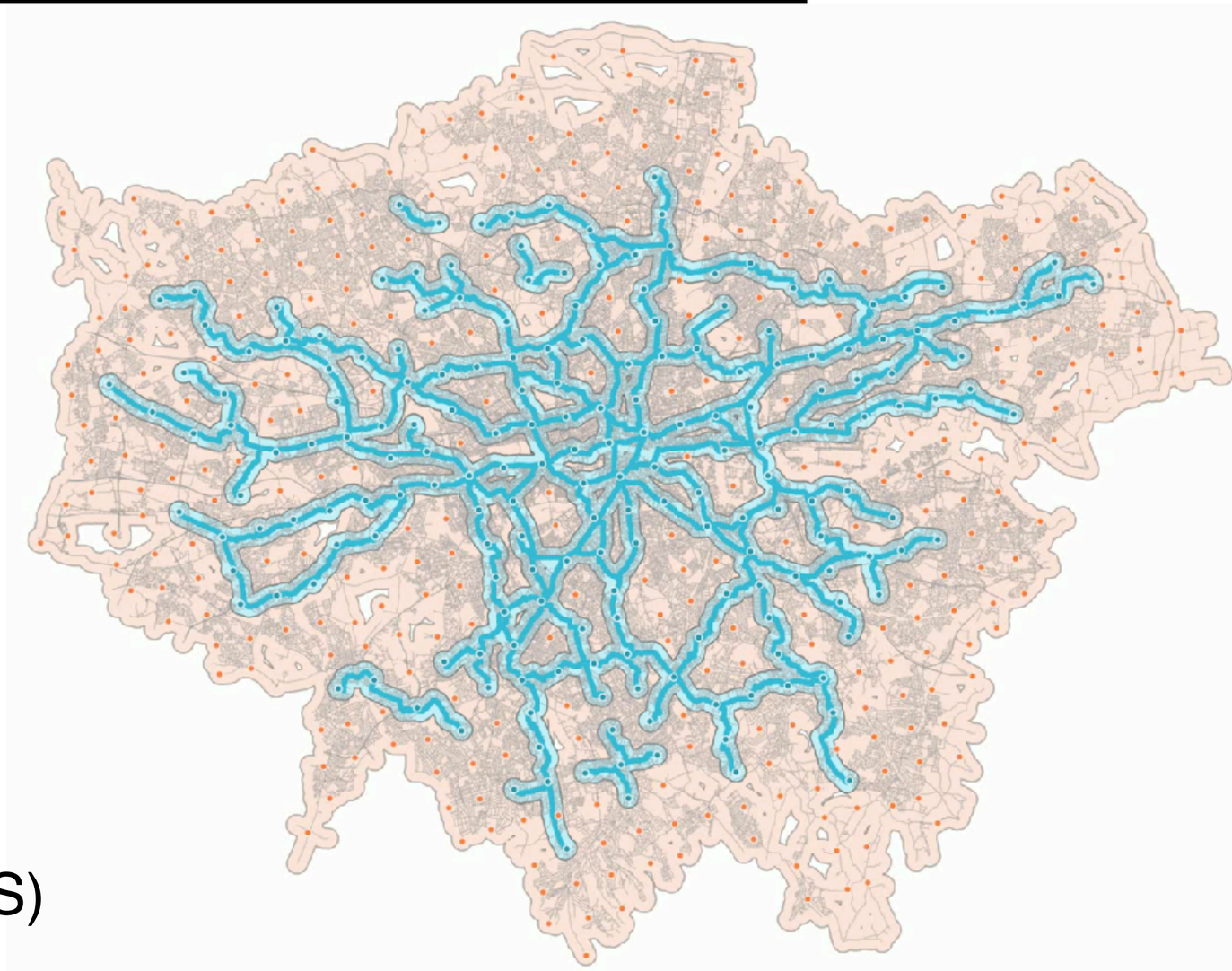
The geometric limits of growing urban bicycle networks

Michael Szell

with:
S. Mimar, T. Perlman,
G. Ghoshal, R. Sinatra

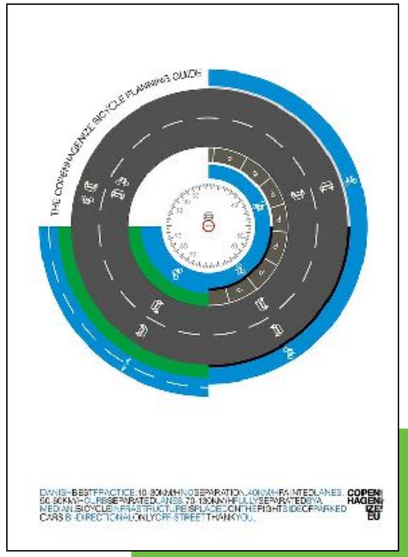
NEtwoRks, Data, and Society (NERDS)

IT UNIVERSITY OF COPENHAGEN



CRBAM21 Copenhagen, Oct 15, 2021

Why we need a scientific theory of bicycle network development



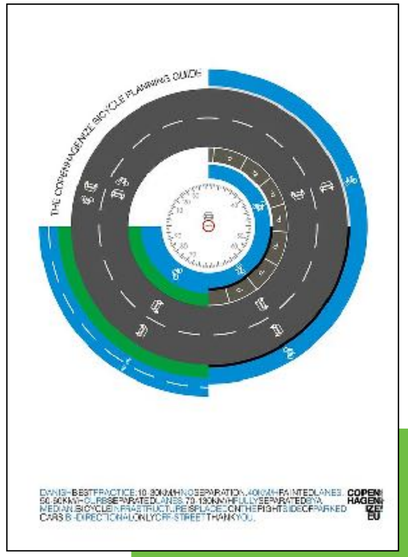
We have great planning guides.. but

NACTO

Urban Bikeway Design Guide

April 2011 Edition

Why we need a scientific theory of bicycle network development



We have great planning guides.. but

NACTO

Urban Bikeway Design Guide

April 2011 Edition

We have no knowledge on the fundamental geometric limitations of network growth.

Previous research

Connecting bicycle networks

Previous research: Connecting bicycle networks

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royalsocietypublishing.org/journal/rsos

Data-driven strategies for optimal bicycle network growth

Research

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

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[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
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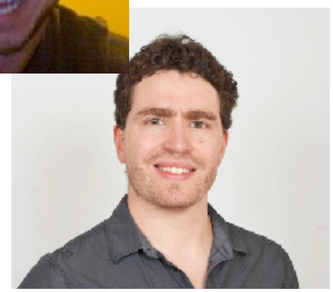
[6]Complexity Science Hub Vienna, 1080 Vienna, Austria

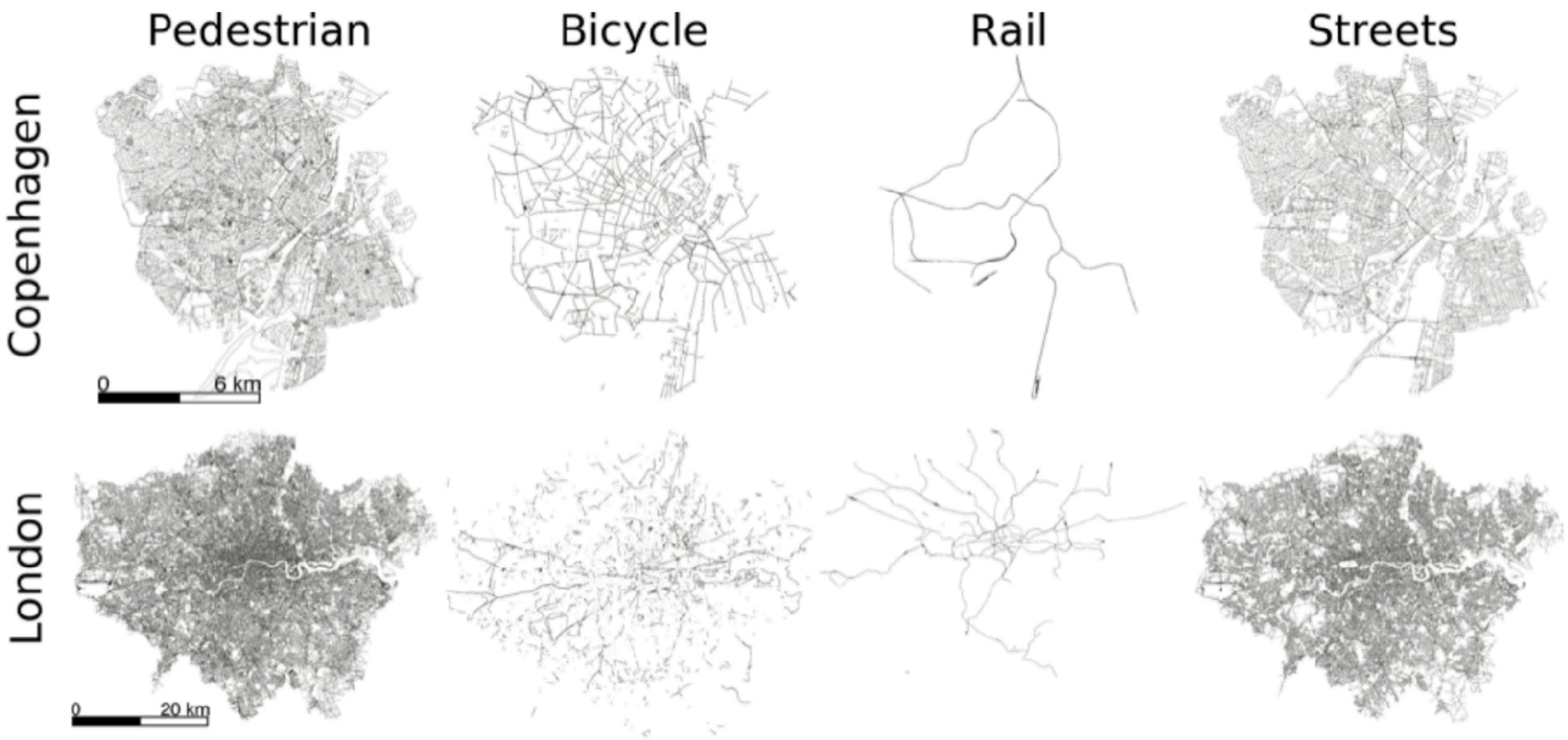


Luis Guillermo Natera Orozco

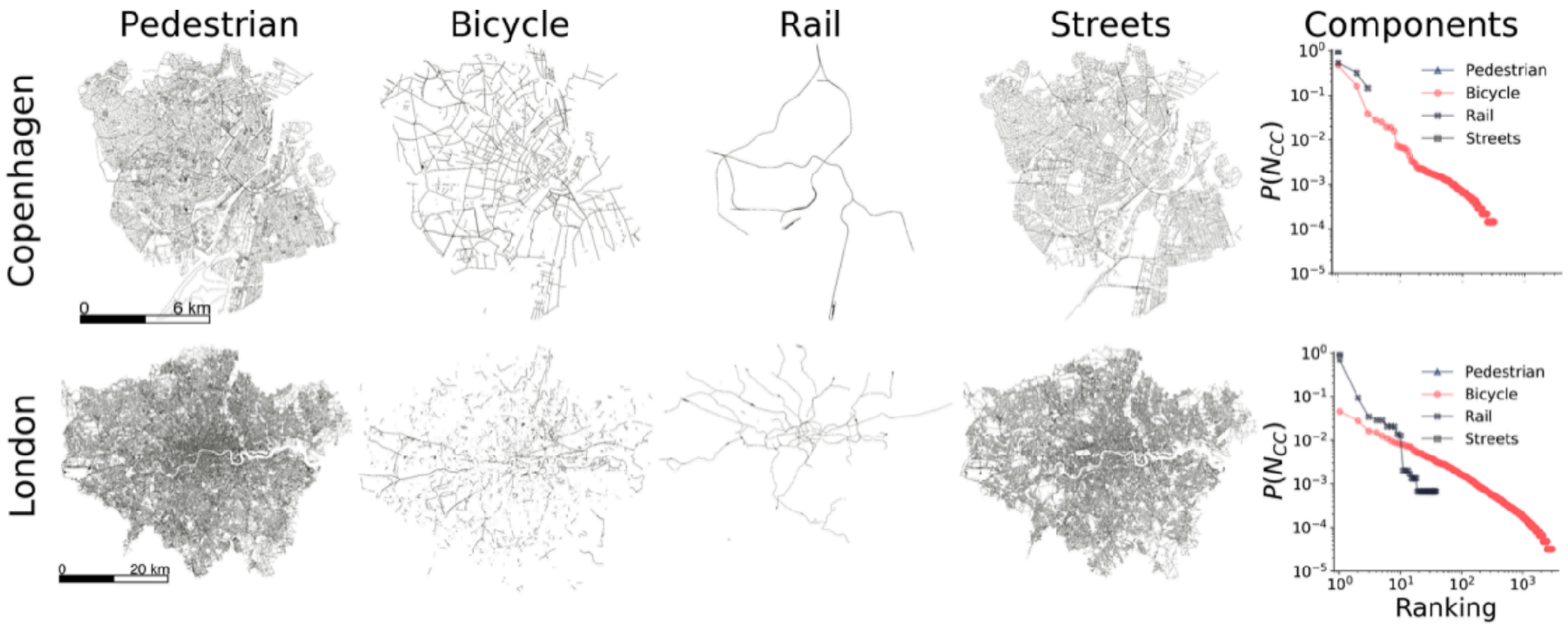
CRBAM19 Delft

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

Cities have different transport network layers



Bicycle networks are highly fragmented



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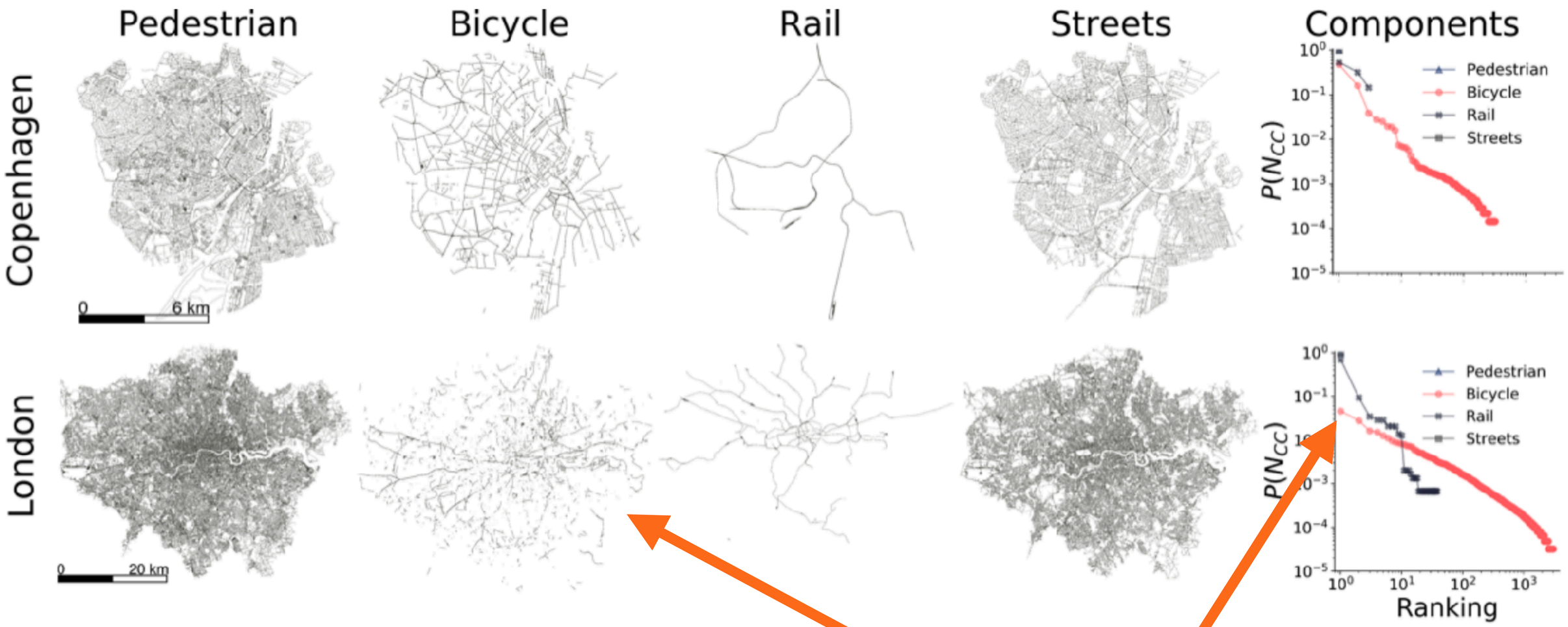

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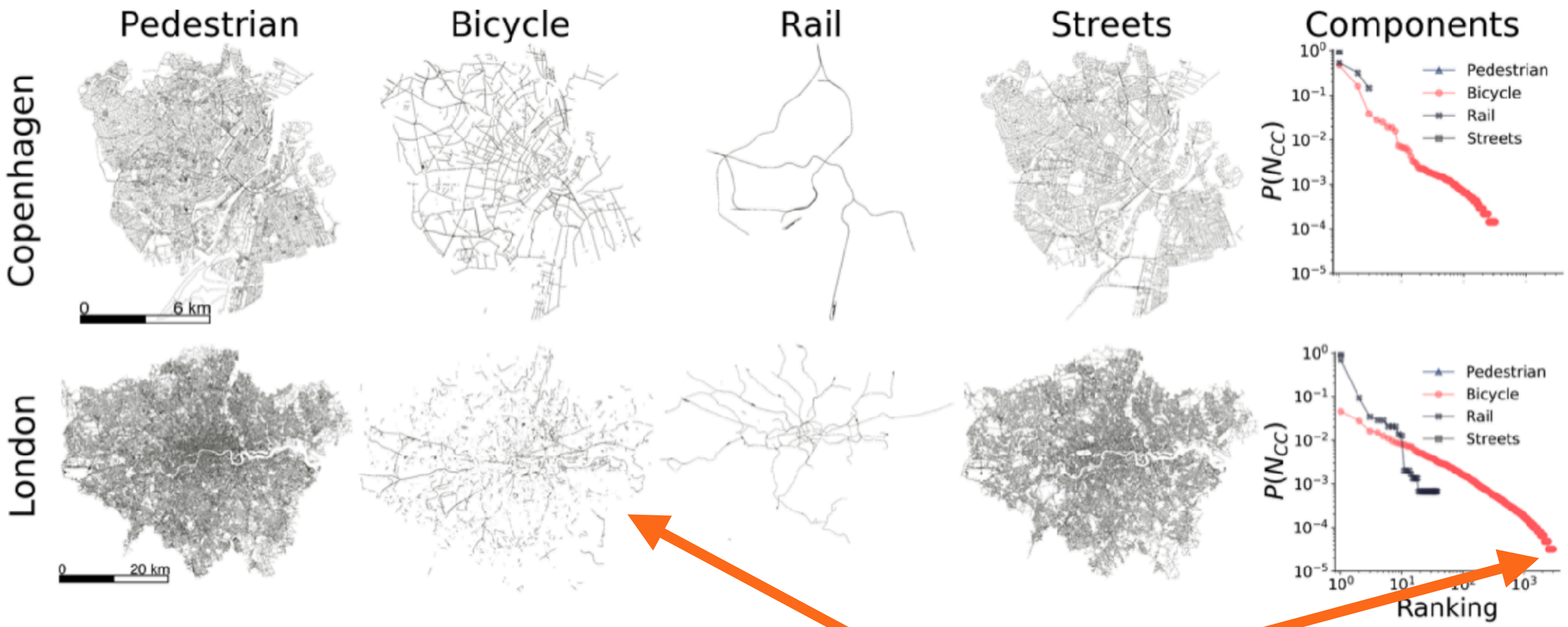
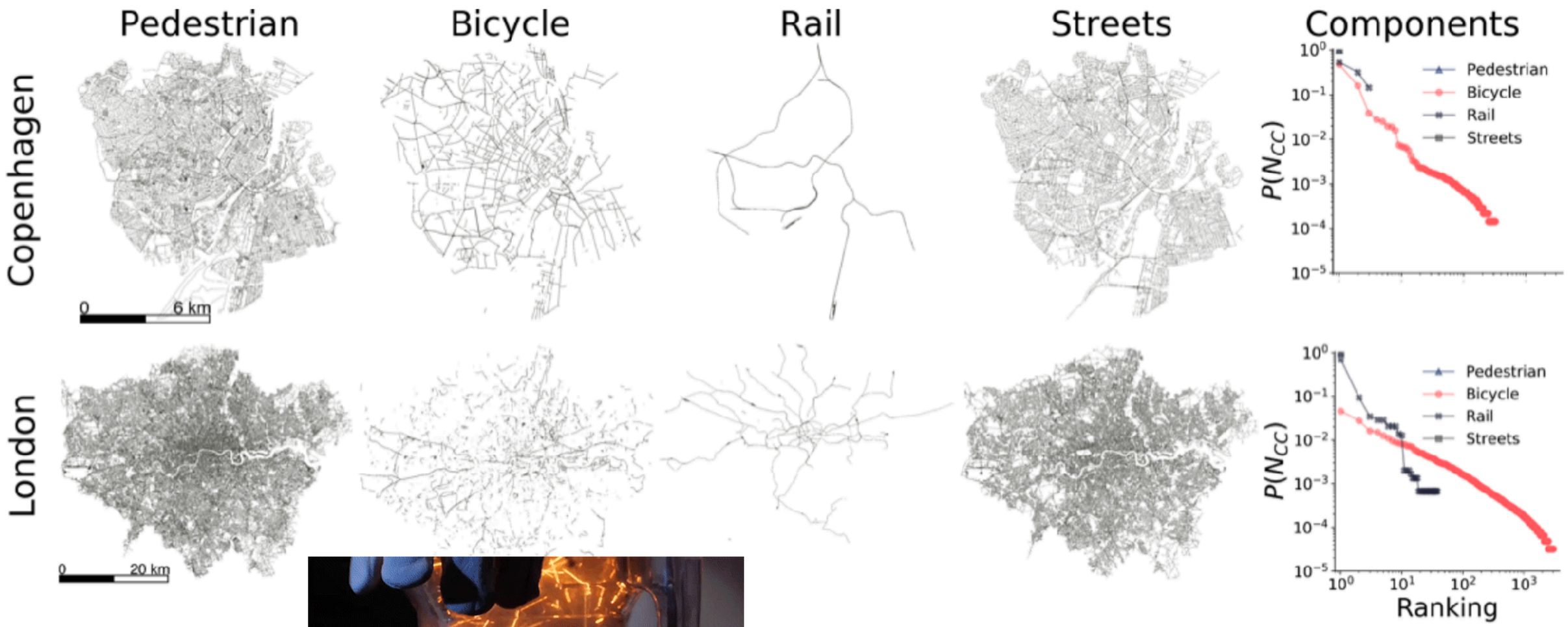


2) In London, the bicycle network has >3000 disconnected components

Bicycle networks are highly fragmented



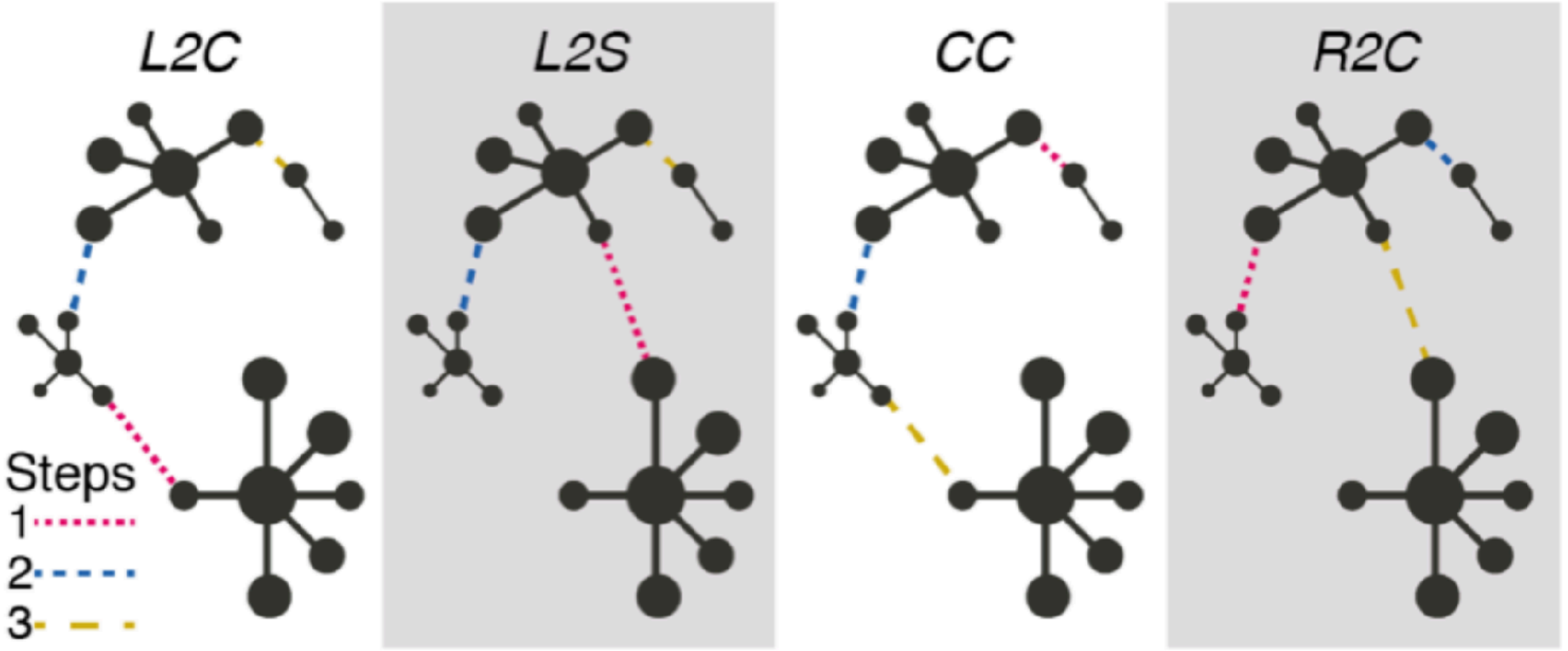
How should we connect the components?

Largest to closest

Largest to second largest

Closest components

Random to closest



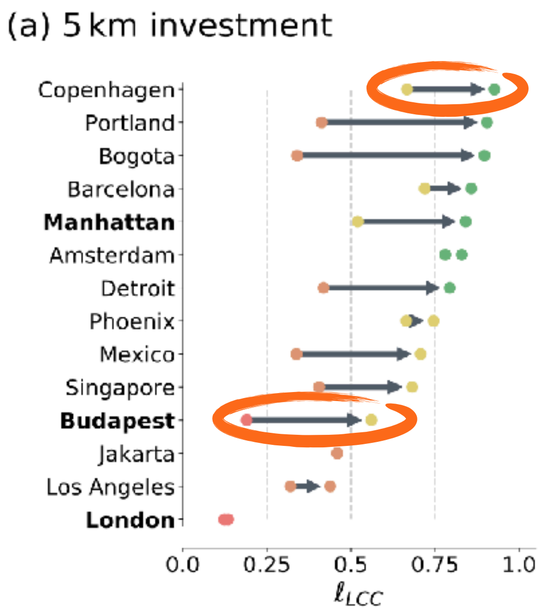
Main insights from our previous study

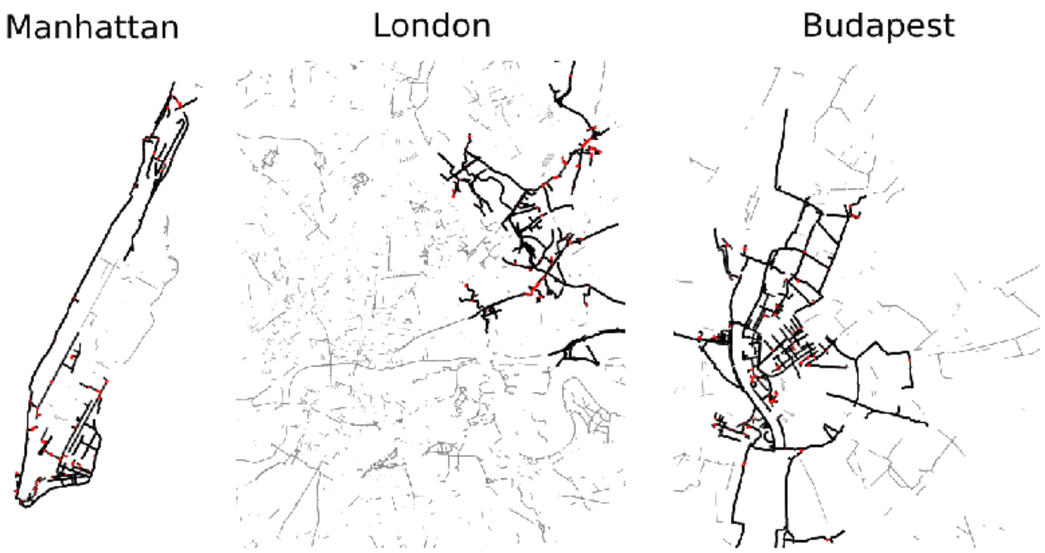
1) Fragmentation

All cities have fragmented bicycle networks, even Copenhagen

2) Effective connectivity improvements possible

In developed cities like Copenhagen, small but focused investments connect the bicycle network effectively





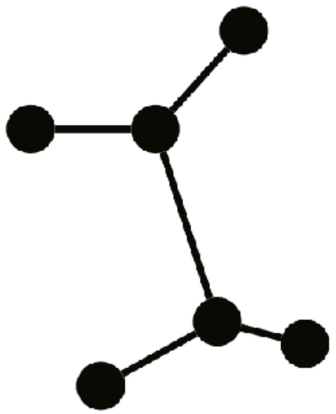
New research

Growing bicycle networks

Just connecting components comes with 3 issues

1) No resilience

Minimum spanning tree



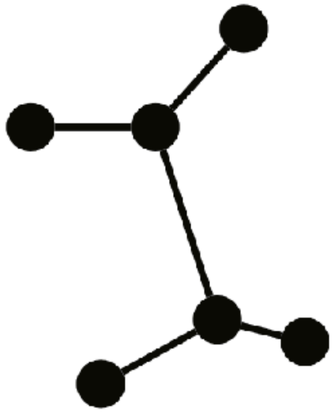
Investor's optimum

Just connecting components comes with 3 issues

1) No resilience

2) Develops only developed areas

Minimum spanning tree



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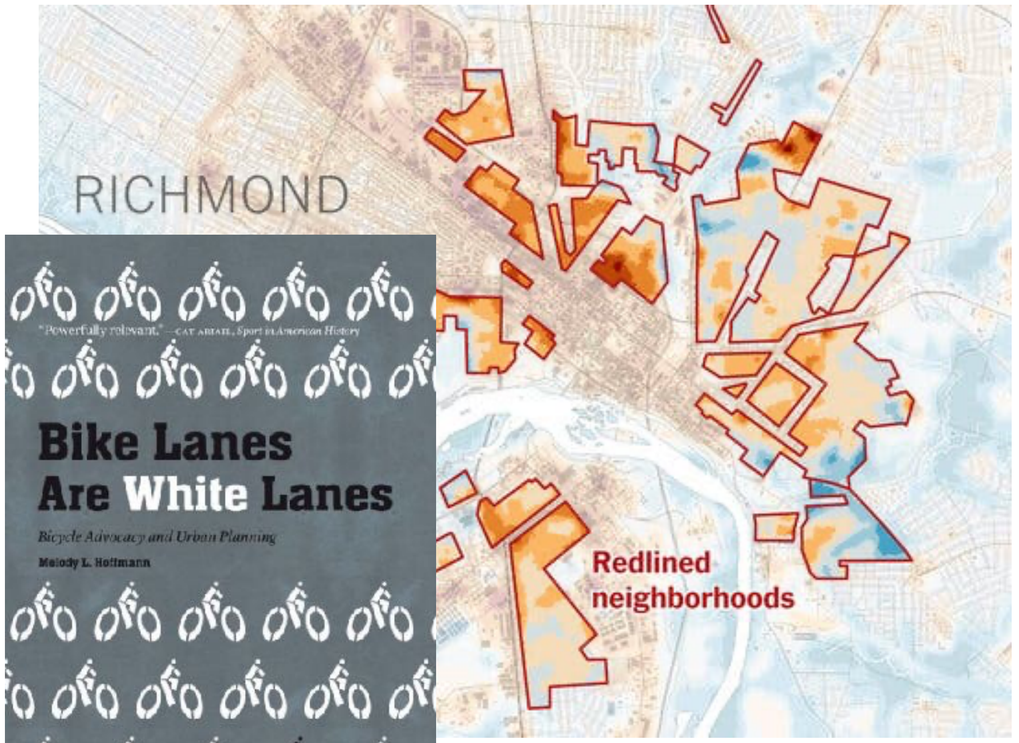

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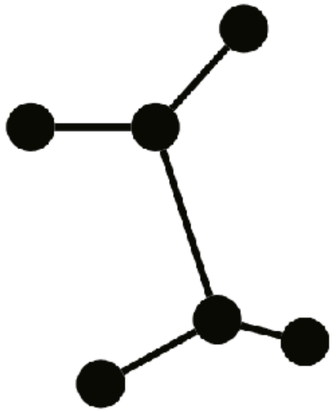

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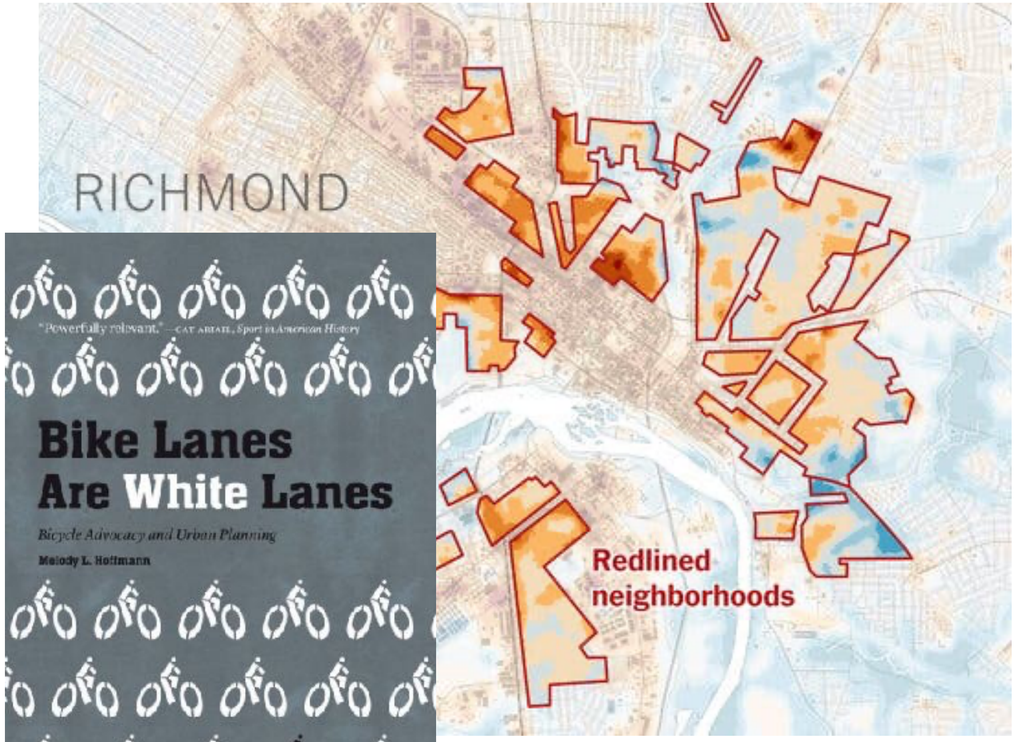
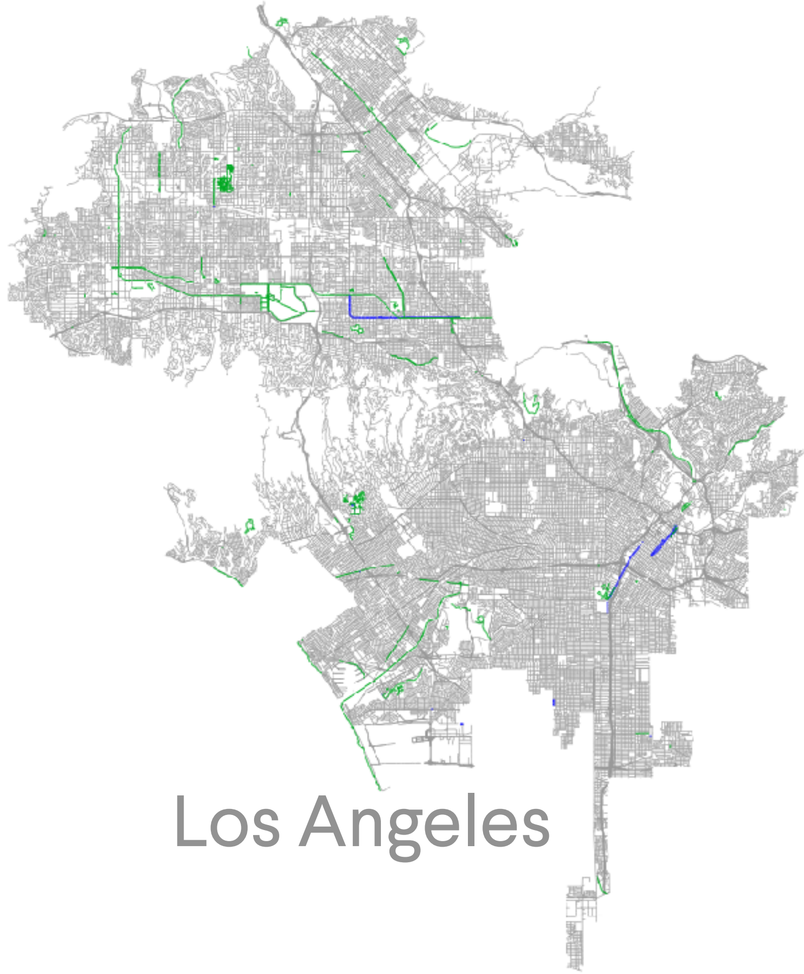


3) Irrelevant for ›99% of cities on the planet

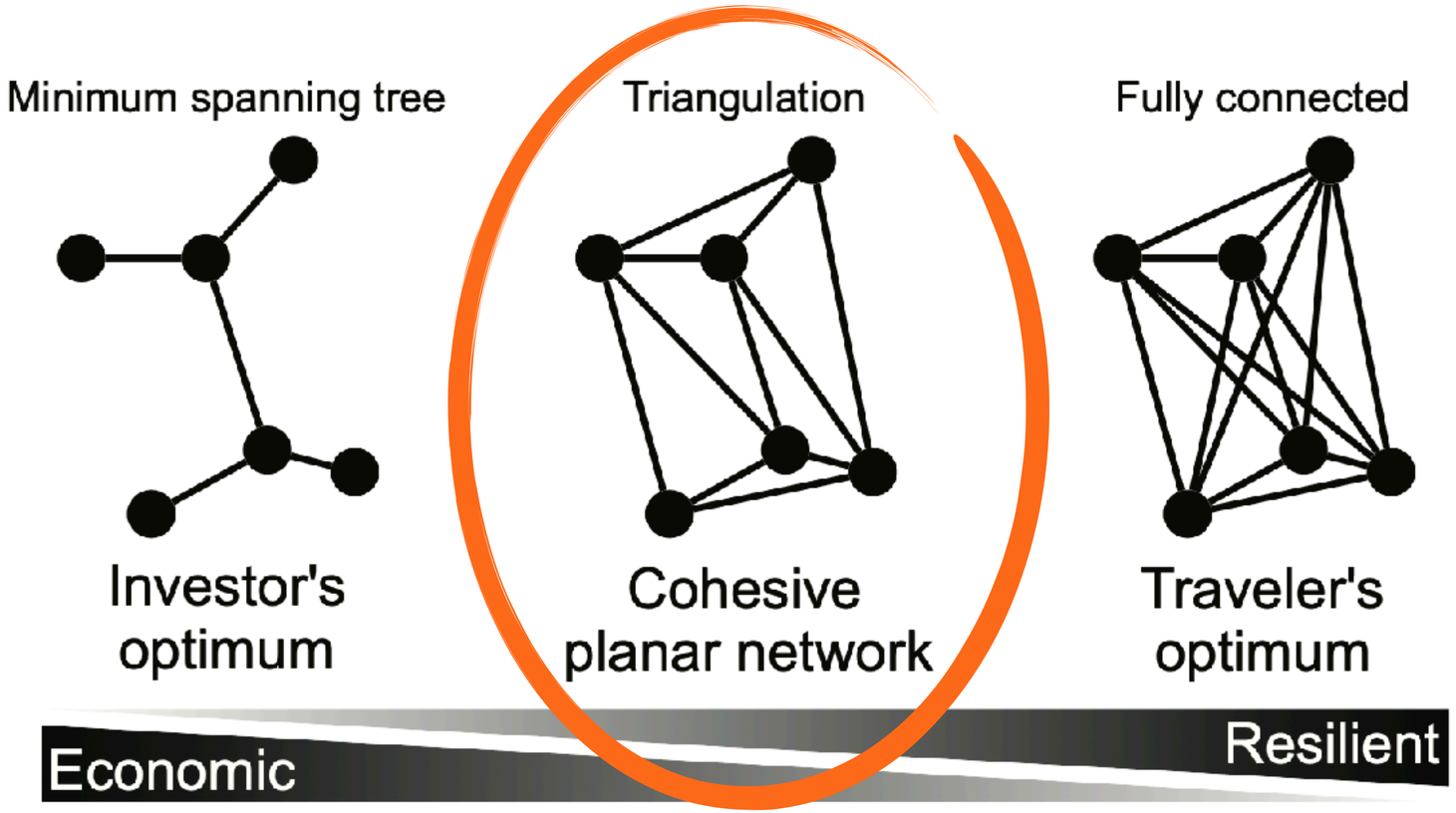


Los Angeles

Let's study growing networks
from scratch

Inspired by CROW, we want a cohesive network

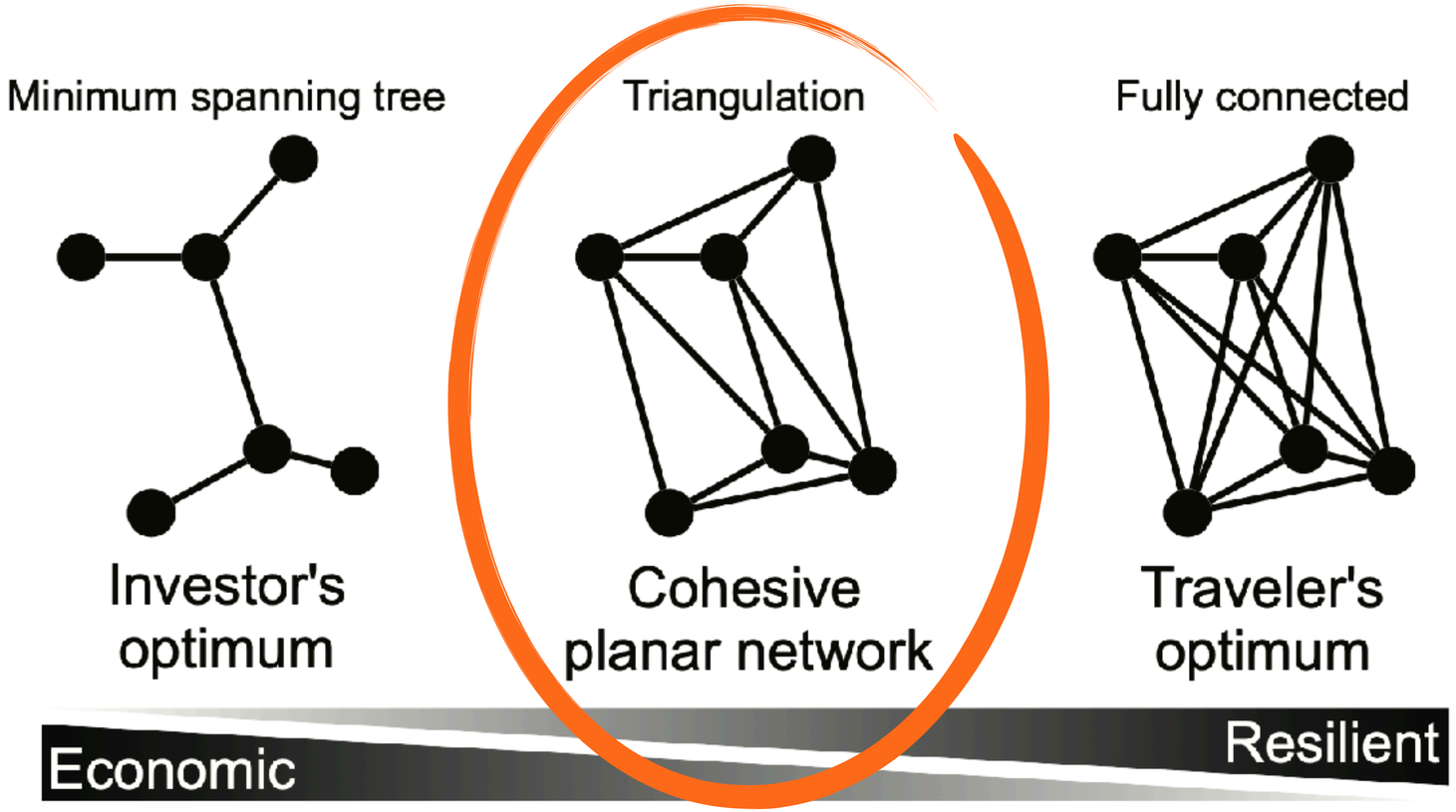
Connectedness & Resilience

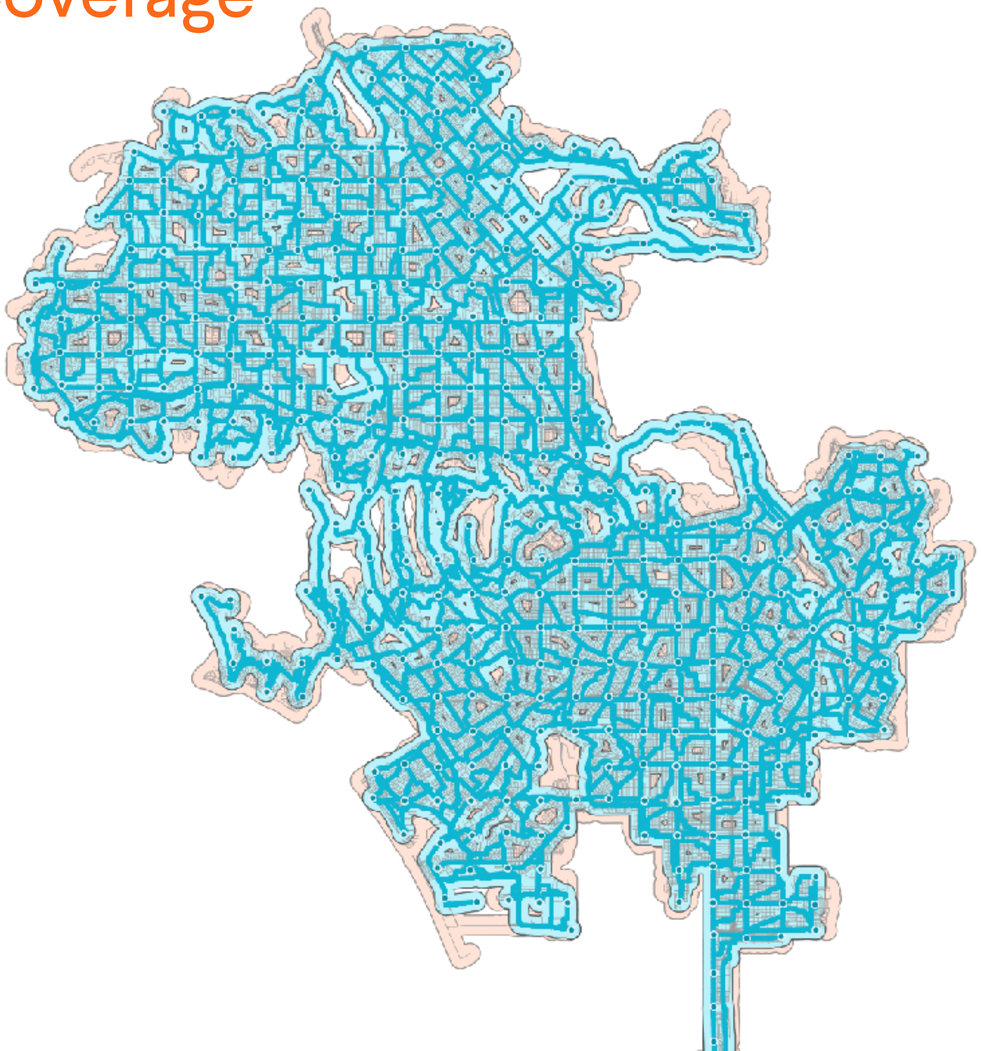


Inspired by CROW, we want a cohesive network

Connectedness & Resilience

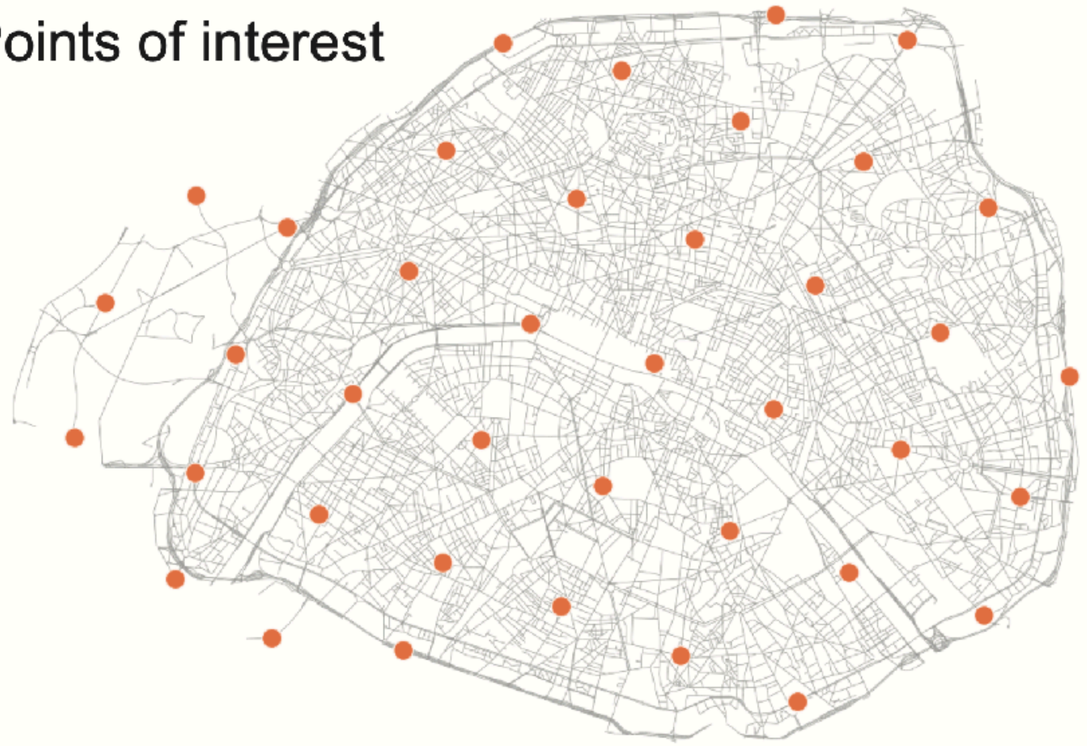
& Coverage



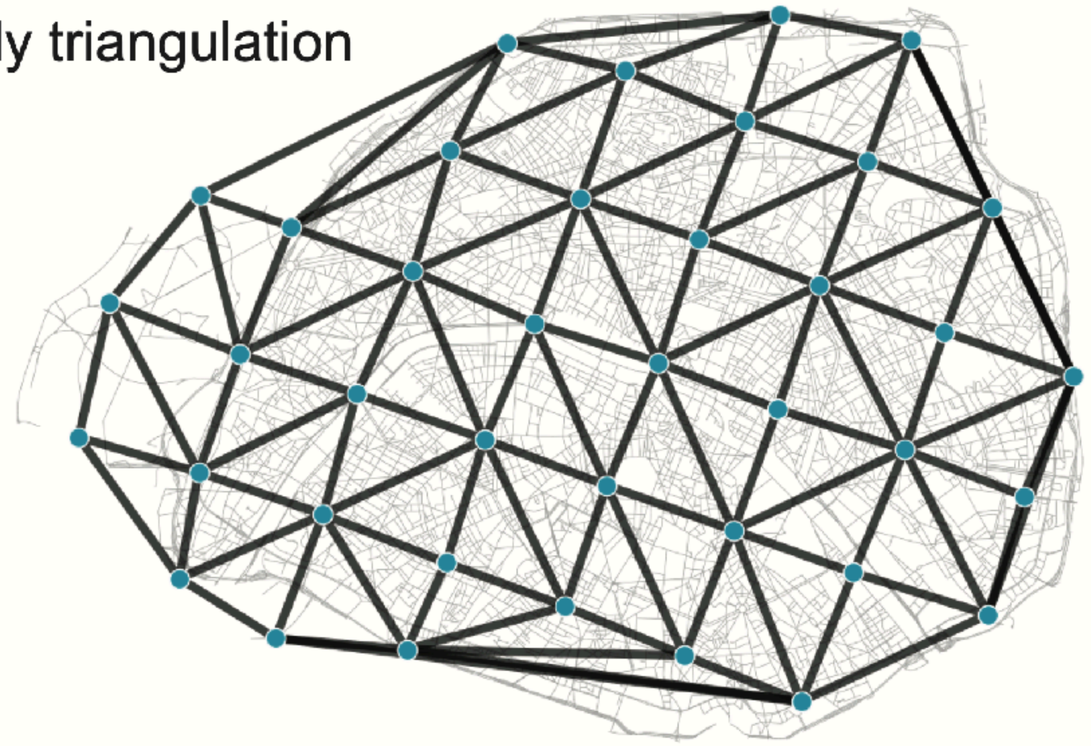


We build a greedy triangulation between points of interest

Street network &
1) Points of interest



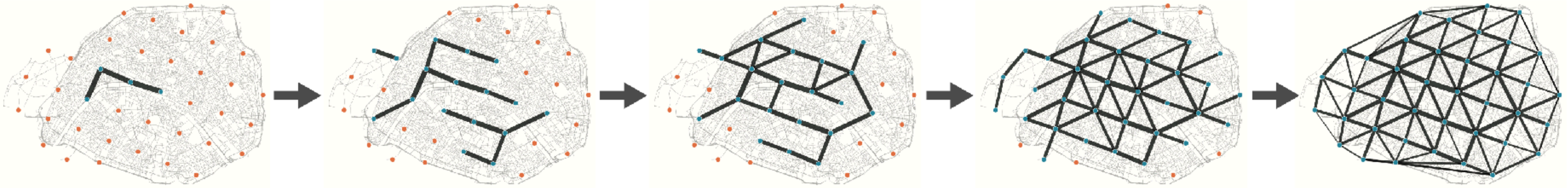
2) Greedy triangulation



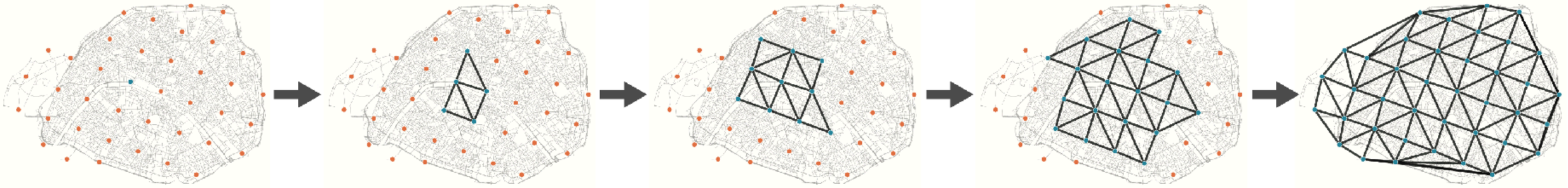
We build a greedy triangulation between points of interest

3) Order by growth strategy

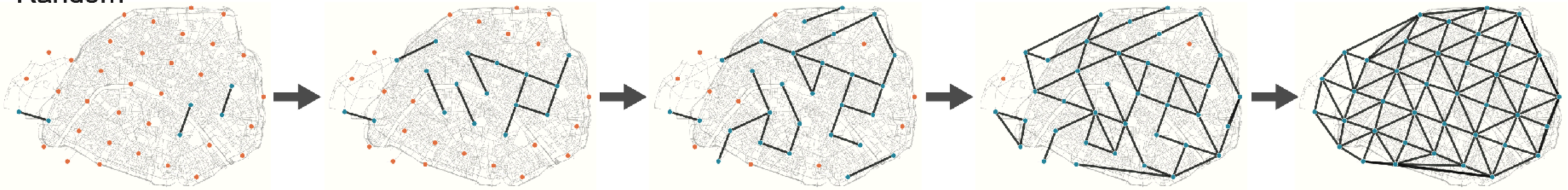
Betweenness



Closeness



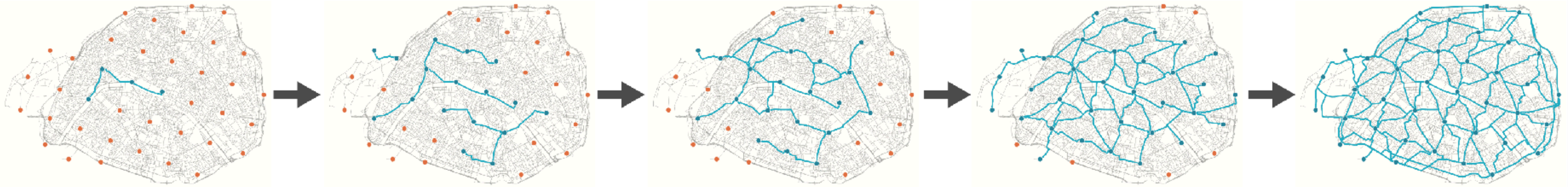
Random



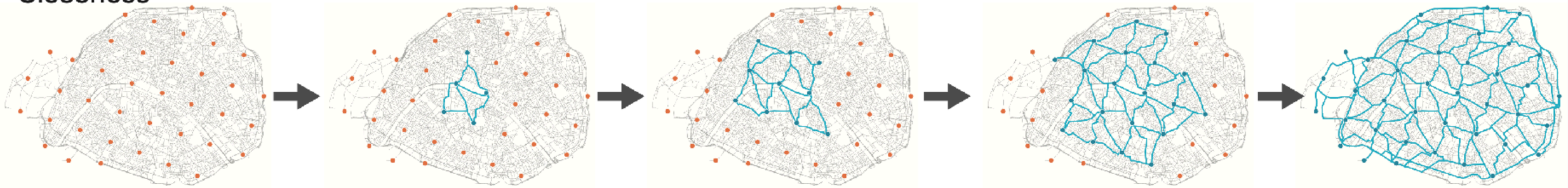
We build a greedy triangulation between points of interest

4) Route on street network

Betweenness



Closeness



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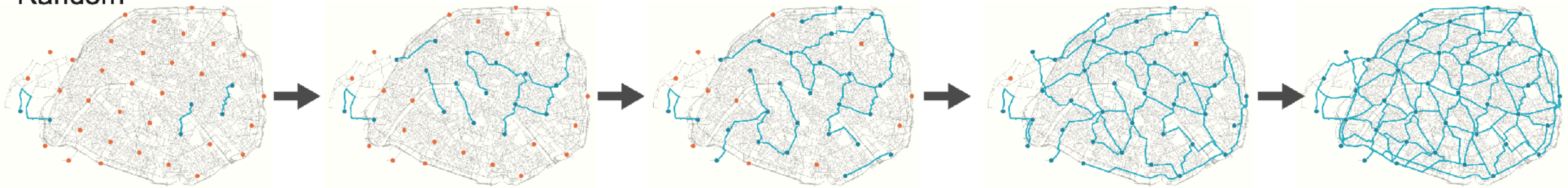
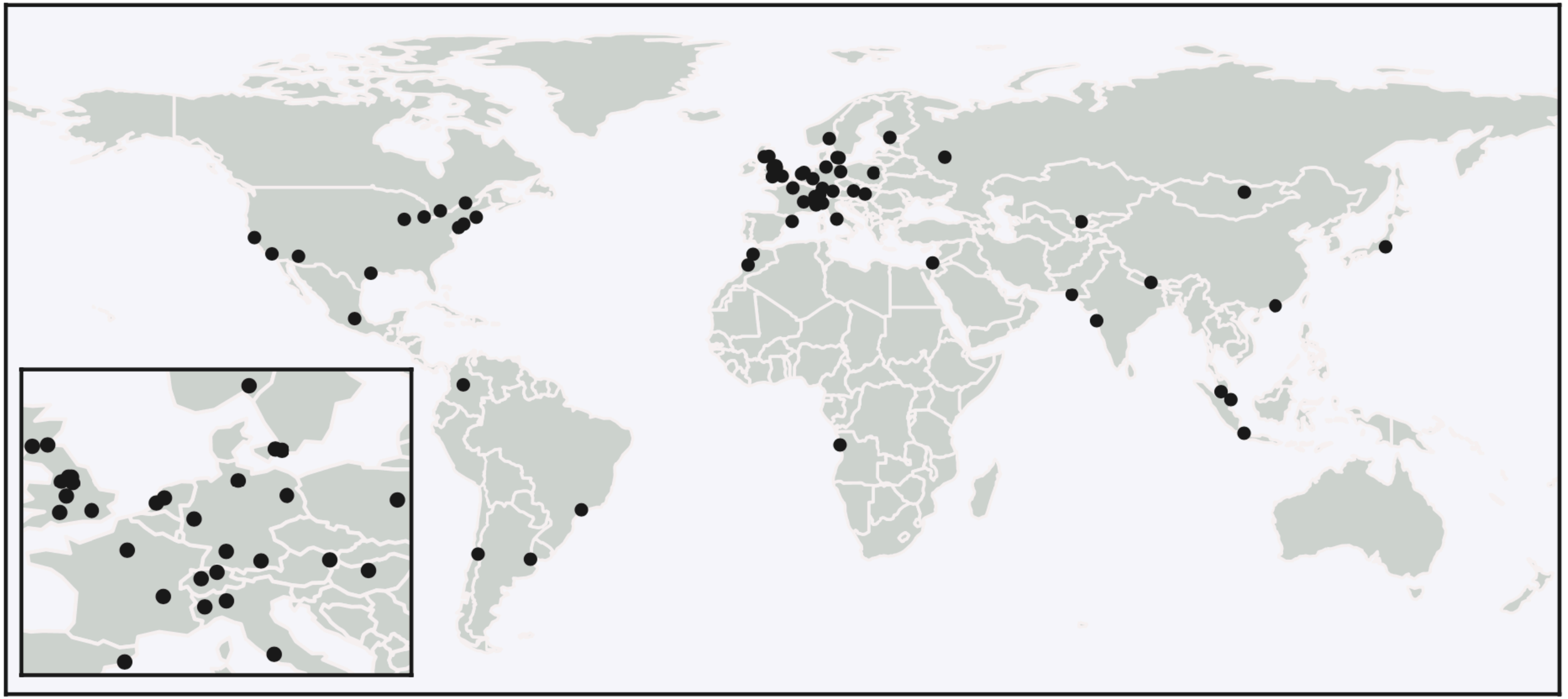
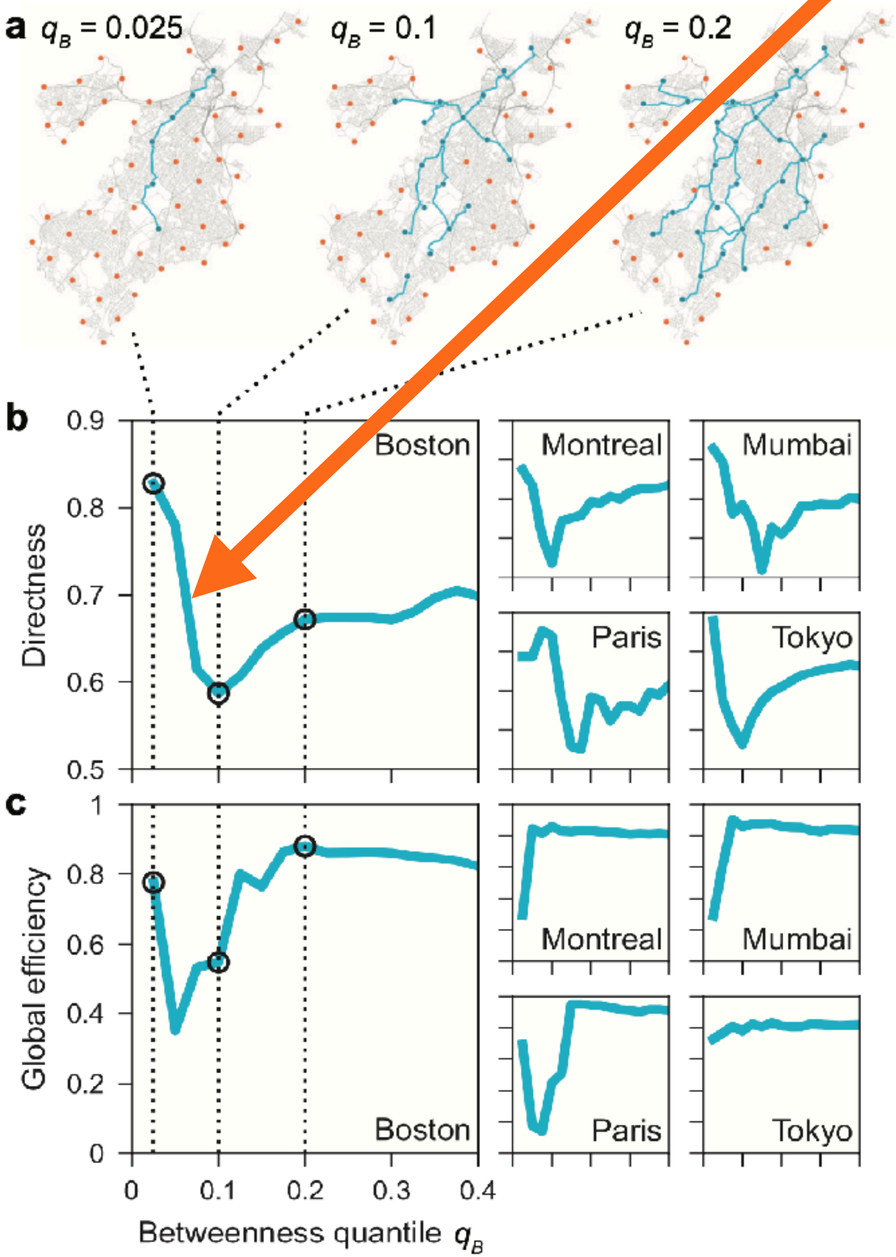


We explore 62 cities, to be general & place-independent



Result 1: First there is decreasing return of investment!



The pieces need to connect and to form cycles

Policy implication 1: Invest persistently!

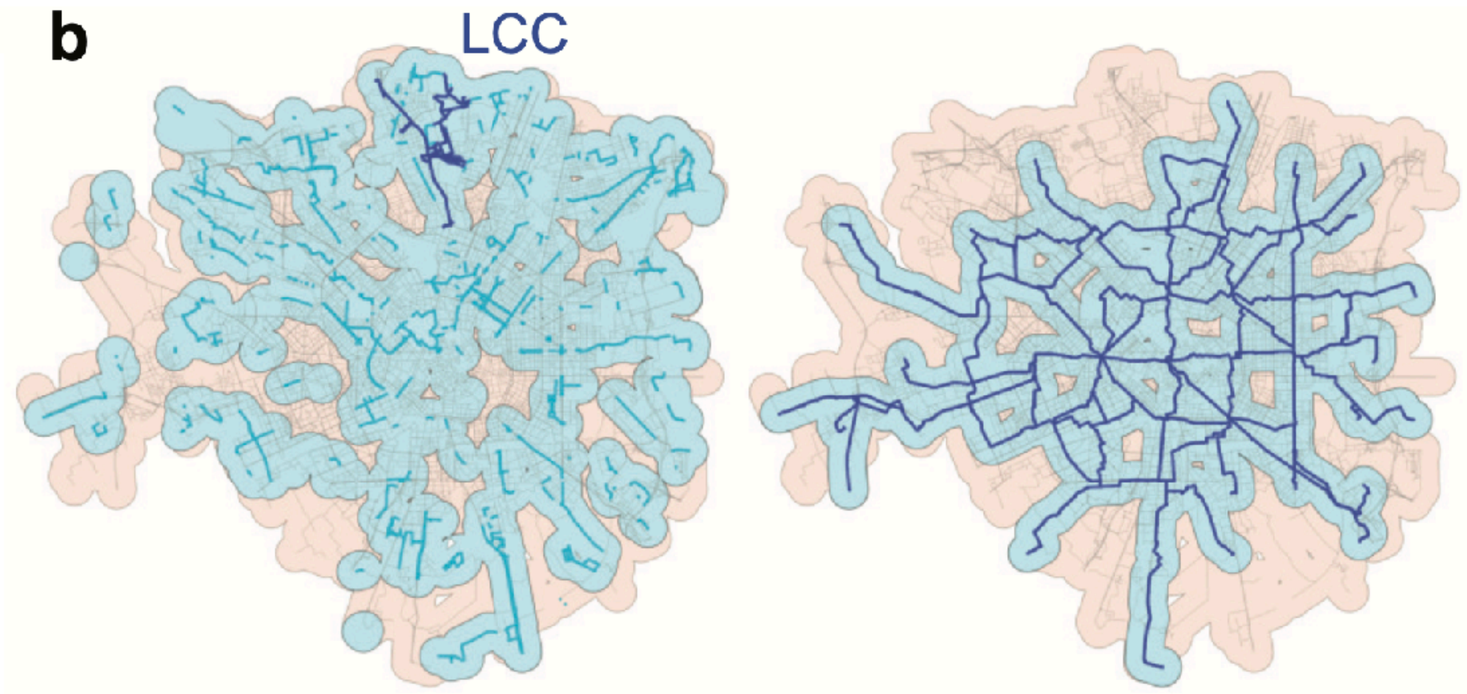
Brent Toderian @BrentToderian · Jul 30

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



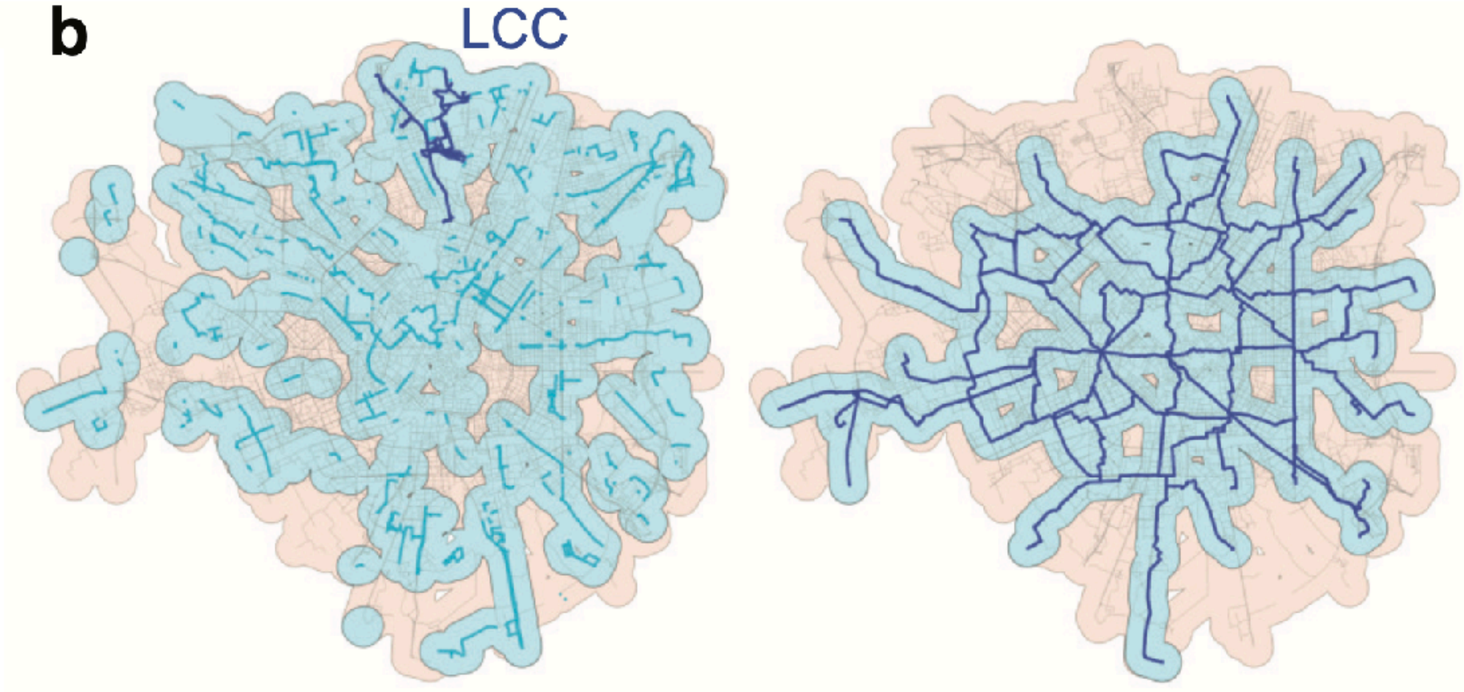
Real Milan

Synthetic Milan

Policy implication 2: Strategy matters - build for the whole city

Avoid "random-like", piecewise growth

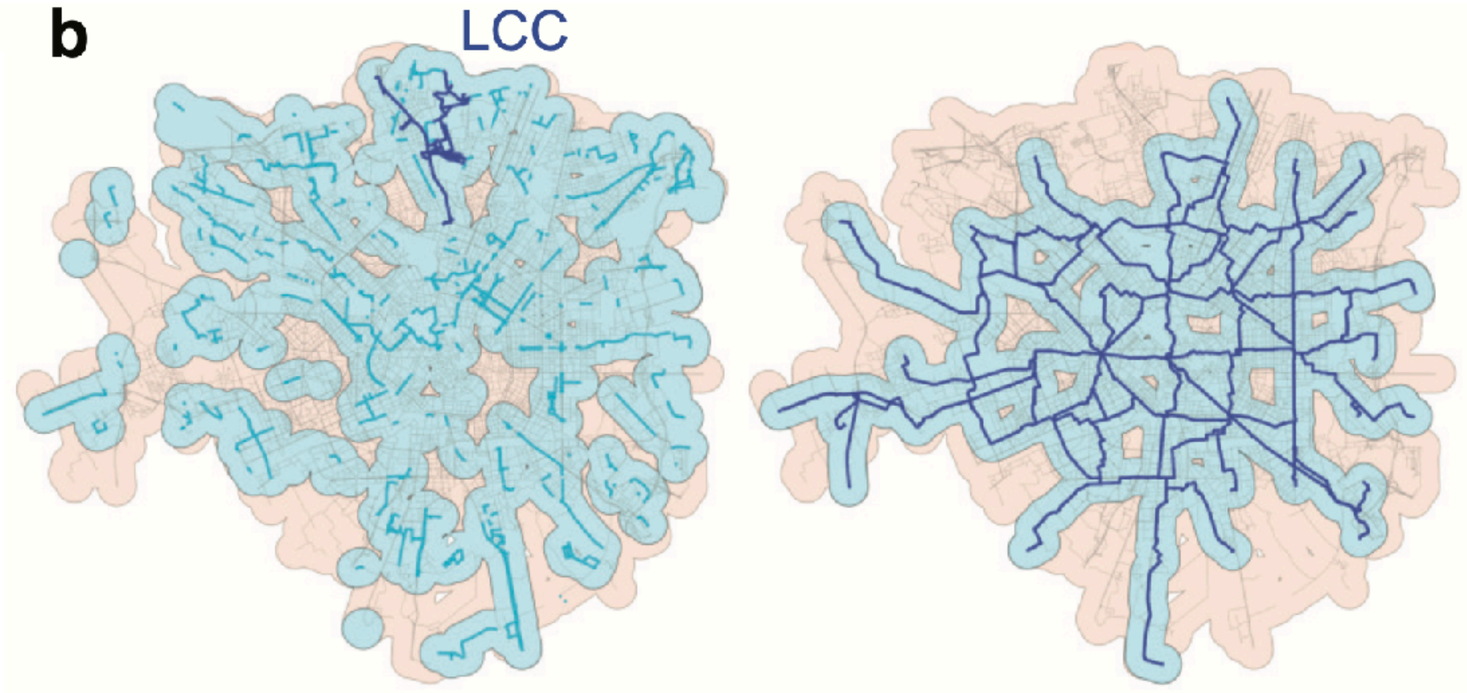
We've built many bike tracks but nobody is using them, so why build more?



Real Milan

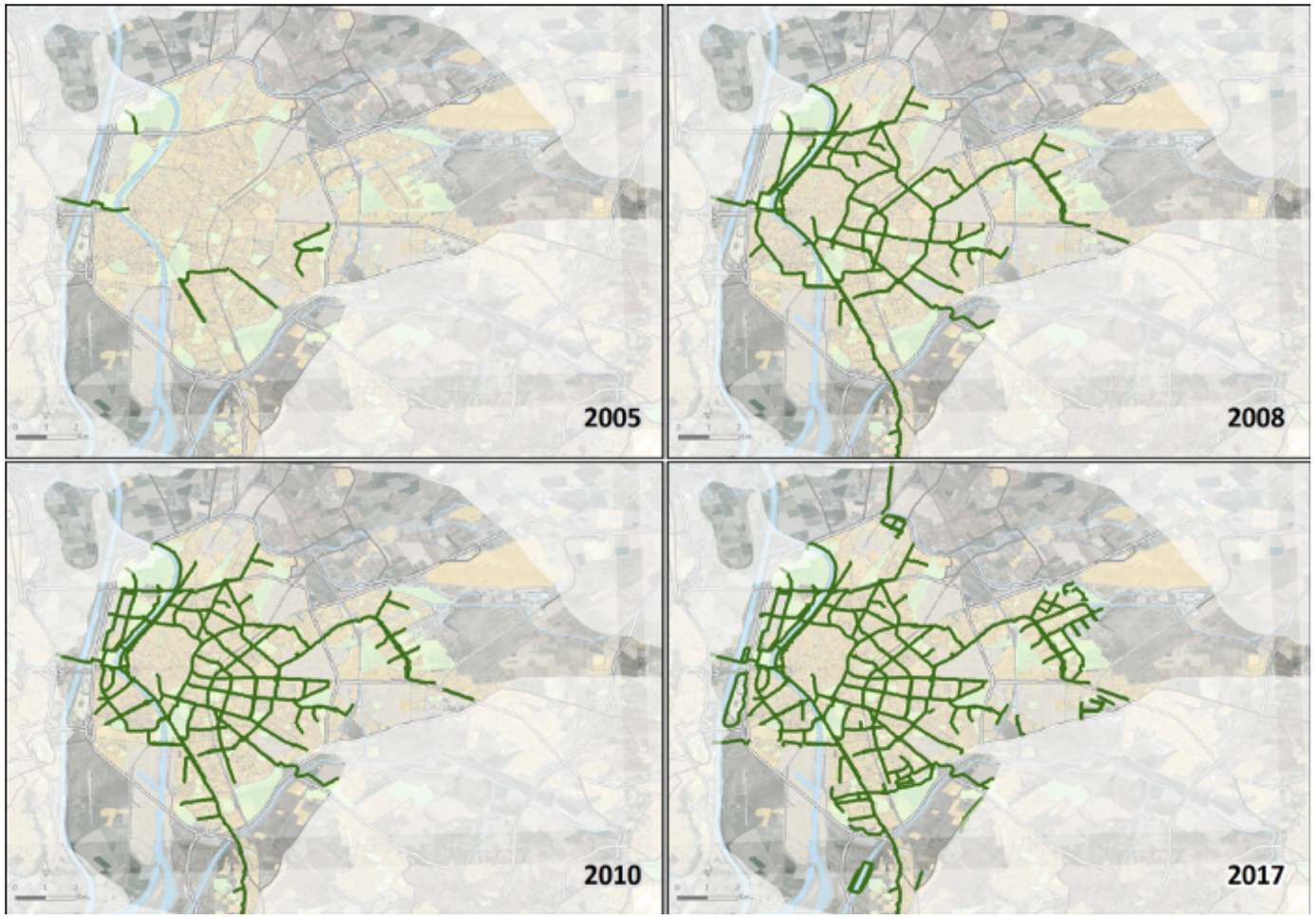
Synthetic Milan

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



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
- Green spaces
- ....

Open-sourced at:

https://github.com/mszell/bikenwgrowth

Explore your city at GrowBike.Net

Download the preprint

https://arxiv.org/abs/2107.02185




Growing Urban Bicycle Networks

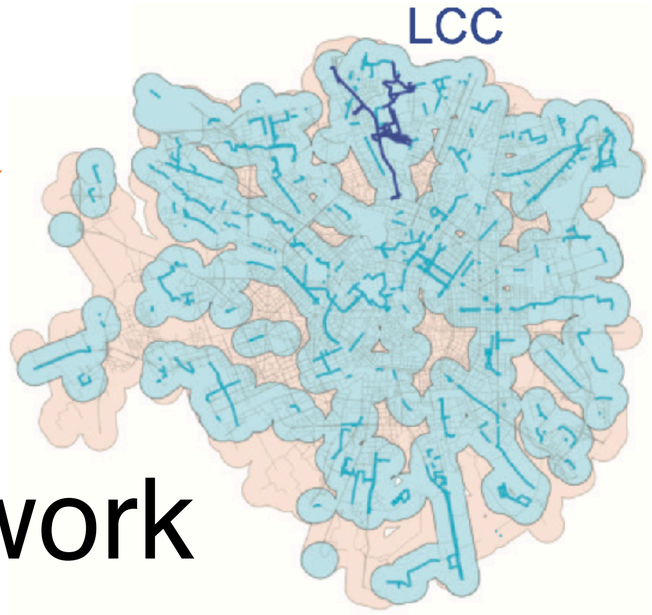
Michael Szell[*a,b], Sayat Mimar[c], Tyler Perlman[c], Gourab Ghoshal[c], and Roberta Sinatra[a,b]

[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*

Bicycle network planning is about both politics and geometry

Politics

Network geometry



Bicycle research at NERDS, ITU Copenhagen

NERDS = NEtwoRks, Data, and Society

nerds.itu.dk

Anastassia Vybornova

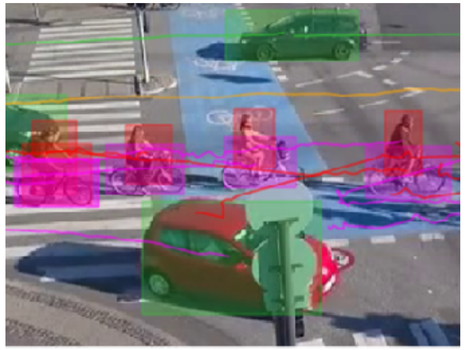
Network algorithms for the identification and classification of gaps in urban bicycle networks based on OSM data

Oct 15, 10:40, Session 2.5: Bicycle network analysis

Bojan Kostic

Analysing cyclist behavior at signalized intersections using computer vision

Oct 14, 15:30, Session 2.4: Modelling bicycle traffic



Michael Szell

The geometric limits of growing urban bicycle networks

Oct 15, 11:00, Session 2.5: Bicycle network analysis

Ane Rahbek Vierø (currently at Aalborg University)

Cyclists' access to everyday amenities

Oct 15, 10:00, Session 2.5: Bicycle network analysis

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