Walkable Cities And Math

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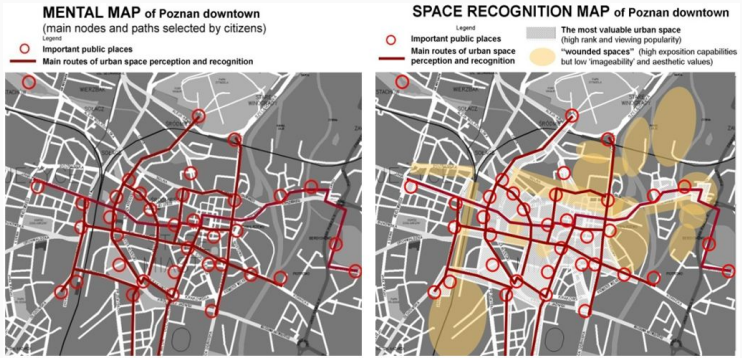
Reminders from Last Time

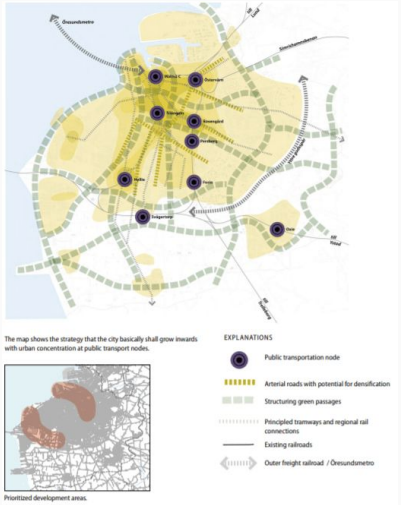
- Cities are fractal!!!
  - Their irregularity and growth can be better described using fractal geometry in comparison to traditional Euclidean Geometry
  - Road networks and cars waste a lot of space and remove the human-scale of connections

The Urban Web

Definition

- The way a city is organized
- Consists of the exterior and connective elements of an urban space
- 3 principles to generate an urban web:
    - Nodes, Connections, and Hierarchy



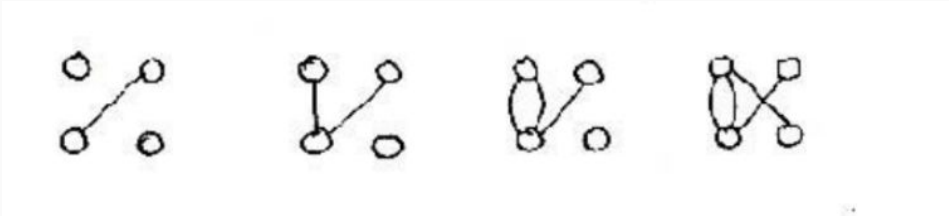


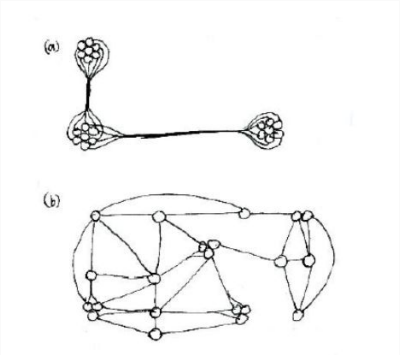
Nodes

- Where human activity takes place (e.g. homes, worksites, stores, etc)
- Nodes are not simply buildings
  - Have to attract people for some reason
  - Architectural sites do not always do this, so they can be isolated from the urban web
  - Ex: A hot dog stand may be a more prominent part of the urban web than a large and unused building

Connections

- An urban web needs to be a well-connected and stable network
- In graph theory, random pairwise connections between N nodes will link about 80% of them after N/2 steps
- We want everything to be accessible, but not every node needs to be directly connected



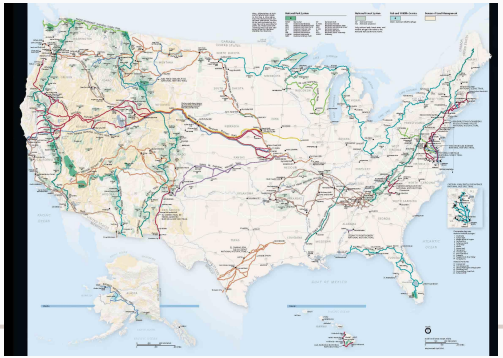


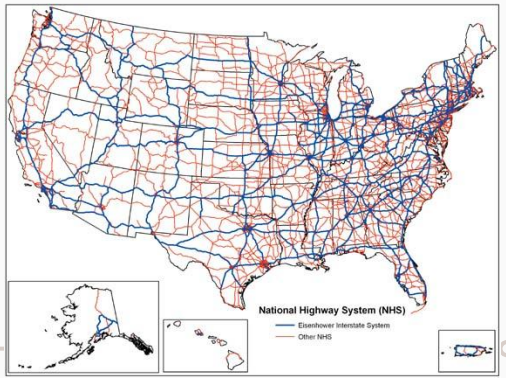
Theory of Multiple-Connectivity

- Idea: There is only 1 unique straight line that can connect 2 nodes, there are infinitely many curved ones
- It is more beneficial to maximize connections between urban nodes by using irregular paths
- Creates a stable system because there is no dependency on just one path: If one road closes, the urban web still functions
    - Also reduces channel overload
- Disagrees with a grid based cities that limit connections
    - Also disagrees with uniformity of zoned areas

Hierarchy

- The Urban Web exists on different levels of connections: cars and pedestrian connections being the two main ones
    - The paths that connect you through roads are usually different from those through walking paths
- These scales cannot be the same (you shouldn't walk along a highway) but they should overlap
- When building a city, urban planners need to create connections for all of the different scales of the urban web





Cities Built for Cars

A World For Cars – Lacking a Human Scale

- Human Scale: The things we interact with every day are of a size and shape for an average person (including pedestrian paths and experiences)
  - Was it built to be experienced on foot?
- Most city development is centered around roads and cars, reducing the human scale of cities
  - Pedestrians have to fit into a city built for cars, not the other way around
- Examples:
  - Buildings built for the benefit of the skyline, not those using it
  - Signs on the sides of highways, made to be seen while driving not walking
- Dependency on a car is a mobility barrier and harms the environment

Why?

- When the US had its big economic boom after WWII, the country was in the middle of the automobile age
- The costs of cars dropped dramatically and suburbs and cities were built, prioritizing highways and cars
- The US focused on the value of practicality over livability: they wanted to create visually simplistic cities (and thus ignored human activities until later)
    - Human activities then had to fit in a pre-existing matrix that cannot accommodate them

The Suburban Sprawl

- Another part of this postwar expansion was a mass movement to suburbs
- Residents wanted to escape crowded neighborhoods in favor of lower land and housing costs
- There were also a lot of propaganda motivating women to quit their wartime jobs in favor of the family and home life
    - Ironically, housing prices increased so much with the demand many women had to go back to work
- Emphasized individualism in society (neglecting the community) and perpetuated racism and discrimination

The Suburban Sprawl-Today

- About 46% of Americans live in suburban neighborhoods today, but many people dislike living in them
- Research has shown that people dislike the suburbs because we have a natural preference for socialization and well-defined spaces (things that suburbs lack)
- Because they are so individual and car focused, they lack walkability, cohesion, and the sense of a community
- Many suburbs are also built with winding streets and culs de sac that make one feel isolated

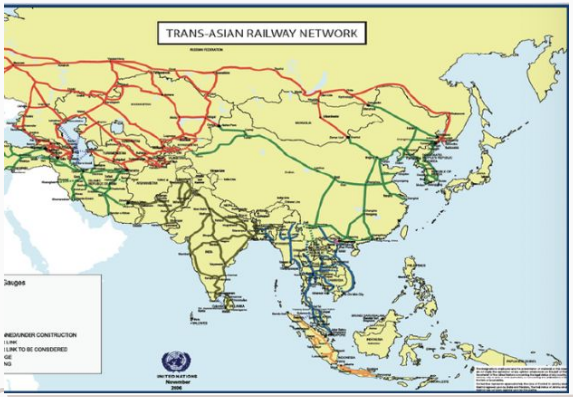
Public Transportation

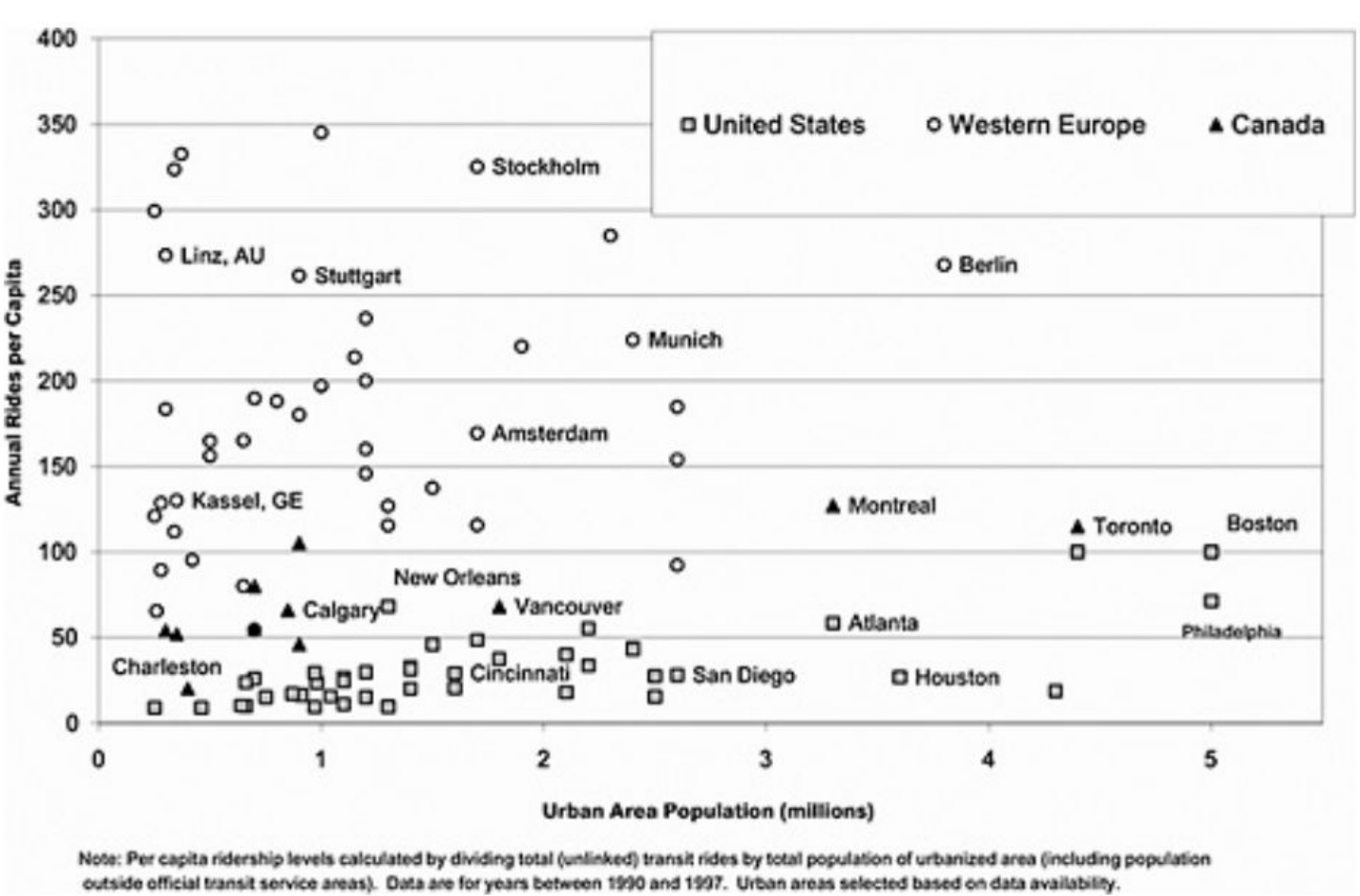
Public Transportation

- It is no secret that the US falls incredibly short when looking at its public transportation networks
- When suburbs and cities were being built in the 30s to the 60s, there were almost no significant rail projects
- It is much more expensive to build a rail infrastructure through an already established city as opposed to farmland (before the city is built)
- When metro systems were developed in the 60s, 70s, and 80s, they did not provide an easy way to get to the rail stations without a car
- Public transit in America is much more expensive and irregular, making it almost impossible to use for day-to-day use

America vs Elsewhere

- Other countries like Germany that were equally car focused still never stopped building rail systems
- European cities tended to prioritize transit connections when building cities
- They were also built before cars, so cars had to fit into their already established pedestrian cities versus pedestrians having to fit into already established car cities





Note: Per capita ridership levels calculated by dividing total (unlinked) transit rides by total population of urbanized area (including population outside official transit service areas). Data are for years between 1990 and 1997. Urban areas selected based on data availability.

Suburban Public Transportation

- It is often seen as being impossible to create a well-functioning public transportation system in the suburbs
- But in Toronto, they succeeded through a bus network
- Nearly everyone who lives in Toronto is within a 15-minute walk of a 24-hour bus route
    - Even the station near golf courses, large parking lots, and houses on large land plots gets 10,890 riders a day
    - That is more than many stations in Manhattan and most in Brooklyn

Walkable Cities

Why Do We Need Walkable Cities?

- In one survey of Great Britain, they analyzed the effects of living in a car centered community
- They quantified the effect of road traffic on local residents
- The focus of this survey was not on direct effects of road traffic (like collision risk, noise, and air pollution), but instead on indirect effects like avoiding making trips in the first place.

Why Do We Need Walkable Cities?

- The survey specifically looked at the characteristics of the busiest road near the participant, and they analyzed whether that had an effect on whether they walked to their destination
- When places within walking distance were on the other side of the major road, the individuals make fewer trips than average and have a higher probability of making zero trips
- Trip suppression (avoiding walking somewhere) can result in a reduction in physical activity, reduced accessibility, lower levels of social interaction and support, and poorer mental health
- Based on their statistical model, an increase in the minutes spent walking for recreation would increase both the neighborhood social capital score and wellbeing

Why Do We Need Walkable Cities?

- Reduced traffic can improve air quality/reduce pollution
- Lowers the risk for obesity, heart disease, and diabetes
- Reduces stress and improves mental health
- An increase in walkability is associated with an increase in home values
- It costs the average American over $9,500 a year to own a car
    - An unlimited annual pass on New York's MTA buses costs $1,524
- Facilitates civic engagement

How Can We Fix It?

- Increase bus networks that connect people to metros and trains
  - Make them run 24/7 and frequently for cheaper prices
- Turn some road areas into pedestrian zones
  - Copenhagen turned its main Stroget street into a pedestrian zone
- Create more isolated bike and walking paths
- Alter roads to prevent speeding and dangerous walking situations
- Increase multiple-connectivity!
  - Get rid of homogeneous urban regions
  - Add more segments (almost piecewise elements) to pedestrian paths
  - Connect pedestrian and public transportation paths
- Superblocks

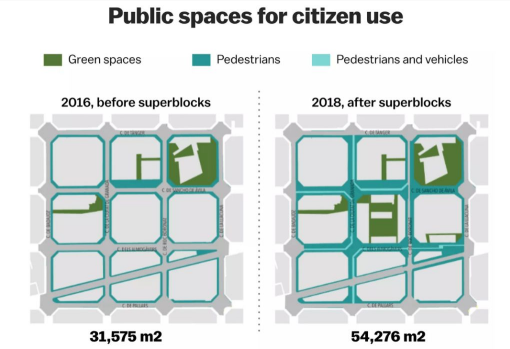
Superblocks

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

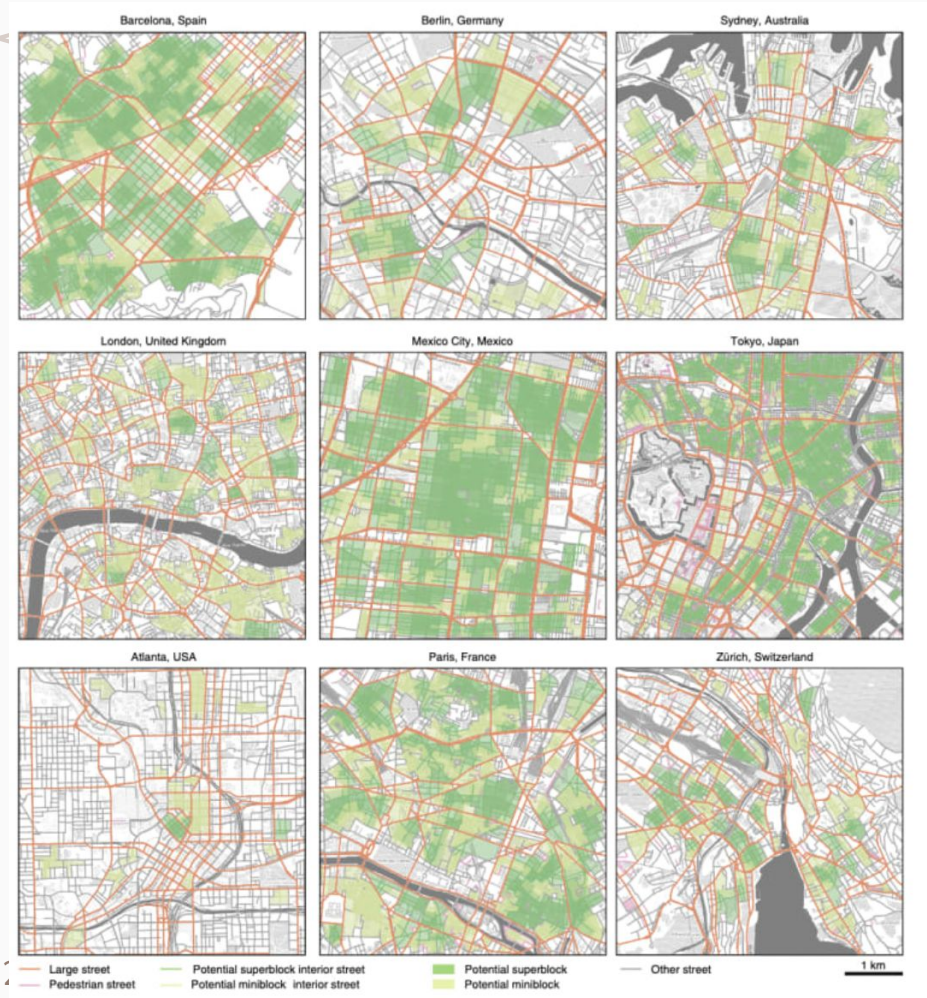
Superblocks

- That video was from 7 years ago, and Barcelona started this project back in 2016
- Even today the superblock system reduced traffic, air pollution, and noise
- It also reduced the “heat island” effect and increased access to parks for movement and children to play

- A study found that more than 40% of Mexico City could transform into super blocks with little disruption of traffic
- But cities with lower density but a regular grid are less suitable for a super block
    - You need to have an active street life and good public transportation
- The “15 minute city” is the type of living that makes superblocks possible



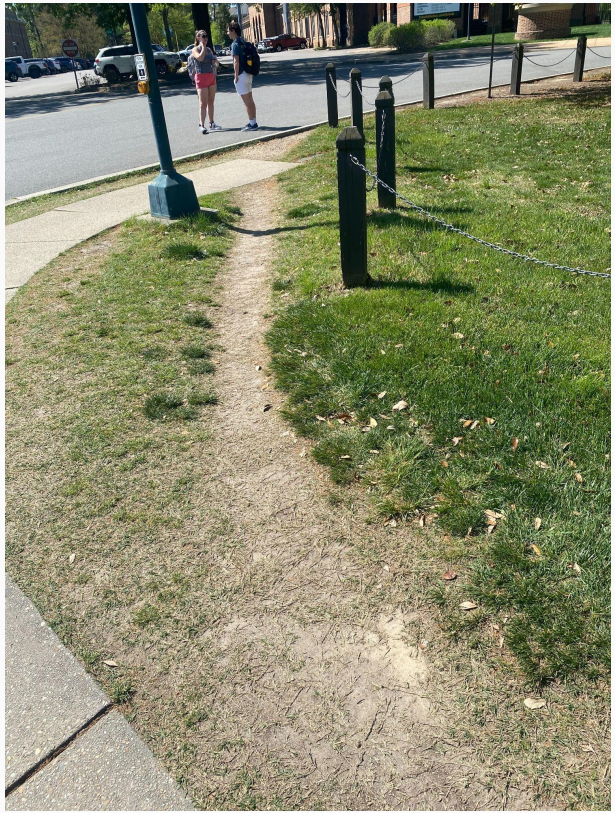
Superblocks



Aside: Desire Paths

- An example of how urban planners don't always accommodate pedestrians
- Some say people should build cities based off of these desire paths, as Jane Jacobs says "There is no logic that can be superimposed on the city; people make it, and it is to them...that we must fit our plans"
- Michigan State University looked at where the students and teachers walk before establishing the paths
- One article referred to them as a record of a collective disobedience
- Dirk Helbing, a German physics and math professor, found that travelers will form a desire path if the prescribed route is 20-30 percent longer
- Once one is formed, it tends to have an "attraction effect"

Aside: Desire Paths



Measuring Walkability

Types of Systems

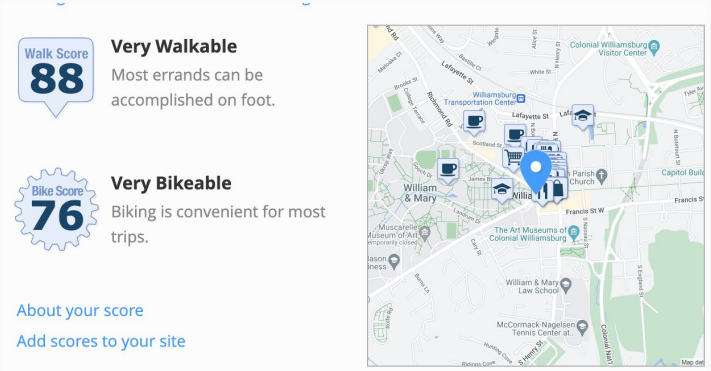
1. Those that quantify the walkability retrospectively:
    a. Pedestrian Environment Review System
        i. Rated from -3 to 3
    b. Walk score
        i. Rated from 0-100
2. Those that predict pedestrian traffic
    a. Spatial Syntax
    b. Urban Network Analysis

Walk Score

- A number between 0-100 that quantifies how walkable an address is
  - 90-100–daily errands do not require a car
  - 70-89–most errands can be accomplished on foot
  - 50-69–some errands can be accomplished on foot
  - 25-49–most errands require a car
  - 0-24–almost all errands require a car
- The most walkable cities in the US: New York (88), San Francisco (89), and Boston (83)
- Visual of Walk Scores

Walk Score

- Analyzes walking routes to nearby amenities
- Point awarded based on distance to each amenity in a given category
    - Anything a 5-minute walk or less away (.25 miles) gets maximum points, a decay function gives points to more distant amenities, with no points given after 30 minutes
    - They don't publish their functions :(
- It also takes into account block length and intersection density
- But does not look at conditions of sidewalks or how truly walkable a path is
- They rated 130 cities in the US and Canada with a population of 200,000 or greater, their average Walk Score was 48
- See graph here
- My city: Walk Score of 23
- Williamsburg: Walk Score of 88



Urban Network Analysis (UNA)

- Used to simulate and predict pedestrian traffic using networks and the urban web

3 steps

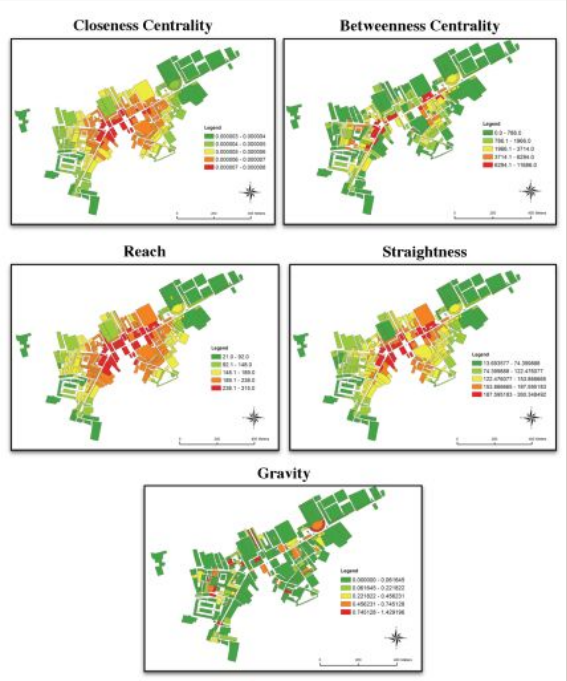
1. Input the origins and destinations (making buildings and facilities nodes that are connected)
2. Use the key tool-Patronage betweenness to generate pedestrian flow (more on this later)
3. Fix the city based on the results

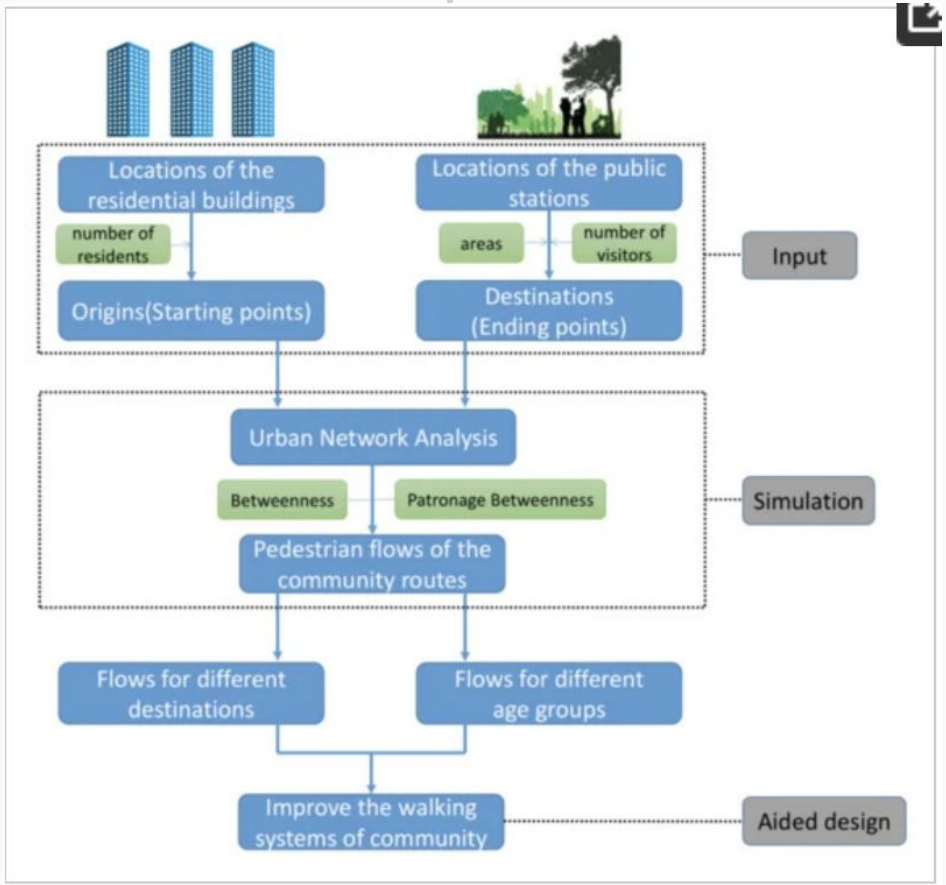
- Used in ArcGIS (essentially a toolbox you can buy and install for it)
- Unlike prior tools that only looked at nodes and edges, they introduced buildings as a separate feature that can be weighted based on characteristics like the population or volume
- Also supports 3d spatial networks for things like tunnels or overpasses

Urban Network Analysis (UNA)

- Based on 5 different measurement indices
- Reach: the number of nodes in the graph reachable from a certain node (looking at shortest distance)
- Gravity: A version of reach that takes the weight of buildings and destination nodes
- Betweenness: The number of times a node lies on shortest paths between other buildings
- Straightness: How closely the shortest distances resemble Euclidean distance
- Closeness: How close each location is to each other

- You can adjust the weights to determine the output
    - Ex: weights based on jobs will show spatial accessibility to jobs




Locations of the residential buildings
Locations of the public stations
number of residents
areas
number of visitors
Input
Origins(Starting points)
Destinations (Ending points)
Urban Network Analysis
Betweenness
Patronage Betweenness
Simulation
Pedestrian flows of the community routes
Flows for different destinations
Flows for different age groups
Improve the walking systems of community
Aided design

Urban Network Analysis (UNA): A Case Study in Guangzhou, China

- Used residential buildings as origins (with the number of residents as the origin weight) and public spaces as the ending points (with the area or visitor number their weight)
- Used patronage-betweenness: which is a combination between betweenness (how many pedestrians pass through a certain node) and patronage, which is the probability that a person starting at point i will end up at point j
- Background on the community: 209,266 square meters, 536 buildings, a relatively small and dense population

Results: From Residential Buildings to Public Activity Areas

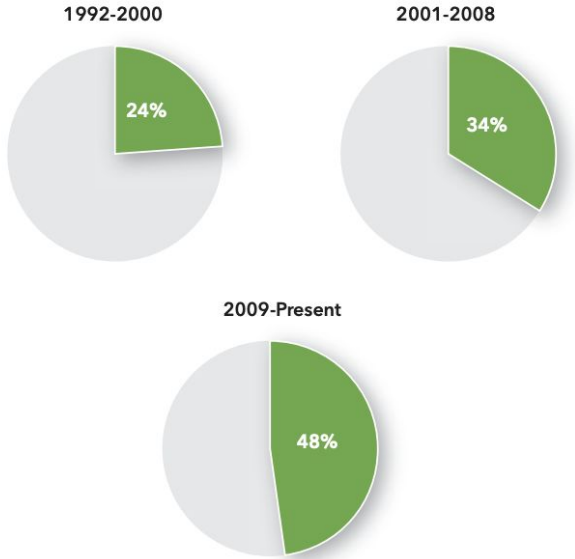
- Note: detour ratio is the ratio of the total length of a specific travel route to the shortest one
    - People usually walk 15-20% more than the shortest routes, so 1.2 takes into account the change in radius
- High pedestrian flow rates are mostly public municipal roads that lead to certain public activity areas
- Crowded routes connect to each other (with little buffer zones), which can cause traffic congestion
- Pedestrian flow through intersections is significantly higher than terminal paths

Results: From Residential Buildings to Commercial Facilities

Current Walkable Cities

WalkUPS

- Walkable Urban Places
- Focused on DC (specifically all places inside the beltway)
- There is a shift from a development of driveable suburban to walkable urban spaces
    - This shift started in the mid-1990s



WalkUPS

6 types:

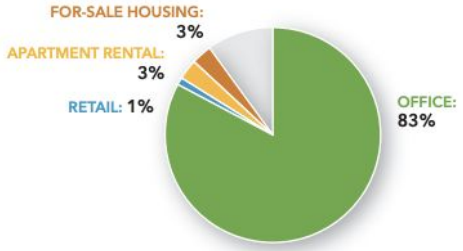
1. Downtown
    a. Dominated by office space (83%)
    b. Ex: Downtown DC
2. Downtown Adjacent
    a. Substantial office space but significant residential space (58% and 24%)
    b. Ex: Capitol Hill
3. Urban commercial
    a. Primarily residential and retail (56% and 15%)
    b. Ex: Georgetown
4. Suburban Town Center
    a. Relatively less office space, much more residential and retail
    b. Ex: Old town Alexandria

WalkUPS

5. Strip Commerical Redevelopment
    a. Focus of walkable urban development, many include regional malls that have been urbanized
    b. Ex: Tysons Corner
6. Greenfield
    a. Most balanced
    b. Ex: National Harbor

Product Mix: Downtown

Average % of Total Square Footage

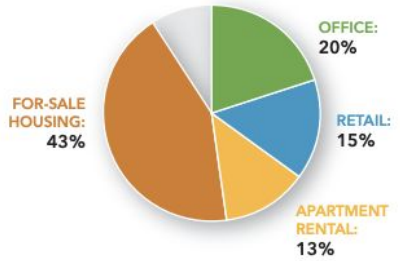


Product Mix: Downtown-Adjacent

Average % of Total Square Footage

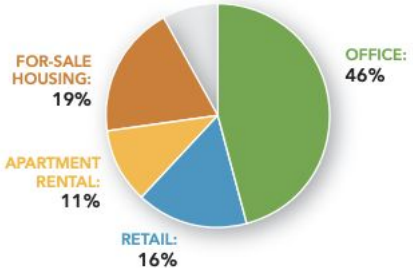
Product Mix: Urban Commercial

Average % of Total Square Footage



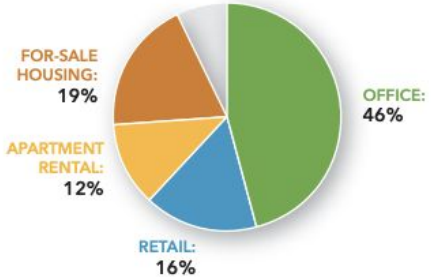
Product Mix: Suburban Town Center

Average % of Total Square Footage



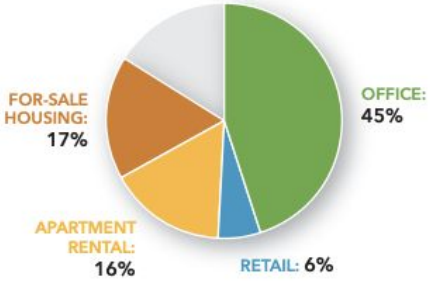
Product Mix: Strip Commercial Redevelopment

Average % of Total Square Footage



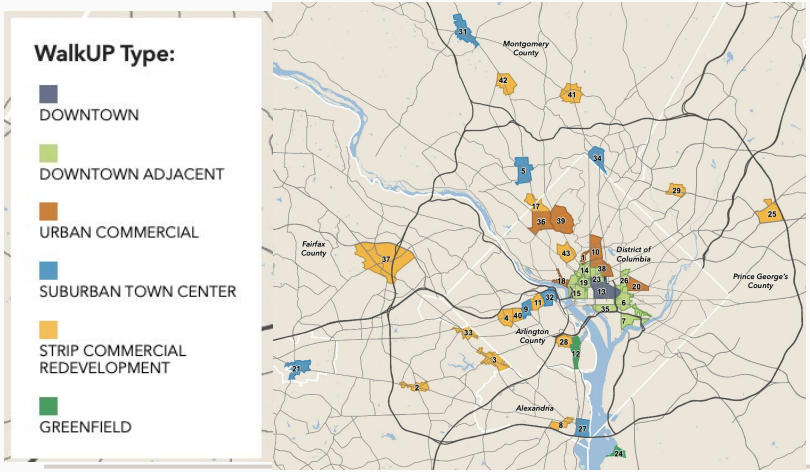
Product Mix: Greenfield

Average % of Total Square Footage



Findings

- 43 regionally significant WalkUPs in metro DC in 2012
- 34% of jobs are located in WalkUPS
- 77% of the WalkUPs have access to rail transit
- By itself, Walk Score explains 67% of the increase in economic performance



Takeaways

What to Remember

- An urban network is not the buildings, but the way people interact with them
- It is important that everyone is connected at all scales (including cars, public transportation and walking)
- Creating a walkable city improves the environment, wellbeing, safety, and the economy
- There are a lot of ways to both measure and improve cities to make them more human-scaled
    - Many are easy (and reasonably cheap) options!
- Back to fractals: We need to have irregularity and scaling to have a successful city

Thank you!

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