Autonomous Vehicles for Mobility On Demand

Scott Pendleton

Autonomous Vehicles

Future Urban Mobility (FM-IRG)

Singapore-MIT Alliance for Research and Technology (SMART)

SMART
Singapore-MIT Alliance for Research and Technology

FUTURE URBAN MOBILITY

NUS National University of Singapore

Massachusetts Institute of Technology

Outline

- Introduction to Autonomous Vehicles (AVs) & SMART
- Environmental Impact
- Developments in Singapore
- Considerations for the Audience

Research Motivation

Challenges of built-up cities

- Road congestions
- Peak hour traffic

- Increased commuting/ traveling time
- Increased accidents
- Increased stress

Improved Transportation System = Improved Quality of Life

To improve the efficiency of urban transportation

Imagine…

- An integrated autonomous train, car and shuttle system
- Providing mobility on demand
- For both passengers and goods
- Which is completely adaptive to how the landscape of any city changes

- The first city that does this will be a global leader!

Photo Credit: Minority Report (2002)

Autonomous Vehicles for

Mobility on Demand to address the

“First and Last Mile” Problem

Mobility on Demand @ NUS

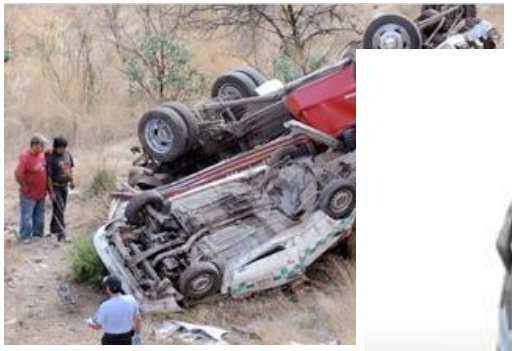
- Video available on YouTube: search “FMAutonomy” channel

https://youtu.be/1aiEJETbjRs

Why Automated Vehicles?

Productivity

Safety

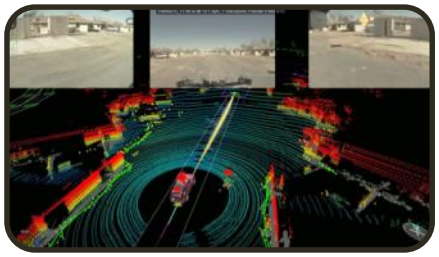


Accessibility

Environment

Efficiency

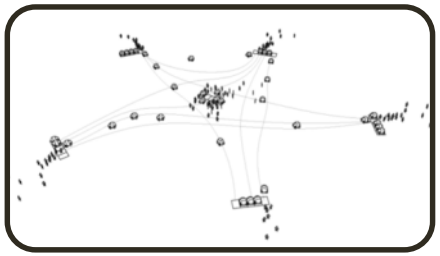
Reinventing the Automobile



Autonomy

Availability
Accessibility

Affordability



Car Sharing

Efficient design

High utilization

Electric Vehicles

Native integration

Active Safety

AUTONOMOUS VEHICLES

If only autonomous vehicles…

- In 2011, Singapore had:
  - Total population: **5,184,000**
  - Total vehicles: **956,704**
- How many autonomous vehicles for Mobility-on-Demand would be required?

For a peak waiting < 15-20 minutes
only 300,000 shared cars needed

K. Spieser, K. Treleaven, R. Zhang, E. Frazzoli, D. Morton, and M. Pavone. Toward a systematic approach to the design and evaluation of automated mobility-on-demand systems: a case study in Singapore. In S. Beiker, editor, Road Vehicle Automation, Lecture Notes in Mobility. Springer, 2014.

Land Use Implications

Without AV MoD

- Total vehicles: **956,704**
- Vehicle Occupied Area*: 16.1 km²
- Total Parking Area*: 128.9 km²

AV MoD

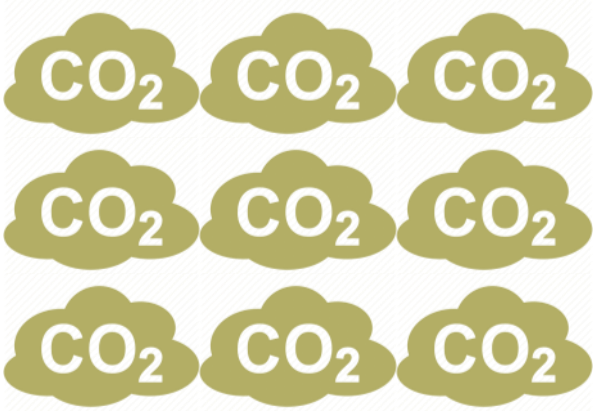
- Total vehicles: **300,000**
- Vehicle Occupied Area*: 5.05 km²
- Total Parking Area*: 40.4 km²

*Not accounting for multi-story parking

Emissions Implications

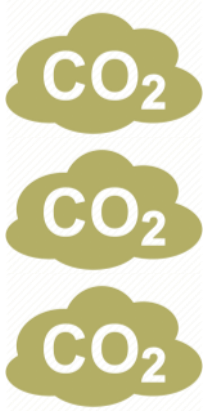
Without AV MoD

- Total vehicles: **956,704**
- Annual CO_2 Emissions*: 4.50M metric tons



AV MoD

- Total vehicles: **300,000**
- Annual CO_2 Emissions*: 1.41M metric tons

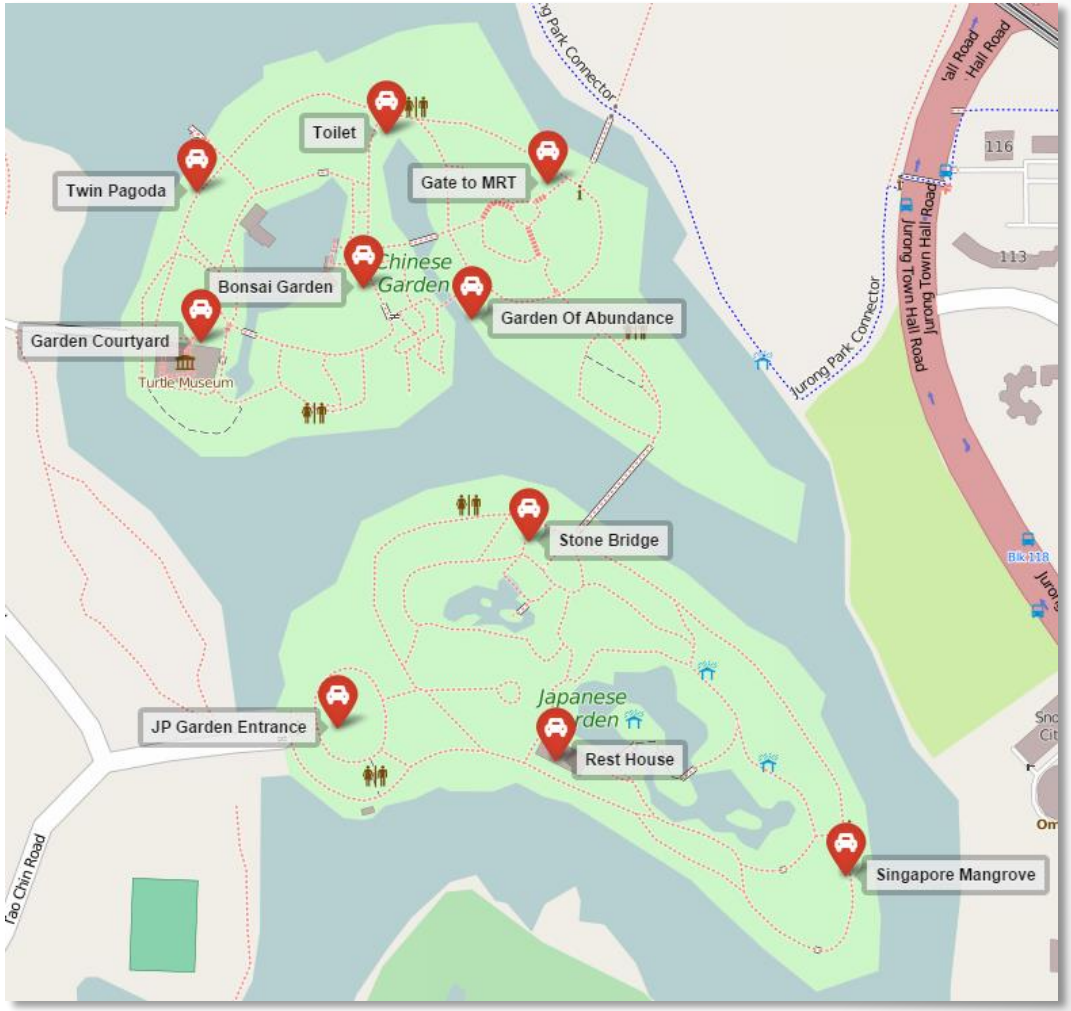


Public Deployment
Chinese Gardens – Oct 2014

- Public AV pilot program
- Co-sponsored by IDA

- **Long term vehicle testing**
- **To raise awareness**
- **To gain public acceptance**

2 Golf Cars
6 Days
360 km
500 Visitors
220 Trips
225 Surveys



AUTONOMOUS VEHICLES

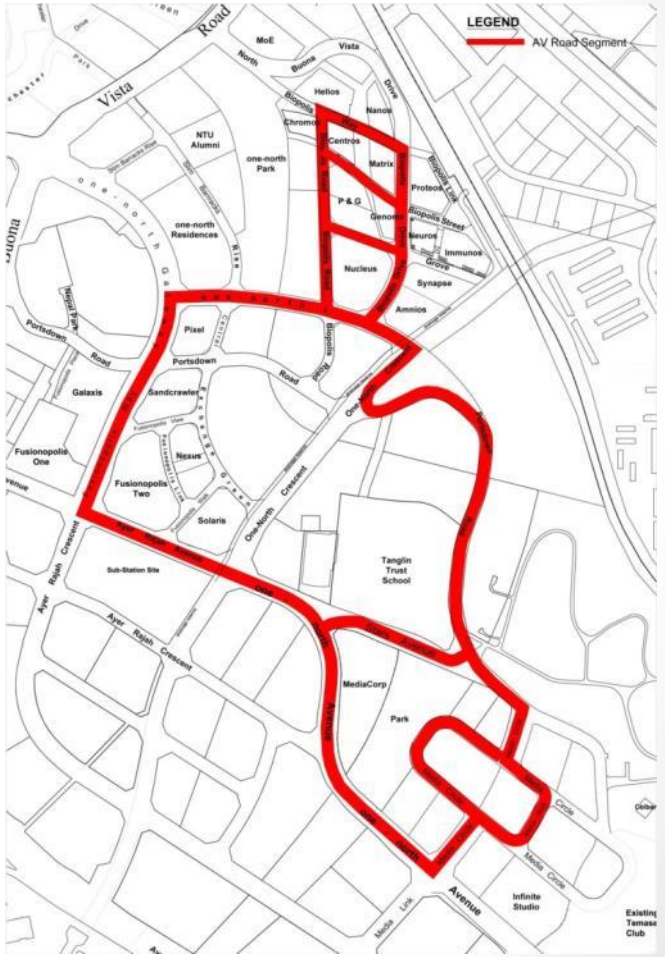
Chinese Gardens Public trial

- Video available on YouTube: search “FMAutonomy” channel

https://youtu.be/aSm027Rzj9E

One-North AV Testing

- First time government approval to test AVs on public roads alongside human drivers
- Testing over 6 km route since Sept 2015
- RFI from LTA for AV R&D projects at One-North leading towards deployment



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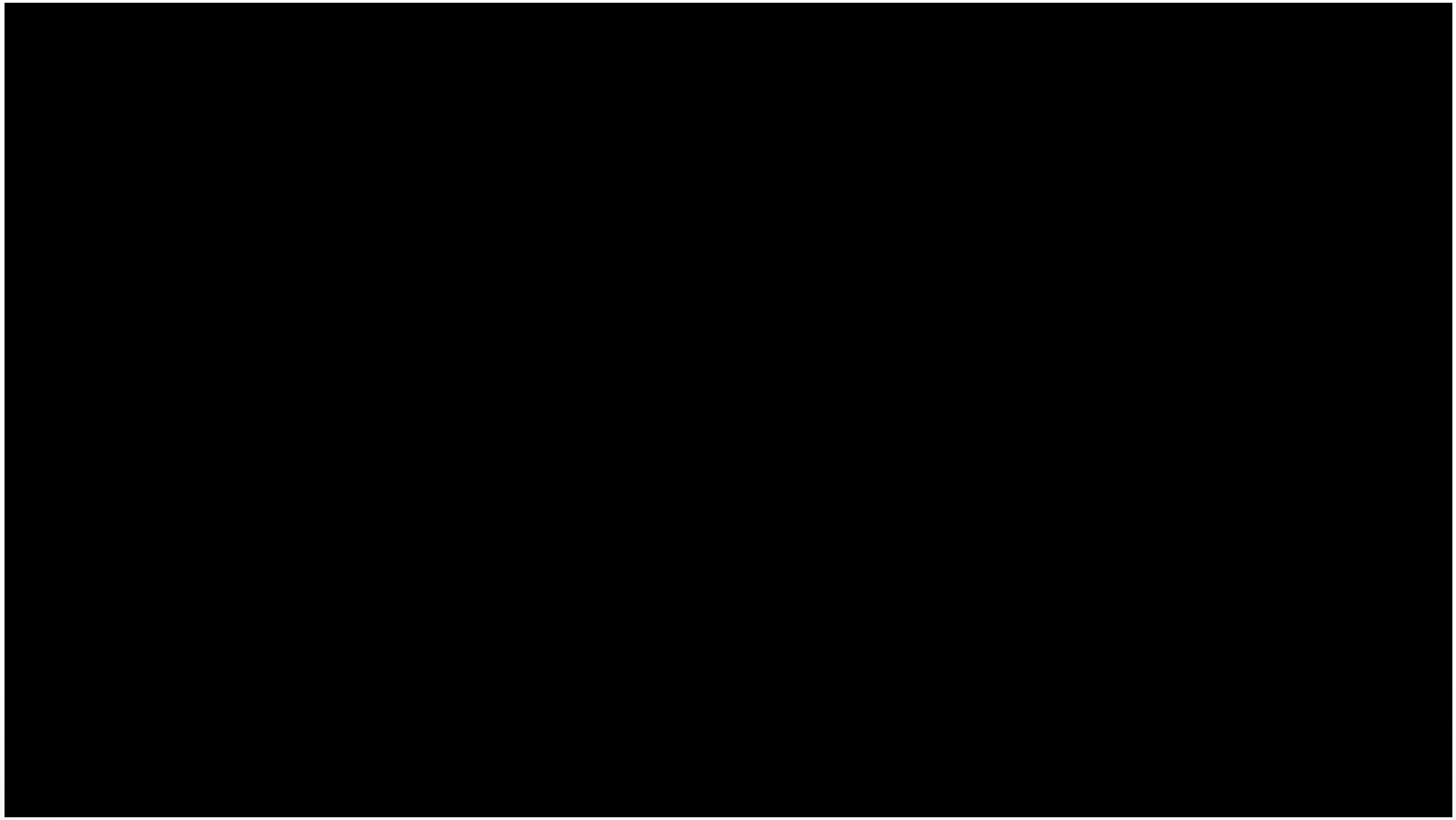

https://youtu.be/bIGcG4K2ckc

Would you ride on an AV?

- Self-driving cars: not and ‘if,’ but a ‘when’
- Disruptive technology
  - Would autonomous MoD incentivise you to use public transportation more often?
  - Will you choose not to own a personal car?
- Policy support
  - Testing stage – access to testing areas, sponsored projects, supportive forward planning
  - Deployment stage – non-restrictive policy, supportive infrastructure
- Industry and Universities/Research Institutes
  - Partnerships to develop an effective technology pipeline: R&D to commercialization

Thank you!

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Singapore total land area: 719 km²

*2.76m x 6.1m typical parallel parking space. Estimate of 8 parking spots per vehicle in a city. Multi-storey parking facilities and mixed use land not included in calculation

Chester, M., Horvath, A., & Madanat, S. (2010). Parking infrastructure: energy, emissions, and automobile life-cycle environmental accounting. Environmental Research Letters, 5 (3) DOI: 10.1088/1748-9326/5/3/034001

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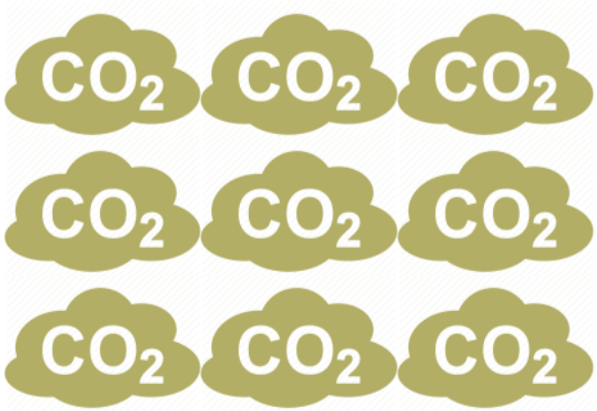

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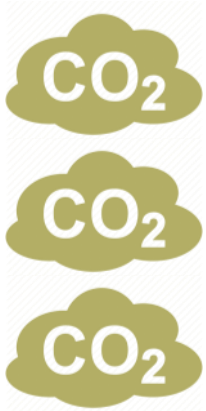

*4.7 metric tons of CO_2 per vehicle per year average

US Environmental Protection Agency (2014). Greenhouse Gas Emissions from a Typical Passenger Vehicle, EPA-420-F-14-040a

A financial perspective (US Market)

- **Safety:**
  - "Cost of a statistical life": **$9.1M**
  - 2011 AAA report (2009 data):
    The societal cost of traffic accidents is about **$300B/year**.
- **Cost of congestion:**
  - Texas Transportation Institute, 2012: approx. **$100B/year**
- **Health costs of congestion:**
  - Harvard School of Public Health, 2010: approx. **$50B/year**
- **Increased productivity/leisure:**
  - Estimate **$1.2T/year**
- **Car sharing:**
  - Assuming a "sharing factor" of 4, estimate **$1.8T/year** of benefits to individuals.
  - Other studies [Burns et al., '13, Fagnant, Kockelman '14] suggest higher sharing factors, up to ~10.