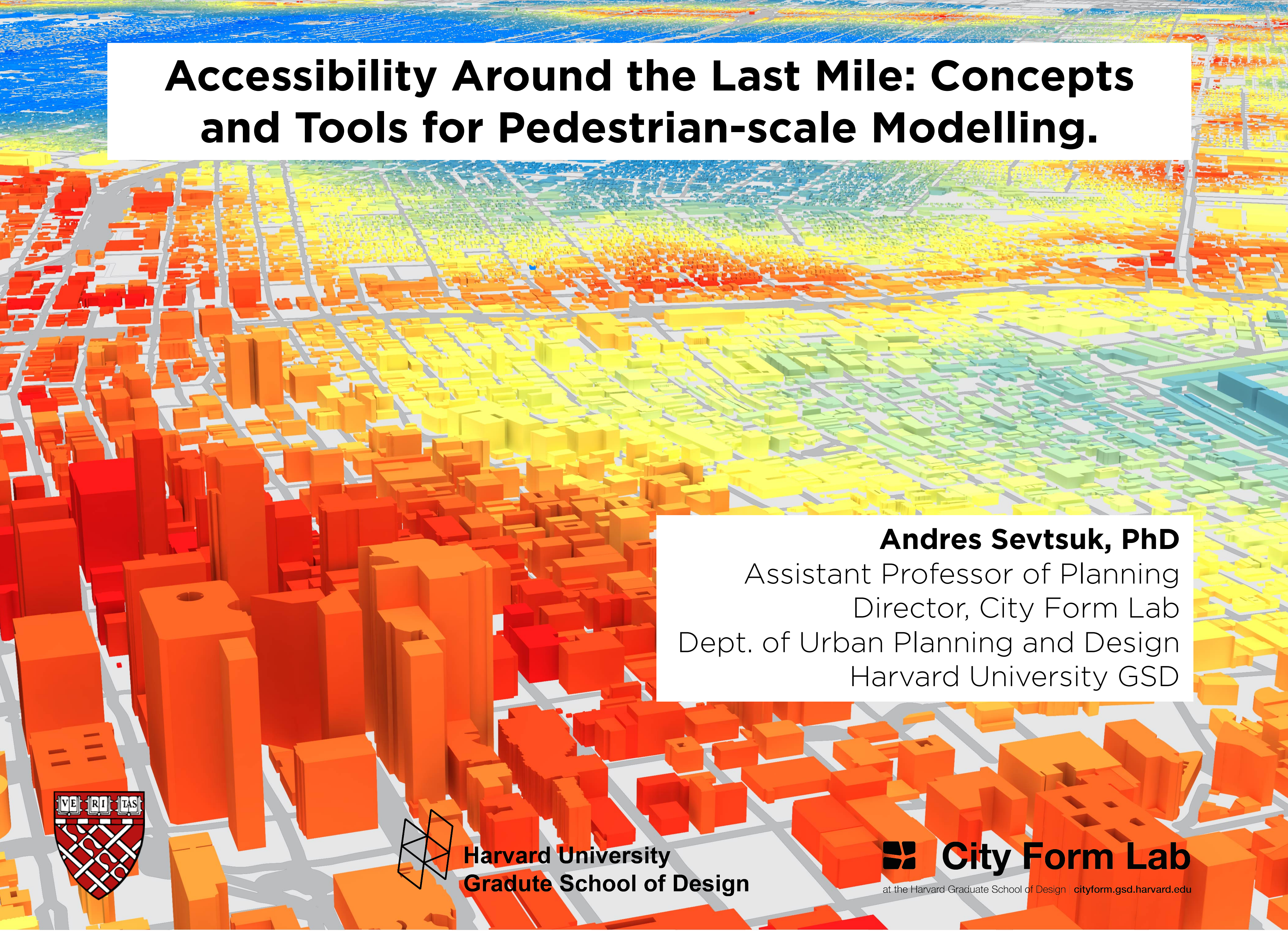
Accessibility Around the Last Mile: Concepts and Tools for Pedestrian-scale Modelling.



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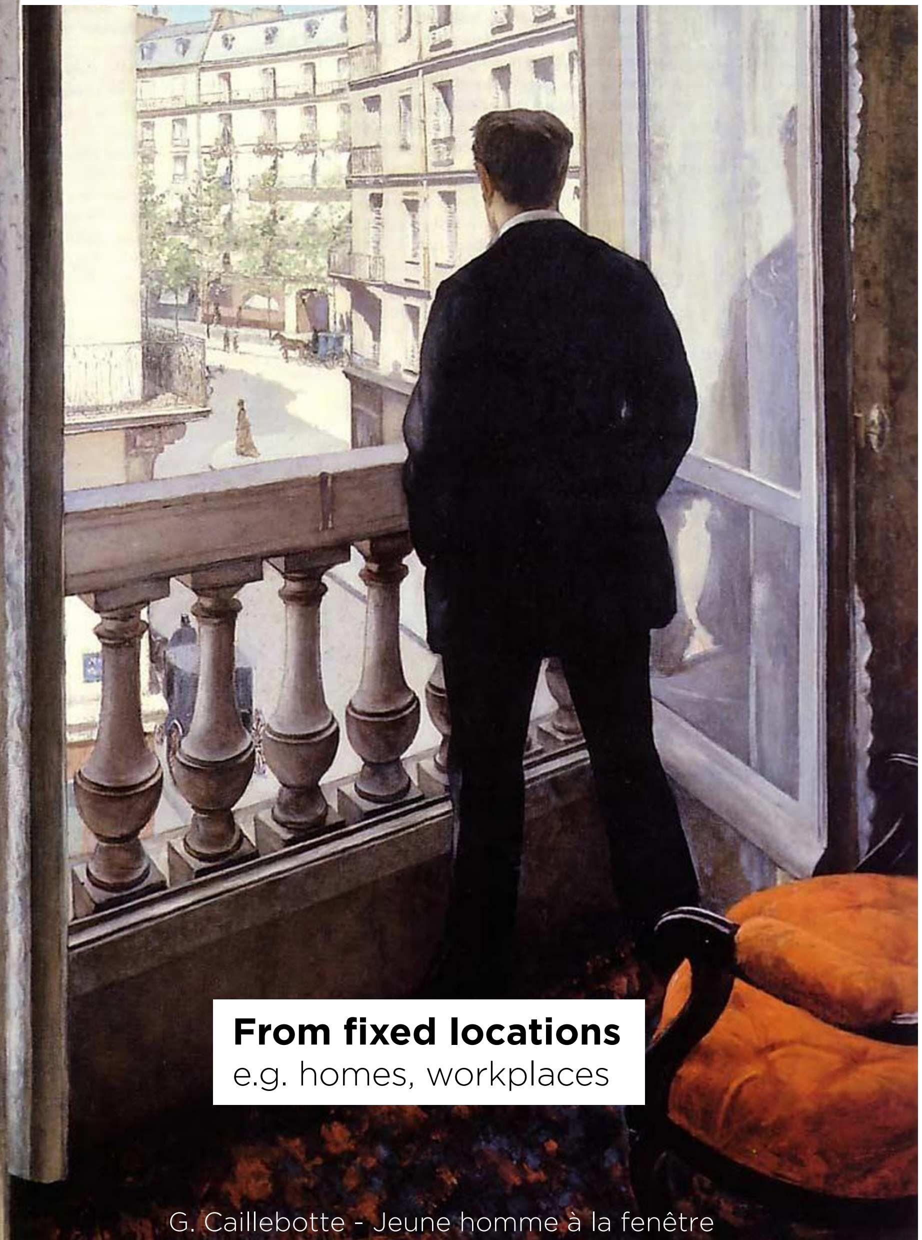
Two common ways of approaching destinations in the city

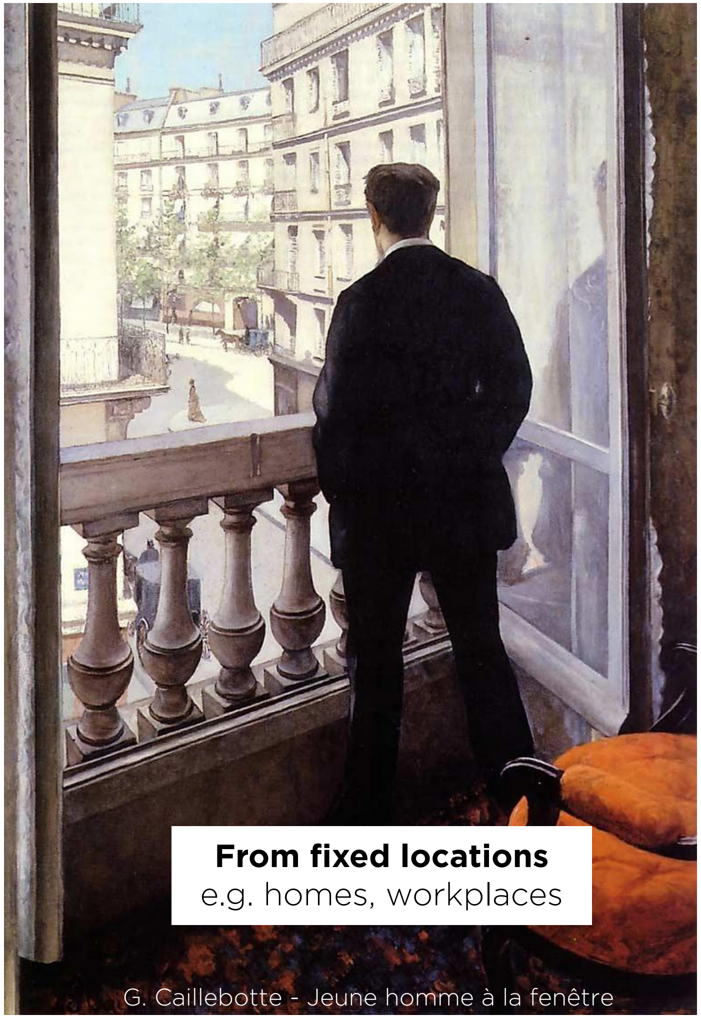


From fixed locations
e.g. homes, workplaces

G. Caillebotte - Jeune homme à la fenêtre

While moving around
e.g. on the way to transit

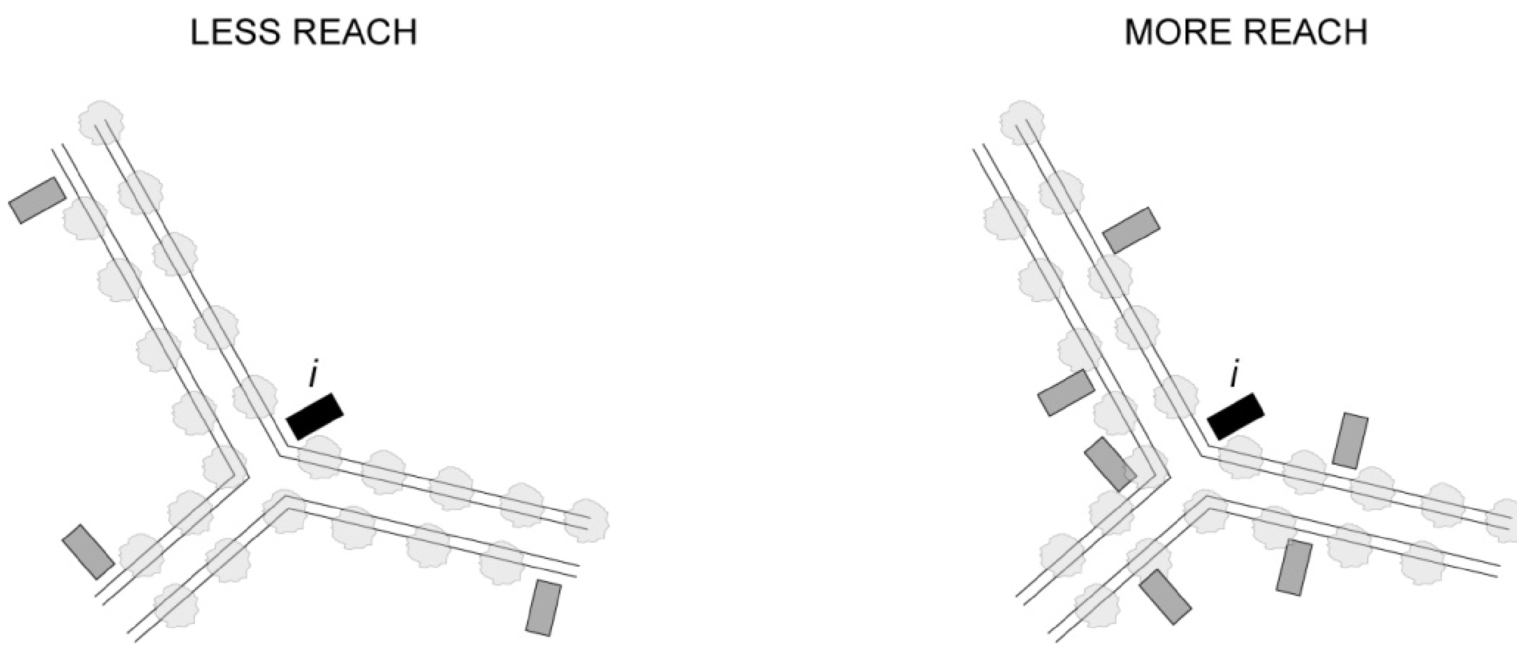
1. Fixed Origin Spatial Accessibility Metrics



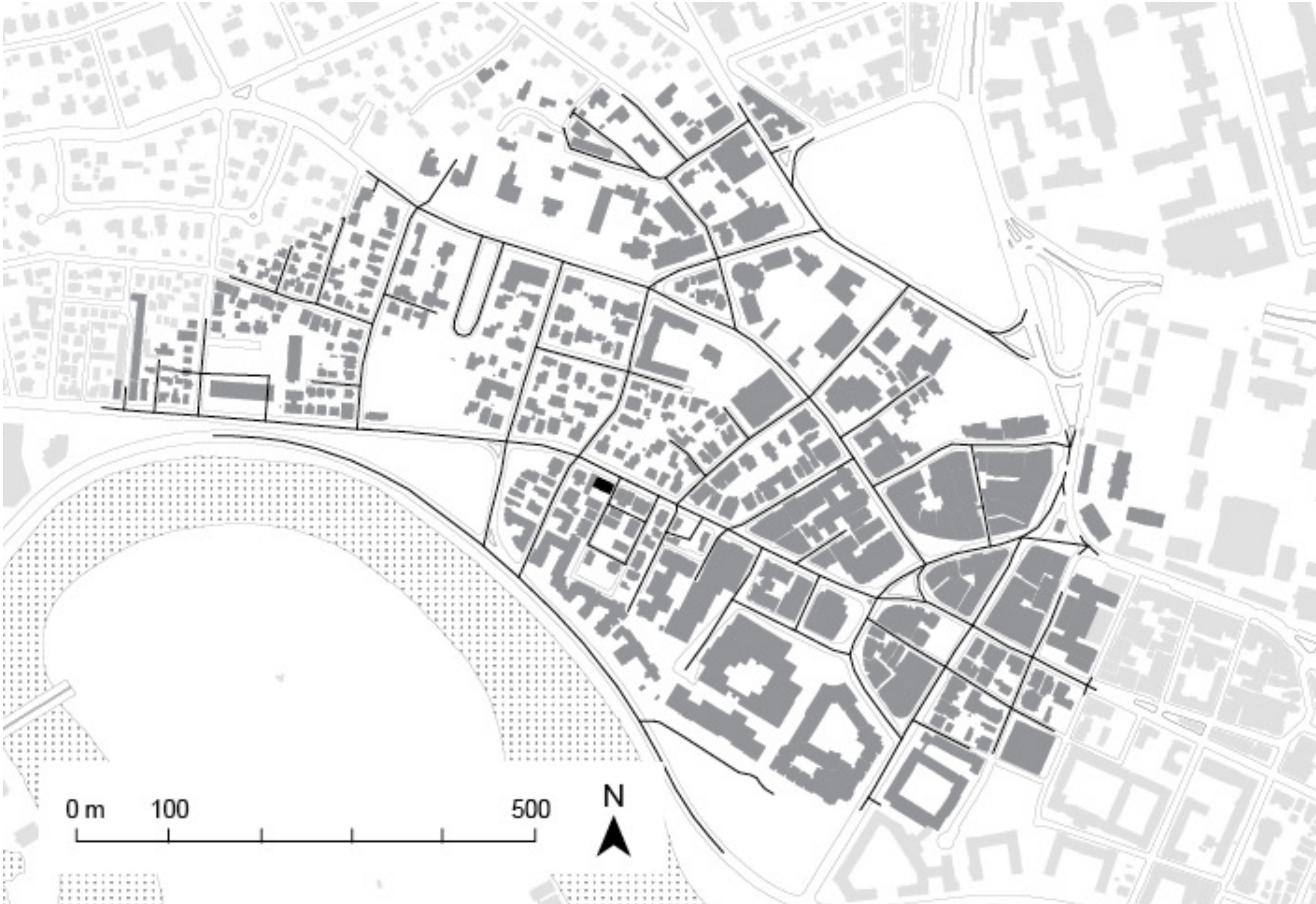
Reach accessibility index

How many surrounding destinations j can be reached from building i within a given network radius?

$$Reach[i]^r = \sum_{j \in G - \{i\}, d[i,j] \leq r} W[j]$$



The map shows buildings that lie within a 10-minute (600m) walkshed from Darwin's café (shaded dark). On Brattle St.



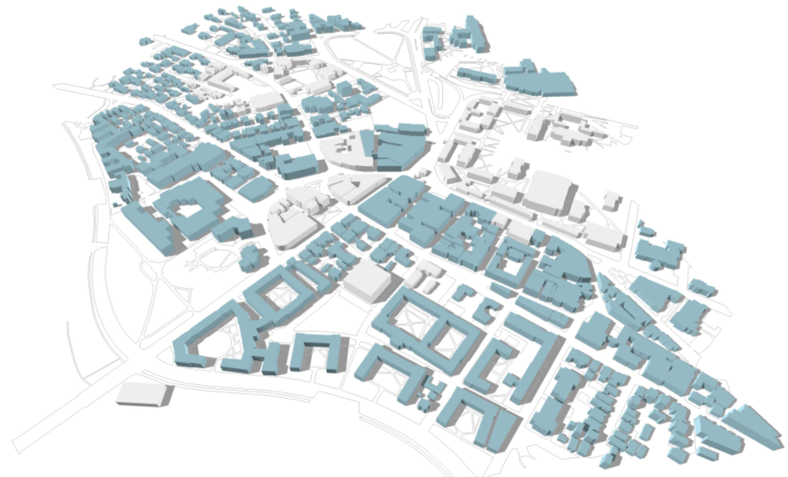
Accessibility can be specified to any type of destination

Transit

Businesses

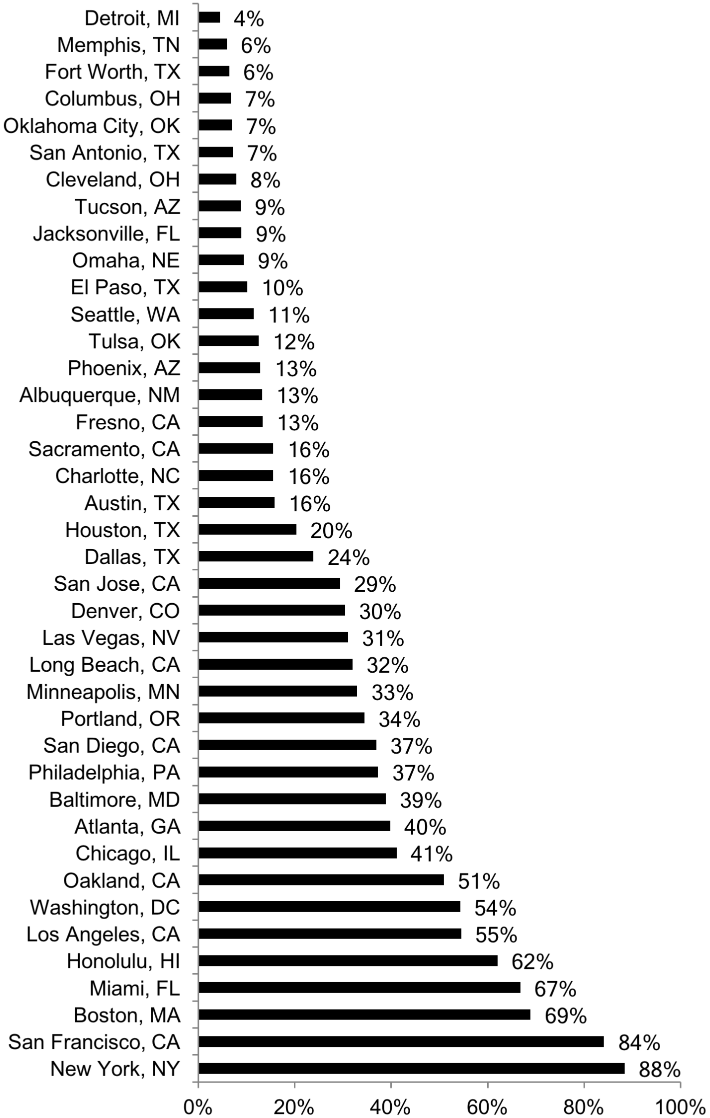
Jobs

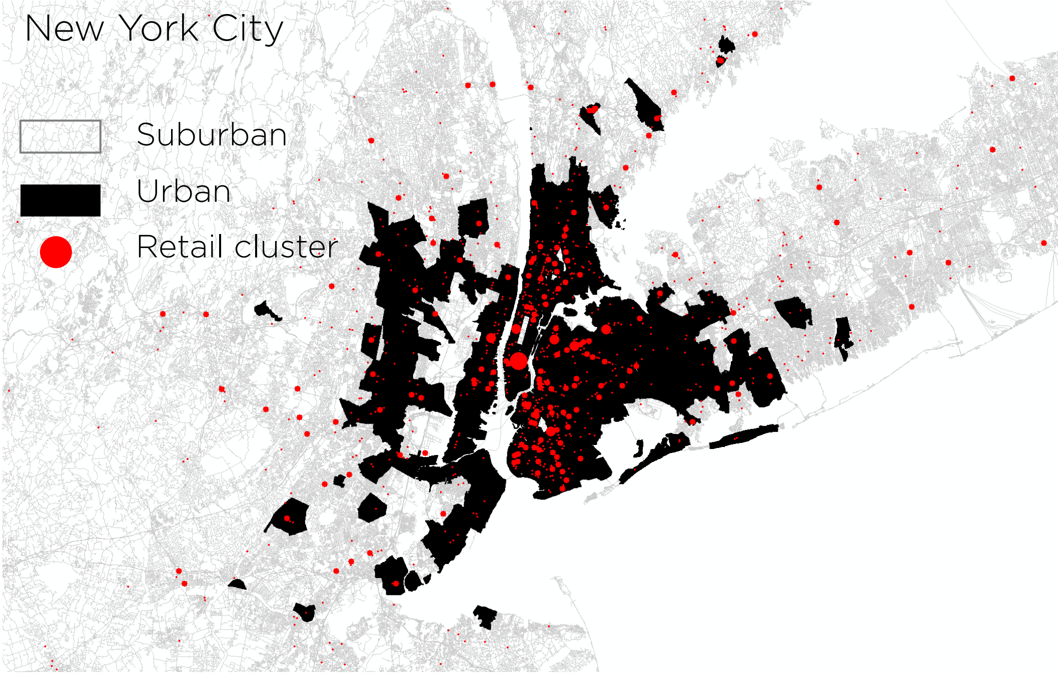
Residents

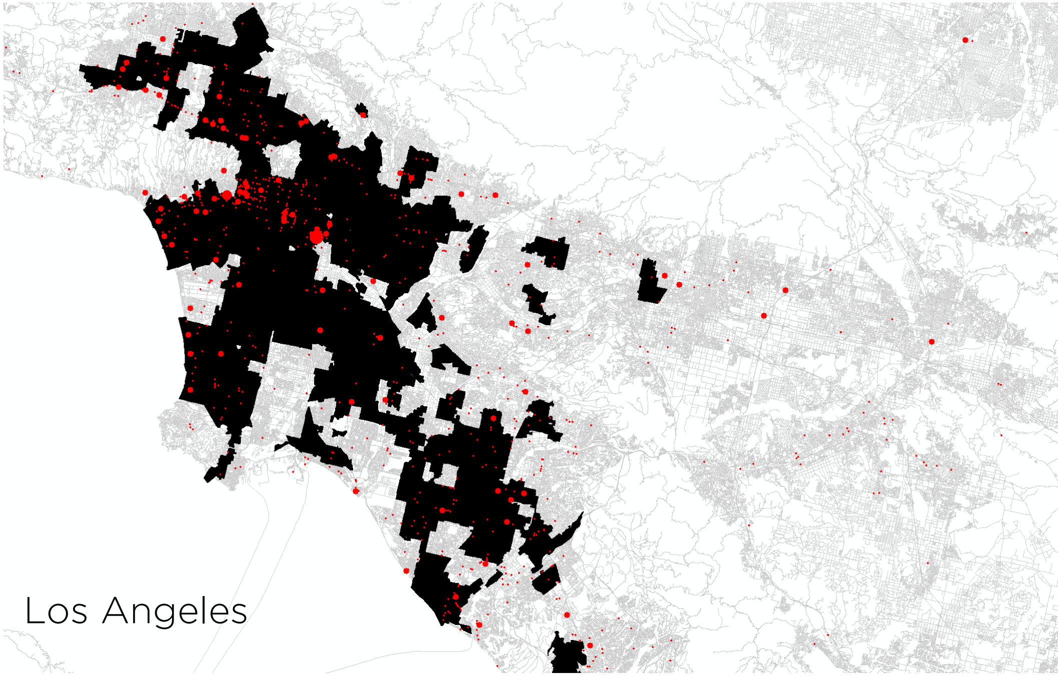


% population within 1KM of a retail cluster of >25 stores

walking distance







Towards Amenity Oriented Development (AOD)

Comparison of urban form and population density metrics across cities that provide a high (top) and a low (bottom) share of populations with walking access to retail clusters.

	Rank	City	Population within 1000m of a retail cluster	Population 2010	Land Area (km2)	Residential Density	FAR	Built Coverage
Highest	1	New York City, NY	88%	8,175,133	783.0	10,890 km^2	1.66	35.38%
	2	San Francisco, CA	84%	805,235	121.5	7,174 km^2	0.43	27.42%
	3	Boston, MA	69%	617,594	125.4	2,700 km^2	0.71	16.14%
	4	Miami, FL	67%	399,457	93.2	4,866 km^2	-	-
	5	Honolulu, HI	62%	337,256	156.7	2,236 km^2	1.50	14.16%
	6	Los Angeles, CA	55%	3,792,621	1,214.0	3,275 km^2	1.40	18.67%
	7	Washington, DC	54%	681,170	158.1	4,308 km^2	0.83	16.47%
	8	Oakland, CA	51%	390,724	144.8	2,901 km^2	0.69	17.04%
	9	Chicago, IL	41%	2,695,598	589.6	4,572 km^2	-	14.15%
	10	Atlanta, GA	40%	417,735	344.9	1211.17 km^2	-	-
		Mean	**61%**	**1,831,252**	**373.1**	**4,413.4 km^2**	**1.03**	**19.93%**
Lowest	31	Omaha, NE	9%	383,964	329.2	1166.35 km^2	-	-
	32	Jacksonville, FL	9%	822,050	1,934.7	425 km^2	0.05	1.23%
	33	Tucson, AZ	9%	520,116	611.7	868 km^2	0.21	6.52%
	34	Cleveland, OH	8%	396,815	201.2	1,972 km^2	-	-
	35	San Antonio, TX	7%	1,469,845	1,193.7	1,147 km^2	-	-
	36	Oklahoma City, OK	7%	579,999	1,556.9	360 km^2	-	-
	37	Columbus, OH	7%	787,033	562.5	1,399 km^2	-	-
	38	Fort Worth, TX	6%	854,113	886.3	842 km^2	-	-
	39	Memphis, TN	6%	646,889	816.0	770 km^2	0.26	6.42%
	40	Detroit, MI	4%	713,777	359.4	1,900 km^2	0.25	14.78%
		Mean	**7%**	**717,460**	**845.2**	**1,084.9 km^2**	**0.19**	**7.24%**

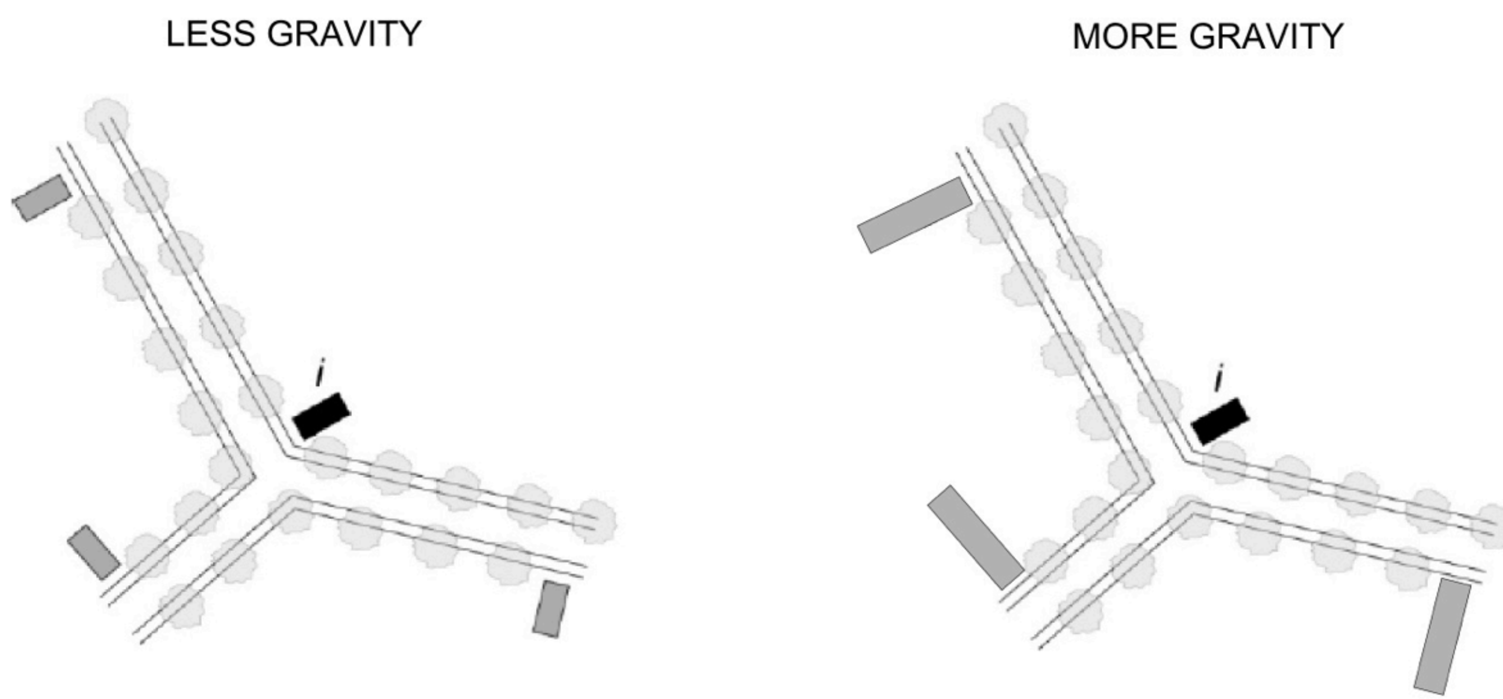
Key user inputs for Reach accessibility:

1. Origin points
2. Destination points
3. Optionally weights for destinations (e.g. jobs field for census tracts)
4. Search radius (along the network, e.g. 400m)

Gravity Index

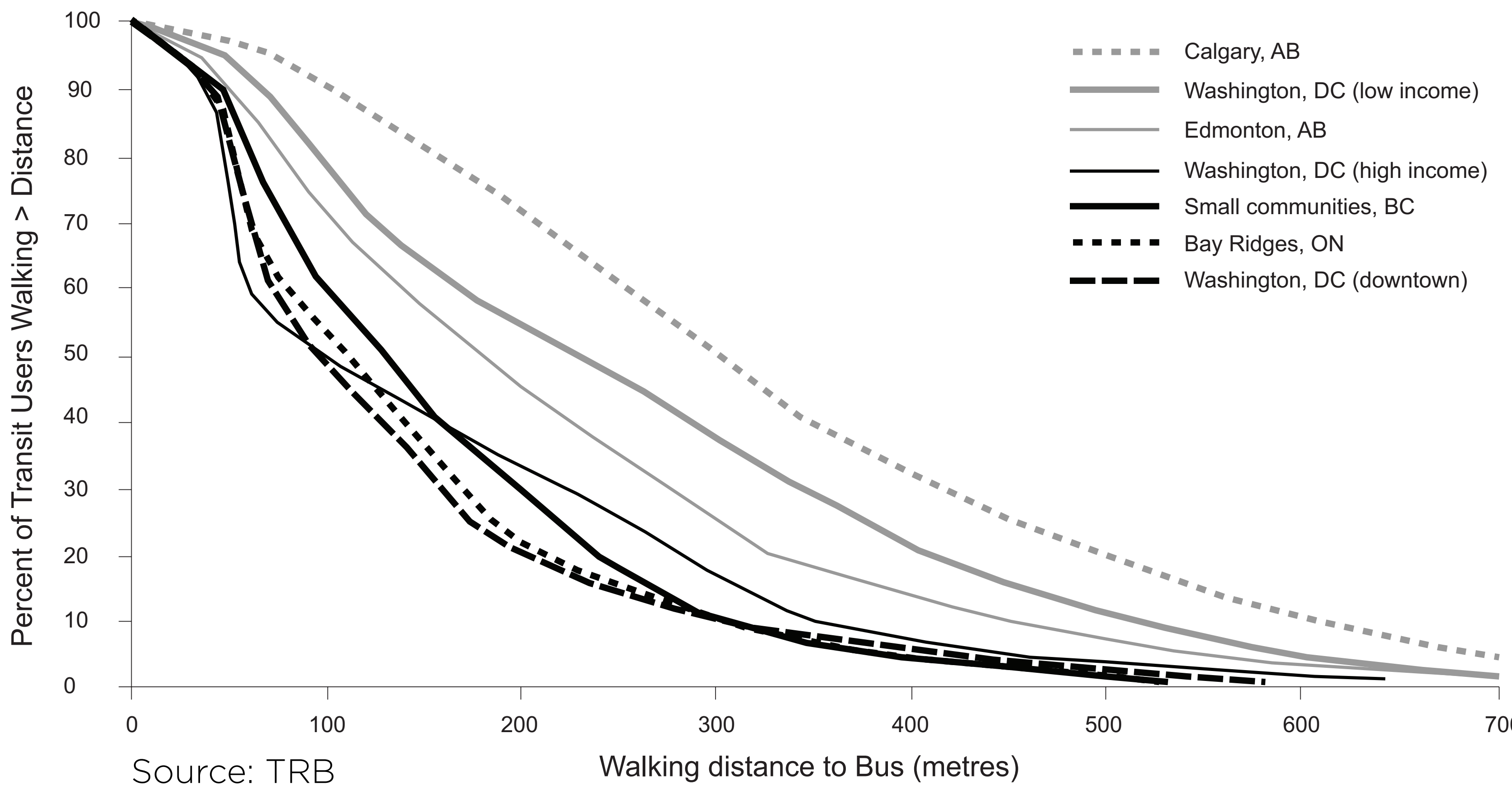
Accessibility is proportional to the attractiveness & inversely proportional to the distance of reaching surrounding destinations j (Hansen 1959)

$$Gravity[i]^r = \sum_{j \in G - \{i\}, d[i,j] \leq r} \frac{W[j]^\alpha}{e^{\beta \cdot d[i,j]}}$$



Walking distance to bus stops in different cities

% transit users



Source: TRB

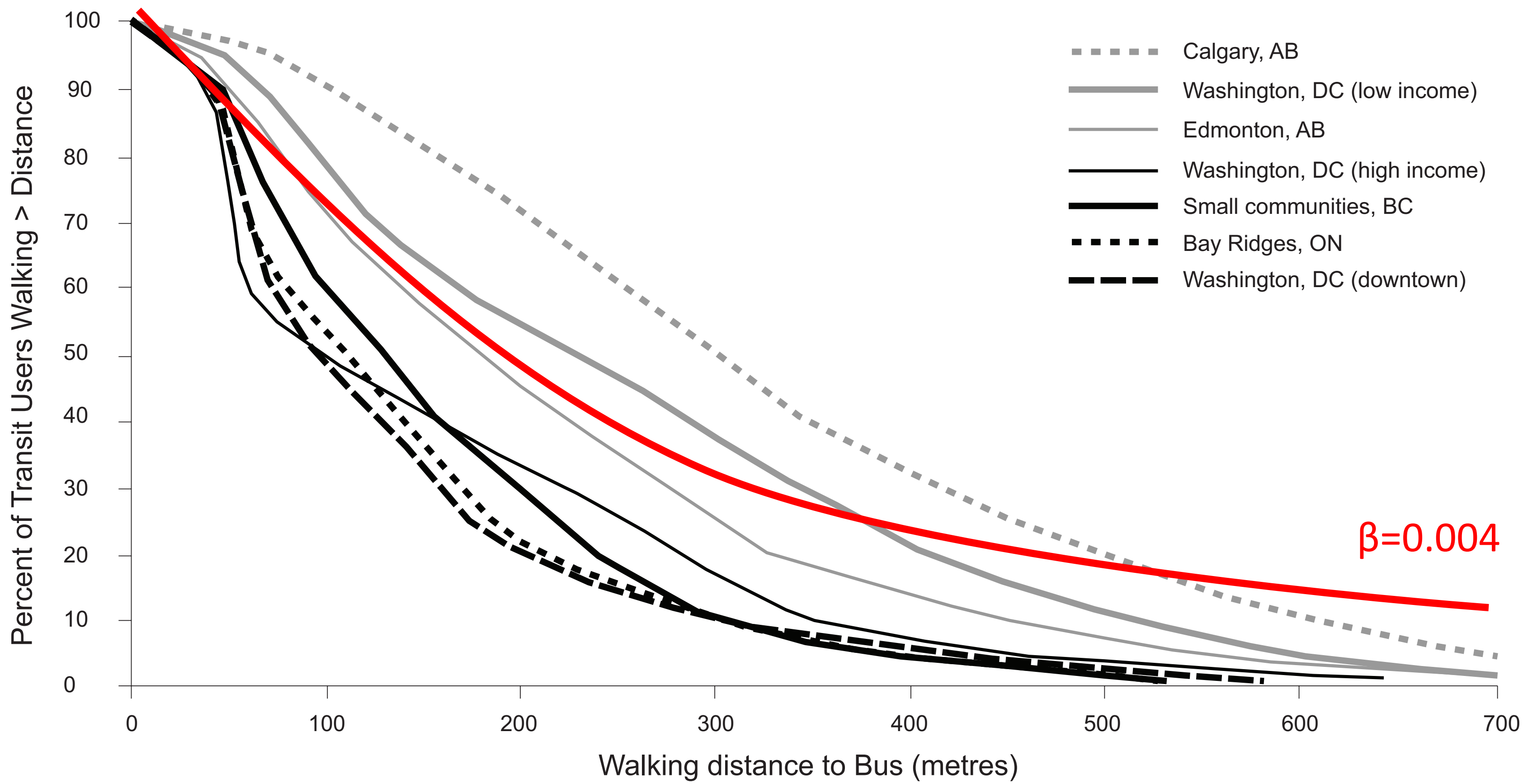
Walking distance to bus stops in different cities

% transit users

$$Gravity_{ij} \sum_{j=1}^{n} \frac{1}{e^{\beta \cdot dist[i,j]}}$$

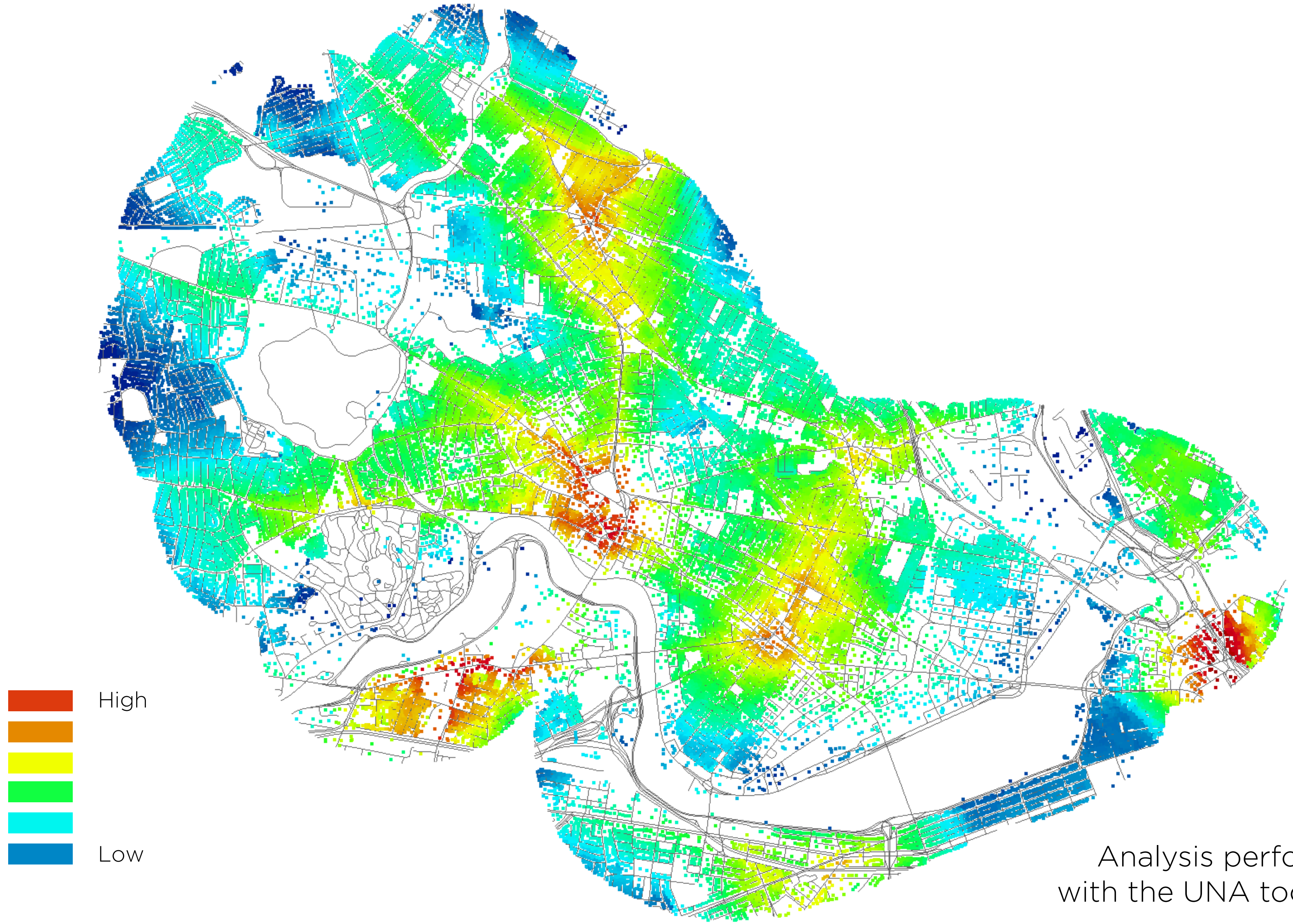
NB! Beta depends on distance units (e.g. meters, feet)

$$\beta = 0.004$$



Gravity access from buildings to public transit in Cambridge, MA

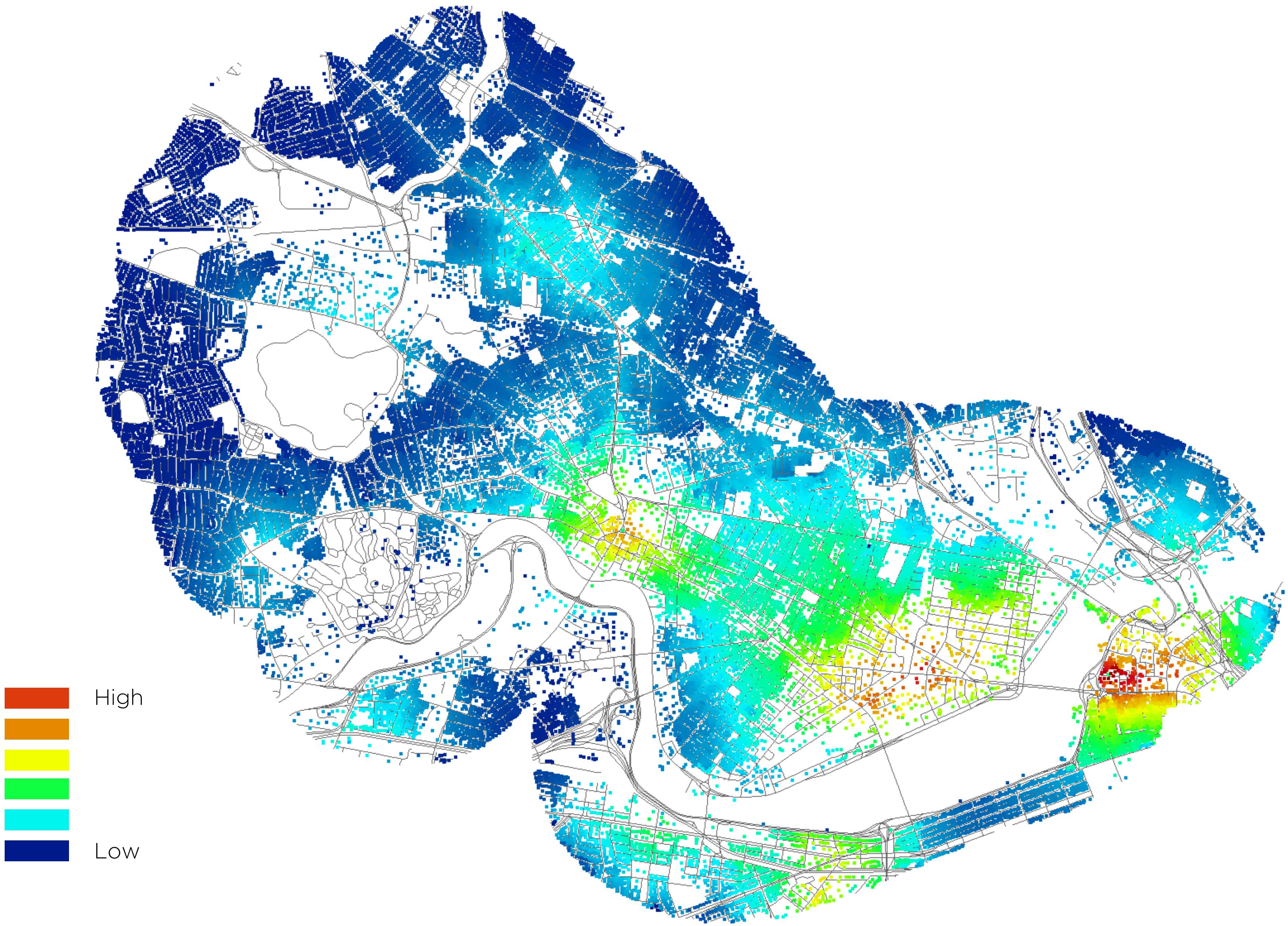
T-stops and bus stops (T = 5x bus). Search radius= 1,000m; beta= 0.002



Analysis performed
with the UNA toolbox.

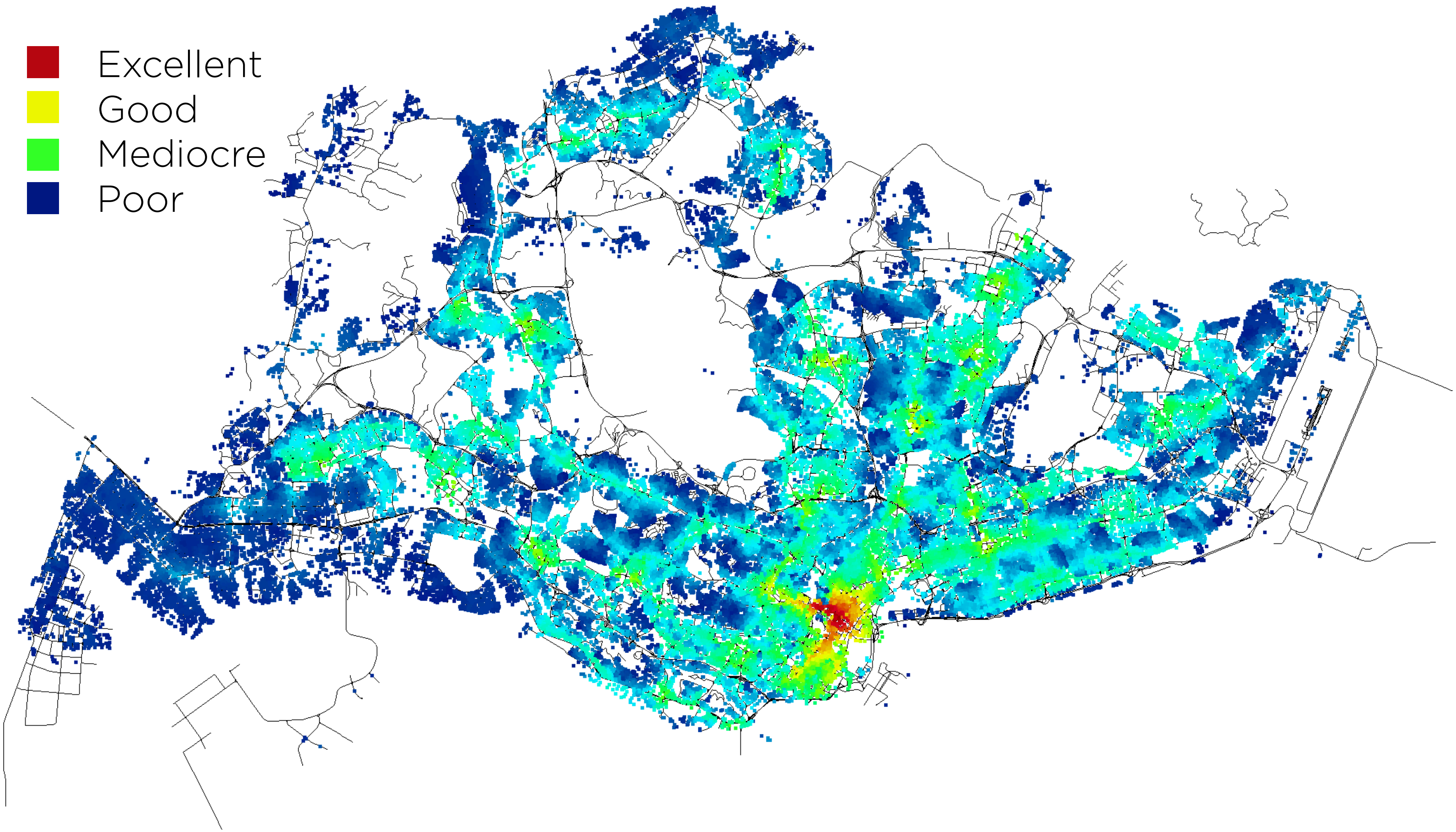
Gravity access from buildings to jobs in Cambridge, MA

Search radius= 1,000m; beta= 0.002



Example: Public transit accessibility in SG from each building

Gravity access



Key user inputs for Gravity accessibility:

1. Origin points
2. Destination points
3. Optionally weights for destination points (e.g. jobs field for census tracts)
4. Search radius (along the network, e.g. 400m)
5. Beta value for the decay effect*

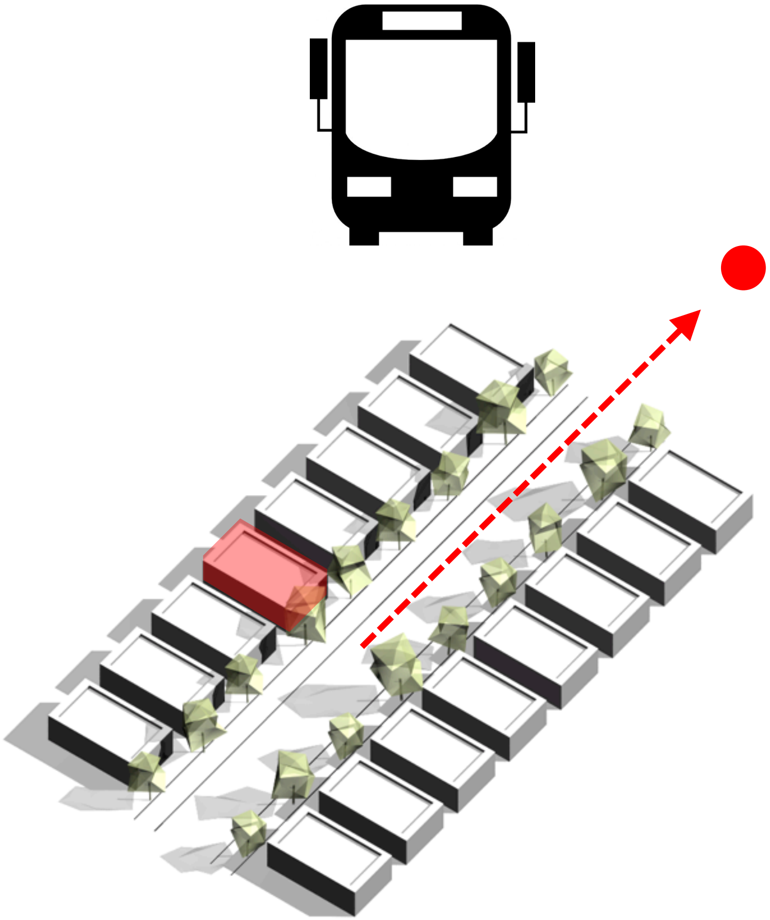
i.e. use the following beta values if drawing units are:

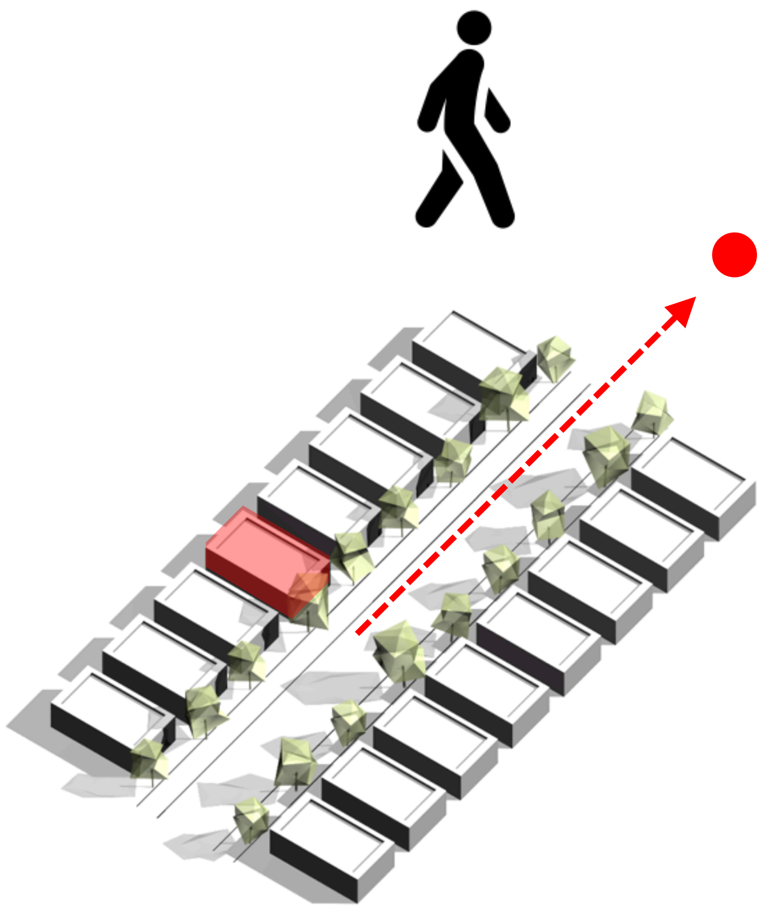
"meters" 0.002
"feet" 0.000663
"kilometers" 2.175
"miles" 3.501.

How can accessibility be improved?

a. Facilitate transportation to destinations

All else being constant



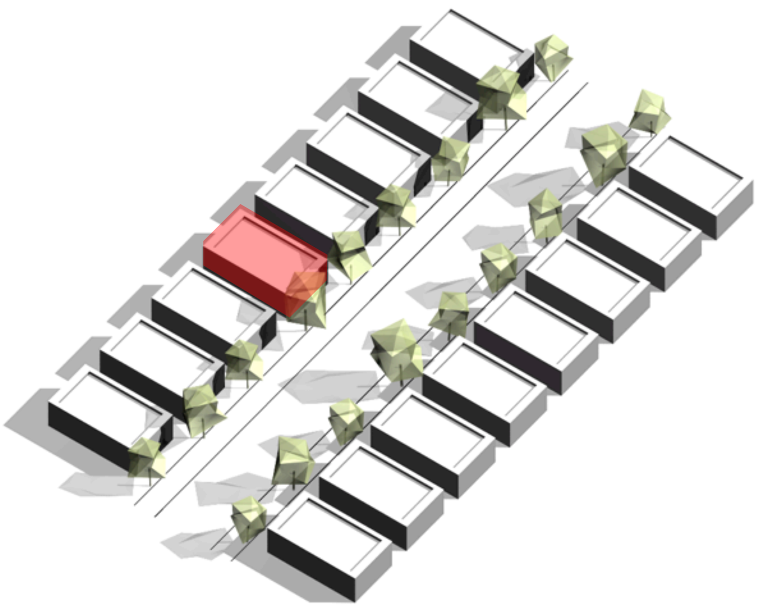


How can accessibility be improved?

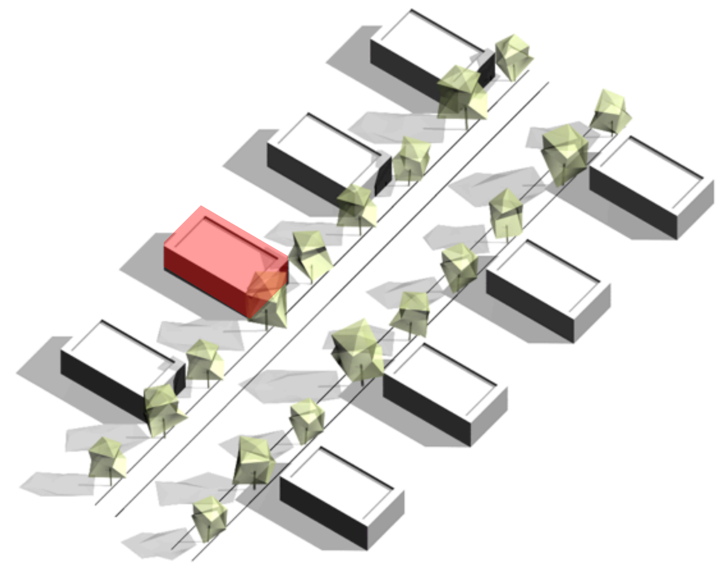
Increase the density of destinations around a location

All else being constant

Denser destinations
+ accessibility



Sparser destinations
- accessibility

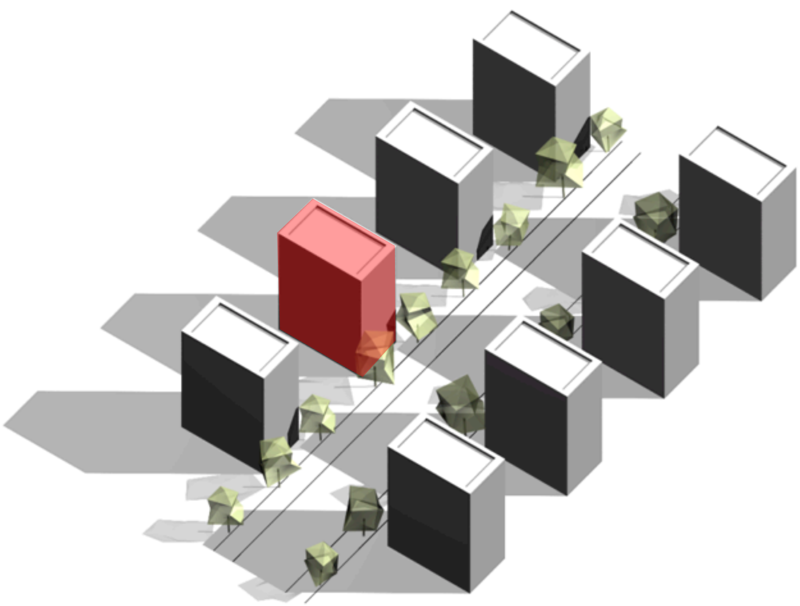


How can accessibility be improved?

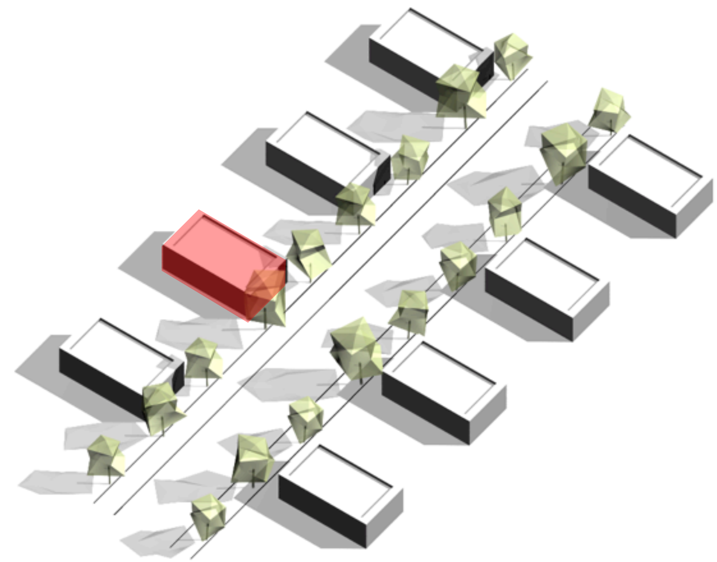
Increase capacity (or attractiveness) of destinations

All else being constant

Bigger destinations
+ accessibility



Smaller destinations
- accessibility

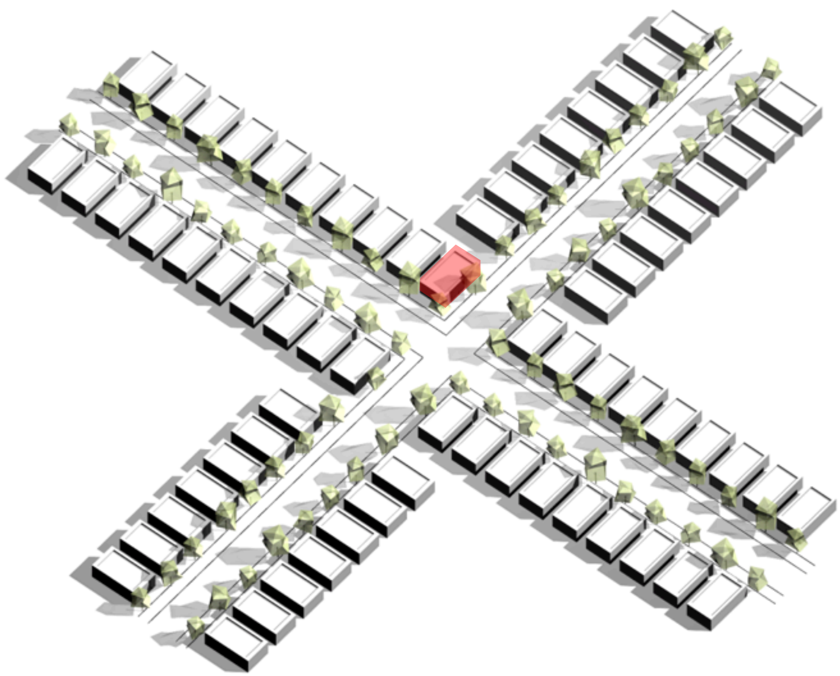


How can accessibility be improved?

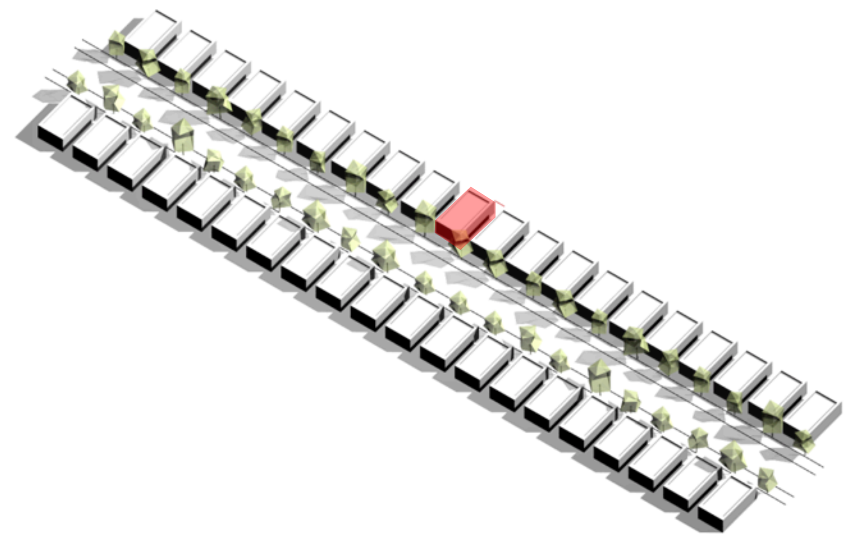
Improve spatial connectivity to destinations

All else being constant

More connectivity
+ accessibility



Less connectivity
- accessibility

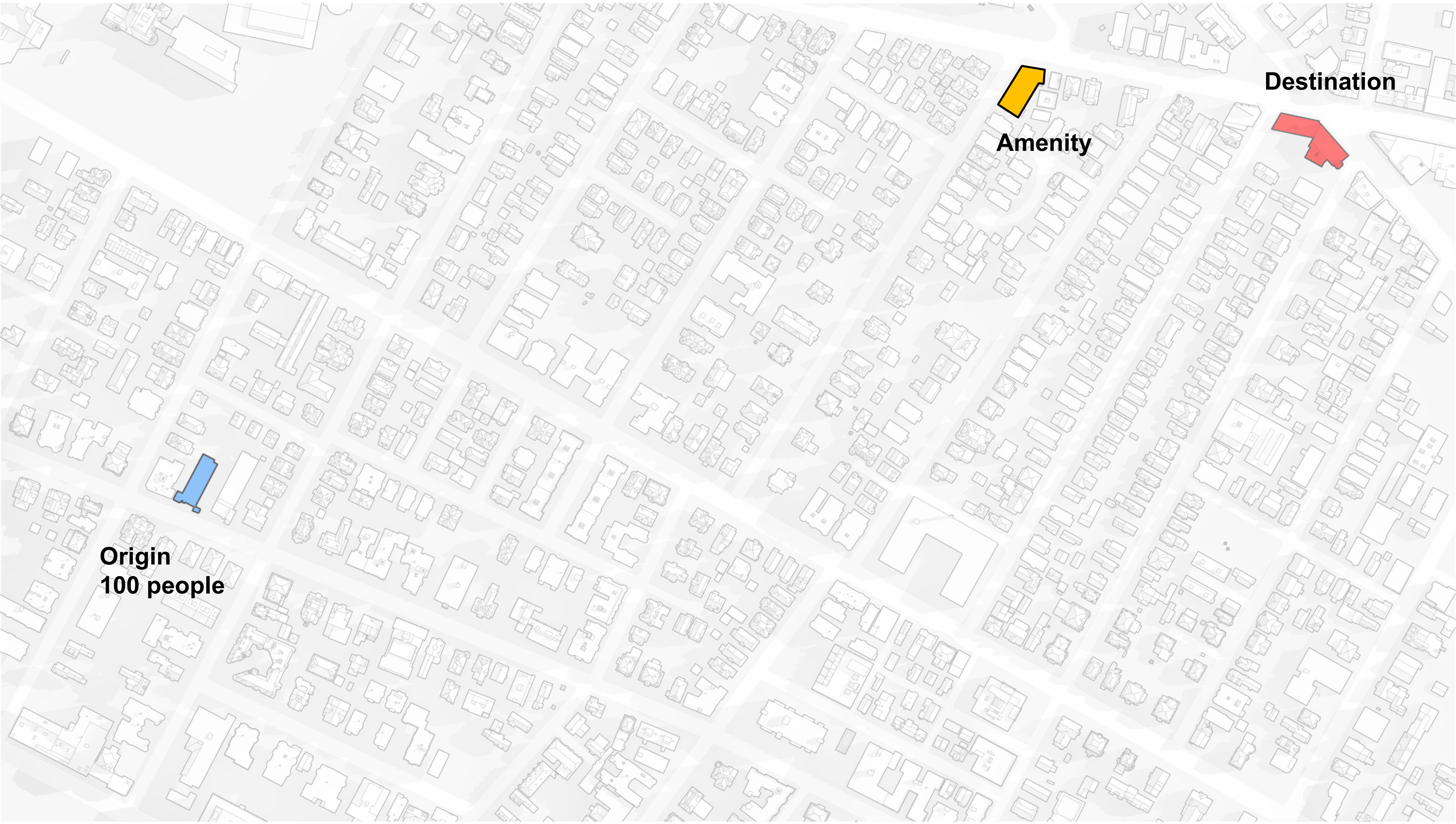


2. Mobile Origin Spatial Accessibility Estimation

While moving around
e.g. on the way to transit

Distribute Origin Weights

Spatial origins and Destinations



Shortest route

Spacing synthetic points along the shortest route between the O and D at 10m intervals.
Overall origin weight remains the same.

All plausible routes

Up to 20% longer than shortest route

Key user inputs for Distributing Weights :

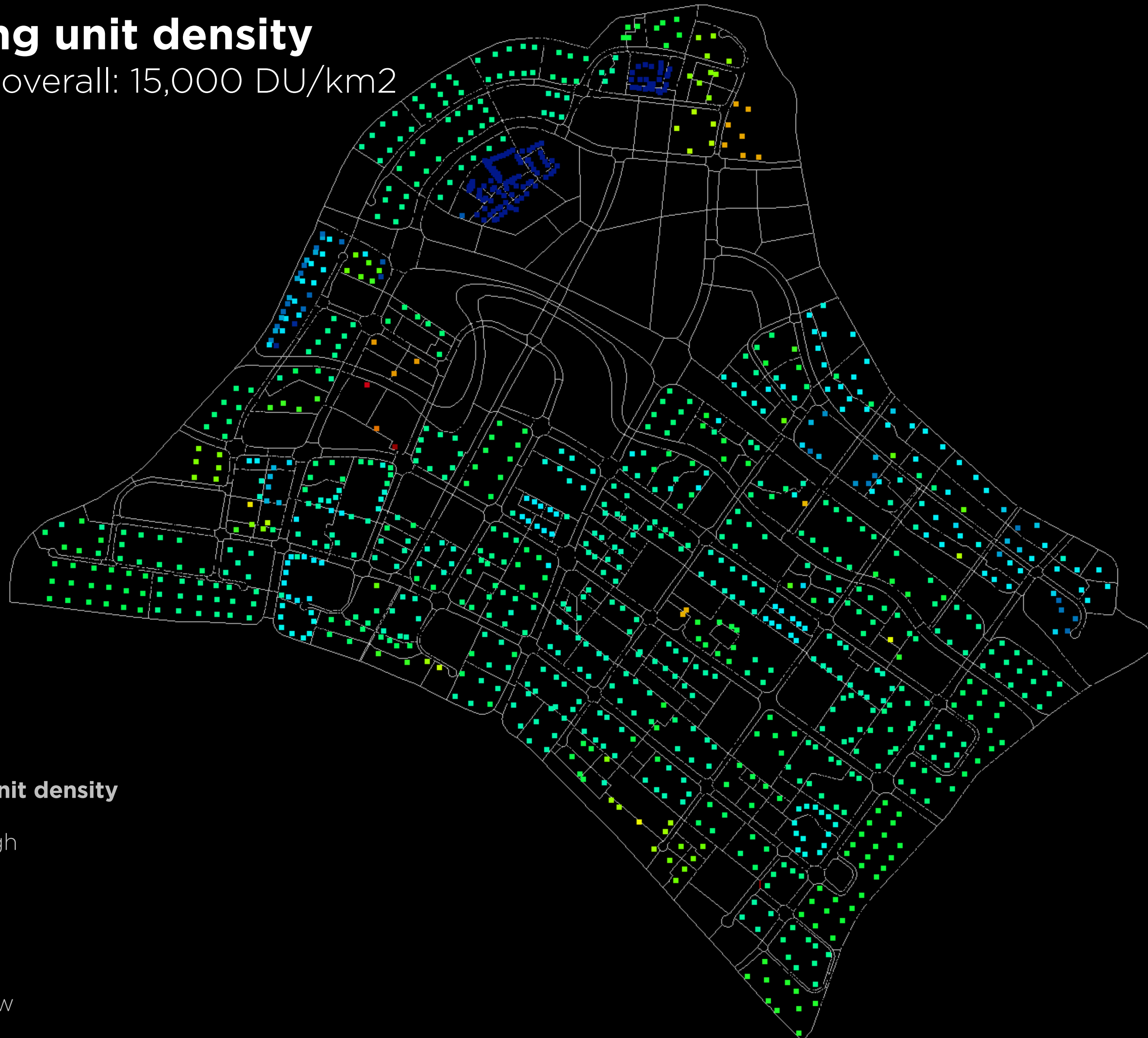
1. Origin points.
2. Destination points.
3. Optionally **weights for origin points** (e.g. people in buildings).
4. Observer points, that can count passersby but do not send out or receive any trips themselves.
5. Nearest, All, Search radius (determines which destinations are used).

Example 1: Planning Commercial Centers in Singapore

Sevtsuk, A., Kalvo, R. (2017). Patronage of urban commercial clusters: a network-based extension of the Huff model for balancing location and size. Environment and Planning B: Urban Analytics and City Science. Issue 0(0). pp. 1-21. PDF

Dwelling unit density

Punggol overall: 15,000 DU/km2



Dwelling unit density

High

Low

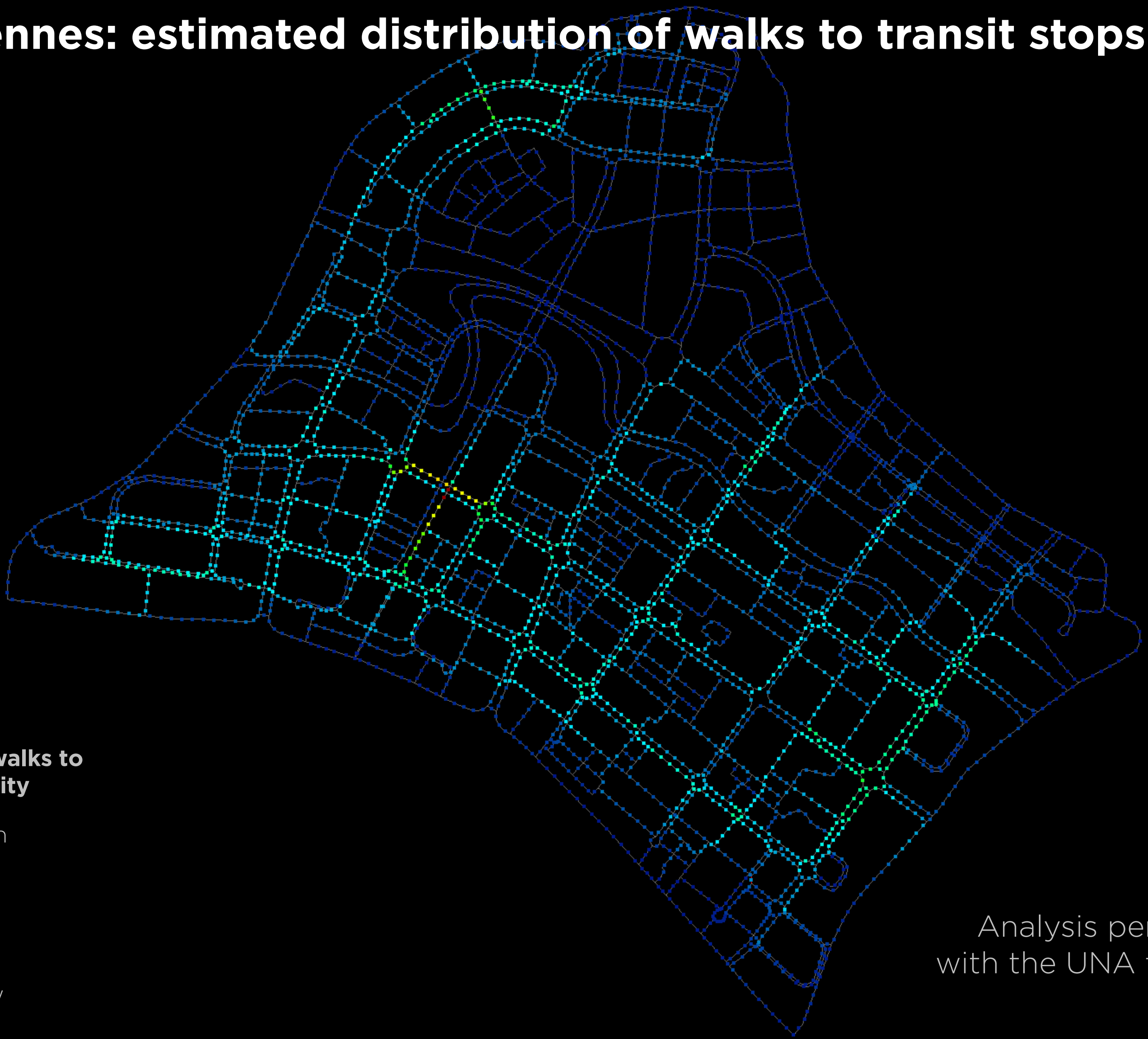
MRT, LRT and bus stop locations
Punggol

Transit stations

- Metro
- Light-rail
- Bus

Betweennes: estimated distribution of walks to transit stops

Punggol



Estimated walks to transit density

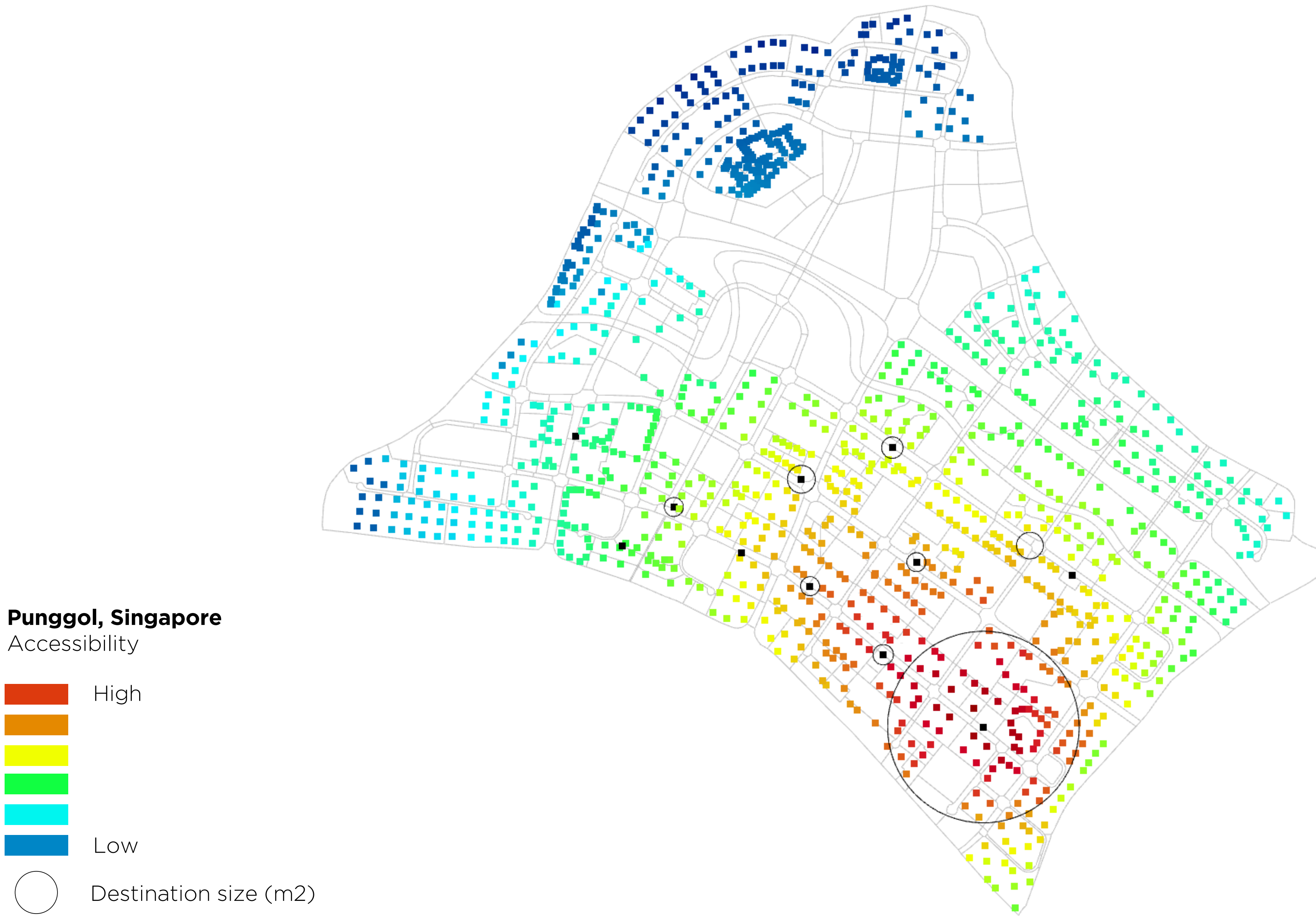
High

Low

Analysis performed with the UNA toolbox.

Gravity access from homes to retail centers

Weighted by store size. Radius= 3,000m; beta= 0.001



Gravity access from metro walk routes to retail centers

Weighted by store size. Radius= 3,000m; beta= 0.001

Punggol, Singapore
Accessibility

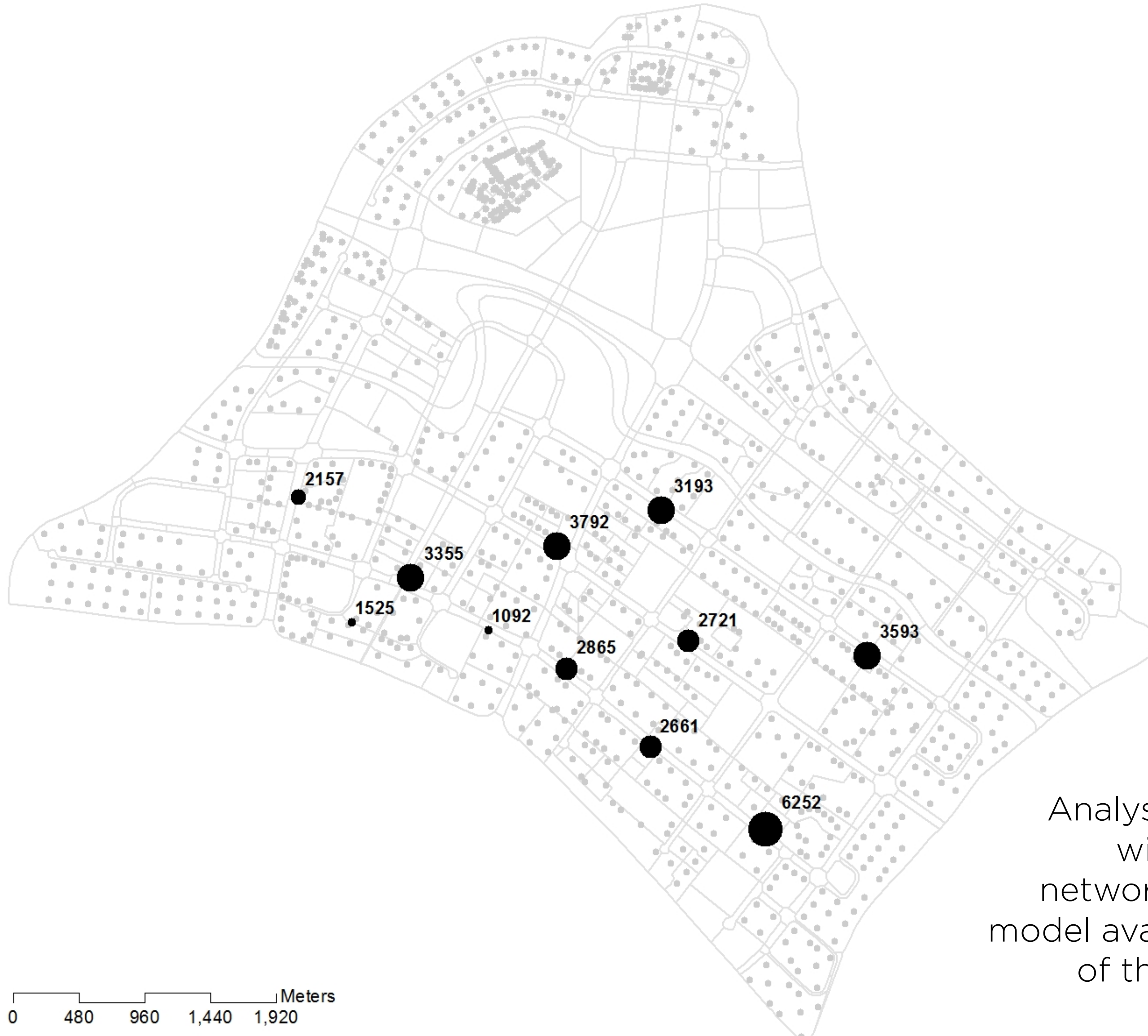
High

Low

Destination size (m2)

Estimated center patronage assuming trips start from homes.

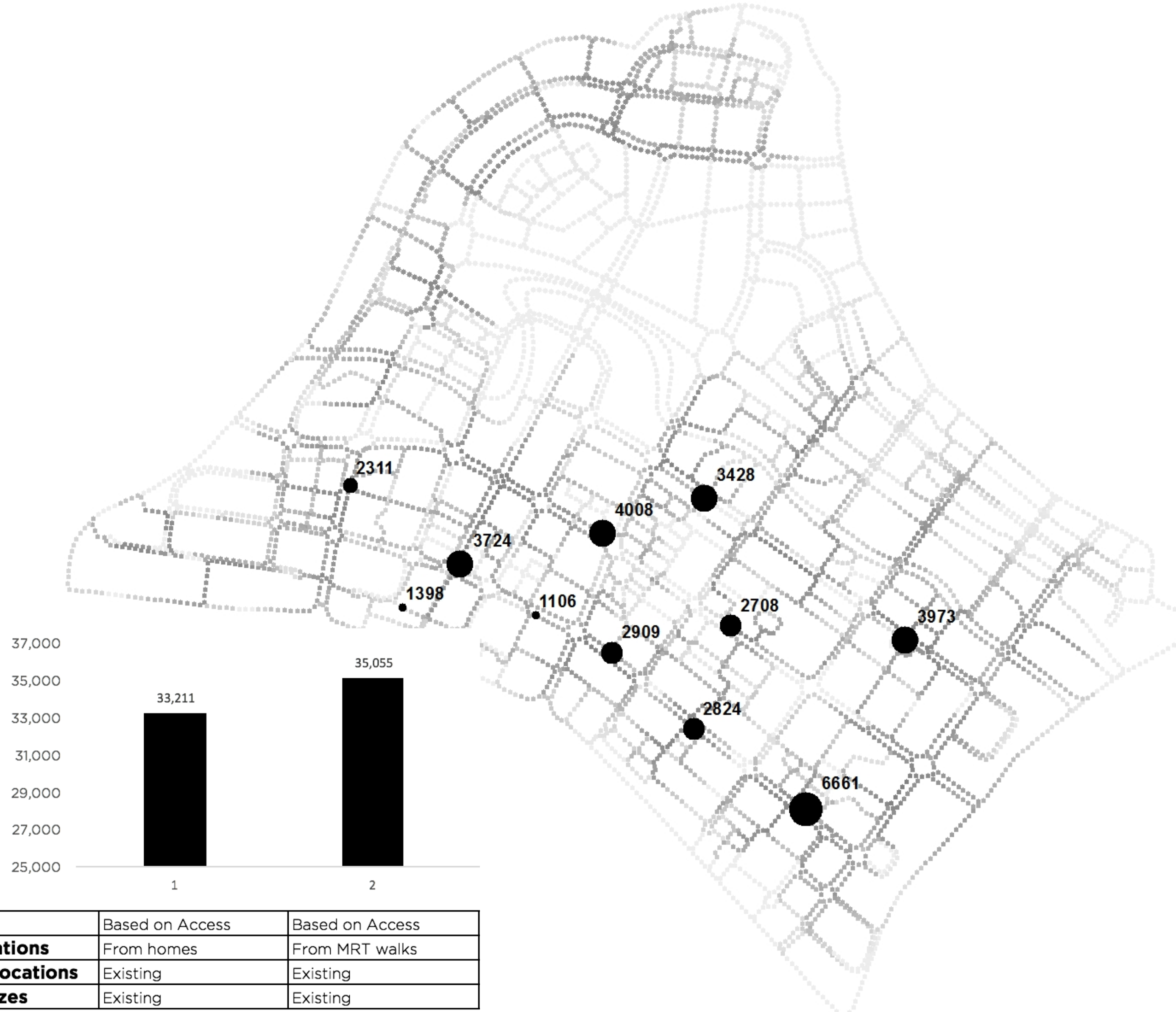
Total visits in town 33,211.



Analysis performed with the spatial network-based Huff model available as part of the Rhino UNA toolbox.

Estimated center patronage assuming trips start from metro walk routes.

Total visits in town 35,055.

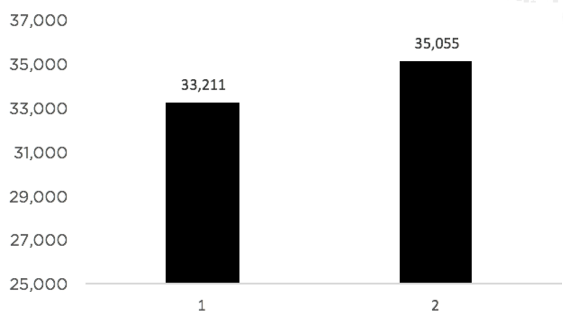


Model type	Based on Access	Based on Access
Demand locations	From homes	From MRT walks
Destination locations	Existing	Existing
Dstination sizes	Existing	Existing

Estimated center patronage assuming trips start from MRT walk routes.

Total patronage in town= 35,055 households.

Changing our assumption about where trips originate from changes accessibility results and alters how many people we expect to actually patronize urban amenities…



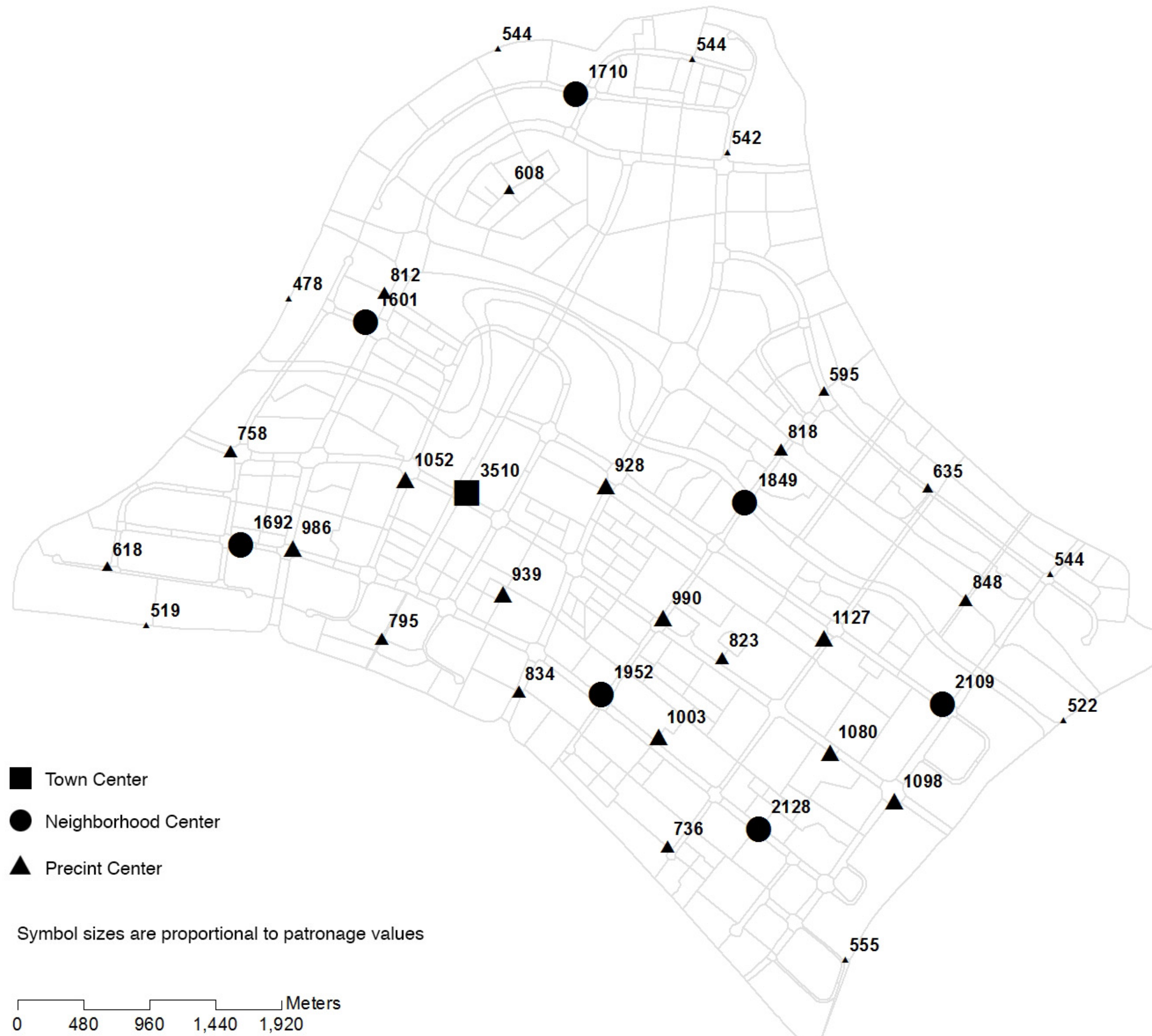
Model type	Based on Access	Based on Access
Demand locations	From homes	From MRT walks
Destination locations	Existing	Existing
Dstination sizes	Existing	Existing

Estimate of retail patronage, where existing and future commercial clusters are located according to HDB's current plans. Total quantum of commercial space is 136,500m2.

Total patronage in town: 38,243 households.

Estimate of retail patronage, where the same number of commercial centres are located deliberately closer to MRT walk routes and their sizes reallocated so as to maximize access. Total quantum of commercial stays the same at 136,500m2.

Estimated patronage across all clusters is 41,254 households.



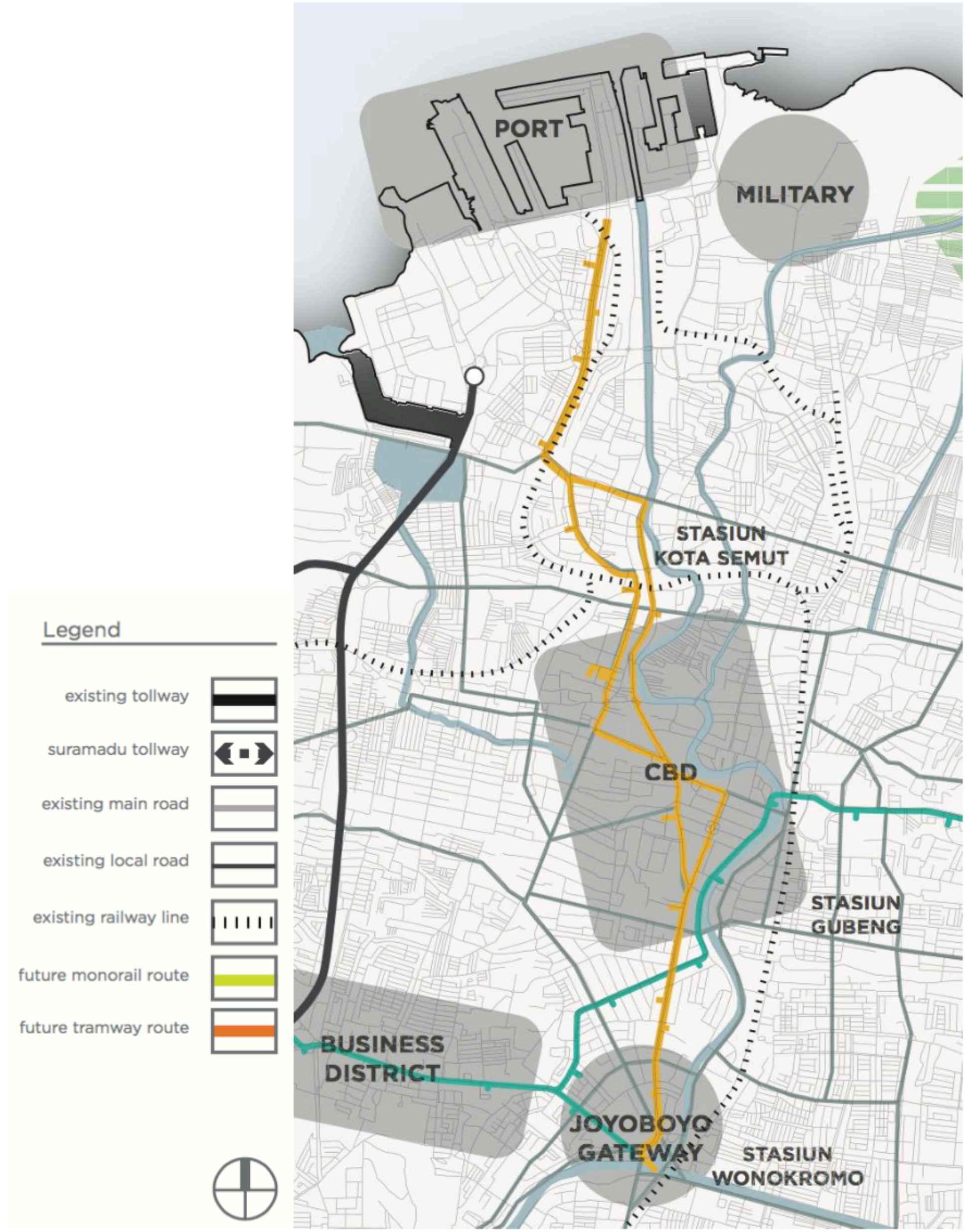
Towards active street fronts

Example 2

City Form Lab & Hansen Partnership. (2015). Surabaya Urban Corridor Development Program. The World Bank. PDF

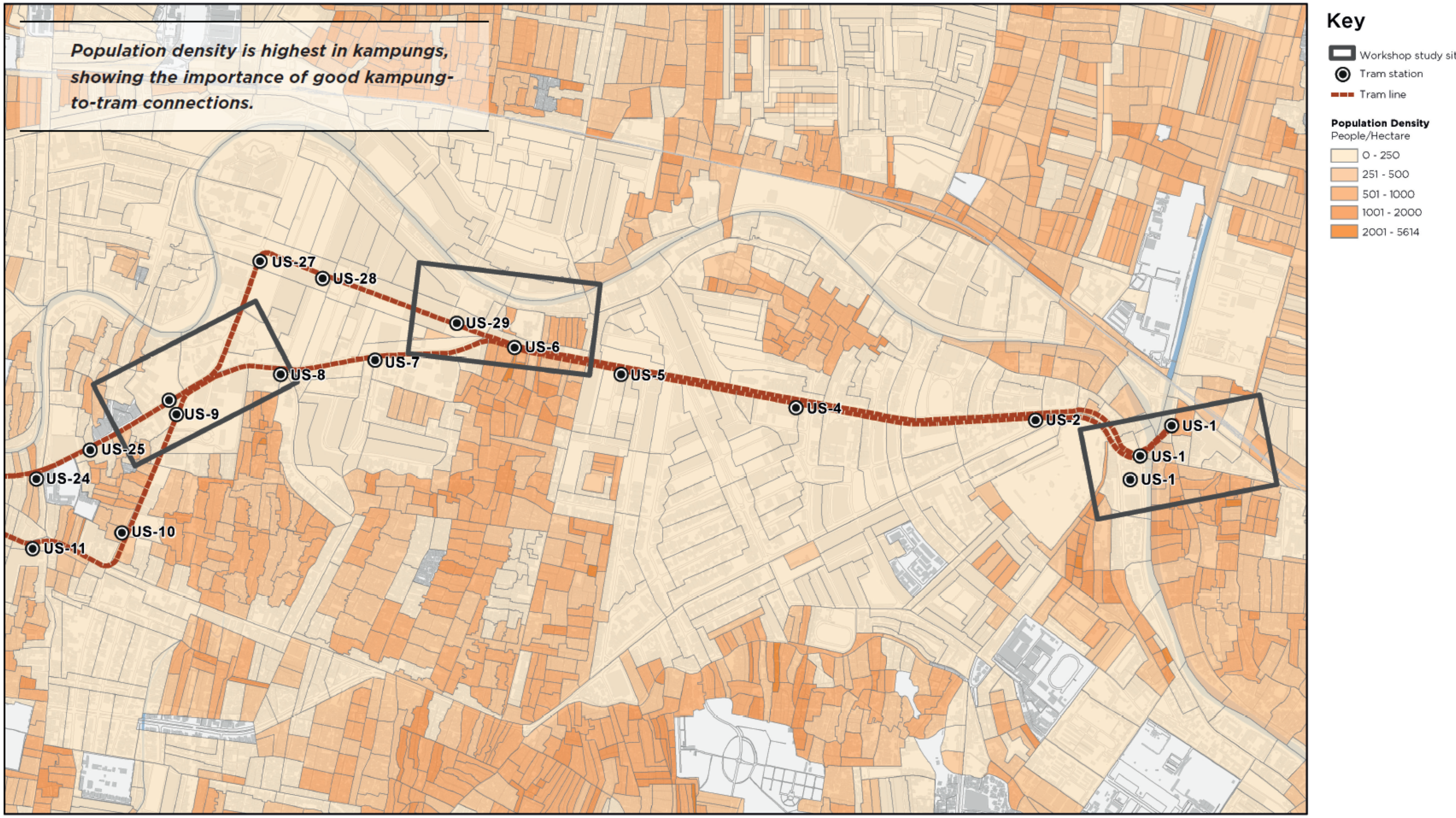
Surabaya Tram Corridor

Context



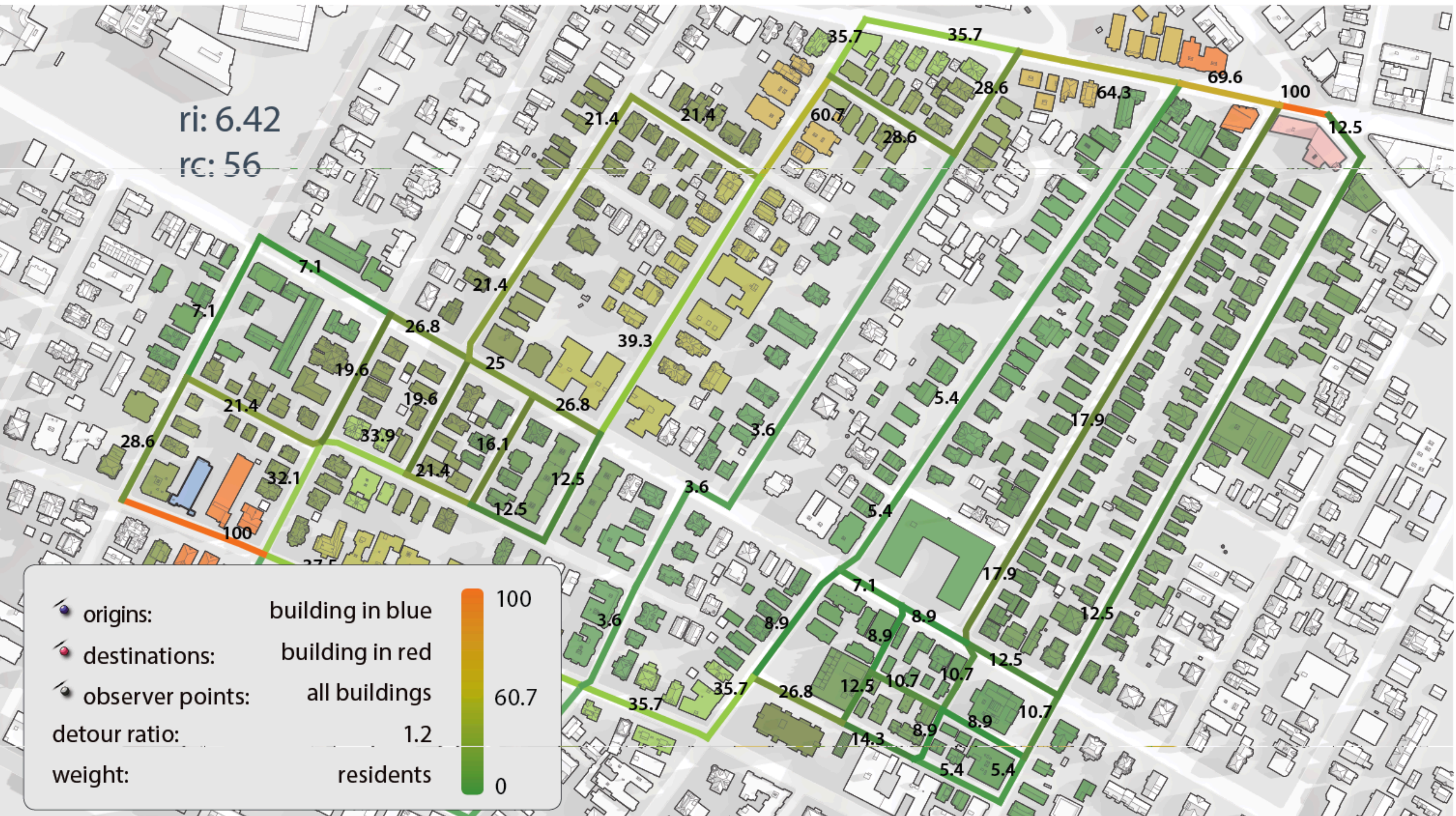
Population density at RT level

South Surabaya



Estimating foot-traffic from origins to destinations

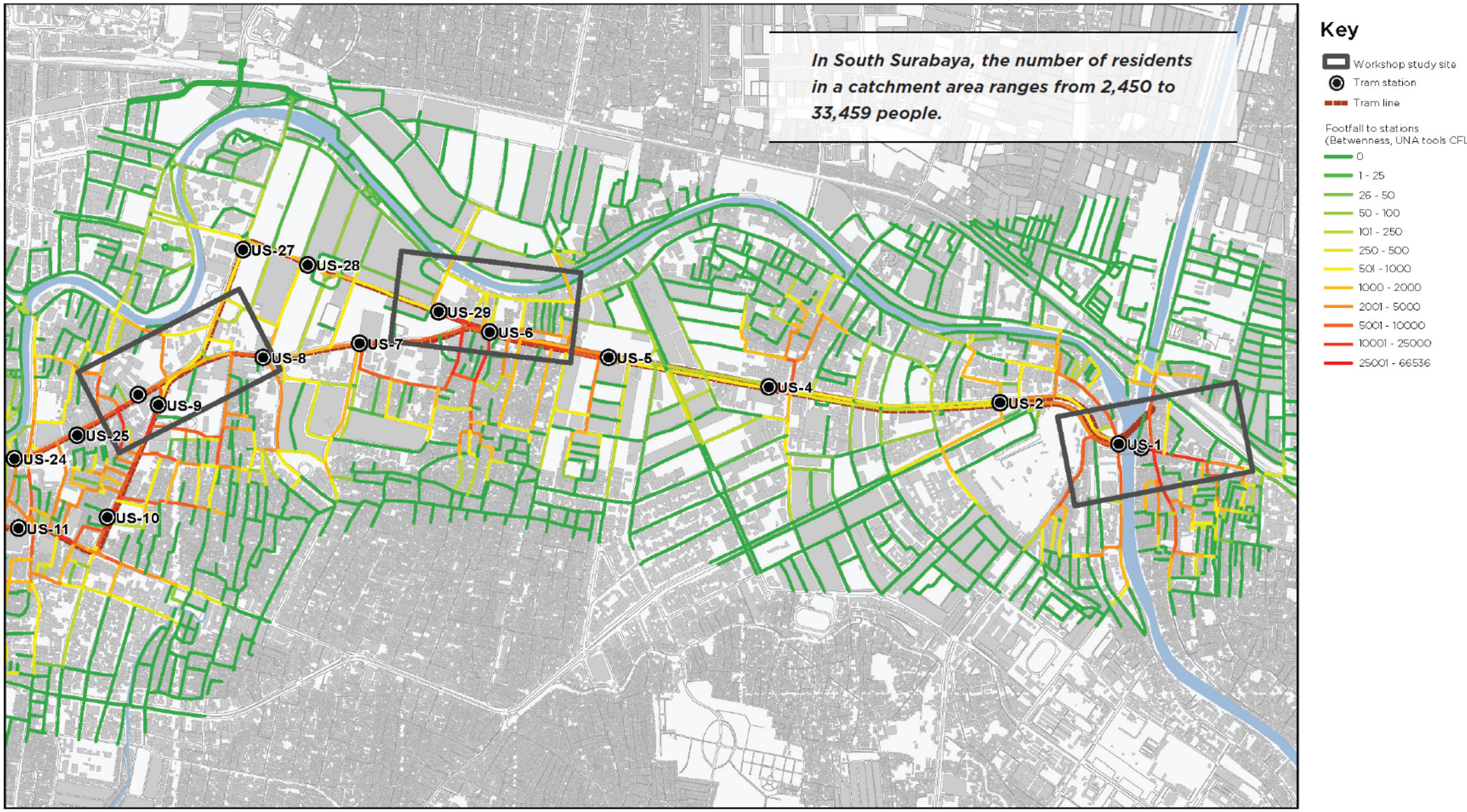
Betweenness analysis, UNA Toolbox



Predicted footfall from homes to MRT stations

to stations up to 800m away

269 km of paths!

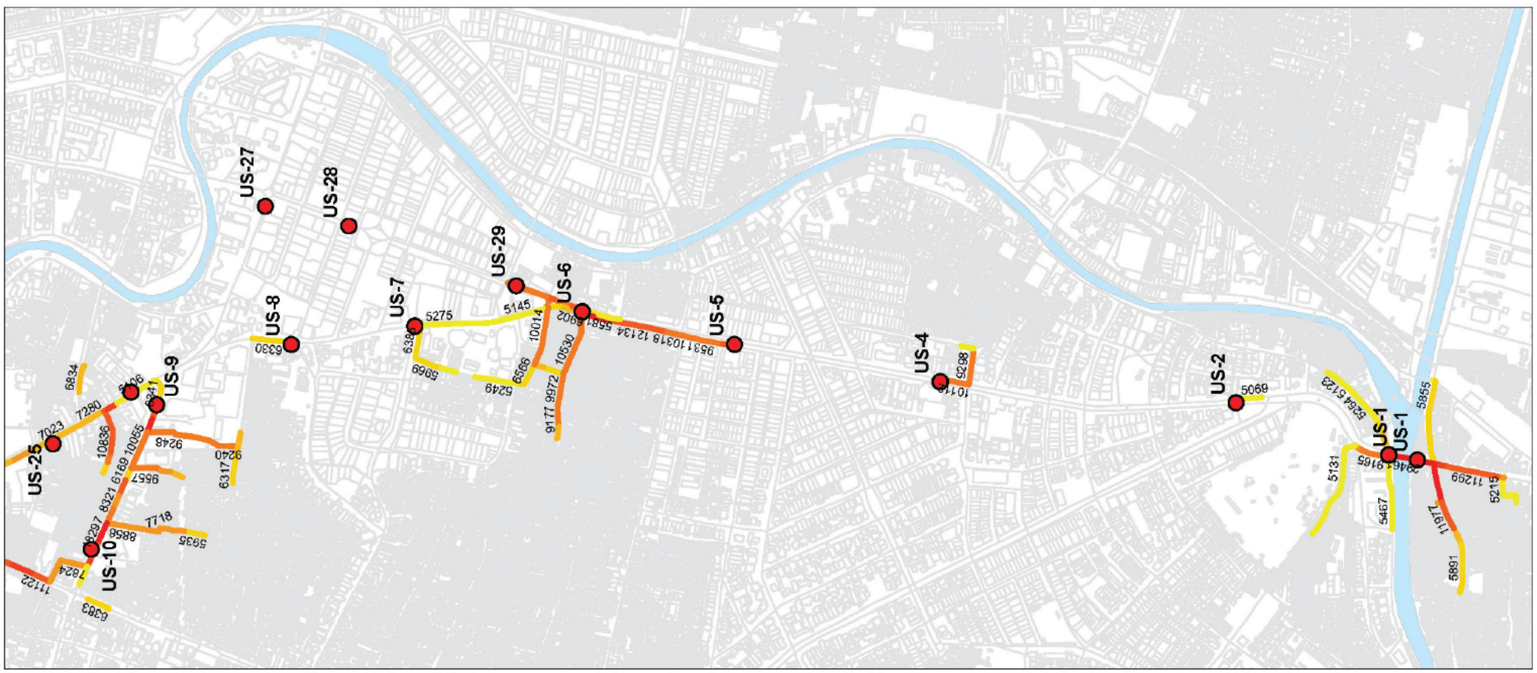


Prioritize paths with highest footfall >5,000p day

to stations up to 800m away

Priorities for investment and amenities can be directed according to level of demand of specific catchment areas.

17 km of paths to upgrade!



Key

- tram_stations

Avg_ Footfall

- 5063 - 5631
- 5632 - 6567
- 6568 - 7568
- 7569 - 8991
- 8992 - 10630
- 10631 - 12818
- 12819 - 16707
- 16708 - 22339
- 22340 - 31999

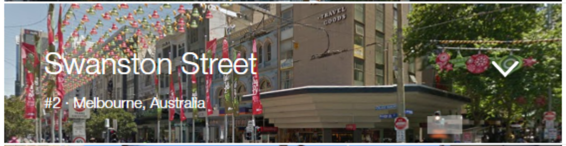
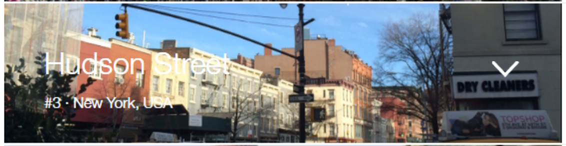
City Form Lab | Projects | Papers | Videos | People | Courses | Lectures | News | Street catalogue

http://cityform.mit.edu/street-catalogue

Street catalogue

The catalogue provides a visual and numeric reference to streets around the world. It allows users to compare the accessibility and connectivity measurements of different streets with time-lapse videos and corresponding pedestrian counts of the same streets. Videos captured during different times of the day allow you to examine temporal changes in the character of a street between times of a day, days of a week or times of the year. Read more

Submit street

Case ID / Country / City / Street name	Date & Time	Weekday	Footfall per hour	Betweenness	Access to Businesses	Access to Transit	Access to Floor Area
Country / City	From / To	min / max	min / max	min / max	min / max	min / max	min / max
 10th Avenue #1 · New York, USA	23:30 15/03/2014	Sun Weekday	1108 Footfall per hour	621 Betweenness	597 Businesses	Transit	2447604 Floor Area
 Swanston Street #2 · Melbourne, Australia	11:00 30/03/2015	Mon Weekday	2223 Footfall per hour	239 Betweenness	1071 Businesses	24 Transit	124000 Floor Area
 Hudson Street #3 · New York, USA	18:57 15/03/2015	Sun Weekday	680 Footfall per hour	1288 Betweenness	801 Businesses	Transit	1768651 Floor Area
 Lujiazui Pedestrian Bridge #5 · Shanghai, China	12:30 02/04/2015	Thu Weekday	1500 Footfall per hour	18 Betweenness	343 Businesses	13 Transit	Floor Area

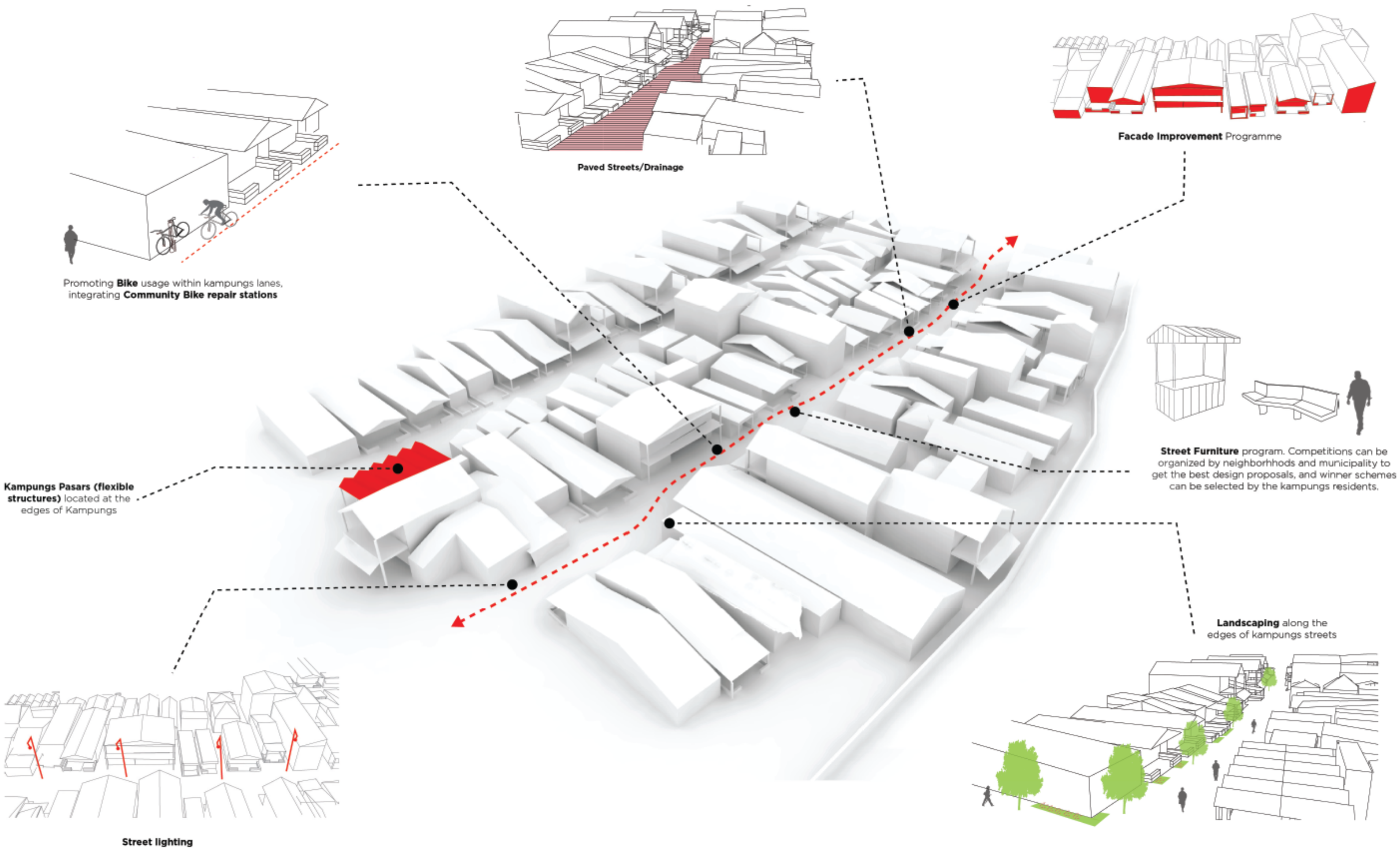
Brattle Street, Cambridge MA

Brattle St at Harvard Square has a number of a popular shopping destinations, street cafes and restaurant. The time-lapse is captured at about 50 meters from the nearest Harvard Square subway entrance. The space in front of the camera contains a large sidewalk with ample seating areas, which also functions as a public plaza for street musicians and people-watchers.

15:50	Mon	904	783	647	19.2	251571
14/09/2015	Weekday	Footfall per hour	Betweenness	Businesses	Transit	Floor Area

Upgrade important kampung lanes leading to MRT stations

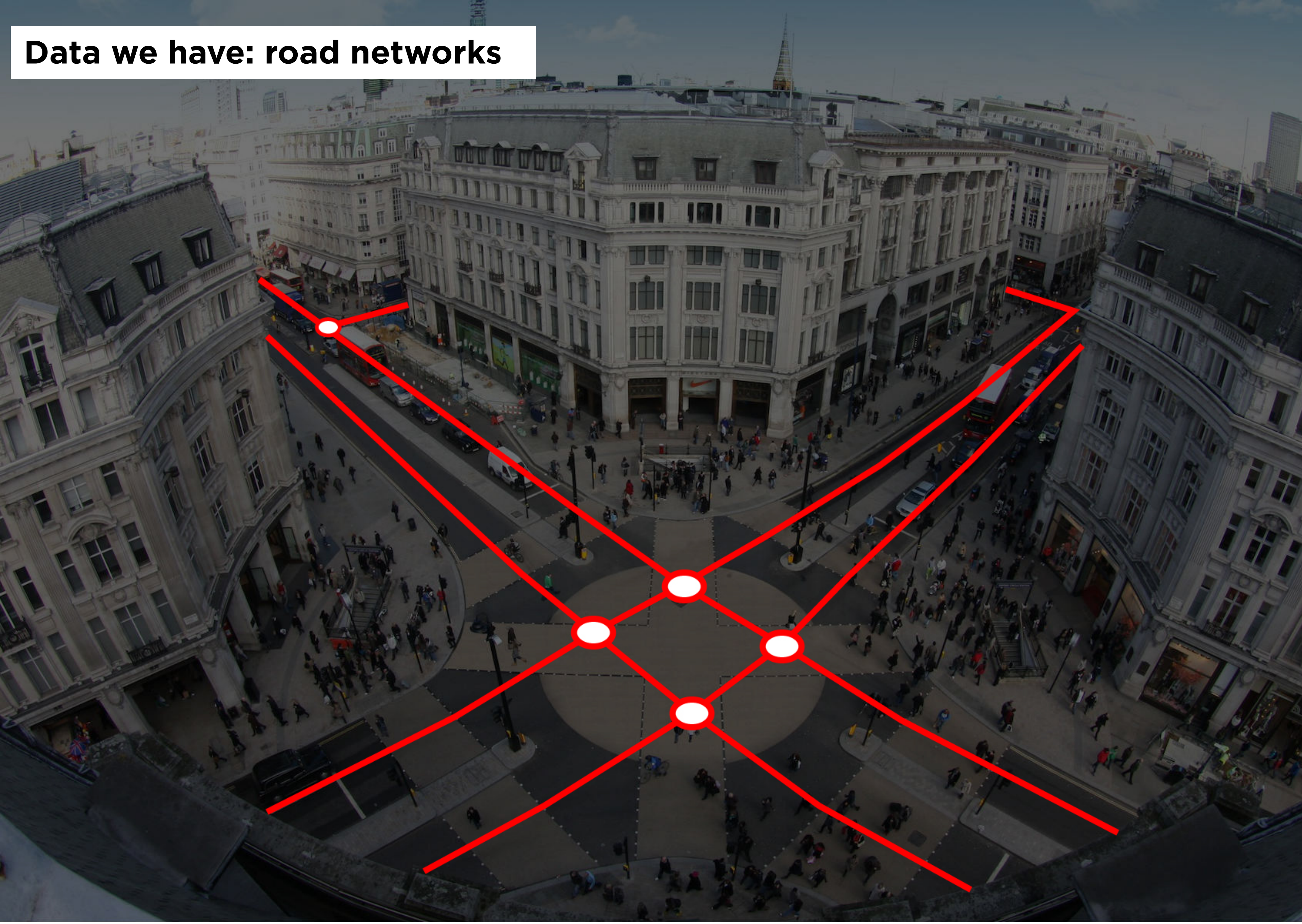
Drainage, lighting, landscaping, activity generating uses, bike-lanes, furniture...



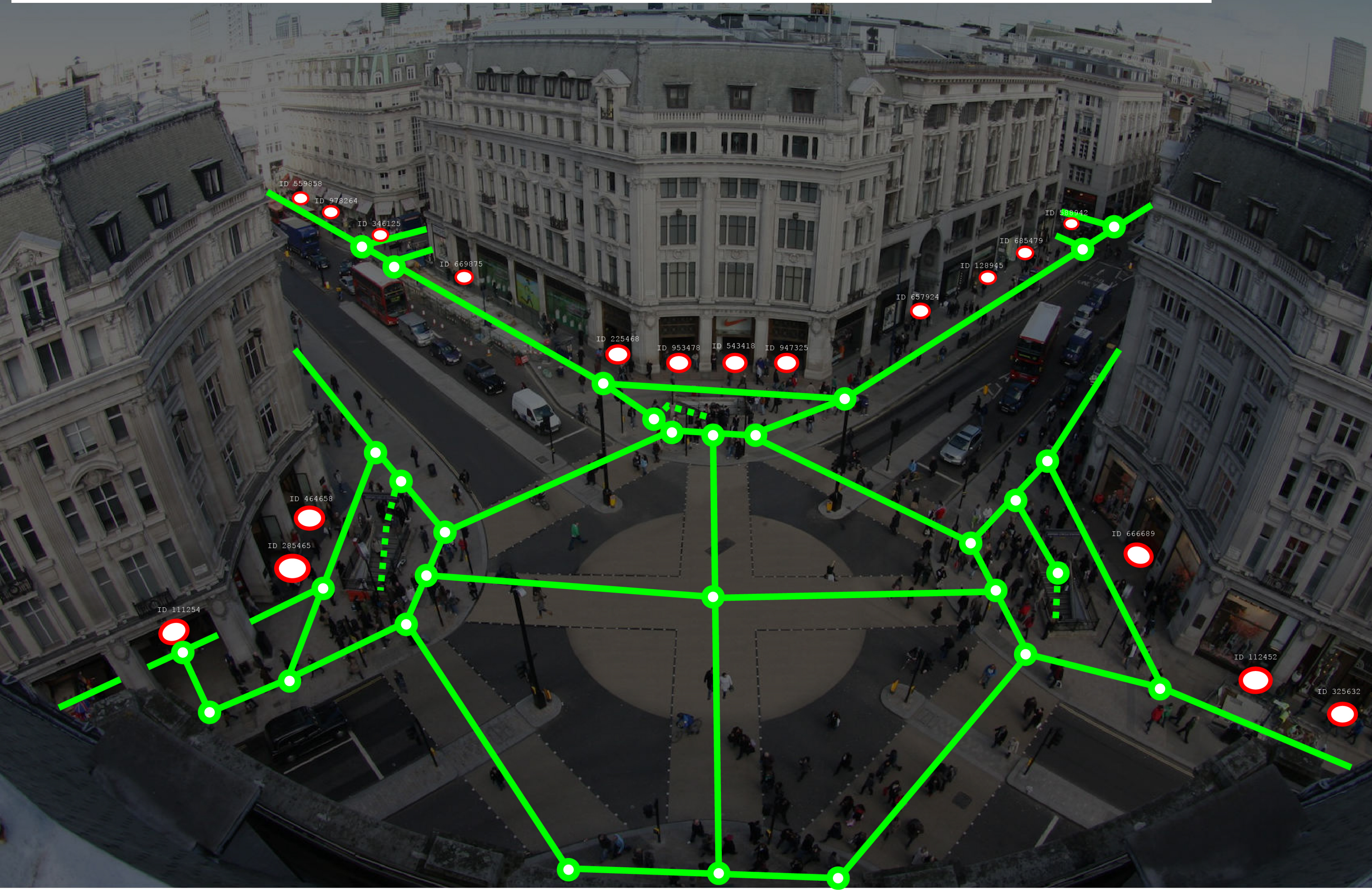
Data...

Complex built environment around the last mile

Data we have: road networks



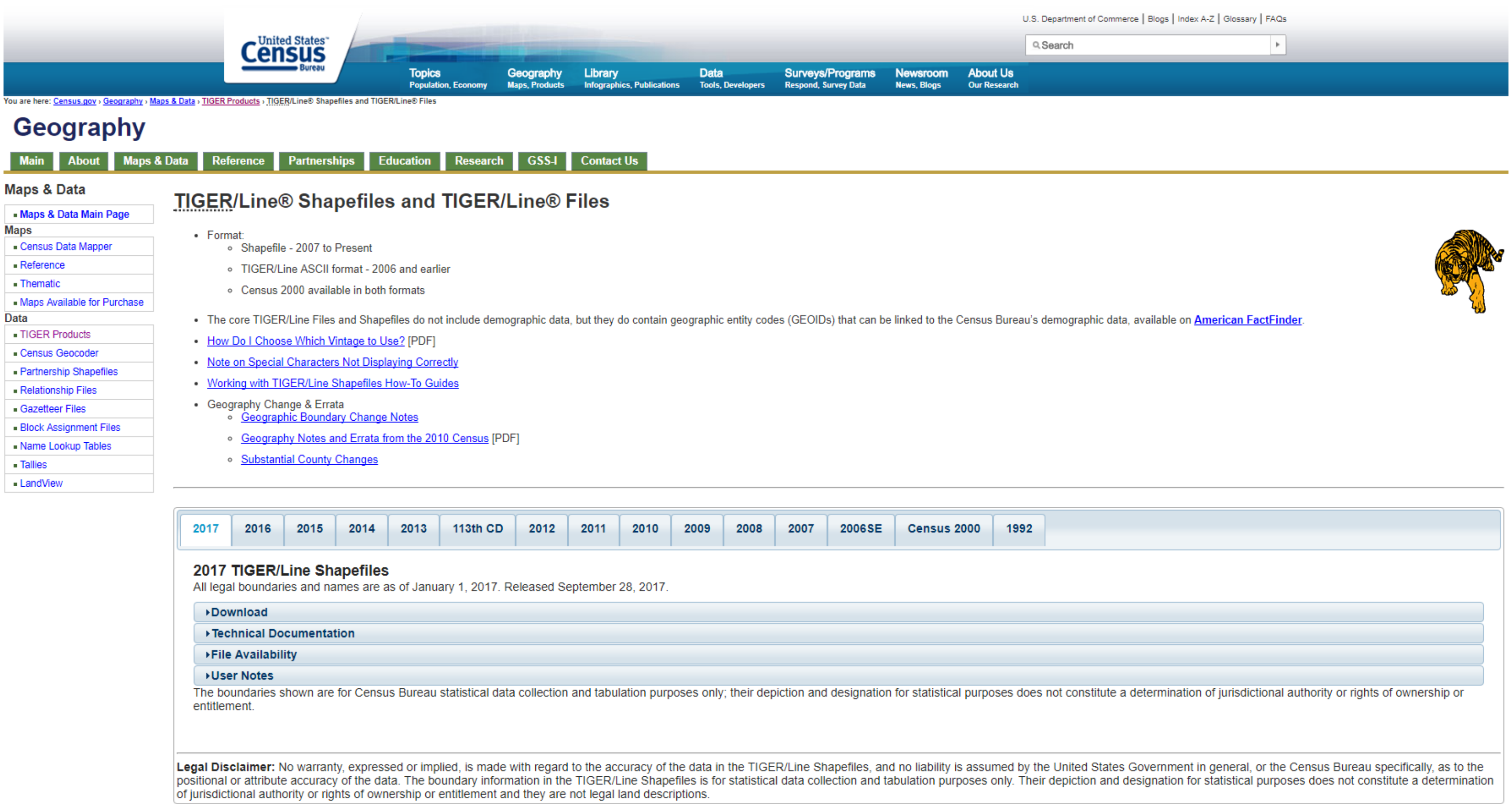
Data we should have: pedestrian networks and building entrances



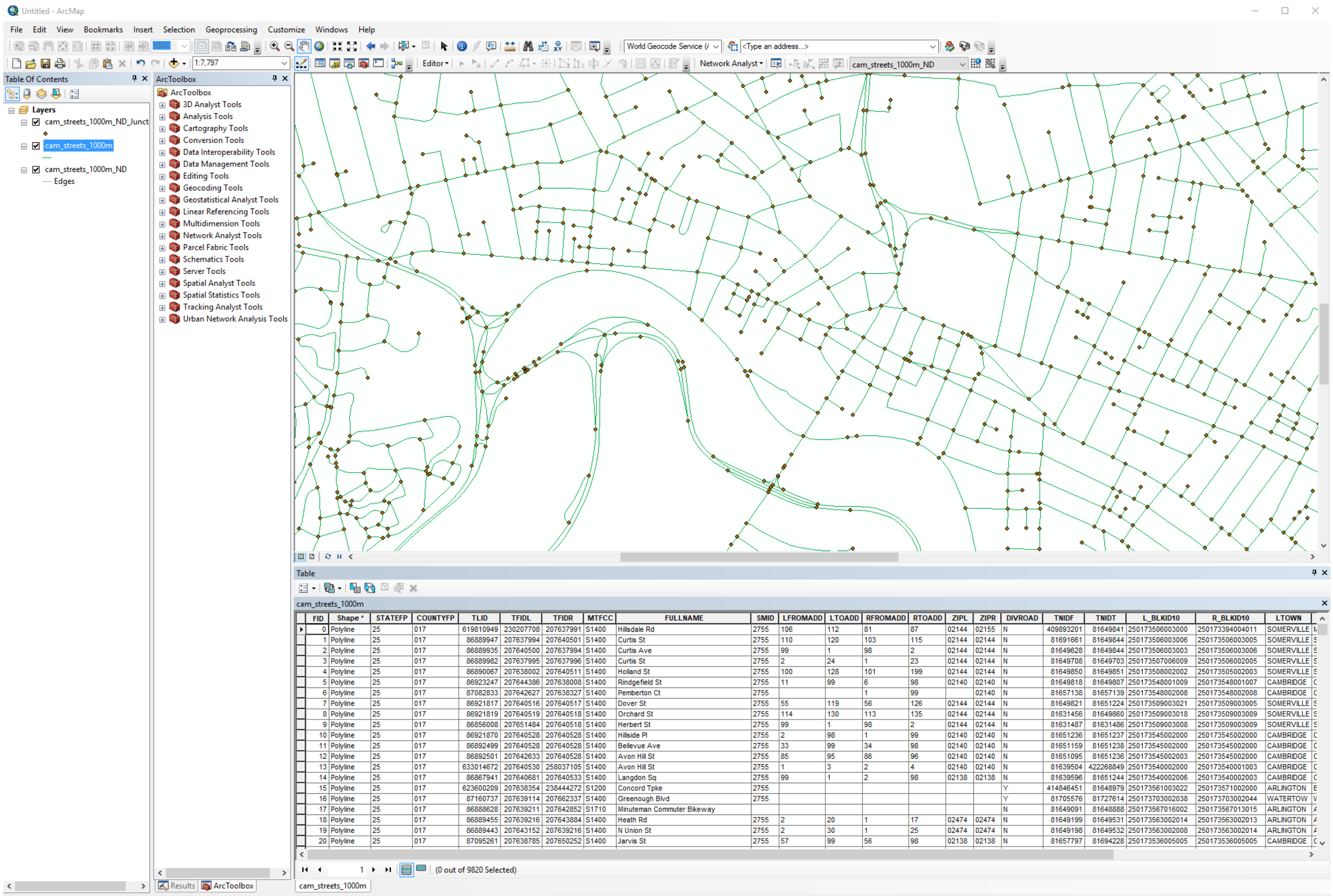

Category counts:
391 pedestrians
342 walking
38 standing
3 baby strollers
8 running
7 cyclists
14 passanger cars
1 truck
4 buses

Governments maintain good databases on vehicular roads

e.g. US Census TIGER roads data



E.g. US Census TIGER roads data

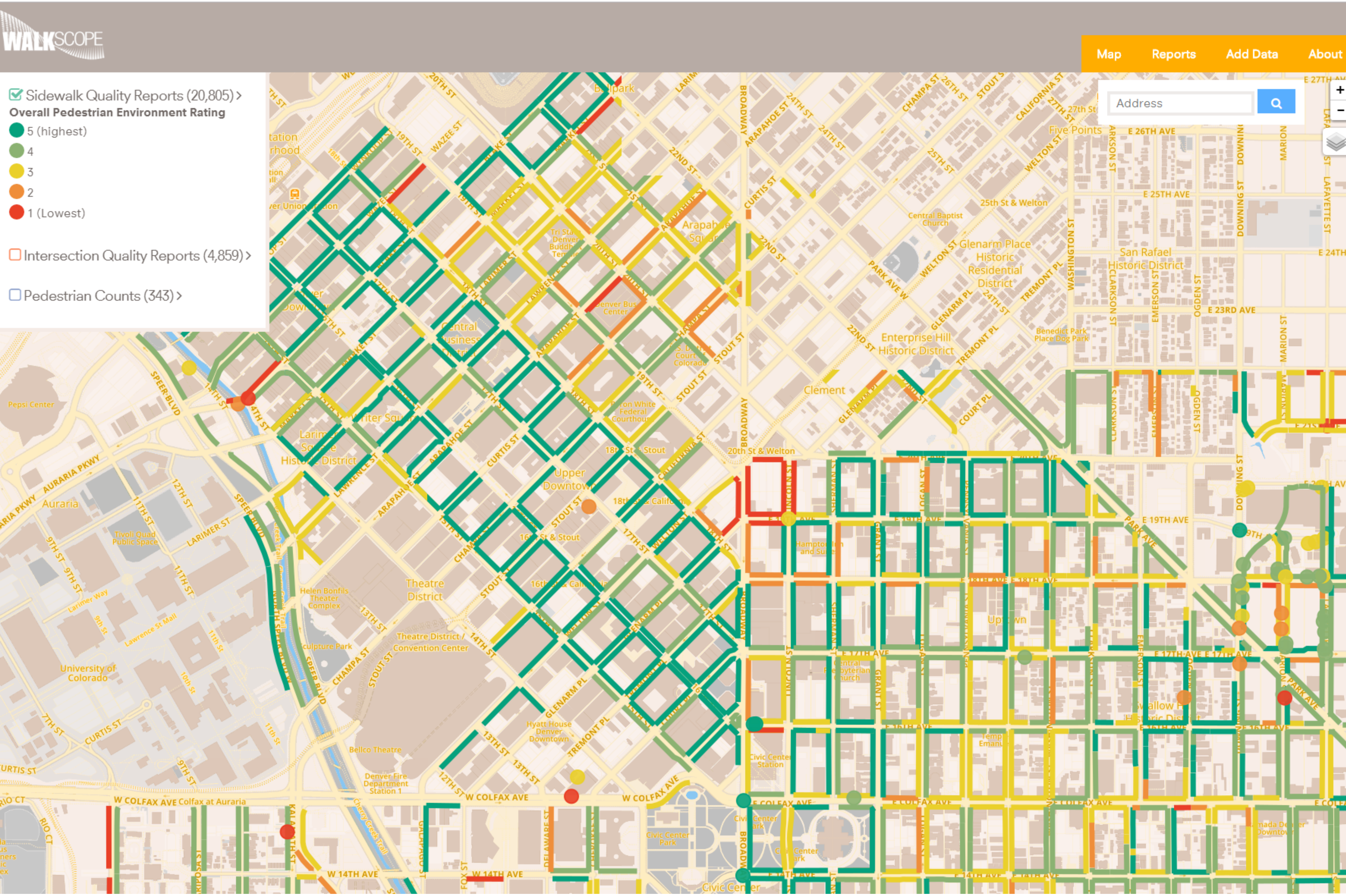


The lack of good data is a huge barrier to better walking infrastructure. Denver, a self-styled Vision Zero city, can't eliminate traffic deaths without a safe walking network. And the city can't improve its walking network if it doesn't know where the weaknesses are. And yet, no city department has an inventory of the city's sidewalks and crosswalks.

Streets Blog Denver

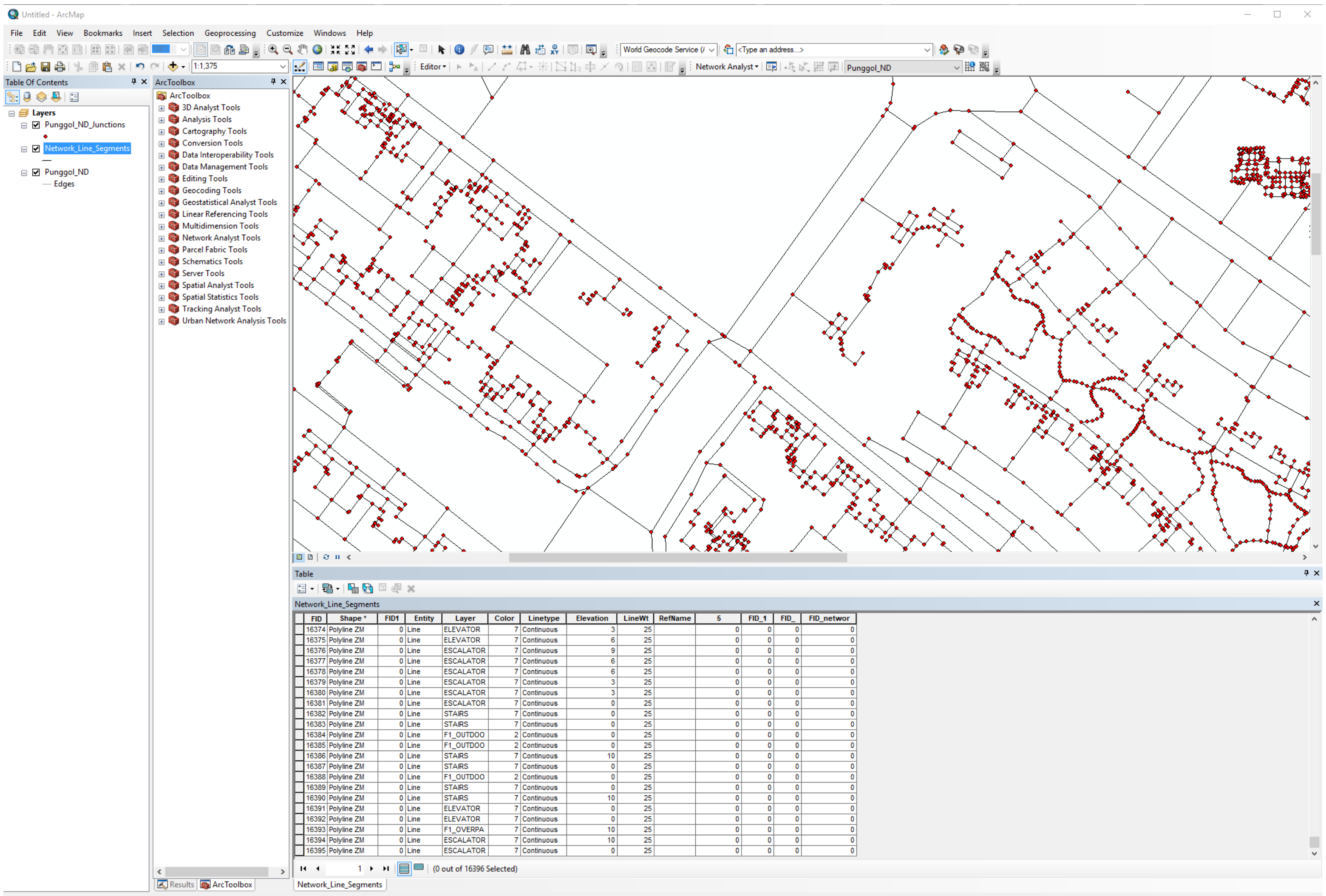
Crowd-sourcing sidewalk data

e.g. Walkscope in Denver



City governments should maintain equally good databases on pedestrian networks…

OECD ITF to develop standards and recommendations for cities around the world?



Conclusions

- It is customary to measure spatial accessibility from fixed locations (e.g. homes, jobs), but people don't necessarily start their trips from these locations.
- Changing our assumption about trip origins, changes our estimates of how frequently and by whom urban amenities can be accessed and are visited.
- When planning accessible environments, we need to not only think about motorized and mechanized transport infrastructure, but also focus on the scale of the *street* which everyone intuitively experiences.
- In order to describe accessibility on streets, we need data about sidewalks and pedestrian infrastructure.
- Could OECD help propose standards and urge cities to collect sidewalk data?
- In order for accessibility analytics to influence city design and planning, analytics needs to move from being retrospective and become projective, applied to synthetic and normative design solutions of the future, shaping decisions about potential built environments.

Thank you!

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Urban Network Analysis toolbox software (FREE)

The free Urban Network Analysis Toolbox can be downloaded for Rhino3D from http://cityform.gsd.harvard.edu/projects/una-rhino-toolbox and for ArcGIS from http://cityform.gsd.harvard.edu/projects/urban-network-analysis

Related Articles

Sevtsuk, A., Mekonnen, M., 2012, “Urban Network Analysis Toolbox,” *International Journal of Geomatics and Spatial Analysis*, vol. 22, no. 2, pp. pp. 287–305. PDF

Sevtsuk, A. (2014). Location and Agglomeration: the Distribution of Retail and Food Businesses in Dense Urban Environments. *Journal of Planning Education and Research*, 34(4), 374–393. Link

Sevtsuk, A., Kalvo, R., & Ekmekci, O. (2016). Pedestrian accessibility in grid layouts: the role of block, plot and street dimensions. *Urban Morphology*, 20(2), pp. 89-106. PDF

Sevtsuk, A., Kalvo, R. (2017). Patronage of urban commercial clusters: a network-based extension of the Huff model for balancing location and size. *Environment and Planning B: Urban Analytics and City Science*. Issue 0(0). pp. 1-21. PDF

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