Three Revolutions in Urban Transportation: How to achieve the full potential of vehicle electrification, automation and shared mobility in urban transportation systems around the world by 2050

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Project Background

- This research project grows out of two previous “High Shift” studies done by ITDP and UC Davis.
- This one focuses on 3 major impending transportation “revolutions” not included in the two previous studies: electrification, shared mobility and automation/connected vehicles.
- Scenario study to 2050 focused on potential scenario impacts on CO2, energy use, costs.
- Study supported by STEPS Funds and by Climate Works, Hewlett Foundation, Barr Foundation.
- Project advisory board established.
3 Revolutions builds on 2 previous ITDP/UC Davis studies

Global High Shift Scenario

- High future urban mode shares of transit and active transport around the world; cut car use in half
- Much lower CO2, significantly cheaper transportation system costs

Global HS Cycling Scenario

- Added very high cycling and e-biking mode shares to previous study
- Cut CO2 use an additional 10% and lowered costs
Passenger Transport Revolutions

1. Streetcars (~1890)
2. Automobiles (~1910)
3. Airplanes (~1930)
4. Limited-access highways (1930s....1956)

2010+
1. Vehicle electrification
   – low carbon vehicles and fuels
2. Real-time, shared mobility
   – less vehicle use
3. Vehicle automation (2025?)
   – Uncertain impacts
Ride sharing is exploding around the world…

…but is it really ride sharing?
### All autonomous vehicles in development feature some form of electrification

<table>
<thead>
<tr>
<th>Parent Company</th>
<th>Make</th>
<th>Model</th>
<th>Powertrain</th>
<th>Production Goal</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Nissan</td>
<td>Nissan</td>
<td>Leaf</td>
<td>Electric</td>
<td>2020</td>
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<tr>
<td>GM</td>
<td>Chevrolet</td>
<td>Bolt</td>
<td>Electric</td>
<td></td>
<td>Testing 40 vehicles in SF and Scottsdale</td>
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<td>FCA</td>
<td>Chrysler</td>
<td>Pacifica</td>
<td>Hybrid</td>
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<td>Testing 100 vehicles with Google</td>
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<tr>
<td>Ford</td>
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<td>Fusion</td>
<td>Hybrid</td>
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<tr>
<td>Volvo</td>
<td>Volvo</td>
<td>XC90</td>
<td>Hybrid</td>
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<td>Uber</td>
<td>Ford</td>
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<td>Uber</td>
<td>Volvo</td>
<td>XC90</td>
<td>Hybrid</td>
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<tr>
<td>Daimler</td>
<td>Mercedes-Benz</td>
<td>F015 Luxury in Motion</td>
<td>Hydrogen Fuel Cell Plug-In Hybrid</td>
<td>Research Vehicle</td>
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</table>
AV costs dropping quickly

Cost of LIDAR used on the Google car was $75 – 85,000, and by early 2016, Velodyne began selling LIDAR for $500 per unit to Ford.
Vehicle Automation Impact on Energy Use: Wide Range of Possible Impacts

Wadud, McKenzie, Leiby 2015

UC DAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

ITDP
Institute for Transportation & Development Policy
This can go in very different directions...

“Heaven” Scenario

• Ride sharing, multimodal (transit/NMT) ecosystem
• More compact, livable cities
• “Right-sizing” of vehicles
• Reduction in traffic/travel times
• Fuel efficiency improvements/ electrification/lower CO2

“Hell” Scenario

• More single-occupant (and zero occupant) vehicles
• More sprawl/car-dependence
• Bigger vehicles
• Longer trips/ time spent traveling/ increased traffic congestion
• Higher energy use/CO2
Some questions and conflicts

• **Automation: lower per-trip costs, lower “time cost” for being in vehicles**
  – Longer trips?
  – Empty running (zero passengers) of vehicles

• **Electrification goes with automation – does it really?**
  – Can get the job done with upgraded electrical system (such as hybrids)

• **Ride sharing: cost savings v. convenience and risk**
  – and perceived risks, esp. with no driver?
  – at conflict with public transit use?
  – Will lower costs/increased incomes reduce the incentive to ride share?
Part 2: our scenarios...we want to explore these interactions and different possible futures
### Rough guide to the three scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Use of Automation</th>
<th>Use of Electrification</th>
<th>Use of Shared Vehicles</th>
<th>Urban Planning/Pricing/TDM Policies</th>
<th>Aligned with 2°C (or Lower) Scenario</th>
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</thead>
<tbody>
<tr>
<td>BAU, limited intervention</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
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<tr>
<td>2R with high electrification, automation</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Maybe</td>
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<tr>
<td>3R with high shared mobility, public transport, walking and cycling</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Yes</td>
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Passenger kilometers of travel by scenario/mode USA

- Automated vehicle travel not significant by 2030 in any scenario, but dominates in 2050. Results in much higher travel in 2R.
- US remains car dominated to 2050 - increase in travel mode mix in 3R, but mostly due to TNCs. Also significant minibus travel. Non-car travel reaches 18% in 3R.
US LDV travel (VKm) by scenario

- **2R** vehicle travel rises sharply after 2030 due to lower travel costs from automated vehicles
- **3R** vehicle travel flat despite declining vehicle stock, given higher travel per vehicle of public vehicles
US LDV stock evolution by scenario

- 2R stocks nearly completely autonomous by 2050
- 3R stocks strongly decline after 2030, due to lower passenger travel levels, intensive vehicle use and higher load factors
India LDV travel (VKm) by scenario

- 2R vehicle travel rises by a factor of nearly 10 in BAU and 2R
- 3R vehicle travel rises much more slowly then levels off as shared mobility kicks in over time
India LDV stock evolution by scenario

- 2R stocks a mix of electric and autonomous vehicles by 2050
- 3R stocks never grow to anywhere near BAU/2R levels
Energy use by scenario, mode

- Far lower energy use in 3R due to low LDV mode shares
Urban passenger transport CO2 by scenario, vehicle type, world

4DS electricity shown; in 2DS, CO2 from electricity drops to near zero in 2050

Global CO2 reduction in a 2DS electricity world, 2R/3R v. BAU, in 2050 and cumulative

<table>
<thead>
<tr>
<th></th>
<th>2050</th>
<th>2015-2050 cumulative</th>
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<tbody>
<tr>
<td>2R v BAU</td>
<td>82%</td>
<td>37%</td>
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<tr>
<td>3R v BAU</td>
<td>93%</td>
<td>53%</td>
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**CO2 Emissions - World**

- **Electric vehicles**
- **ICE vehicles**

<table>
<thead>
<tr>
<th></th>
<th>BAU</th>
<th>BAU</th>
<th>2R</th>
<th>3R</th>
<th>BAU</th>
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Costs start to deviate across scenario after 2030, 3R 40% cheaper in 2050

- The combination of far fewer vehicles, lower travel/fuel levels, lower infrastructure requirements (roads/parking) makes 3R far cheaper.
- 2R more expensive than BAU due to higher cost of AV/EVs and greater travel
Supportive Policies – critical to success of the scenarios

• 3R Scenario (Automation + Electrification + **Sharing**):
  – Compact Urban Development policies
  – Efficient parking policies
  – Heavy investment in transit/walking/cycling
  – VKT fees (incl. congestion & emission factors):
A few takeaways

• 2R without 3R could be a traffic nightmare, even with automation traffic benefits.
  – The rebound travel effects of automation should be carefully managed

• A 2R scenario could lead to deep CO2 reductions IF grid electricity is deeply decarbonized
  – A 3R scenarios provides more robust emissions reductions
  – Automation without electrification could increase CO2

• 3R: Sharing must be strongly incentivized, probably through pricing

• Even a super-rapid transition will take 3 decades to complete
  – Private “legacy” vehicles could be an issue; scrappage incentives could be interesting