"Addressing the unforeseen impact of structural changes on European air quality"

11&12th February 2019, CZiITT, Warszawa

Automated vehicles

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Outline

- The on-going disruption in the mobility ecosystem
- Dimensions of automated mobility
- Examples of research on automated vehicles
  - Transportation models
  - Technology deployment
- Examples of policy making
- Some current trends in research: future mobility vs. air pollution impacts

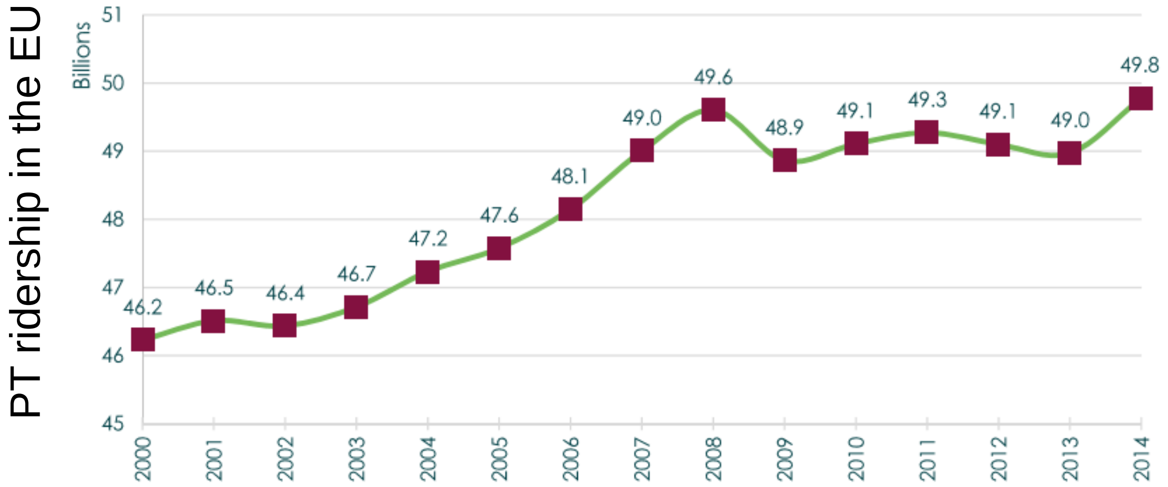
On-going Mobility Disruption

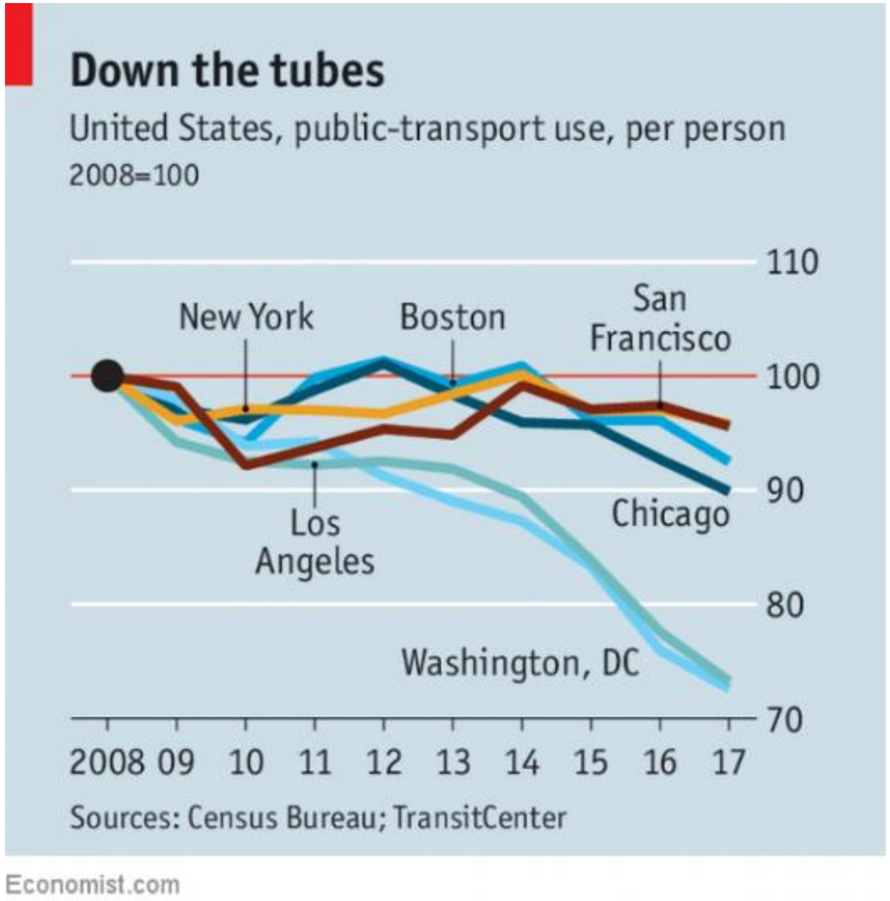
- Population
  - – 54% of world's population residing in urban areas in 2014; to be 66% by 2050[1]
- Congestion
  - – In 2014, US auto commuters lost 6.9 billion hours and 11.7 billion liters of fuel (42h , 72 l / commuter)[2]
  - – Over € 270 billion in total congestion costs in the EU28 in 2018 [7]
  - – Across 38 countries in 2017, urban drivers lost an average of 27 hours and 49 liters of fuel[3]
- Car ownership
  - – Passenger vehicles to grow by 30% in next decade to over 1.3 billion globally[4]
- Mass transit
  - – Decline by 6% in the US from 2014 to 2016[5]
  - – Similar trends from 2000 to 2015 in: Russia (-72%), Spain (-16%), Japan (-9%), Italy (-4%)[6]

[1]United Nations (2018). World Urbanization Prospects.
[2]Schrank, D., et al., (2015). 2015 Urban Mobility Scorecard". Texas A&M Transportation Institute; INRIX.
[3]Cookson, G., (2018) INRIX Global Traffic Scorecard. INRIX Research.
[4]Sperling, D., and Gordon, D., (2009) Two Billion Cars – Transforming a Culture.
[5]Institute for Transportation Studies, 2017. Disruptive effects of ridehailing, UC Davis.
[6]UITP, (2017). Urban Public Transport in the 21st Century. Statistics Brief.
[7] From infrastructure costs to health and environmental impacts – EU Commission Dec. 2018

On-going Mobility Disruption

- Indication of strong demand for mobility on-demand (MOD) services
  – Cannibalization of mass transit and induced travel
- Plausible transformation of MOD to AMOD[1–3]





[1]Silver, D., 2018. **Waymo** Has The Most Autonomous Miles, By A Lot. Forbes. https://www.forbes.com/sites/davidsilver/2018/07/26/waymo-has-the-most-autonomous-miles-by-a-lot/#1f1ad4967ee5

[2]Wakabayashi, D., 2018. **Uber**'s Self-Driving Cars Were Struggling Before Arizona Crash. New York Times. https://nyti.ms/2ugC83C

[3]Norman, H., 2018. **General Motors**' robo-taxis to take on Uber, Lyft in San Francisco. SF Business Times. https://www.bizjournals.com/sanfrancisco/news/2018/07/05/gm-robo-taxis-uber-lyft-sf.html

Dimensions of Automated Mobility: Changes

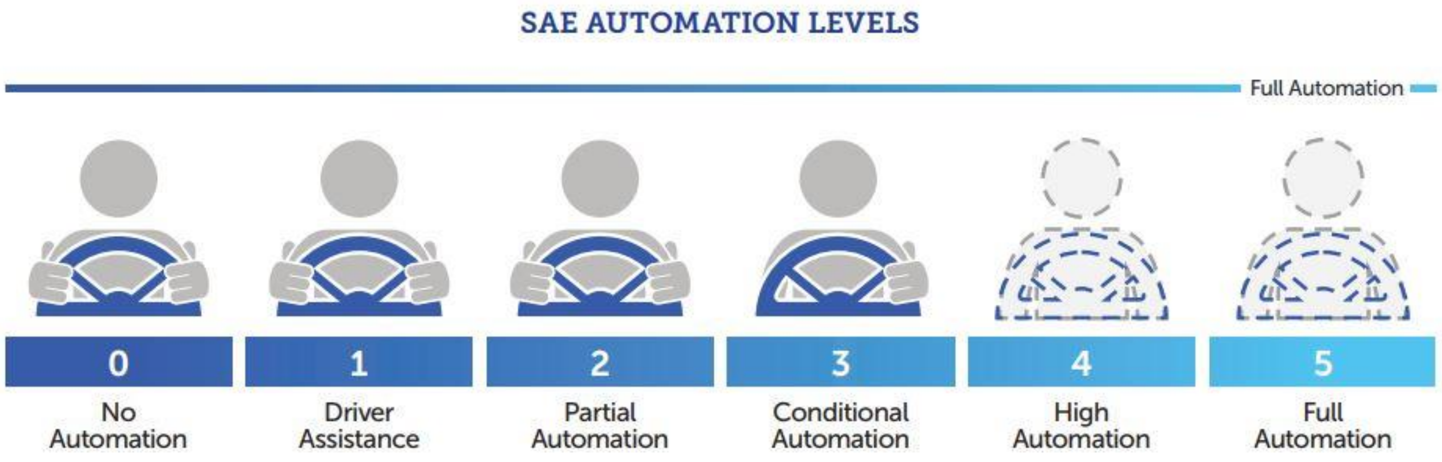
For decades, commuting time has been constant (~ 40 min, independent of region)

1. Value of time drops
2. Better driving efficiency in road segments
   – lower emissions
   – lower cost
3. Parking cost drops
4. Better coordination in route and intersections
   – between AVs
   – with other modes
   – in network management (but may cause problems in infrastructure stress points…)
5. Improved safety
6. Benefits to specific groups
7. Additional empty trips (pick up, drop off, rebalancing)

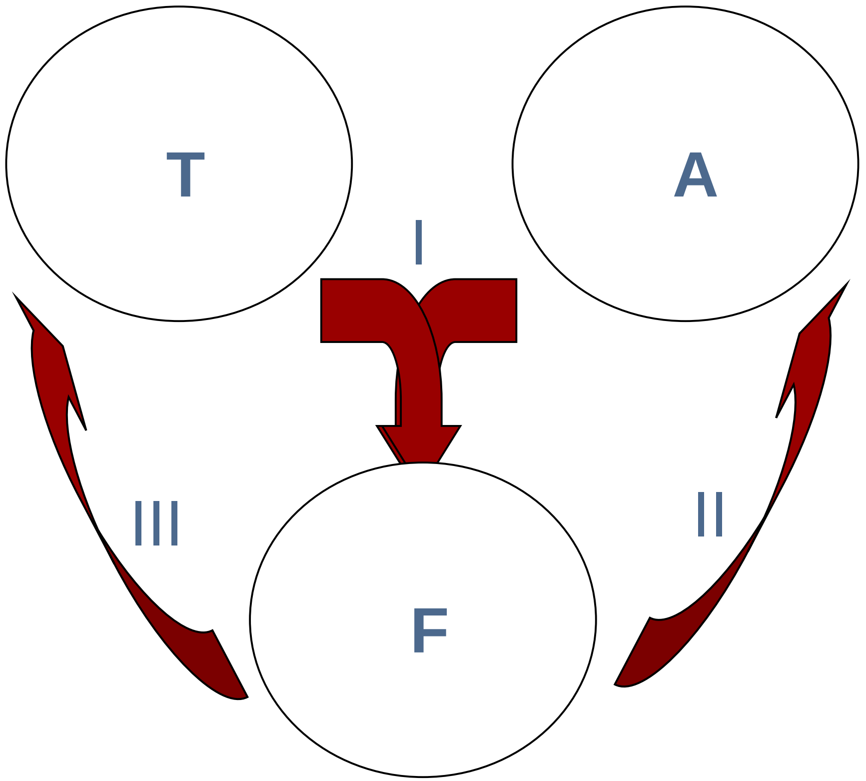
→ studies adopt current trends in demand

Dimensions of Automated Mobility: Challenges

- Technical
- Control & operations
- Behavioural
- Legal
- Privacy, security, economy & social (e.g.:work-force), liability, ethics…



Transportation Models (1)



Key System Elements

T – transport system (supply)

A – activity system (demand)

F – flows & transport system performance

System Interactions/Feedbacks

I Market demand-supply
interactions determine flows & system performance

II System performance
(accessibility) influences activity system markets

III Gov't, public & private
service providers respond system demand & performance

Source: Manheim, M.L. (1978) *Fundamentals of Transportation Systems Analysis Volume 1: Basic Concepts*, MIT Press

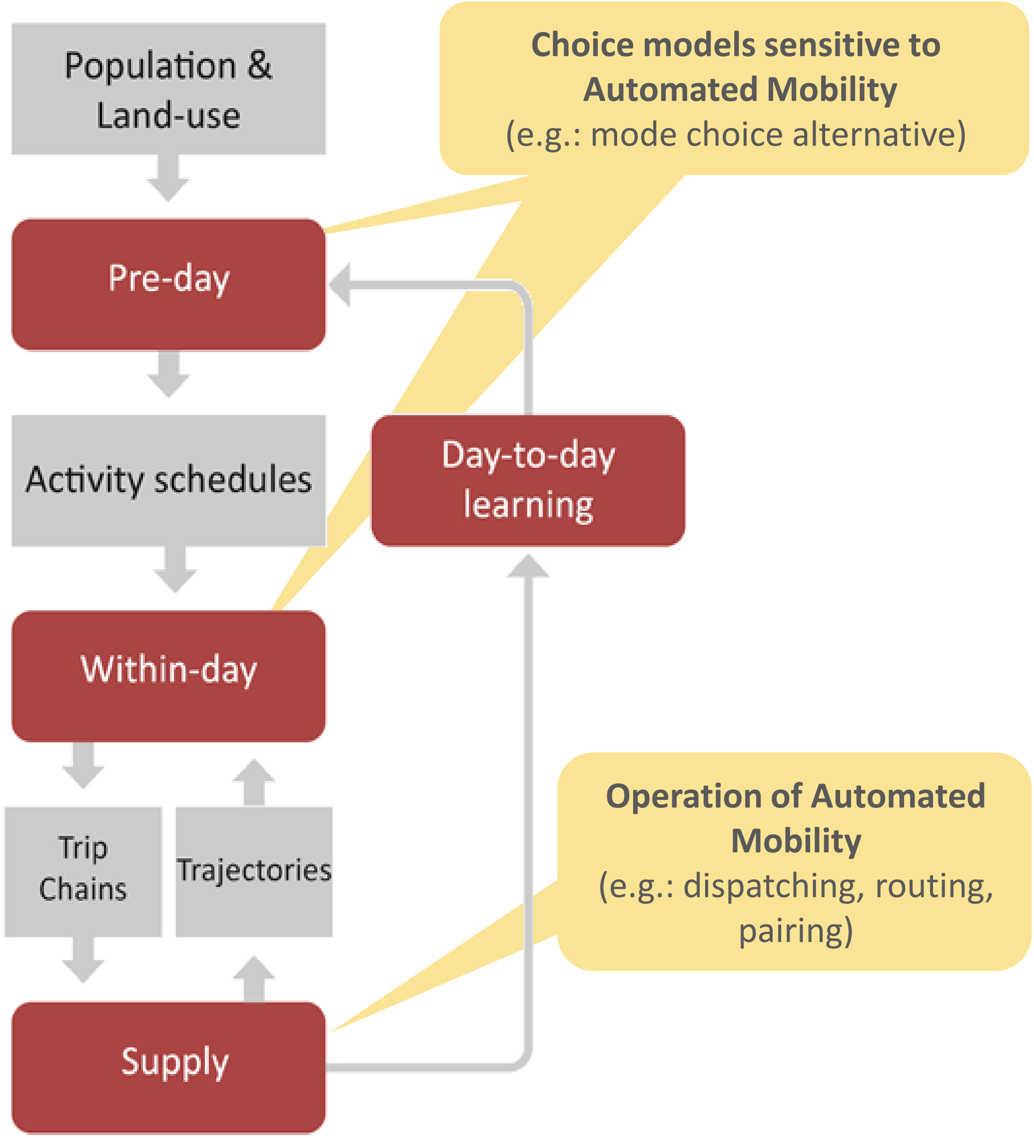
Transportation Models (2): Inferring demand & supply

- Behavior inference:
  - **Stated preferences**, e.g.:
    - Seshadri et al. (2019): trip making in Singapore
    - Targhi, (2017): vehicle ownership in Alberta
    - Bansal and Kockelman’s (2016): residential location choice in Texas
  - **Proxy** services and technology (e.g.: cost and preferences of on-demand and taxis)
  - **Experiments**, e.g.: Harb et al. (2018) “the chauffeur experiment” on travel patterns
- Operations:
  - **Simplification** / **assumptions** on existing human-driving behaviour models
  - Development of strategy-related **algorithms** based on proxy services

Transportation Models (3)

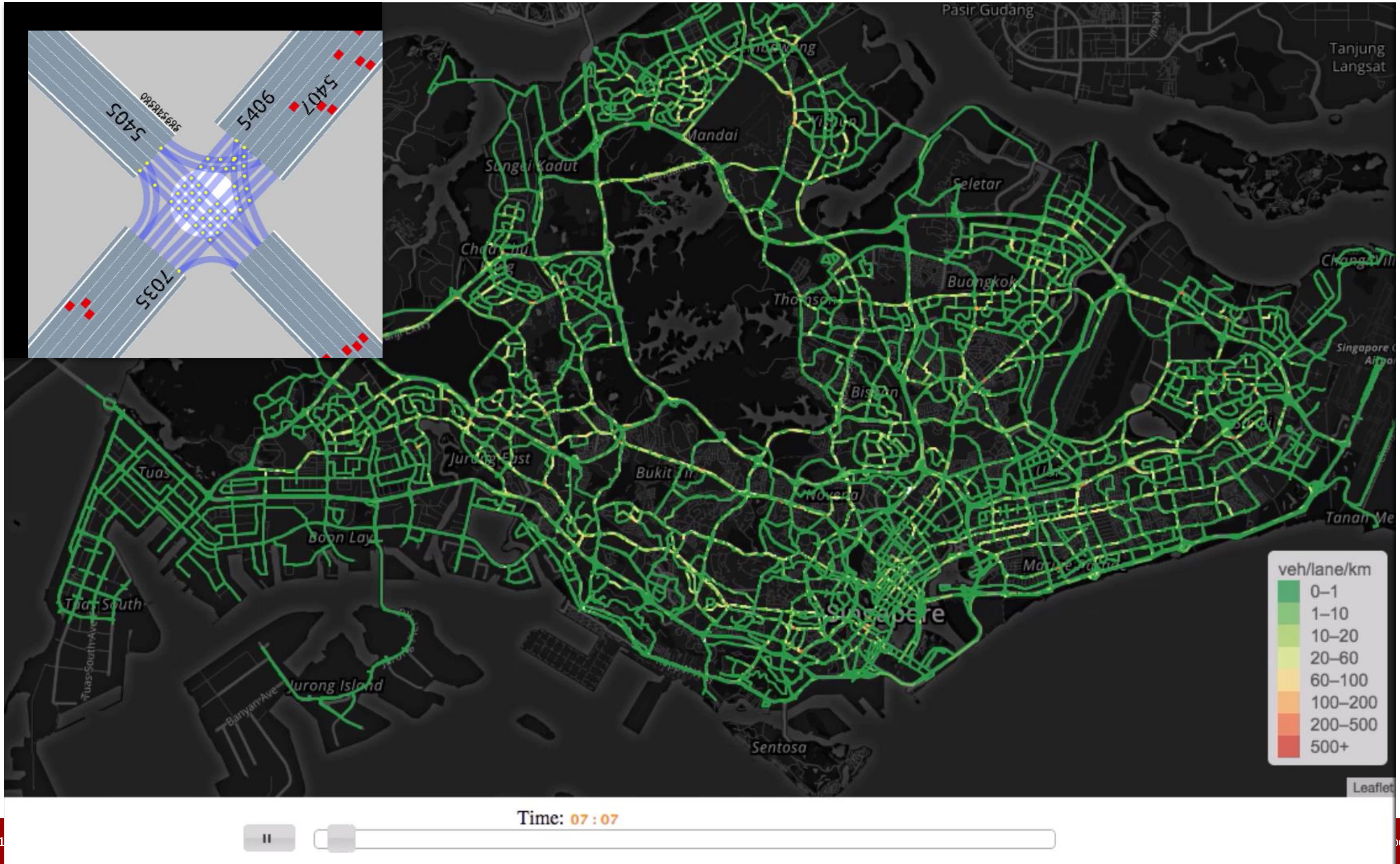
- *SimMobility* is an open source **laboratory** for quantifying impacts of future urban scenarios
  - **Agent-based** platform for city simulation
  - Activity-based **behavioral** dynamic plan/action models
  - Multimodal **network** representation

- Others: MATSim, FEATHERS, POLARIS…



https://github.com/smart-fm/simmobility-prod

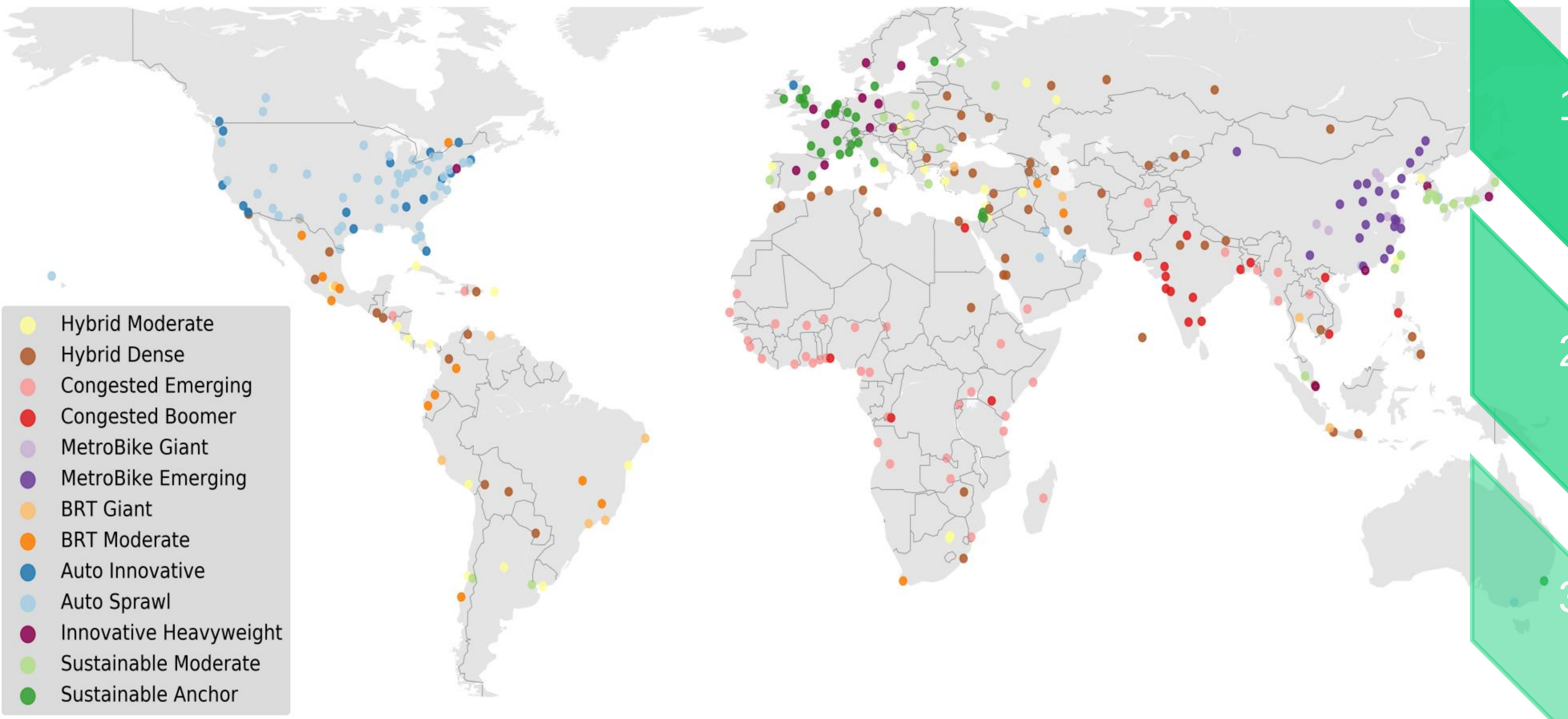
Example: Singapore



Transportation Models (4): Examples of setting-specific analysis

- ITF (2015) in Lisbon (fleet sizing, service performance)
- Azevedo et al. (2016) in Singapore (service operation and congestion vs. demand changes)
- Levin et al. (2016) in Austin (fleet sizing, service performance)
- Maciejewski and Bischoff (2016) in Berlin (service performance and congestion)
- Nuzzolo et, al (2018) in Roma
- and so on…

Transportation Models (5): Scenario Discovery at MITei



1
- Identify **urban typologies** worldwide

2
- Generate **prototype cities** in simulated environment

3
- Discover the impacts of automated mobility via **simulation**

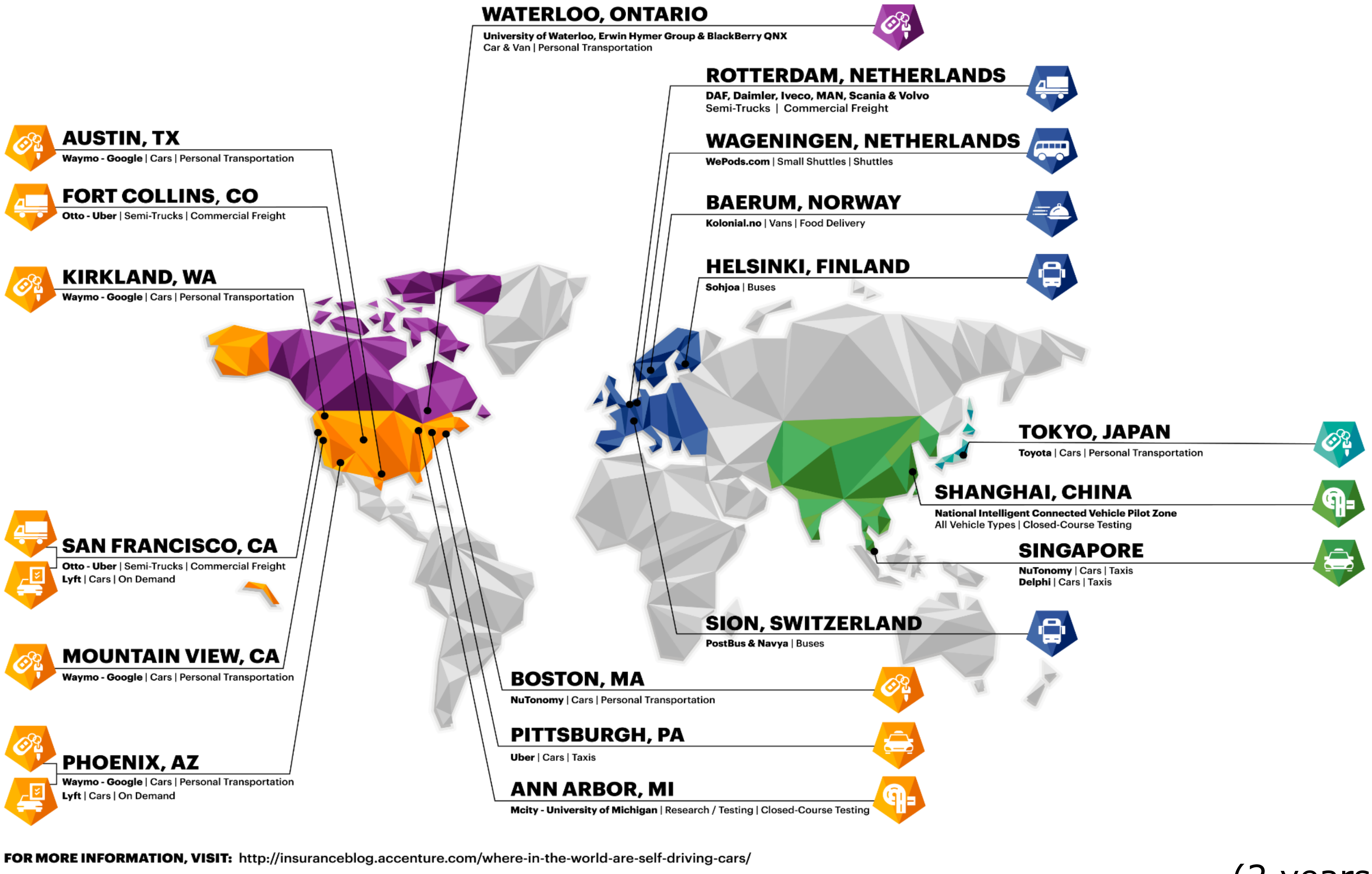
http://energy.mit.edu/research/mobility-future-study/

Technology Deployments

- “regulation driven”

  vs.

- “immune to lack of regulation”



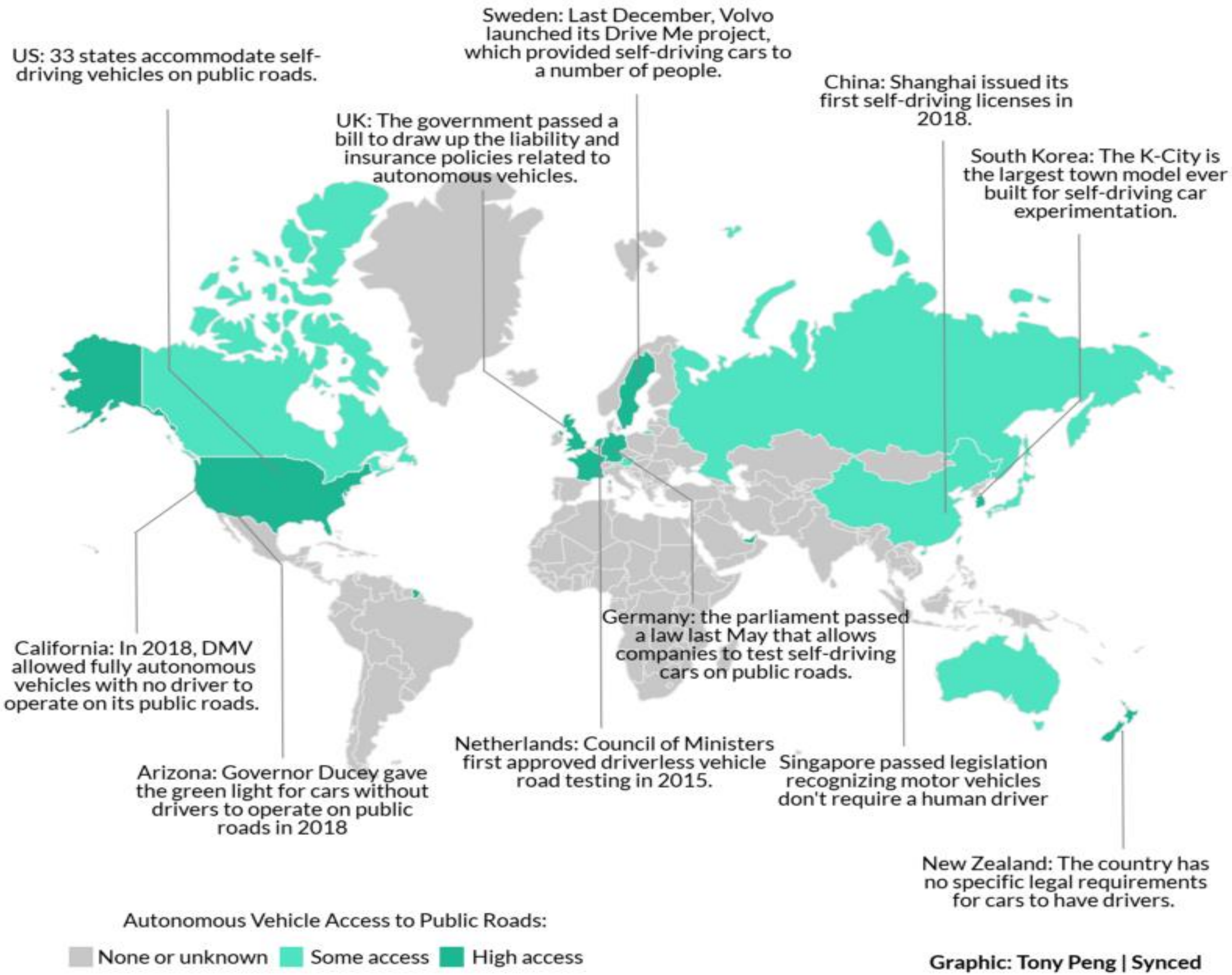
(2 years ago!)

Policy Making (1)

- Issues in current indirect management transport policies
  - Favoring PT on costs (costs of AV are expected to get closer to PT)
  - Parking limitations
  - AV only oriented policies may be counter productive:
    - Regulation of empty trips
    - Mandatory person with license in AV (e.g.: Florida)
- Alternatives
  - Coordinated pricing
  - Tradable permits
  - Integration: 1st / last mile designs, quality and flexibility of PT

Policy Making (2)

- Several pilots are happening
  - More are coming
- Legislation is being relaxed
  - Differently in each regions



(1 year ago!)

Current Trends in Research

Macro, Meso and Micro Traffic models with:

- Static Models (total drive cycle)
  - Aggregate (usually by VMT)
  - Average-speed models (VMT + avg. speed)
  - Traffic situation models (VMT + avg. speed + traffic conditions)
- Dynamic Models (sec-by-sec)
  - Modal models (processed drive cycle data)
  - Instantaneous models
- Very few studies on AVs and impacts are unclear: some projecting a reduced impact (Brown et al., 2014;Greenblatt and Shaheen, 2015) while others doubled emissions (Wadud et al., 2016).

Some thoughts for discussion

- **Experimentation** and acceptance: make use of the pilots!
- Bring technology and service **developers** to contribute in models of supply
- Research in **integrated modeling** and simulation of mobility and emissions is needed
- While public health has been identified as important driver in AV policy, heterogeneous practice shows otherwise.
- What about **freight**?
- What about the **rest of the world**?

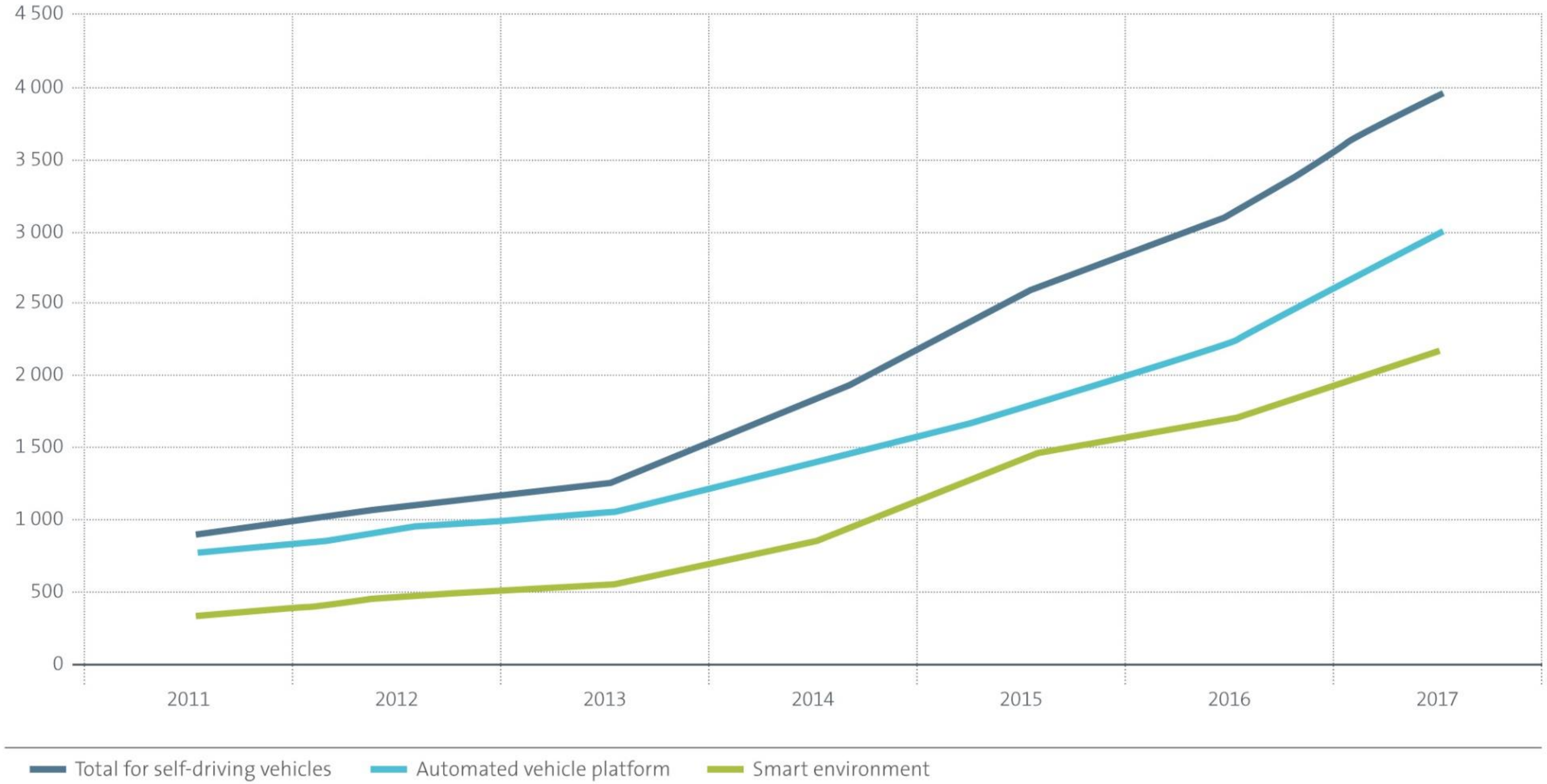
Thank you

http://mlsm.man.dtu.dk

http://its.mit.edu

Technology development

Patent applications at the EPO in self-driving vehicle technologies and their sectors 2011-2017



Source: European Patent Office

The patent statistics in this figure are based on patent applications filed at the EPO in self-driving vehicle technologies. They do not include patent applications filed with the national offices of the contracting states of the European Patent Convention. The reference date for each application is the filing date at the EPO.