IT and Green Transitions, Fall 2022

Lecture 3: Sustainable Mobility and Data-driven Planning

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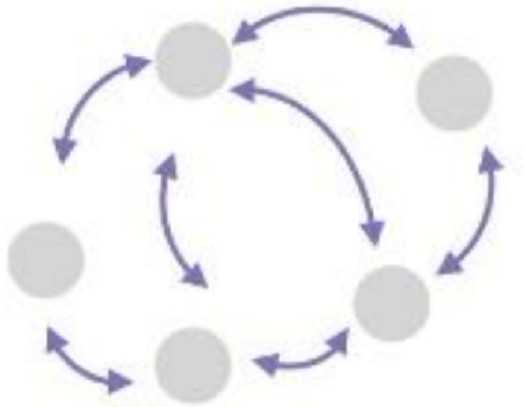
Sep 13, 2022

IT UNIVERSITY OF COPENHAGEN

Today you will learn about IT and sustainable mobility

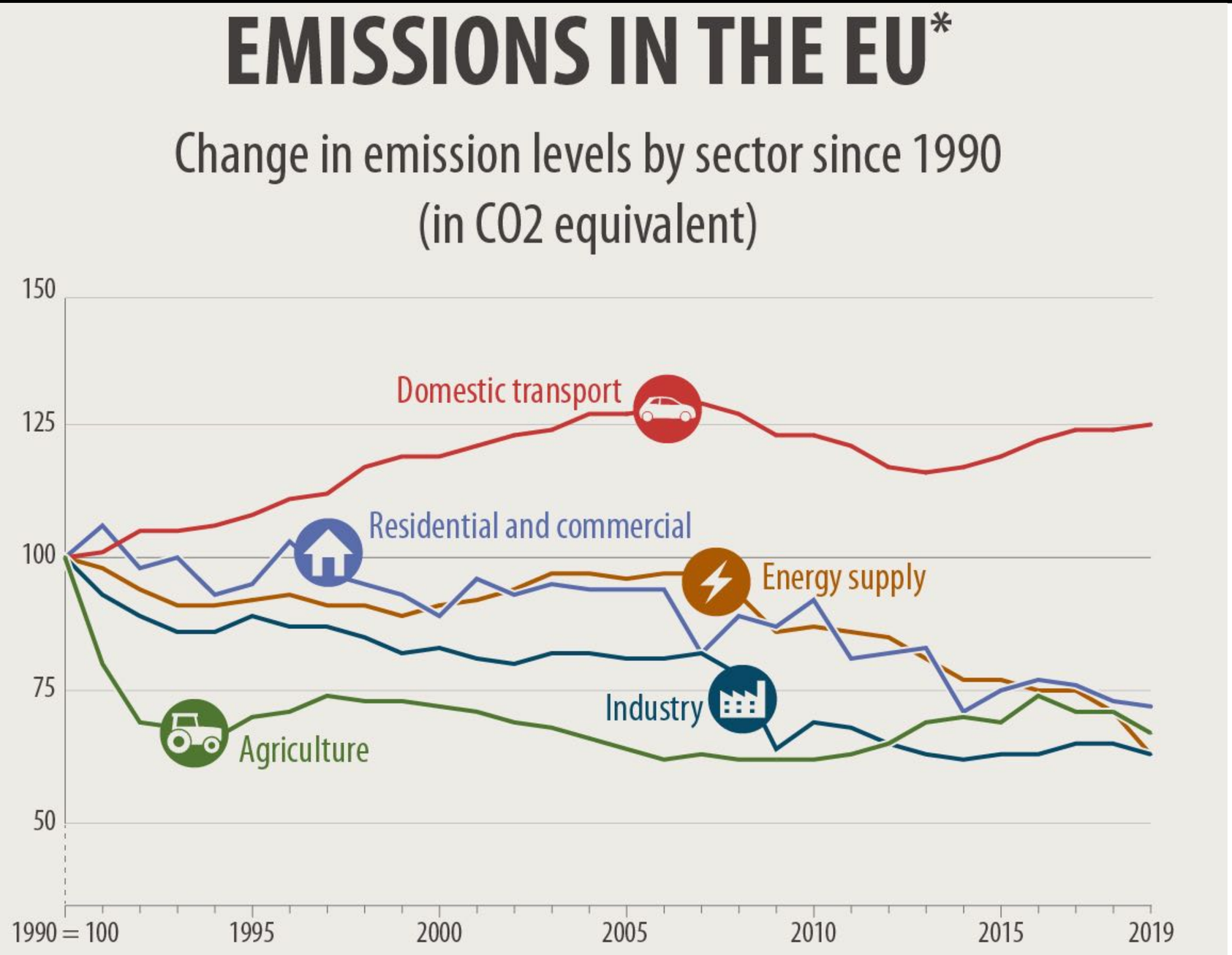
Part I: Bicycle network planning with data science

Part II: Systems thinking, induced demand, priorities



Exercise: How to grow a bike network? How to change the world?

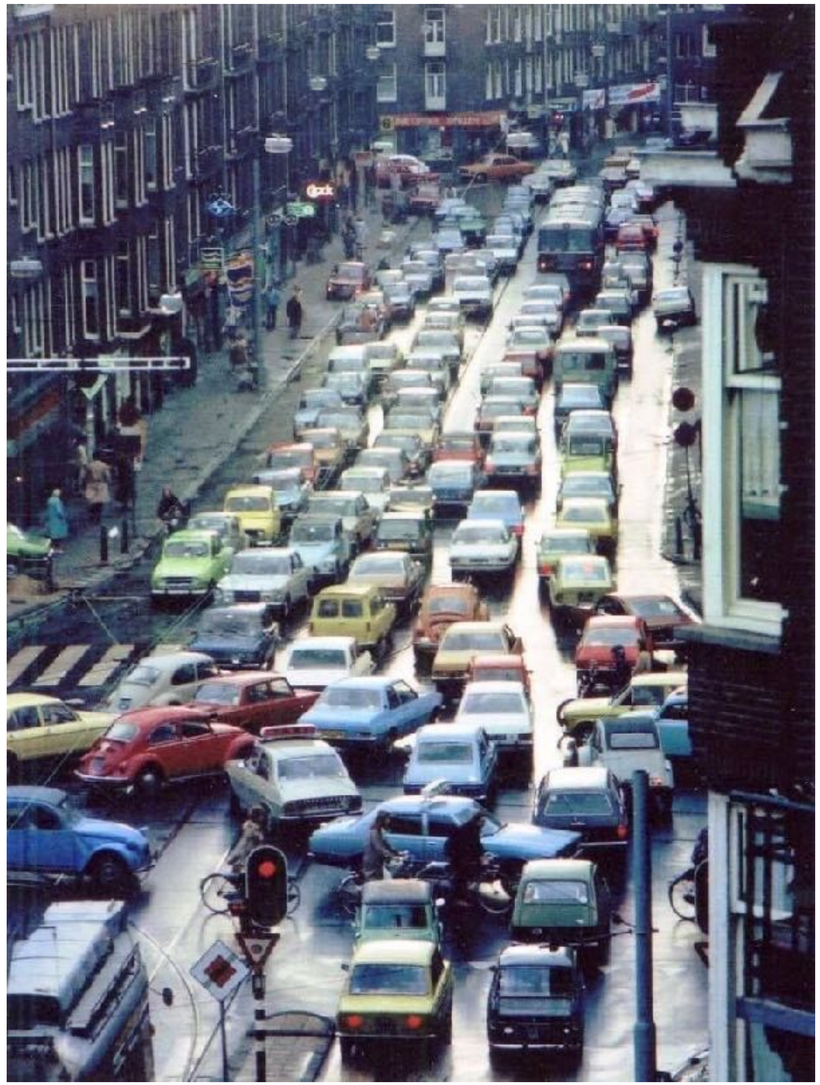
Transport plays a key role in the climate crisis



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

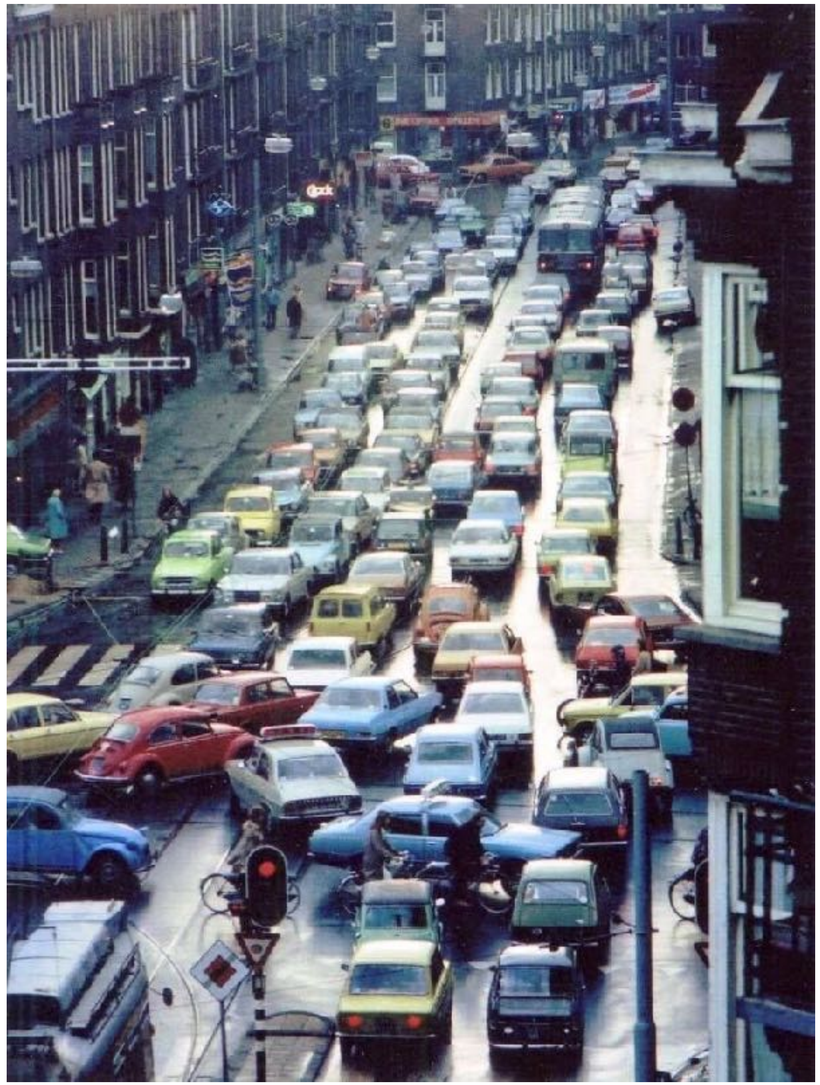
https://ec.europa.eu/clima/policies/transport_en

Which European city is this?



MENTIMETER

Amsterdam



1978

Today

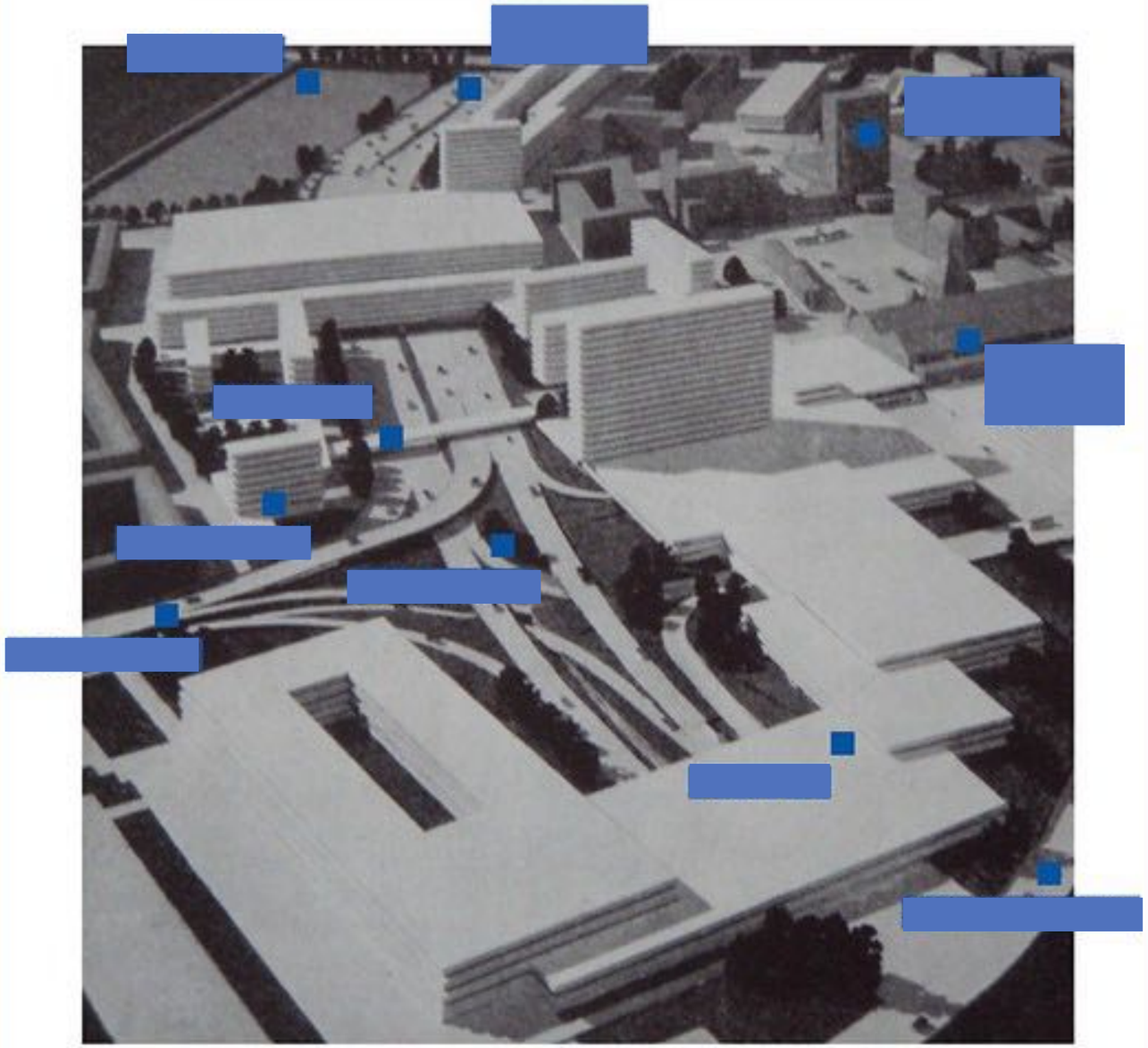
Amsterdam

1920

1978

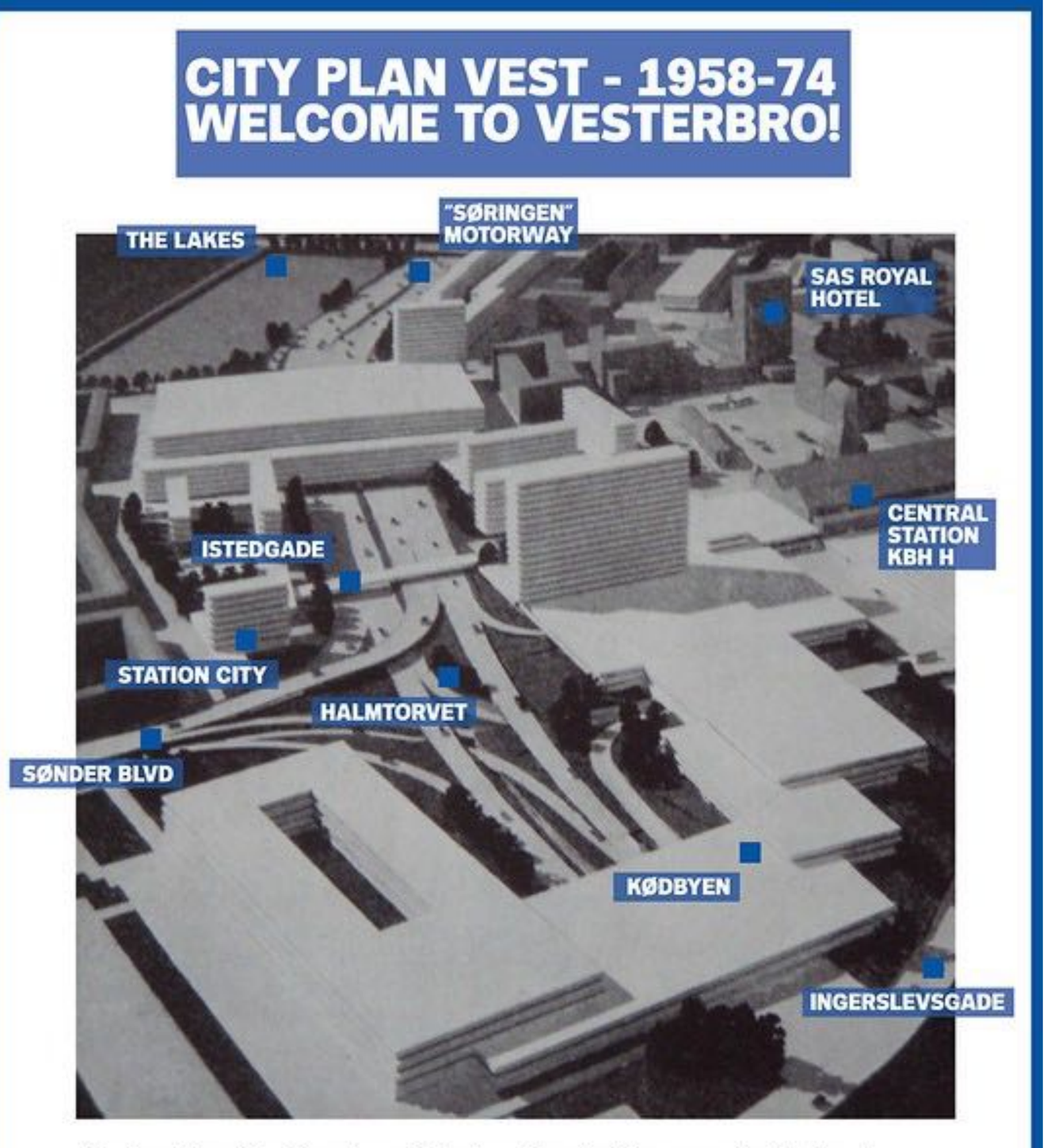
2015

https://www.fastcompany.com/3052699/these-historical-photos-show-how-amsterdam-turned-itself-into-a-bike-riders-paradise



?

Søringen



https://monocle.com/radio/shows/the-urbanist/tall-stories-322/

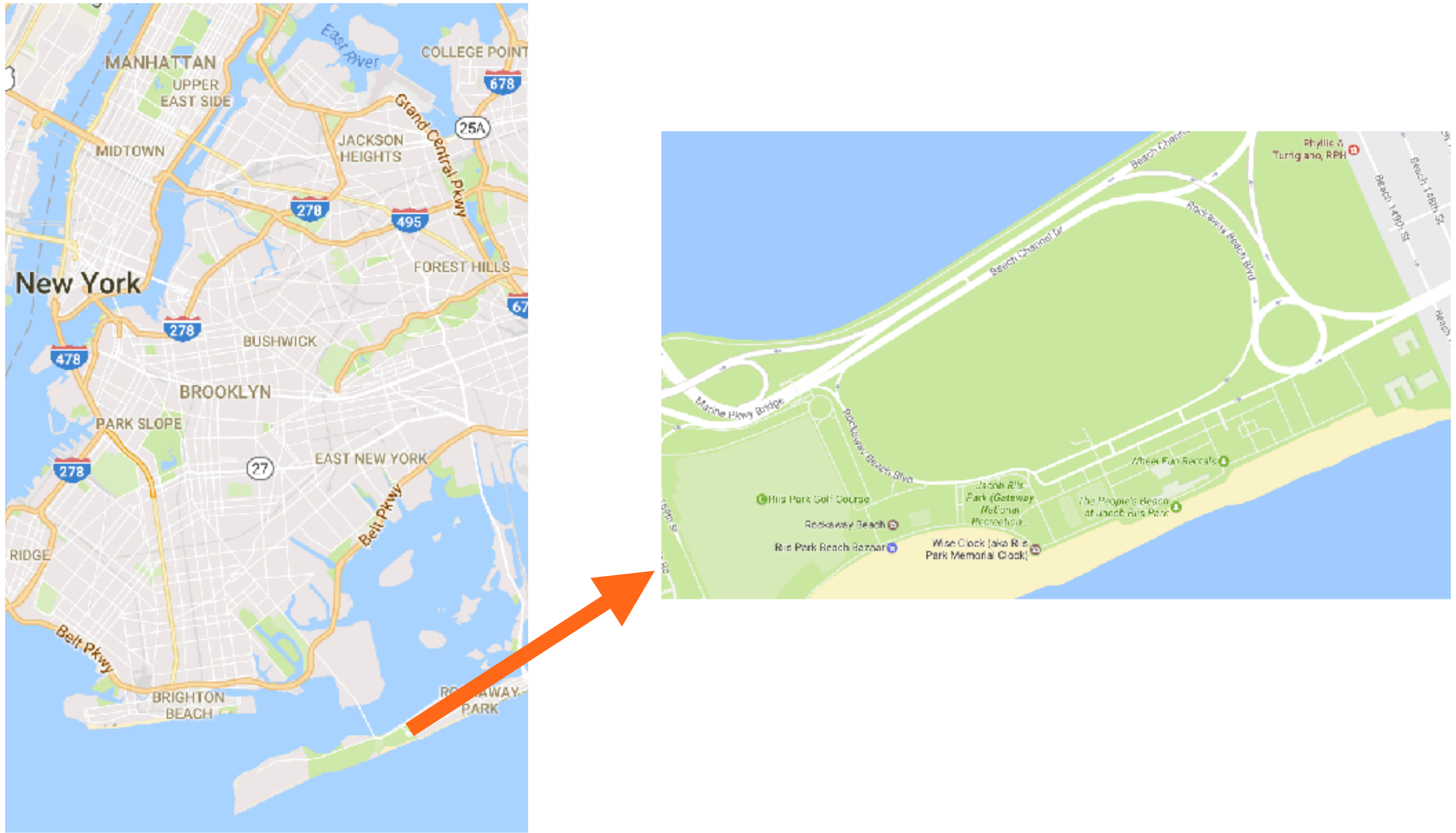
http://www.copenhagenize.com/2012/11/city-plan-vest-and-sringen-1958-1974.html

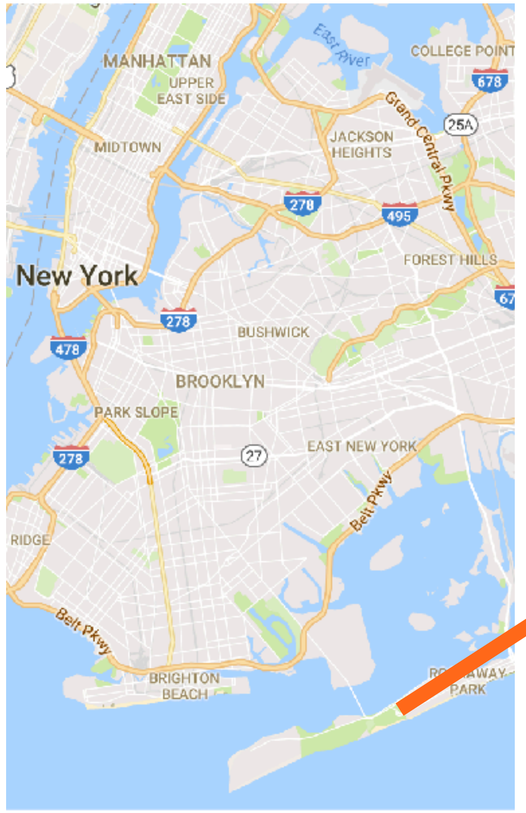

B 14 546
DK
A 19 676
K 80 502

Why is a city planned with a focus on cars not sustainable*?

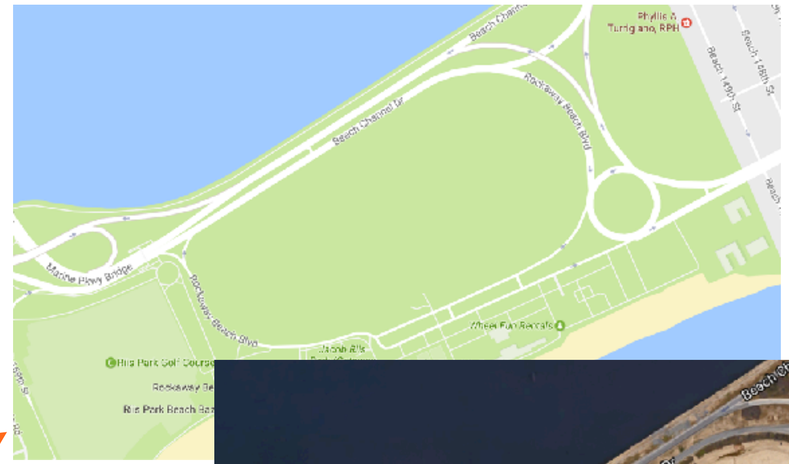
*sustainable system = system with the possibility to continue a specific behaviour over long periods of time

SPACE

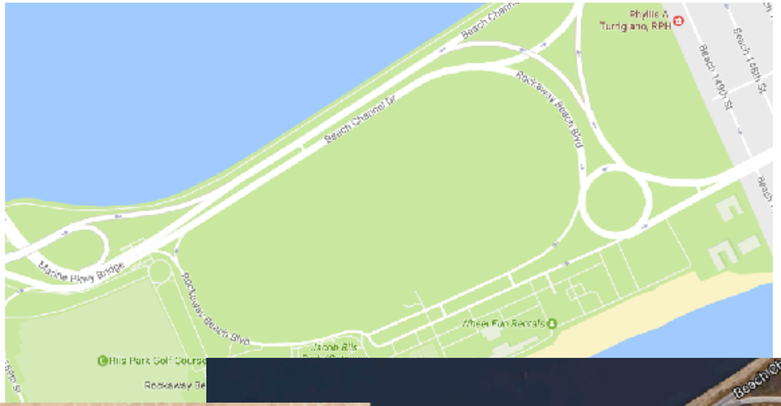

MANHATTAN
UPPER EAST SIDE
East River
COLLEGE POINT
678
25A
Grand Central Pkwy
JACKSON HEIGHTS
MIDTOWN
278
495
FOREST HILLS
New York
278
478
BUSHWICK
BROOKLYN
PARK SLOPE
278
27
EAST NEW YORK
Belt Pkwy
RIDGE
Belt Pkwy
BRIGHTON BEACH
Beach Channel Dr
Rockaway Beach Blvd
Marine Pkwy Bridge
Rockaway Beach
Wheel Fun Rentals

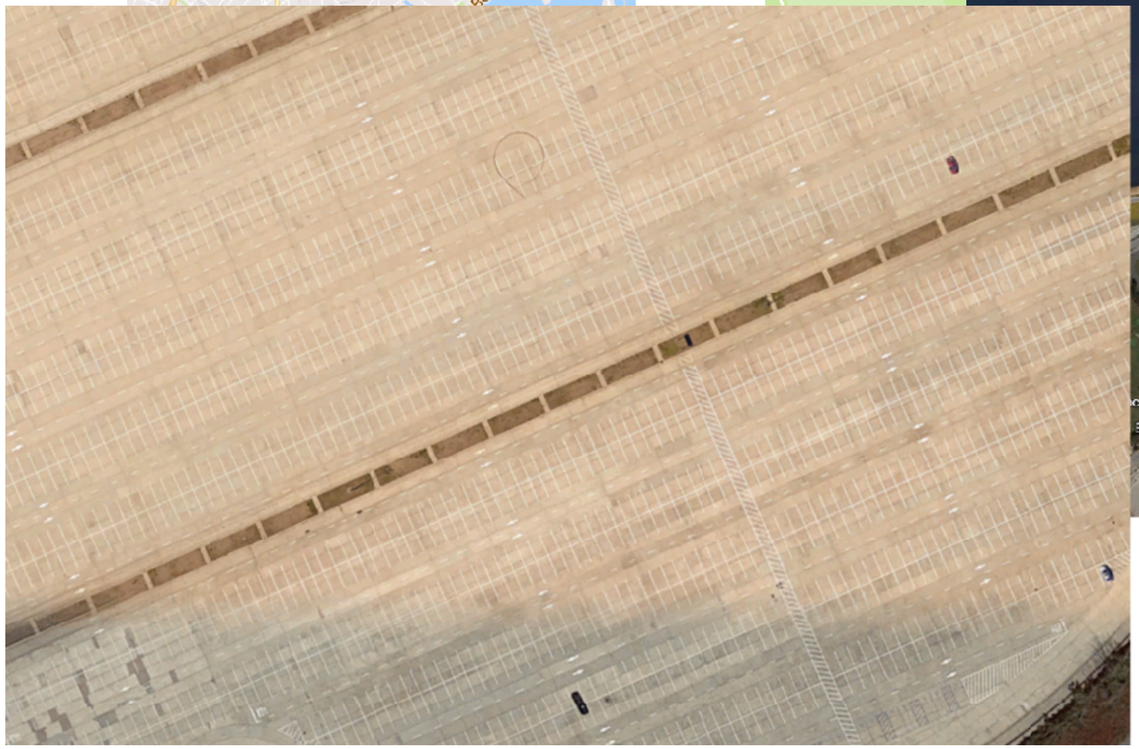


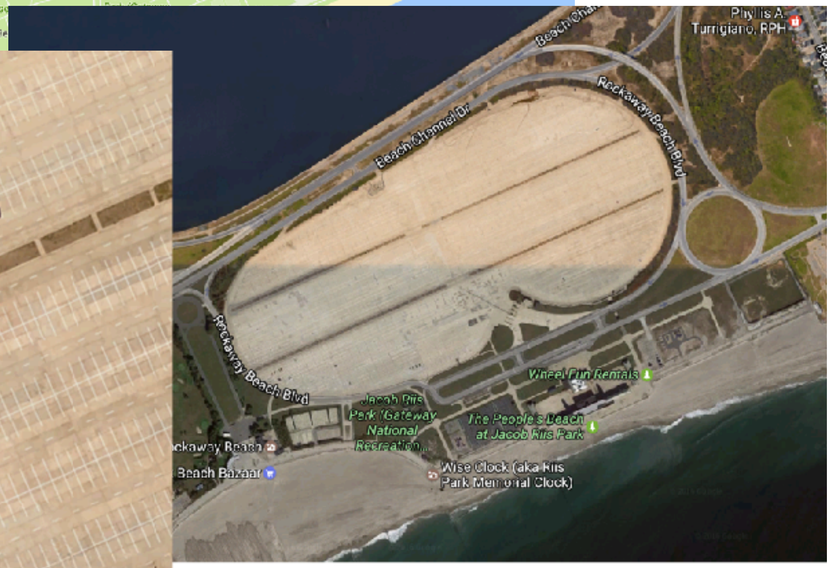
What a lovely ~~green~~..



What a ~~lovely~~ ~~green~~.. MONSTER







800m x 500m


MANHATTAN
UPPER EAST SIDE
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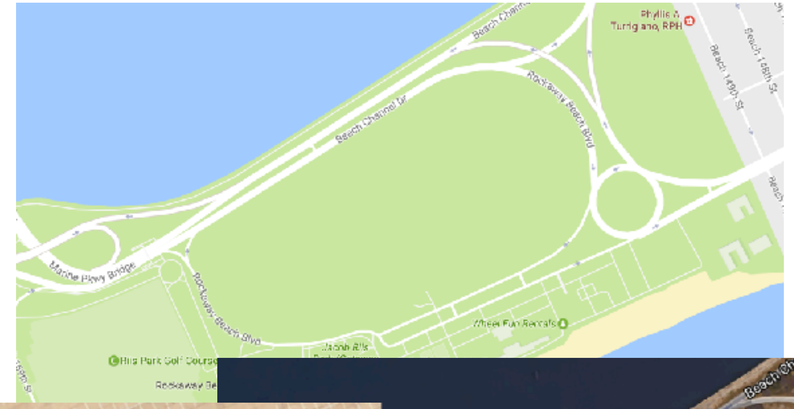
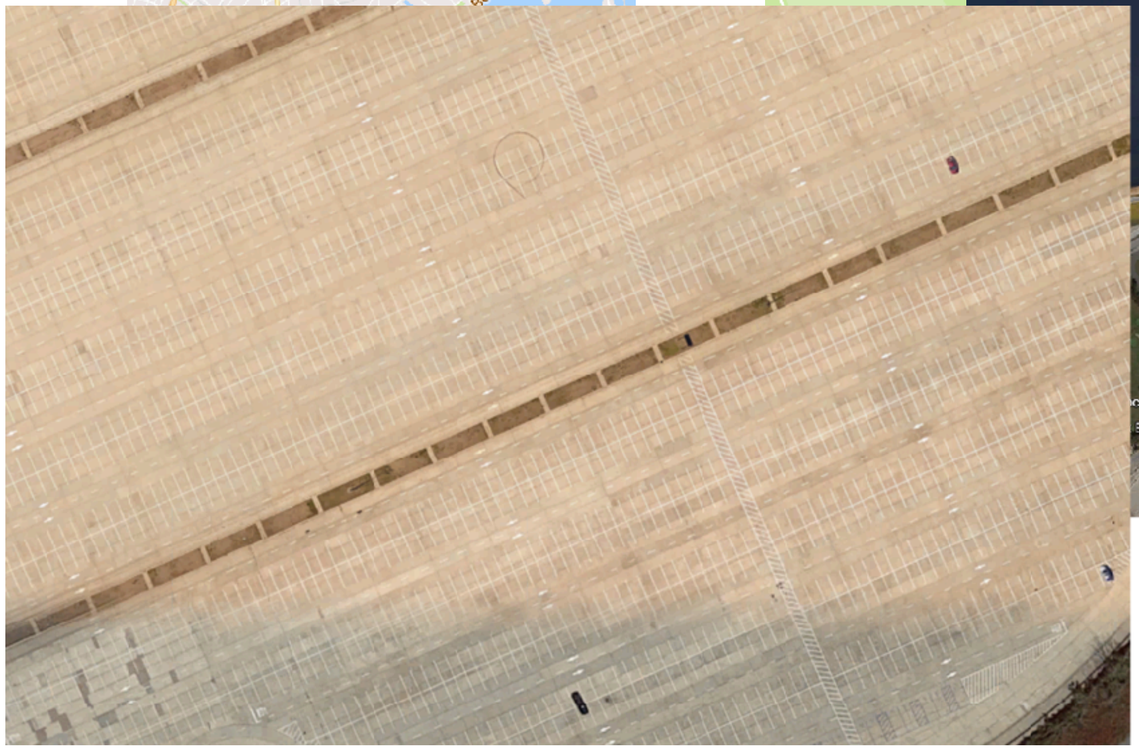

Beach Channel Dr
Rockaway Beach Blvd
Marine Pkwy Bridge
Rockaway Beach Blvd
Wheel Fun Rentals

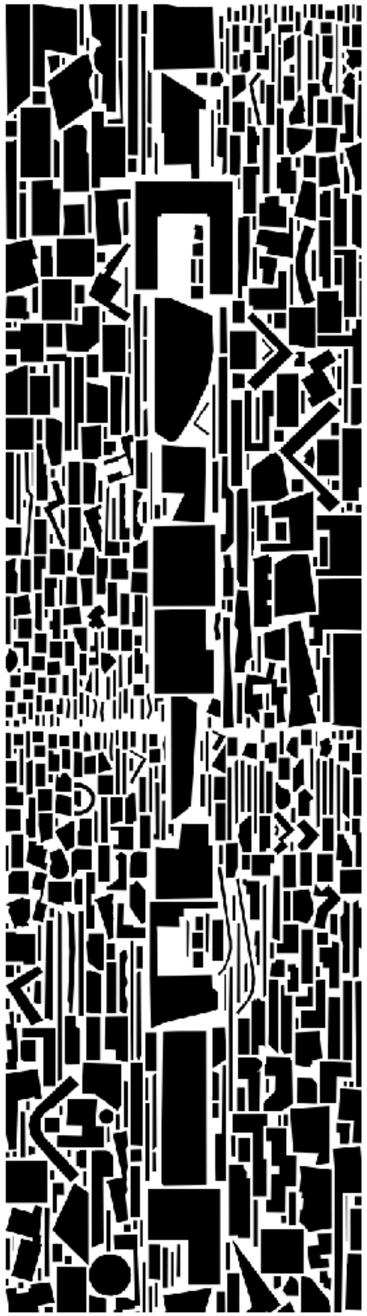


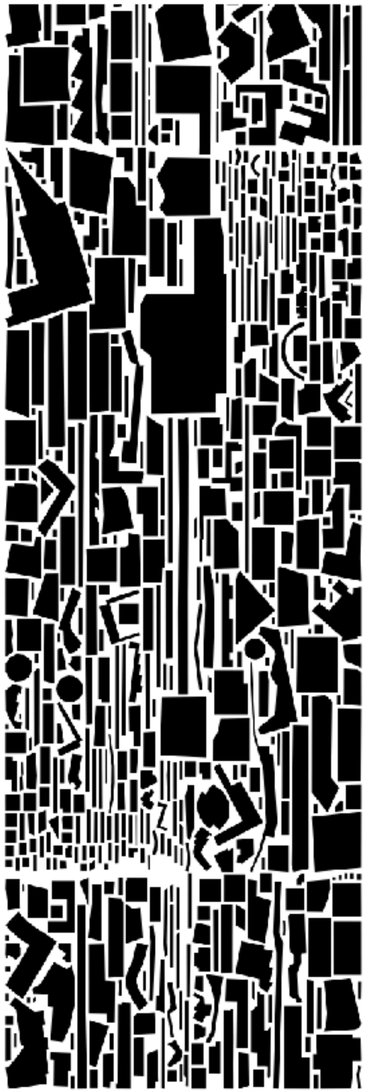

Beach Channel Dr
Rockaway Beach Blvd
Wheel Fun Rentals
The People's Beach at Jacob Riis Park
Beach Bazaar
Wise Clock (aka Riis Park Memorial Clock)

We visualized ALL parking spaces with polygon packing

Copenhagen

What the Street!?
http://whatthestreet.moovellab.com



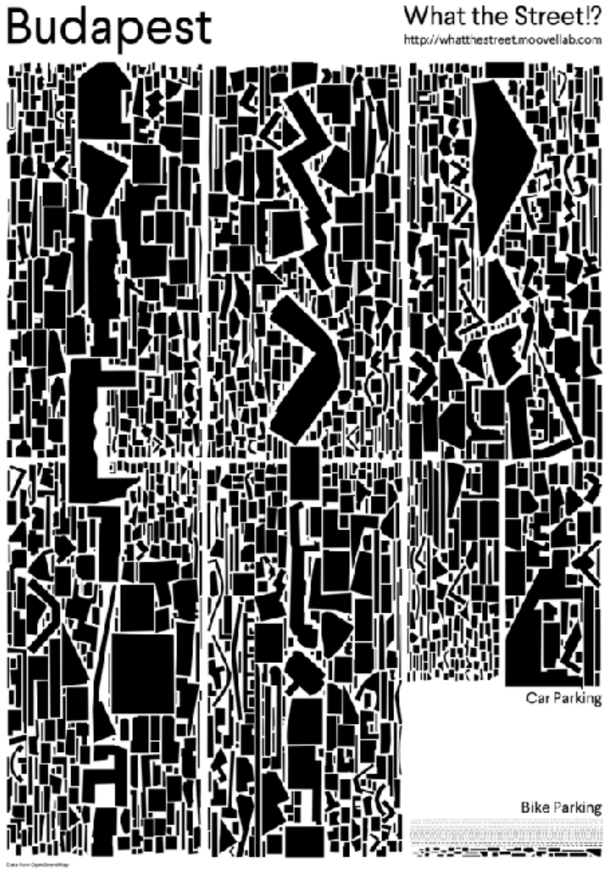


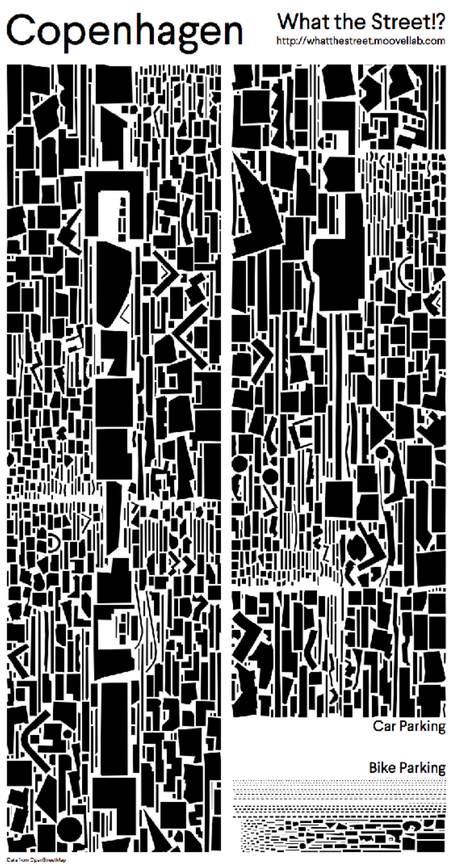
Car Parking

Bike Parking

Data from OpenStreetMap

There are huge differences between car and bike parking





There are huge differences bet d bike parking

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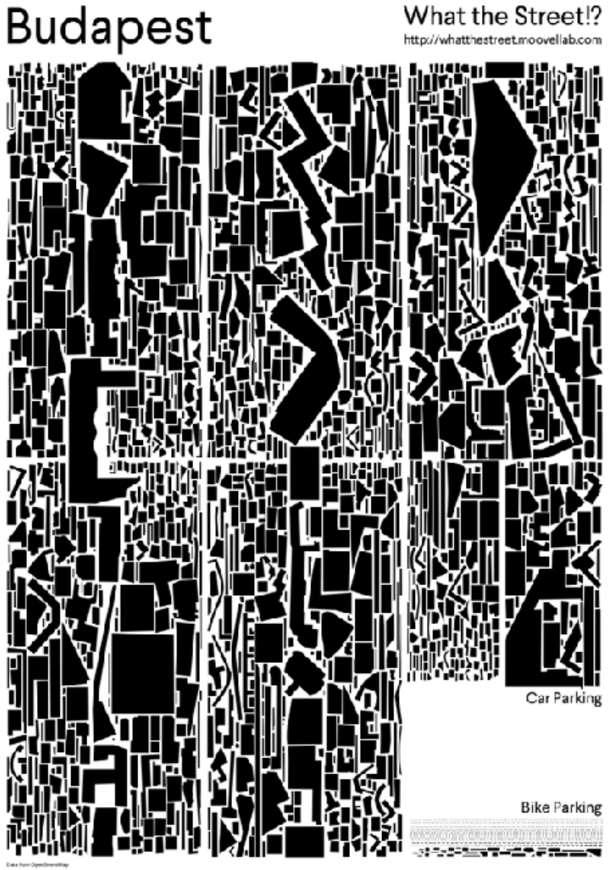
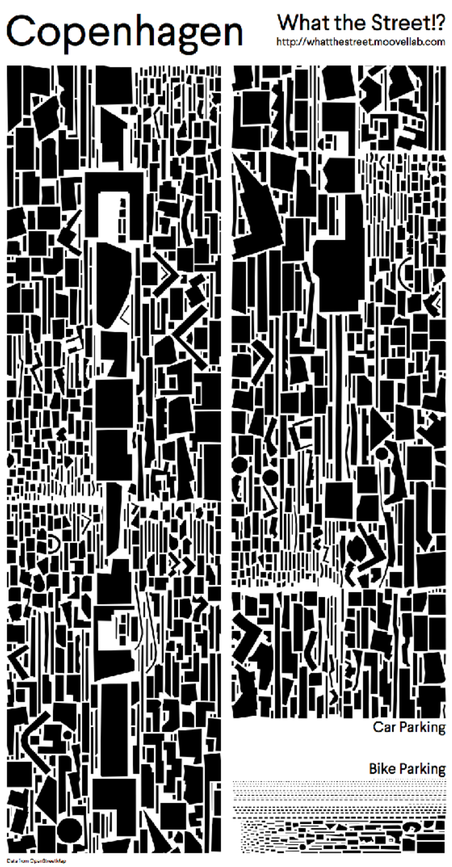
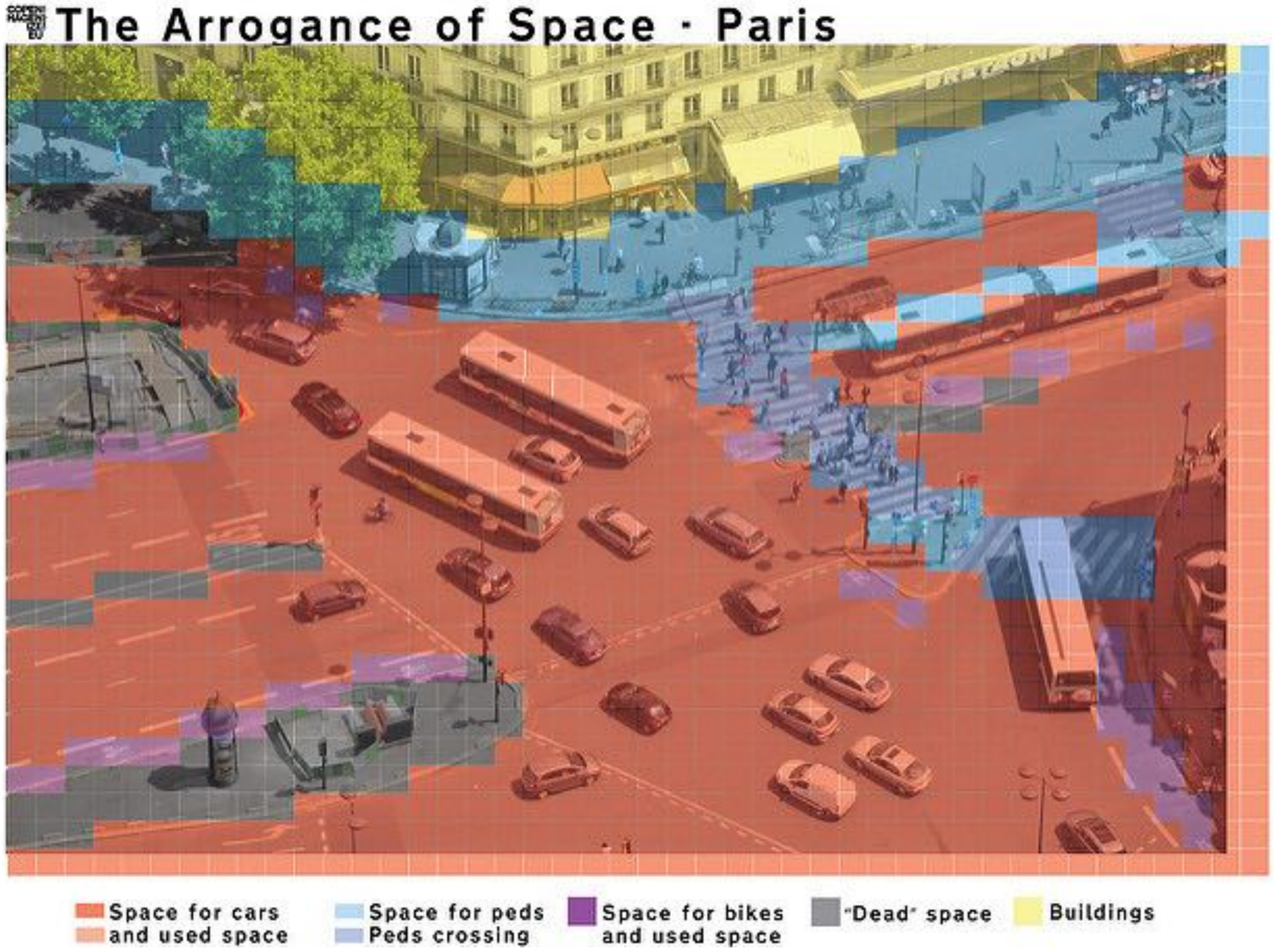




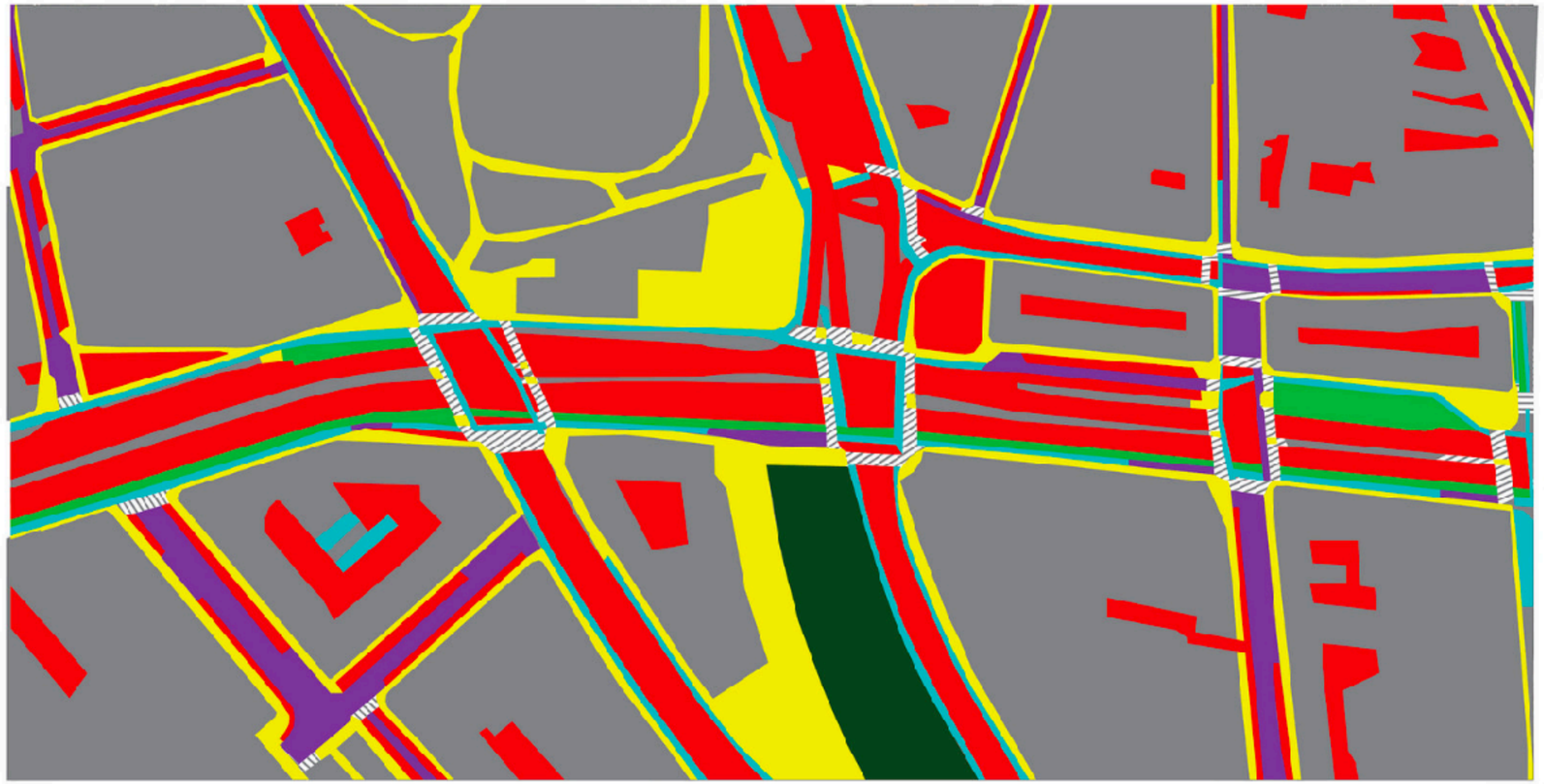
whatthestreet.com

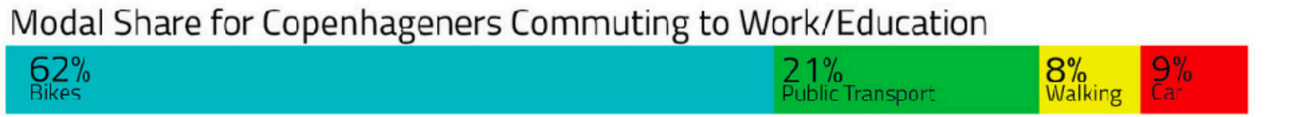
Szell, Urb Plan 3, 1-20 (2018)
Gössling, J Tran Geo 54, 1-9 (2016)

Space is not distributed in a fair way between different modes of transport

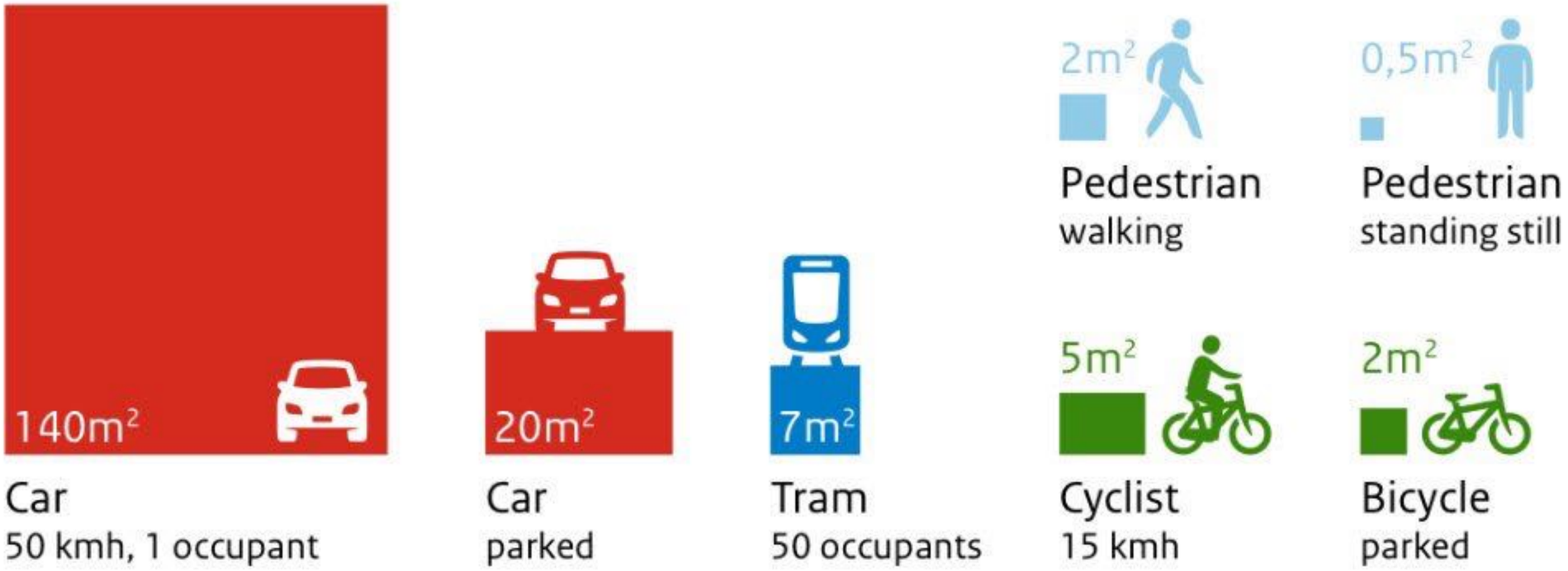


Most space is for cars, but most people use bicycles





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)
Euclid (300 BC)

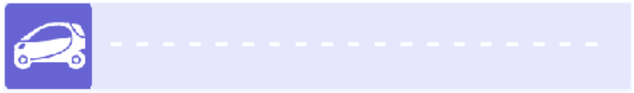
Cars are used 36 minutes per day
Cars are not used 1404 minutes per day

Civity (2016)

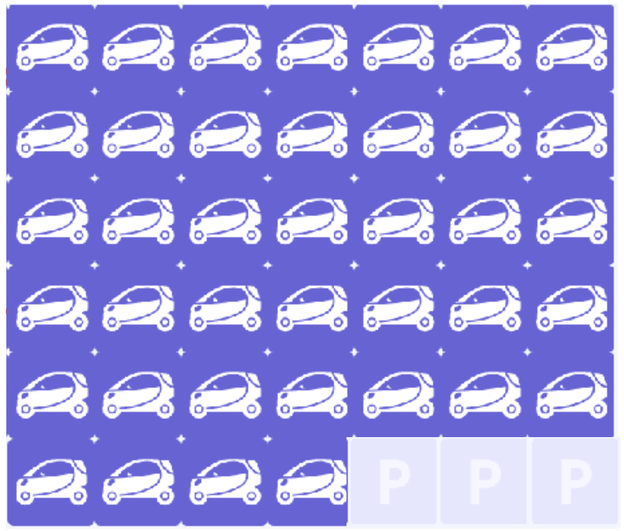
Cars are used 36 minutes per day
Cars are not used 1404 minutes per day

A typical snapshot of Copenhagen

5,500 cars moving



250,000 cars parked



We are wasting space worth 6,000 playgrounds!

A typical snapshot of Copenhagen

5,500 cars moving

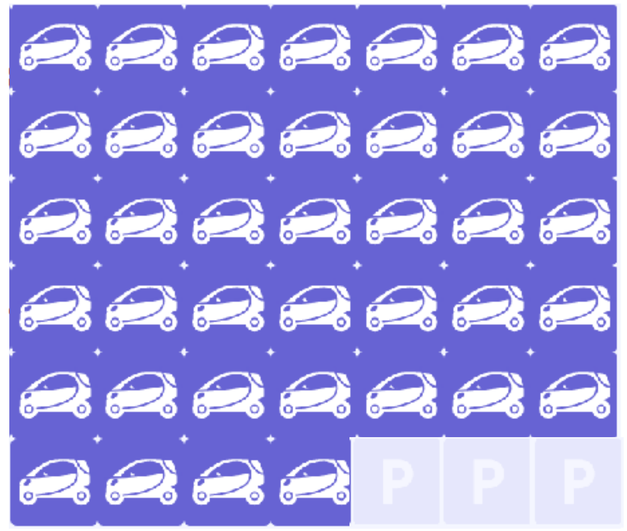
250,000 cars parked

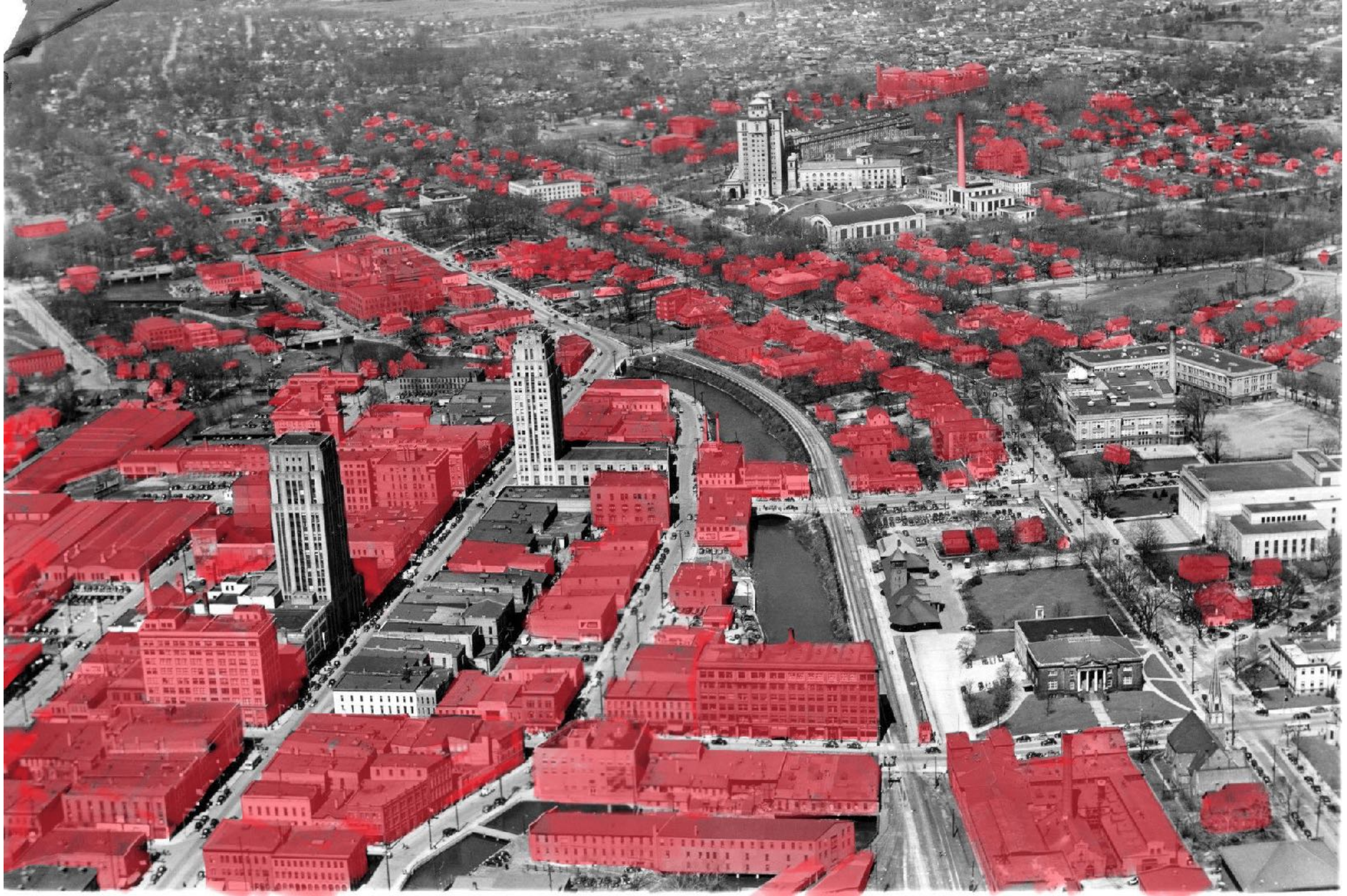
6,000
Playgrounds

=

2.5 x
CHRISTIANIA

=





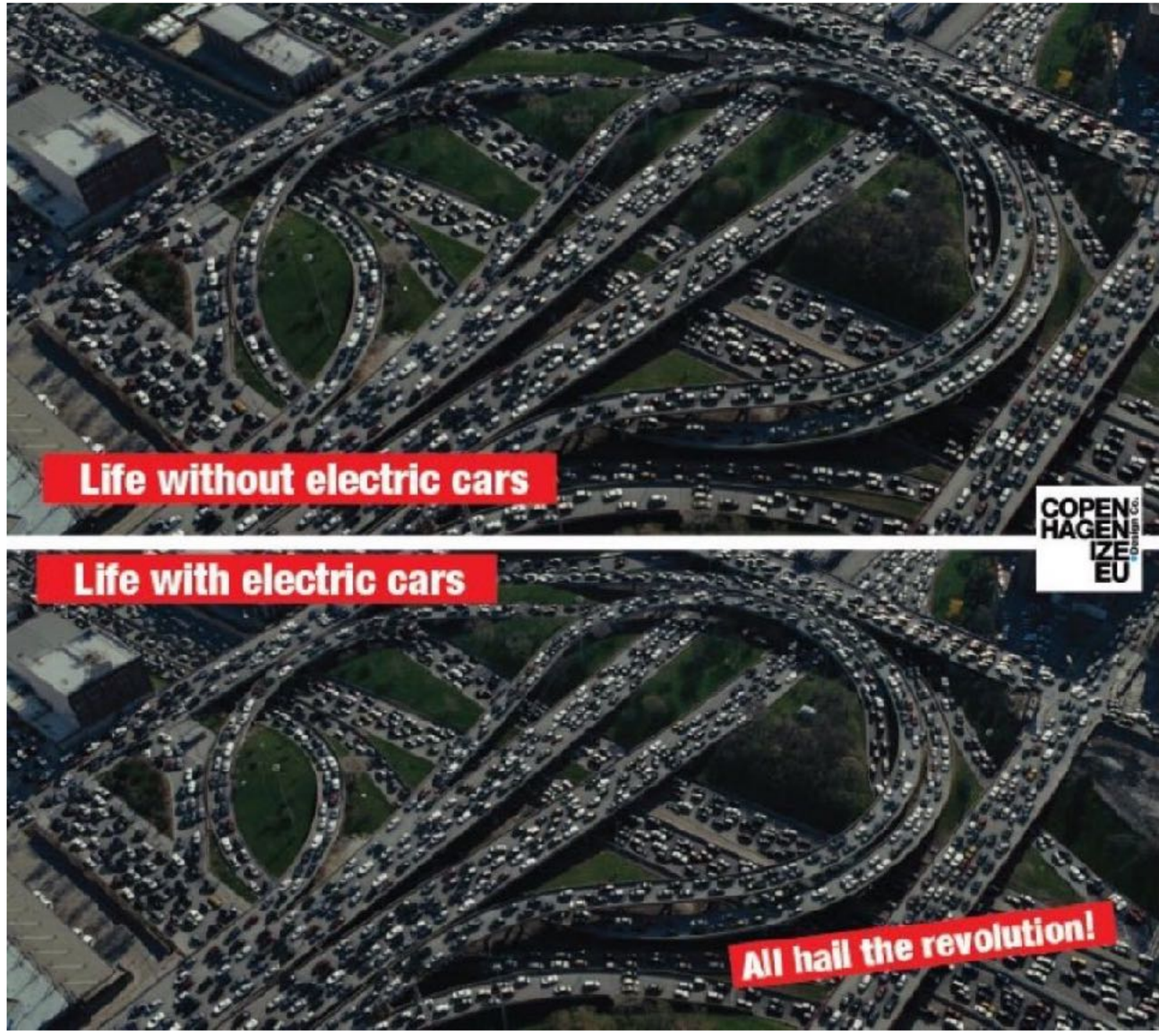
Battle Creek, MI

Battle Creek, MI

Cars eat up our living space in cities

Denver

Cars eat up our living space in cities



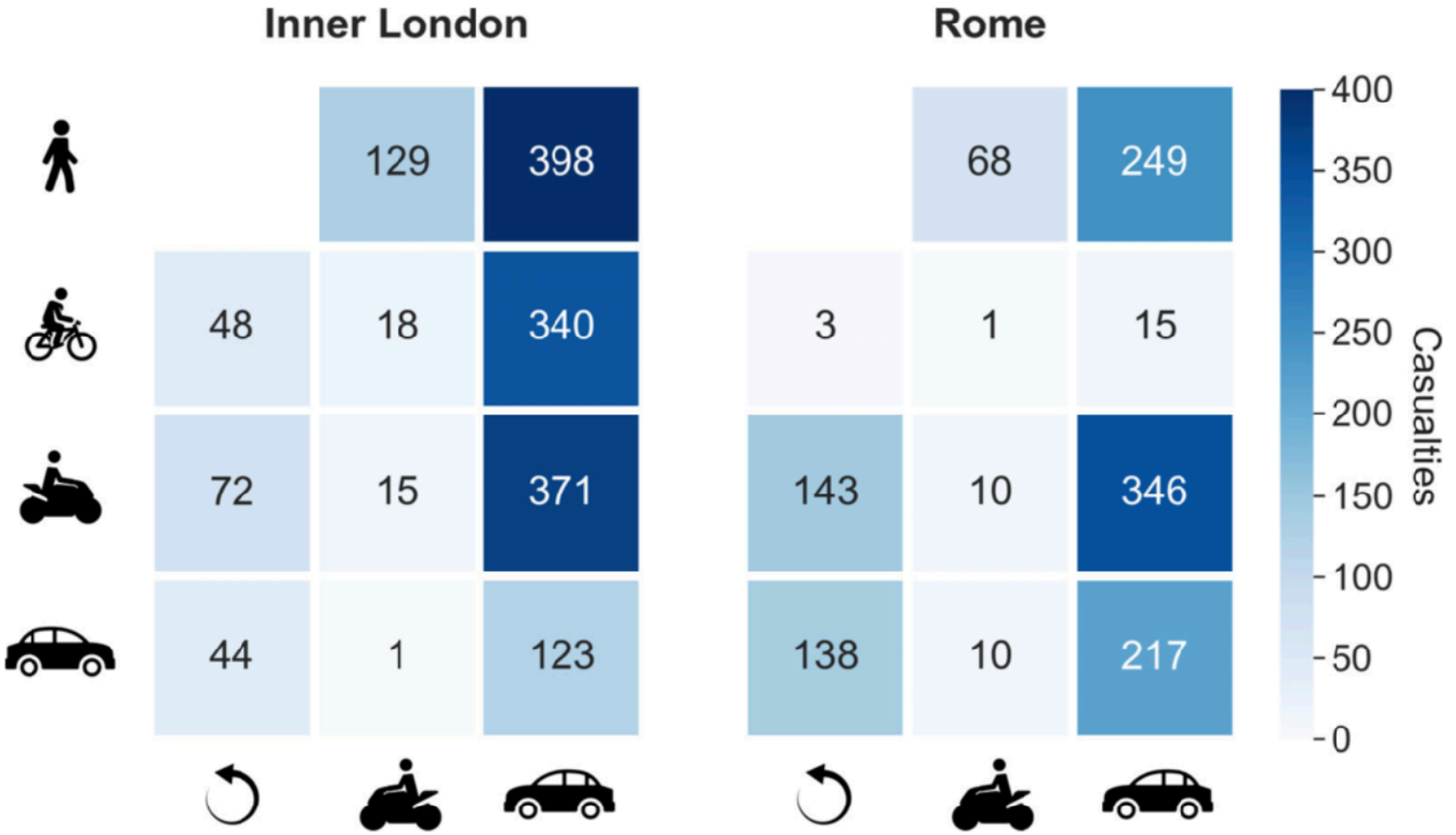
POLLUTION

~9.000.000

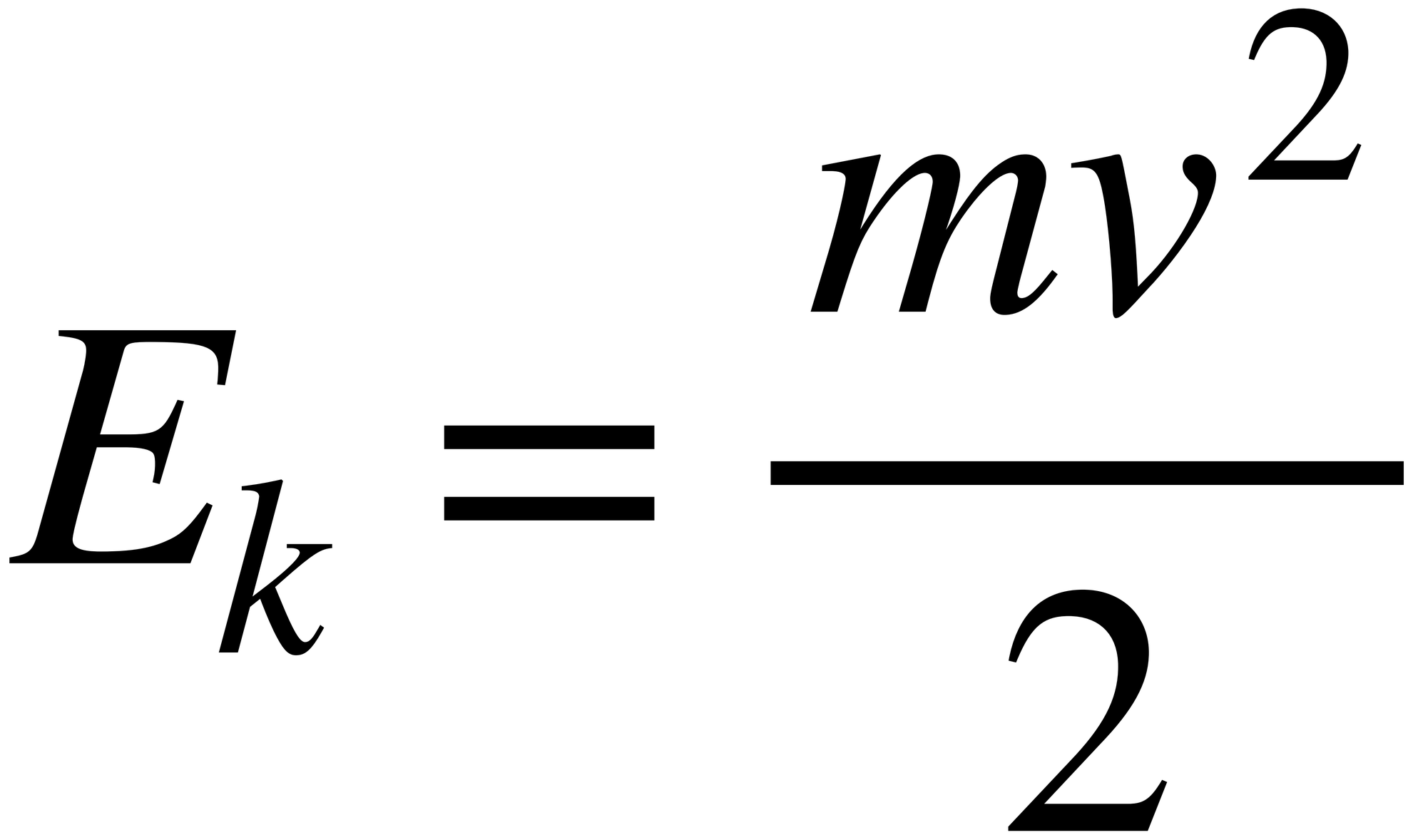
https://ourworldindata.org/data-review-air-pollution-deaths

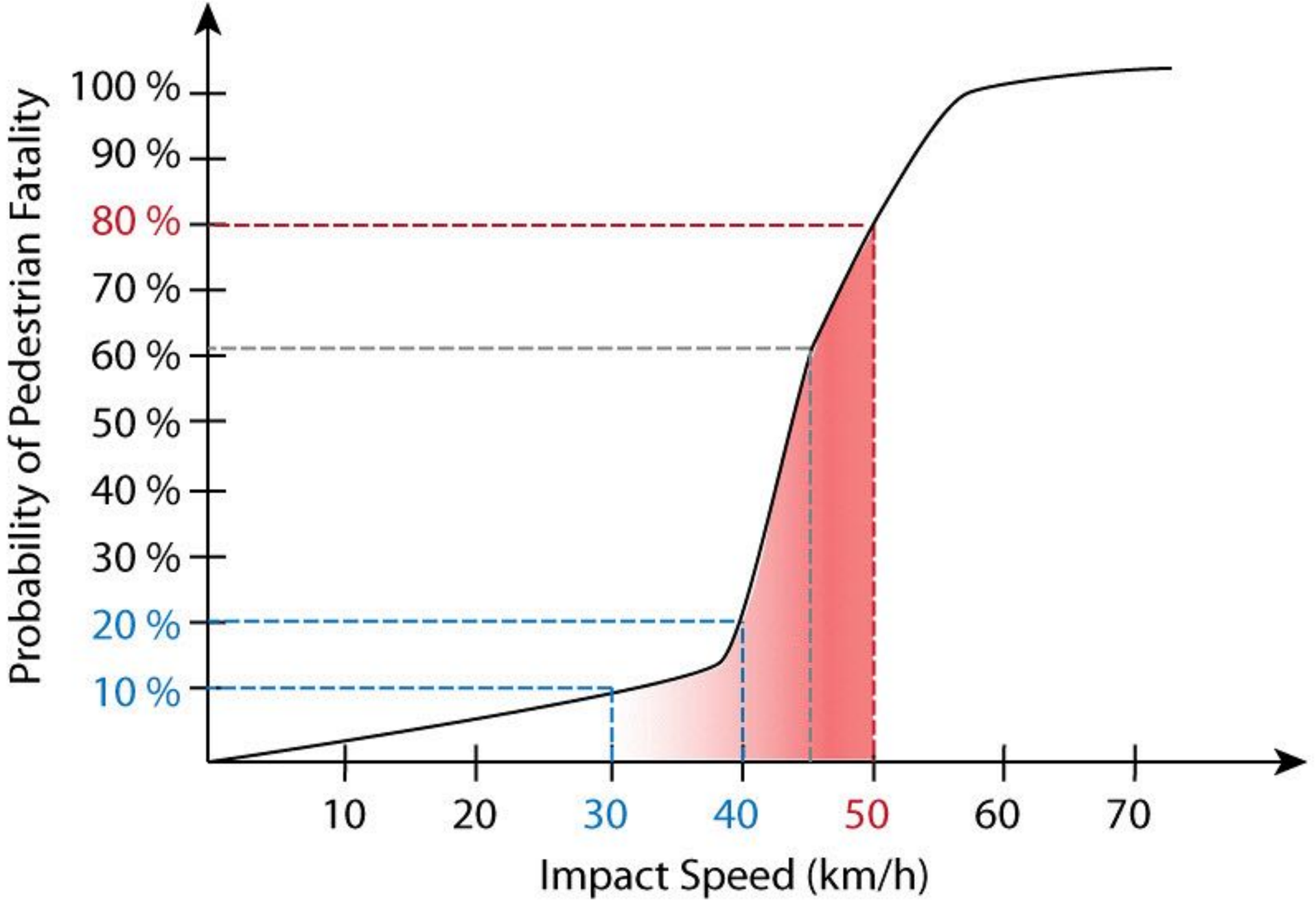
ANYTHING ELSE?


1.350.000



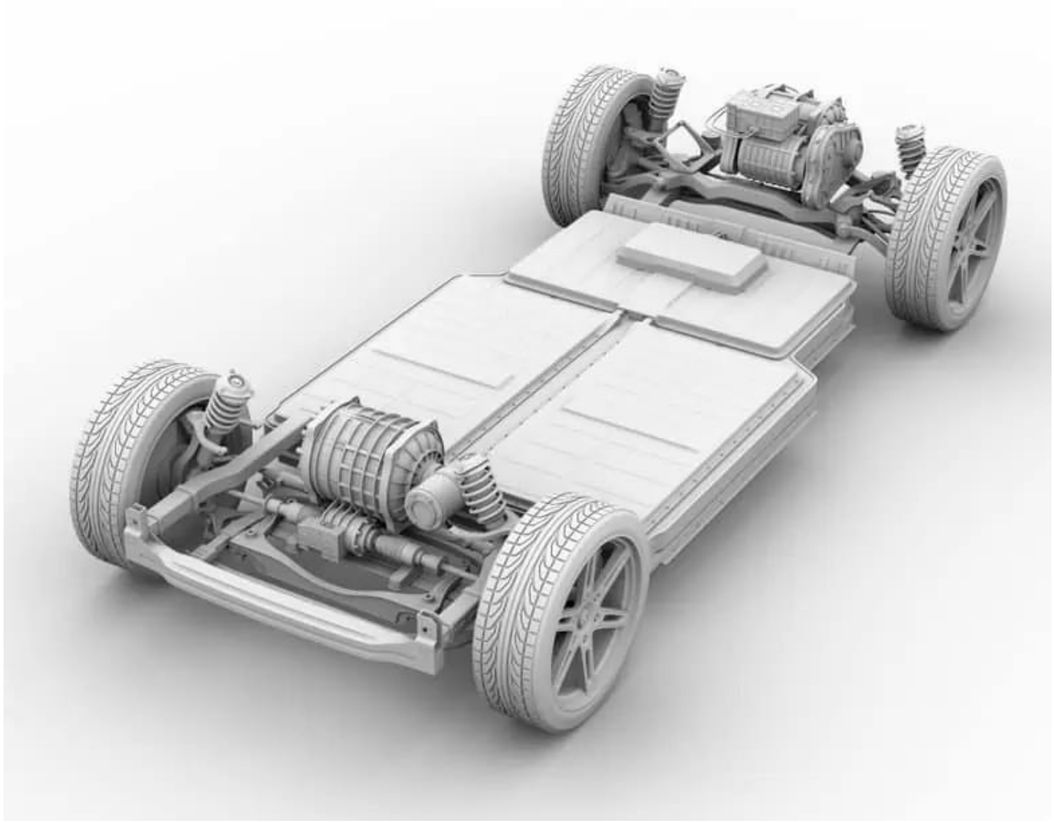
Klanjcic et al, EPJ Data Sci 11, 27 (2022)




Probability of Pedestrian Fatality
100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
10
20
30
40
50
60
70
Impact Speed (km/h)

Casualties are getting worse with e-cars

4500kg

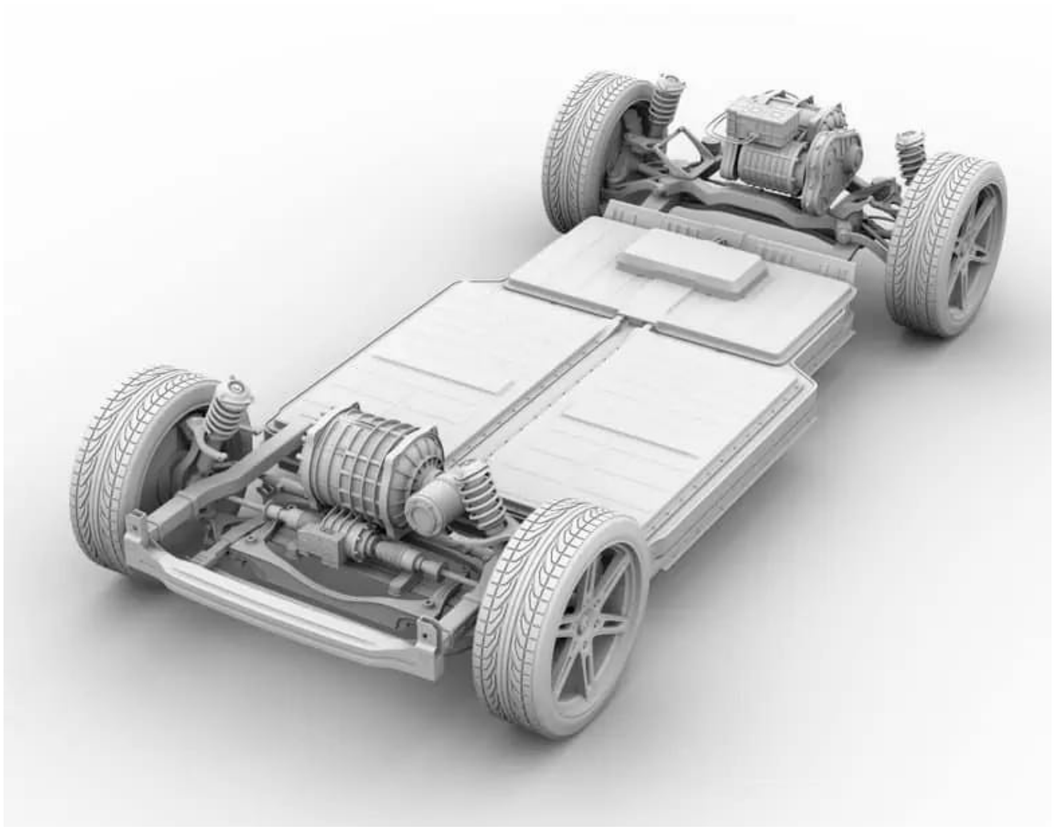


Many 100 kg of batteries

https://www.fastcompany.com/90686171/electric-vehicles-have-a-weight-problem

Casualties are getting worse with e-cars

4500kg



Many 100 kg of batteries

50% more crashes with electric cars due to unadapted behavior and much faster acceleration

https://www.vrt.be/vrtnws/nl/2022/08/25/elektrische-auto-s-test/

https://www.fastcompany.com/90686171/electric-vehicles-have-a-weight-problem

Cycling is a time-tested technology 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 an *economic* "no-brainer"

Cost-benefit analysis in EU that accounts for

- Health
- Environment
- Travel / Congestion

shows:

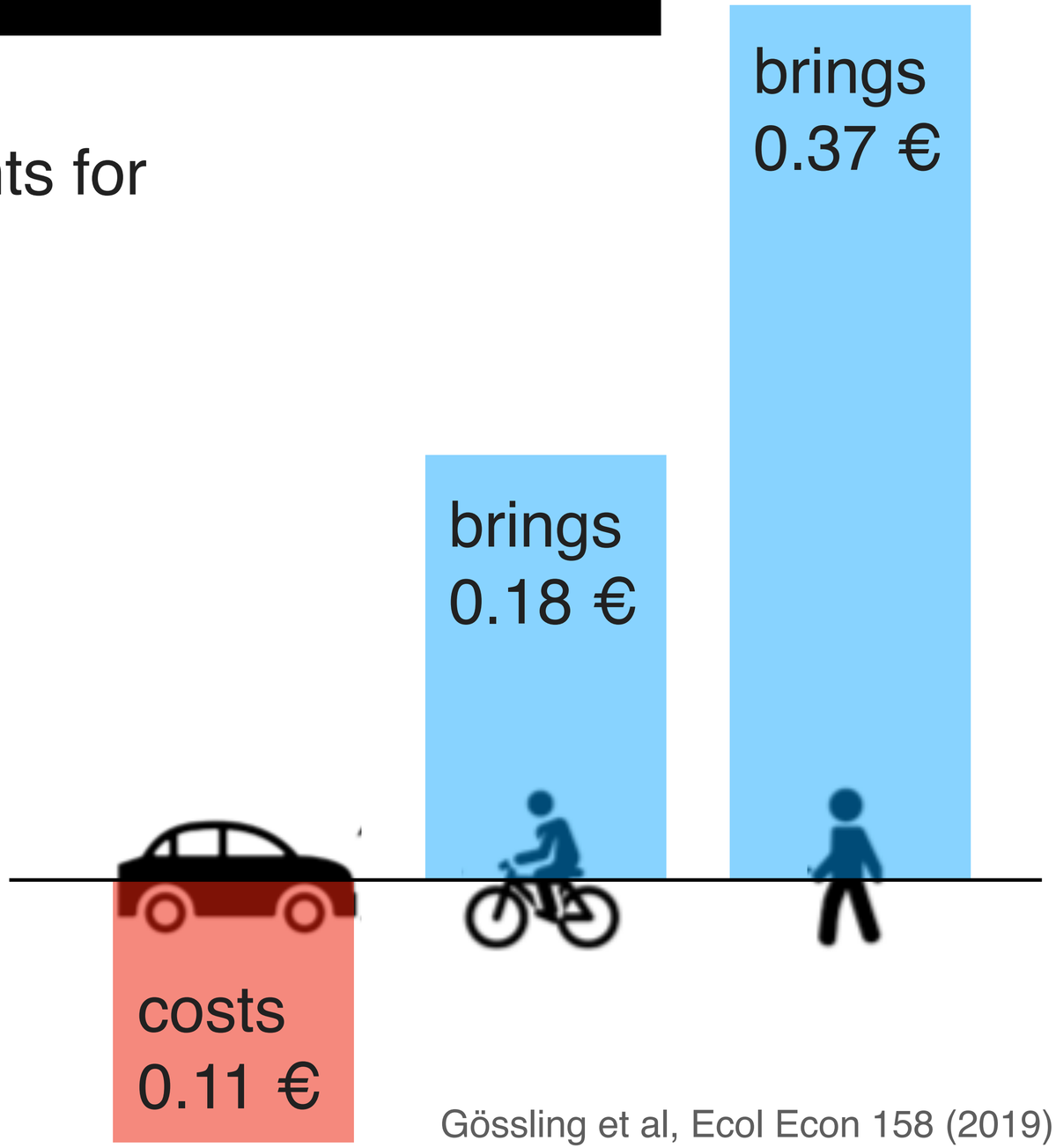
Gössling et al, Ecol Econ 158 (2019)

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

Cost-benefit analysis in EU that accounts for

- Health
- Environment
- Travel / Congestion

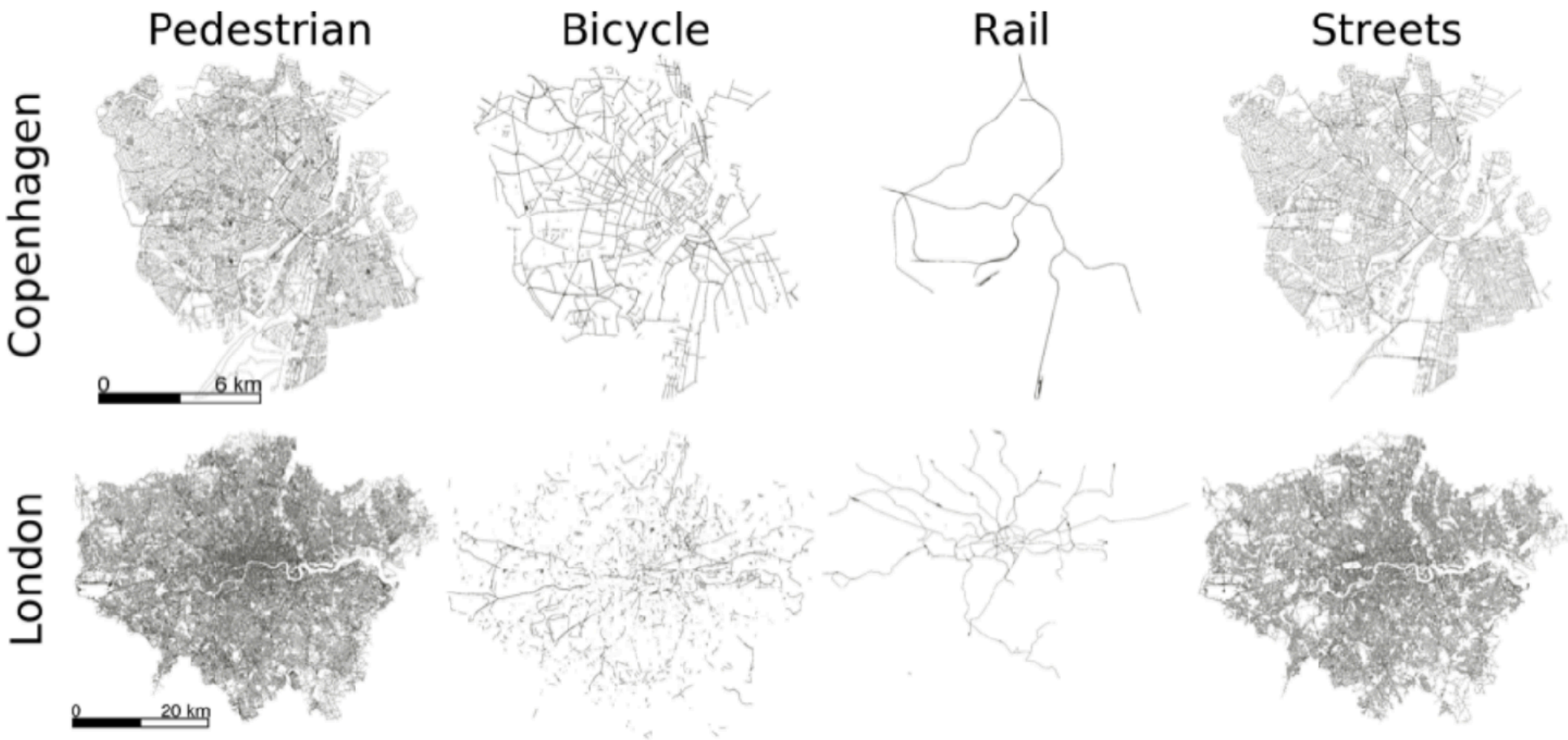
shows: 1 km travelled by



Gössling et al, Ecol Econ 158 (2019)

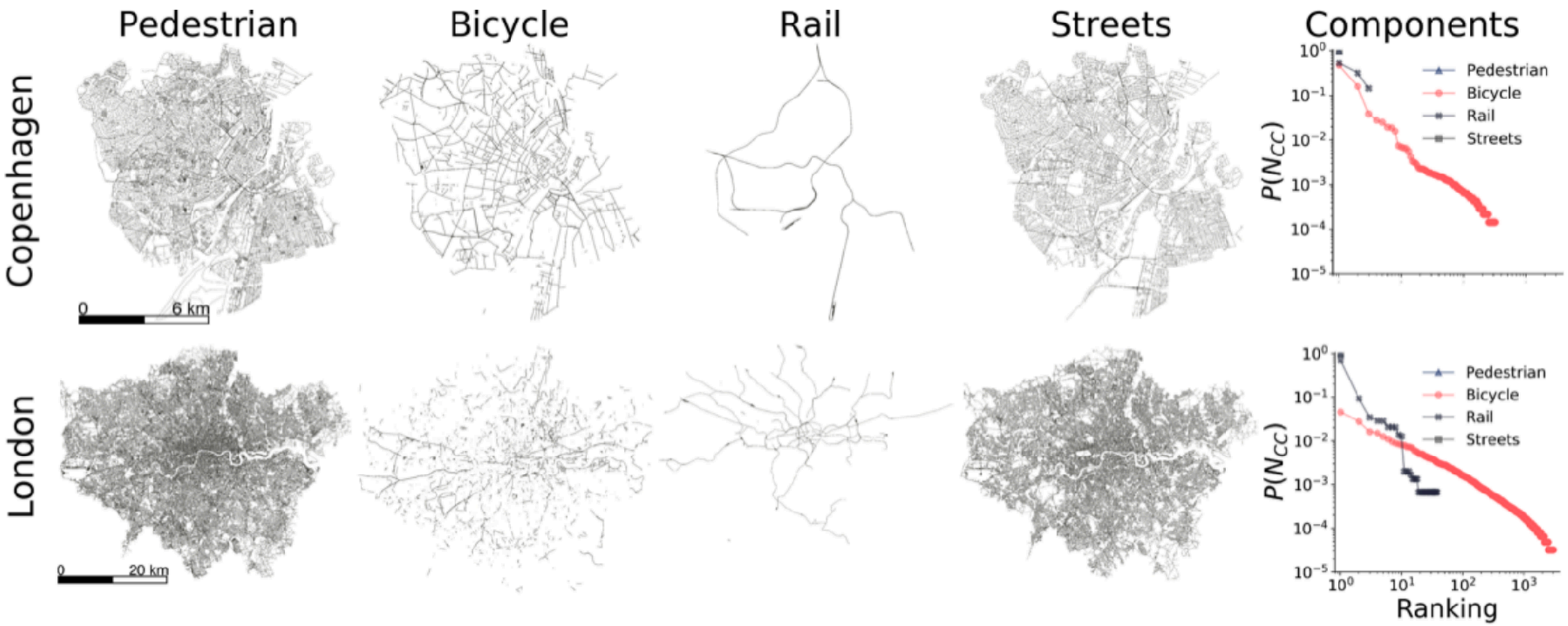
Network Science 101

Cities have different transport network layers



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

Bicycle networks are highly fragmented



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

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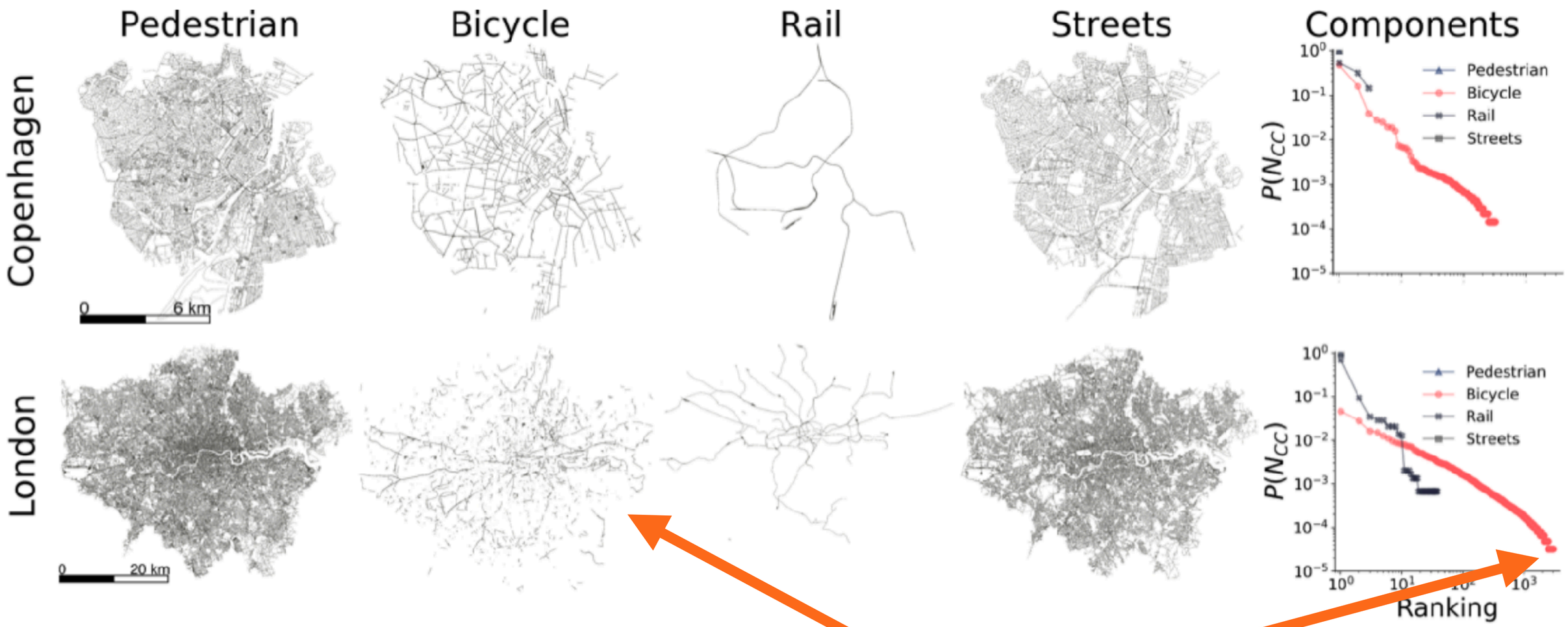
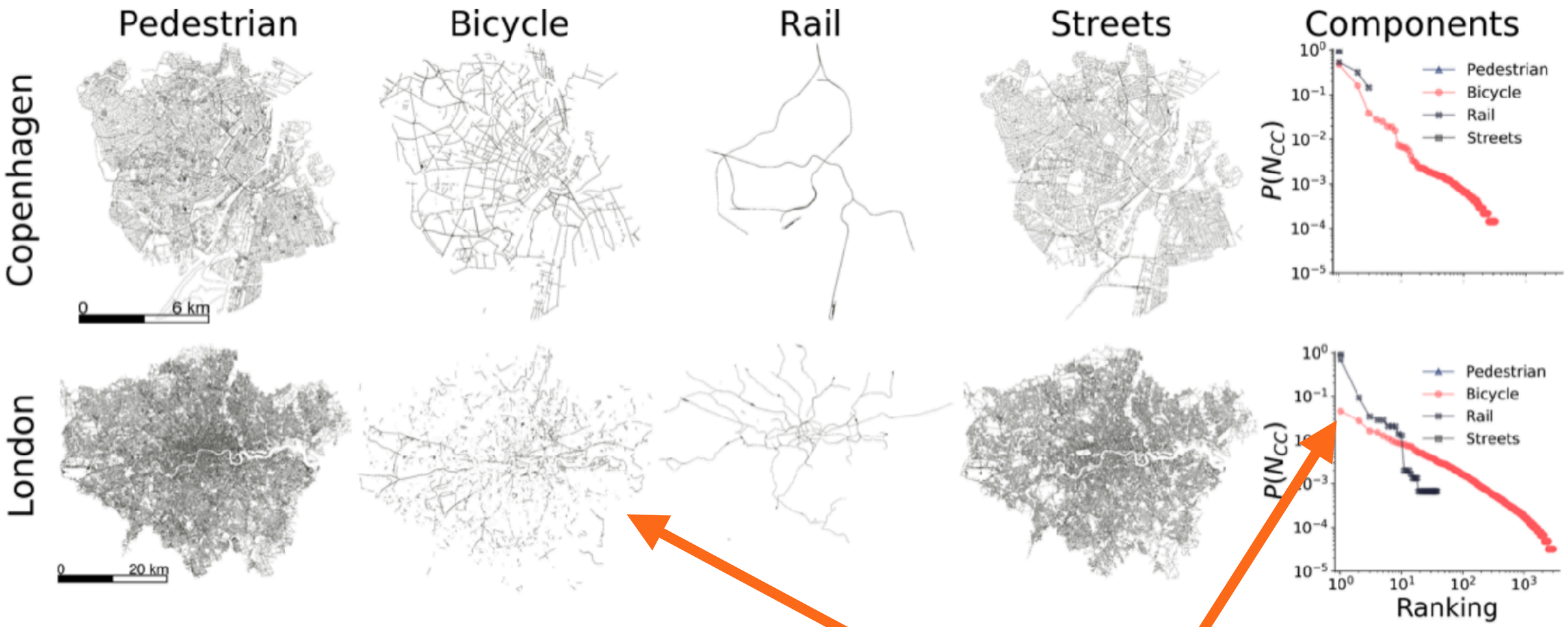
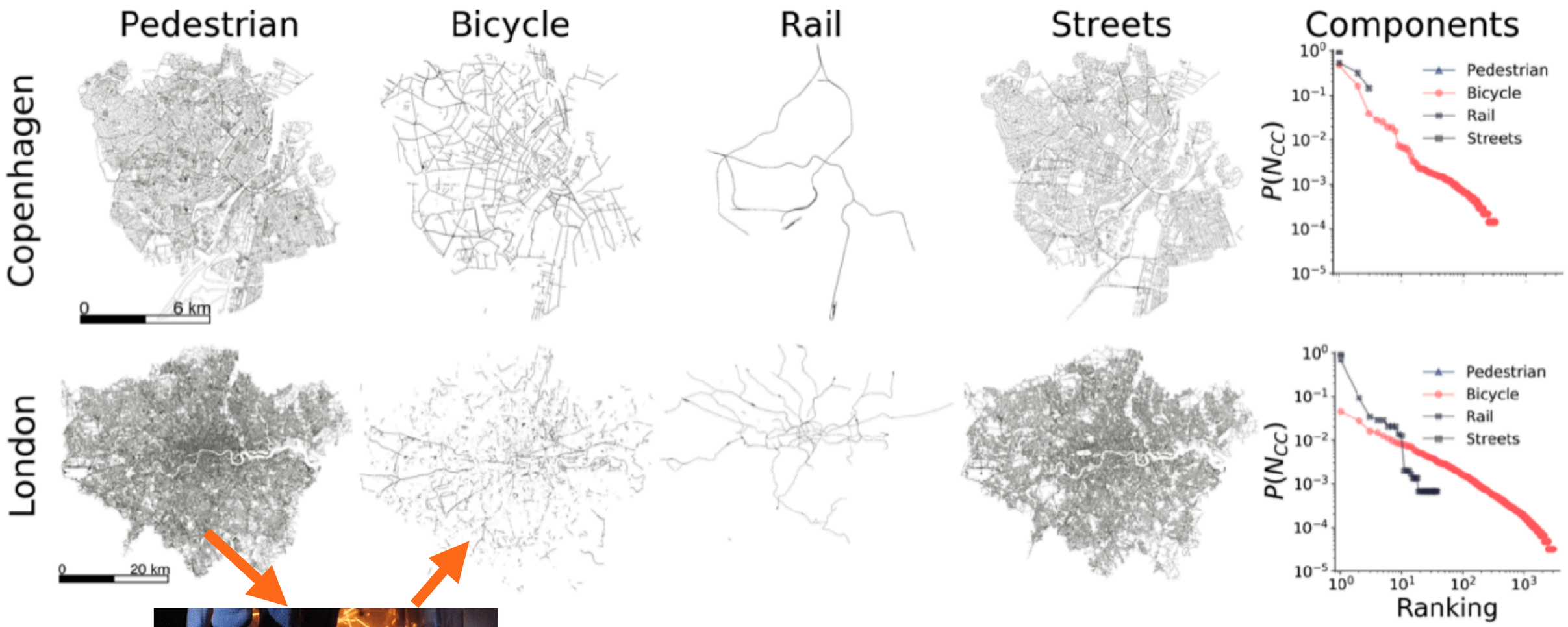


2) In London, the bicycle network has >3000 disconnected components

Bicycle networks are highly fragmented

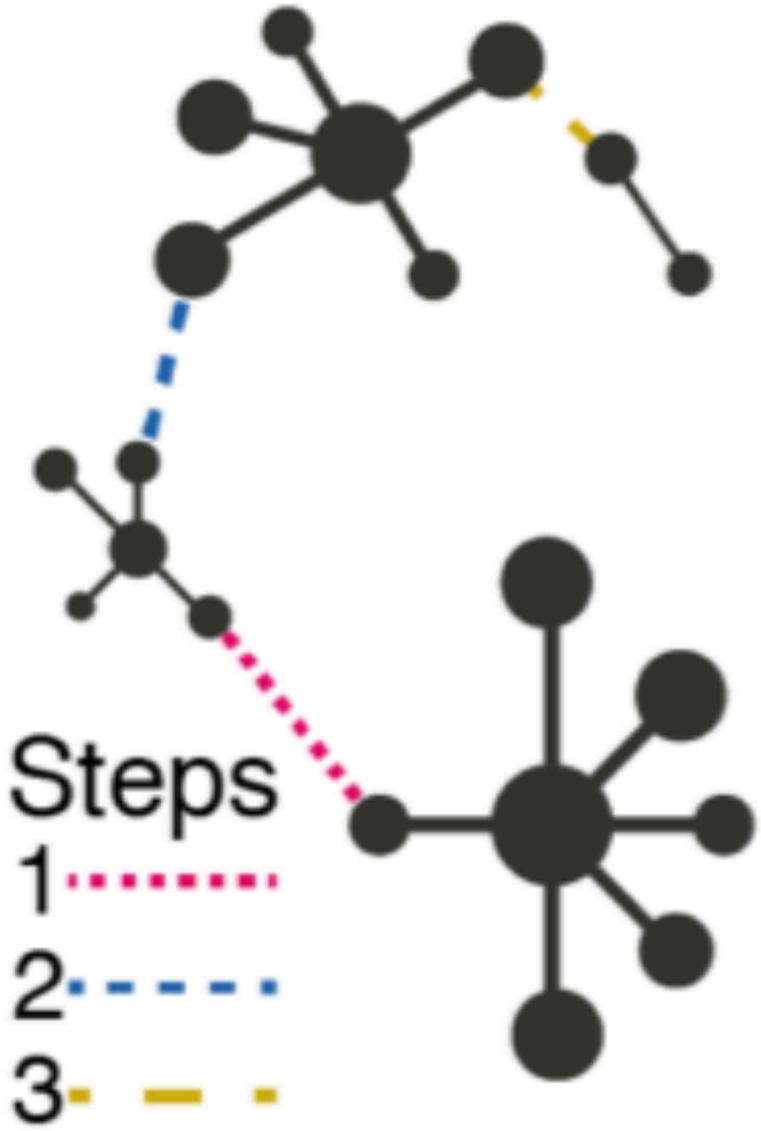


Bicycle networks are highly fragmented



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

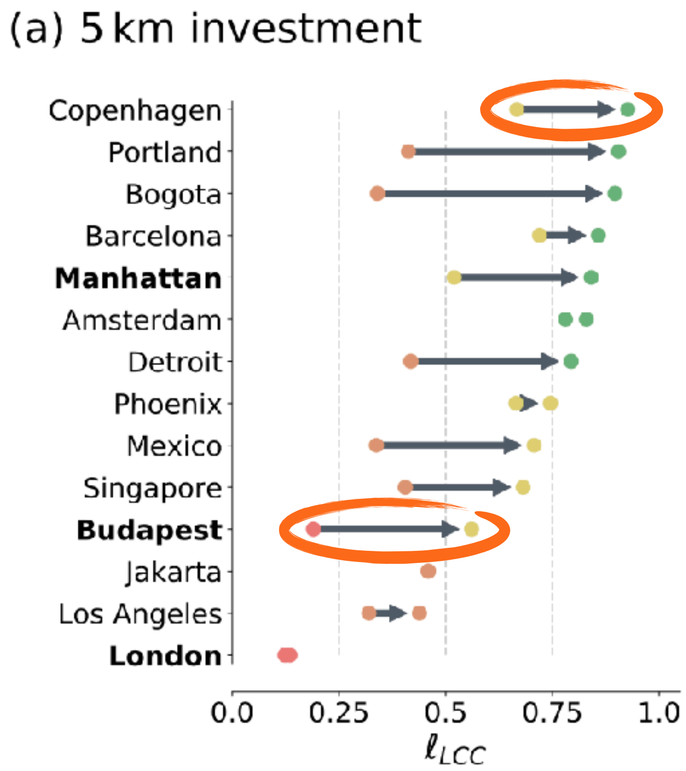
How should we connect the components?

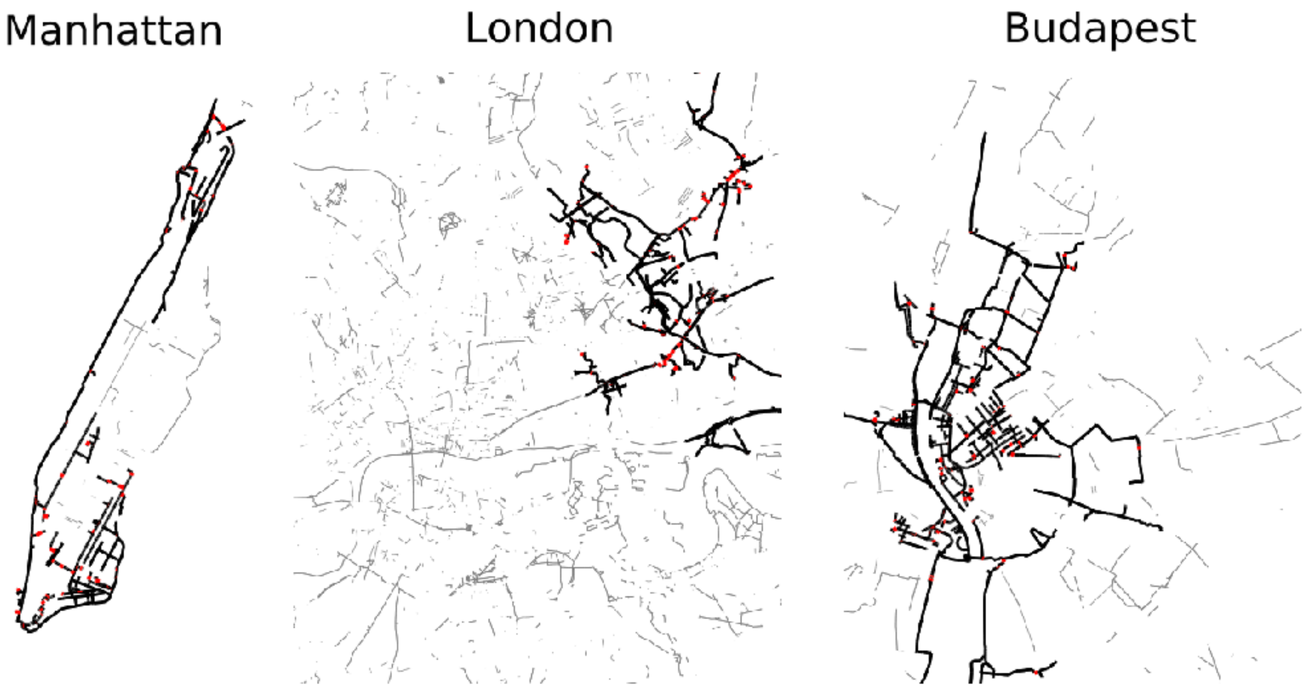


Natera Oroczo et al, R Soc Open Sci 7 (2020)

Effective connectivity improvements are possible

Small but focused investments connect the bicycle network effectively



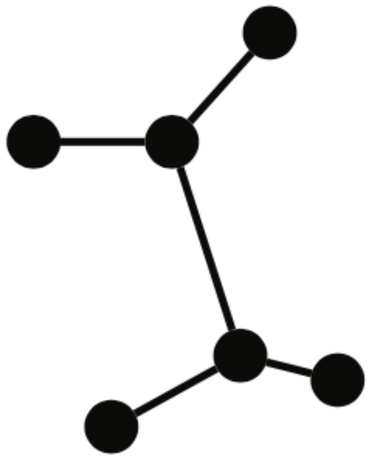


Natera Oroczo et al, R Soc Open Sci 7 (2020)

Just connecting components comes with 3 issues

1) No resilience

Minimum spanning tree



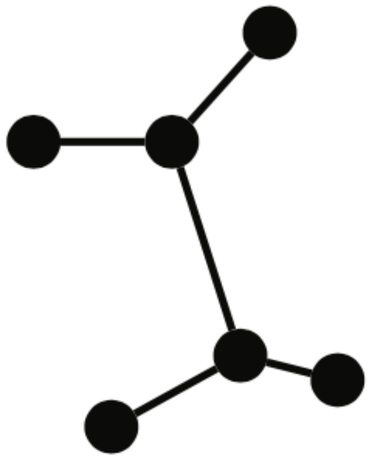
Investor's optimum

Just connecting components comes with 3 issues

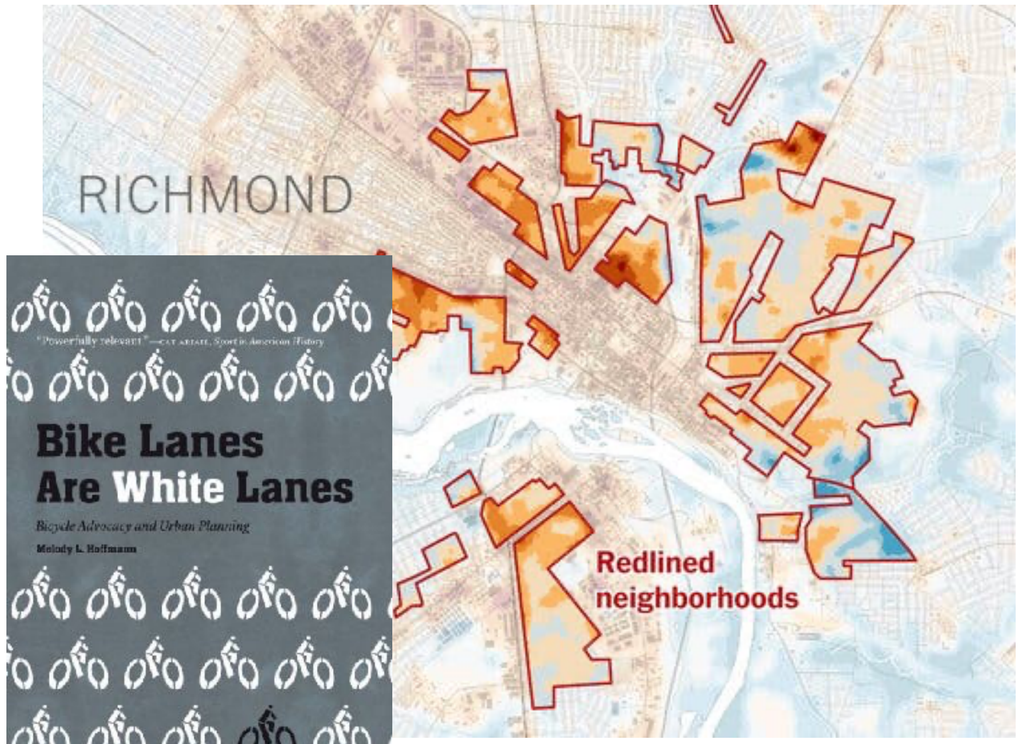
1) No resilience

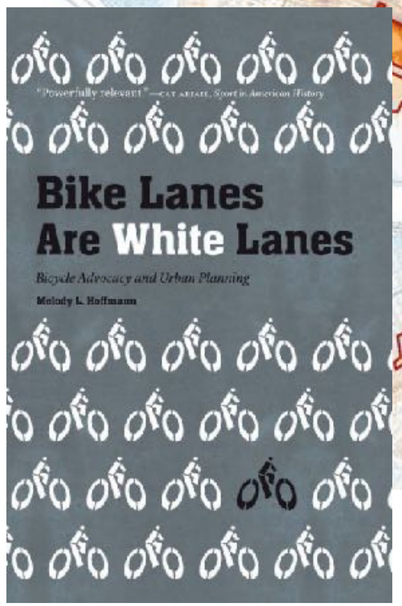
2) Develops only developed areas

Minimum spanning tree



Investor's optimum





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

Just connecting components comes with 3 issues

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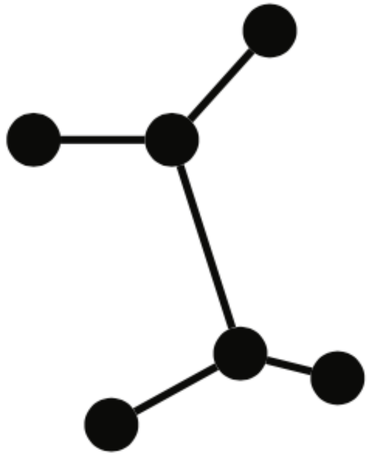
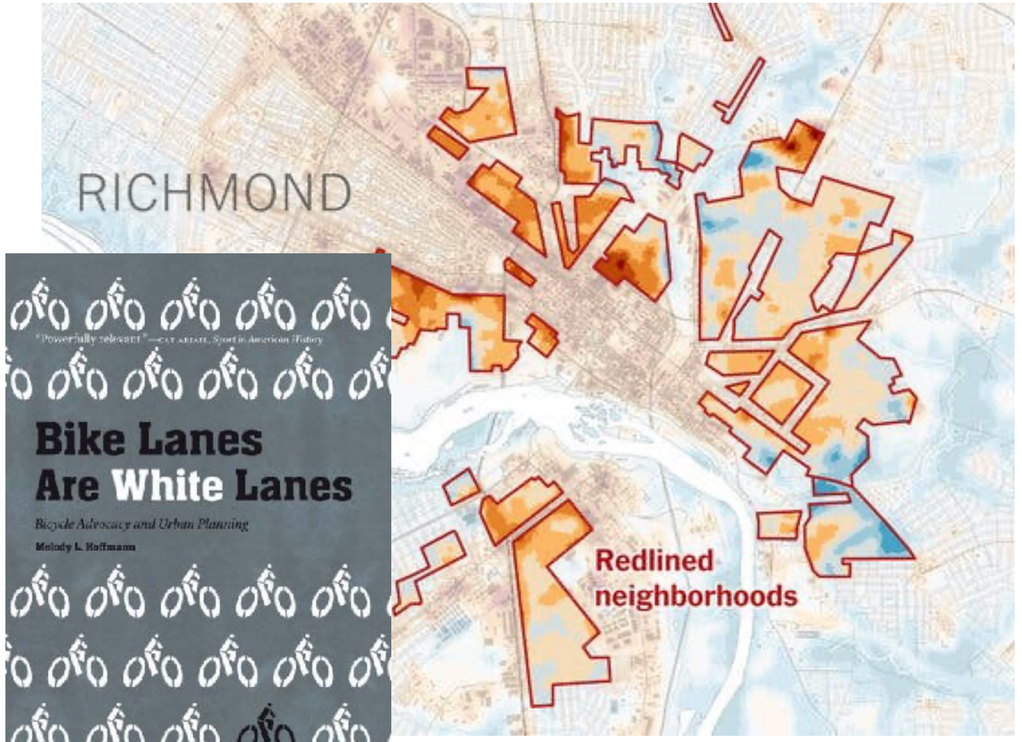
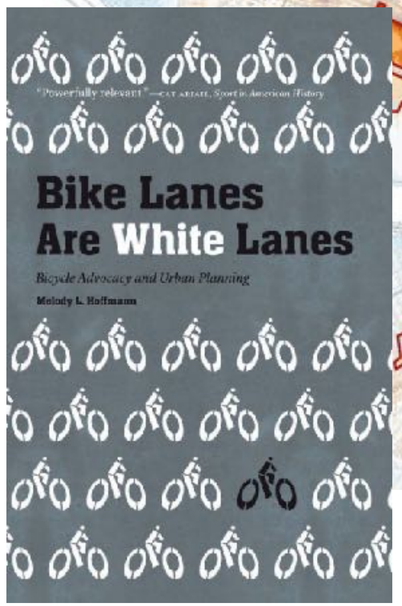
Minimum spanning tree



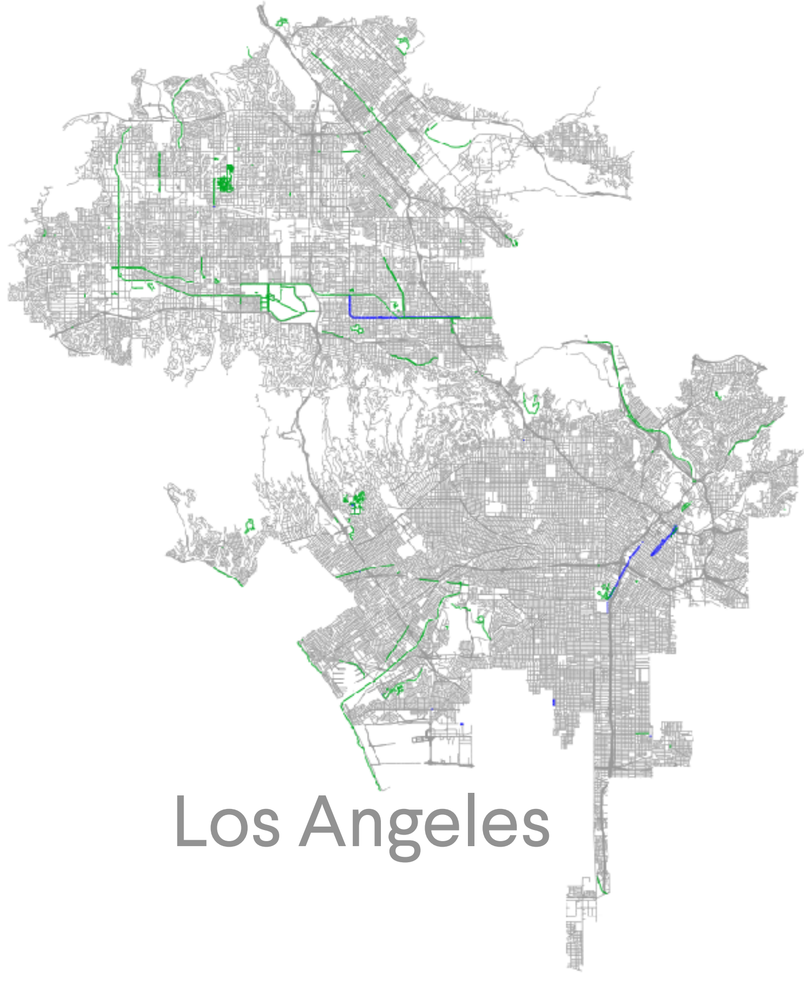
Investor's optimum

2) Develops only developed areas





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



Los Angeles

Let's grow networks
from scratch

What properties should a good bicycle network have?

Copenhagen

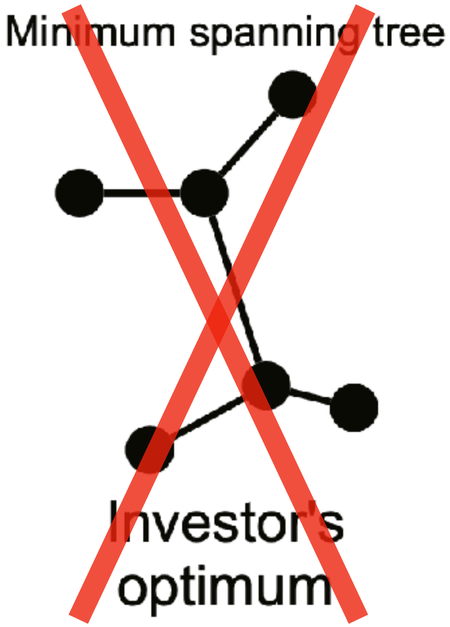
Leeds

fietsberaad CROW

Design Manual for Bicycle Traffic

Inspired by CROW, we want a cohesive network

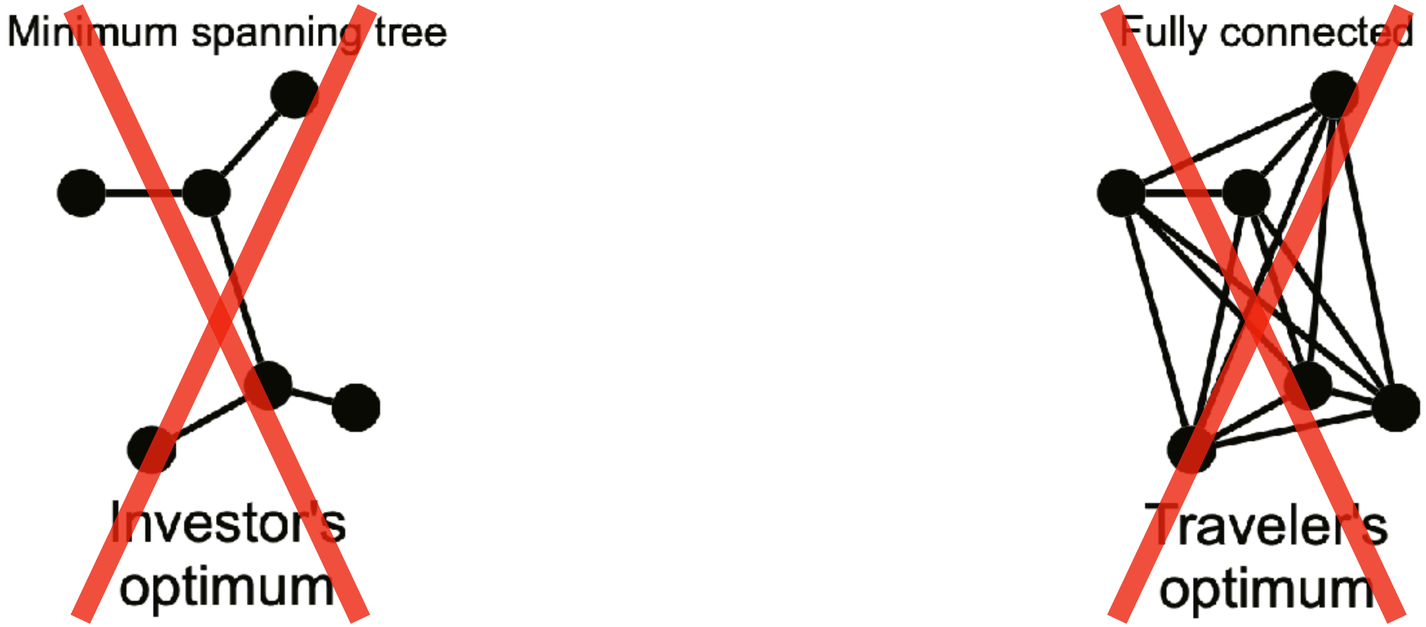
Connectedness & Resilience



Szell et al., Sci Rep 12, 6765 (2022)

Inspired by CROW, we want a cohesive network

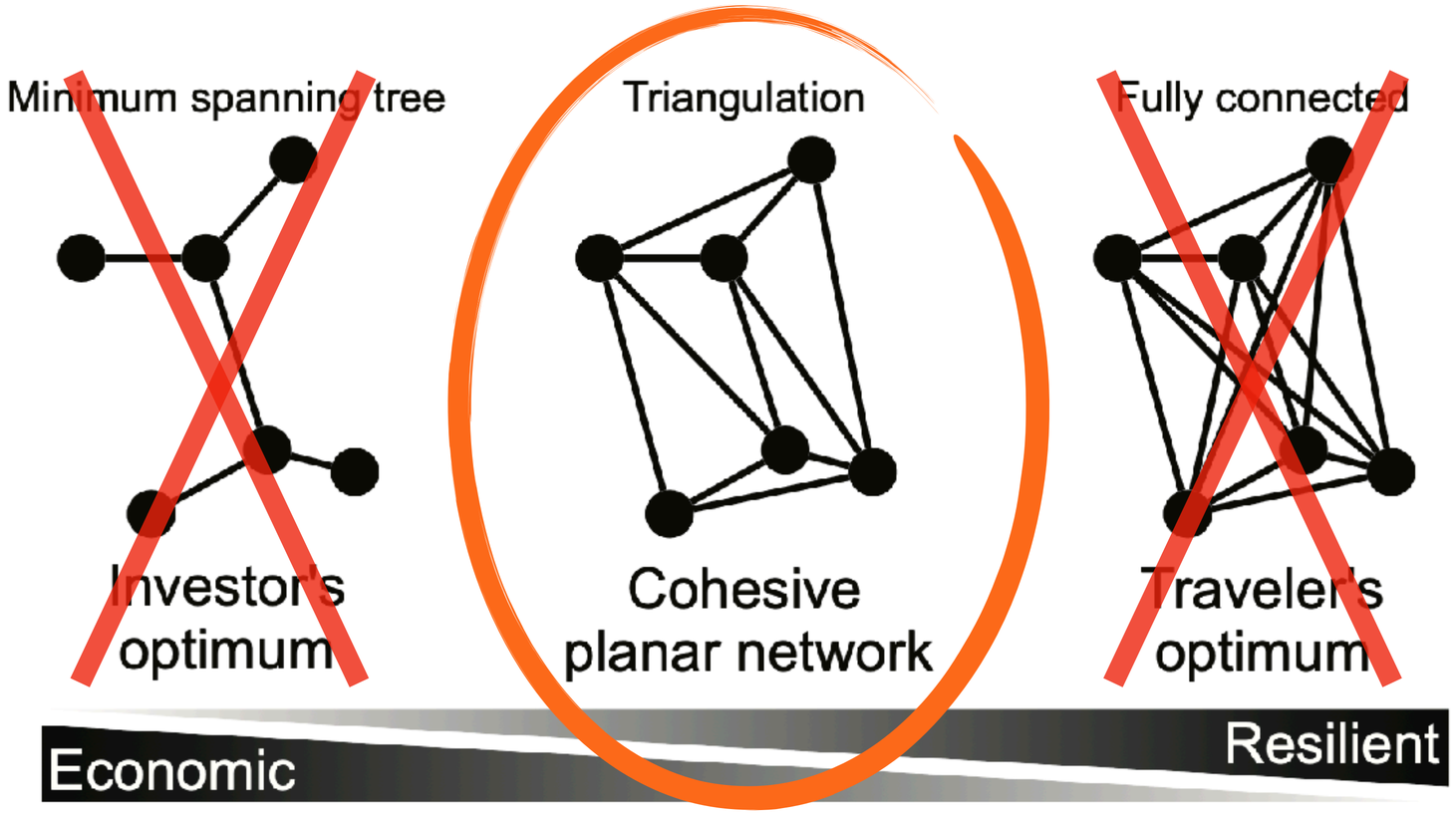
Connectedness & Resilience



Szell et al., Sci Rep 12, 6765 (2022)

Inspired by CROW, we want a cohesive network

Connectedness & Resilience

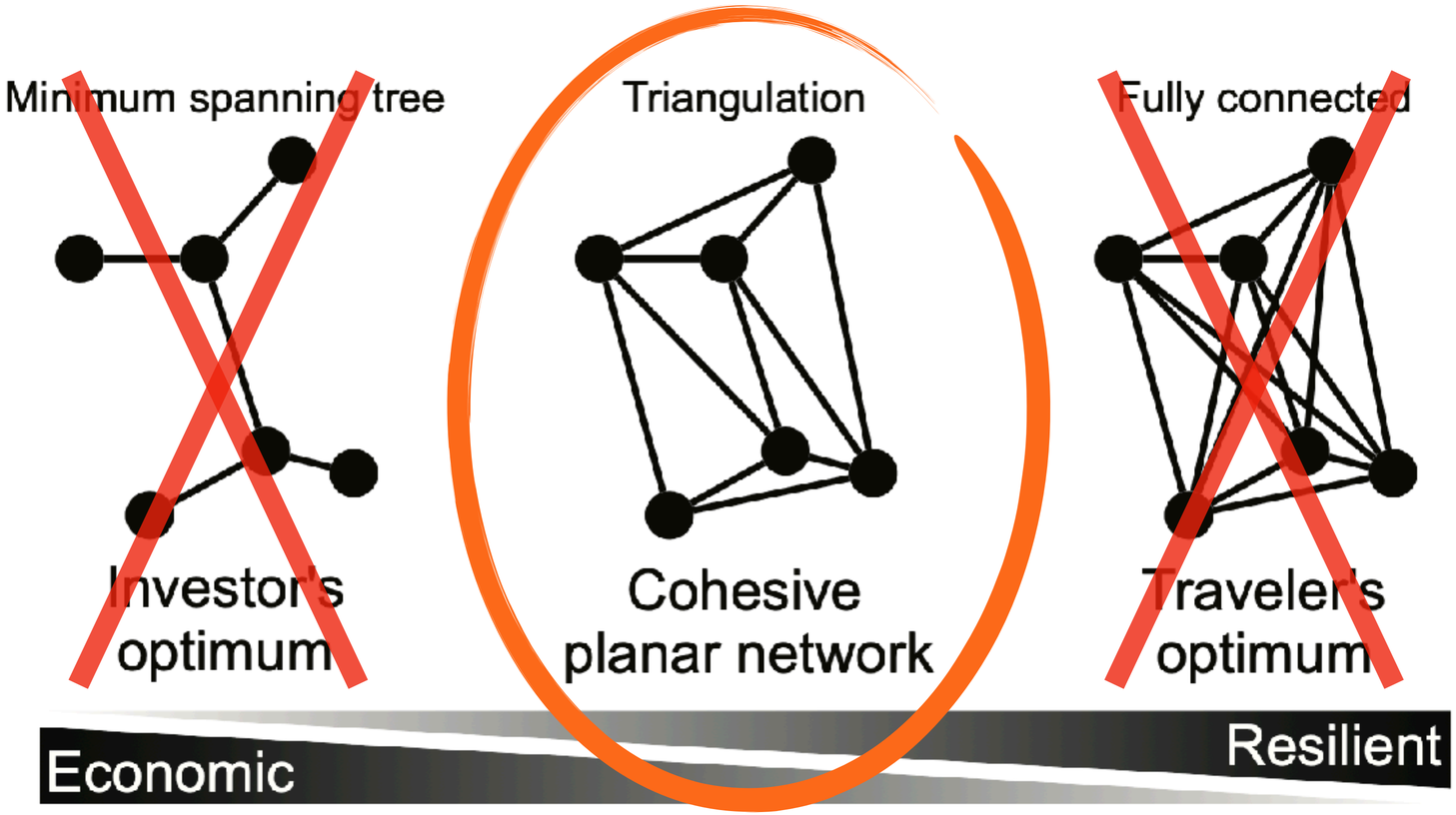


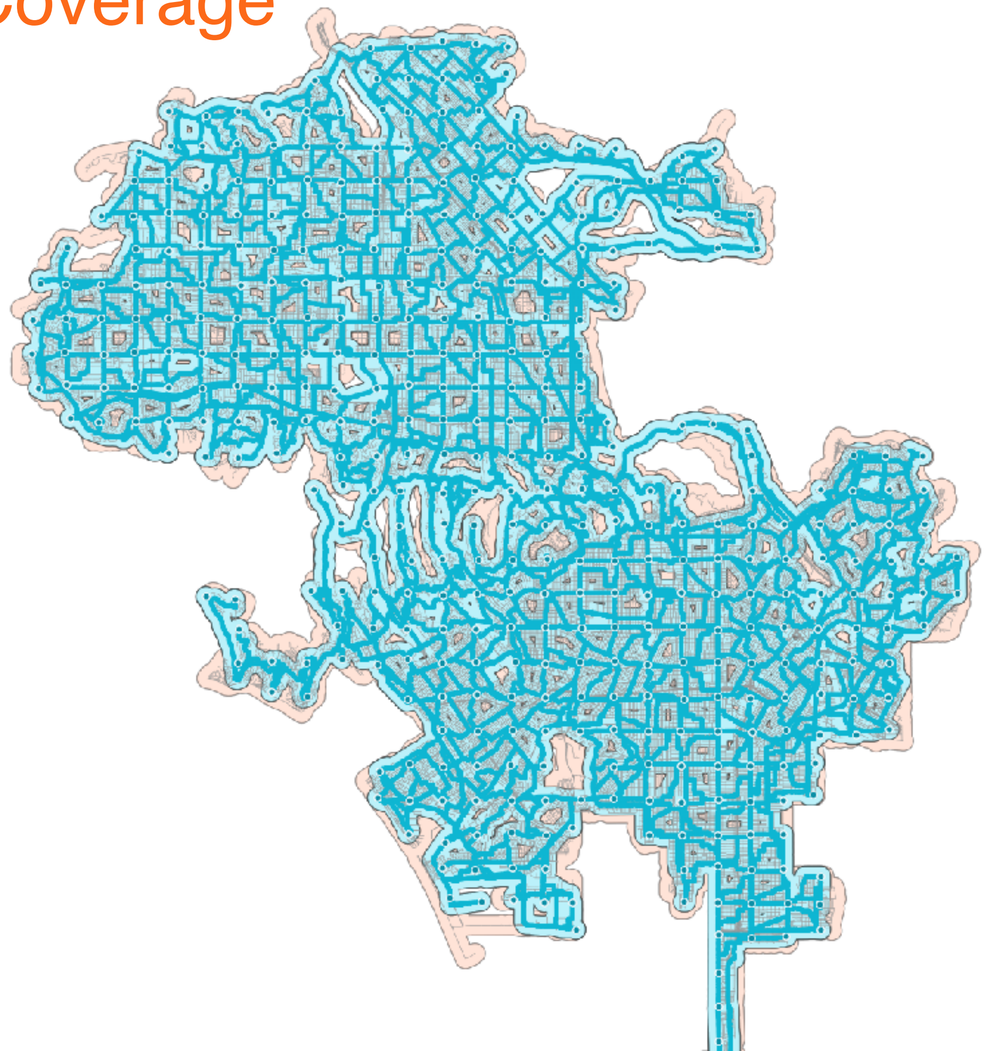
Szell et al., Sci Rep 12, 6765 (2022)

Inspired by CROW, we want a cohesive network

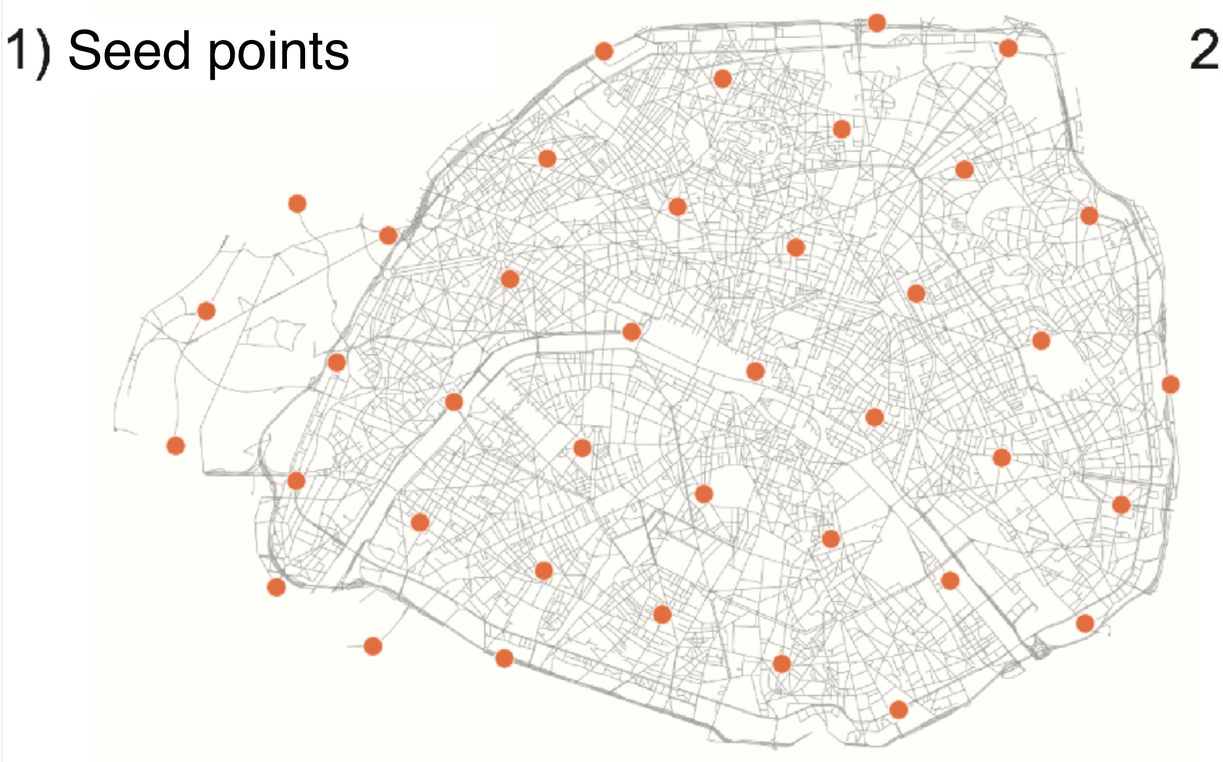
Connectedness & Resilience

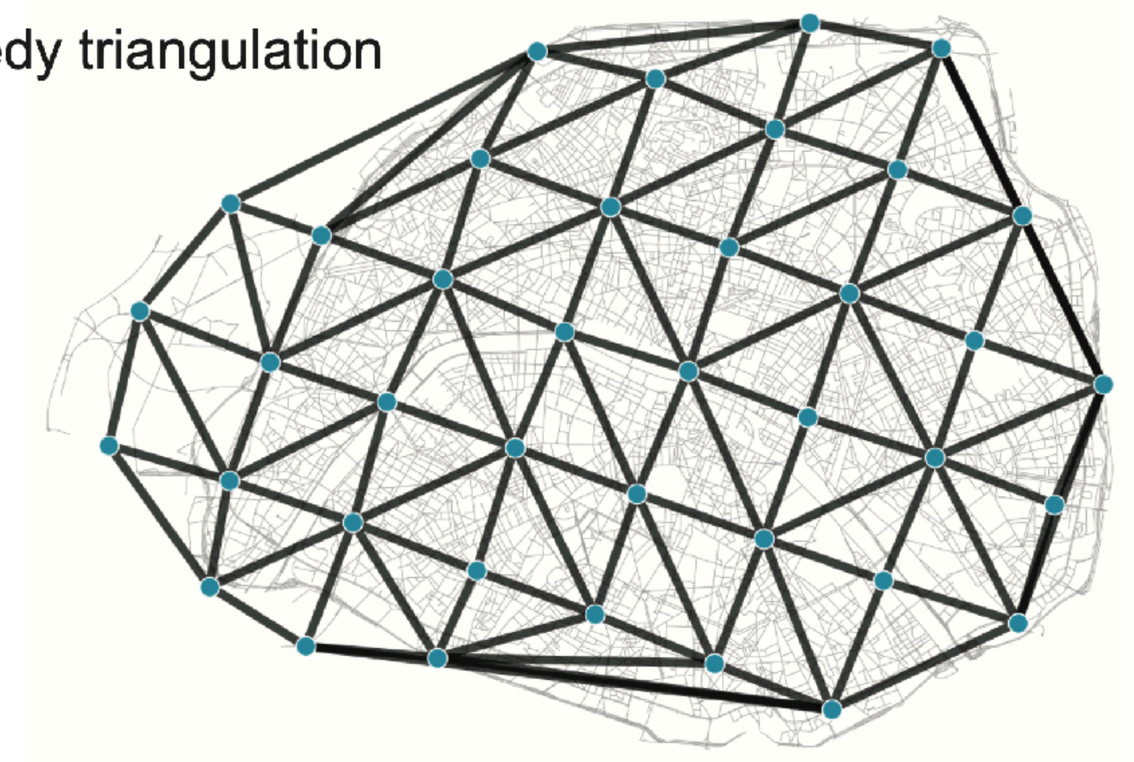
& Coverage





We build a greedy triangulation between points of interest

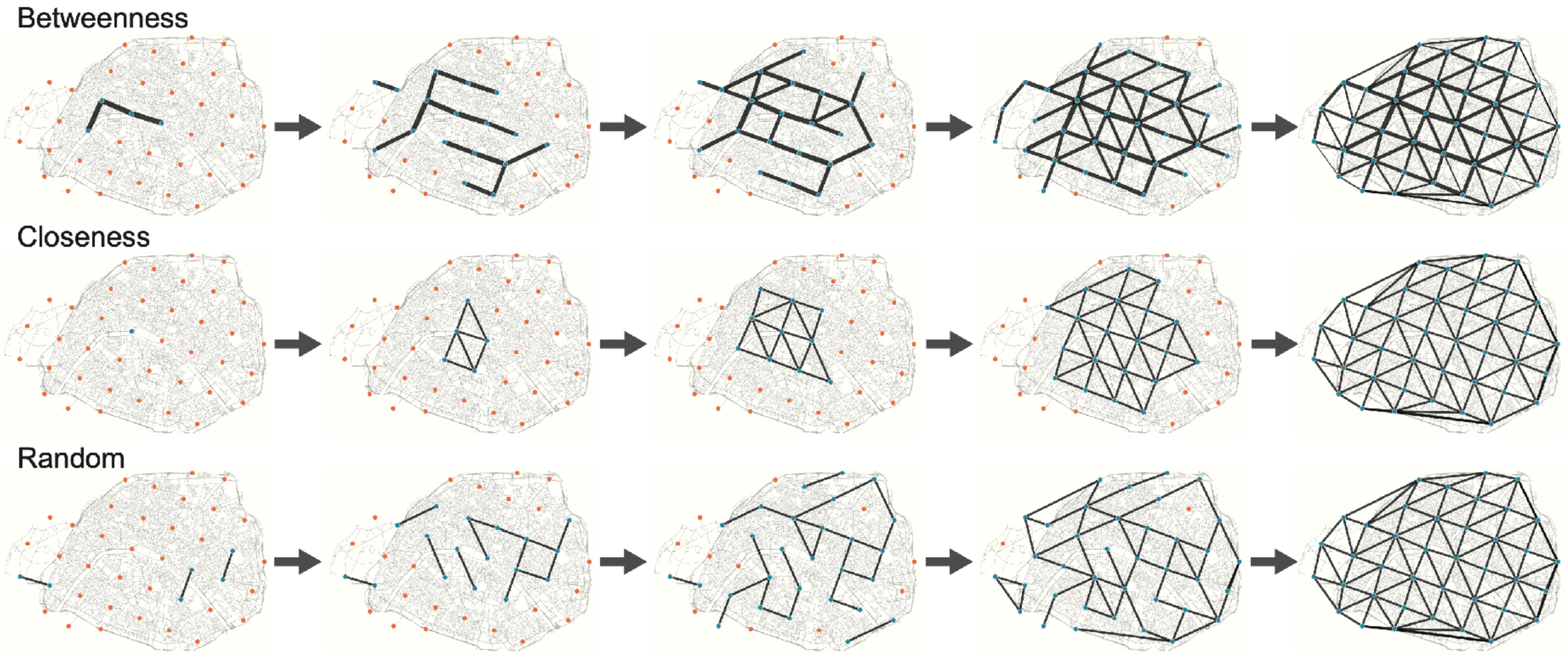




Szell et al., Sci Rep 12, 6765 (2022)

We build a greedy triangulation between points of interest

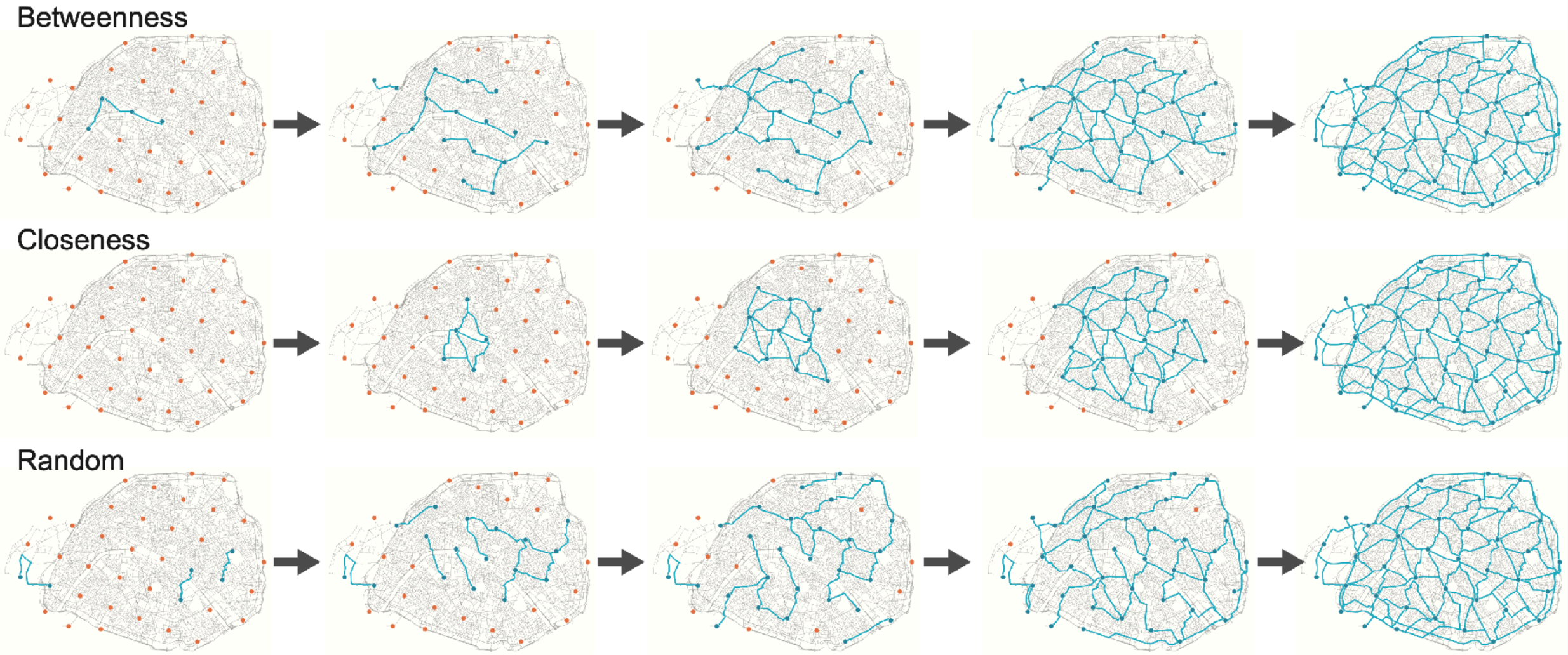
3) Order by growth strategy



Szell et al., Sci Rep 12, 6765 (2022)

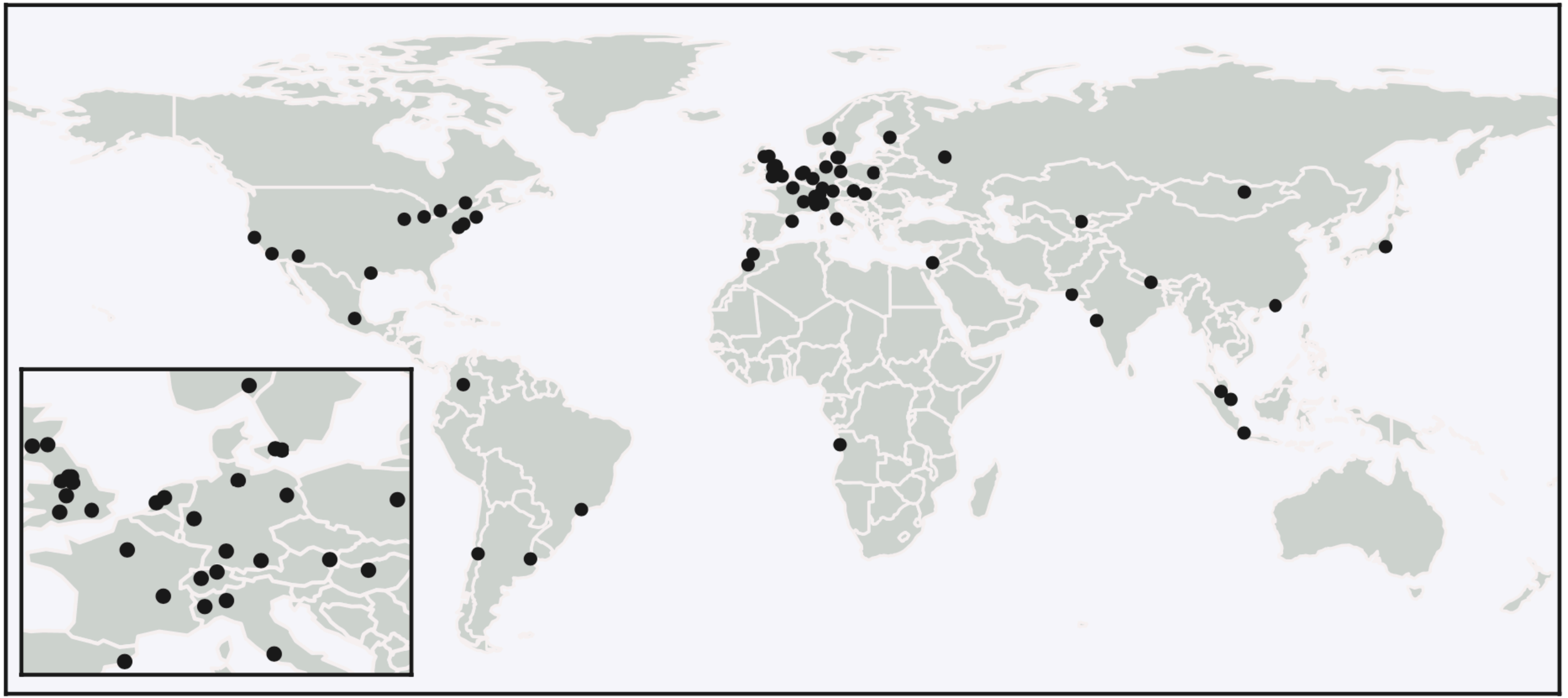
We build a greedy triangulation between points of interest

4) Route on street network



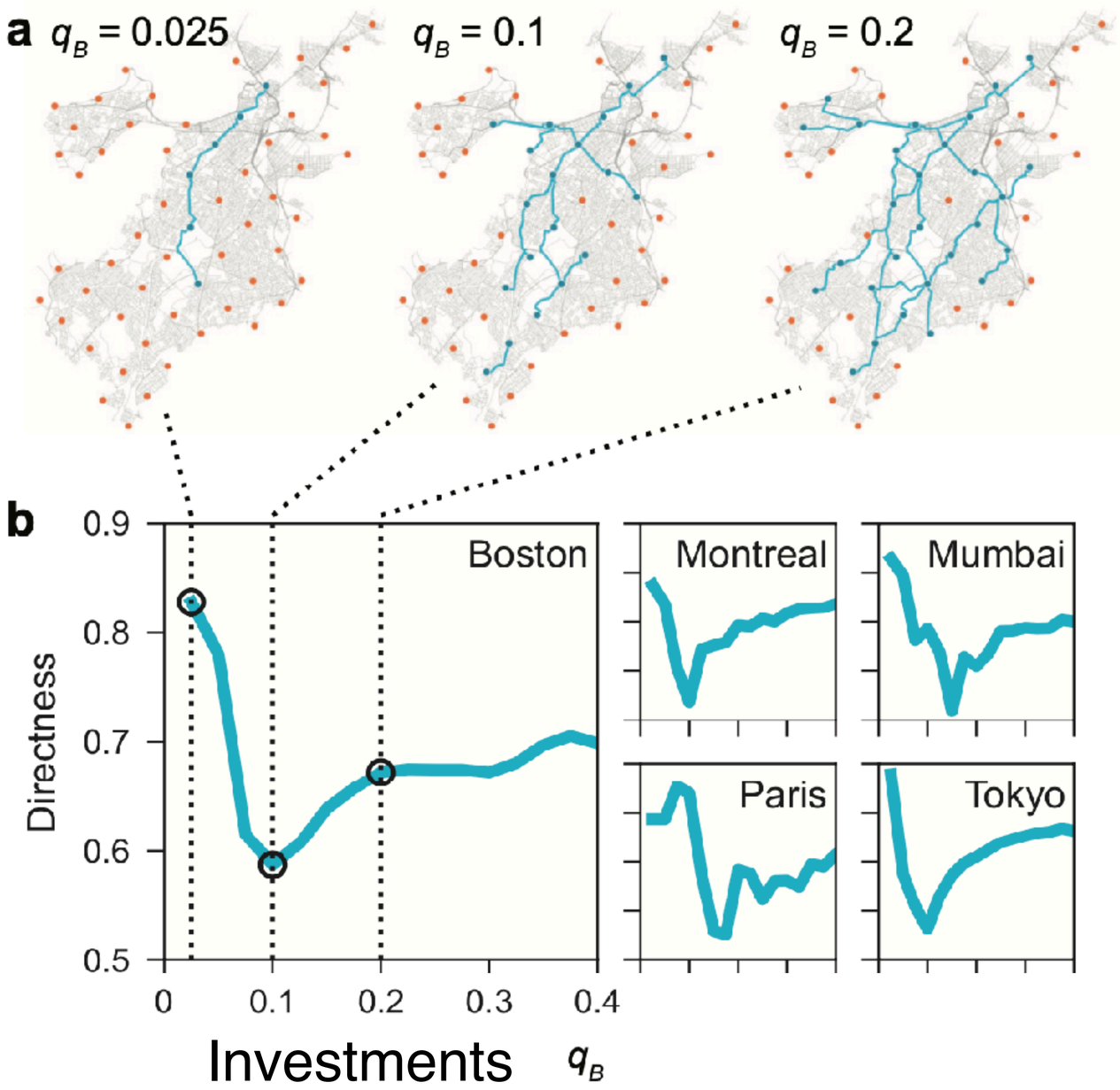
Szell et al., Sci Rep 12, 6765 (2022)

We explore 62 cities



Szell et al., Sci Rep 12, 6765 (2022)

Result 1: Investments need to surpass a critical threshold



The pieces need to connect and to form cycles

Szell et al., Sci Rep 12, 6765 (2022)

Policy implication 1: Invest persistently!

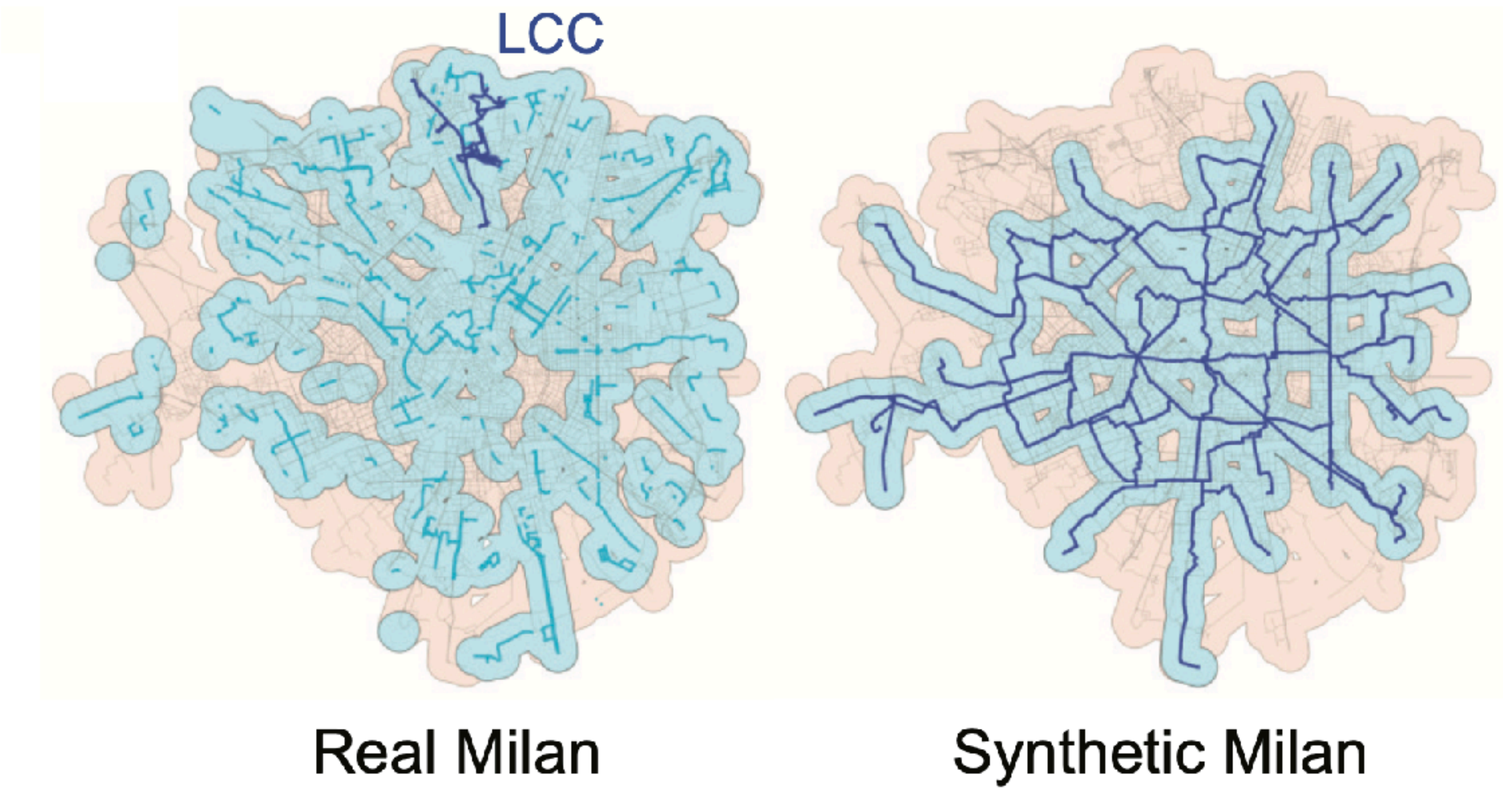
Brent Toderian @BrentToderian · Jul 30

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

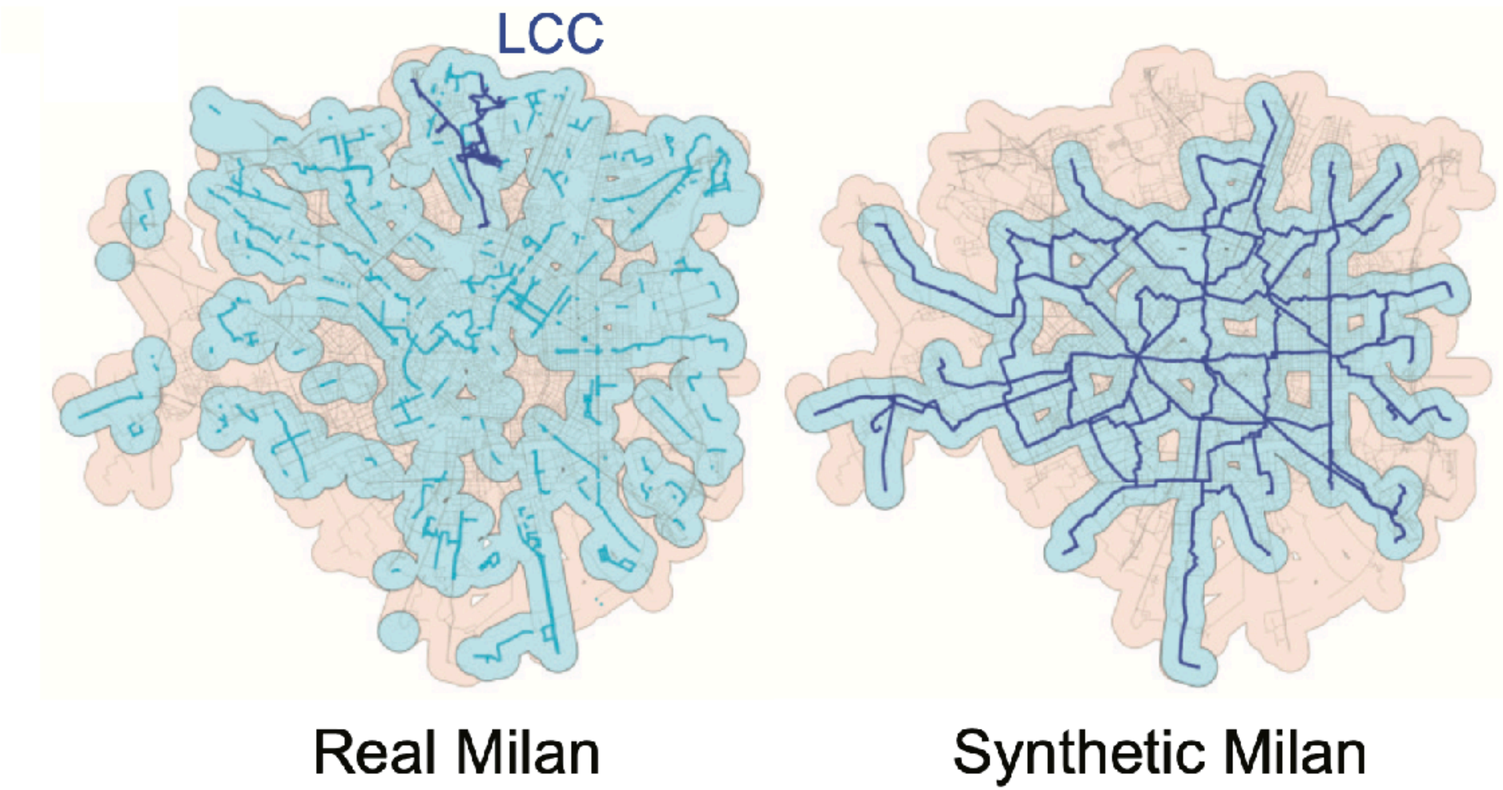
Result 2: It's not a network's length that matters but how you grow it

At same length, we could do much better

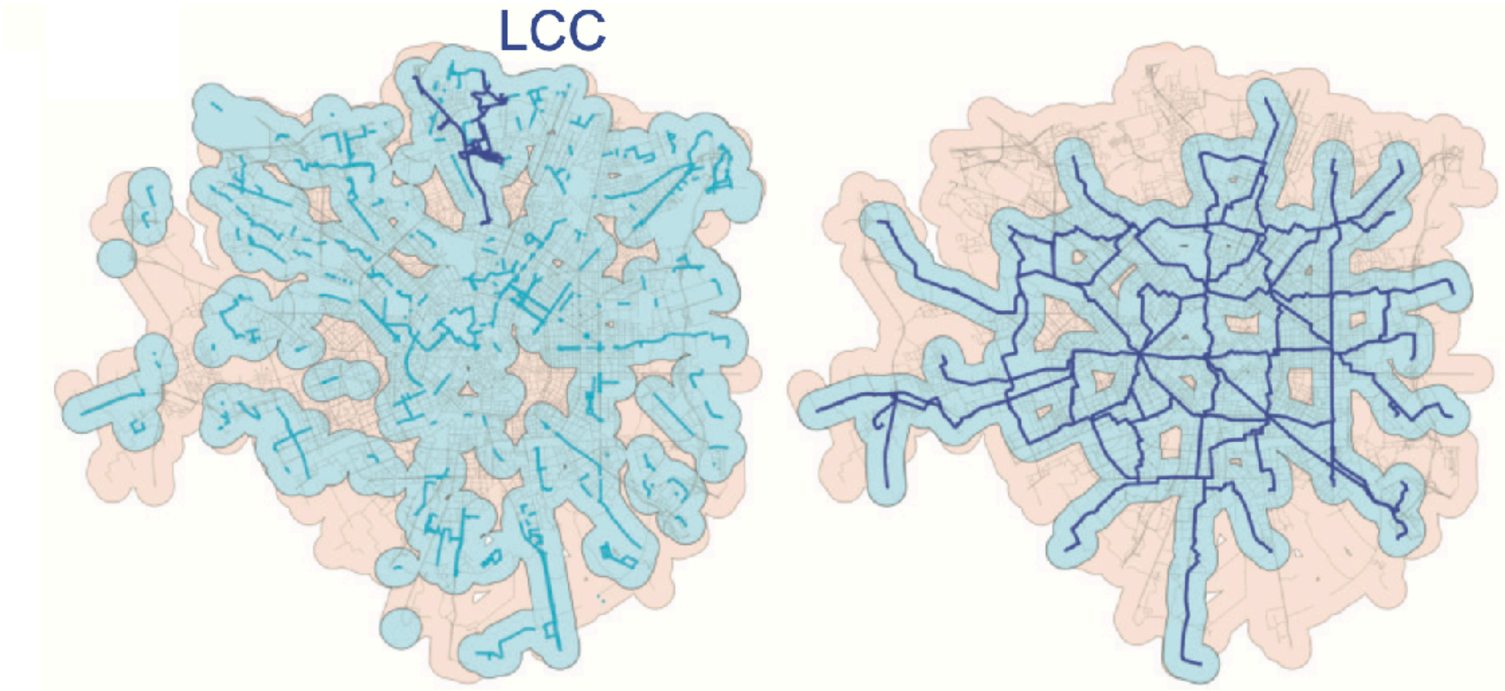


Policy implication 2: Strategy matters: Build for the whole city

Avoid "random-like", piecewise growth

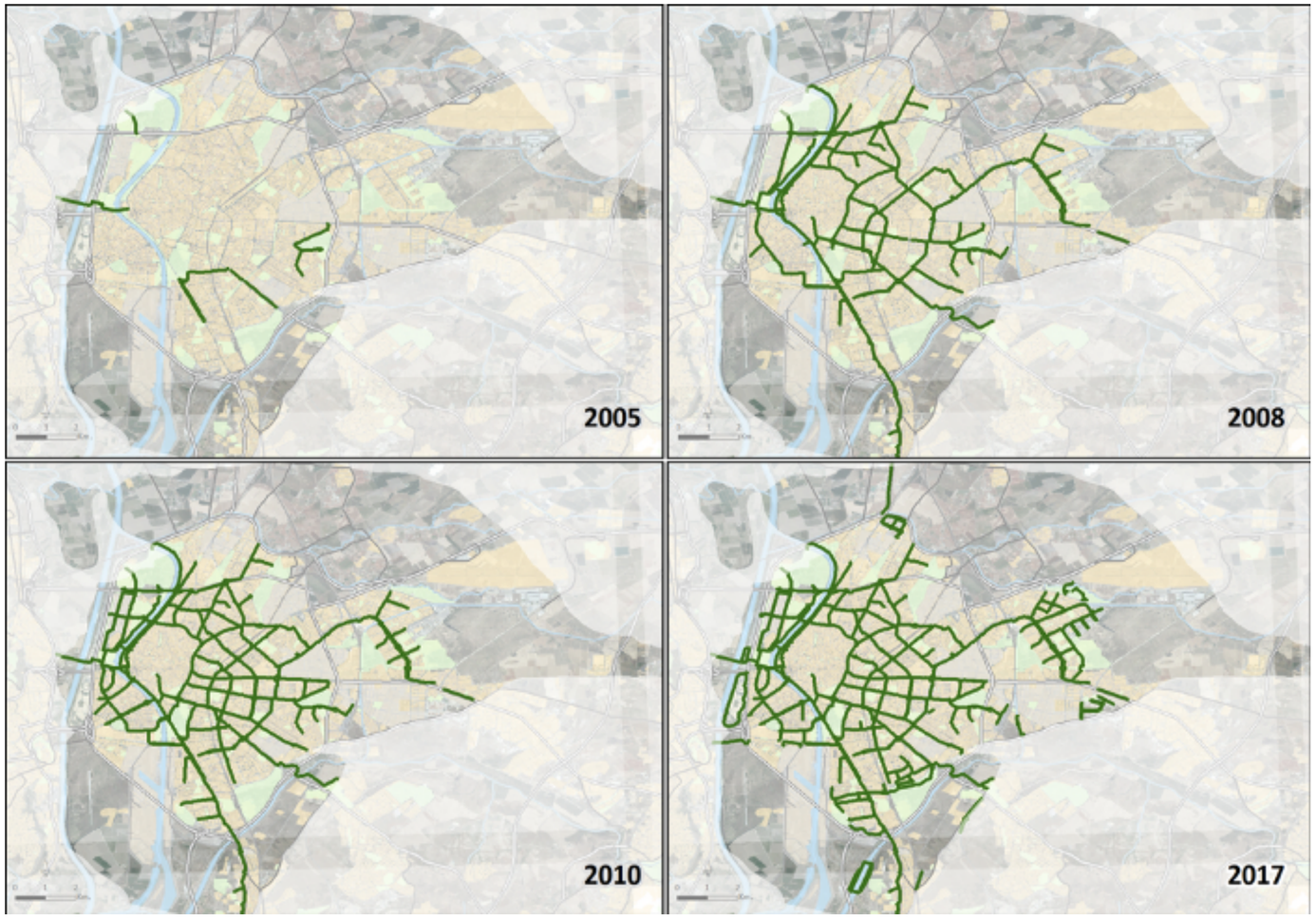


Easier said than done - Isn't this unrealistic??

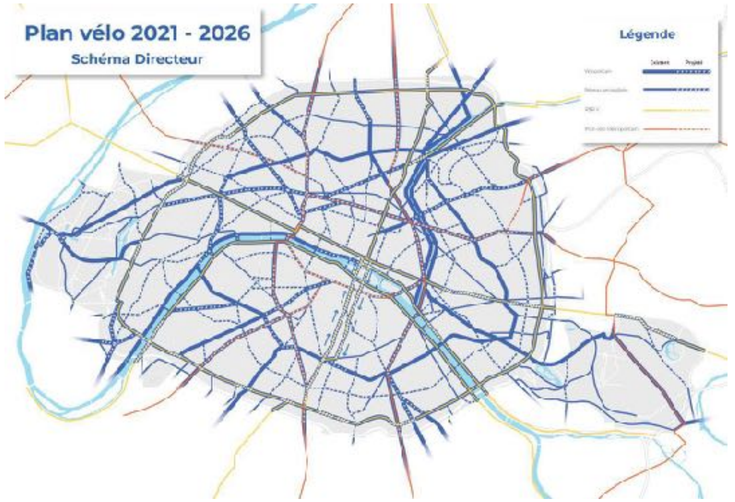


Easier said than done - Isn't this unrealistic??

Nope: See Seville



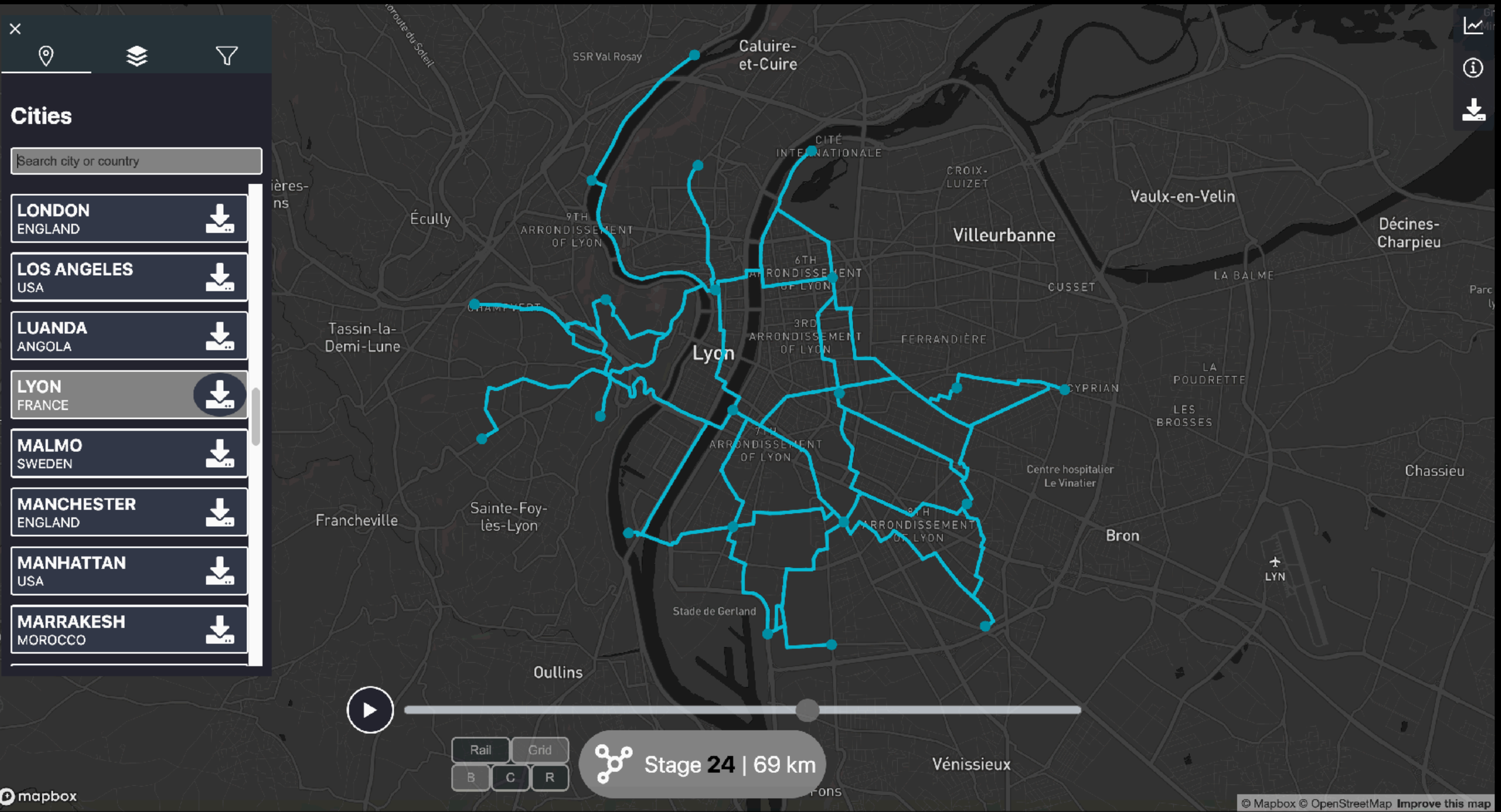
Also: Paris, Oslo, ...



There is no excuse

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

Explore your city at GrowBike.Net



What to do if your bike network is already pretty good?

Identify & Prioritize

We could find millions of gaps…

We need a metric to prioritize them.

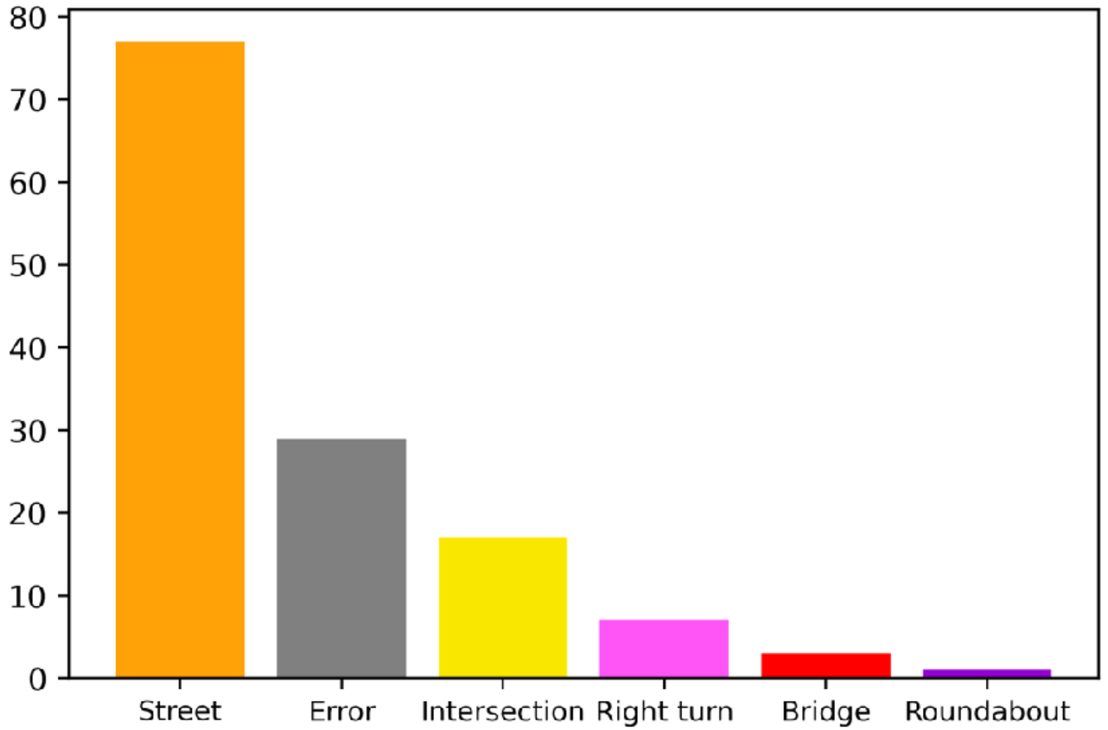
Vybornova et al, Geographical Analysis (2022)

2) Prioritize

“If this gap was closed, how many meters cycled in mixed traffic would be avoided per investment unit?”

Vybornova et al, Geographical Analysis (2022)

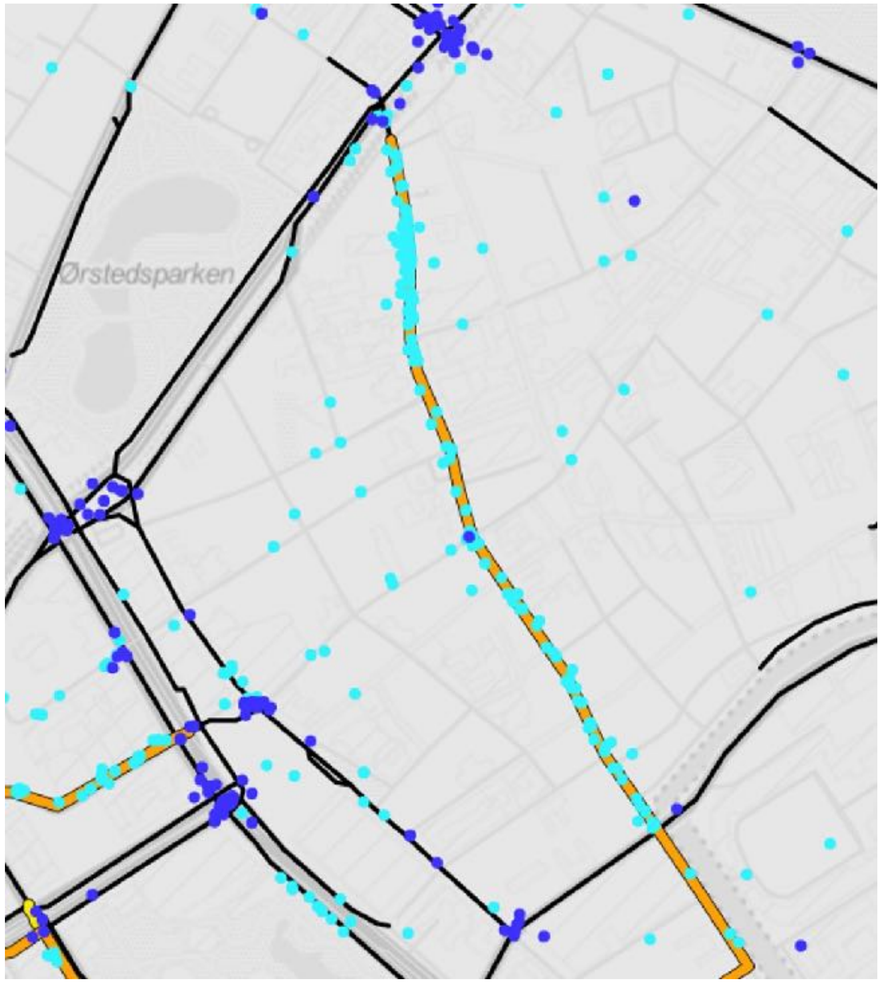
Our top 105 gaps



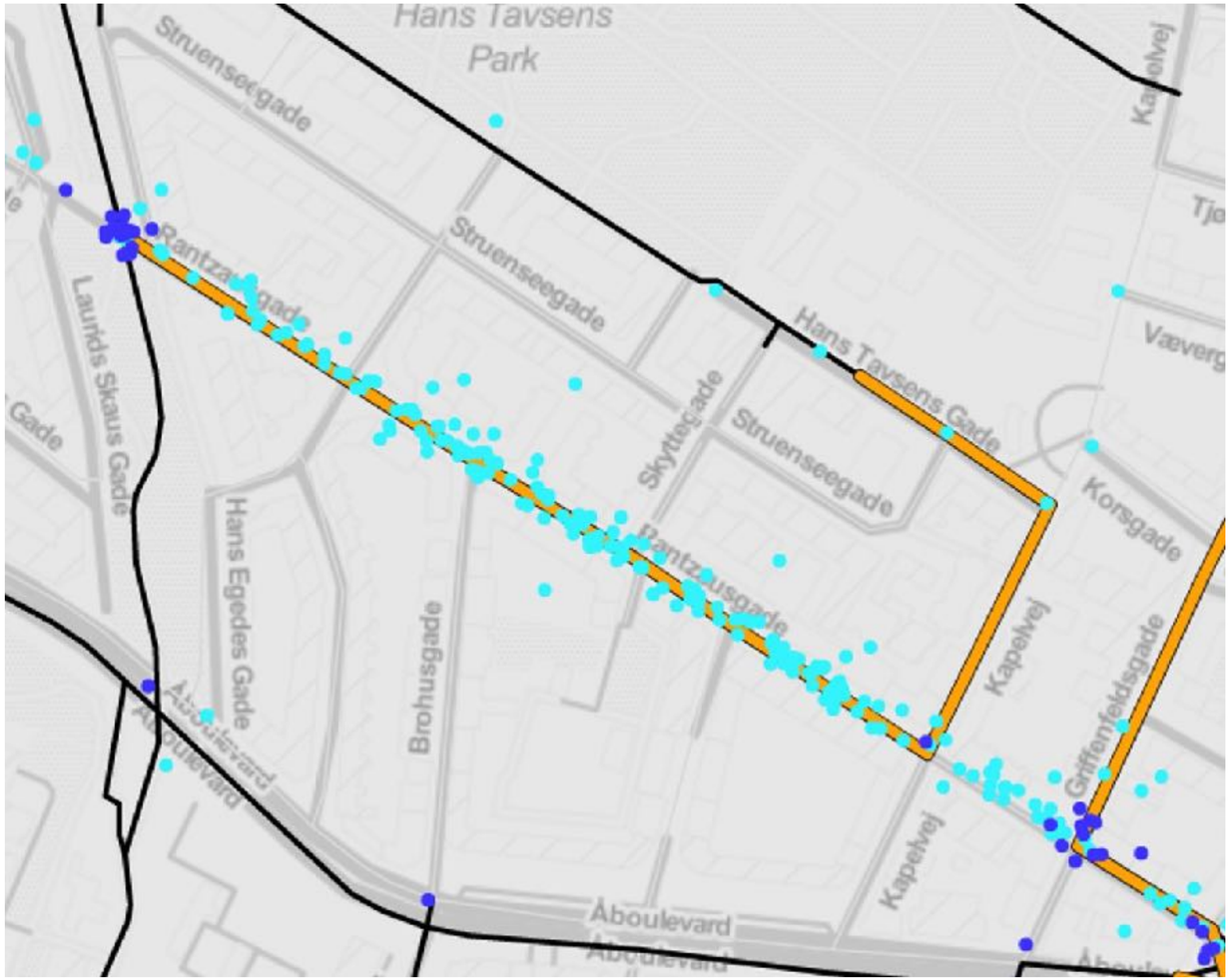
Vybornova et al, Geographical Analysis (2022)

Evaluation: Comparison with Cykelsti-Prioriteringsplan

Evaluation: We find many overlaps



Nørregade



Rantzausgade

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

scientific reports

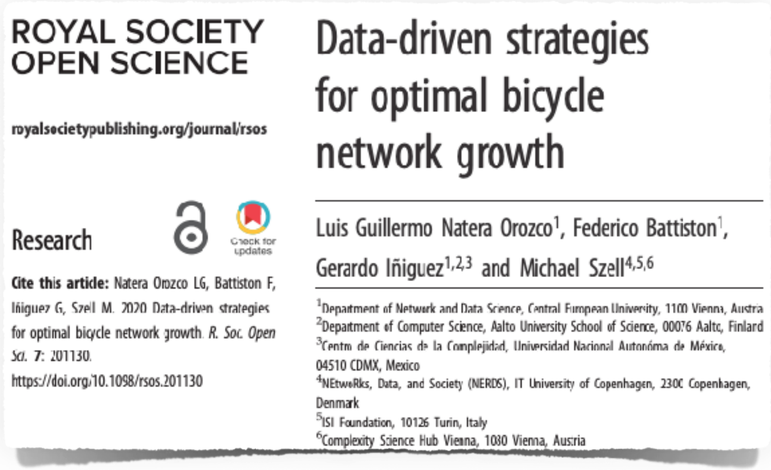
Check for updates

OPEN **Growing urban bicycle networks**

Michael Szell[1,2,3✉], Sayat Mimar[4], Tyler Perlman[4], Gourab Ghoshal[4] & Roberta Sinatra[1,2,3,5]

Grow persistently with focused investments

medium developed



ROYAL SOCIETY OPEN SCIENCE

royalsocietypublishing.org/journal/rsos

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

Check for updates

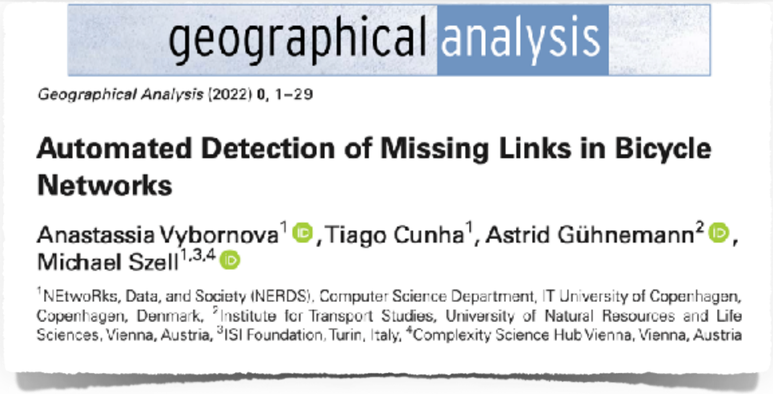
Data-driven strategies for optimal bicycle network growth

Luis Guillermo Natera Orozco[1], Federico Battiston[1], Gerardo Iñiguez[1,2,3] and Michael Szell[4,5,6]

[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 Autónoma 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

Connect with right strategy

well developed



geographical analysis

Geographical Analysis (2022) **0**, 1–29

Automated Detection of Missing Links in Bicycle Networks

Anastassia Vybornova[1], Tiago Cunha[1], Astrid Gühnemann[2], Michael Szell[1,3,4]

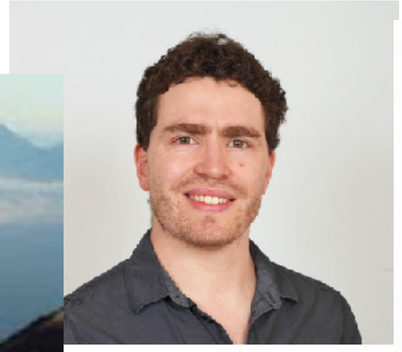
[1]NEtwoRks, Data, and Society (NERDS), Computer Science Department, IT University of Copenhagen, Copenhagen, Denmark, [2]Institute for Transport Studies, University of Natural Resources and Life Sciences, Vienna, Austria, [3]ISI Foundation, Turin, Italy, [4]Complexity Science Hub Vienna, Vienna, Austria

Close the most important gaps








Szell et al., Sci Rep 12, 6765 (2022)

Klanjcic et al, EPJ Data Sci 11, 27 (2022)

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

Vybornova et al, Geographical Analysis (2022)

Break

How are cities planned?

What should you do to relieve congestion?

Building more roads to prevent congestion

is like a fat man loosening his belt to prevent obesity

Lewis Mumford

Induced demand

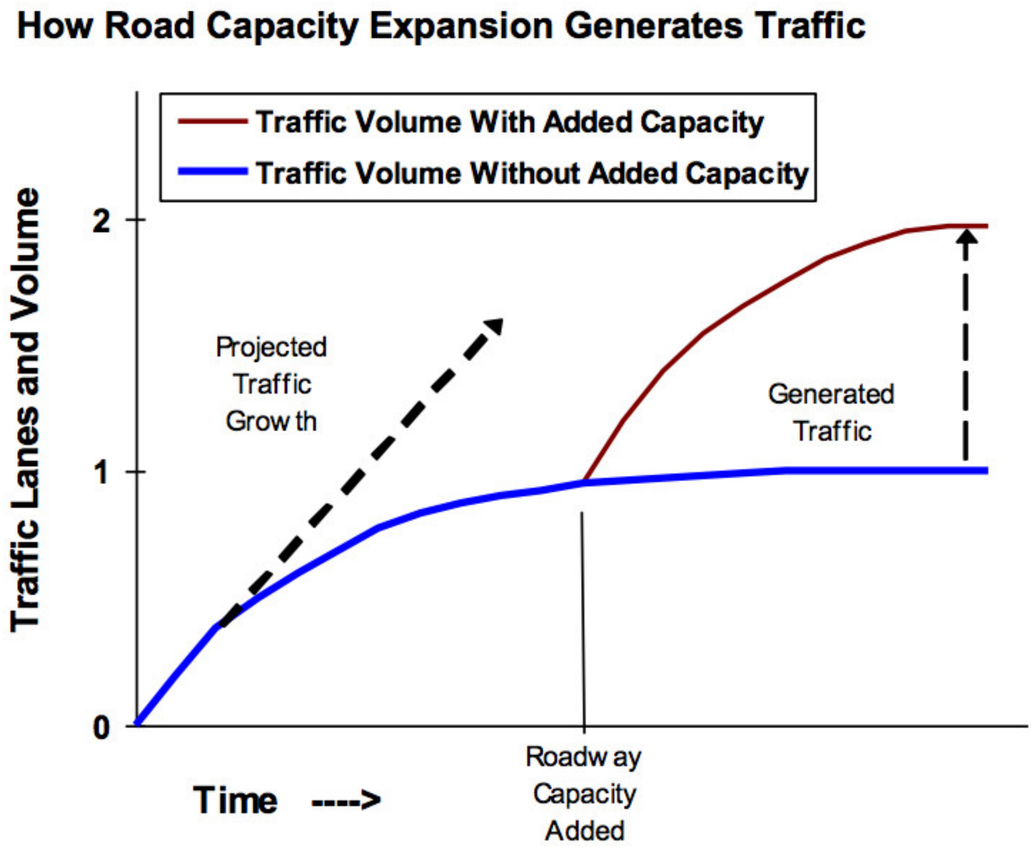
If you widen roads, you create more traffic

https://www.governing.com/now/why-the-concept-of-induced-demand-is-a-hard-sell

https://www.bloomberg.com/news/features/2021-09-28/why-widening-highways-doesn-t-bring-traffic-relief

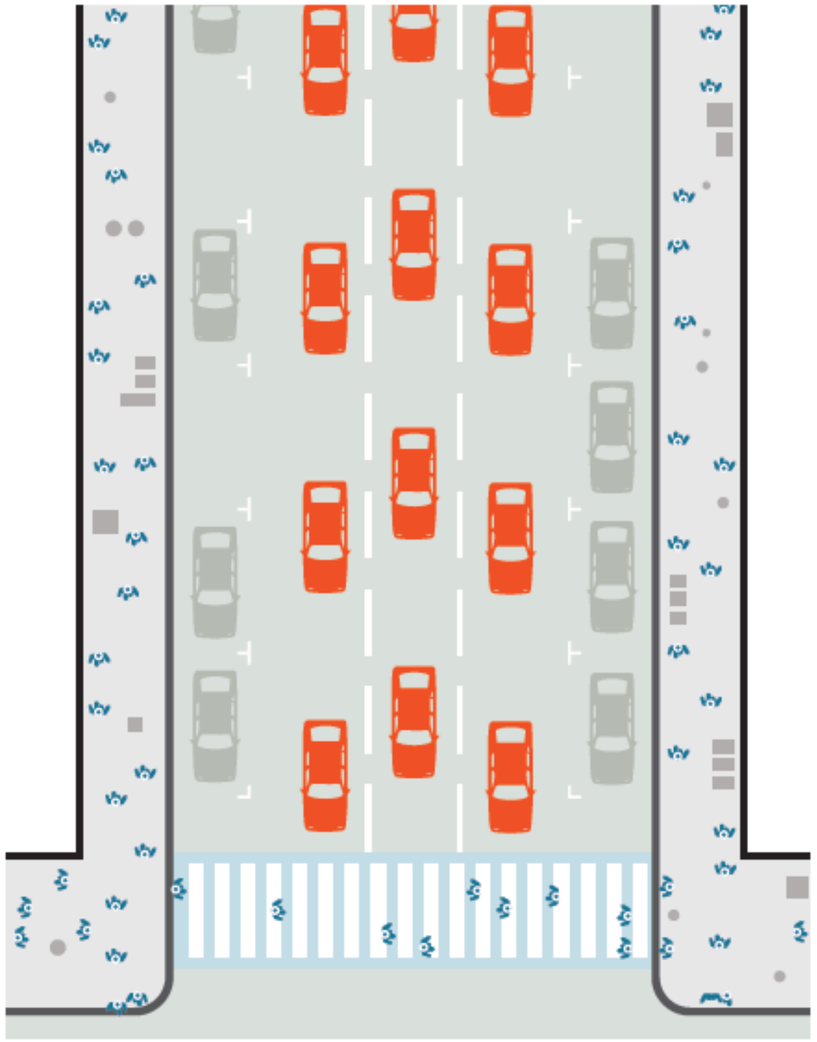
Induced demand

If you widen roads, you create more traffic

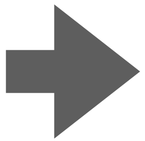


The opposite of induced demand is disappearing traffic

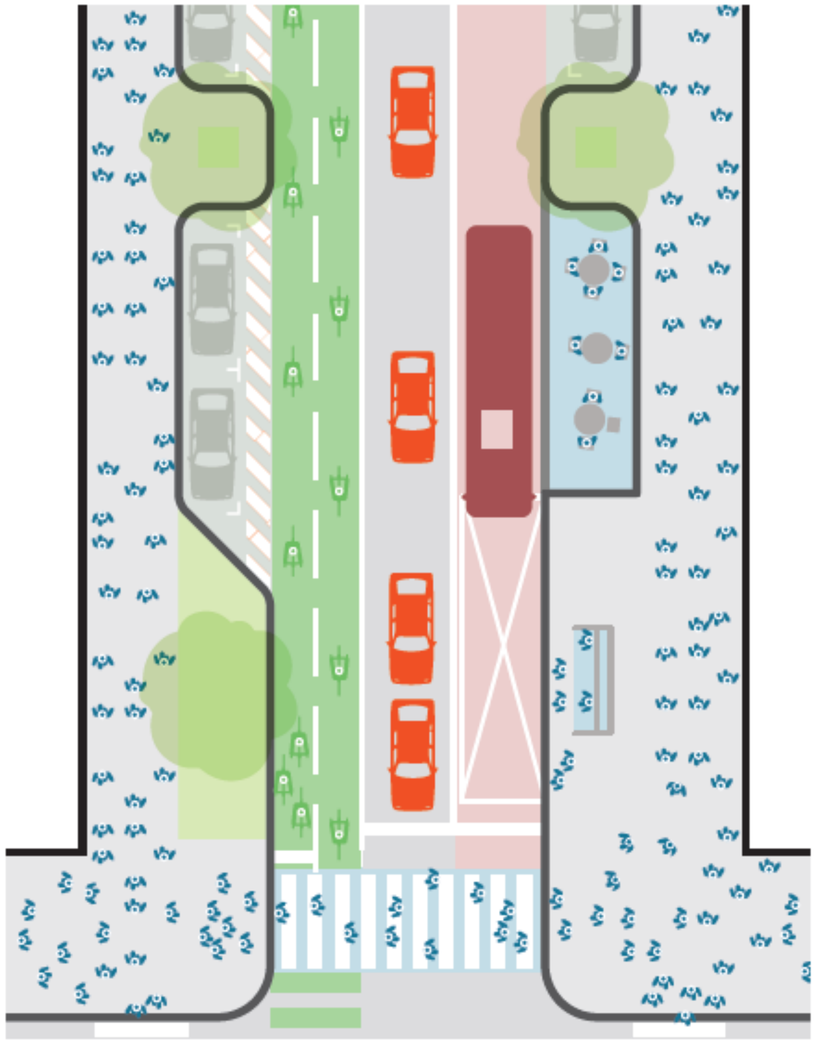
Car-Oriented Street



Road diet



Multimodal Street



https://www.icevirtuallibrary.com/doi/full/10.1680/muen.2002.151.1.13

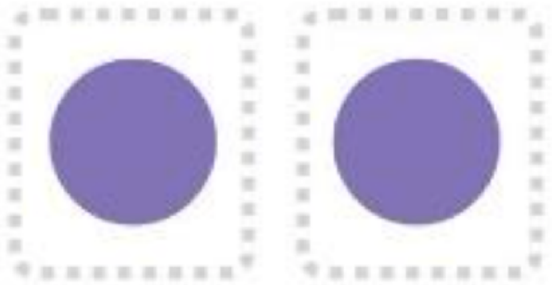
Short-term engineering thinking

vs

Long-term systems thinking

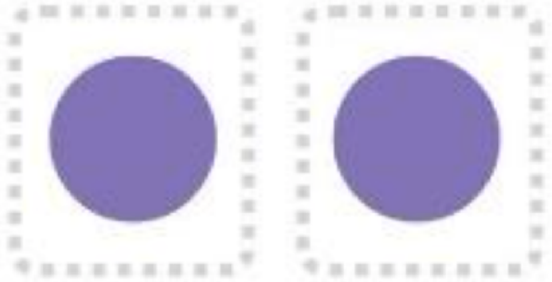
20th century: Short-term engineering thinking

Compartmentalization: We can study a subsystem on its own

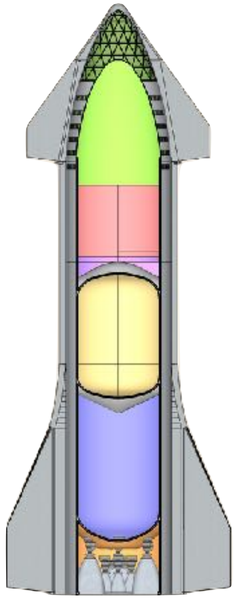


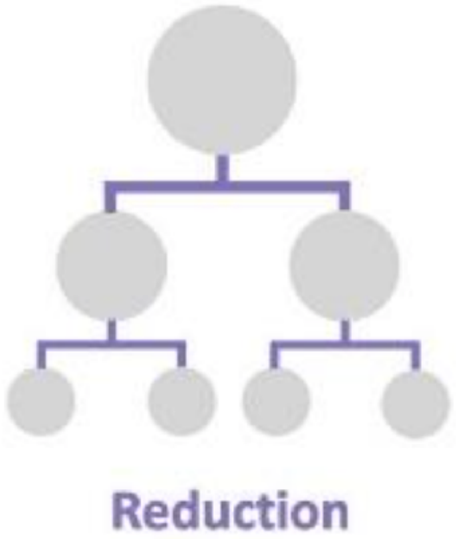
20th century: Short-term engineering thinking

Compartmentalization: We can study a subsystem on its own



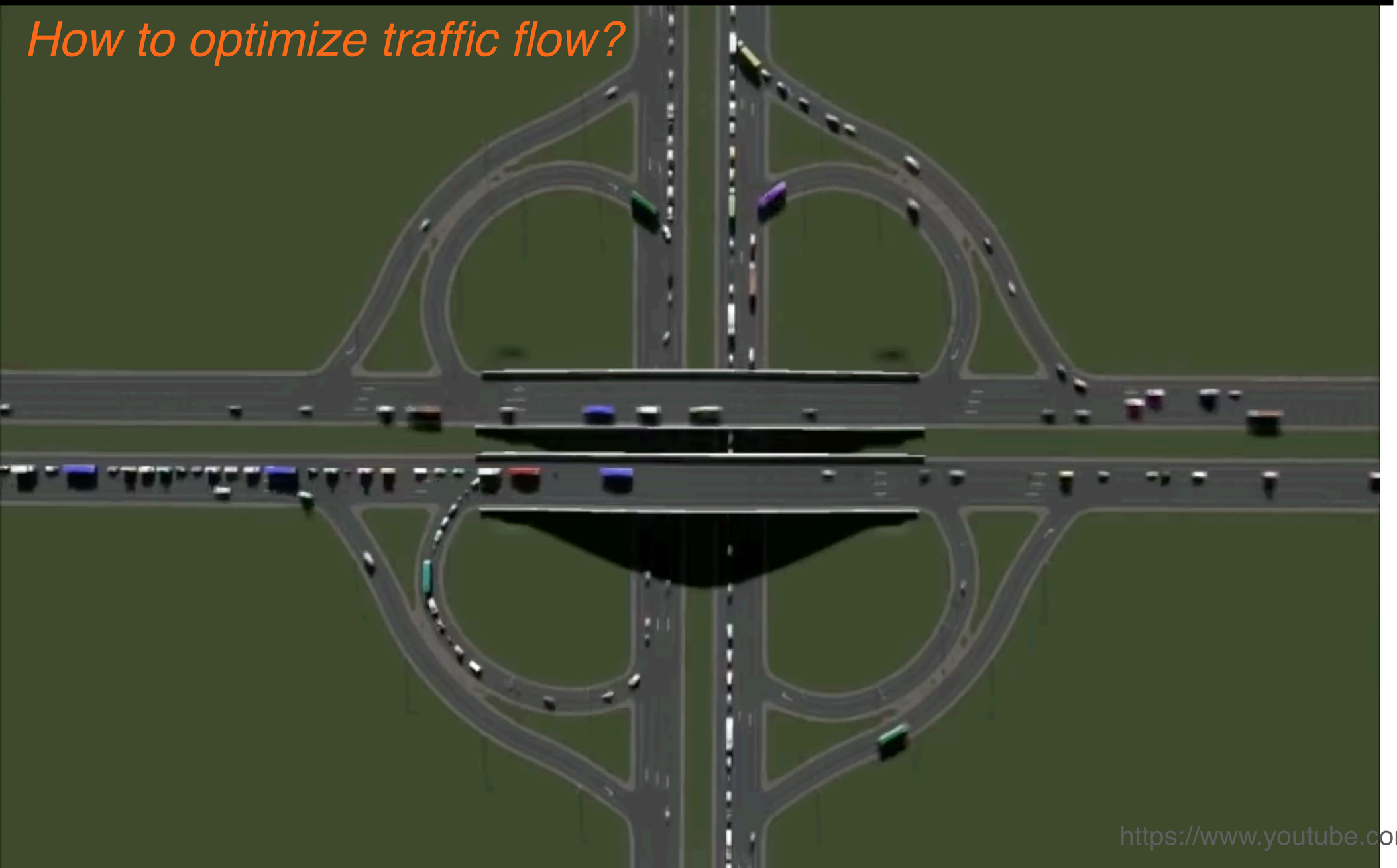
How do we build & shoot a rocket to the moon?





20th century: Short-term engineering thinking

How to optimize traffic flow?



https://www.youtube.com/watch?v=yITr127KZtQ

21th century: Also consider long-term systems thinking

Complexity: We cannot study a subsystem on its own

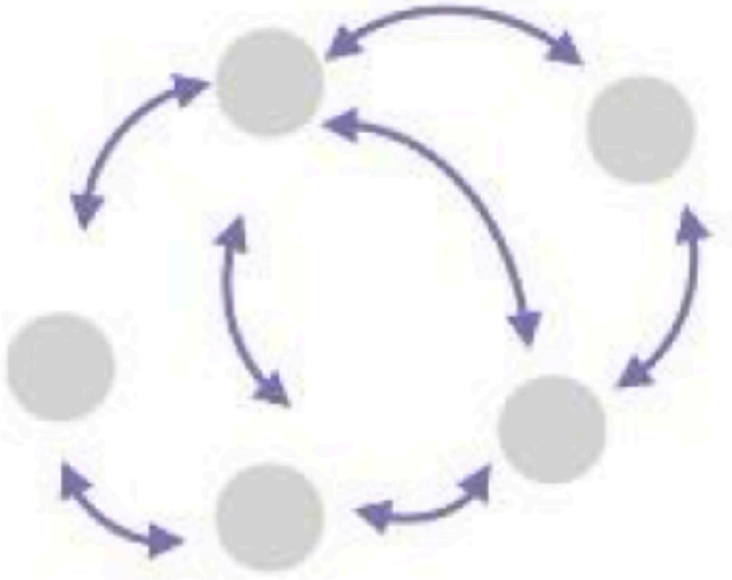
There are strong interactions or feedback loops

21th century: Also consider long-term systems thinking

Complexity: We cannot study a subsystem on its own

There are strong interactions or feedback loops

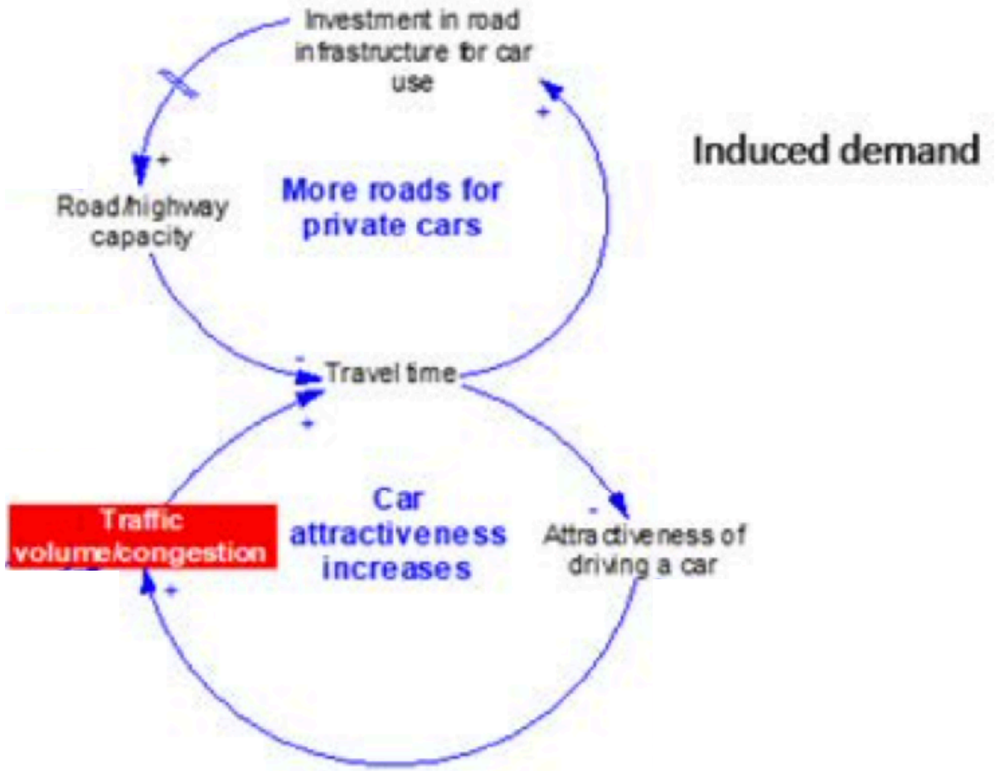
How do cities develop if we optimize streets for traffic flow?



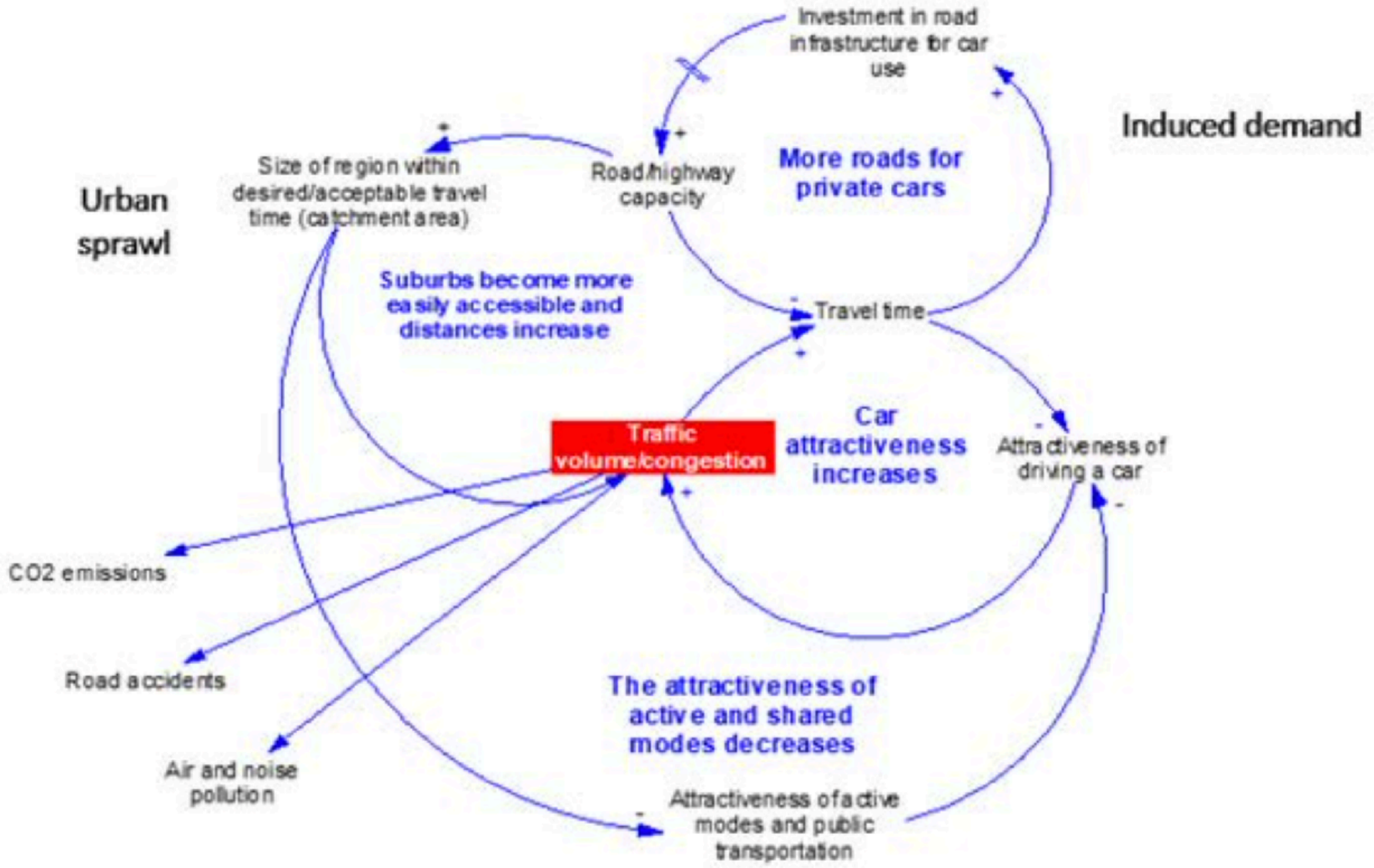
Systems-thinking reveals feedback-loops & long-term dynamics

Causal loop diagram https://www.oecd.org/environment/transport-strategies-for-net-zero-systems-by-design-0a20f779-en.htm

Systems-thinking reveals feedback-loops & long-term dynamics

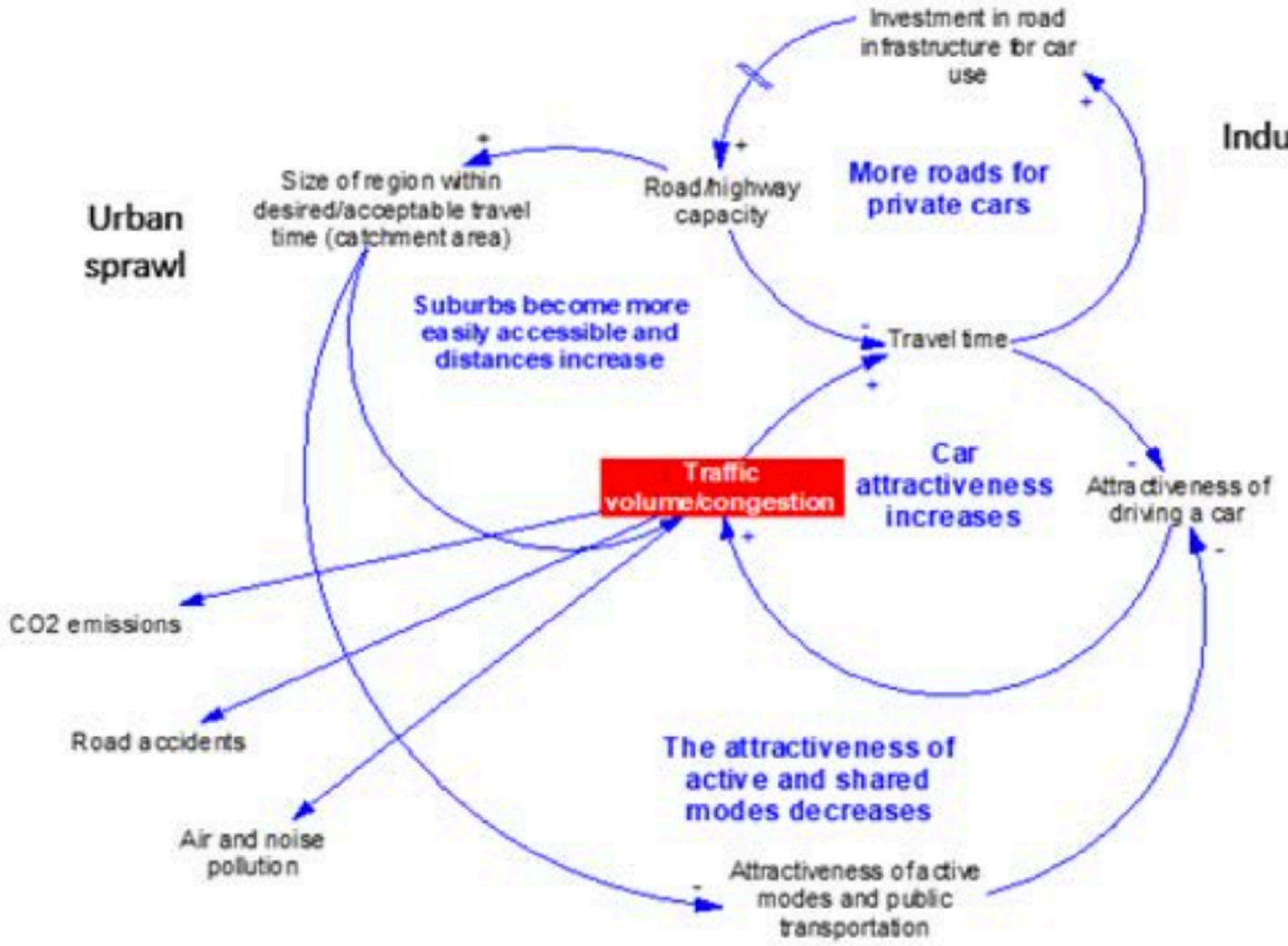


Systems-thinking reveals feedback-loops & long-term dynamics



Erosion of active and shared modes
(e.g. walking, cycling, public transport)

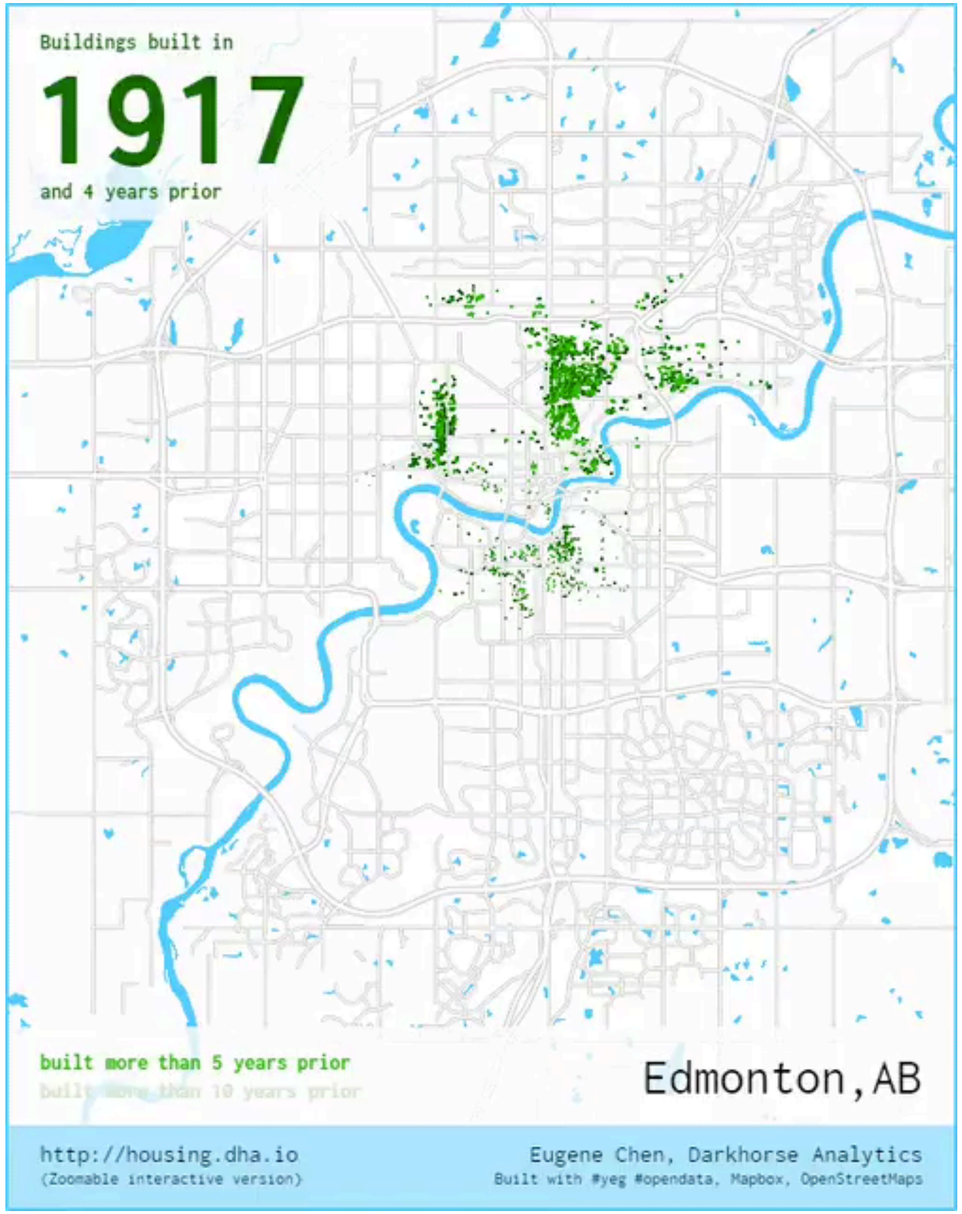
Systems-thinking reveals feedback-loops & long-term dynamics



Car dependency and distances

Attractiveness of sustainable transport modes

Systems-thinking reveals feedback-loops & long-term dynamics



Urban sprawl

As the *size of the region accessible by road* increases, density decreases and the *number of places conveniently accessible by public transport* decrease.

Thus, as the region expands, places may be less well served by public transport, reducing the attractiveness of public transport and increasing the attractiveness of its alternative: the car.

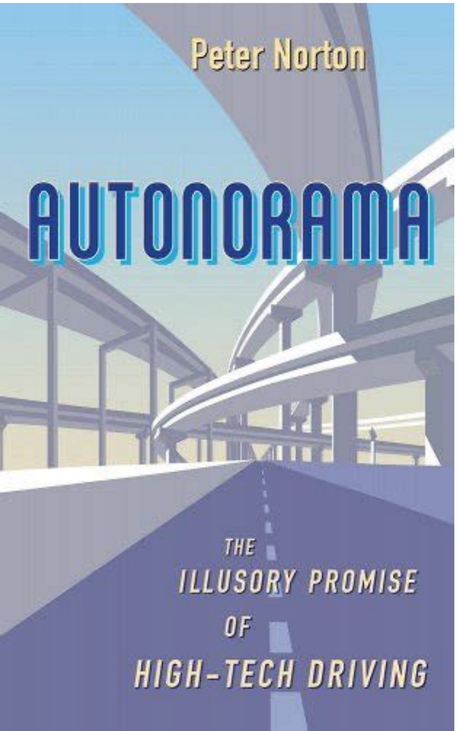
http://housing.dha.io/

Optimizing one part of a complex system can come with unintended consequences

What is "data-driven" planning, and how/why do it?

By "data-driven", we mean "data-informed"

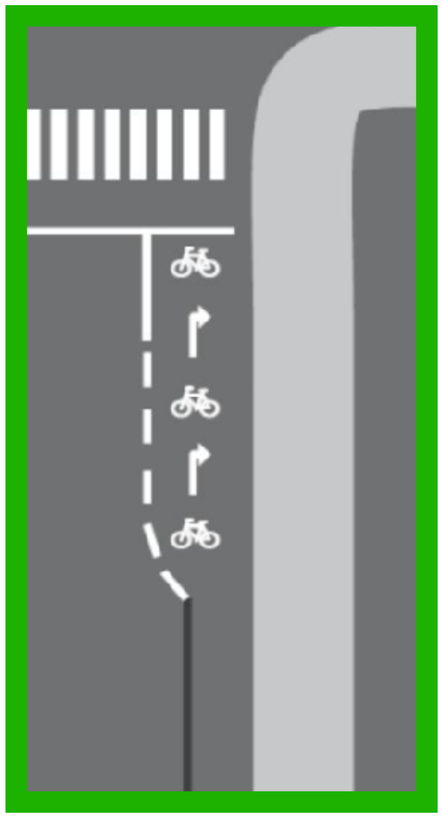
Which data you use, and how you use it, is *always* a political decision



You can argue for/against everything with "data"

Example: Danish intersection design

Based on crash data and a regression model, the Danish road directorate favors this intersection design:



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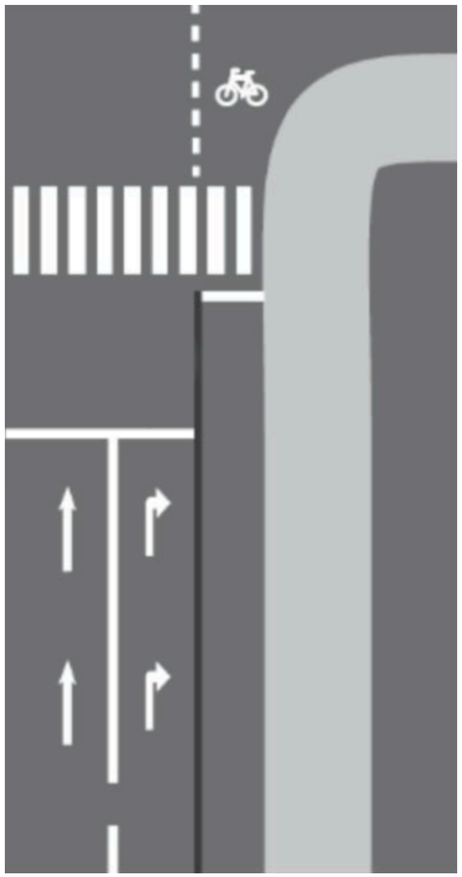


Sørensen, Jensen, Hansen, Proc Ann Trans Conf (2020)

https://en.wikipedia.org/wiki/False_dilemma

Example: Danish intersection design

Would you let a child cycle here?

Example: Danish intersection design

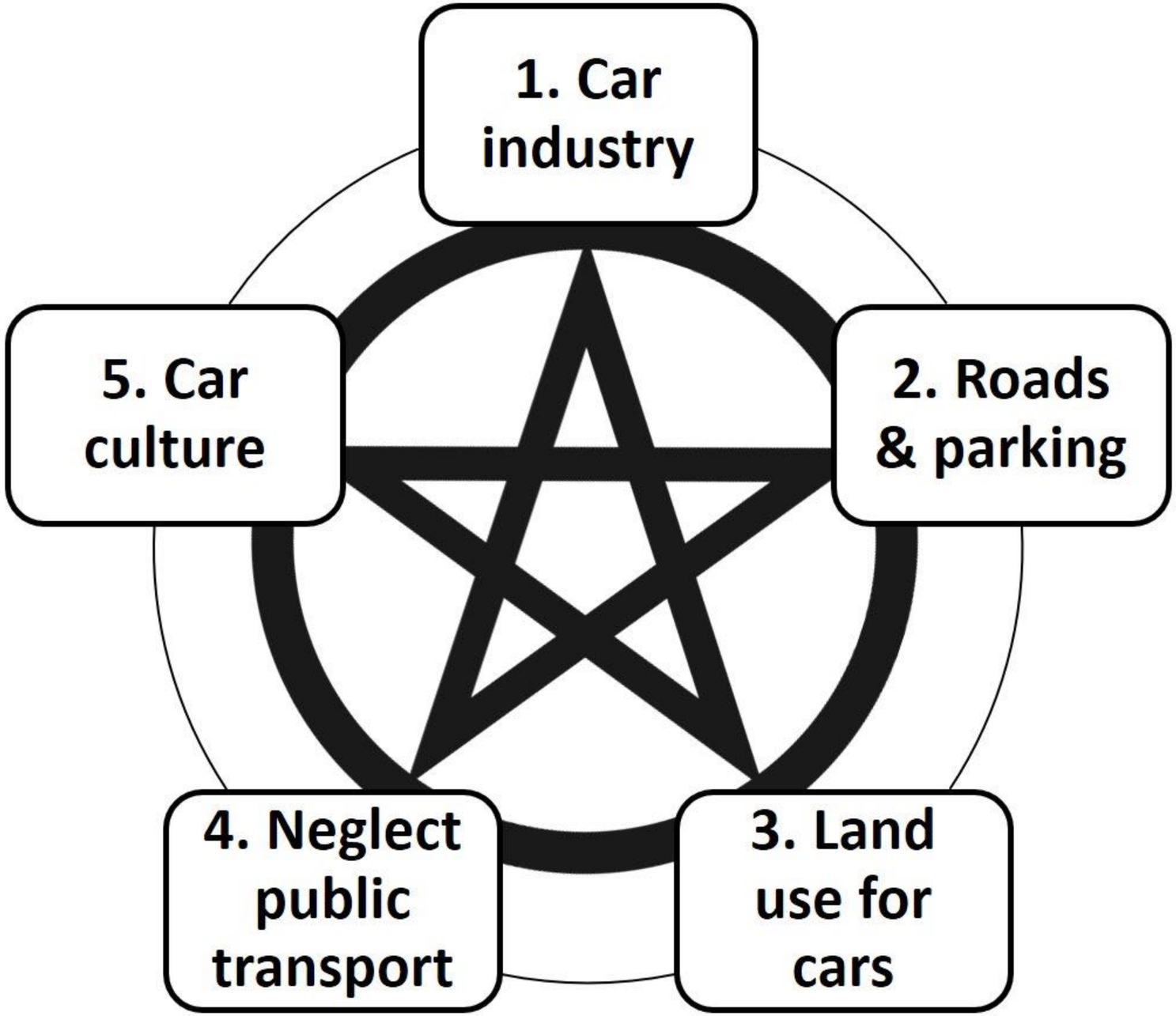
*Hard to measure: Data of how many children did **not** cycle here*

https://en.wikipedia.org/wiki/McNamara_fallacy

Example: Danish intersection design

There are better ways: Minimize mixing with cars

Even better: remove the hazard



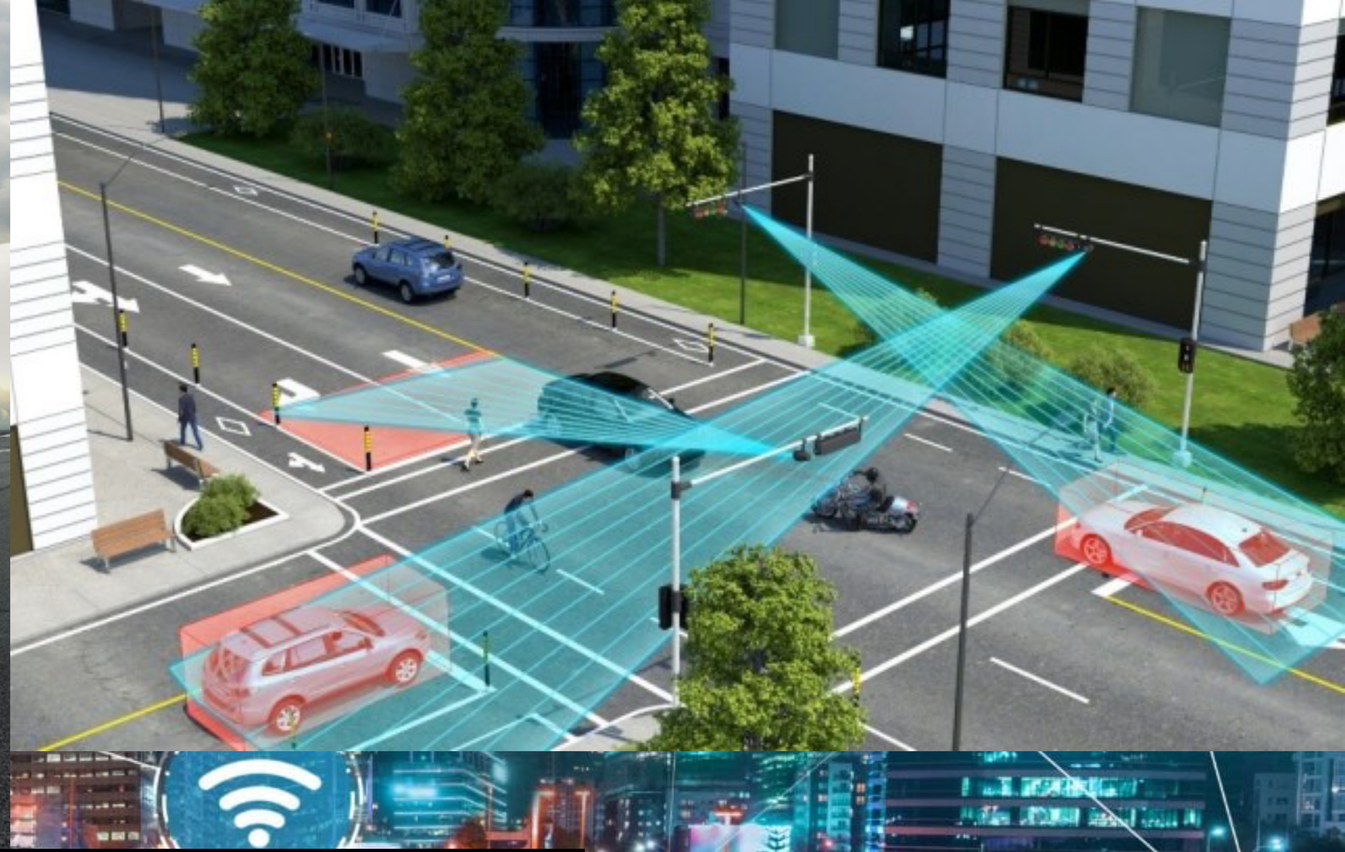
Mattioli et al, Energy Research & Social Science 66 (2020): 101486

The political economy of car-dependency: an anatomy of lock-in

Cause: / *Effect:*	1 Automotive Industry	2 Car Infrastructure	3 Land Use Patterns	4 Public Transport	5 Car Culture
1 Automotive industry		Car infrastructure enables the sale of more cars, by providing space to accommodate them. The status of roads goes from shared public spaces to motorised flow spaces, literally driving other modes out, and enhancing the value of car ownership.	The need for cars to navigate urban sprawl creates an incentive for consumers to purchase more of them, thereby stabilising demand for automobiles. Suburban, car-dependent constituencies further strengthen the car industry's lobbying efforts.	Historically, the legacy of monopolistic public transit companies has strengthened the political hand of the car industry. Currently, deteriorating public transit forces more people to buy cars.	Car culture produces a continuous demand for vehicles that upholds the car industry. It also influences the cultural dynamics of the industry itself, locking in certain approaches and business models.
2 Car Infrastructure	The automotive industry plays a key role in lobbying coalitions which pressure government to invest public resources, and co-opt public space, to make room for cars.		The expansion of the suburbs demands high-capacity roads and highways to serve them, while also making it more challenging to travel by foot, bike, or public transit.	Public transit becomes dependent on car-dependent road infrastructure, bolstering car industry's lobbying efforts.	Car infrastructure has durable cultural associations with progress, modernity, ruralism, and competent governance, which improve its political viability.
3 Land Use Patterns	The car industry, working with other aligned industries, such as suburban real-estate developers, actively promotes urban sprawl. Historically, car companies promoted visions of an efficient, modern cityscapes and suburban areas.	The expansion of car infrastructure encourages suburban and single-purpose development, which become more viable and more desirable due to mass automobility.		Lack of public transport options leads to locational indifference of sprawl, with no reason to prioritize land use around public transit axes.	Suburban land use has a potent set of cultural imaginaries (for example, white picket fences in the USA), which encourage more people to move to the suburbs and own cars.
4 Public transport	The car industry deliberately attempts to undermine public transit, and is strengthened in its attempts to do so by the fact that the public costs it imposes are more hidden than those of public transit. During economic crises, public transit gets cut while the car industry gets bailed out. Meanwhile, the surplus capacity that the car industry builds into cars gives it a critical advantage over public transit in terms of range, marginal cost, and cargo capacity.	Infrastructure designed primarily for cars crowds out public transport road-based options such as buses, and pulls financial resources away from other alternatives, such as railways or streetcars.	Lower population densities make it more challenging to effectively organise public transit networks, leading to more car dependency and settlements outside public transit networks, in a vicious cycle.		Public transit is portrayed as unattractive, burdensome, and for the poor, young, or infirm.
5 Car Culture	The car industry actively supports the development of car culture, both deliberately, through advertising and marketing, and tacitly, through the built-in redundancy in the vehicles they sell, and the effects this has on people's daily practices.	Car infrastructure creates practices and habits & thence cultural trends, including daily dispersed activities connected by car journeys. Car infrastructure has also been normalised as a prominent symbol, for example in children's toys.	Land use patterns, both for residential and work developments, normalise commuting and car transport, ensuring that alternatives are portrayed as marginal.	The collapse of public transit networks encourages more people to adopt car-centric lifestyles.	

Mattioli et al, 2020

https://youtu.be/2973tOyZ-TA?t=1821



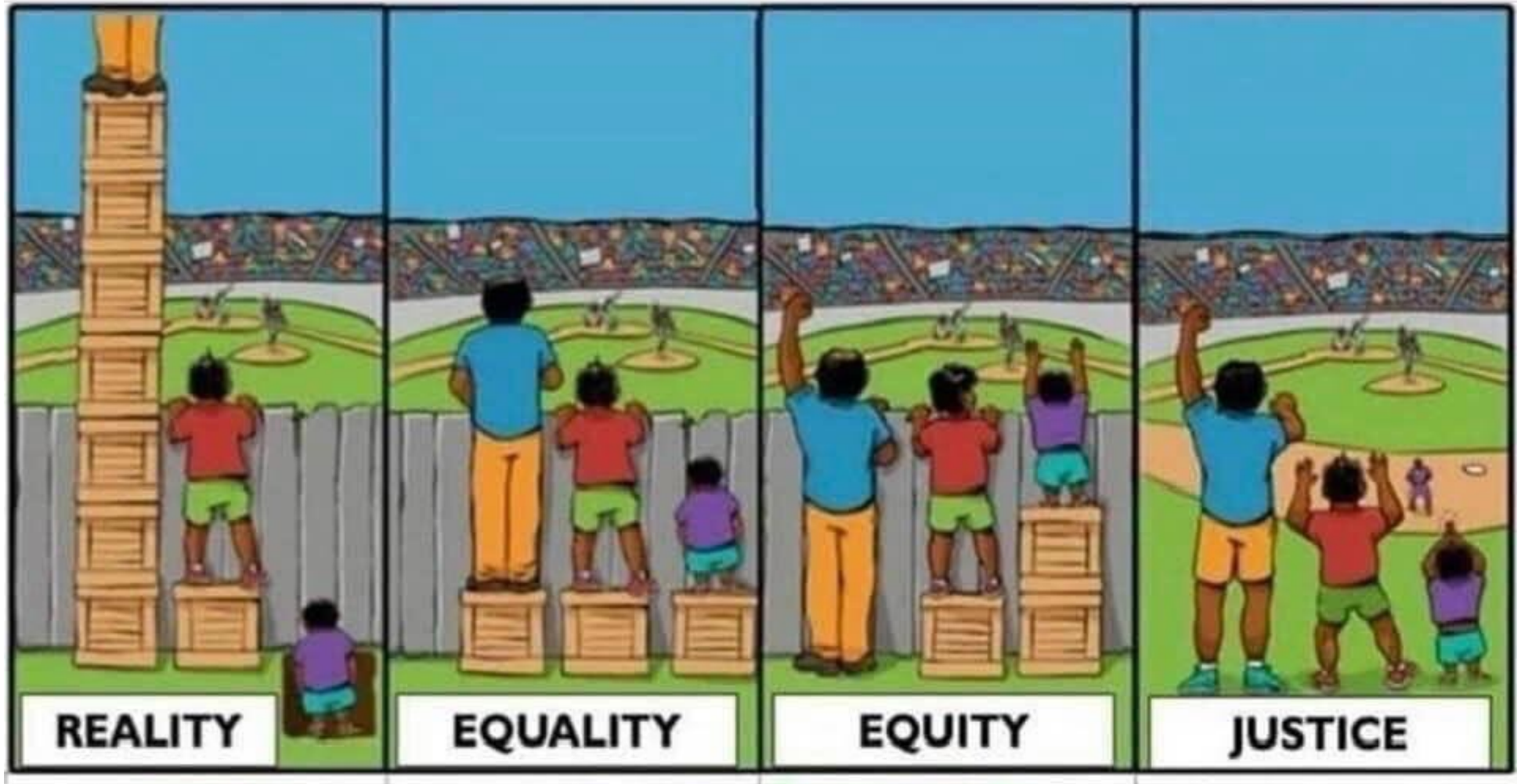
Tech alone won't save us

Short-term thinking has led to
"predict and provide"

But we should
"decide and provide"

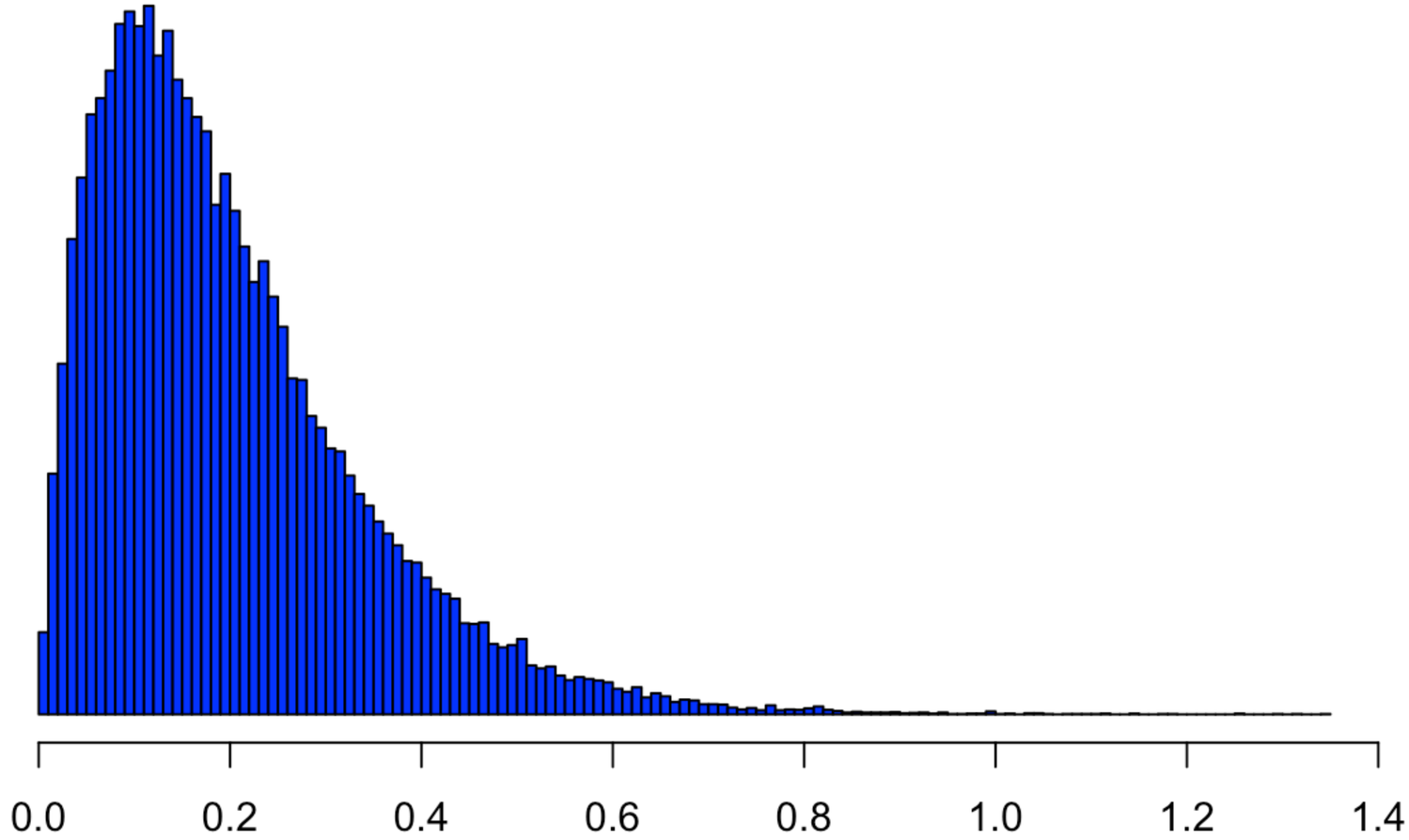
What are possible problems of just focusing on building bike networks?

30km bike highway
South Korea

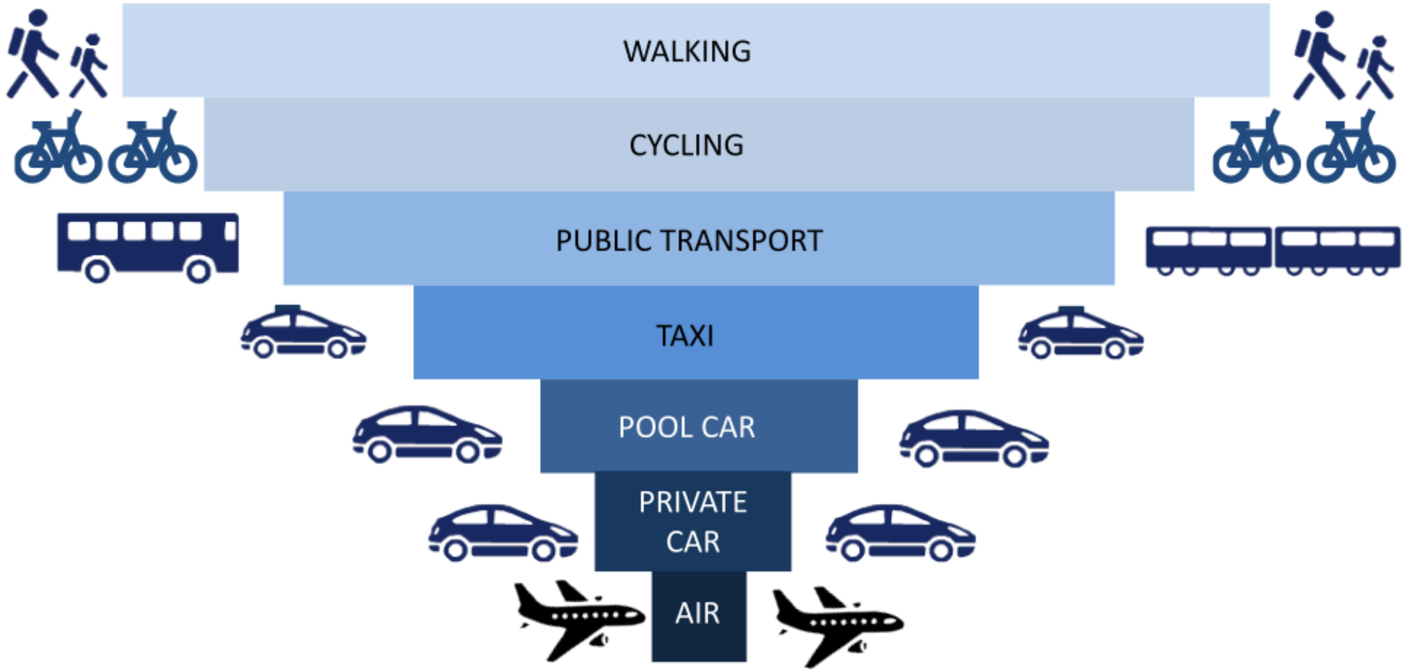


One gets **more than** is needed, while the other gets **less than** is needed. Thus, a huge disparity is created.	The assumption is that **everyone benefits from the same supports.** This is considered to be equal treatment.	**Everyone gets the support they need,** which produces equity.	All 3 can see the game without supports or accommodations because **the cause(s) of the inequity was addressed.** The systemic barrier has been removed.

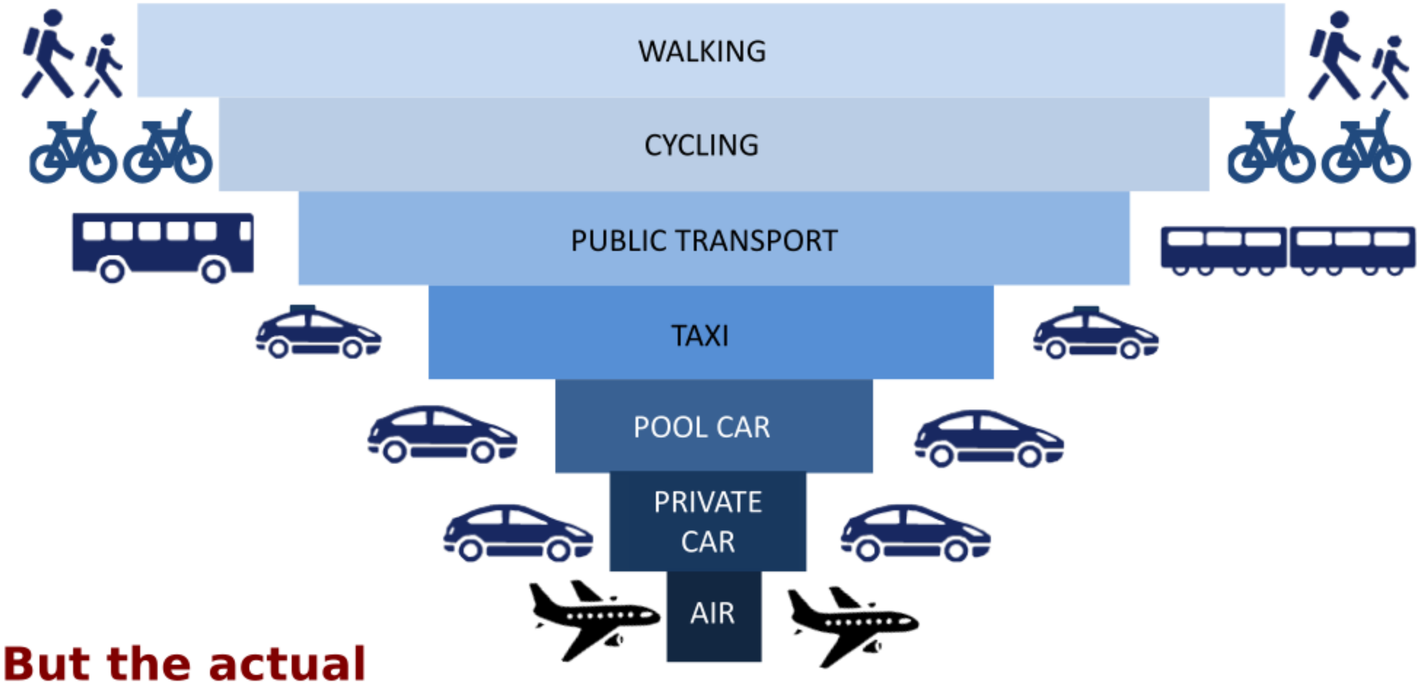
Most systemic problems are about skewed power and priorities



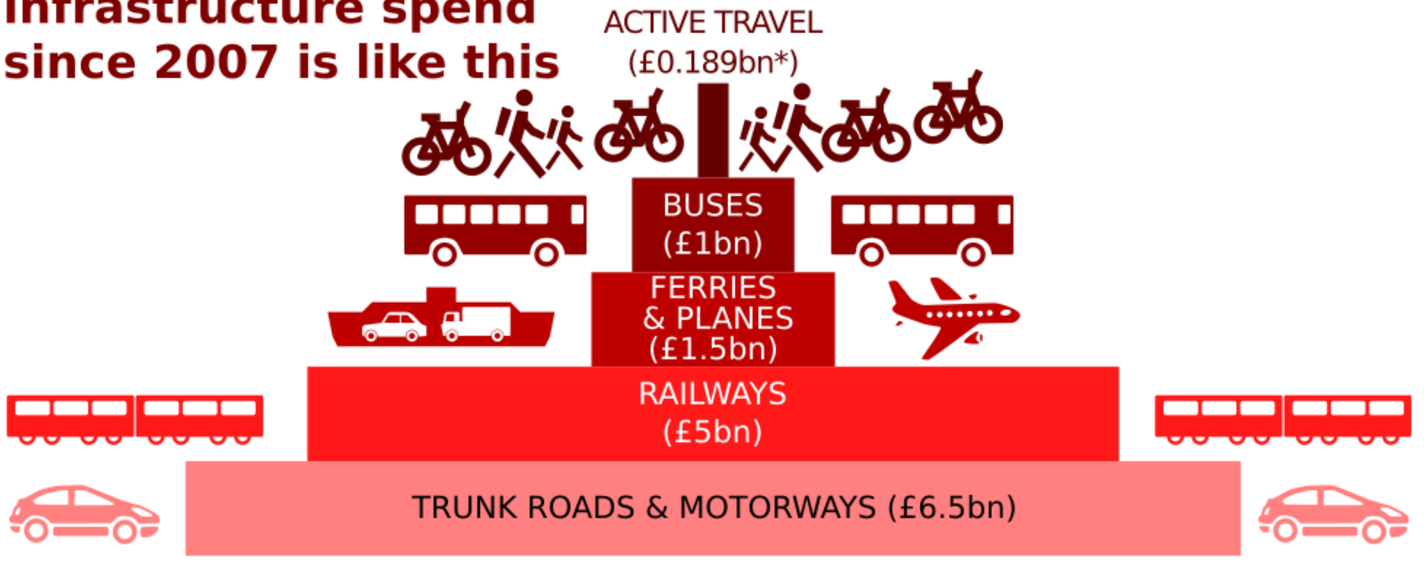
The sustainable travel hierarchy looks like this



The sustainable travel hierarchy looks like this



But the actual infrastructure spend since 2007 is like this



Denmark is a cycling nation

Cycling: 3bn DKK

TRUNK ROADS & MOTORWAYS 64bn DKK

Denmark is a cycling nation

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TRUNK ROADS & MOTORWAYS 64bn DKK

Er Danmark en cykelnation?

CYKLING

ANDRÉS FELIPE VALDERRAMA PINEDA,
LEKTOR, AALBORG UNIVERSITET
ANDERS FJENDBO JENSEN,
LEKTOR, DTU
CAROLINE SAMSON,
PH.D.-STUDERENDE, AALBORG UNIVERSITET
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HILDA RØMMER KRISTENSEN,
LEKTOR, KØBENHAVNS UNIVERSITET
JASPER SCHIPPERIJN,
PROFESSOR, SYDDANSK UNIVERSITET
MADS PAULSEN,
POSTDOC, DTU
MALENE FREUDENDAL-PEDERSEN,
PROFESSOR, AALBORG UNIVERSITET
MICHAEL SZELL,
LEKTOR, IT-UNIVERSITETET
OG MICHALA HVIDT BREENGAARD,
POSTDOC, AARHUS UNIVERSITET

'CYKELNATIONEN DANMARK' bliver flittigt fremhævet, i anledning af at Tour de France kommer til Danmark. Vi præsenterer os for omverdenen som det gode eksempel på en nation med mange hverdagscyklister og en succesfuld cykelstrategi. Og i Danmark – særligt i de store byer – er det i store træk godt at cykle.

Der er dog også en anden virkelighed, der presser sig på. Tendensen landet over er, at flere kører i bil og færre på cykel. Data fra den årlige transportvaneundersøgelse (tudata.dk) viser, at ud af det daglige antal kørte kilometer er kun 3,5 procent på cykel, mens mere end 84 procent er i bil m.v. Disse tal virker især påfaldende, når vi sammenholder dem med, at 25 procent af alle daglige rejser er under 4 km, og 46 procent er under 10 km. Der burde være masser af potentiale for at cykle. Det uundgåelige spørgsmål er, om billedet af Danmark som cykelnation er ved at krakelere lidt. Tallene tyder nemlig på, at vi i stigende grad er en bilnation. Det har en lang række konsekvenser – ikke mindst i forhold til folkesundhed, byrum og klimaudfordringen, ligesom det bliver svært fortsat at brande Danmark som 'det gode eksempel' for cyklisme.

Det er blevet fremhævet, at siden 2009 har Danmark investeret mere end 3,5 milliarder i cykling. Derudover er der med 'Infrastrukturplan 2035' kommet en investering i cykling på 3 milliarder kroner. Dette beløb skal dog ses i lyset af, at der i samme periode investeres mere end 64 milliarder i at bygge nye veje. Når der samtidig ikke er en strategisk plan for investeringer i cykling, risikerer vi, at de 3 milliarder ender i fragmenterede små projekter over hele landet, som vi har oplevet de seneste år.

HVIS DANMARK fortsat skal fremstå som den cykelnation, vi praler af, skal der ske et kvantespring i forhold til investeringer og fokus på cykling i hele landet. Vejdirektoratets nye Cykel Videnscenter og cykeltopmødet 30. juni med den fælles deklaration om øget samarbejde på cykelområdet er en start, men det er ikke nok.

Cykling foregår i mange tempi, som er afhængige af lokale og regionale forskelle såvel som borgernes alder, fysik og formål med turen, herunder pendling til arbejde og studie, adgang til fritidsaktiviteter, ærinder, turisme og cykling som aktivitet i sig selv. Hvis vi skal være en cykelnation, er vi nødt til at tænke de forskellige behov ind i vores cykelstrategi.

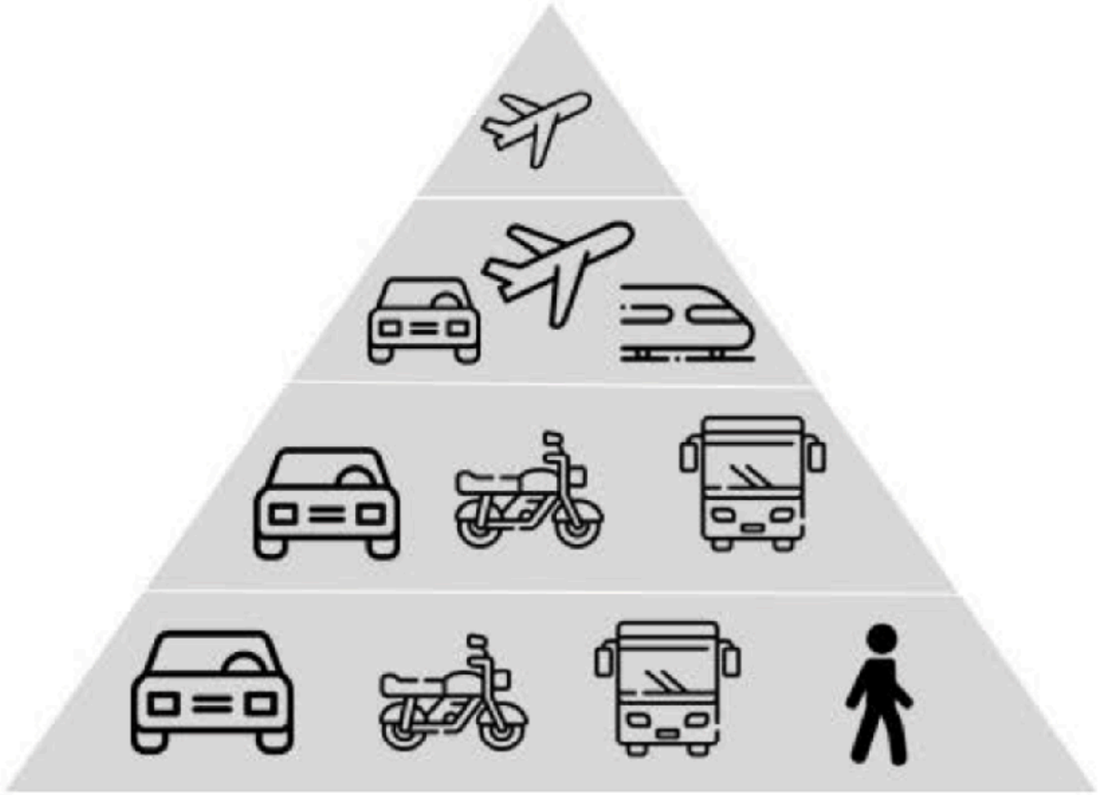
Når der samtidig er evidens for store sundhedsgevinster ved aktiv mobilitet, virker det åbenlyst, at investeringer i cykling har en stor samfundsmæssig gevinst. Samtidig gør det Danmark mindre sårbart over for stigende internationale brændstof- og energipriser. Øget cykling kan også medvirke til at løse de store udfordringer, som vores transport udgør på klimaområdet.

EN CYKELNATION skal for alvor investere i cykelinfrastruktur og -kultur mere bredt. Samtidig bør de nationale infrastruktur- og vidensinstitutioner være med til at sikre, at disse investeringer hænger sammen. Det er essentielt at samle og kommunikere erfaring og viden, hvis vi skal have flere op på cyklen, såvel som for at kunne etablere et landsdækkende cykelsystem, som giver tryg og sikker cykelmobilitet for alle. Det er nødvendigt, hvis vi fortsat gerne vil brande og eksportere den danske cykelmodel til andre lande.

Der er mange lande rundtomkring i verden, der kigger mod Danmark som en model for håndtering af klimaudfordringerne på transportområdet. Det vil vi gerne have, at de bliver ved med. Det kræver dog, at vi værner om det, vi har opnået, og viser, at vi kan gøre det endnu bedre.

Politiken, 2022-06-27


SLOW ROLL...
DECADES OF MISTAKES
BUFFALO
ADAM ZYGLIS ©2016 THEBUFFALONEWS

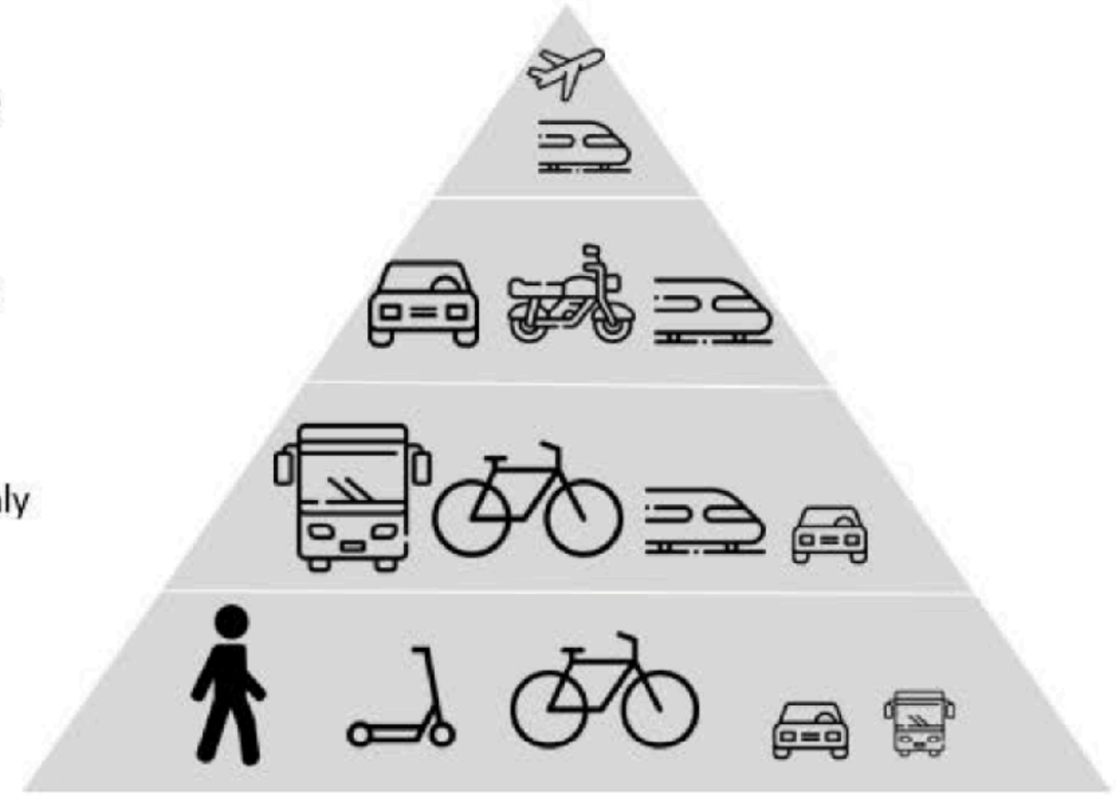


Once in a while

Occasional trips

Weekly or monthly trips

Daily trips



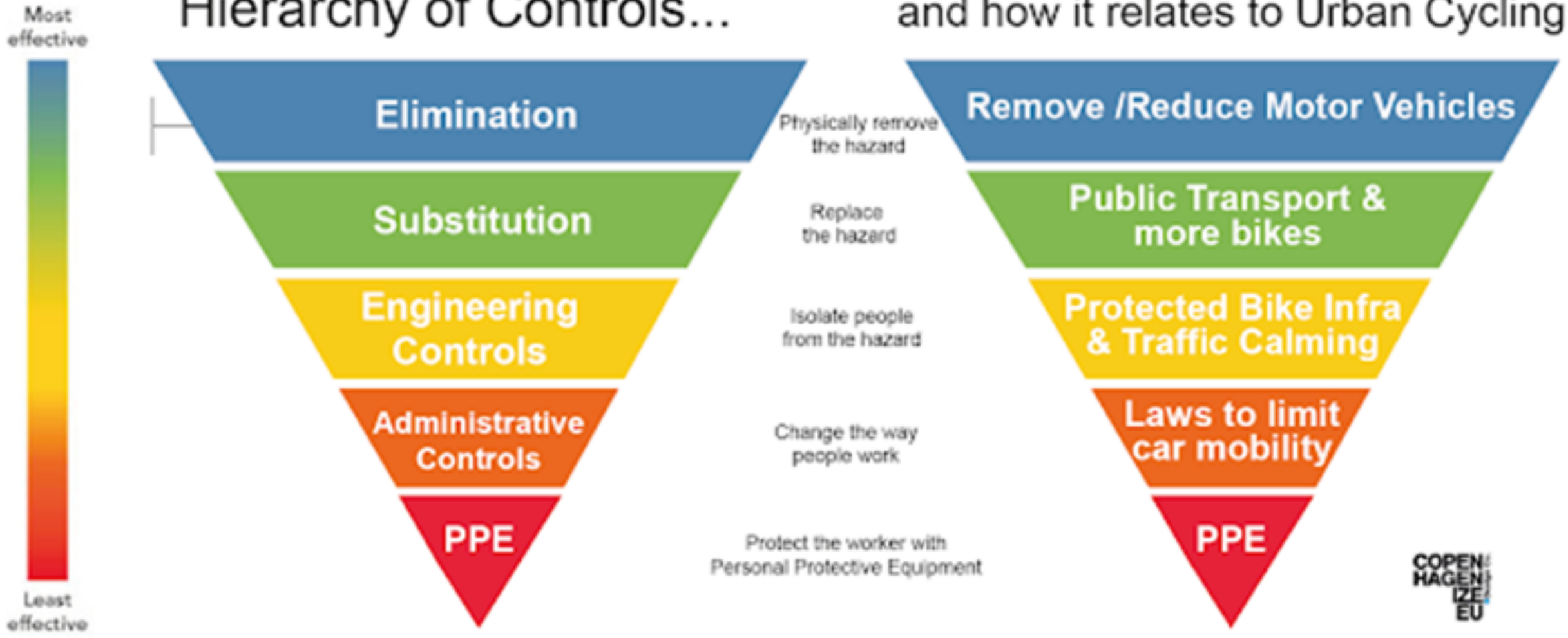
"Unhealthy" system

"Healthy" system

Hierarchy of Controls...

COPENHAGENIZE EU

Hierarchy of Controls... and how it relates to Urban Cycling



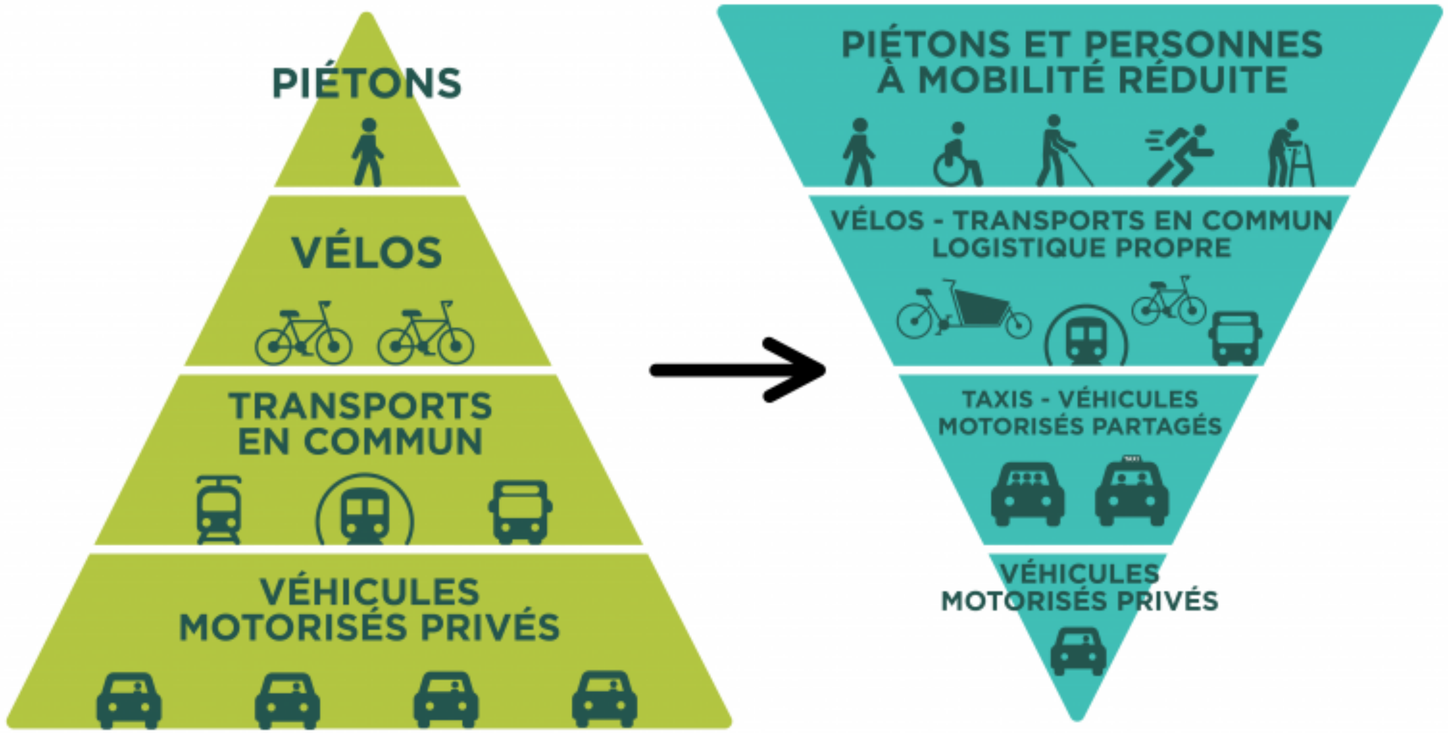

Avoid
Avoid unnecessary travel
Shift
Shift to more sustainable transport
Improve
Improve efficiency of transport

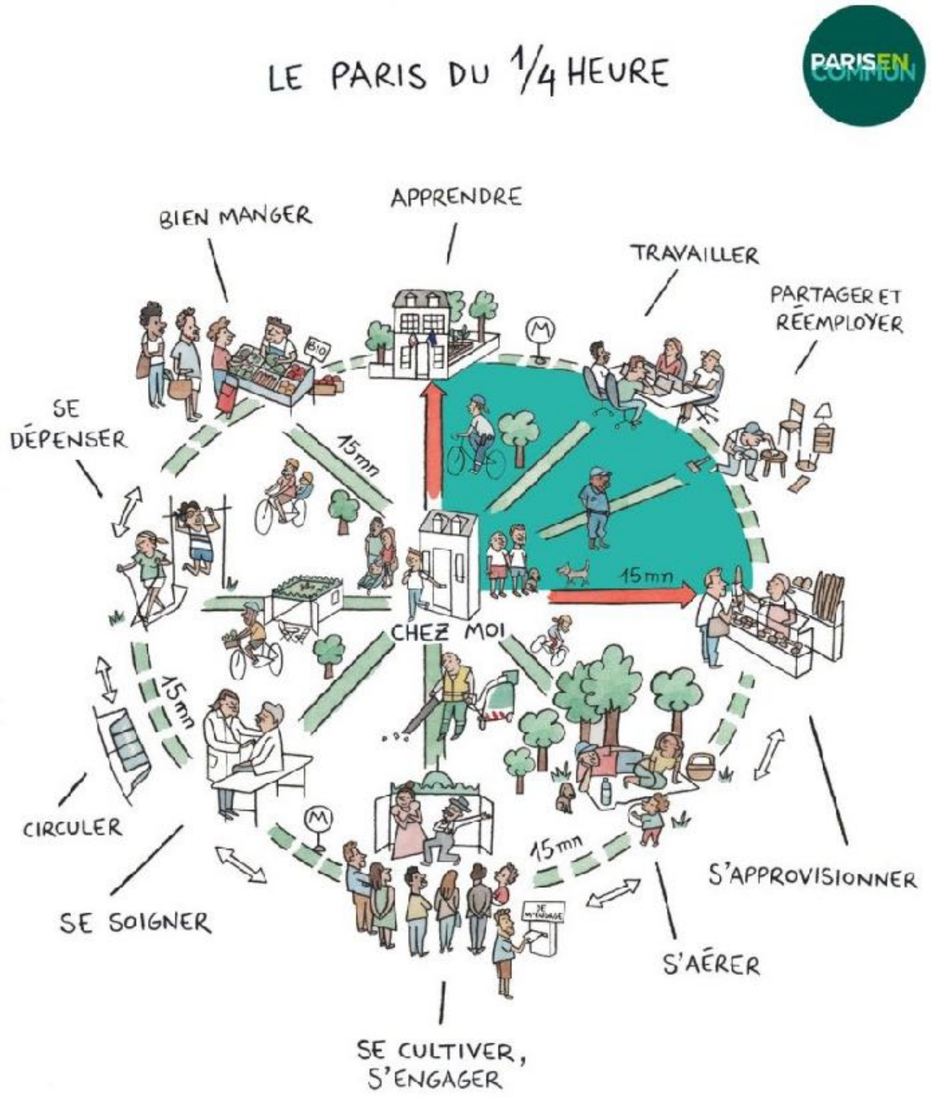
Our top priority should be building sustainable systems

Not just removing cars

Not just building bike networks

...





Building sustainable cities is 99%
a political, not a technical question

If there is the will (and pressure), cities can change radically

Take-home messages

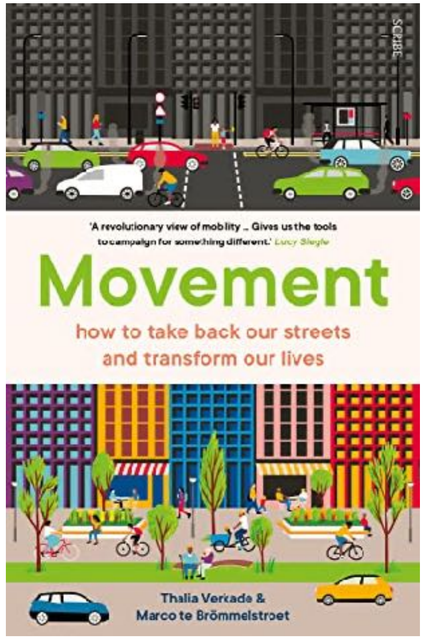
We can use IT to help design better, sustainable cities, but:

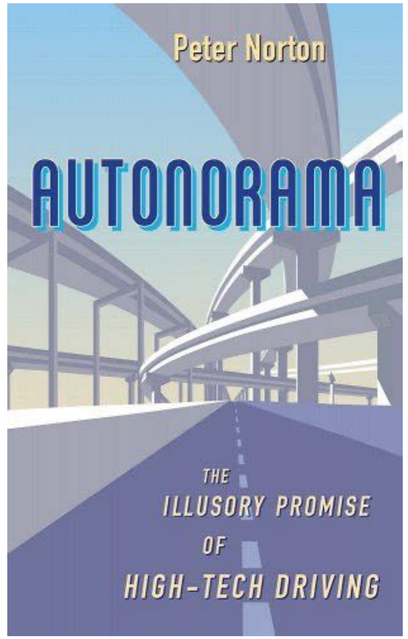
1) Inadequately applying engineering thinking can lead to unintended consequences

2) Induced demand: Widening or building new roads causes more traffic

3) We can't use tech like e-cars to "solve" mobility, but must rebuild the whole system, and reverse skewed political priorities that come from power inequalities

Further materials





Geospatial Data Science (Spring 2022)

https://github.com/mszell/geospatialdatascience

Henderson (2020): EVs are not the answer

Gössling (2016): Urban transport justice

Youtube: Julia Steinberger: The importance of climate activism

THE WAR ON CARS

thewaroncars.org

NOT JUST BIKES

Not Just Bikes

Exercises

How to grow a bike network?
How to change the world?