Network Design, Built & Natural Environments & Active Travel

Robert Cervero
University of California, Berkeley

Civil Engineering
University of Toronto
Distinguished Lecture Series
March 20, 2017

Active Transport/NMT

Why?

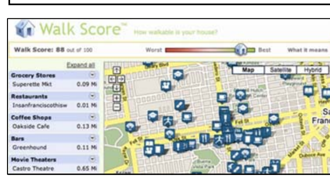
- **Public Health Benefits**

- **The Cleanest/Greenest Modes**

	Car	Bus	Light rail	Subway	Pedestrian	Bicycle
PM (g/pkm[a])	0.023	0.024	0	0	0	0
NO_x (g/pkm)	0.29	0.83	0.07	0.07	0	0
CO_2 (g/pkm)	144	75	72	72	0	0
Energy use (kJ/pkm)	2,325	612	385	385	na	na

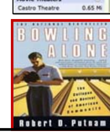
Sources: FEA, 2009; Ifv, 2002.
[a] pkm = passenger-kilometres.

- **Livability = Walkability**

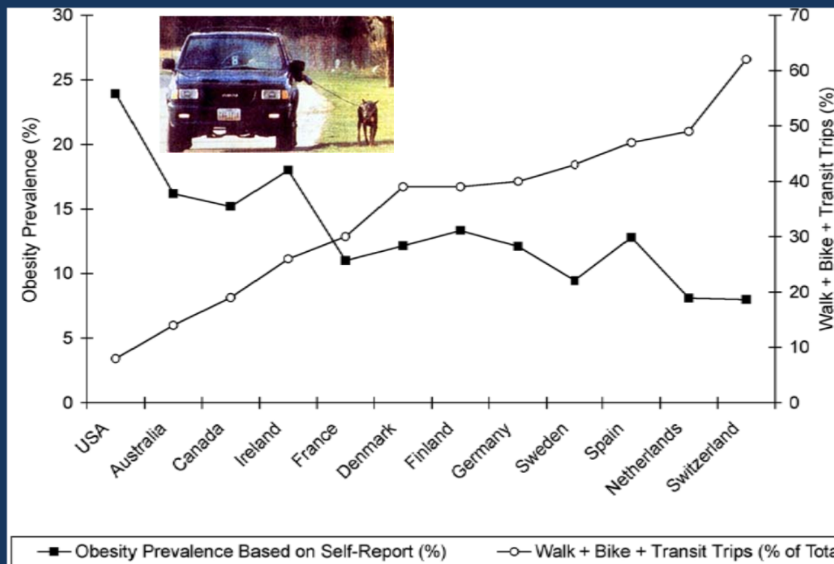


High Walkscore = Land Price/Rent Premiums

- **Build Social Capital**



Obesity and Active Transportation

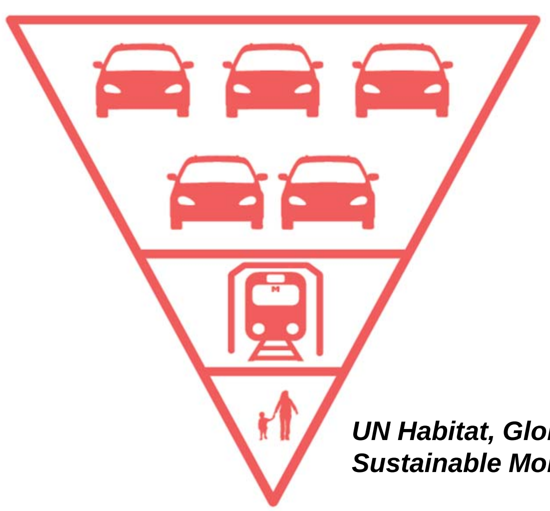


Bassett DR et al. *JPAH* 2008; 5:795

SHIFT:

In Mobility Priorities

– FROM THIS



UN Habitat, Global Report on Sustainable Mobility, 2013.

http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3503

SHIFT: … TO THIS

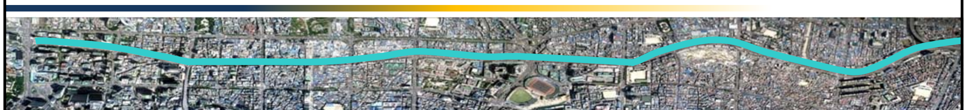
In Mobility Priorities

UN Habitat, Global Report on Sustainable Mobility, 2013.

http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3503

Seoul: Freeway Removal-Stream Restoration

Cheong Gye Cheon



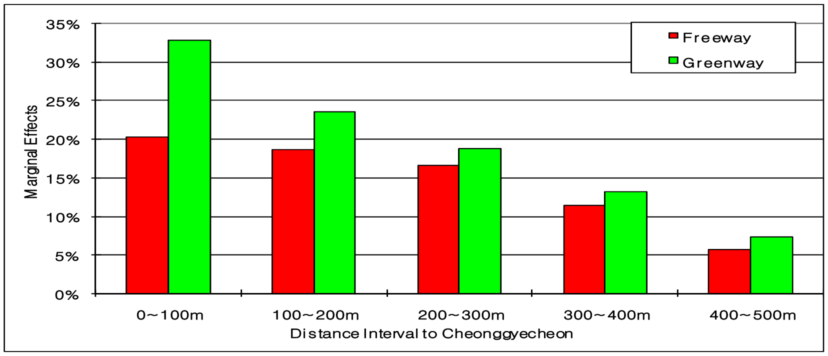
June 2003
Before Restoration

June 2004
Under Restoration

September 2005
After Restoration

The Place-Making Premium

Marginal Effects** of Freeway vs Greenway on *Commercial Land Price*



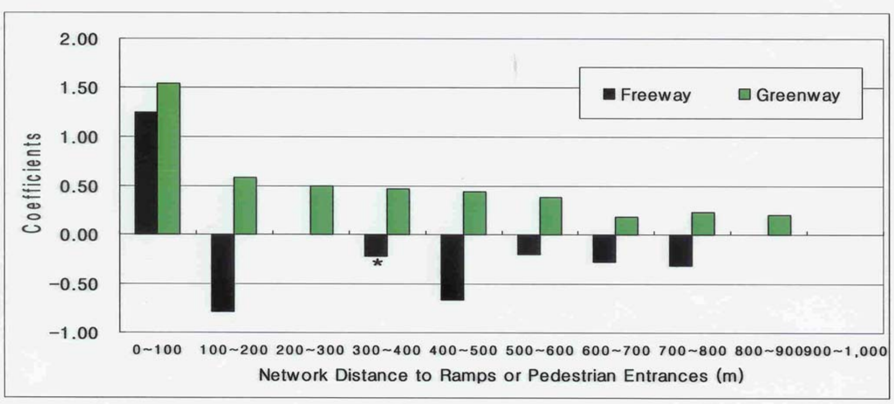
** Effects relative to otherwise comparable site > 500m

C. Kang & R. Cervero, From Elevated Freeway to Urban Greenway: Land Value Impacts of Seoul, Korea 's CGC Project, *Urban Studies*, 2009.

Impact on Employment in "Creative Class" Sectors

Distance to Ramps or Pedestrian Entrances

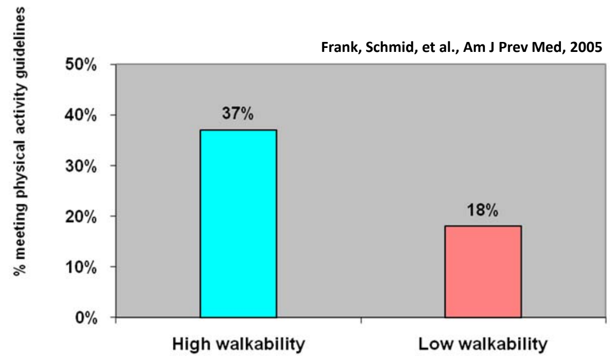
Marginal Effects on Location Quotients



* 10 % Probability Level

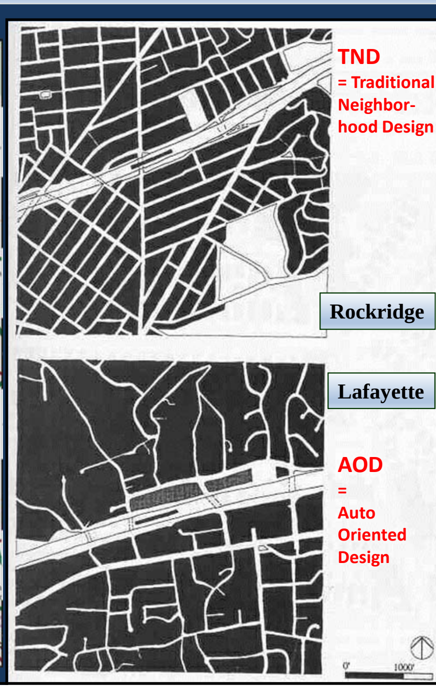
BUILDING THE EVIDENCE

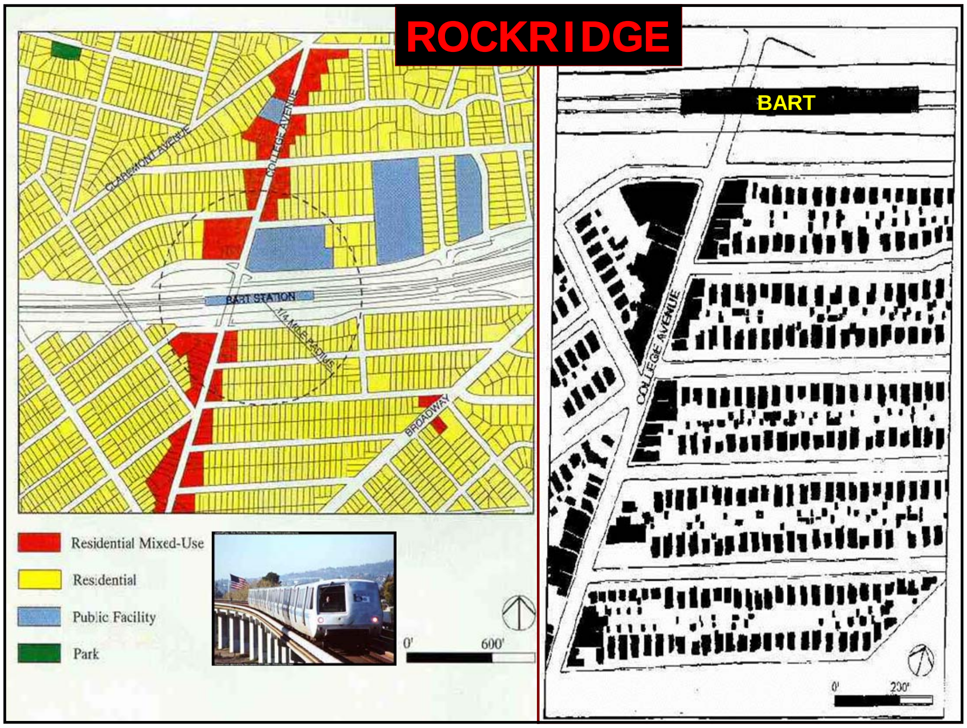
Atlanta adults: accelerometer showed people who live in walkable neighborhoods are more likely to meet recommended daily levels of physical activity.



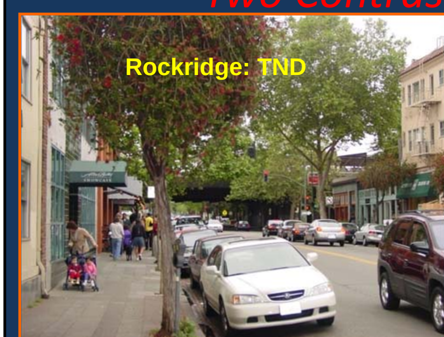
ACTIVE LIVING RESEARCH
Promoting activity-friendly communities

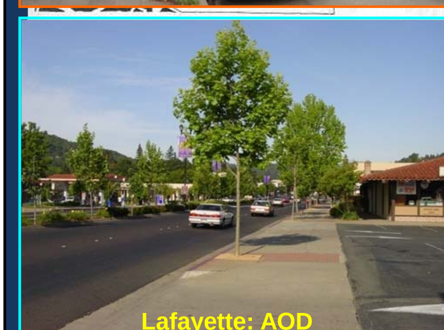
Matched Pair: Rockridge (TND) & Lafayette (AOD)





Two Contrasting Neighborhoods



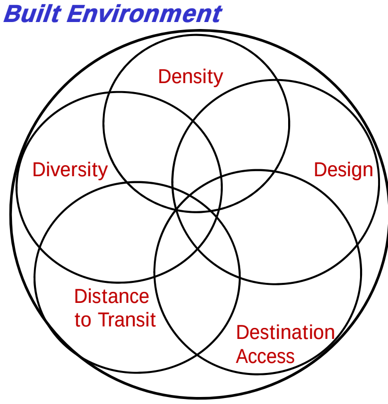


	Community Type TND	AOD
▪ VMT/person/ day	14.5	27.7
▪ % Rail	23%	7%
▪ % Walk/Bike	14%	3%
▪ Out of Neighborhood Shop Vehicle Trips/Day	0.5	2.1

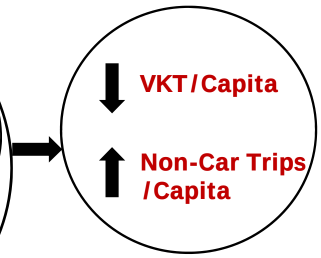
R. Cervero and C. Radisch. Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods, *Transportation Policy*, Vol. 3, 1996, pp. 127-141.

Travel & the "D"s

5D's of the Built Environment



Impacts



R. Cervero & K. Kockelman, **Travel Demand and the 3Ds: Density, Diversity, Design**, *Transportation Research*, 1996;
R. Ewing & R. Cervero, **Built Environment and Travel,** *TRR,* 2001; *JAPA*, 2010

Walking/Built-Environment Elasticities

Meta-Evidence from Predictive Models:
***Global Experiences* (mainly U.S.)**

Variable	Description	Walking Increase
Density	**Household/Population Density**	**0.07**
Diversity	**Land Use Mix (entropy)**	**0.15**
Design	**Intersection/Street Density/Connectivity**	**0.39**
Destination Accessibility	**Job Accessibility By Auto**	**0**
Distance to Transit	**Distance to Nearest Transit Stop**	**0.15**

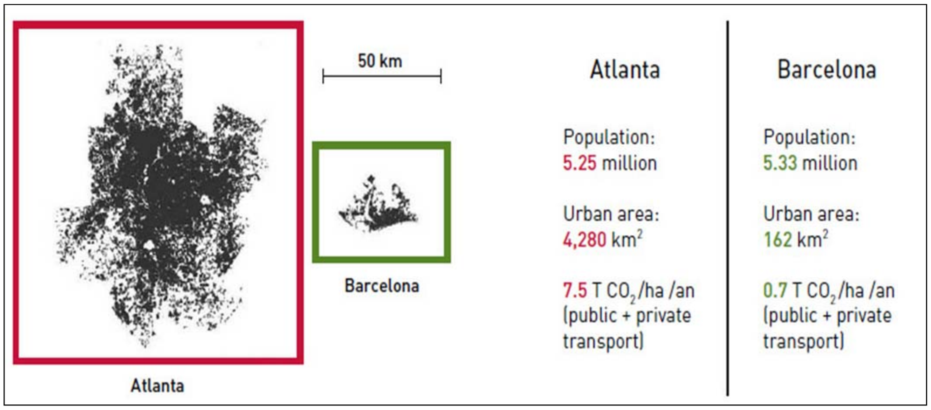
Elasticity = (% Δ Walk Trips) / (% Δ in Built Environment Metric)

Source: R. Ewing & R. Cervero, Travel and the Built Environment: A Synthesis, *Transportation Research Record* 1780, 2001; Confirmed in Ewing & Cervero, *Journal of the American Planning Association* 2010.

NMT & Travel: *Meta-Review*

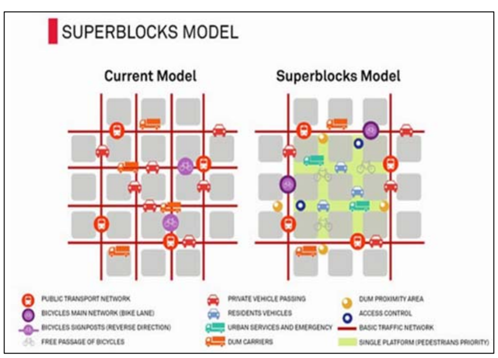
Catalysts:

➢ **Dense, Compact Cities**



Source: A. Bertaud, World Bank, 2005.

Barcelona
City of Short Distances
by Slower Modes



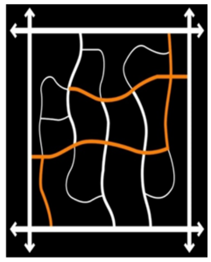
First Year Impacts:

- Reduction in car-NMT accidents and neighborhood crime
- Higher residential satisfaction and community rating
- Small shops prospering (... though higher rents)

NMT & Travel

Catalysts:

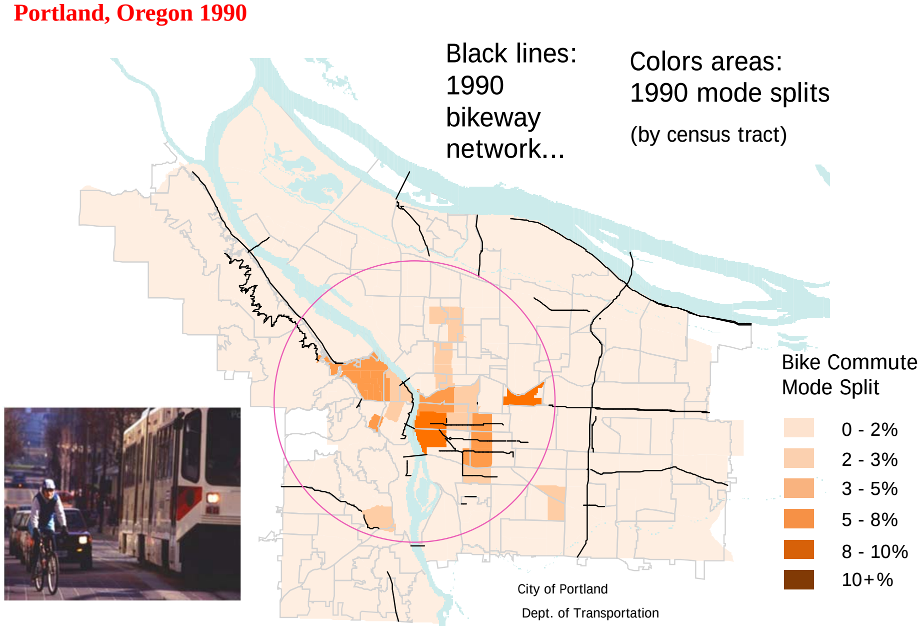
- **High Connectivity**
- **Low-Stress, Direct Paths**



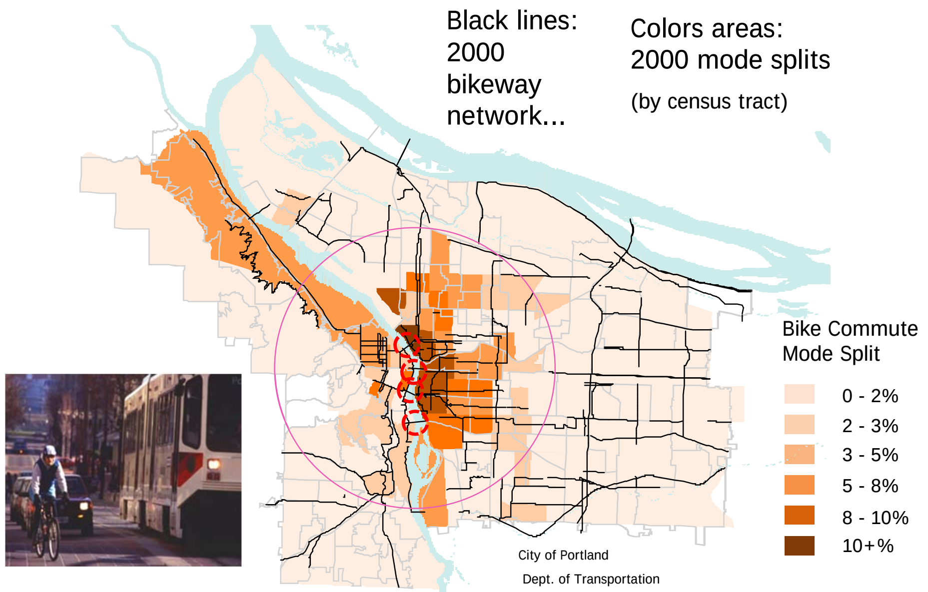
BUILDING A NETWORK

Bike lanes encourage bike commuting:

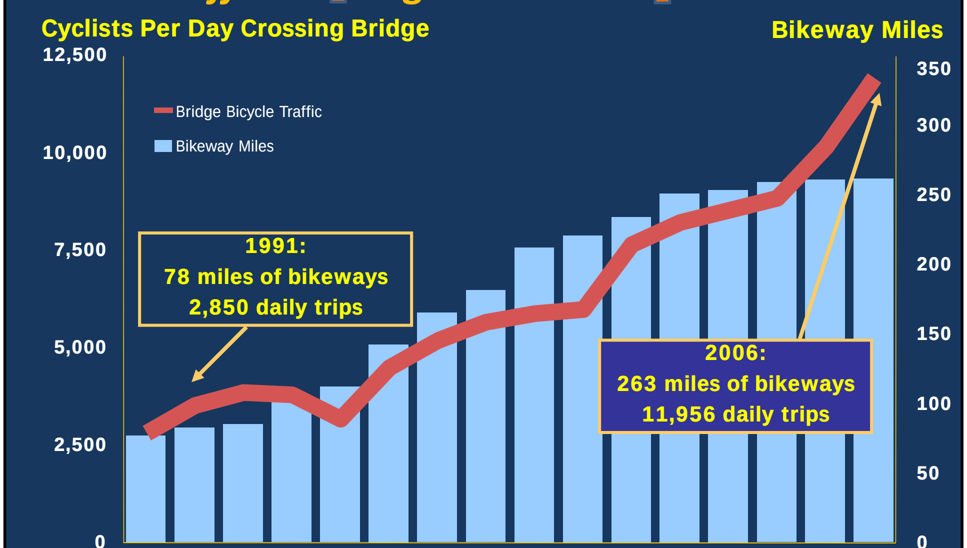
Portland, Oregon 1990



BUILDING A NETWORK
Bike lanes encourage bike commuting:
Portland, Oregon 2000



Network Effects: ⬆Regional Links = ⬆Cordon Counts



Year:	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bridge Bicycle Traffic	2,850	3,555	3,885	3,830	3,207	4,520	5,225	5,690	5,910	6,015	7,686	8,250	8,562	8,875	10,192	11,956
Bikeway Miles	78	83	86	103	113	144	166	183	213	222	235	252	254	260	262	263

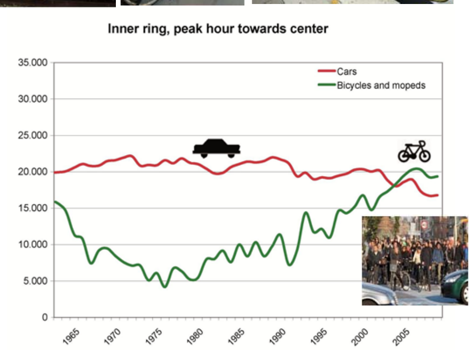
NMT & Travel

Catalysts:

- **Hardware - Infrastructure** ("Build It and They Will Come")

Catalysts:

- **Software – Pro Active-Transport Public Policies**



Bike-Friendly Copenhagen

Inclusive Cycling

NMT & Travel

Catalysts:

- **Design; Art; Aesthetics; Amenities – Green & Blue**
- **Land-Use Mixes**

Study: Sidewalk conversations, photos, pause to admire & 'strangers chatting' increased to 32% of users vs. 7% at similar intersection w/o a Mural; Many cyclists took detours

Mixed Uses: walking & cycling advantageous for intermediate stopping

Built Environments & Active Transport in Bogotá

Influences of Built Environments on Walking and Cycling: Lessons from Bogotá

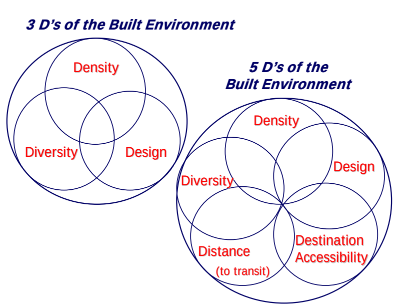
Robert Cervero, Ph.D., University of California, Berkeley

Olga L. Sarmiento, M.D., Los Andes University, Bogotá

Enrique Jacoby, M.D., PanAmerican Health Organization, Washington

Luis Fernando Gomez, M.D., Foundacion Social, Bogotá

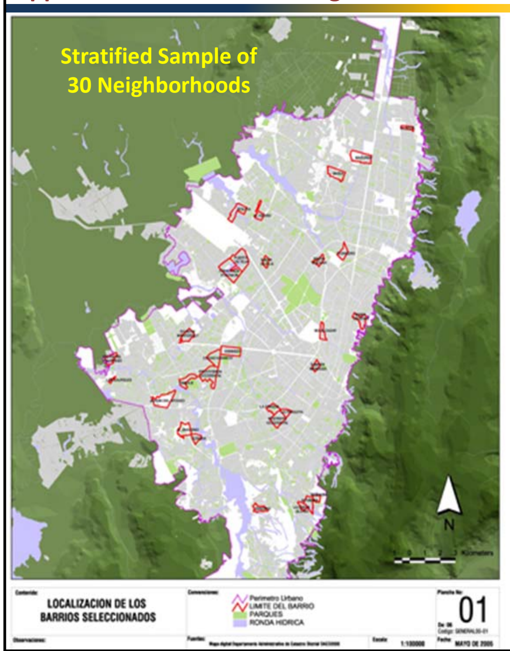
International Journal of Sustainable Transport, Vol. 3, 2009, pp. 203-226

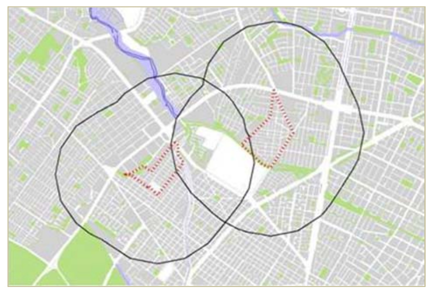


Physical Activity & Travel Data: weekly dairies completed from International Physical Activity Survey (IPAQ) of 1335 HHs; validated by accelerometers

IUHPE www.iuhpe.org International Union for Health Promotion and Education · CDC · Fundacion FES social · Organización Panamericana de la Salud · Berkeley IURD Institute of Urban and Regional Development

Sample & Scales of Analysis for Built Environment Variables:
Applied Multi-Level Modeling





Dimension	Candidate Variables
(1) DENSITY	Persons per hectare; dwelling units per hectare; % of land area occupied by buildings; average building floor height; plot ratio (building m^2/land m^2)
(2) DIVERSITY	Entropy index of land-use mix (0-1 scale); proportion of buildings vertically mixed; proportion of total floorspace in buildings with 2+ uses
(3) DESIGN *Amenities*	Public park area as % of total land area; average park size (hectares); % of road links with median strips; traffic light density (traffic lights/street length); tree density (trees/street length);
(3) DESIGN *Site & Street Design*	Average lot size (m^2); quadrilateral lots as % of total; percent of blocks with contained housing and access control; street density (street area/land area); proportion of intersections with: 1 point (cul de sac), 3 points, 4 points, 5+ points; bike lane density (lineal m of bikelane/lineal m of streets); route directness (0-1 scale measuring shortest street distance/straightline distance between neighborhood centroid and 8 compass points); connectivity index (intersection nodes/street links); number of bridges; ciclovia twoway length (lineal m)
(3) DESIGN *Safety*	Number of pedestrian bridges; pedestrian accidents per year; average automobile speeds on main streets; deaths (all types) in traffic accidents per year; number of reported crimes per year
(4) DESTINATION ACCESSIBILITY	Number of: public schools; hospitals; public libraries; shopping centers (> 500m^2); churches; banks
(5) DISTANCE TO TRANSIT	Number of TransMilenio (BRT) stations; shortest network distance to closest TransMilenio station; number of feeder TransMilenio stations.

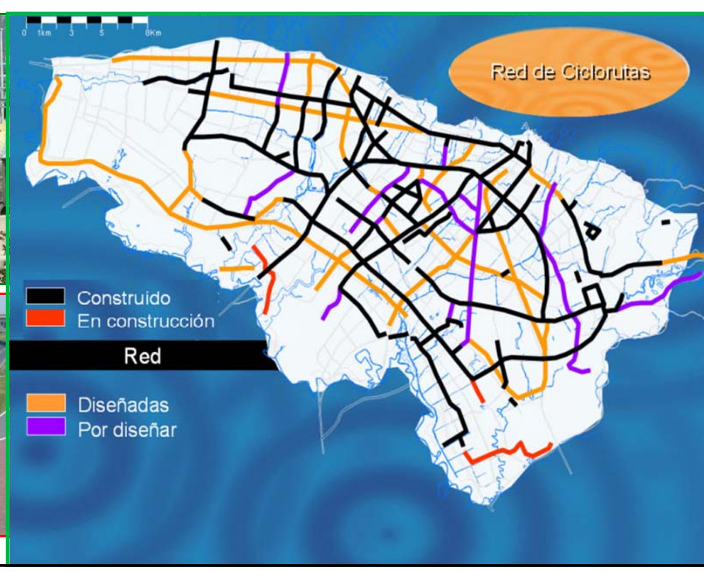
Site & Street Design: Walking Quality

- **Lighting**: # street lights/road length (centerline)
- **Trees**: # street trends/road length
- **Furniture:** # benches/road length
- **Prop. of signals with**:
  - Ped phase
  - Marked crosswalks
- **Ped Signal Lengths:** average of: (Duration of Ped. Lights / Signal Cycle Length)
- **Average block length**
- **Average street width**
- **Prop. of road links with median strips**
- **Bike-lane density**: bikelane distance (centerline) / km^2 of land
- **Distance between overhead lights**
- **Ped. Accident rates**
- **Average auto speeds**

Diverse Streetscapes

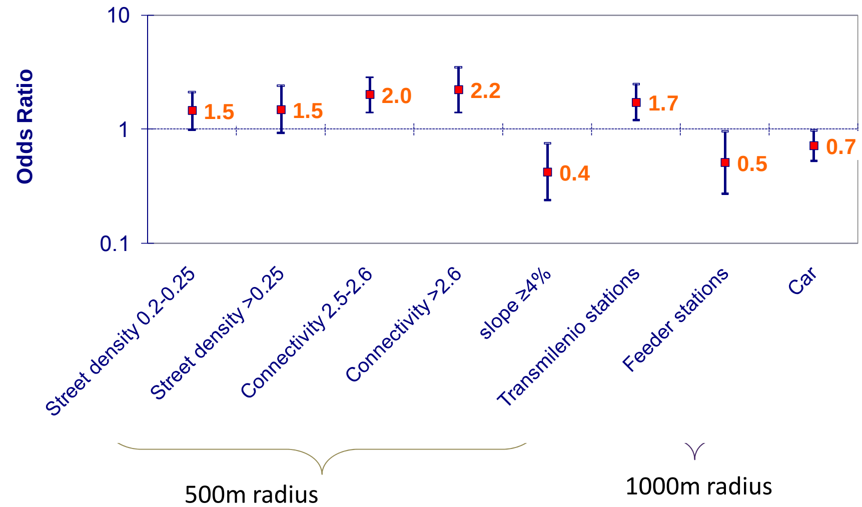
➢ *Bogota's* Green Connectors -- CICLORUTA

(Today: 344 kms; 285K daily bicyclists (2% of trips); 70% BRT access by Biking or Walking)

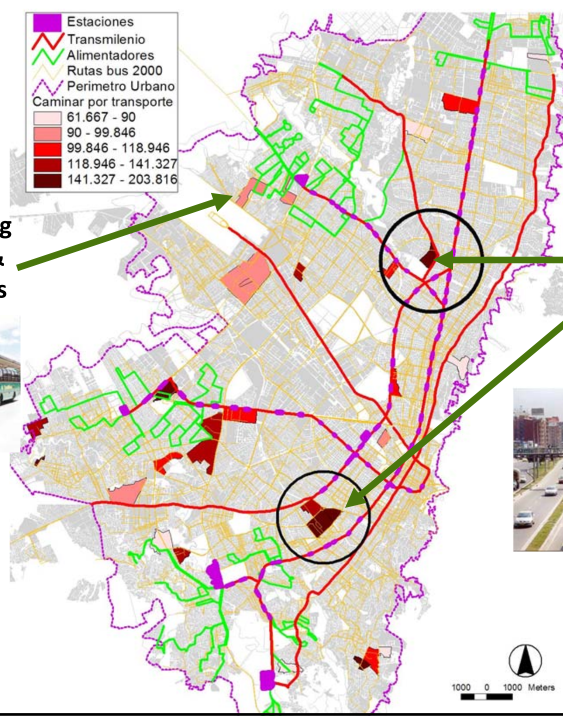


Odds Ratios & 95% Conf. Intervals for MLM on

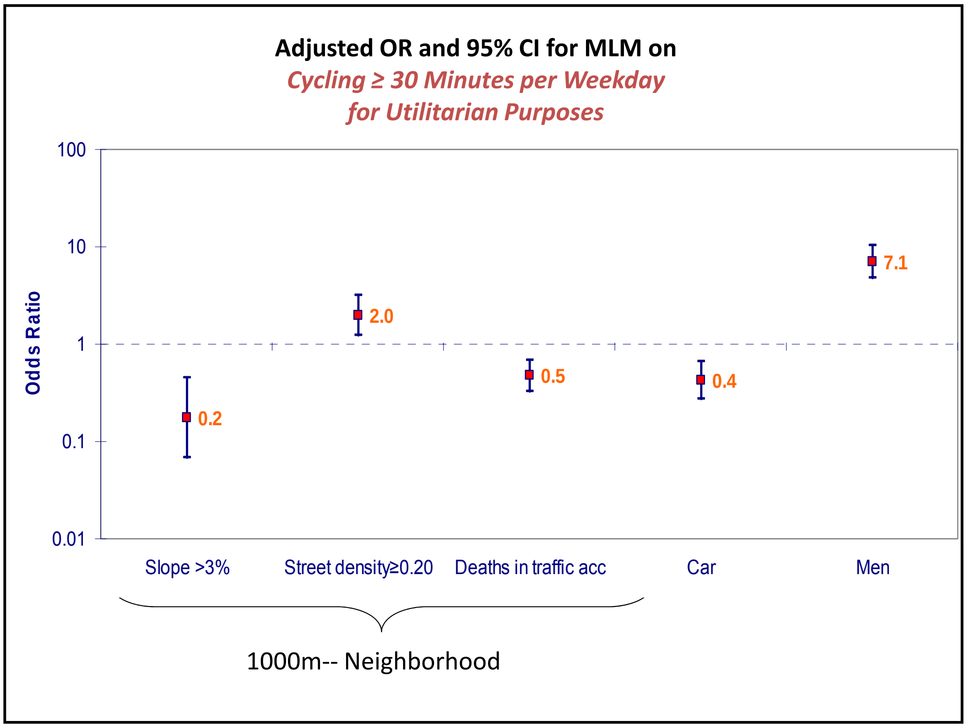
Walking ≥ 30 Minutes per Weekday for Utilitarian Purposes

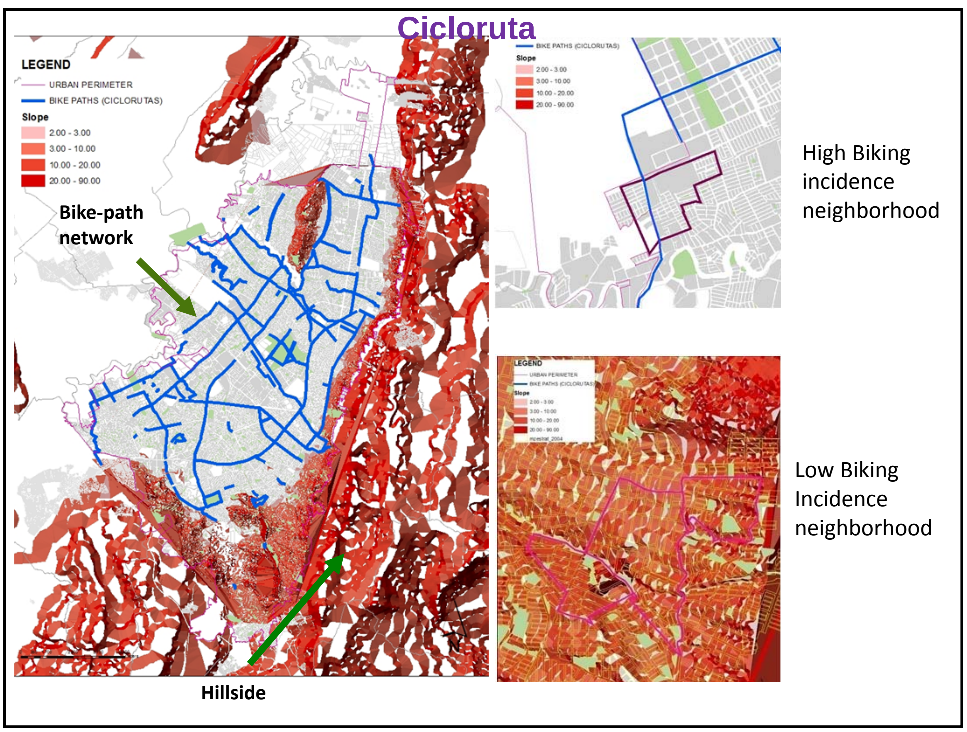


Low walking incidence & Bus Feeders



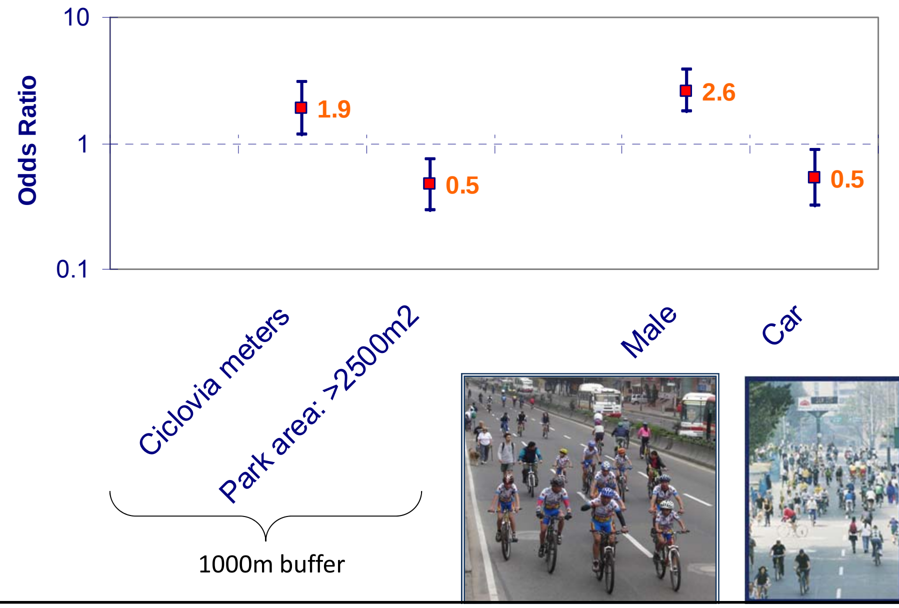
High walking incidence & Transmilenio Stations


Adjusted OR and 95% CI for MLM on
Cycling ≥ 30 Minutes per Weekday
for Utilitarian Purposes
Odds Ratio
100
10
1
0.1
0.01
0.2
2.0
0.5
0.4
7.1
Slope >3%
Street density≥0.20
Deaths in traffic acc
Car
Men
1000m-- Neighborhood

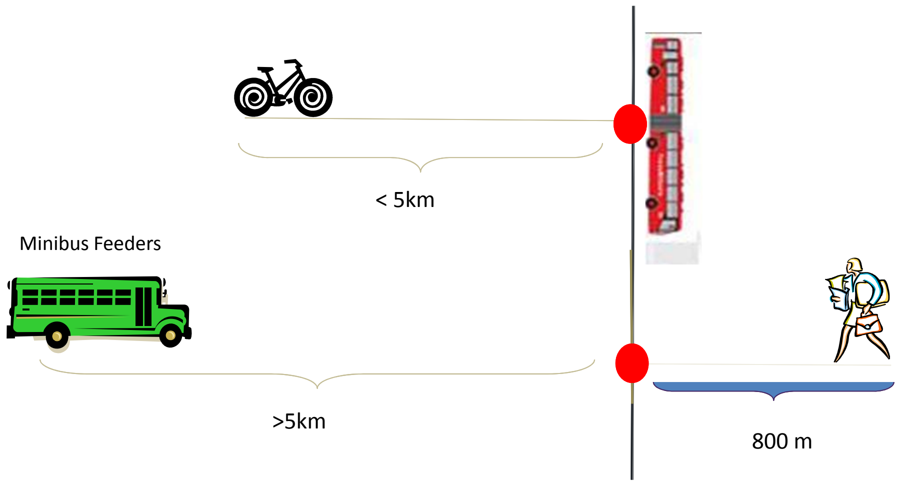

Cicloruta
LEGEND
URBAN PERIMETER
BIKE PATHS (CICLORUTAS)
Slope
2.00 - 3.00
3.00 - 10.00
10.00 - 20.00
20.00 - 90.00
Bike-path
network
Hillside
High Biking
incidence
neighborhood
Low Biking
Incidence
neighborhood

Adjusted OR and 95% CI for MLM on

Ciclovia Participation in Past 30 Days



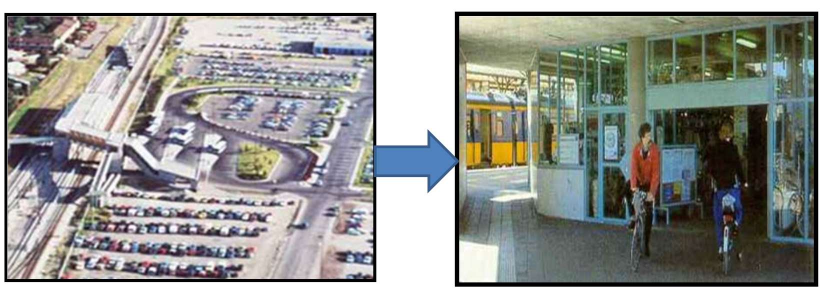
TransMilenio (BRT) & Active Transport



Policy Choices:
Invest in Feeder Buses or "Green Connectors"?

From Parking-&-Ride to Bike-&-Ride & Walk-&-Ride

Robert Cervero, University of California, Berkeley



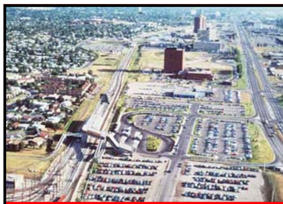
Walk-and-Ride: Factors Influencing Pedestrian Access to Transit
Journal of Public Transportation Article in Volume 3, Issue 4 (2000) by Robert Cervero, University of California, Berkeley

2001

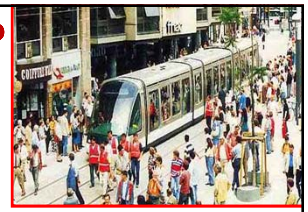
Journal of Public Transportation

Bike-and-Ride: Build It and They Will Come
Robert Cervero, Benjamin Caldwell, Jesus Cuellar
University of California, Berkeley

2011



Why NMT Access?
Walk & Ride/
Bike & Ride



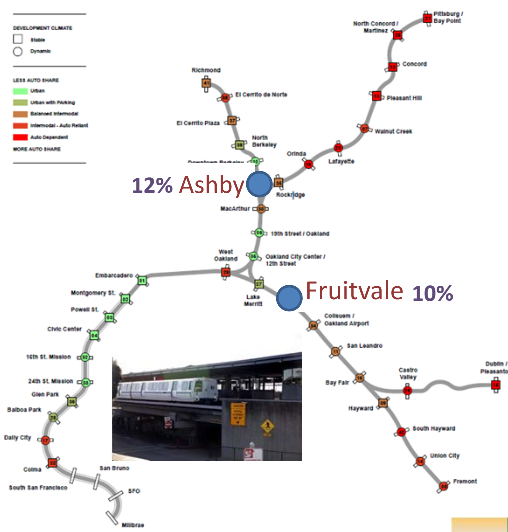
- Environmental/Energy Benefits
- Less station-area traffic congestion/ improved TOD environment
- Land Conservation/Reduced Impervious Surface
- Active Transport = Improved Fitness
- Social Justice/Pro-poor policy

Elasticity Estimates for BART (Bay Area):

percentage change in probability of Walk-and-Ride travel with a one-percent increase in explanatory variable

Explanatory Variables:	Mid-point elasticities for:	
	Walk-Access	Walk-Egress
Employment Density	.220	.196
Residential Density	.269	.328
Street Connectivity (Links/Nodes)	.733	.775
Land-Use Diversity	.119	.152
Park-and-Ride spaces at station	-.484	-.257
Transit Service Levels	.474	.107
Terminal or Near-Terminal Station	-.093	-.033
Station in Freeway Median	-.134	-.029

R. Cervero, 2001, "Walk-and-Ride: Factors Influencing Pedestrian Access to Transit, *Journal of Public Transportation*, Vol. 3, No. 4, pp. 1-23.



BART Station Type	1998-2008 % Δ Bike Access Share
Urban	1.6%
Urban w/ Parking	3.0%
Balanced/ Intermodal	0.4%
Intermodal / Auto-Reliant	1.5%
Auto-Dependent	0.3%

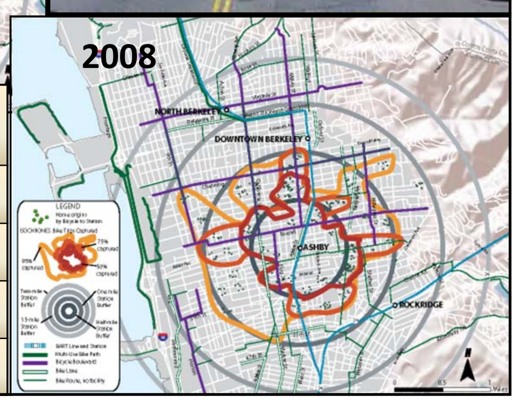
Journal of Public Transportation

Bike-and-Ride: Build It and They Will Come

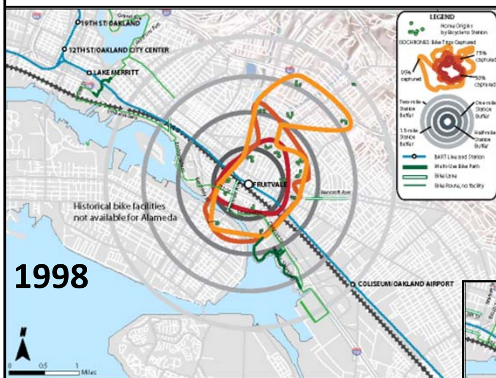
Robert Cervero, Benjamin Caldwell, Jesus Cuellar
University of California, Berkeley

Bikeshed Analysis

	% Δ 1998-2008
Bike Infrastructure (lineal km)	
50 Percentile Bike-shed	172.4%
75 Percentile Bike-shed	200.0%
95 Percentile Bike-shed	217.7%



Bikeshed Analysis



Fruitvale BART Station

Urban Parking Station

	% Δ 1998-2008
Bike Infrastructure (lineal km)	
50 Percentile Bike-shed	**827.3**
75 Percentile Bike-shed	**242.5**
95 Percentile Bike-shed	**352.5**

First/Last Mile Connectivity

New Age Access: Smart Mobility

Autonomous Shuttles

Autonomous Vehicles/Self-Driving Cars/Connected Vehicles – ***Game Changer?***

Impacts:

- **Safety** ✓
- **Traffic/Urbanization?**

Could increase VKT/Car-Oriented Growth

- Lowering generalized costs of travel & parking, inducing travel
- Reduce non-recurrent congestion from fewer collisions
- Enabling car users to be more comfortable and productive while traveling
- Provide automobility to seniors, youth, disabled

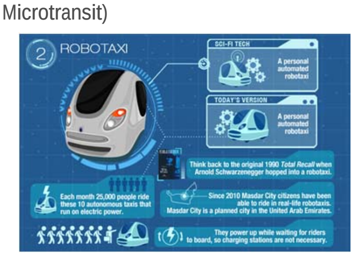


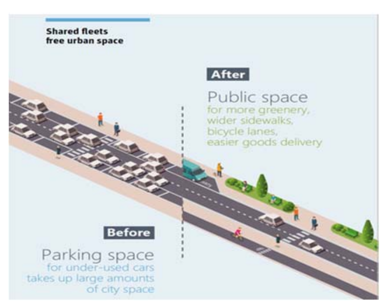

Could reduce VKT/Promote Ped-Friendly Growth

- Car-sharing
- Smart pricing

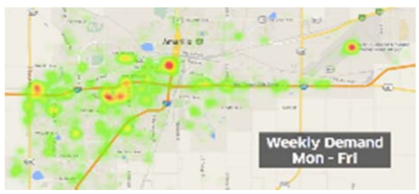
Marriage of Self-Driving Cars & Car Sharing: Shared, Smart Urban Mobility

- **Accelerated by Megatrends**: Millennials; Urban Regeneration; Collaborative Consumption; Shifting Lifestyle Preferences
- **Google's Vision**: Car-Sharing Subscription Service
- **Reduce demand and urban space for parking**
  - ***ITF Study***: could eliminate 90% of existing cars, reducing congestion; totally remove on-street parking; medium-sized cities – obviate the need for public transport (replaced by Smart Microtransit)





Micro-Mobility/Dynamic Ridesharing



- ***Growth Market***:
  - Achieved Scale Economies
  - UberPool in > U.S. 30 cities;
  - > 50% trips in many cities; SF, LA,NY
    >100,000 trips per week
- ***Transit Complement***:
  First/Last Mile connectivity
  - LA – 14% trips start/end at Metro
  - SF – 10% trips start/end at BART
- ***Hot Spots***: operational efficiencies; smart jitneys

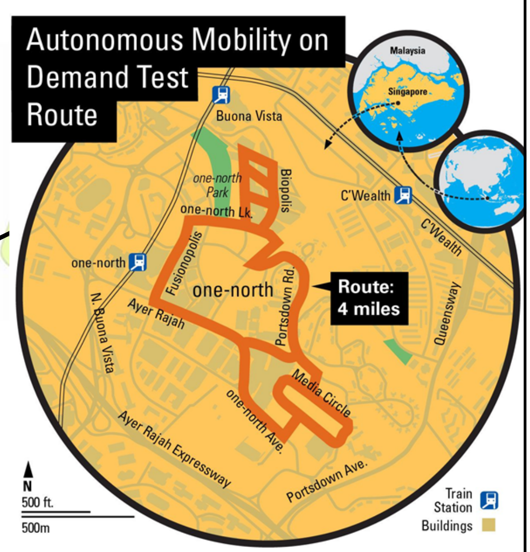
SINGAPORE:

People-Mover

Autonomous Station Cars:

Pilot Test Delphi Cars on 3 routes … First-Mile/Last-Mile Feeders

Extended TOD



Smarter Pricing
ERP 2.0

From Cordon Pricing/Gantries
… to Dynamic, Distance-based Pricing

Singapore:
Electronic Road Pricing (ERP)

Land Transport Authority
We Keep Your World Moving

Next generation ERP: Global Navigation Satellite System (GNSS) -- overcomes the inflexibility of physical gantries and makes distance-based congestion charging possible.

Fairer since ERP charges will be *based on the actual length of congested roads used by motorists.* More dynamic adjustments of charges with time (tied to changing levels of congestion) will also be possible.

THE ACCESS ALMANAC
Running to Work
ROBERT CERVERO

ACCESS

- **Run Commuting**: popular in *London, Washington DC*: Natural habitats: traffic congestion; crowded subways; legions of fitness-minded professionals; workplaces that offer showers, downtown gyms; linear networks of parks, bike paths, and trails that feed into the business districts; well landscaped, run-inspiring riverfronts.

THE RUN COMMUTER
TRC
Live to run. Run to work.

- **Main Reasons**: (SurveyMonkey: N=77)
  - **Get in a Workout (68%)**
  - **Mental: better mood; elation (38%)**
  - **Efficient: saves time (26%)**
  - **Being outdoors (23%)**
  - **Save $ (19%)**
  - **Reduce Stress (15%)**

Network Design, Built and Natural Environments and Active Commuting

ROBERT CERVERO

Professor Emeritus of City & Regional Planning
University of California, Berkeley

Moderator

Paul Hess
Professor, Geography and Planning, University of Toronto

Panelists

Geoff Wright
Commissioner of Transportation and Works, City of Mississauga

Barbara Gray
General Manager, Transportation Services, City of Toronto

Steven Farber
Assistant Professor, Department of Human Geography, UTSC

UTTRI