

Mobility

Presentation

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MOBILITY **YALE NUS COURSE 2017**

October 6, 2017

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(FCL) FUTURE CITIES 未来 城市 LABORATORY 实验室

(SEC) SINGAPORE-ETH 新加坡-ETH CENTRE 研究中心





OUTLINE

Today's lecture

/ Why mobility?

/ Transport planning

/ Disruption

Next week

- / Networks & representation
- / Infrastructure design

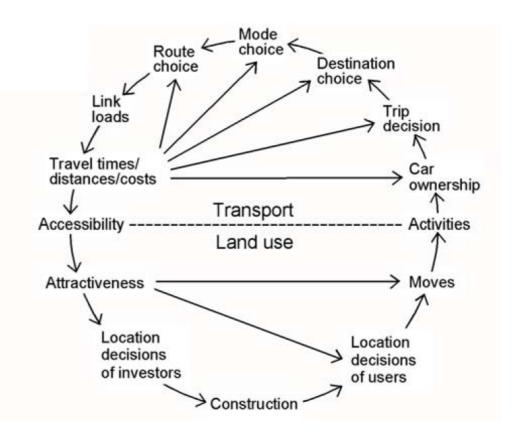
WHY TRANSPORT?



http://www.evolo.us/competition/times-squared-3015/

WHY TRANSPORT? TRANSPORT AND LAND-USE

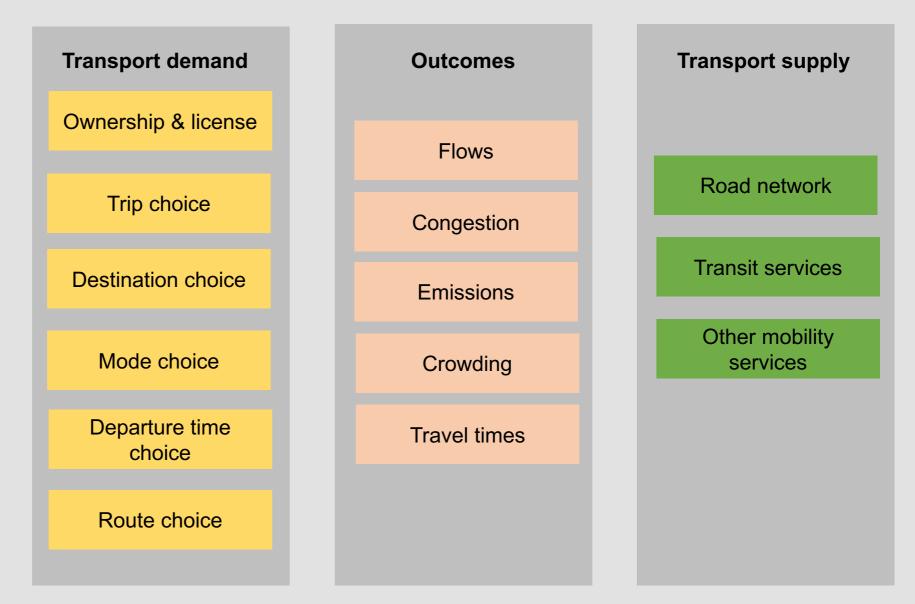
- / Transportation system provides spatial accessibility.
- / Spatial accessibility influences location decisions for the land use system.
- / The land use system -- residential, industrial or commercial -- affects the locations of human activities such as living, working, shopping, education or leisure.
- / These **human activities** form trip patterns in the transportation system.



Source: Wegener and Fuerst (2004)

TRANSPORT PLANNING

Cities are the subsequent result of a series of cumulative decisions of many agencies and persons (Lynch, 1984)



TRANSPORT PLANNING EVALUATION

/ Vehicle travel

Refers to vehicle movement and speed are beneficial; congestion or inadequate roads are seen as the problem

/ Measure

Vehicle miles

/ Indicators

Vehicle traffic volumes and speeds, roadway Level of Service, costs per vehicle-mile, parking convenience

/ Mobility

Refers to the movement of people and goods

/ Measure

Person-miles and ton-miles

/ Indicators

Travel distance and speeds, road and transit Level of Service, cost per person-mile, travel convenience

/ Accessibility

Refers to the ease of reaching goods, services, activities and destinations (opportunities)

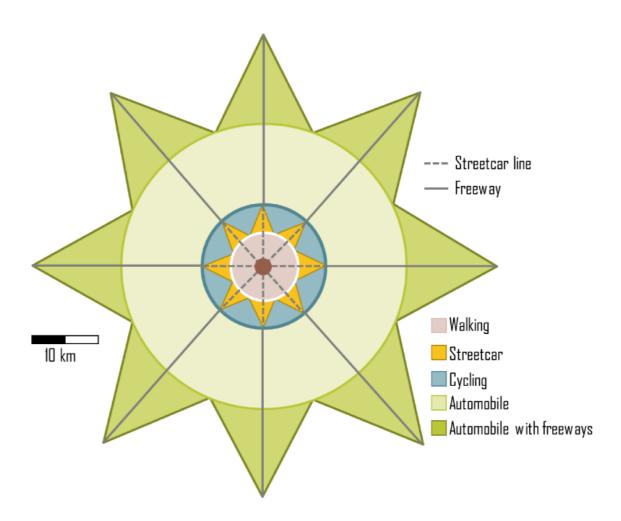
/ **Measure** Trips, generalized costs

/ Indicators

Quality of available transportation choices. Distribution of destinations. Cost per trip

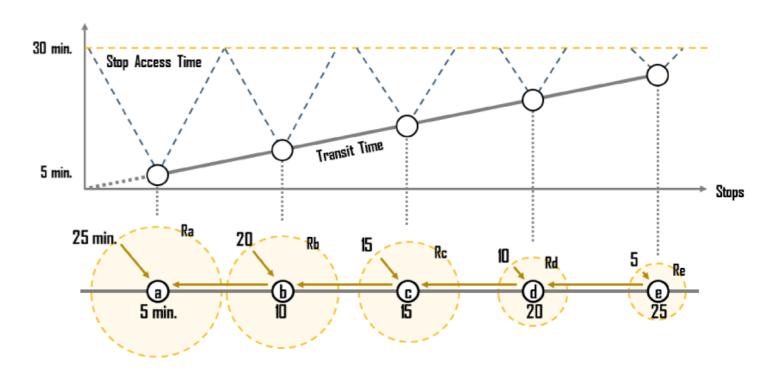
TRANSPORT PLANNING ACCESSIBILITY

Different catchment areas: 1 hour commute by different modes



TRANSPORT PLANNING ACCESSIBILITY | MULTI-MODAL

30 minute commute by public transport and walking



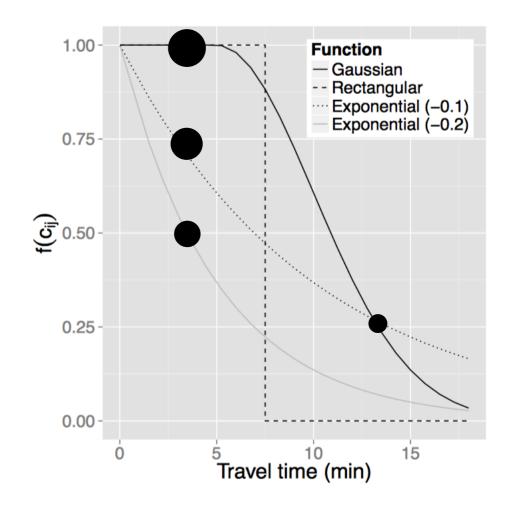
TRANSPORT PLANNING ACCESSIBILITY

First Law of Geography, "everything is related to everything else, but near things are more related than distant things." (Waldo Tobler, 1970)

Decay functions

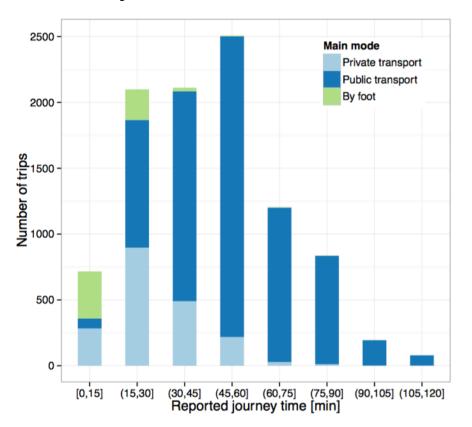
Function	Form
Rectangular	$f(c_{ij}) = \left\{egin{array}{ccc} 1 & ext{if} & c_{ij} \leq C \ 0 & ext{if} & c_{ij} > C \end{array} ight.$
Exponential	$f(c_{ij}) = \exp\left(-\beta c_{ij}\right)$
Power	$f(c_{ij}) = c_{ij}^{-n}$
Gaussian	$f(c_{ij}) = \exp\left(\frac{c_{ij}}{v}\right)$
Cumulative Gaussian	$f(c_{ij}) = \begin{cases} 1, & \text{if } c_{ij} \le C \\ \exp\left(\frac{c_{ij}-C}{v}\right), & \text{if } c_{ij} > C \\ f(c_{ij}) = \frac{1}{s} \exp\frac{c_{ij}-m}{s} (1 + \exp\frac{c_{ij}-m}{2^s})^{-2} \end{cases}$
Logistic	$f(c_{ij}) = rac{1}{s} \exp rac{c_{ij} - m}{s} (1 + \exp rac{c_{ij} - m}{s})^{-2}$
Log-normal	$f(c_{ij}) = rac{1}{\mathrm{c}_{ij}\sigma\sqrt{2\pi}} \mathrm{exp}(rac{-(\ln\mathrm{c}_{ij}-\mu)^2}{2\sigma^2})$

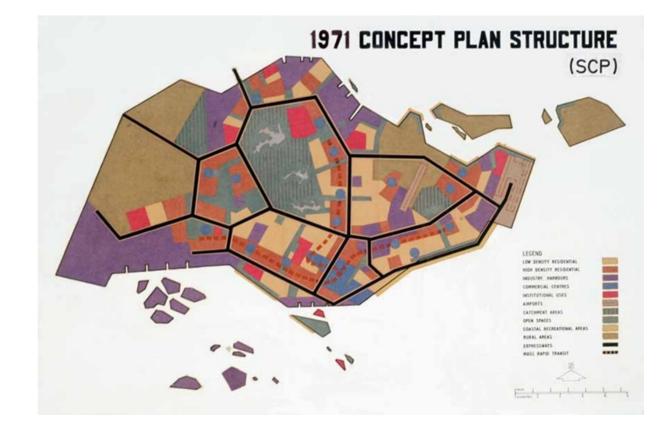
... and plotted



TRANSPORT PLANNING ACCESSIBILITY AND SPATIAL STRUCTURE | OBSERVERD HOME-WORK TRAVEL TIMES SINGAPORE

Travel survey



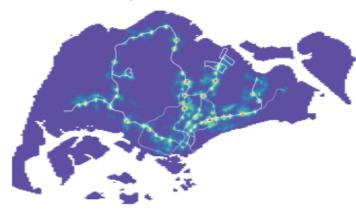


van Eggermond (2017) Diversity, accessibility and its impact on vehicle ownership and residential locations choices. PhD Thesis, ETH Zurich

TRANSPORT PLANNING ACCESSIBILITY AND SPATIAL STRUCTURE | OBSERVERD HOME-WORK TRAVEL TIMES SINGAPORE

Home-work trips in Singapoore by travel time

Start locations of trips between 15 and 30 minutes, n=177,002



End locations of trips between 15 and 30 minutes, n=177,002



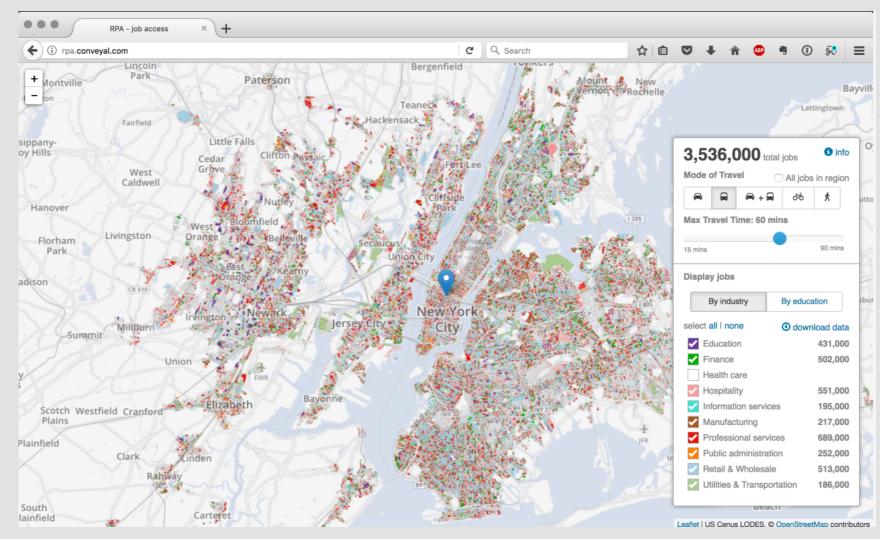
Start locations of trips between 45 and 60 minutes, n=92,718

End locations of trips between 45 and 60 minutes, n=92,718



van Eggermond (2017) Diversity, accessibility and its impact on vehicle ownership and residential locations choices. PhD Thesis, ETH Zurich

TRANSPORT PLANNING ACCESSIBILITY



http://rpa.conveyal.com/

TRANSPORT PLANNING TRAVEL AND THE BUILT ENVIRONMENT | 5 D'S

Density 265 **Travel and the Built** Household/population density Transpn Res.-D, Vol. 2, No. 3, pp. 199-219, 1997 C 1997 Elsevier Science Ltd Pergamo All rights reserved. Printed in Great Britain 1361-9209/97 \$17.00 + 0.00 Environment PII: S1361-9209(97)00009 Job density A Meta-Analysis TRAVEL DEMAND AND THE 3Ds: DENSITY, DIVERSITY, AND Reid Ewing and Robert Cervero DESIGN Diversity ROBERT CERVERO and KARA KOCKELMAN Department of City and Regional Planning, College of Environmental Design, University of California, Berkeley, CA 94720, U.S.A. Land use mix (entropy index) (Received 2 July 1996; accepted 13 February 1997) Abstract-The built environment is thought to influence travel demand along three principal dimensionsdensity, diversity, and design. This paper tests this proposition by examining how the '3Ds' affect trip rates and mode choice of residents in the San Francisco Bay Area, Using 1990 travel diary data and land-use Jobs-housing balance Problem: Localities and states are nome of today's most vexing problems, including sprawl, o turning to land planning and urban dependence, and climate change, are prompting states and records obtained from the U.S. census, regional inventories, and field surveys, models are estimated that Uturn to land planning and urban design to rein in automo design for help in reducing automobile relate features of the built environment to variations in vehicle miles traveled per household and mode choice, mainly for non-work trips. Factor analysis is used to linearly combine variables into the density and design use and related social and environmental have concluded that roads cannot be built fast enough to keep u dimensions of the built environment. The research finds that density, land-use diversity, and pedestriancosts. The effects of such strategies on Intersection/street density travel demand induced by the road building itself and the spraw oriented designs generally reduce trip rates and encourage non-auto travel in statistically significant ways, travel demand have not been generalized though their influences appear to be fairly marginal. Elasticities between variables and factors that capture The purpose of this meta-analysis is to summarize empirical in recent years from the multitude of the 3Ds and various measures of travel demand are generally in the 0.06 to 0.18 range, expressed in absolute between the built environment and travel nce on personal business trips. Withinbecome a supporter subscribe Q search ciated with mode choice for work trips 🚊 📄 sign in iobs dating more - International edition related to mode choice for non-work restricted commercial parking were d rely less on single-occupant vehicles theguardian tween each dimension of the built equential. Thus it sup-Design npact, diverse, and pedestrian-orien Americans travel. @ 1997 Elsevie 🔒 UK world sport football opinion culture business lifestyle fashion environment tech travel ≡ browse all sections Intersection density home > UK > society law scotland wales northern ireland education media sit-oriented development, traditional Housing ways of shaping travel demand. All Inner-city living makes for healthier, number of motorized trips, what has ed, increase the share that are nonhappier people, study finds trips that are produced, reduce travel Destination accessibility age shorter trips and more travel by e of degenerating trips and weaning g of the negative consequences of an Residents of higher-density areas are more active, more socially engaged - and llution, fossil fuel consumption, and Local accessibility less obese - than people who live in the sprawl of suburbia ittmar, 1995) ed designers argue for changing three f y 🖸 in 🖗 G: iversity, and design-to achieve these have long been acknowledged (e.g. Regional accessibility a have just as long been ignored. This \times ilt environment and travel demand. three dimensions after controlling for . It does this mainly by applying the Reuters f each dimension as well as their colw urbanists and others that compact Friday 6 October 2017 01.13 BST esigns 'degenerate' vehicle trips and Distance to transit tes for automobile travel, particularly

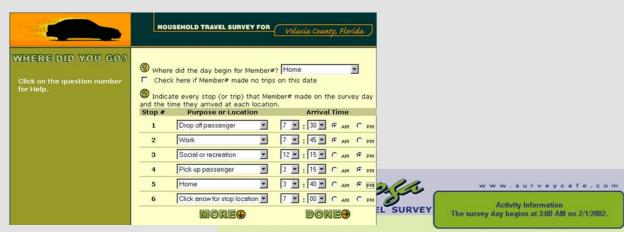
e.g. Ewing and Cervero (2010), Cervero and Kockelman (1996), Guardian

DATA

DATA TRAVEL DIARY SURVEYS | REVEALED PREFERENCE

Classic

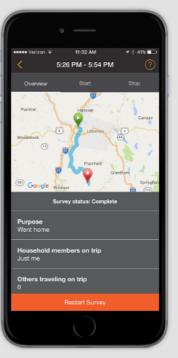
Paper-based / CAPI / CATI / Respondent-interactive



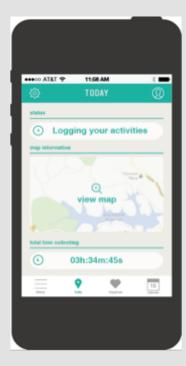
Please list all the trips MOM made that required traveling by car, bus, bicycle, or by walking 5 or more minutes. Stops along the way, such as for gas or to drop off a passenger, should be listed as separate places.

Го Hor	lid MOM go to p Click arrow to sele w did MOM mal trip? k arrow to select	ect 💌	Vhat time	00 • •	arrive at the 1?	Г	Who went w traveled alone DAD Others, how ma	
ou mu Place #	st select the ' Departure Time	CONTIN Arrival Time	UE' button to sa Purpose	ve this da Mode of Travel	ata. Travel Companions	5	COR Edit this trip?	Delete this trip
	Departure	Arrival		Mode of	Travel	5	Edit	Delete
Place #	Departure Time	Arrival	Purpose	Mode of Travel	Travel	5	Edit this trip?	Delete
Place #	Departure Time Started at HOME	Arrival Time	Purpose	Mode of Travel	Travel Companions	5	Edit this trip?	Delete this trip

State-of-the-art Trackers, Smartphone based surveys



Rmove by RSG



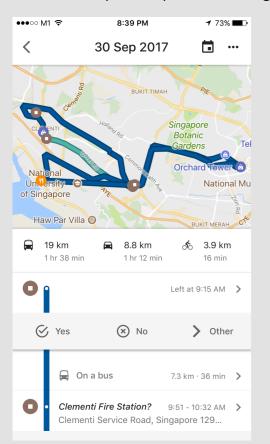
Future Mobillity Sensing (FMS) by MIT



DATA PASSIVE TRACKING & DIY

Google

/ Track yourself by enabling timeline/ Provides (limited) mode recognition



Information <u>here</u>

Strava

/ Datasets available for purchase/ Self-selection?



Information here

Androsensor, Funf

/ Get access to a wide range of sensors

->• 🔺			00:23
AndroS	ensor		
+	x:2.1835 m/s^2 y:1.3791 m/s^2 z:9.1554 m/s^2	oniacy	
?	IGHT: (3.0mA) 6.0 lux		
U	MAGNETIC FIELD: (4. X:13 uT Y:-25 uT Z:37 uT	0mA)	
(DRIENTATION: (0.0m X:188.0° Y:-8.0° Z:13.0°	iA)	
I	PROXIMITY: (1.0mA) 1.0 cm		
4	ATTERY STATUS: Temperature: 41.0 ° Level: 100% Voltage: 4.245 Volt Status: Full Health: Good Technology: Li-ion	°C	
C 😳	SOUND LEVEL: 50.155 dB		

Androsensor, Funf

TRANSPORT PLANNING DATA | TRANSPORT SUPPLY

Public transport

I Generalized transit feed (schedule & realtime)

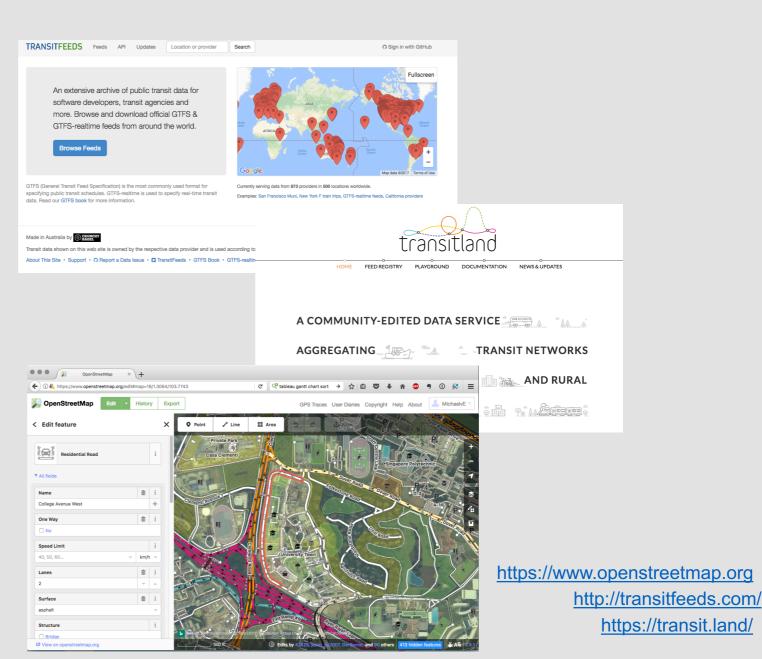
Roads

/ Teleatlas, Navteq / OpenStreetMap

Challenges

/ Capacity information (e.g. number of lanes)
/ Lacking speed restrictions (max speed)
/ Traffic light timings
/ Mobility services beyond public transport

(e.g. bike share, Uber, Grab, company buses)



DISRUPTION





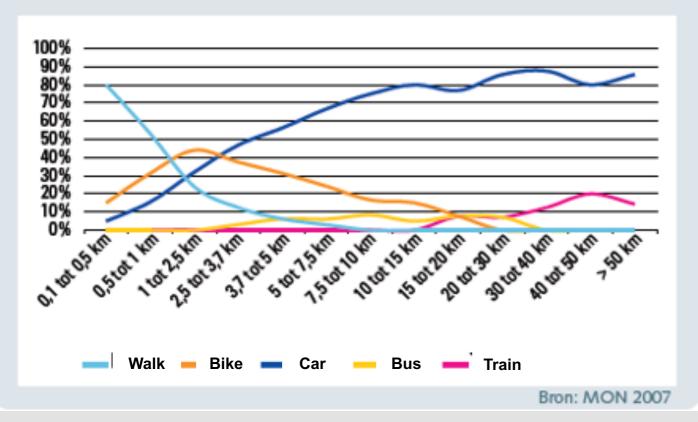
How the delivery economy is disrupting Philadelphia's street grid (2017) The Inquirer Philidelphia, http://www.philly.com/philly/columnists/inga_saffron/how-the-delivery-economy-is-disrupting-philadelphias-street-grid-20170608.html

Popstation @ Ang Mo Kio https://www.mypopstation.com/locations

DISRUPTION E-BICYCLES

Now

7. Aandeel vervoerwijzen naar afstandsklasse



Future: e-bicycles

< 2,5 km no increase

- 2,5 -5 km increase by 10%,
- 5- 7,5 km increase by 43%,
- 7,5-10 km increase by 23% and
- 10-15 km increase by 38%.

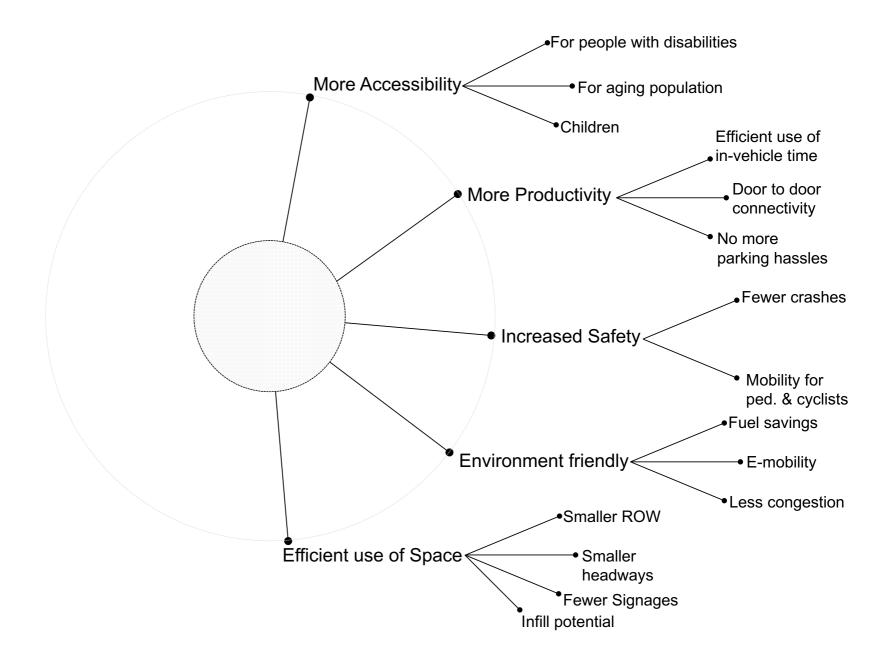
CROW (2012) E-bike kan fietsverkeer met meer dan 20% doen toenemen, http://kpvvdashboard-6.blogspot.sg/2012/09/e-bike-kan-fietsverkeer-metmeer-dan-20.html

DISRUPTION AUTONOMOUS VEHICLES

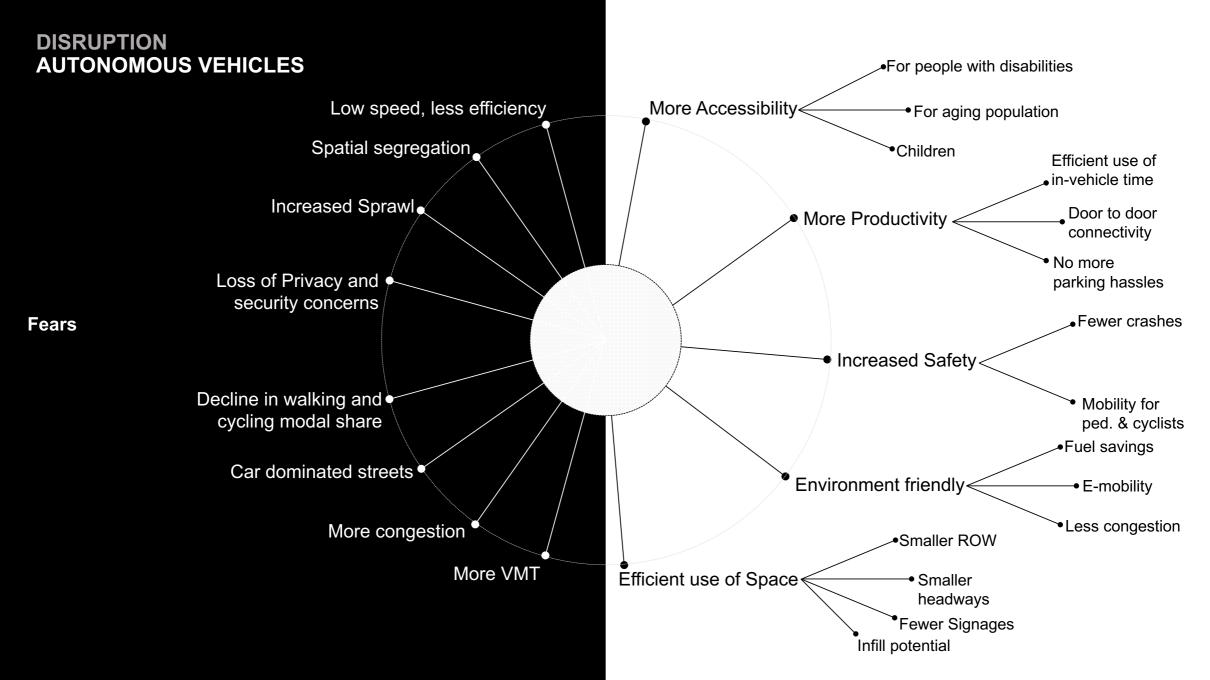
The Magic Highway" (1958)



DISRUPTION AUTONOMOUS VEHICLES



Potential Gains



DISRUPTION LEVELS OF AUTOMATION

Level 0 Driver controls the car

Level 1

Driver-assistance; specific functions can be done by the car

Level 2

One driver assistance system of both steering and accelerating using environment information is automated

Level 3

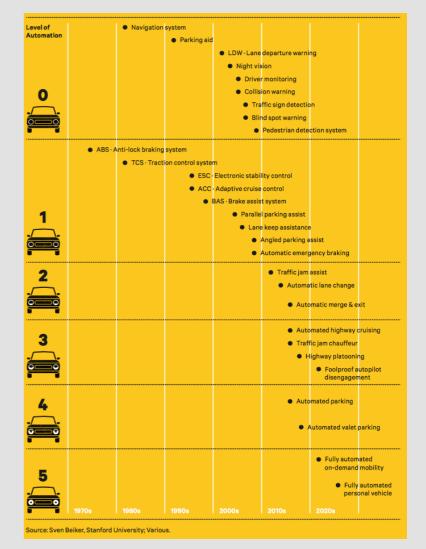
Drivers are still in the car, but can shift safety-critical features to the vehicle

Level 4

Fully autonomous under certain driving conditions

Level 5

Fully autonomous under all driving conditions



DISRUPTION OWNERSHIP MODELS

SHIP MODELS	Sha	ared		
	Taxi and Ridesharing Model Eg. Uber	Govt. Regulated Fleet		
	No one needs to own a car! Just hail a ride. A danger of oligopoly/ monopoly by taxi companies. More VMT and Instability in service provision	Fully integrated ticketing and management with all public transport modes. Centralized Planning and Control leads to more control over mode share. Administrative burden, political implications.		
Laissez Faire 🔶			→ Structured	Type of AV Policies
	Personal Ownership Model Eg. American Model	Demand Management Model Eg. COE		
	Car owners can now choose between human driven or autonomous cars with various levels of automation. You can choose to drive or choose to work while you are being driven. Car ownership becomes even more attractive	Whether you own or AV or share one, they are all subject to demand management regulations. In this way the government indirectly manages mode share. Because vehicles are connected strategies like ERP are easier to implement.		
	Priv	vate		

Operating Mode

DISRUPTION **TYPES OF VEHICLES**



- **⊙** 4
- Å 4,000-6,000 lbs
- 🚵 4-6 passengers
- Q 25-35 mph
- Pittsburgh, San Francisco, Singapore

Autovot / Taxibot



- 🚵 10-12 passengers
- Q 25-35 mph
- Lyons, Helsinki, Washington D.C.

Driverless Shuttle



6 6 A 40-55 lbs A 33,000 lbs O passengers 🚵 44,000 lbs cargo Q 4 mph Q 55 mph Talinn, London, Bern, Redwood City, CA, Washington D.C. Colorado, Rotterdam, EU (various) Deliverybot Software Train

Starship Technologies

Otto (Volvo), Scania

- 18
 18





DISRUPTION FLYING CARS

-

MOTIVATION

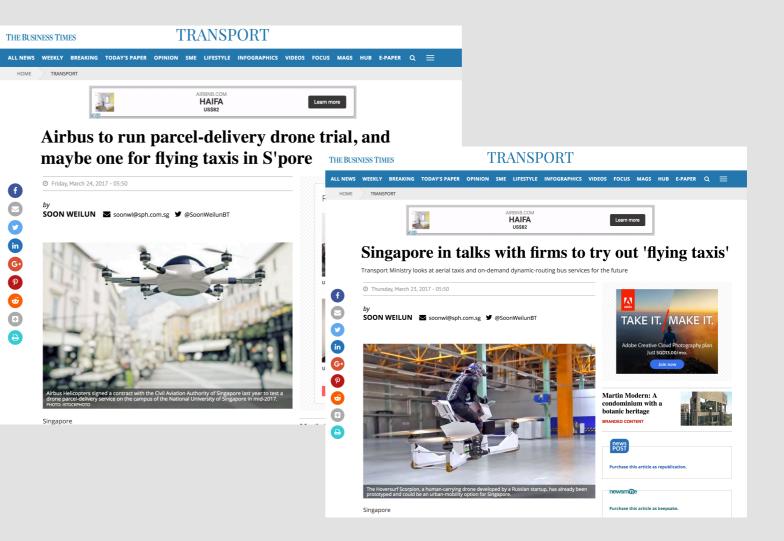
Flying taxis

- / Uber.com/elevate
- / It's closer than you think
- / Low noise, safe, autonomous (after FAA approval), electric
- / Starting in 2020 in Dubai
- / Cheap retrofitting of existing parking structures
- / Typical expectation is reducing travel time by > 50%, door-to-door, of 60%+ of trips over 15km (depending on the city see white paper)



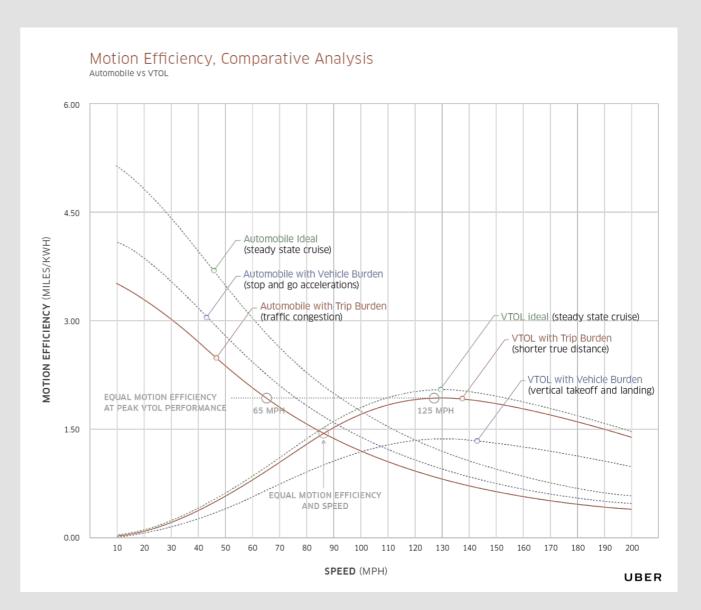
MOTIVATION

- Attracting serious money (<u>here</u>)
- / Big industry support (here)
- Uber is not alone (<u>here</u>)
- / See, e.g., PM of MOT's vision of future SG (<u>here</u>)

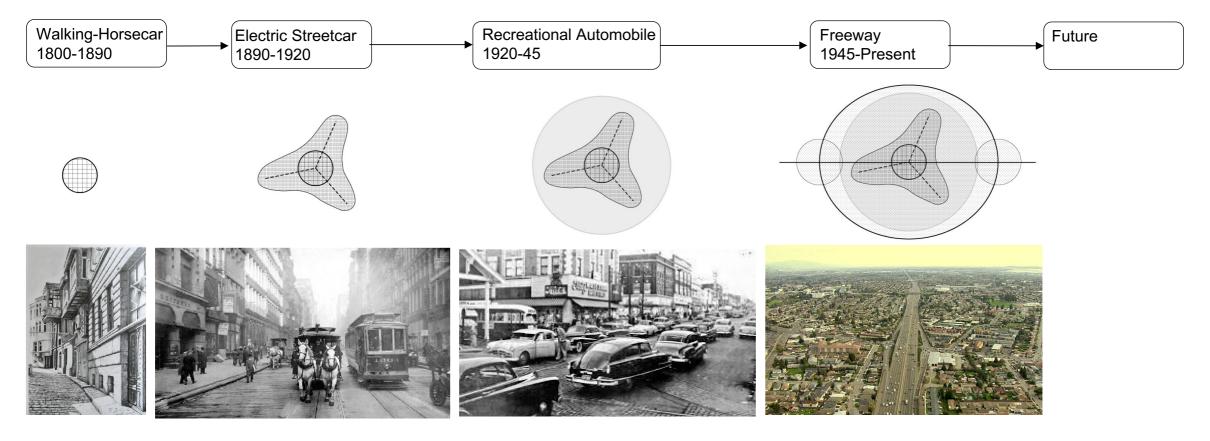


IMPLICATIONS

- / Longer distance trips due to dynamics and efficiency
- / (Implication on share of those trips..?)
- / SG implication (high speed rail)
- / The comparison is about speed, but does not highlight the implication on trip distance
- / Transport equity

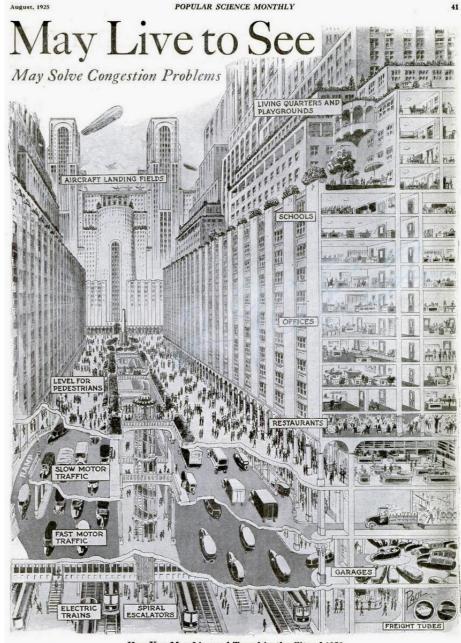


IMPLICATIONS





Corbett style cities, taken from <u>here</u>



How You May Live and Travel in the City of 1950

Future city streets, says Mr. Corbett, will be in four levels: The top level for pedestrians; the next lower level for slow motor traffic; the next for fast motor traffic, and the lowest for electric trains.. Great blocks of terraced skyscrapers half a mile high will house offices, schools, homes, and playgrounds in successive levels, while the roofs will be aircraft landing-fields, according to the architect's plan



DISCUSSION

- Let's assume it happens, and price drops to existing taxi prices (Uber's ultimate vision)
- What are the implications for urban development?
- Consider speed, cost of development compared to rail infrastructure
- Anticipate collective human reaction to disruptive transport tech
- Consider implications of 1950s decisions still today when faced with similar situation

- / In groups of 5-8, discuss and sketch out the dystopian and utopian mind-map visions of a future where aerial mobility is a reality, such as the example on the right for autonomous vehicles
- / Consider context (1 ea. group?):
 - / Asian cities, e.g. Jakarta, Manilla, Bangkok
 - / Regional development & integration e.g. Indonesia, Sijori
 - / US suburbs
 - / Africa
 - / ...
- Social and psychological factors
- / Does zero emissions imply zero environmental impact?

RECOMMENDED READINGS & REFERENCES

Littman, Todd (2017) Evaluating Accessibility for Transport Planning Measuring People's Ability to Reach Desired Goods and Activities, available <u>here</u>

Lynch, Kevin (1984) Good City Form. Cambridge: MIT Press

Ortúzar, Juan de Dios, and Luis G. Willumsen (2011) *Modelling Transport*. Fourth edition. Chichester, West Sussex, United Kingdom: John Wiley & Sons

Rodrigue, Jean Paul (2013). The Geography of Transport Systems, available here

Townsend, Anthony (2017) Taming the Autonomous Vehicle: A Primer for Cities. Bloomberg Philanthropies, available <u>here</u>