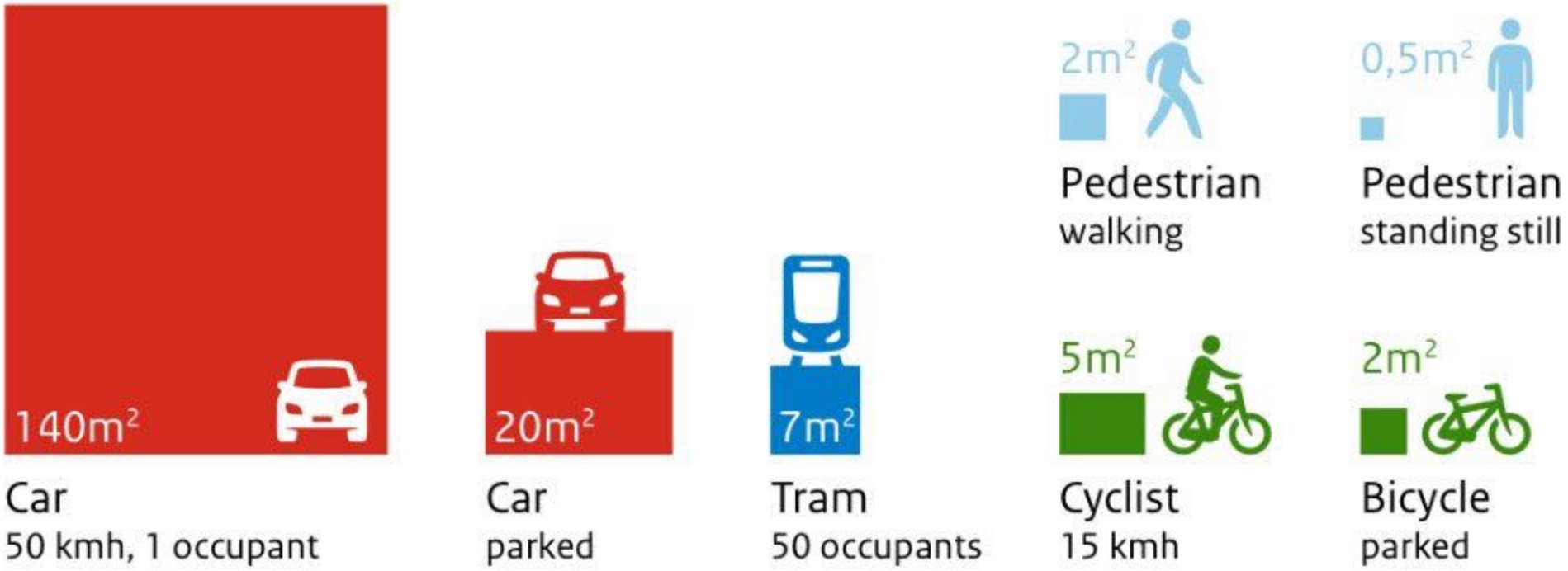
But what about E-cars?

E-cars are not THE solution: Cars take too much space



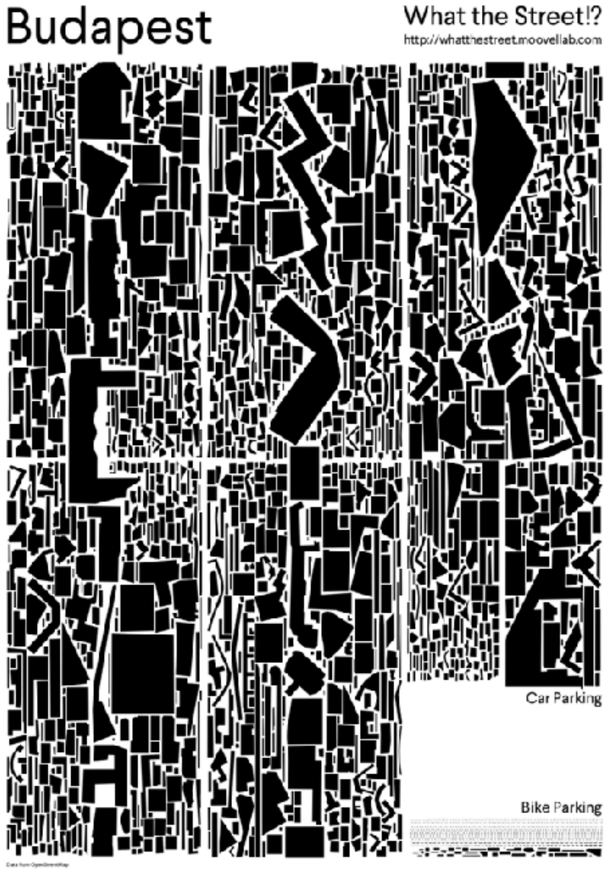
Prieto Curiel et al, R Soc Open Sci 8 (2021)

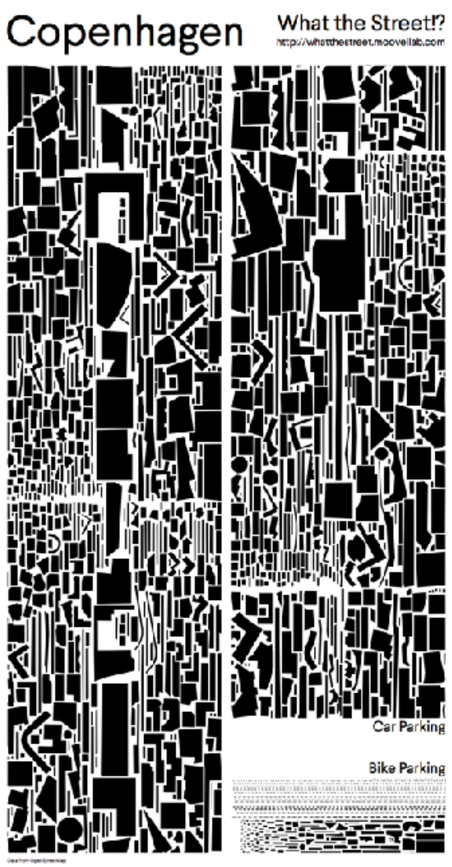
You can't beat geometry: Cars will ALWAYS be inefficient



Harms and Kansen, Netherlands Institute for Transport Policy Analysis (2017)
Szell, Urb Plan 3, 1-20 (2018)

There are huge differences between car and bike parking

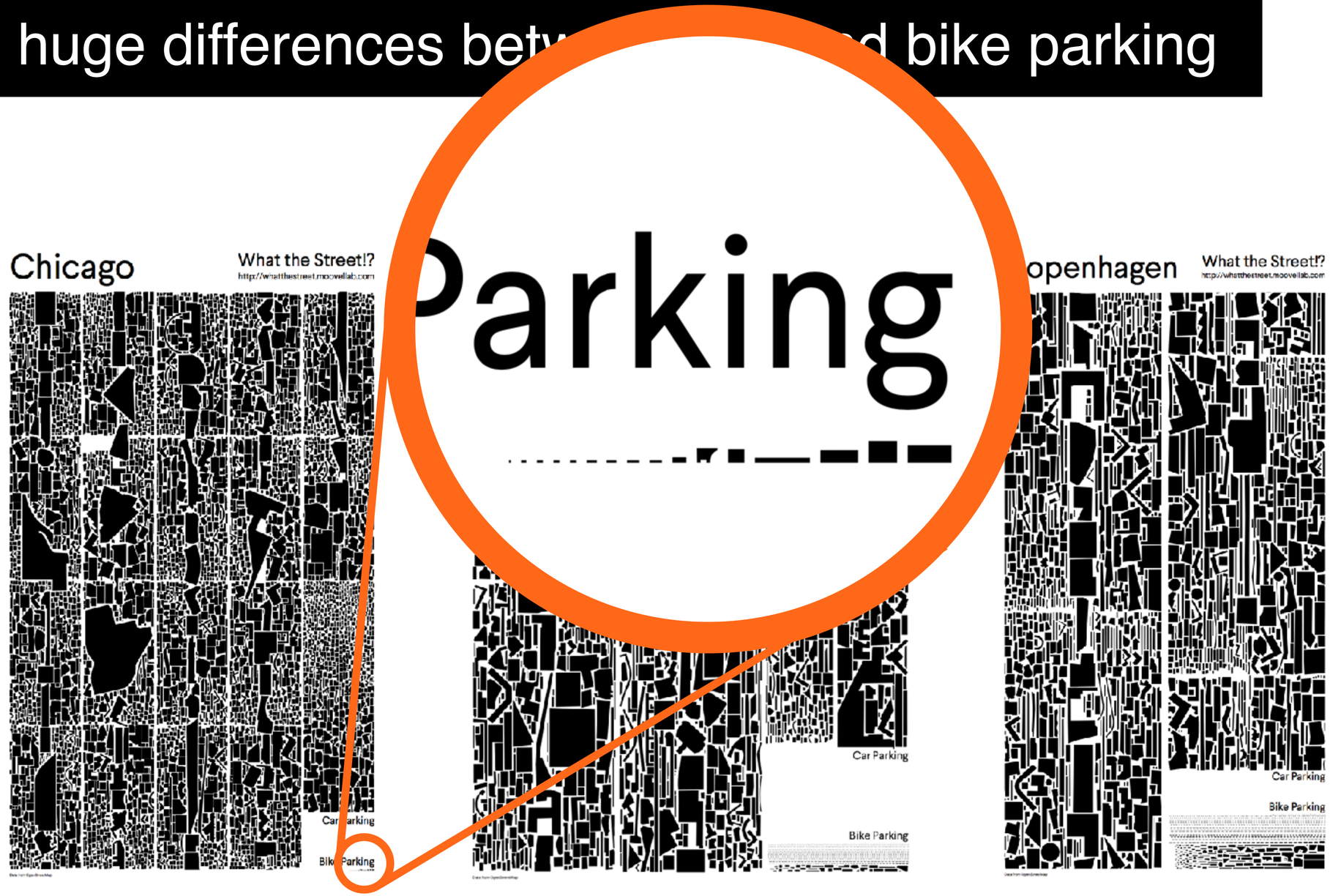




whatthestreet.com

Szell, Urb Plan 3, 1-20 (2018)

There are huge differences bet[illegible]d bike parking



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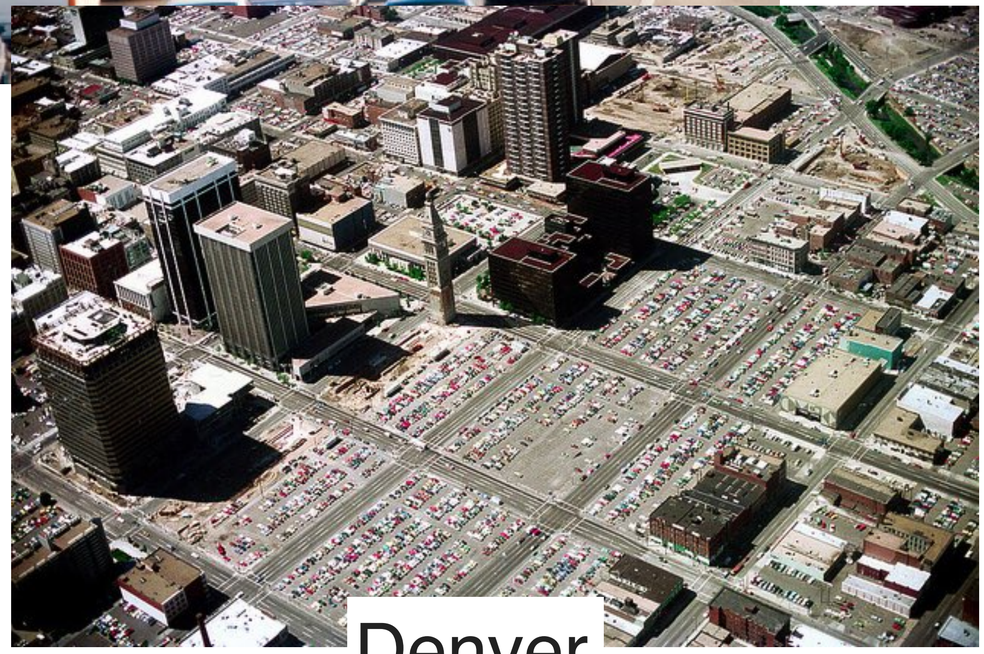
Szell, Urb Plan 3, 1-20 (2018)

Reclaiming parking is key to the livability crisis



Denver

Groningen

E-cars are not THE solution: >50% of particles are from non-exhaust

Jeong, Ryu, & Ra, Env Pol 292 (2022)

E-cars are not THE solution: Replacement takes too long

Home 〉 News 〉 Obsessing over electric cars is impeding the race to net zero: More active travel is essential

Obsessing over electric cars is impeding the race to net zero: More active travel is essential

https://www.ox.ac.uk/news/2021-06-14-obsessing-over-electric-cars-impeding-race-net-zero-more-active-travel-essential

Brand et al, Trans Res D 93 (2021)

Cycling is a time-tested solution that delivers on 11 SDGs

CYCLING DELIVERS ON THE GLOBAL GOALS

Shifting towards a better economy, society, and planet for all

https://unric.org/en/sustainable-development-goals-cycling/

More active travel is also an *economic* "no-brainer"

Cost-benefit analysis in EU that accounts for

- Health
- Environment
- Travel / Congestion

shows:

Gössling et al, Ecol Econ 158 (2019)

More active travel is also an *economic* "no-brainer"

Cost-benefit analysis in EU that accounts for

- Health
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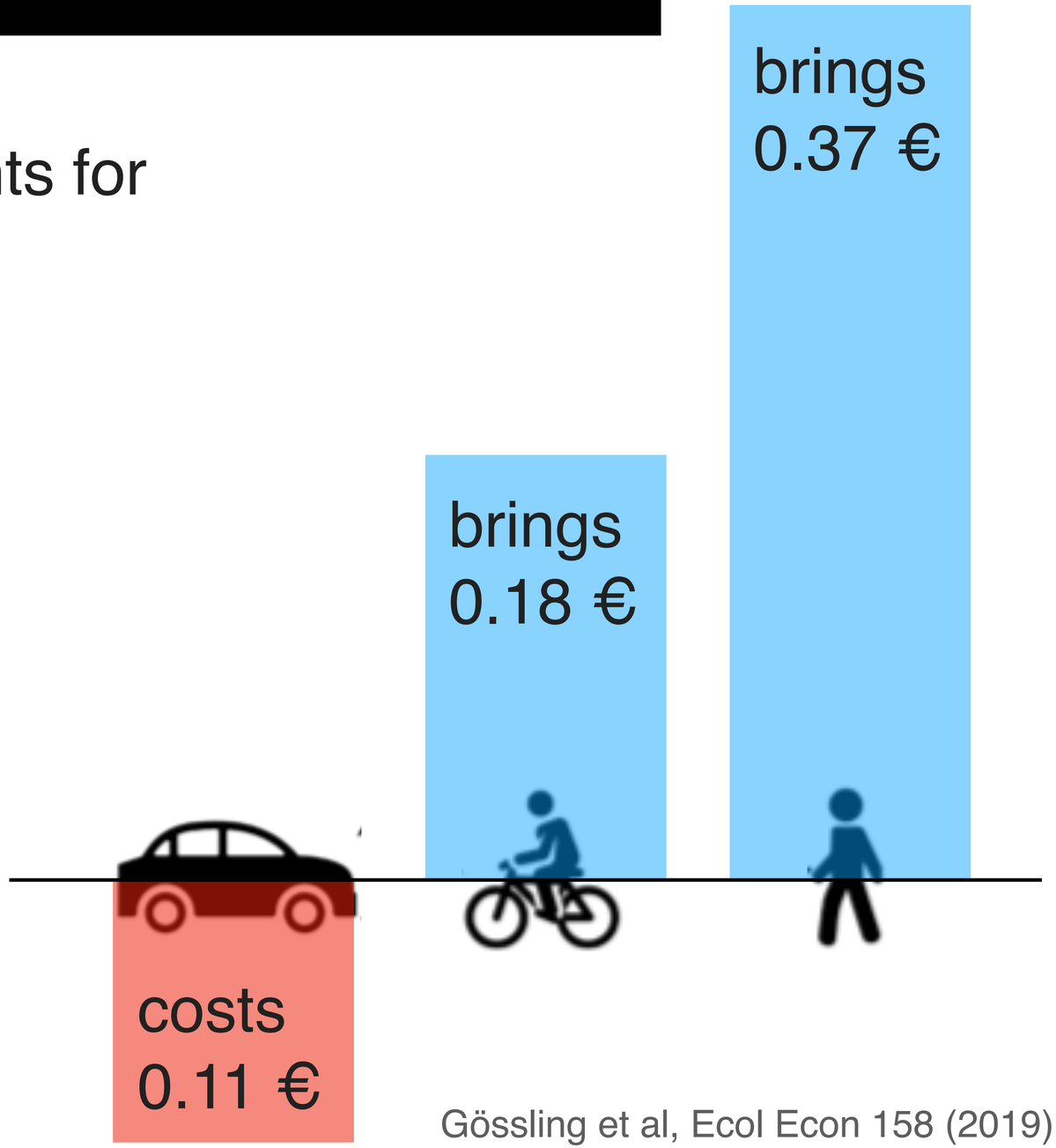
shows: 1 km travelled by



Gössling et al, Ecol Econ 158 (2019)

1.350.000 people
die every year on the road.

Why?

The solution: Set a goal

UNITED NATIONS

3 GOOD HEALTH AND WELL-BEING

3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents

United Nations General Assembly. The 2030 agenda for sustainable development

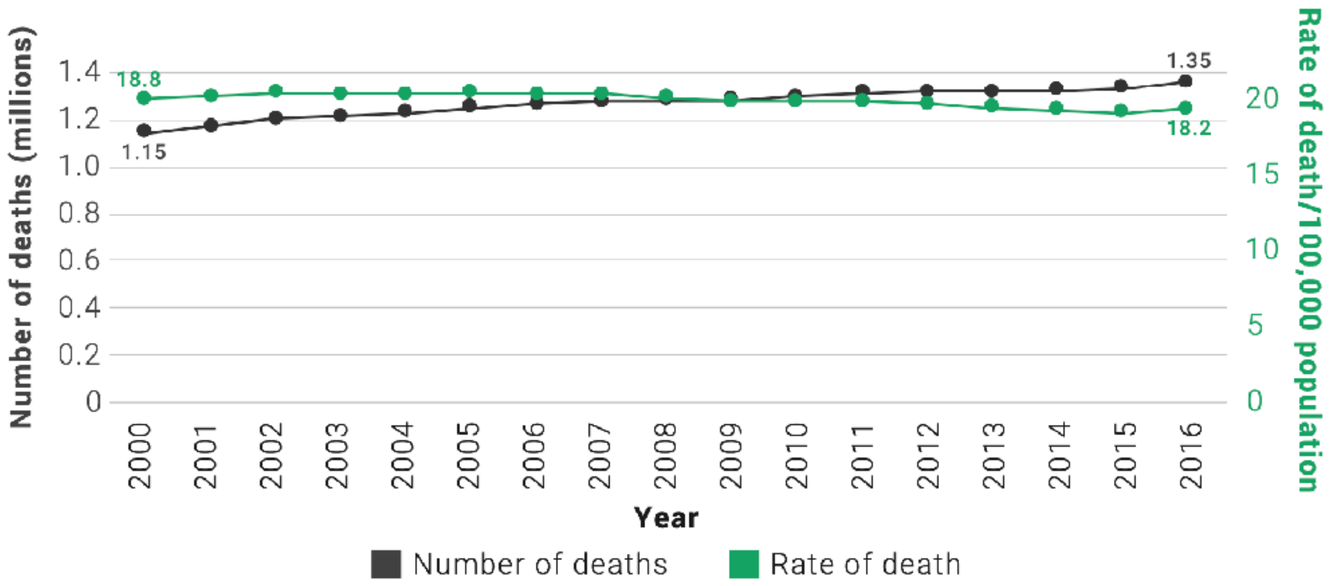
~~The solution: Set a goal~~

UNITED NATIONS

3 GOOD HEALTH AND WELL-BEING

3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents

Unfortunately, global levels stayed the same



WHO Global Status Report on Road Safety 2018

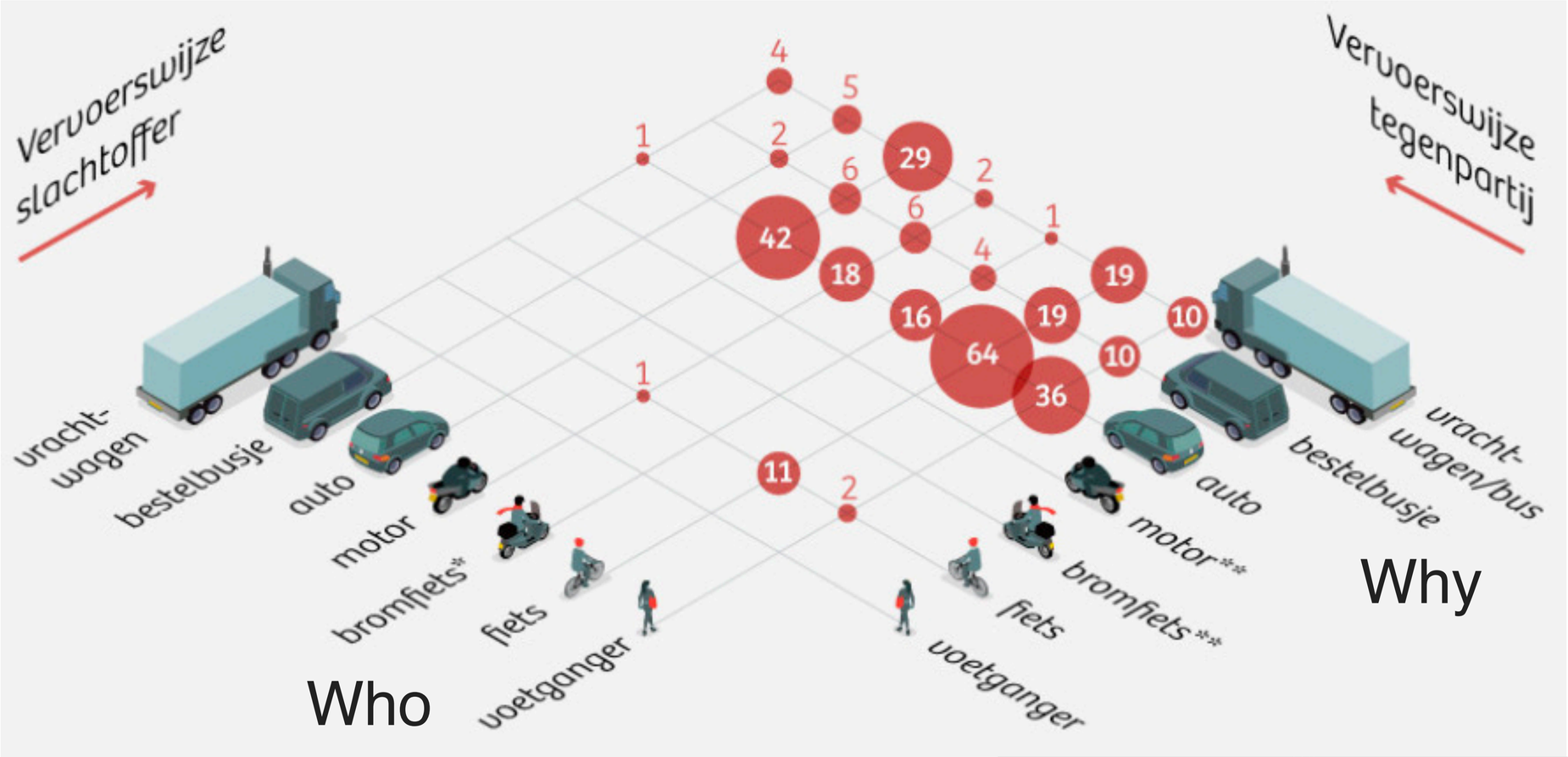
Who is dying and why?

Vulnerable road users disproportionately impacted

Who

WHO Global Status Report on Road Safety 2018

Who is dying and why?



Why Who

Thalia **VERKADE** + *Marco* **TE BRÖMMELSTROET**

Verkade, T., & Te Brömmelstroet, M. (2019). Het grootste taboe in het verkeer: we kunnen elkaar doodrijden. De Correspondent

The OECD recommends:

1) Analyze such casualty matrices

2) Collect data from many cities

3) Investigate relation between urban shape, modal share, and road risk

ITF. Road Safety in European Cities: Performance Indicators and Governance Solutions. OECD Publishing, Paris, 2019

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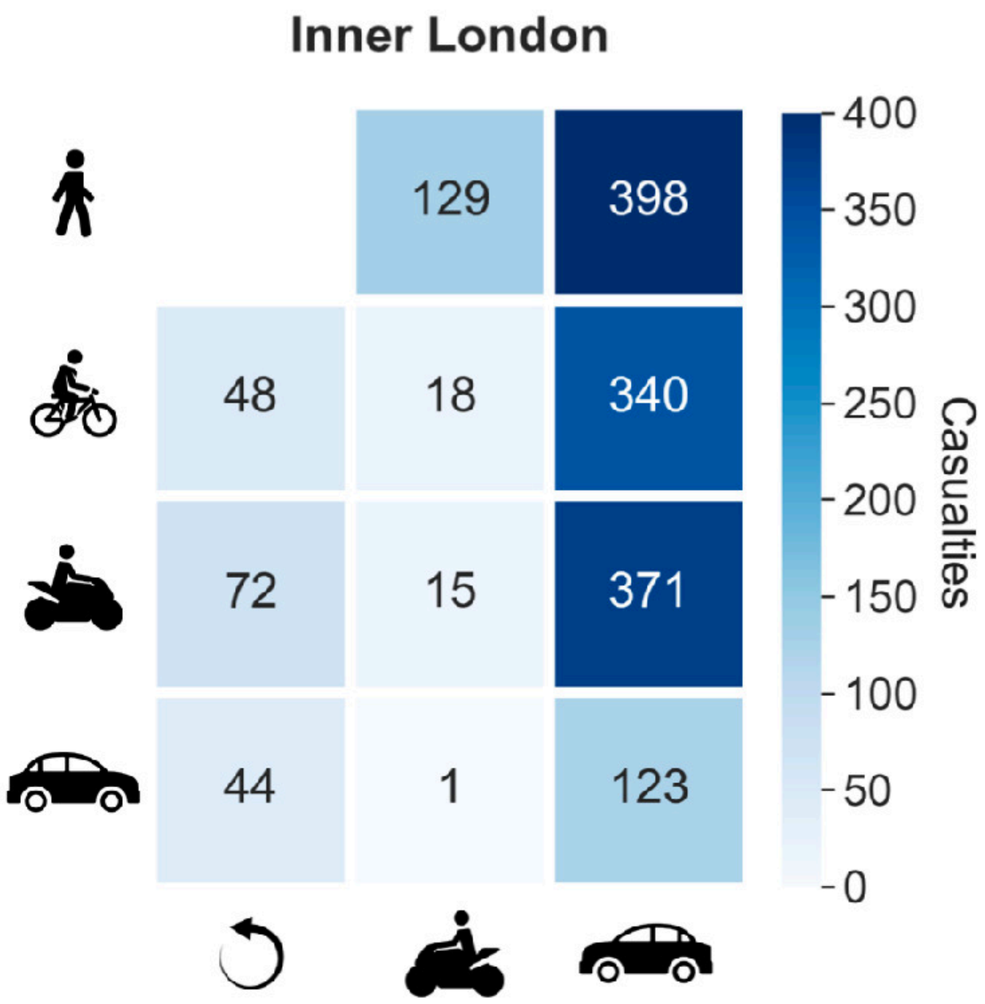
ITF. Road Safety in European Cities: Performance Indicators and Governance Solutions. OECD Publishing, Paris, 2019

We collected data from 24 European cities / 5 countries

Klanjcic et al, socarxiv: http://osf.io/89cyu (2021)

Casualty matrices confirm the deadly role of cars



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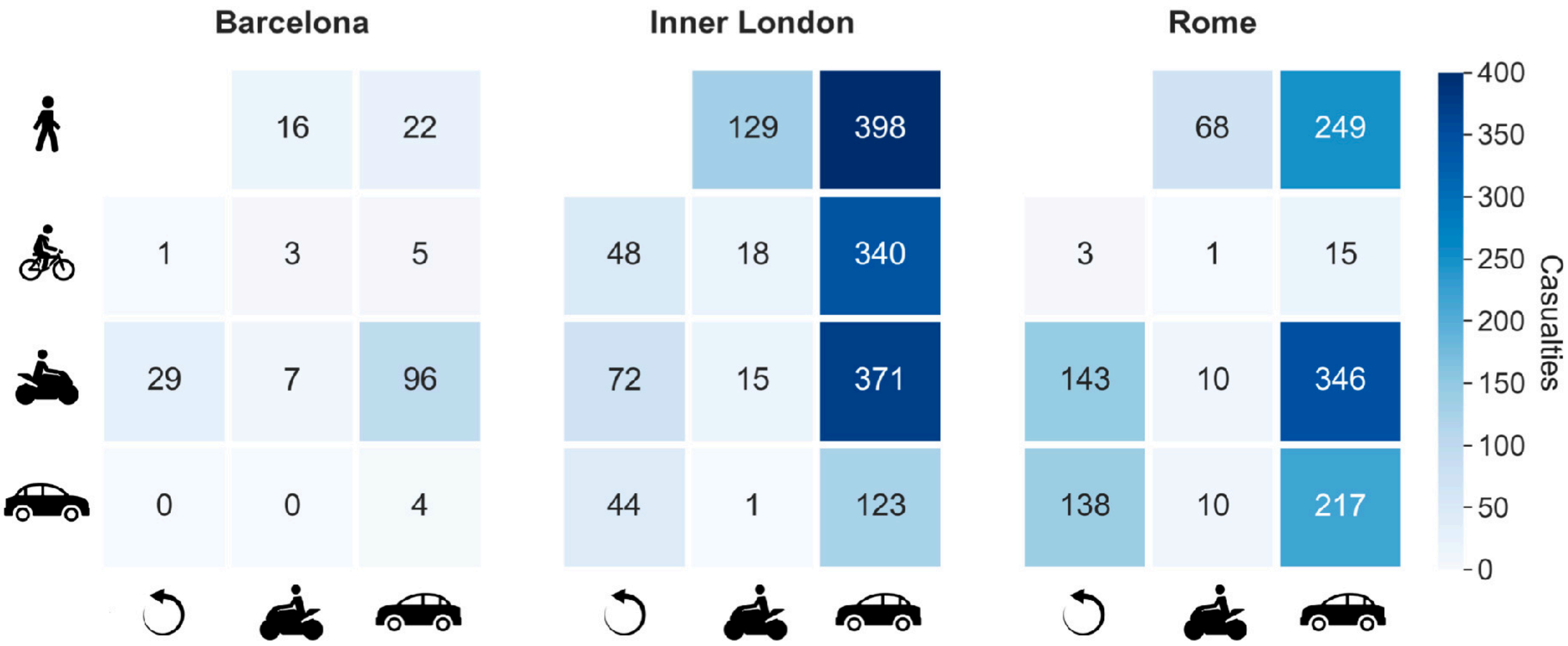


Klanjcic et al, socarxiv: http://osf.io/89cyu (2021)

We collected urban indicators to explore possible causes

OpenStreetMap: Urban indicators

EPOMM
European Platform on Mobility Management

Modal shares of different transport modes

Klanjcic et al, socarxiv: http://osf.io/89cyu (2021)

We built a statistical model using LASSO regression

$$\hat{\beta}_{\text{lasso}}(\alpha) = \text{argmin}_{\beta}||\mathbf{y} - X\beta||_2^2 + \alpha||\beta||_1$$

Predictors:

area share

area share

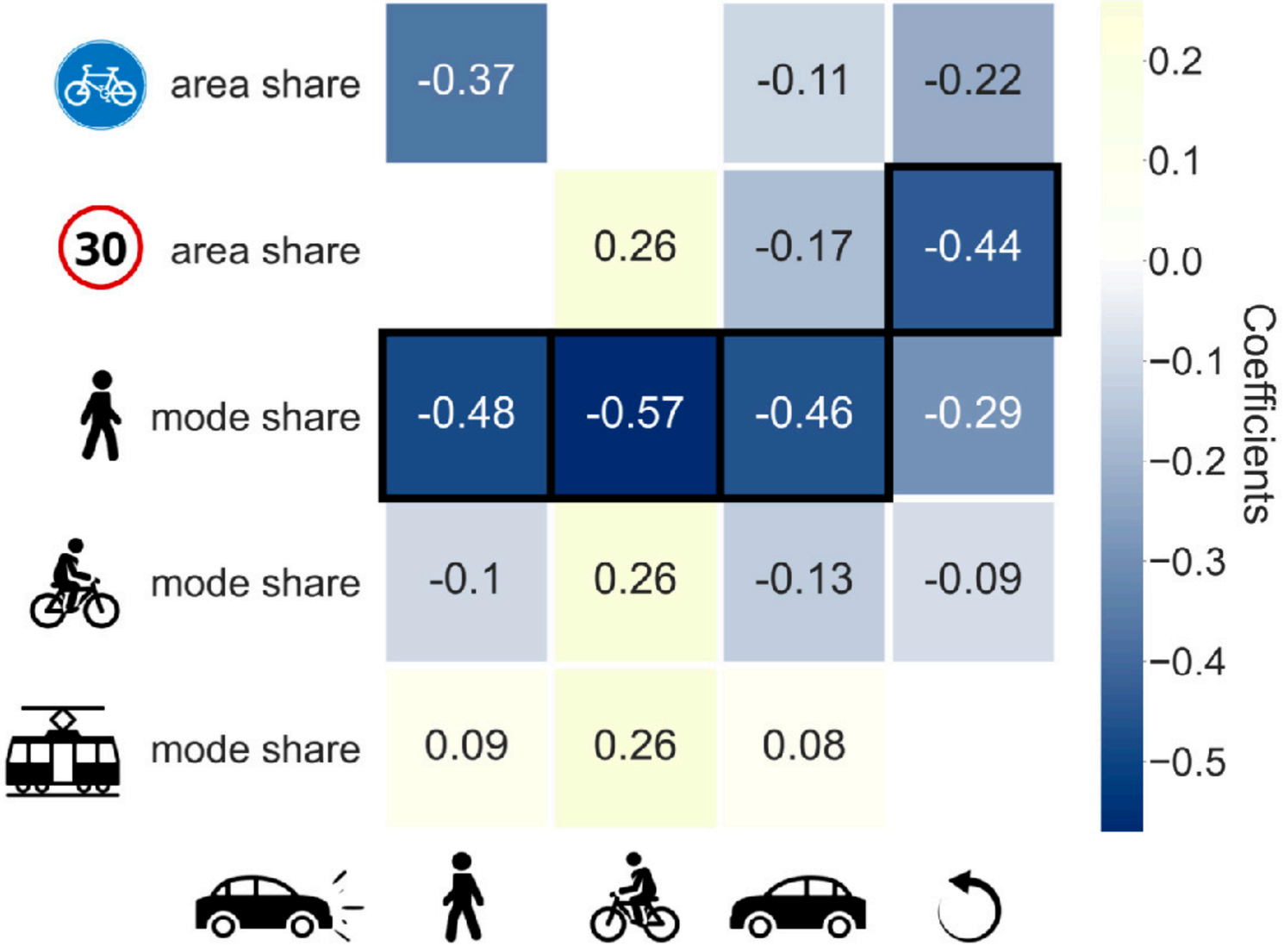
mode share

mode share

mode share

Klanjcic et al, socarxiv: http://osf.io/89cyu (2021)

More walking = Safer cities for all!



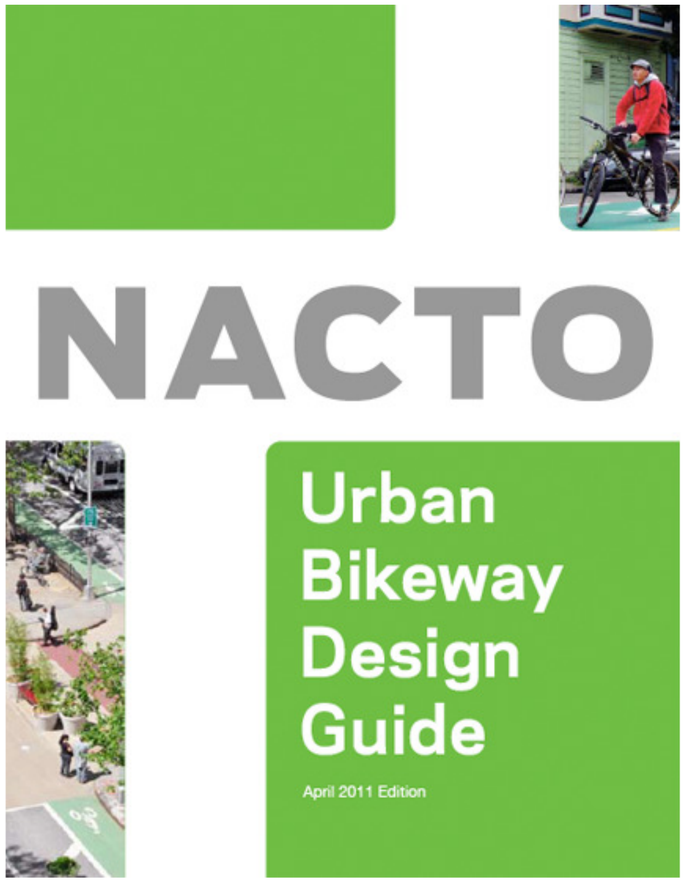
Klanjcic et al, socarxiv: http://osf.io/89cyu (2021)

More active travel is crucial to make cities better.

How to build bicycle infrastructure?

How to build bicycle infrastructure?

We have great planning guides.



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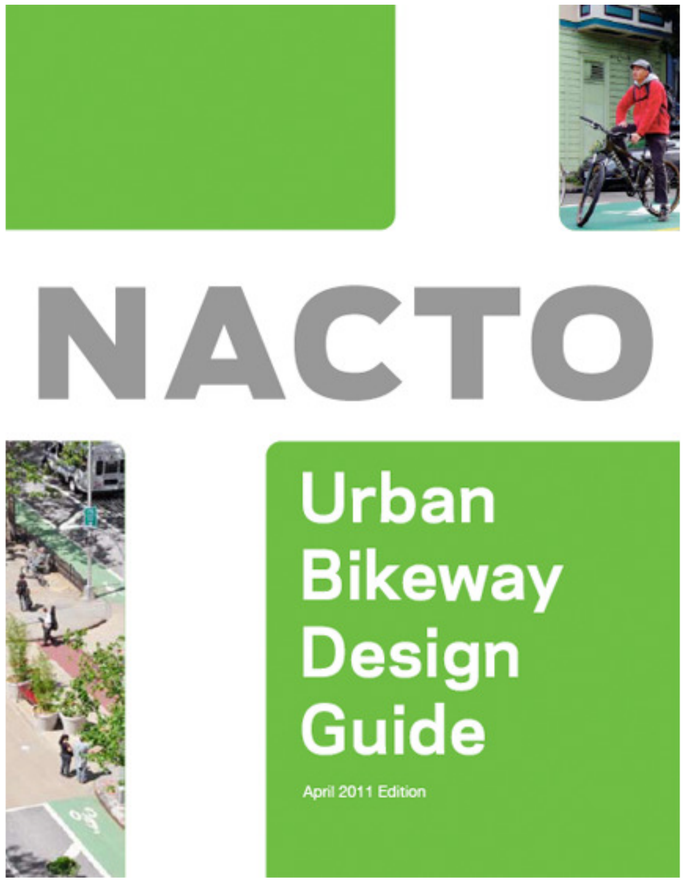
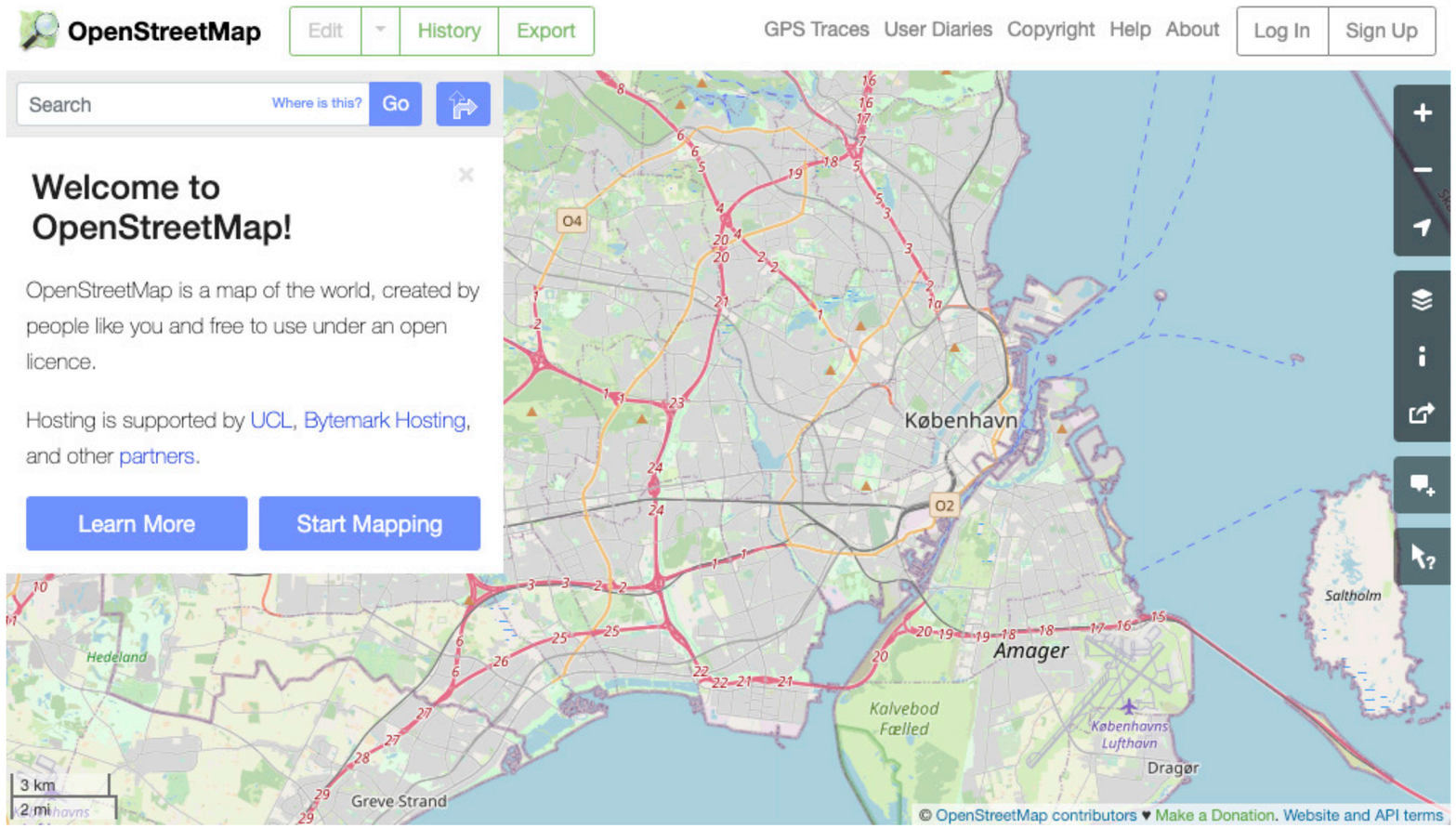


But no knowledge:

- on the fundamental topological limitations of network growth
- or on how hard/easy it is to fix existing networks

All our research builds on OpenStreetMap (OSM)



OSM data are quite reliable in western countries

Haklay et al, Cart J 47 (2010)

Barrington-Leigh & Millard-Ball, PLOS ONE 12, (2017)

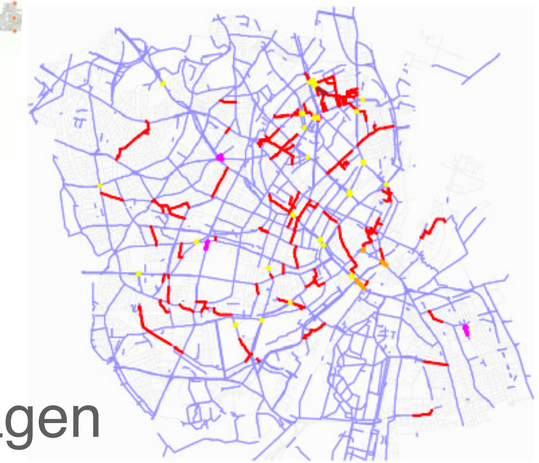
1) Connecting bicycle networks

Budapest

2) Growing bicycle networks

Los Angeles

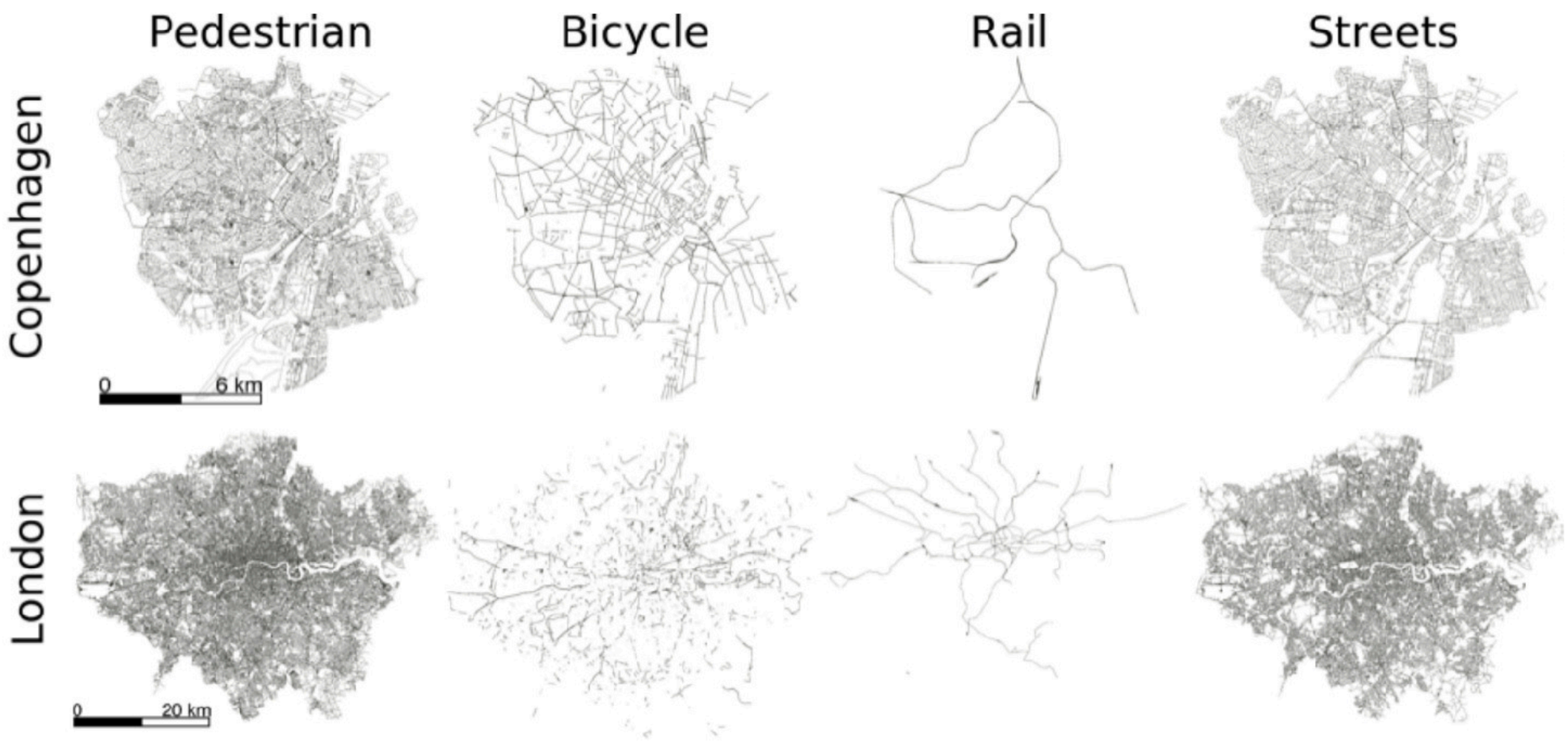
3) Repairing bicycle networks



Copenhagen

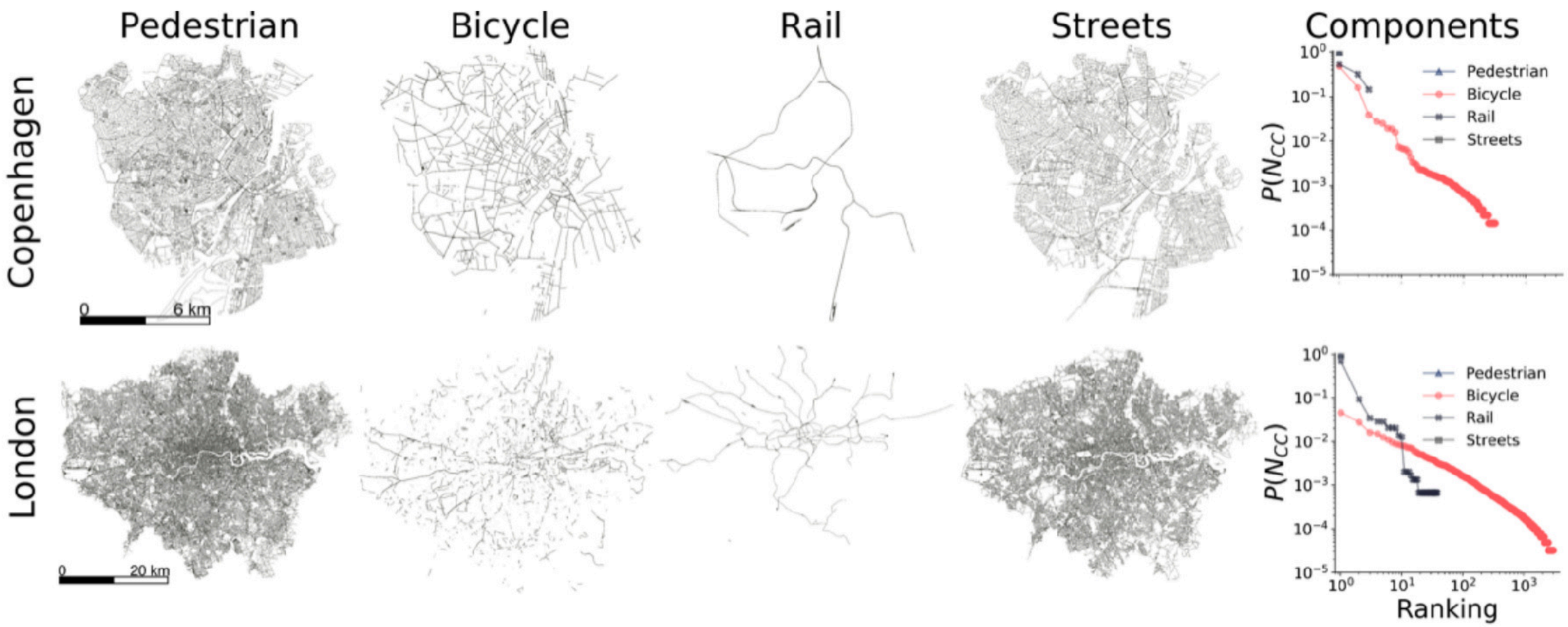
1) Connecting bicycle networks

Cities have different transport network layers



Natera Oroczo et al, R Soc Open Sci 7 (2020)

Bicycle networks are highly fragmented



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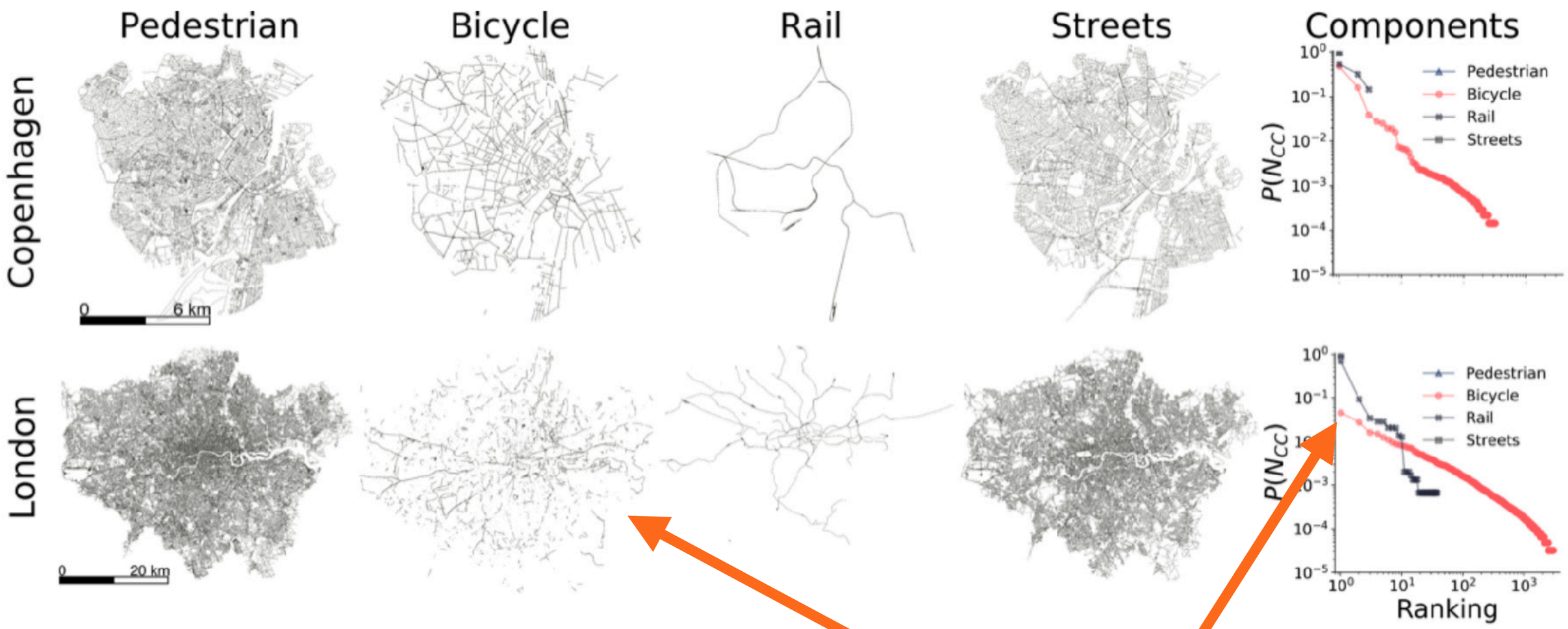
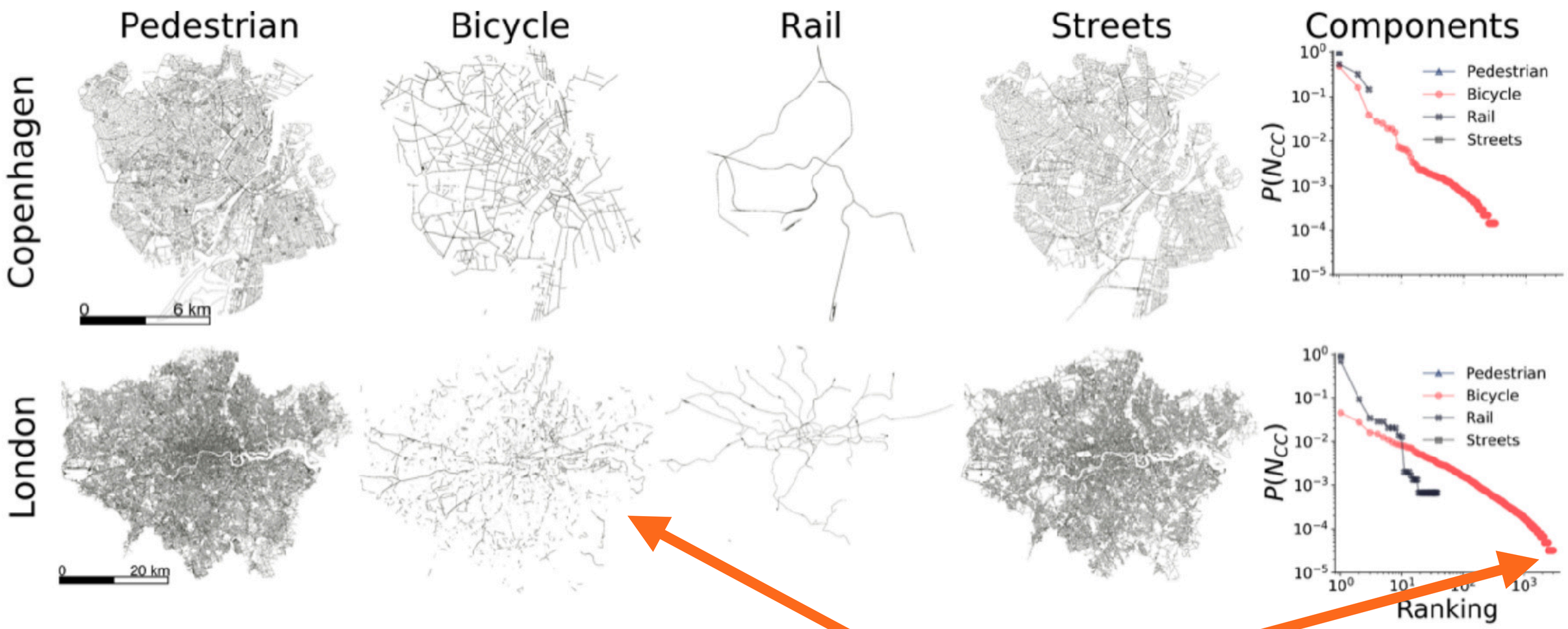


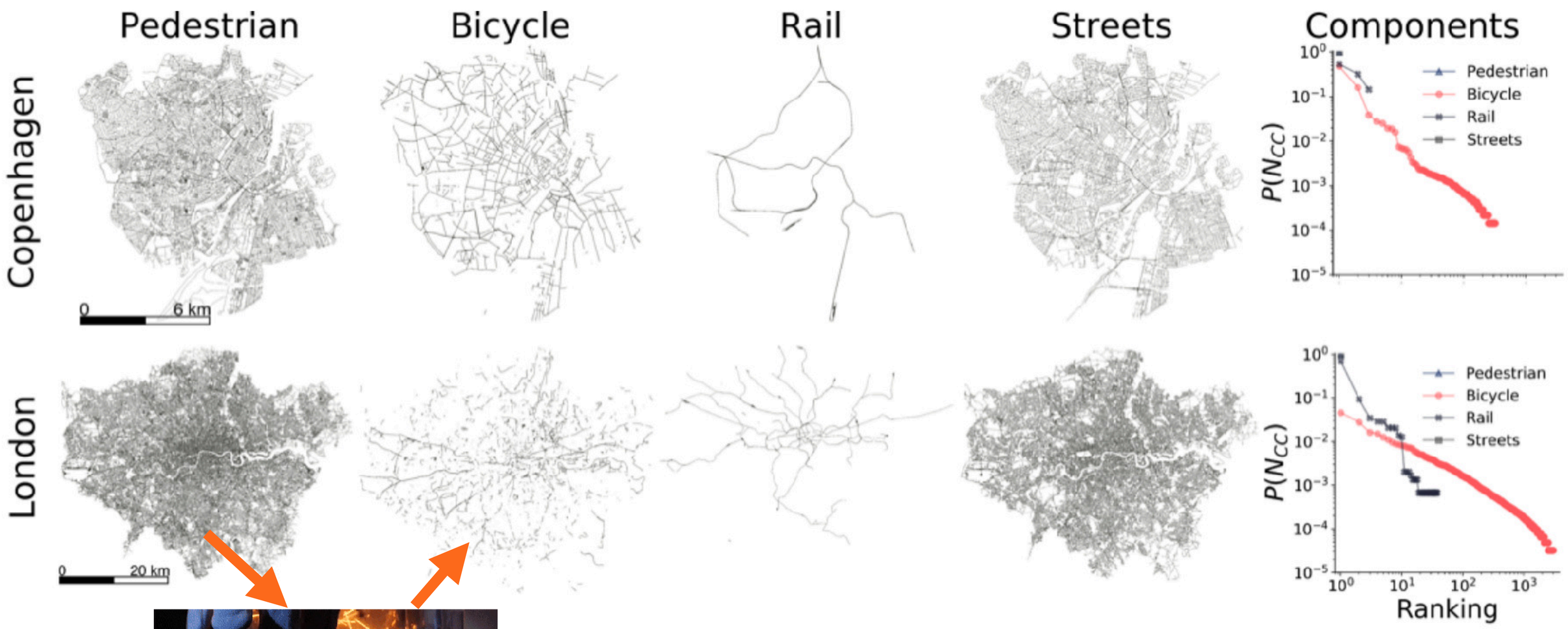
1) In London, the largest connected bicycle component covers only 5% of nodes

Bicycle networks are highly fragmented



2) In London, the bicycle network has >3000 disconnected components

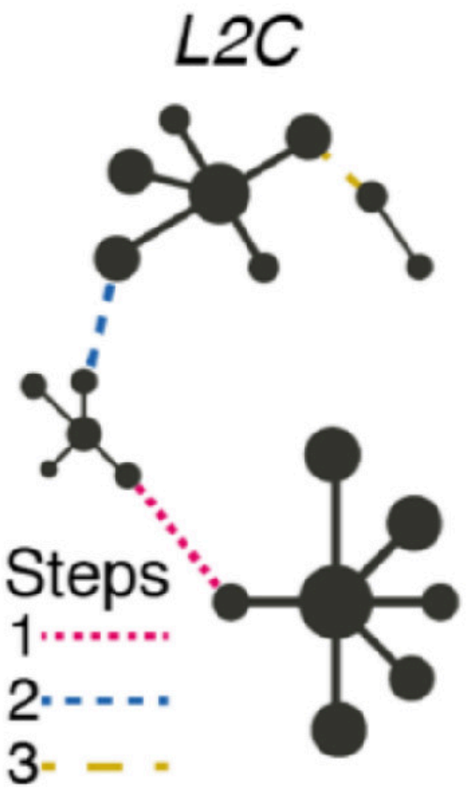
Bicycle networks are highly fragmented



Natera Oroczo et al, R Soc Open Sci 7 (2020)

How should we connect the components?

Largest to closest



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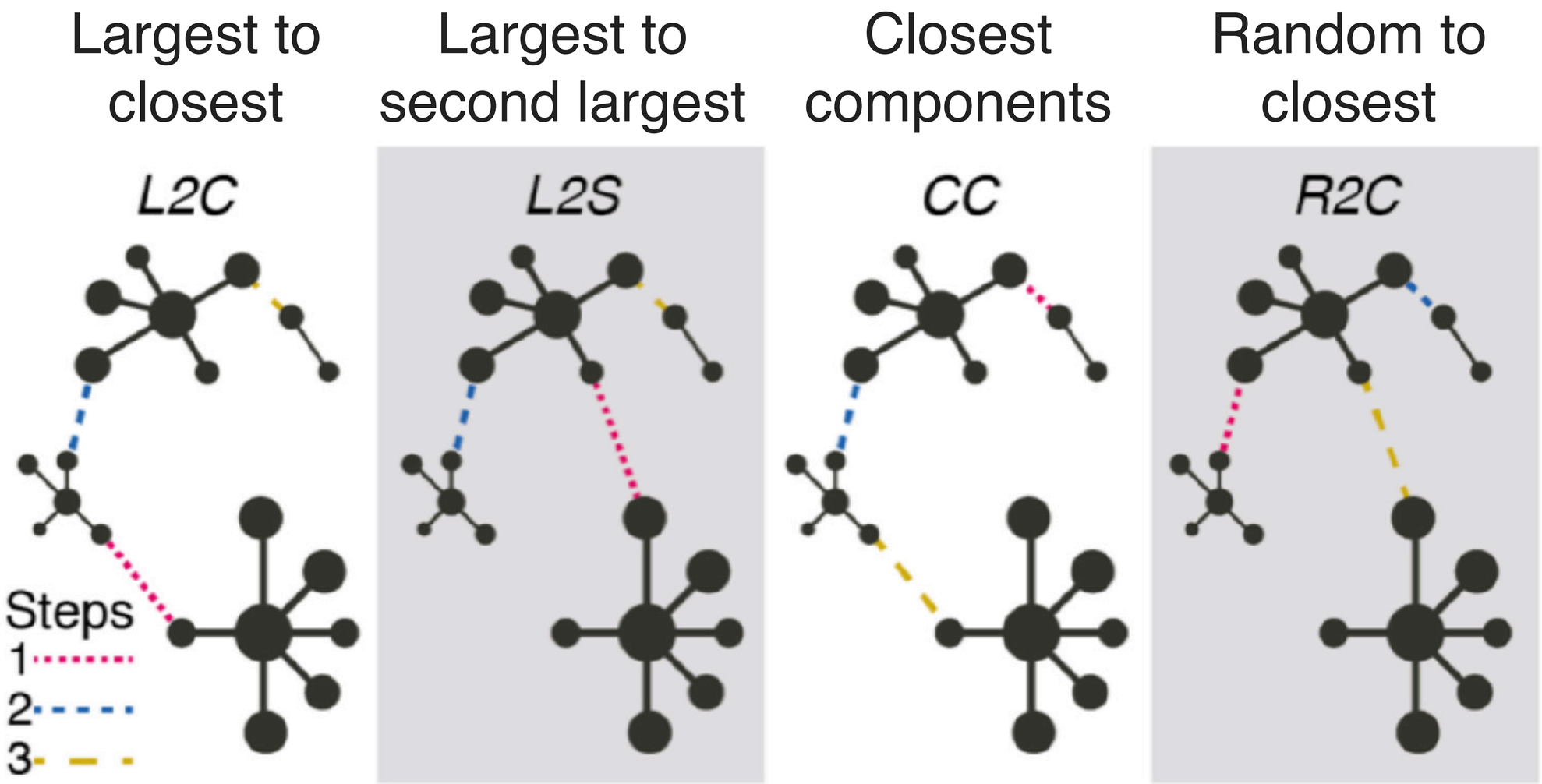
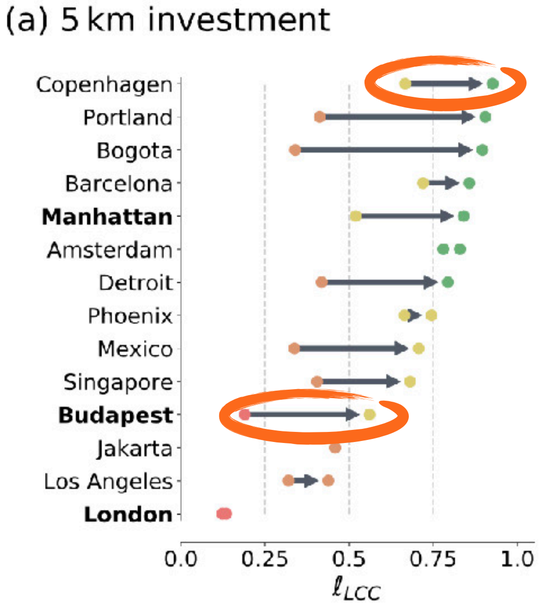
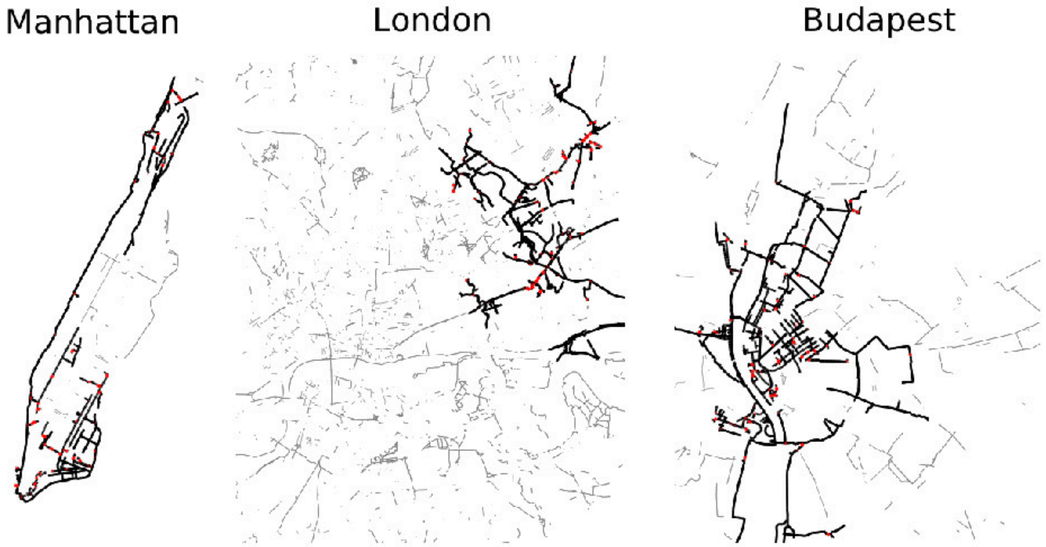


Natera Oroczo et al, R Soc Open Sci 7 (2020)

Effective connectivity improvements are possible

Small but focused investments connect the bicycle network effectively



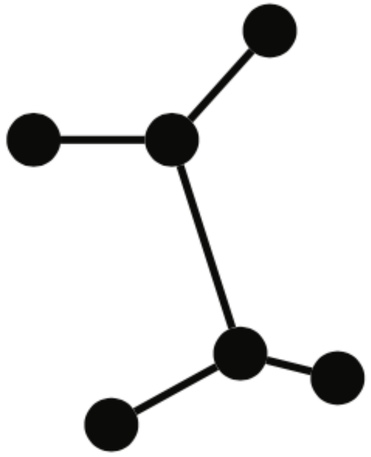


Natera Oroczo et al, R Soc Open Sci 7 (2020)

Just connecting components comes with 3 issues

1) No resilience

Minimum spanning tree



Investor's optimum

Just connecting components comes with 3 issues

1) No resilience

2) Develops only developed areas

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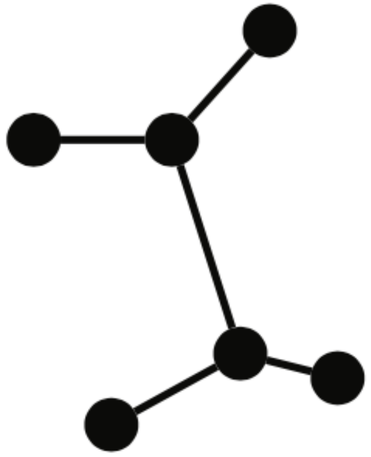

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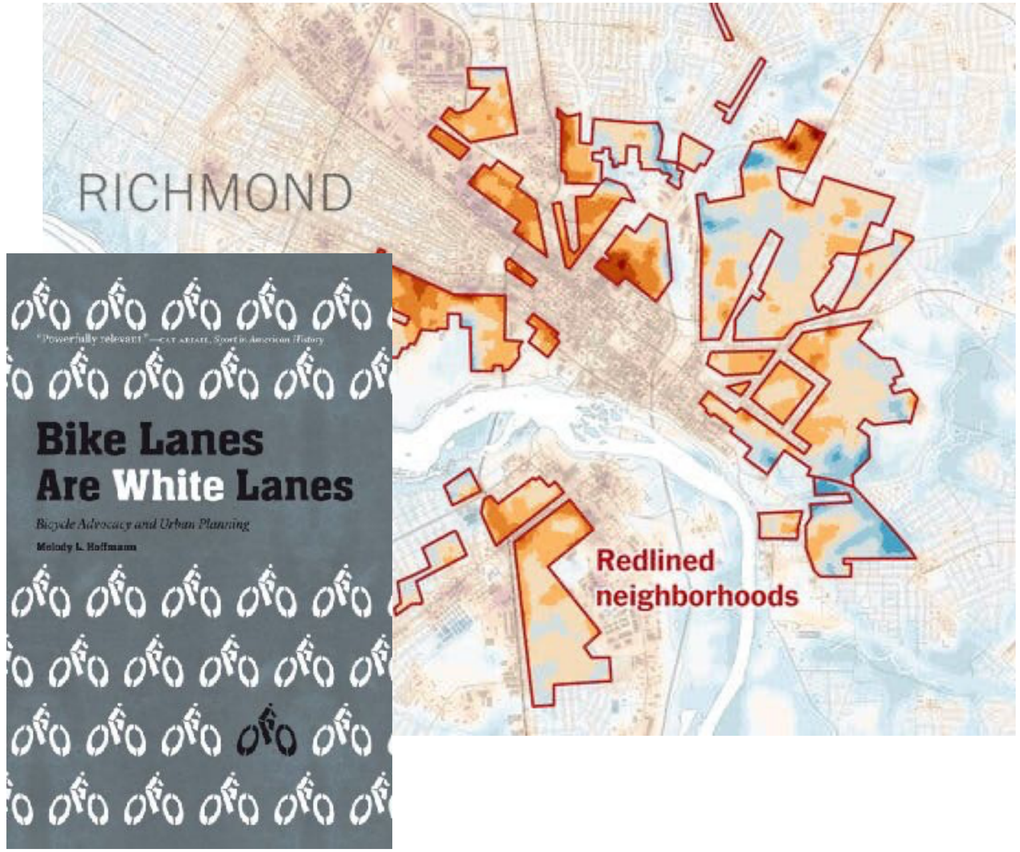

Pereira, Schwanen & Banister, Trans Rev 37 (2017)

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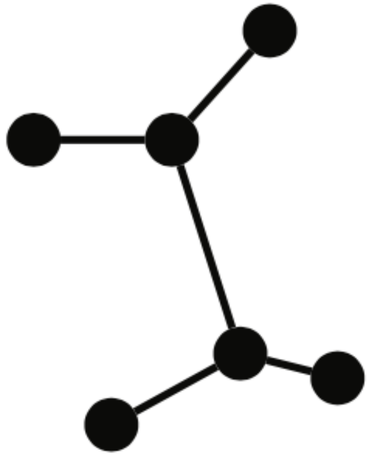

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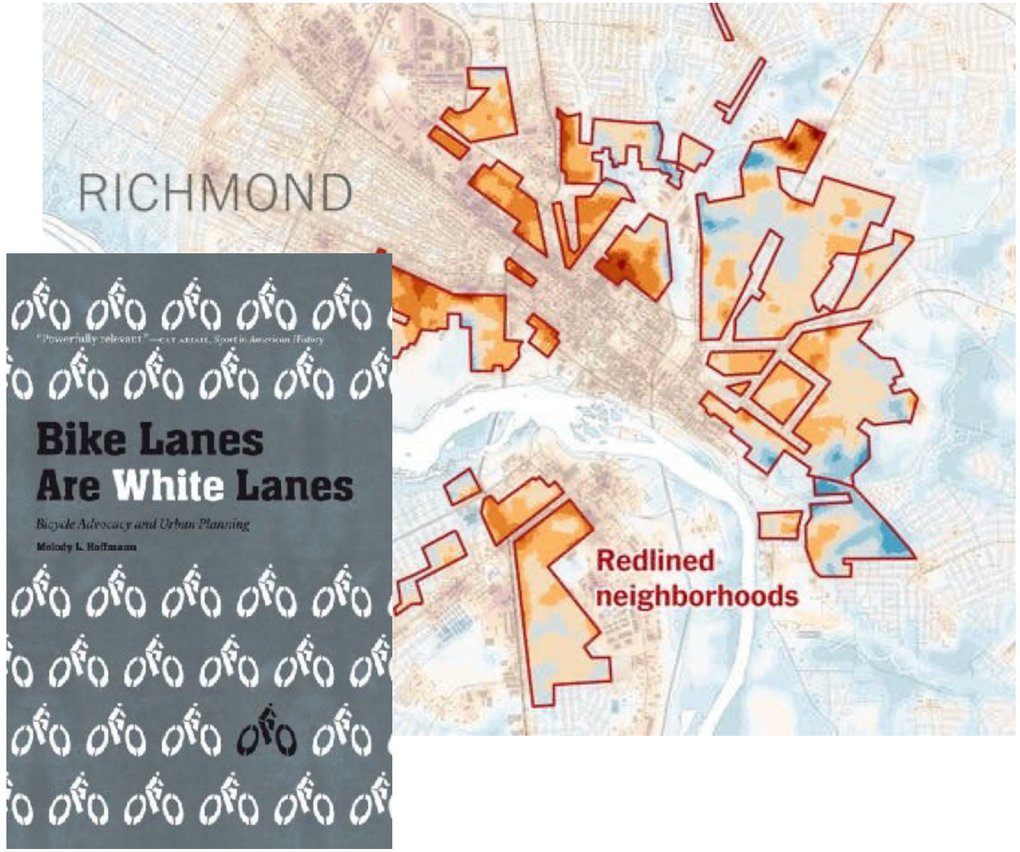
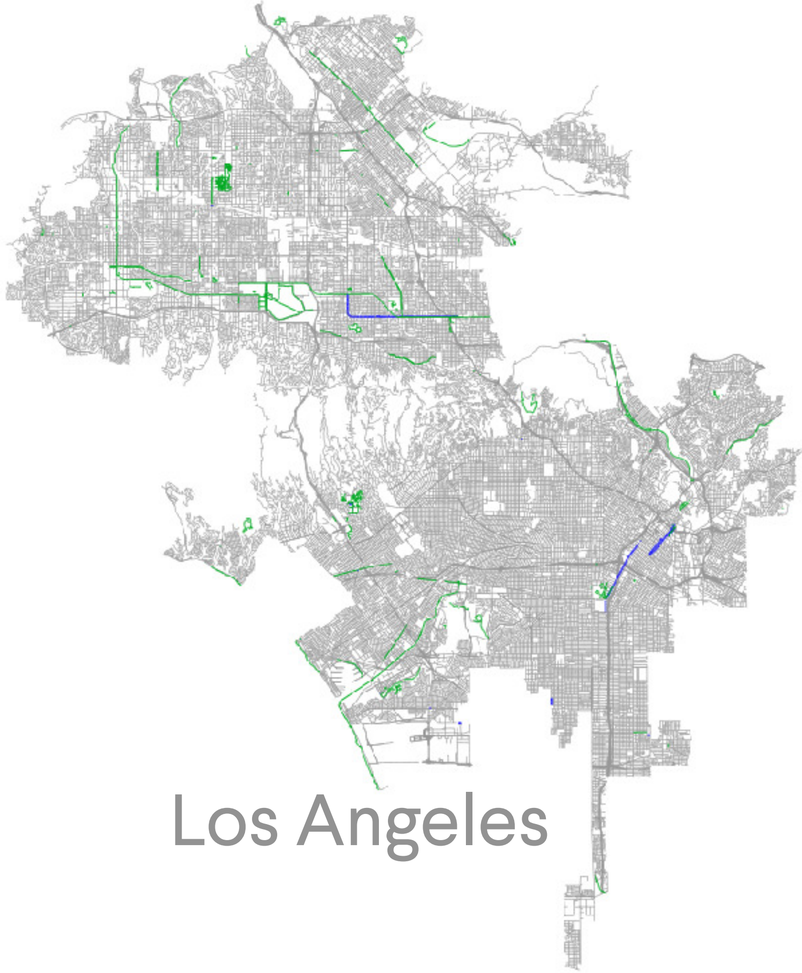


3) Irrelevant for >99% of cities on the planet

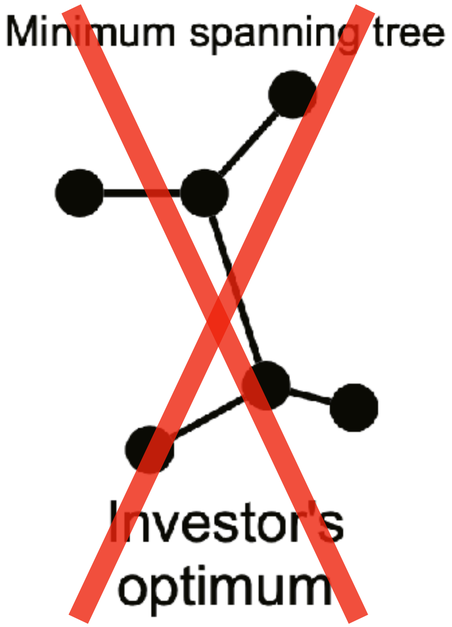


Let's grow networks
from scratch

2) Growing bicycle networks

Inspired by CROW, we want a cohesive network

Connectedness & Resilience



Szell et al., arxiv:2107.02185 (2021)

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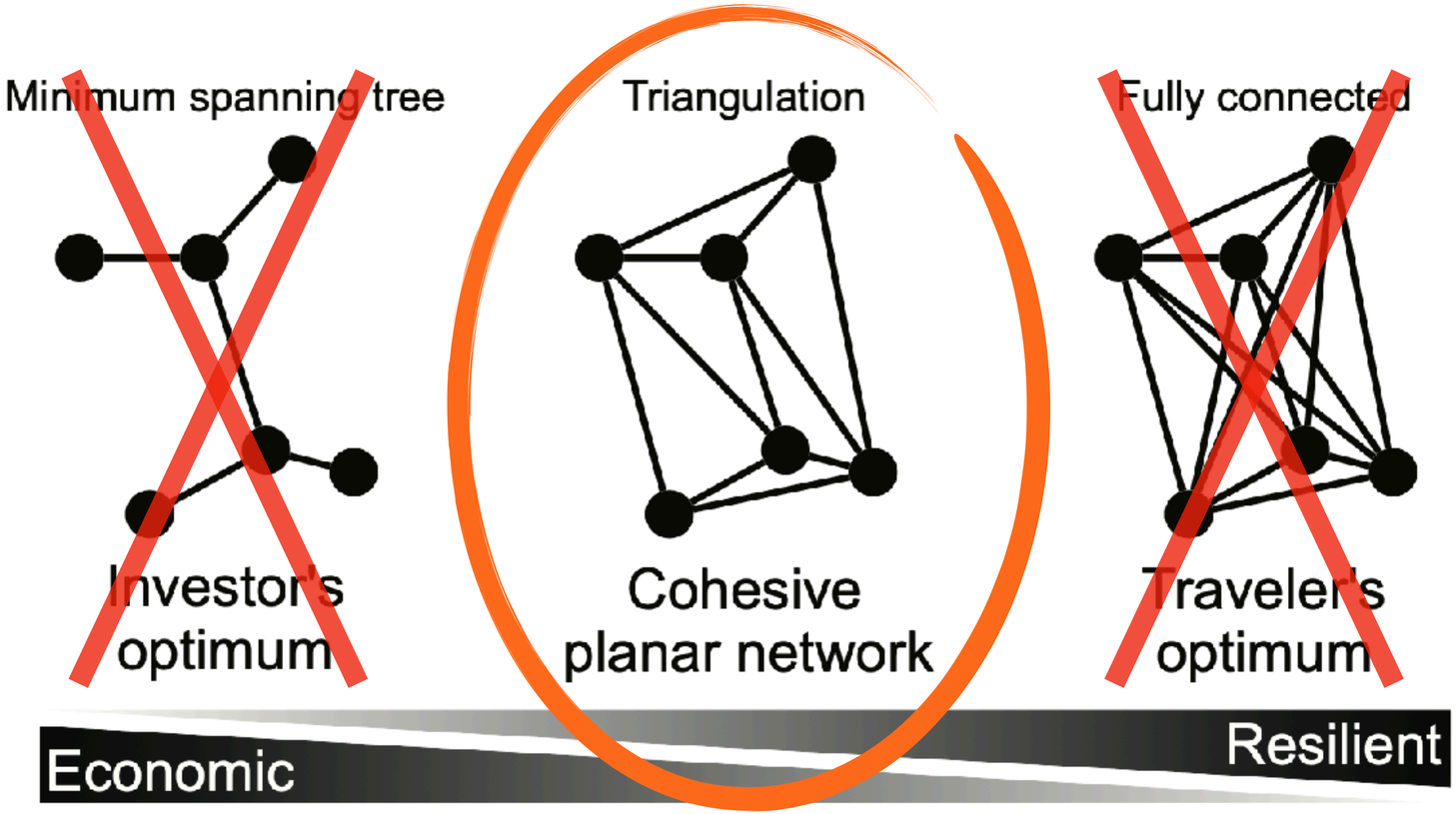
Connectedness & Resilience



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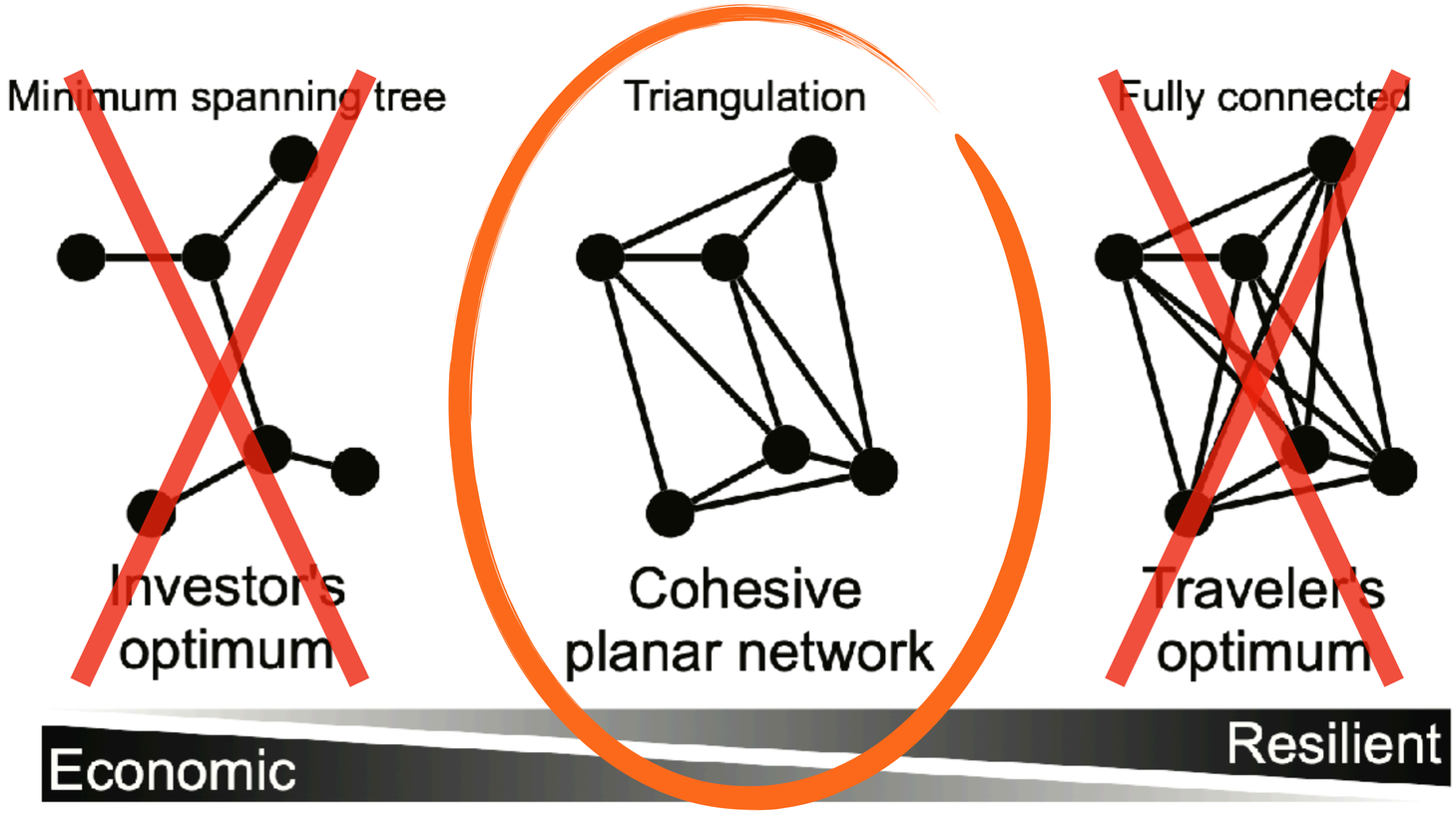
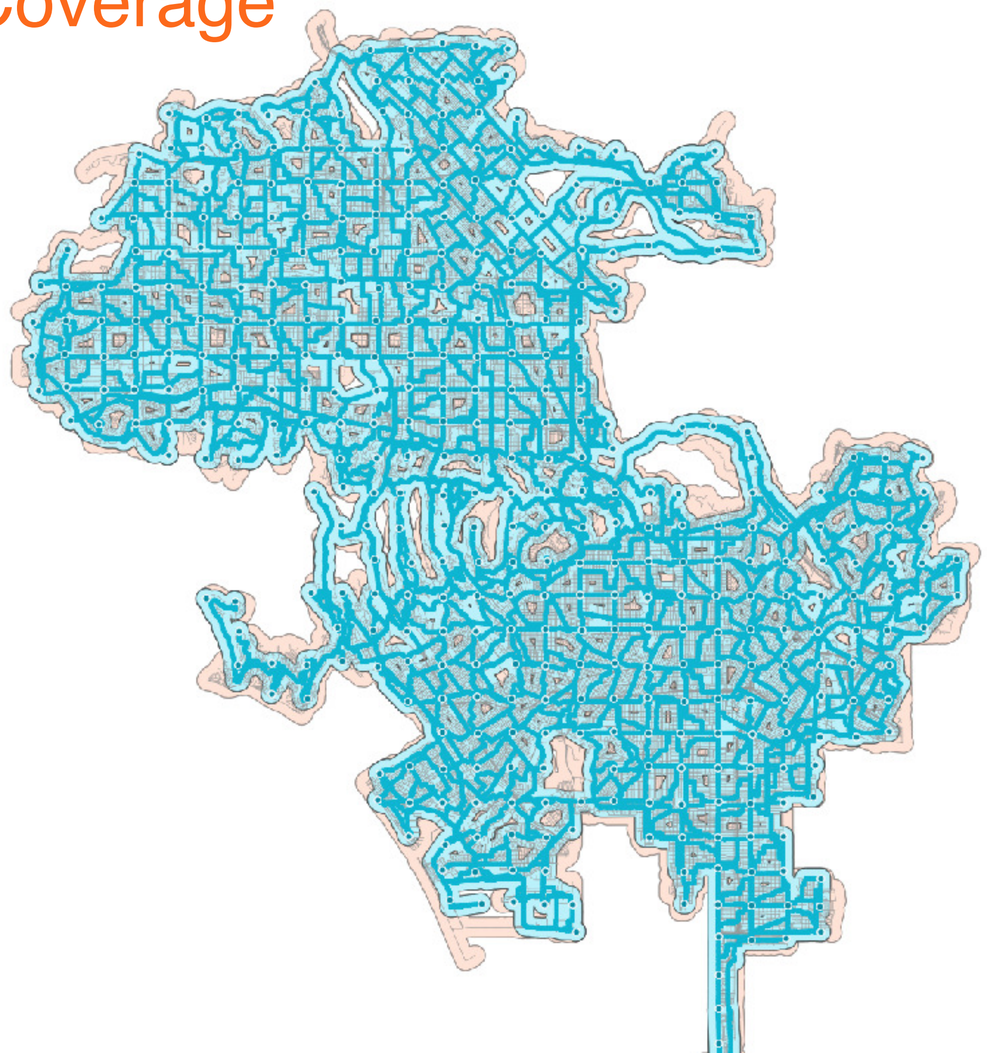
Inspired by CROW, we want a cohesive network

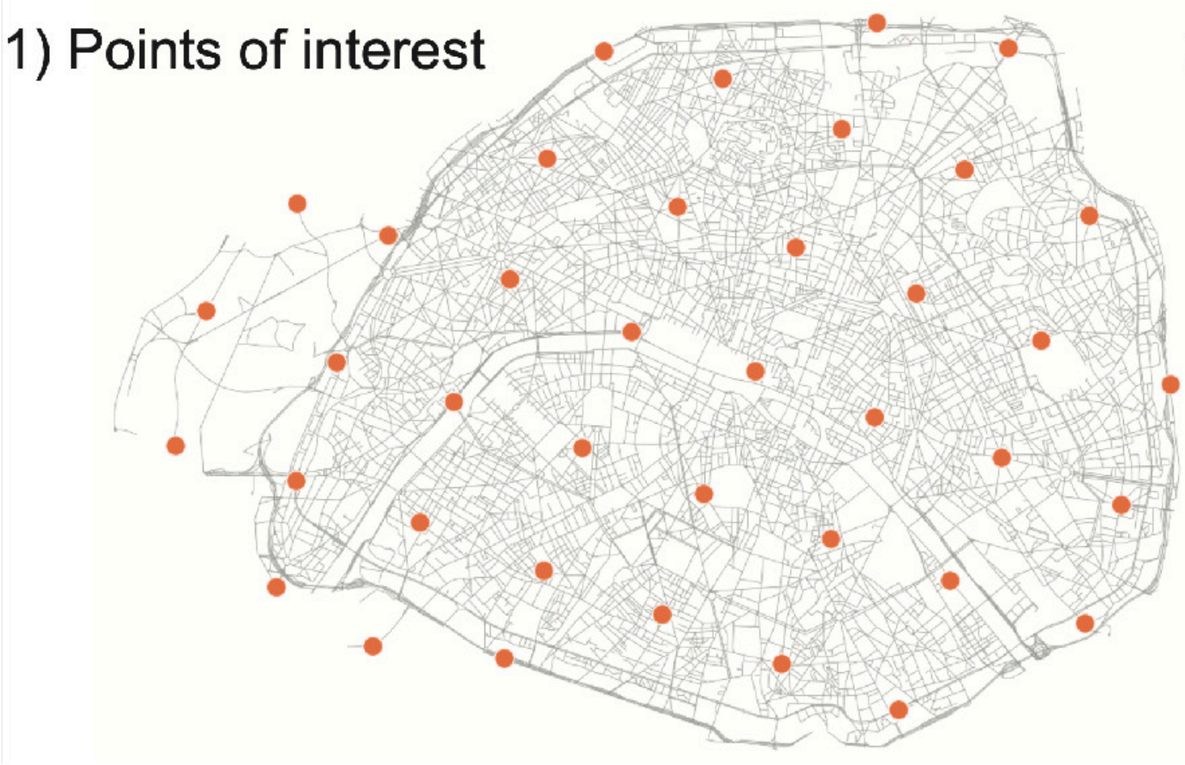
Connectedness & Resilience

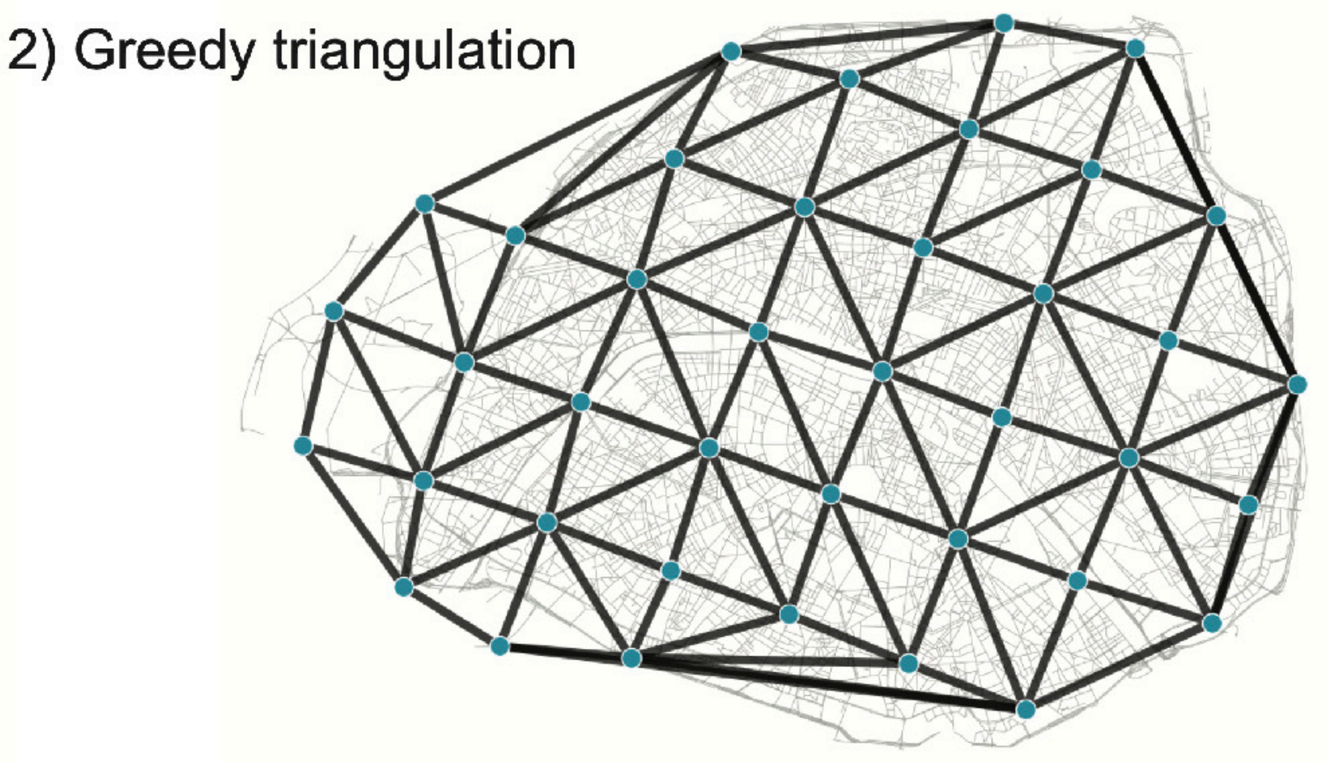
& Coverage





We build a greedy triangulation between points of interest

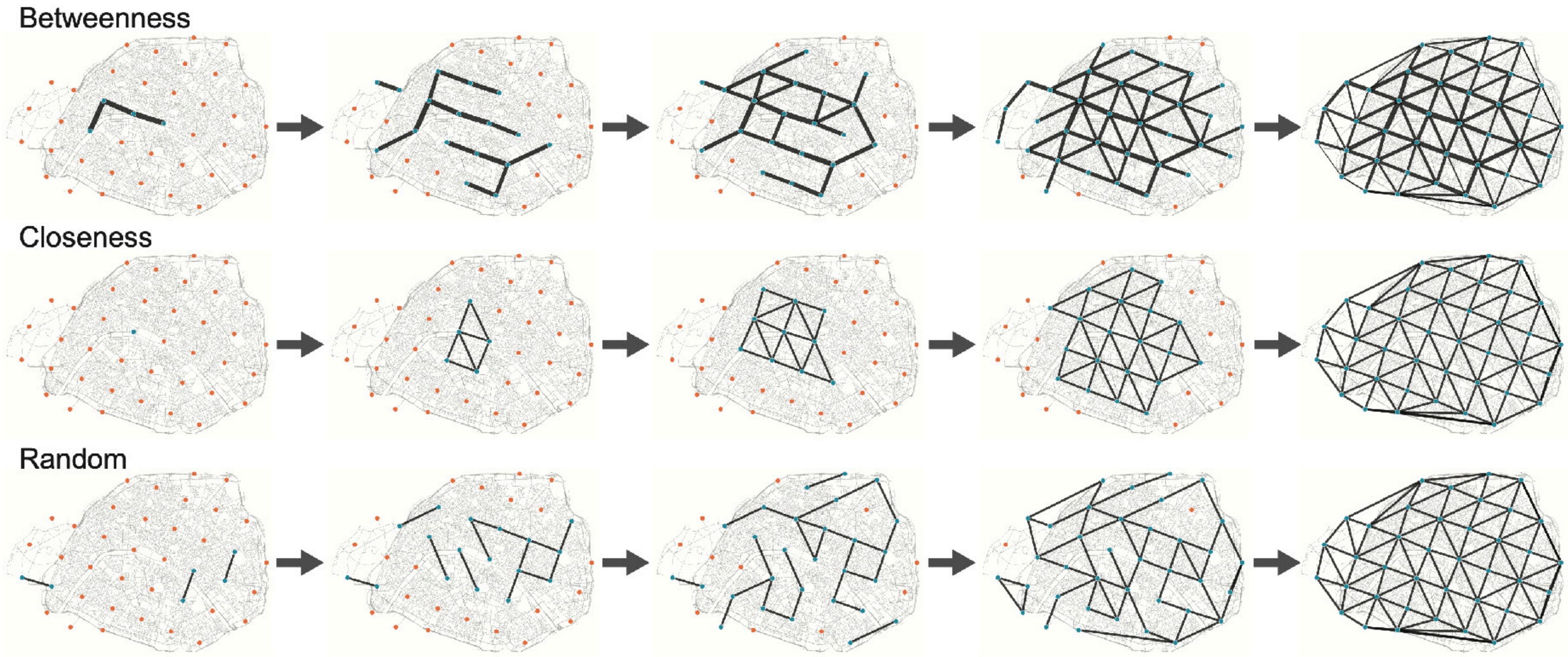




Szell et al., arxiv:2107.02185 (2021)

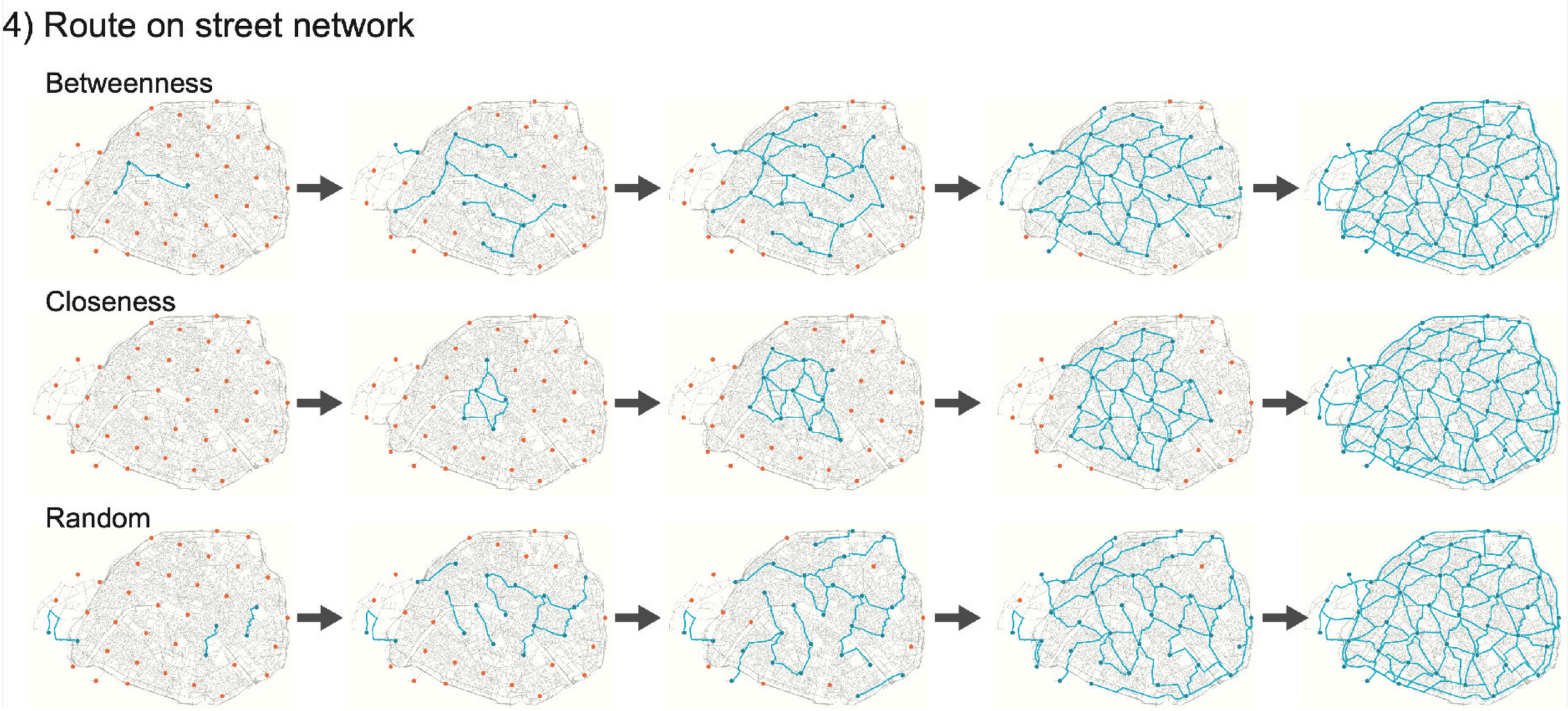
We build a greedy triangulation between points of interest

3) Order by growth strategy



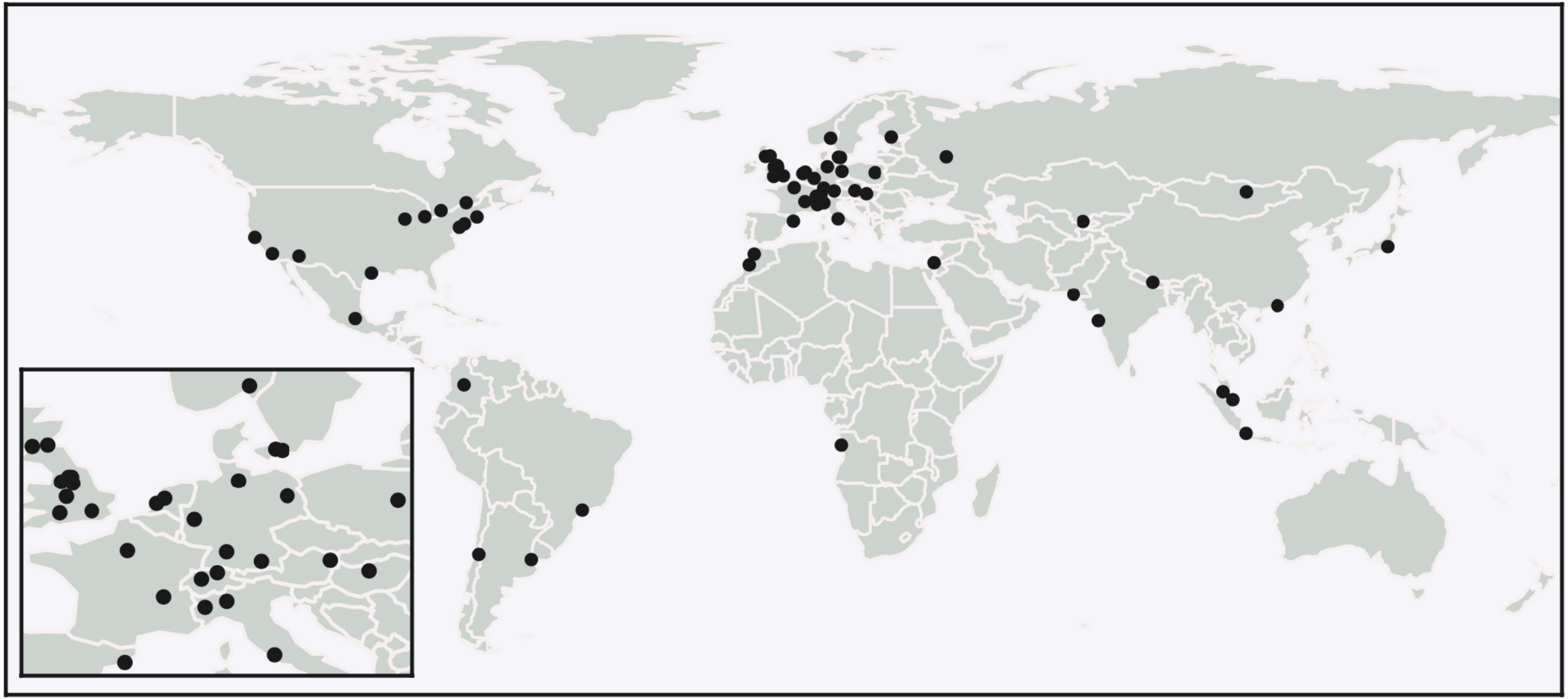
Szell et al., arxiv:2107.02185 (2021)

We build a greedy triangulation between points of interest



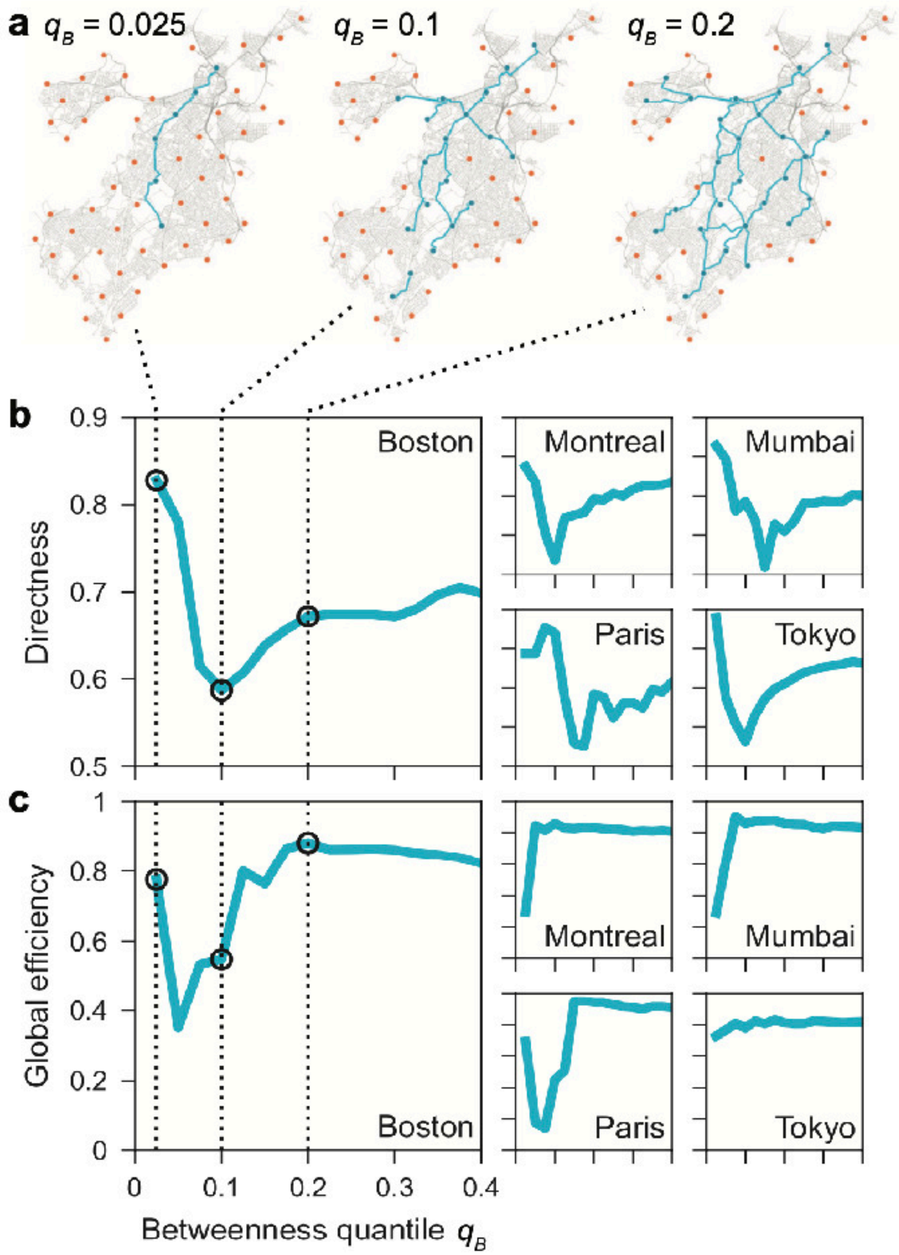
Szell et al., arxiv:2107.02185 (2021)

We explore 62 cities



Szell et al., arxiv:2107.02185 (2021)

Result 1: First there is decreasing return of investment!



The pieces need to connect and to form cycles

Szell et al., arxiv:2107.02185 (2021)

Policy implication 1: Invest persistently!

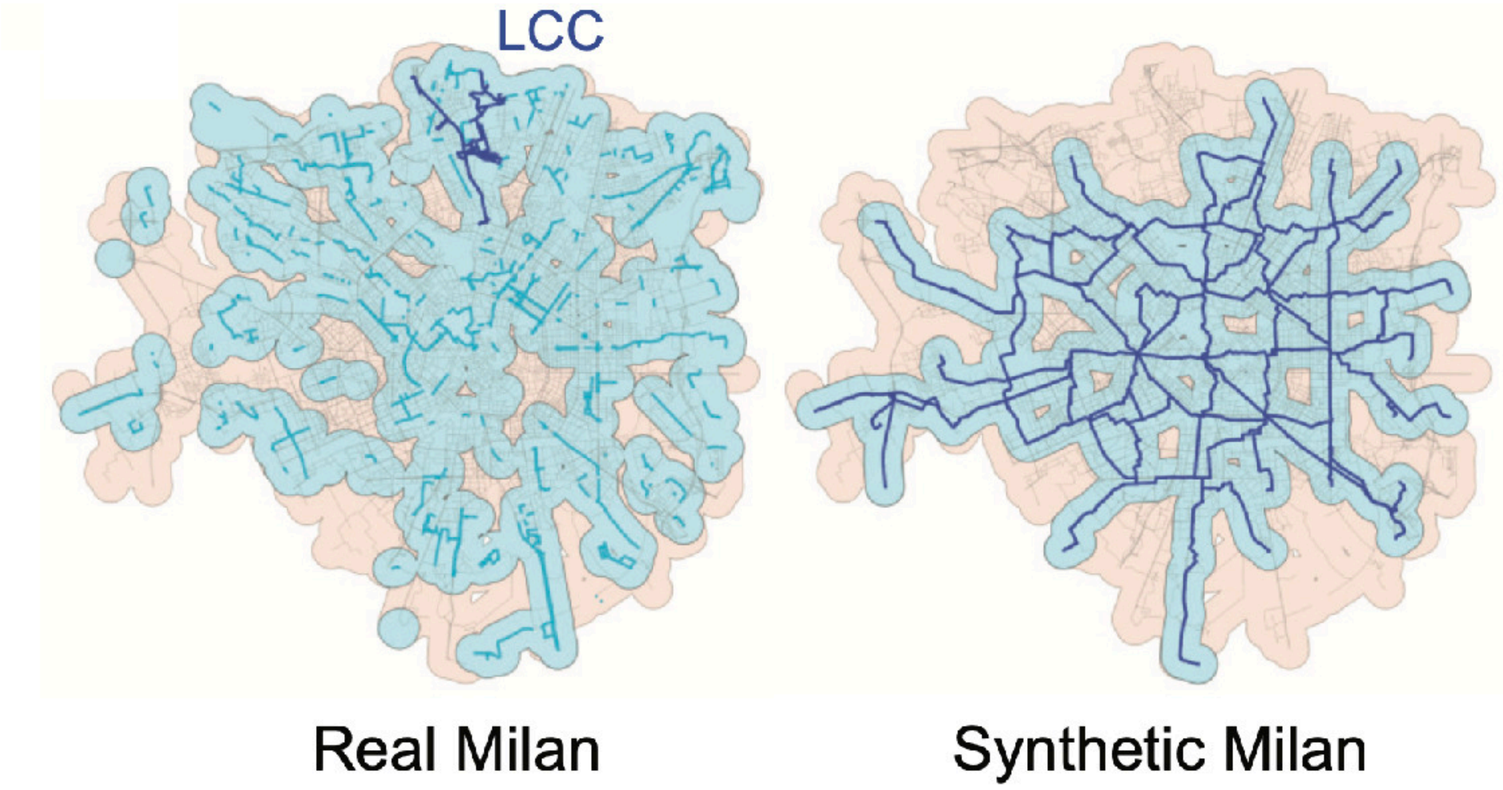
Brent Toderian @BrentToderian · Jul 30

My real advice for ambitious municipal elected leaders on building a safe, connected network of REAL (not painted lines or sharrows) bike infrastructure — direct your staff to do ALL of the work that you're currently planning to build over the next 5-10 years, ALL IN ONE YEAR.

https://twitter.com/BrentToderian/status/1420907319982915587?s=20

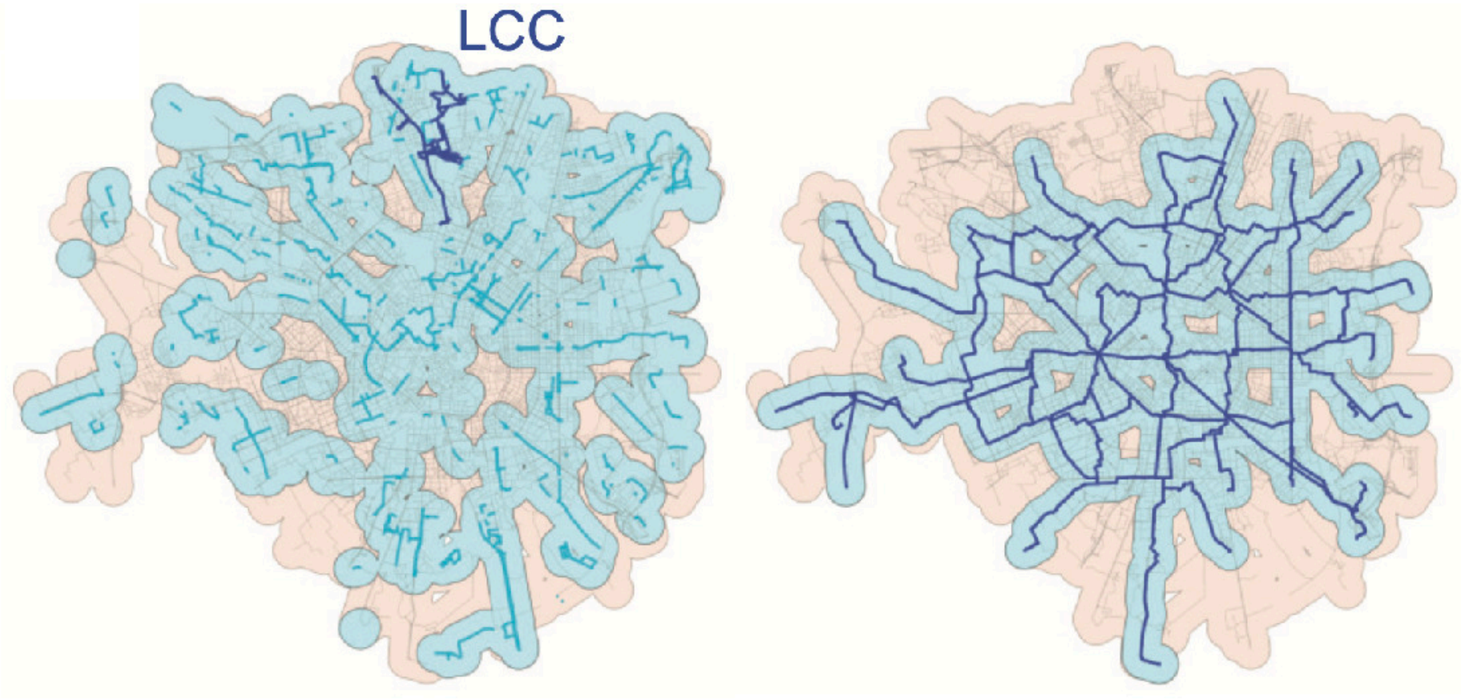
Result 2: It's not a network's length that matters but how you grow it

At same length, we could do much better



Policy implication 2: Strategy matters: Build for the whole city

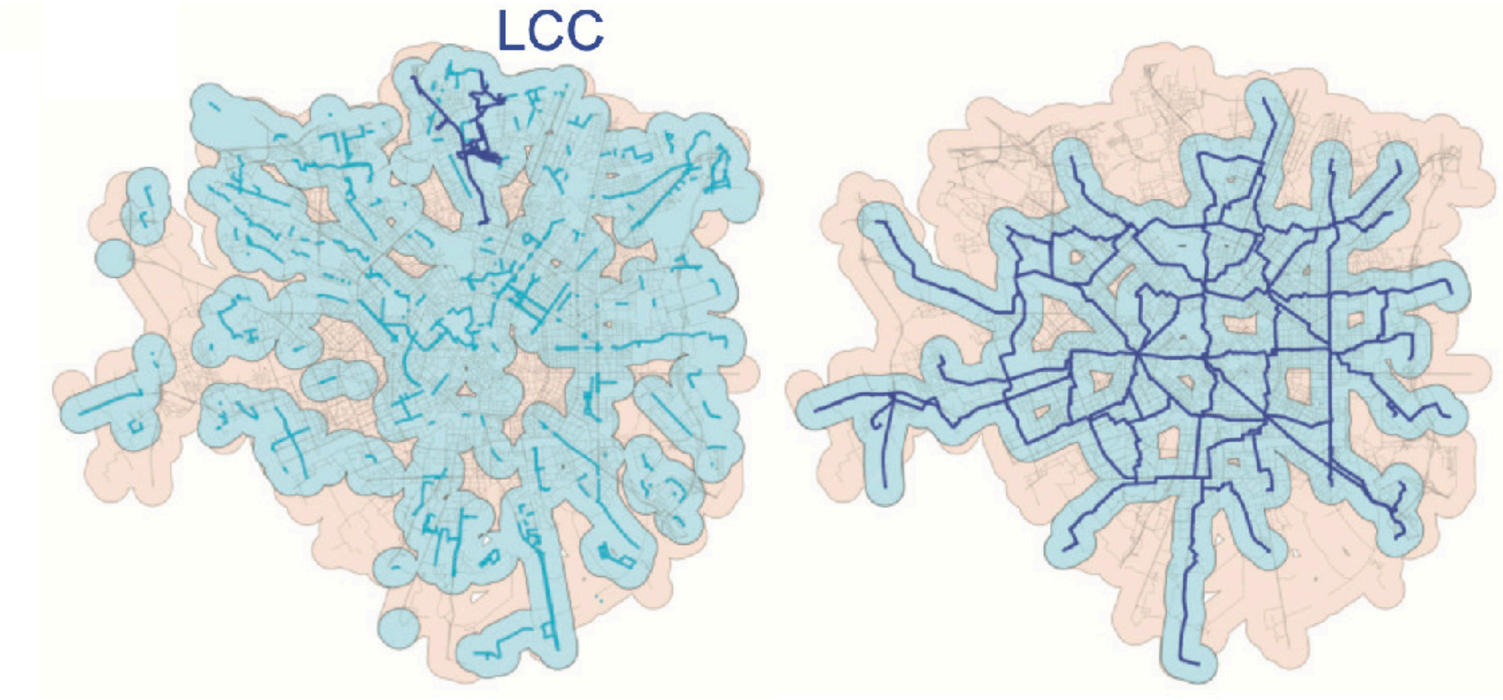
Avoid "random-like", piecewise growth



Real Milan

Synthetic Milan

Easier said than done - Isn't this unrealistic??

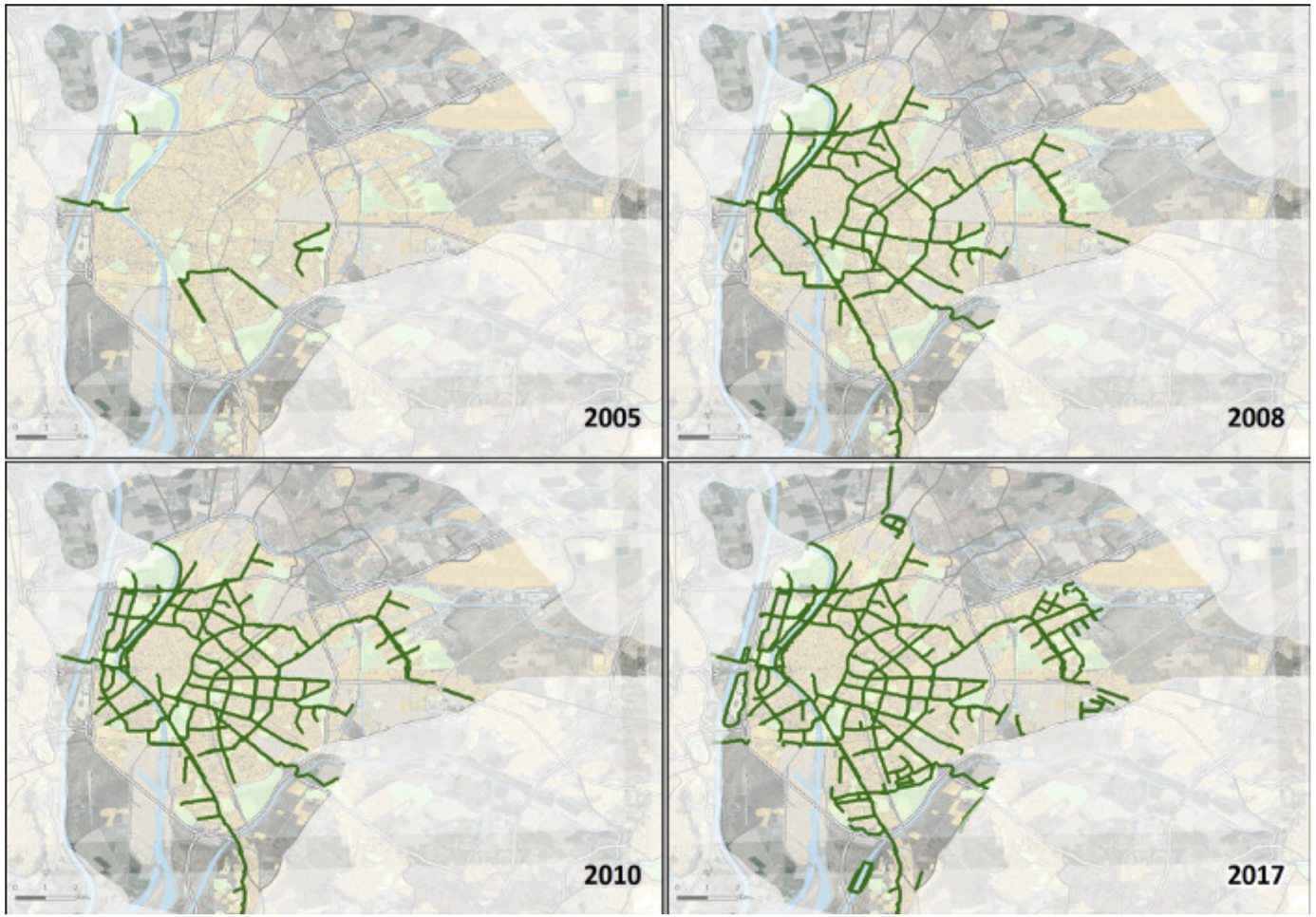


Real Milan

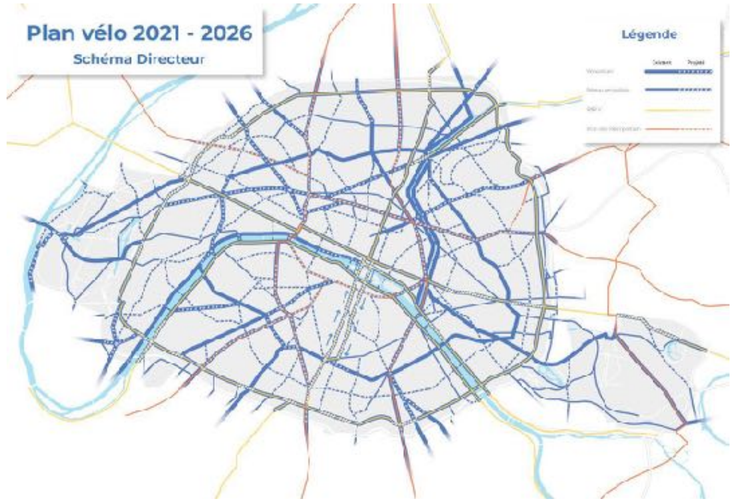
Synthetic Milan

Easier said than done - Isn't this unrealistic??

Nope: See Seville



Also: Paris, Oslo, ...



There is no excuse

https://usa.streetsblog.org/2020/10/13/best-practices-how-seville-became-a-city-of-cyclists/

Our procedure generates a first cohesive network

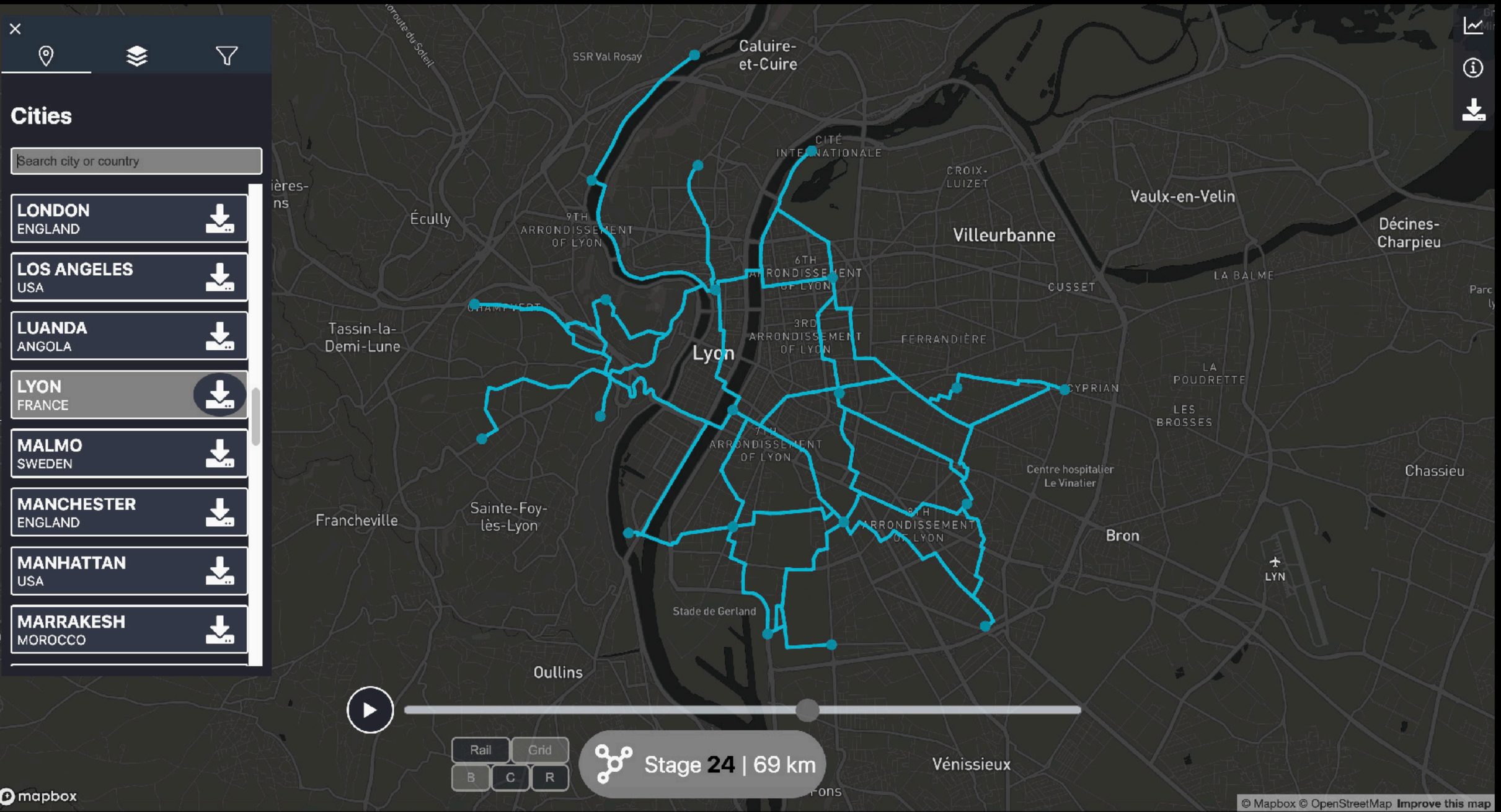
Can be refined arbitrarily:

- Population density
- Road type
- Inclination
- Traffic / Stress
- Routes
- ....

Open-sourced at:

https://github.com/mszell/bikenwgrowth

Explore your city at GrowBike.Net



3) Repairing bicycle networks

How to find the missing links in well-developed networks?

In Copenhagen, most of the network is 1 connected component.

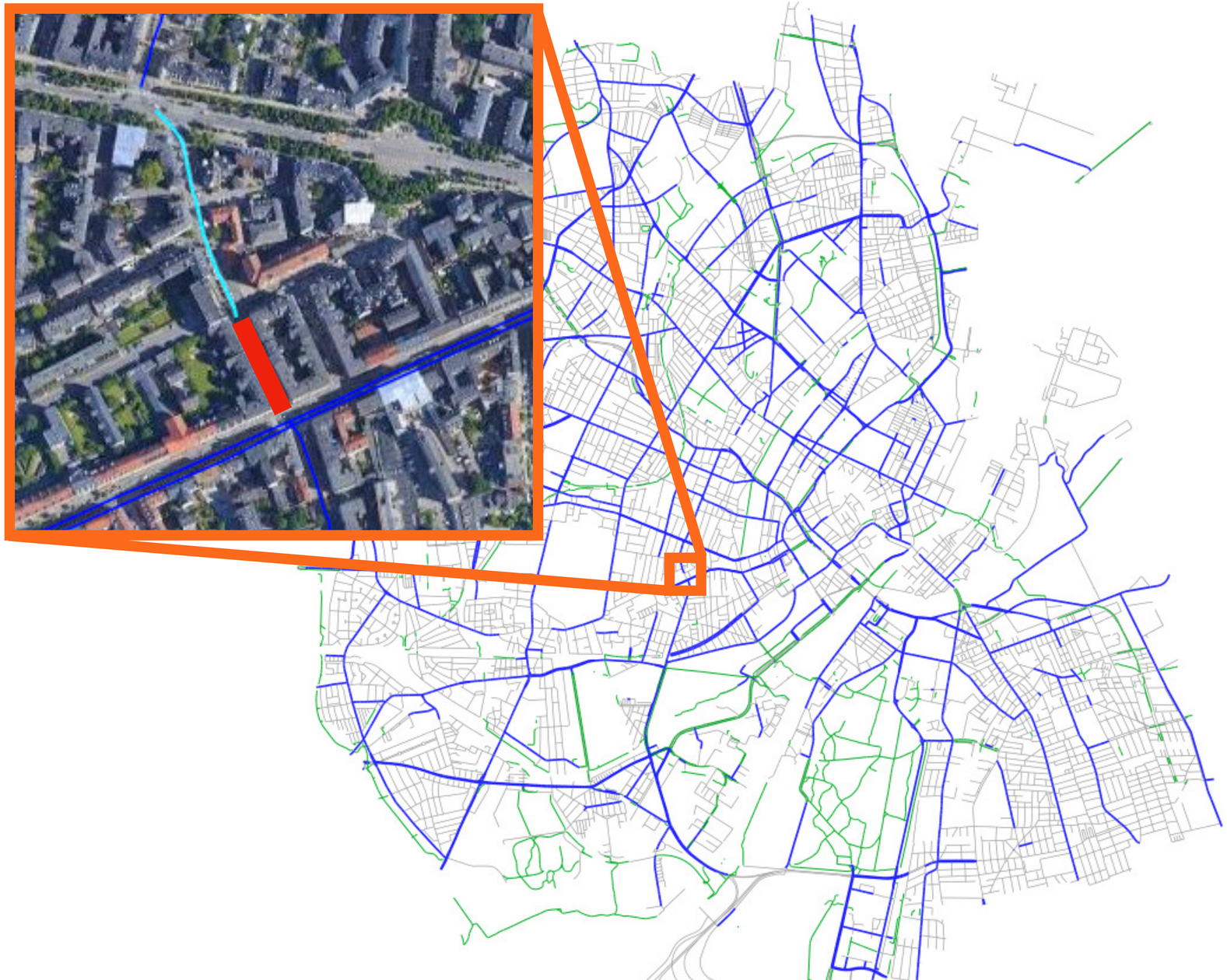
How to find the missing links in well-developed networks?

In Copenhagen, most of the network is 1 connected component.

Still, there are a lot of "missing links".

How to find them?
How to prioritize them?

Example: Kingosgade

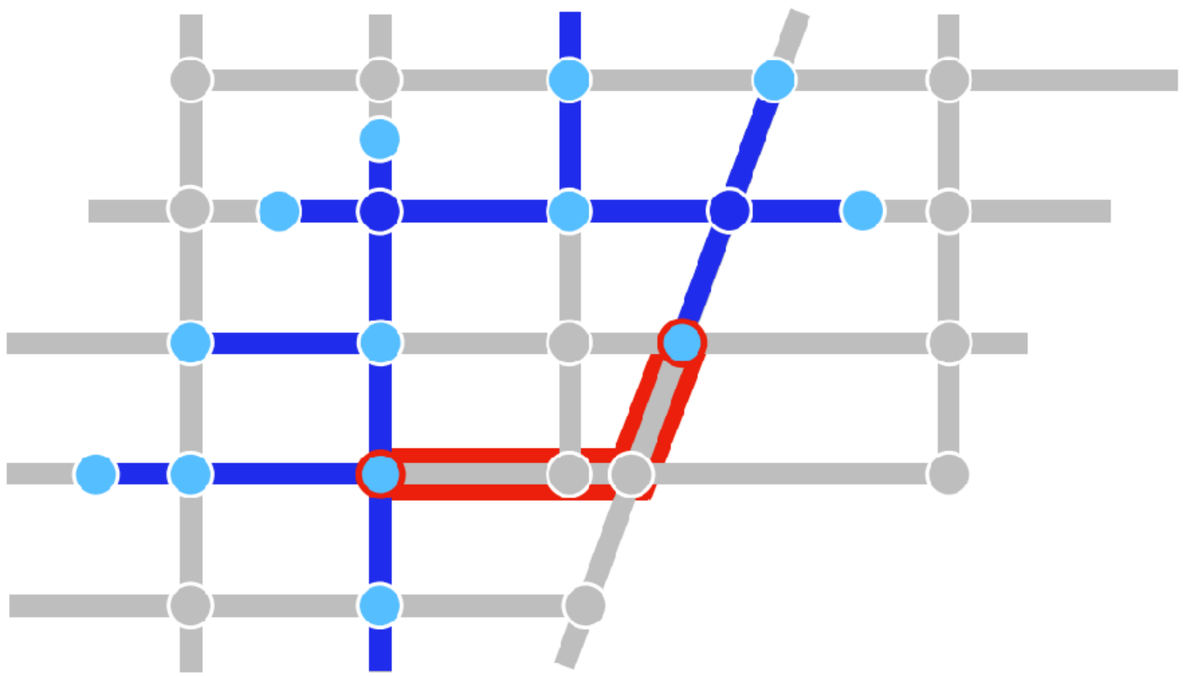


First: Define "gap"

Multiplex network

Links
1) unprotected
2) protected

Nodes
1) unprotected
2) protected
3) contact



Vybornova et al (2021)

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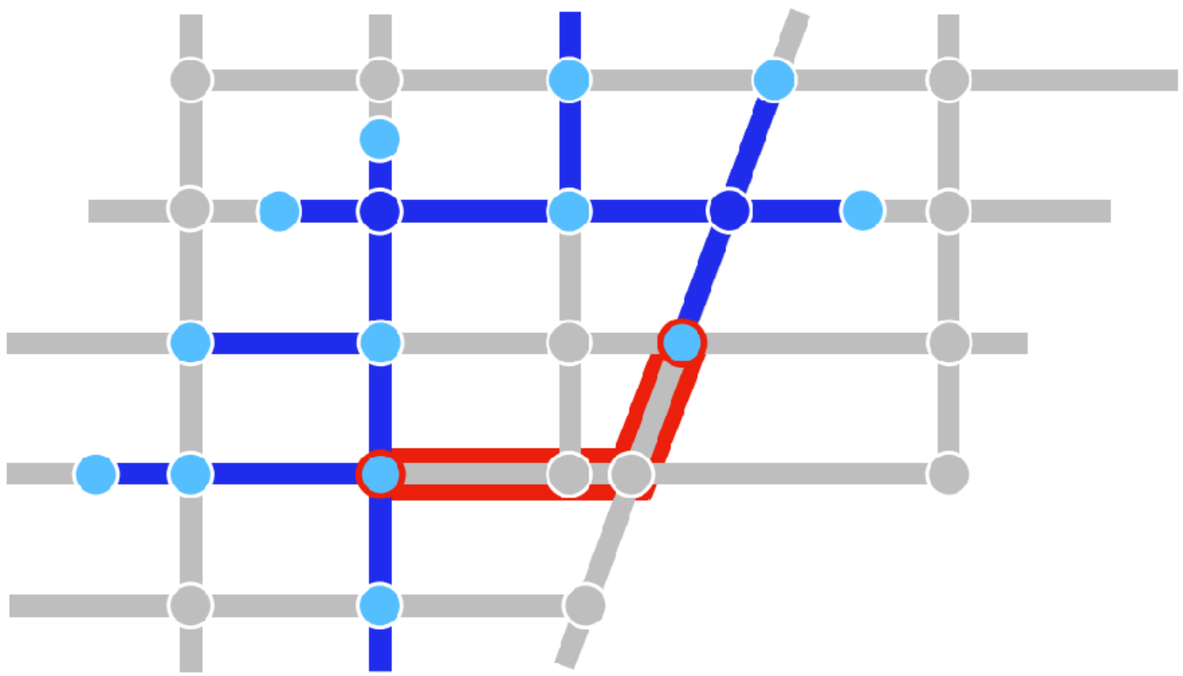
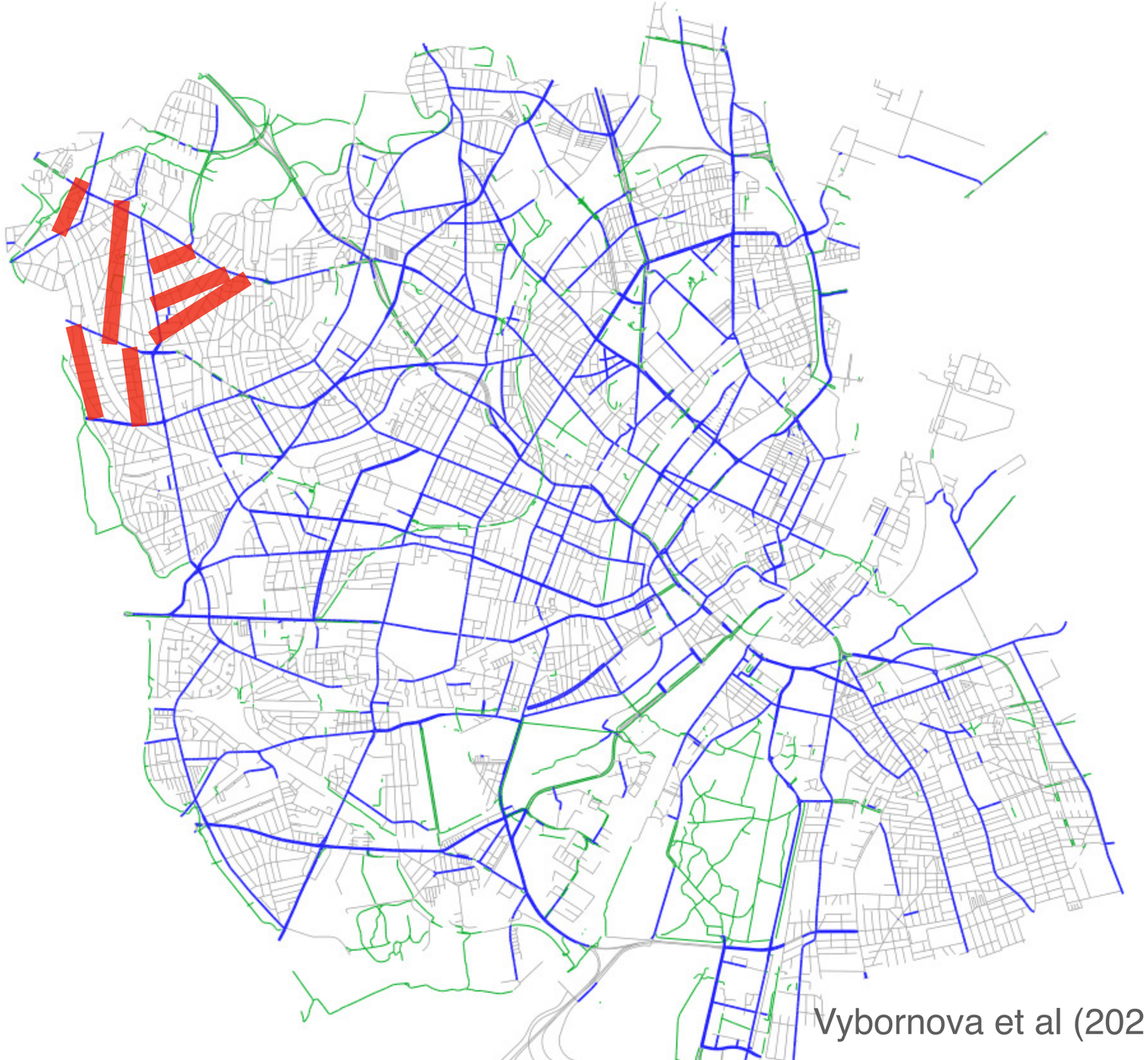


A gap is a shortest path
between two contact nodes
that consists only of unprotected links

Vybornova et al (2021)

We need a metric to prioritize gaps

We could find millions of gaps.



Vybornova et al (2021)

We need a metric to prioritize gaps

We could find millions of gaps.

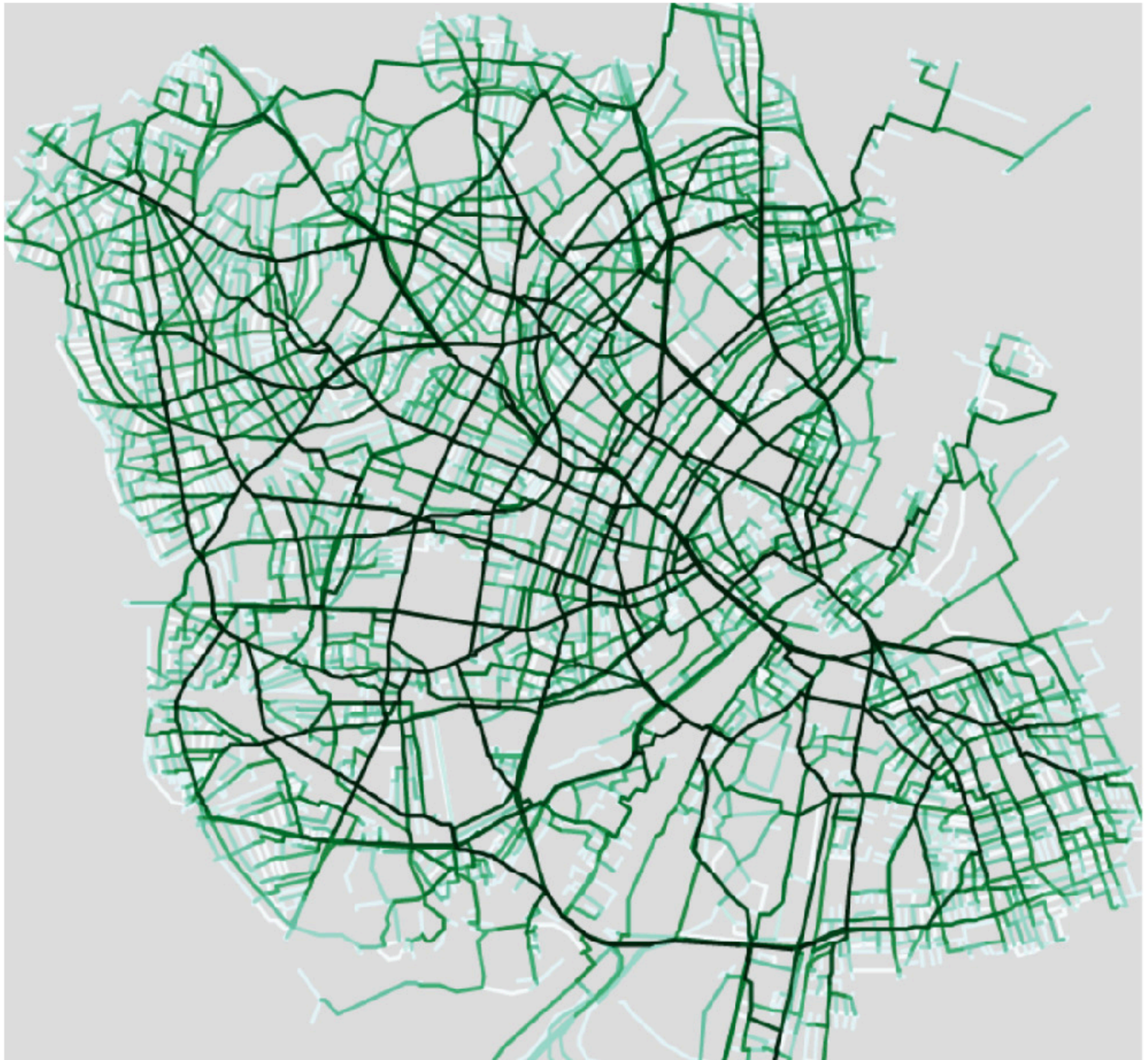
Is gap 1 or gap 2 more important?

Vybornova et al (2021)

We can use betweenness centrality as a proxy for flow

$$C_B(i) = \sum_{i \neq j \neq k} \frac{\sigma_{jk}(i)}{\sigma_{jk}}$$

And account for gap length



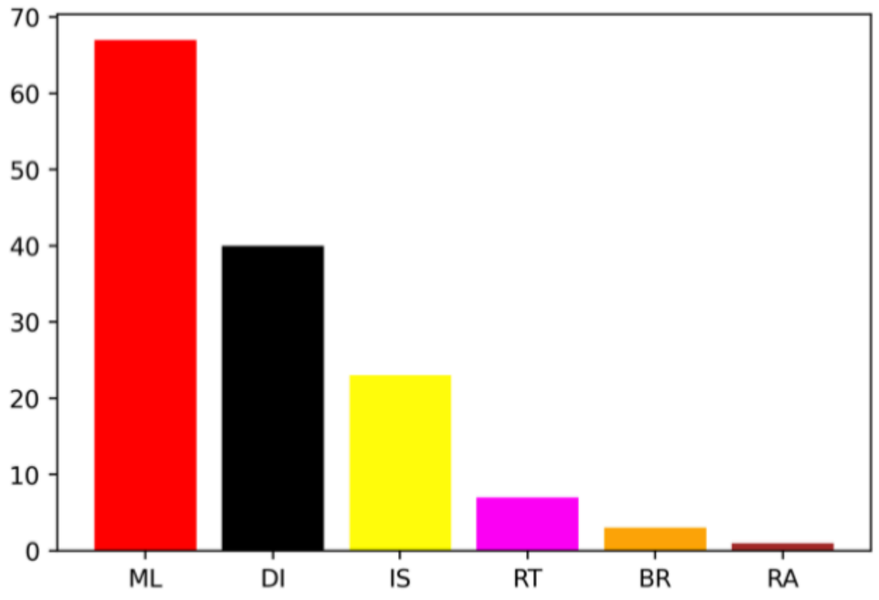
Our top 101 gaps

Vybornova et al (2021)

Most gaps are missing street parts or intersections

Our method:

- classifies gaps

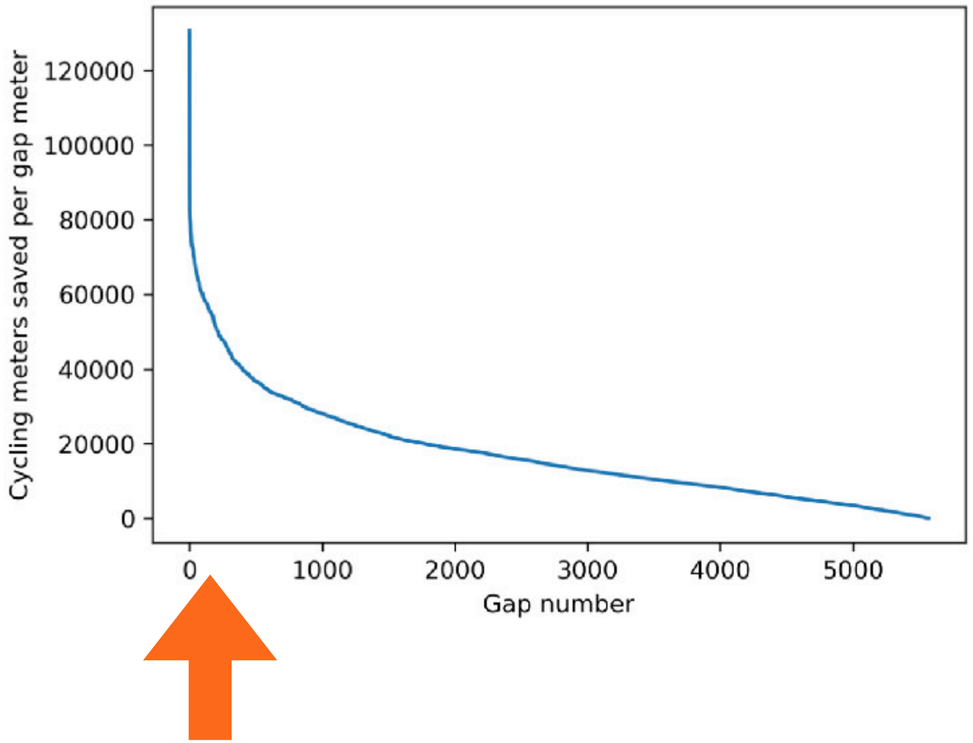


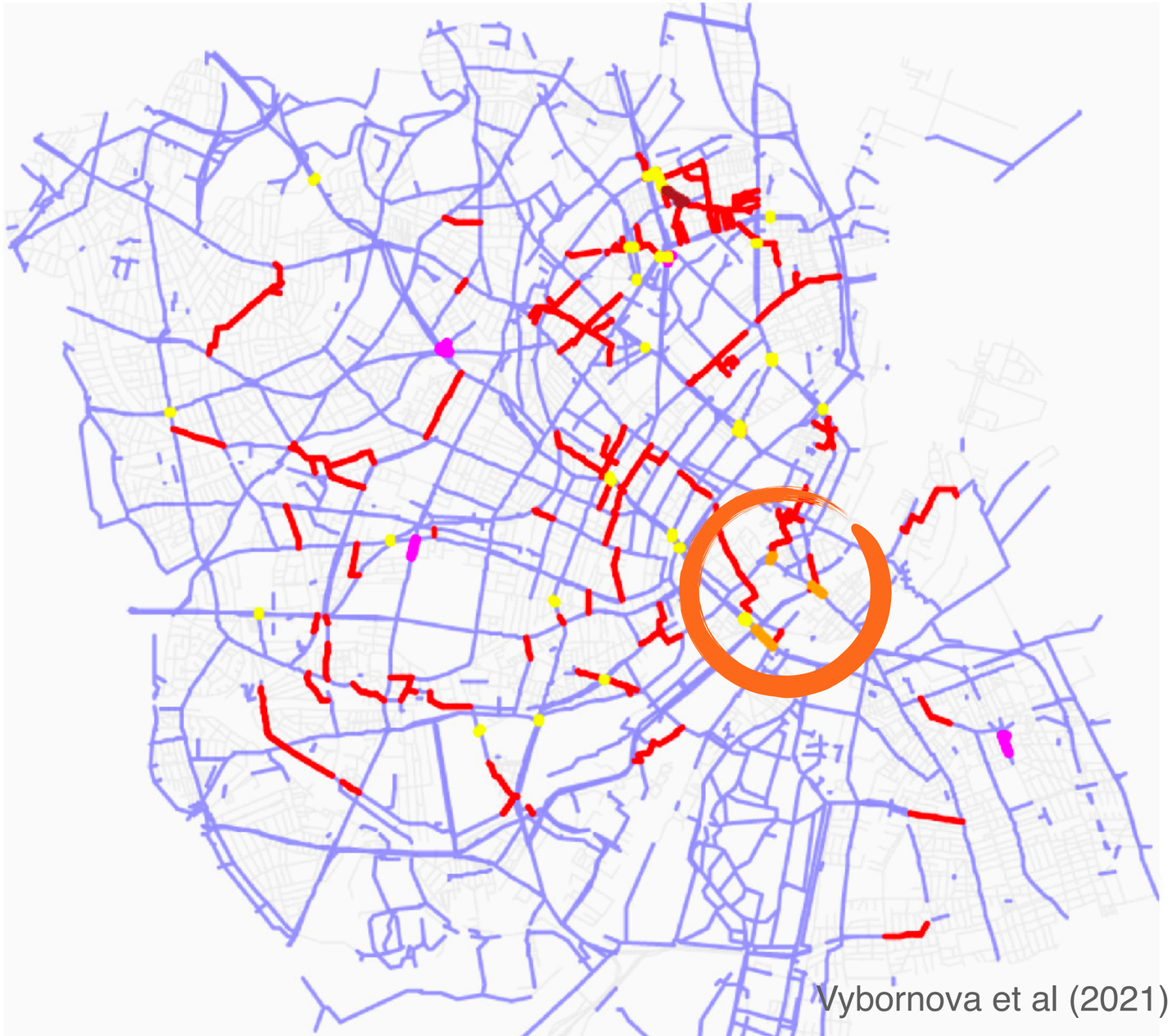
Vybornova et al (2021)

Bridges are most important

Our method:

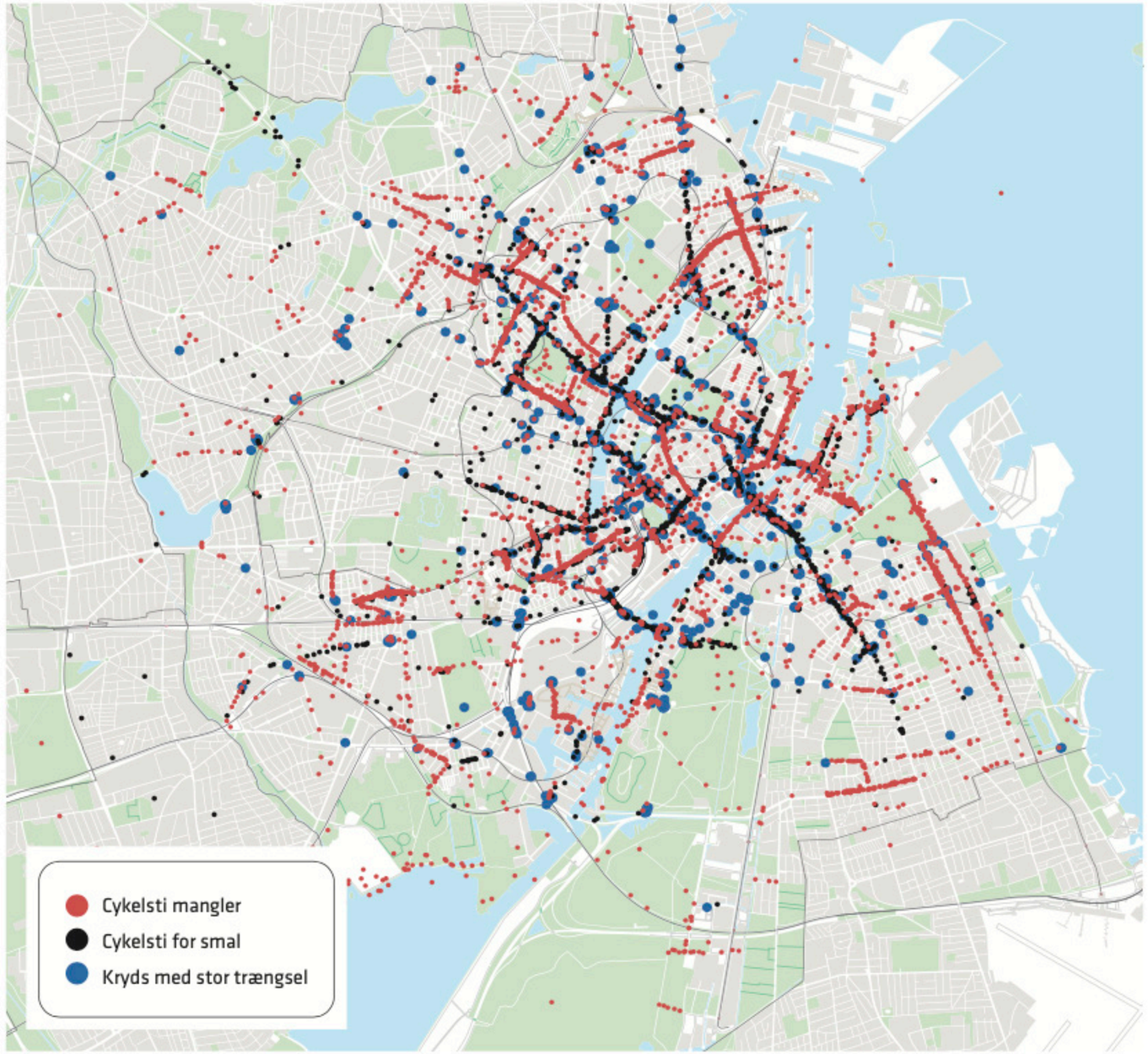
- classifies gaps
- prioritizes gaps





Vybornova et al (2021)

To evaluate, we can compare with citizen surveys

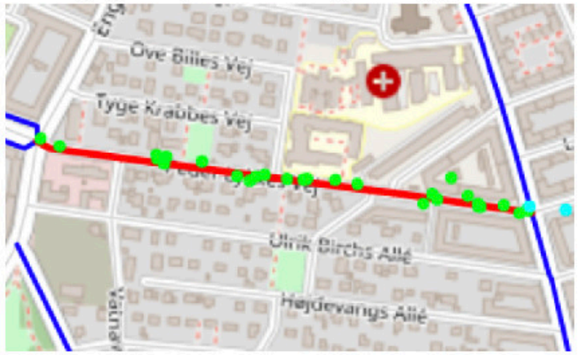


Cykelsti-Prioriteringsplan 2017

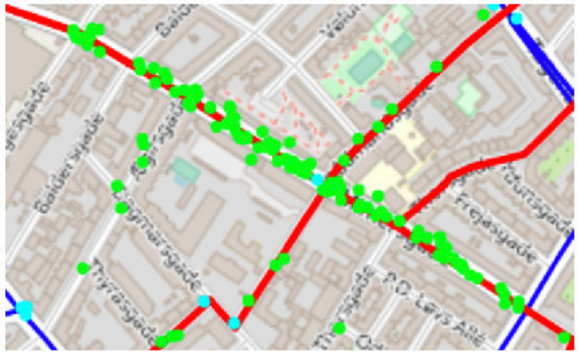
The citizen survey shows some good overlaps

(a) Gap 54: Rantzausgade

(b) Gap 77: Valby Langgade



(c) Gap 91: Peder Lykkes Vej



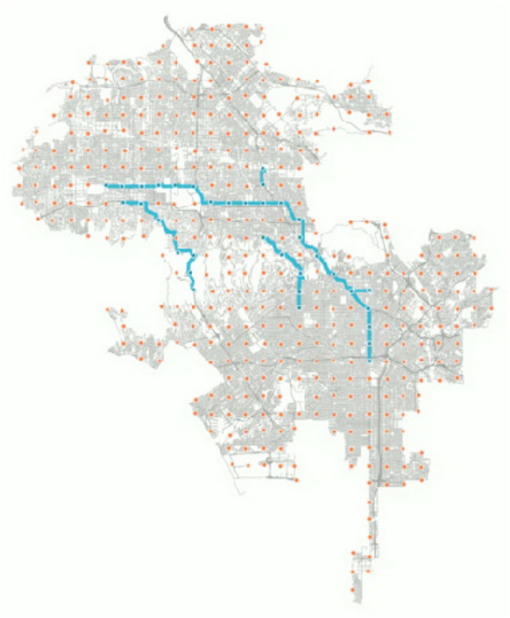
(d) Gap 93: Mimersgade

Vybornova et al (2021)

If your city is:

not developed

Los Angeles

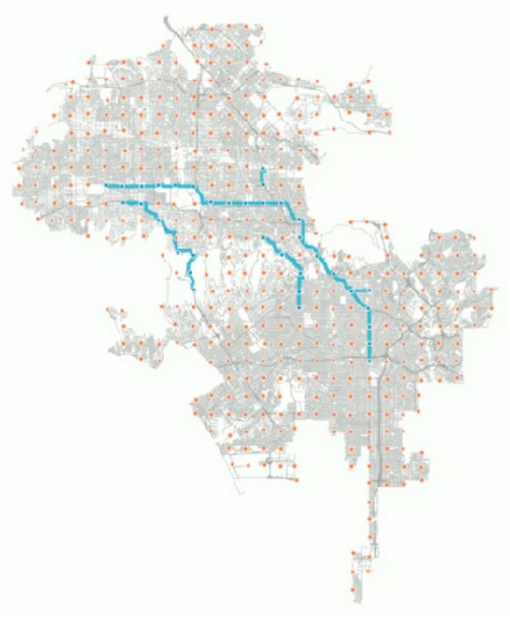


Grow persistently with focused investments

If your city is:

not developed

Los Angeles



Grow persistently with focused investments

medium developed

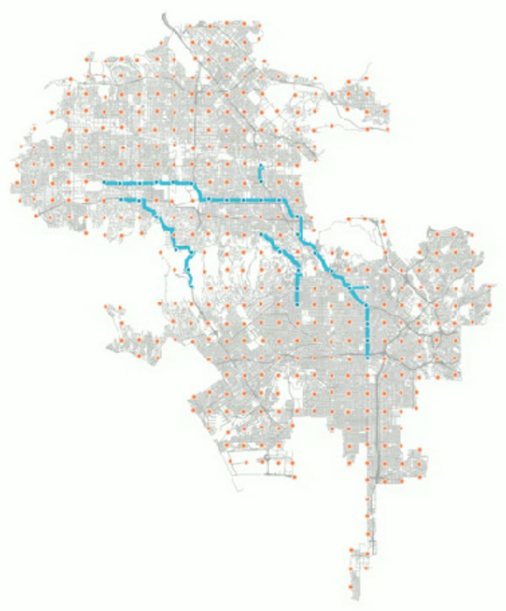
Budapest

Connect with right strategy

If your city is:

not developed

Los Angeles



Grow persistently with focused investments

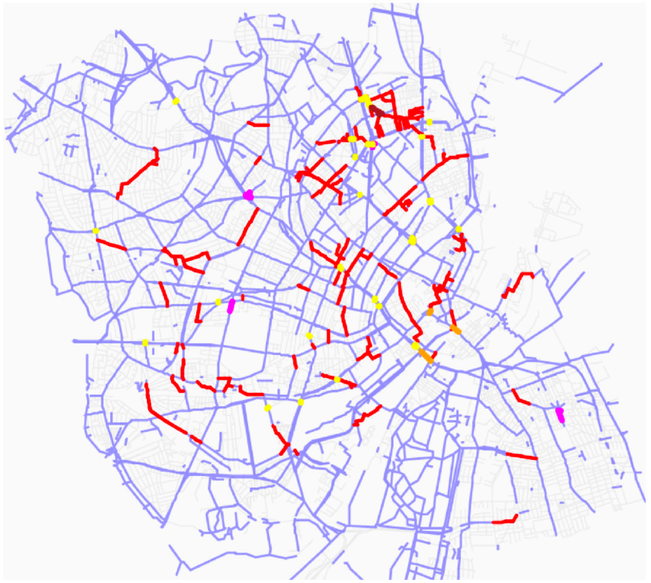
medium developed

Budapest

Connect with right strategy

well developed

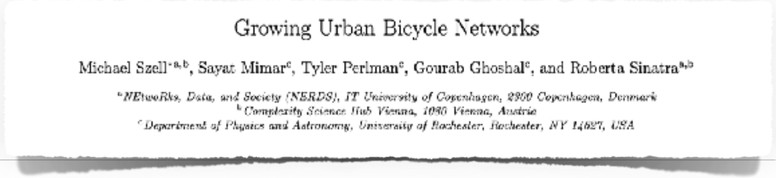
Copenhagen



Close the most important gaps

If your city is:

not developed



Growing Urban Bicycle Networks

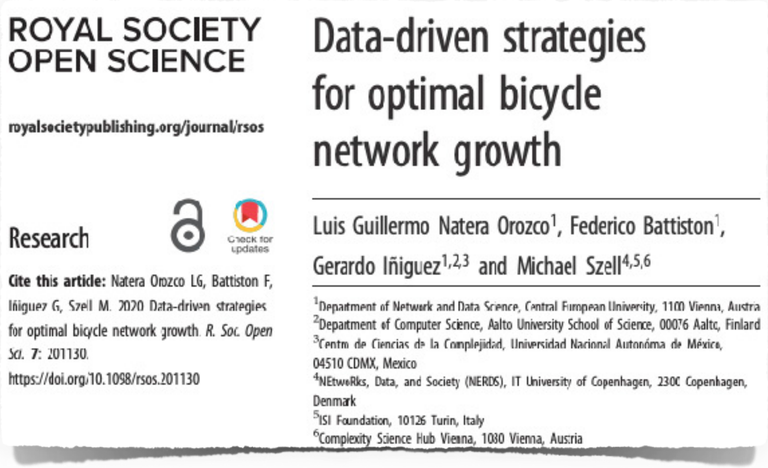
Michael Szell[a,b], Sayat Mimar[c], Tyler Perlman[c], Gourab Ghoshal[c], and Roberta Sinatra[a,b]

[a]NEtwoRks, Data, and Society (NERDS), IT University of Copenhagen, 2300 Copenhagen, Denmark
[b]Complexity Science Hub Vienna, 1080 Vienna, Austria
[c]Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627, USA

https://arxiv.org/abs/2107.02185

Grow persistently with focused investments

medium developed



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Research

Cite this article: Natera Orozco LG, Battiston F, Iñiguez G, Szell M. 2020 Data-driven strategies for optimal bicycle network growth. *R. Soc. Open Sci.* **7**: 201130.
https://doi.org/10.1098/rsos.201130

Data-driven strategies for optimal bicycle network growth

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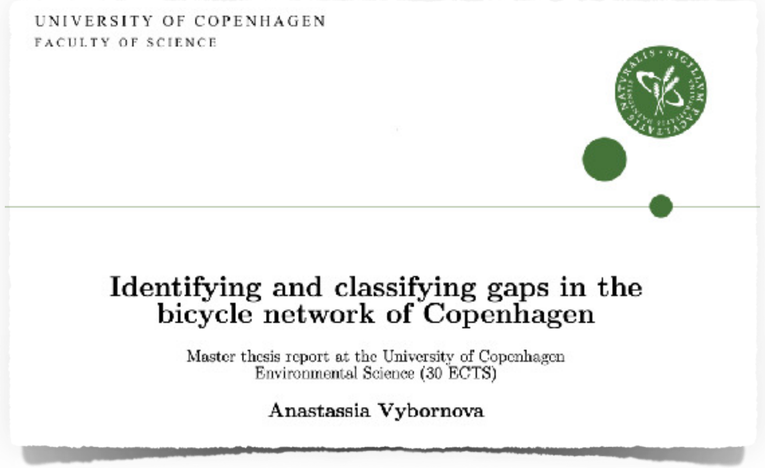
[1]Department of Network and Data Science, Central European University, 1100 Vienna, Austria
[2]Department of Computer Science, Aalto University School of Science, 00076 Aalto, Finland
[3]Centro de Ciencias de la Complejidad, Universidad Nacional Autonóma de México, 04510 CDMX, Mexico
[4]NEtwoRks, Data, and Society (NERDS), IT University of Copenhagen, 2300 Copenhagen, Denmark
[5]ISI Foundation, 10126 Turin, Italy
[6]Complexity Science Hub Vienna, 1080 Vienna, Austria

https://royalsocietypublishing.org/doi/10.1098/rsos.201130

Connect with right strategy

well developed



UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE

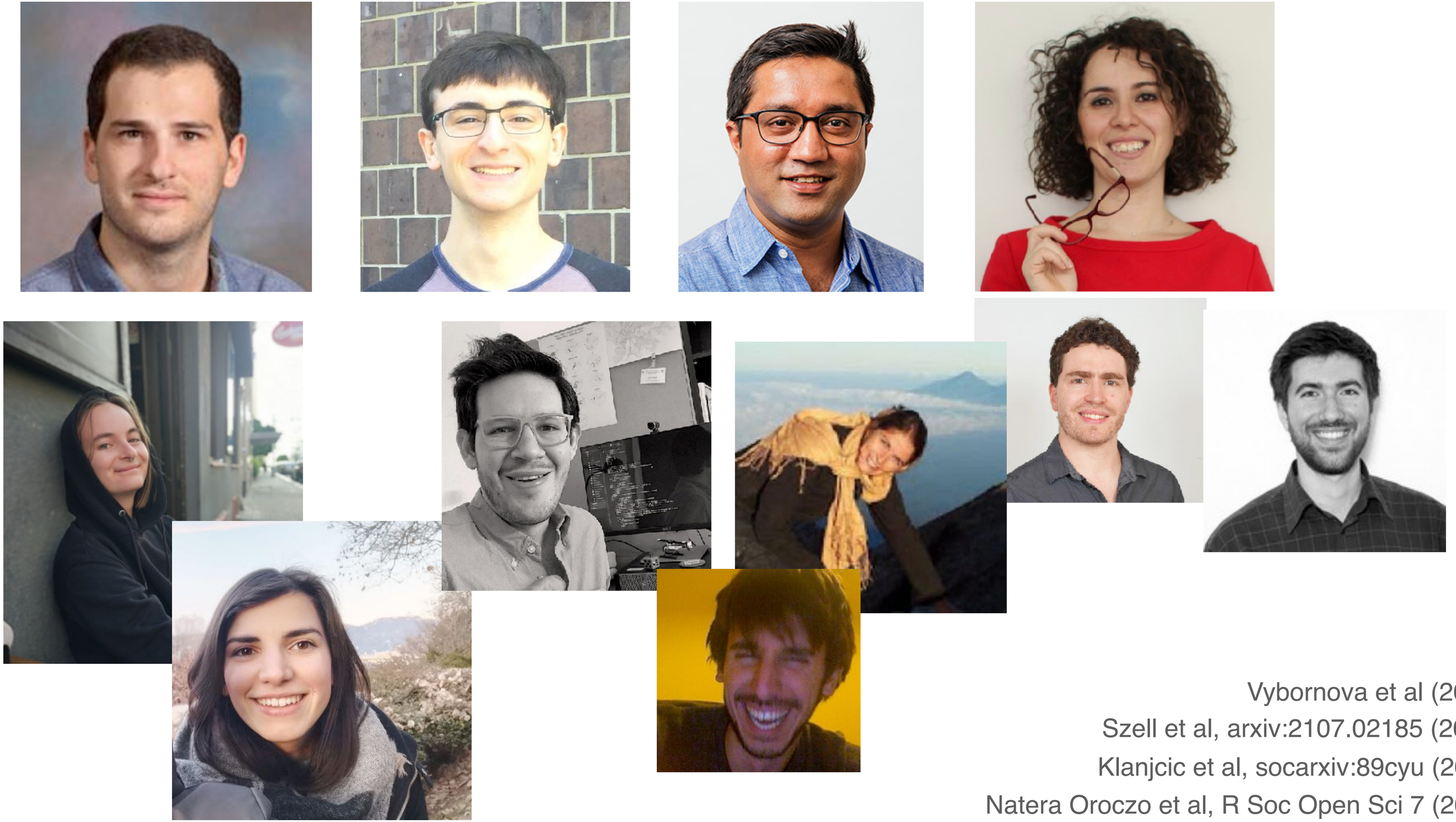
Identifying and classifying gaps in the bicycle network of Copenhagen

Master thesis report at the University of Copenhagen
Environmental Science (30 ECTS)

Anastassia Vybornova

fixbike.net/vybnornova2021icg.pdf

Close the most important gaps



Vybornova et al (2021)

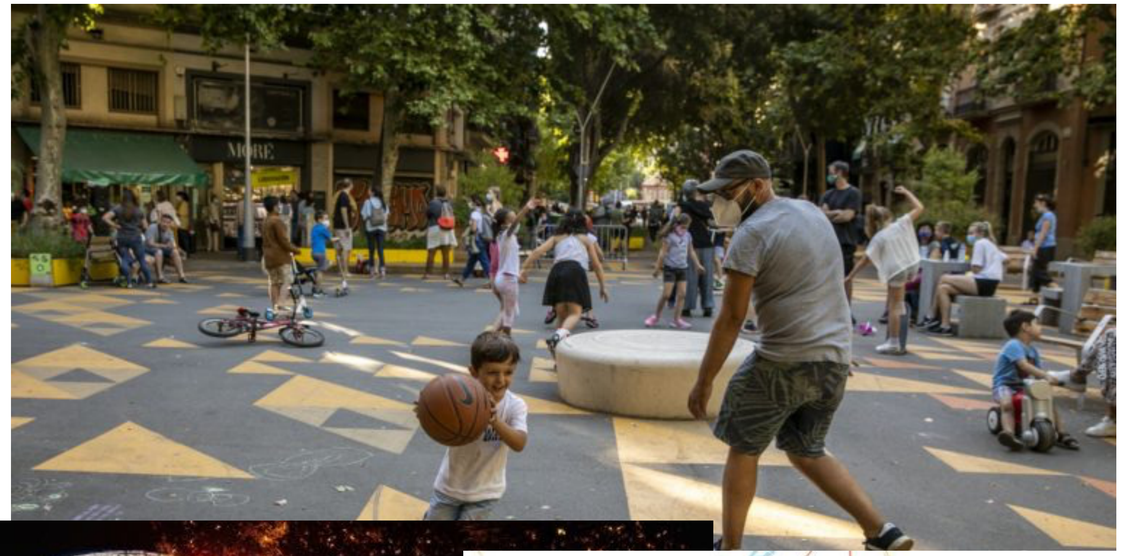
Szell et al, arxiv:2107.02185 (2021)

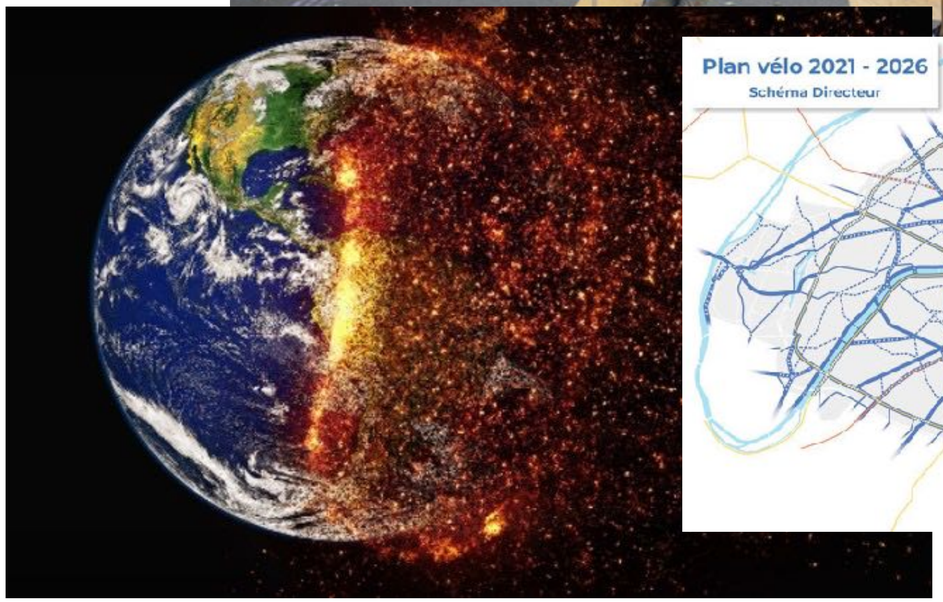
Klanjcic et al, socarxiv:89cyu (2021)

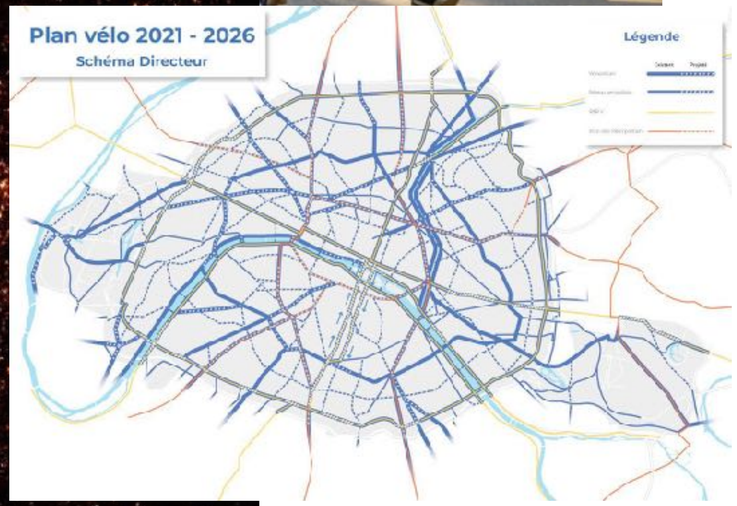
Natera Oroczo et al, R Soc Open Sci 7 (2020)

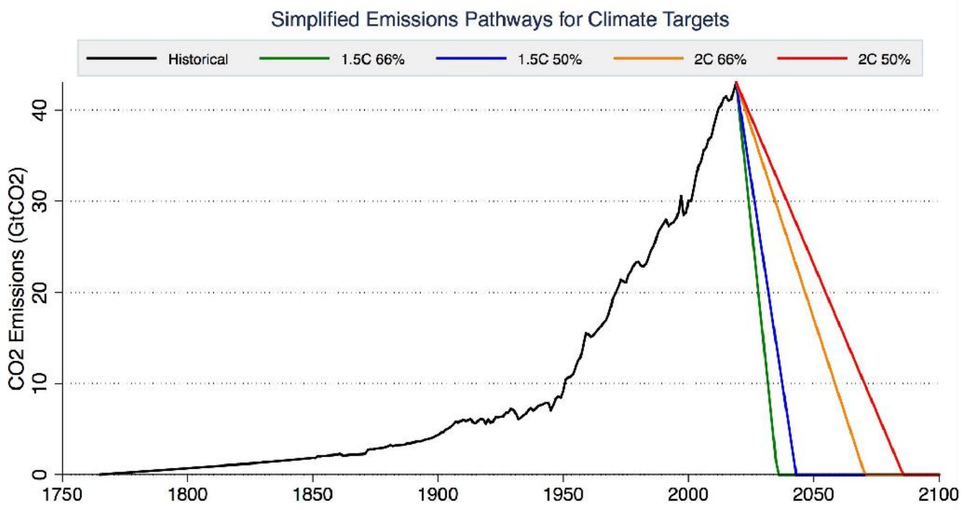
To make cities better, we need *radical* transformation ASAP

E-cars help against CO_2, but only as a LAST RESORT

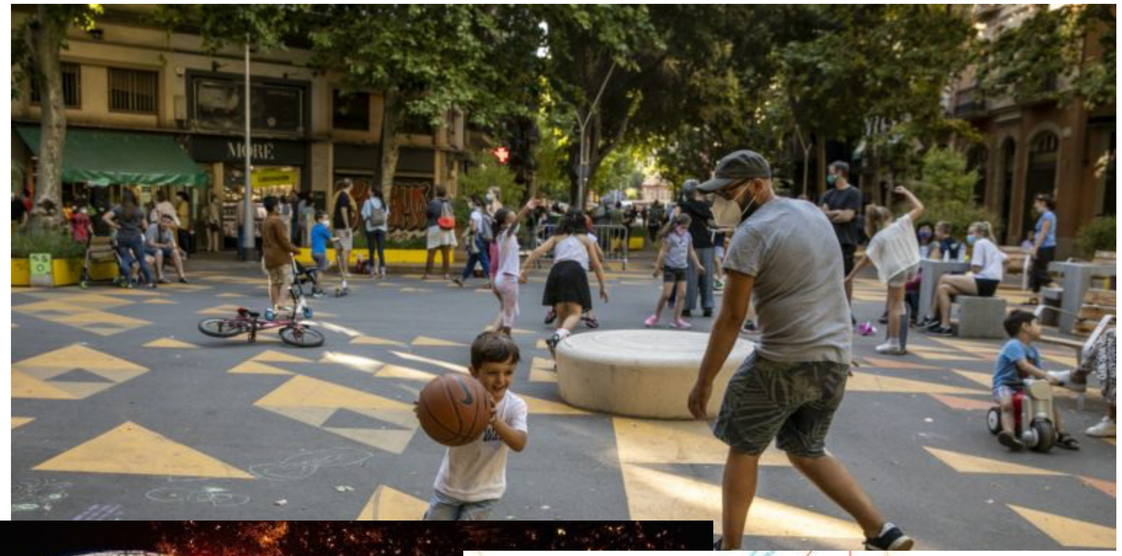


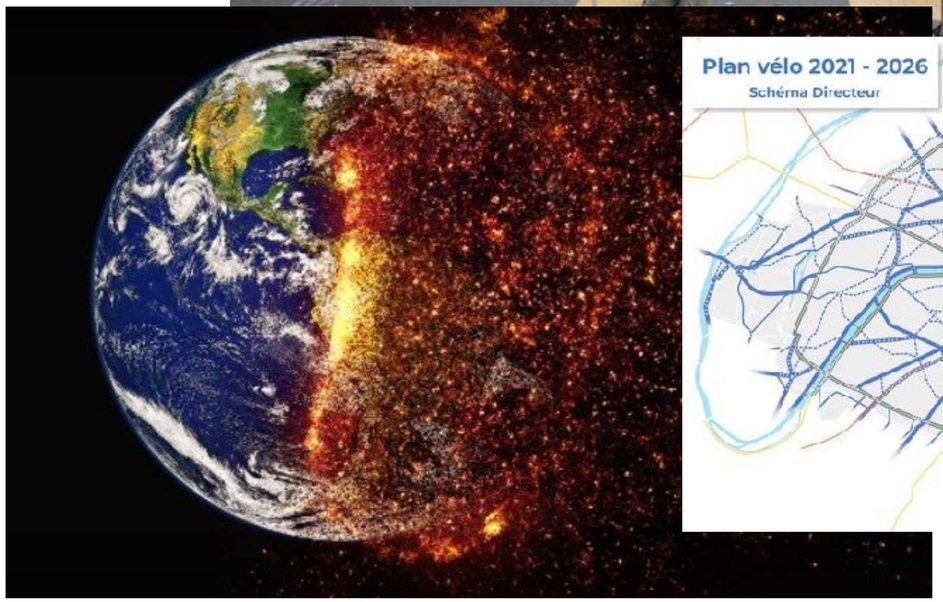




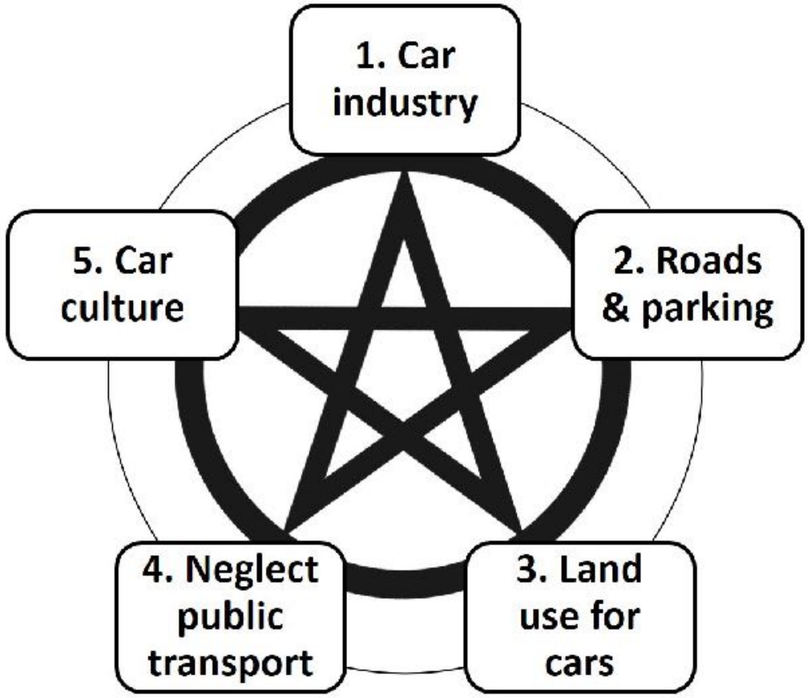


To make cities better, we need *radical* transformation ASAP





Why is it so hard?



Mattioli et al, Energy Research & Social Science 66 (2020): 101486

We need a:

Editorial

Human-Centric Data Science for Urban Studies

Bernd Resch [1,2,*,†] **and Michael Szell** [3,4,5,*,†]

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2 Center for Geographic Analysis, Harvard University, Cambridge, MA 02138, USA
3 NEtwoRks, Data, and Society (NERDS), IT University of Copenhagen, 2300 Copenhagen, Denmark

nerds.itu.dk
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Resch & Szell, ISPRS Int J Geo-Inf 8, 584 (2019)