Shared Mobility Simulations for Auckland

Jari Kauppila, Head of Statistics and Modelling
Outline

• Introduction
  – International Transport Forum
  – Shared modes
  – Simulation model
  – Study area

• Focus group study

• Scenarios for the simulations

• Aggregated results

• Results for selected scenarios

• Recommendations
59 countries
Shared Mobility
Innovation for Liveable Cities

Corporate Partnership Board Report

Shared Mobility Simulations for Helsinki
Case-Specific Policy Analysis

Shared Mobility Simulations for Auckland
Case-Specific Policy Analysis
Shared Taxis
simultaneous ride-sharing
Taxi-Bus

demand-responsive bus
Agent-Based Model

• Micro-simulation of personal mobility, one working day.

• Reproduces interactions between users and shared mobility services in a transport network.

• Transport network includes detailed road and PT network of the study area. PT modes: bus, rail, ferry.

• Enables dynamic optimization that matches supply and demand, minimizing detour distances and travel times.

• Three main agents that interact in a common environment: users, vehicles, and dispatcher.
Modelling Framework

Characterisation of the study area

- Transport infrastructure and services
  - Road network
  - PT GTFS model

- Spatial definition and resolution
  - Study area boundaries
  - Grid system definition

Mobility seed and transport mode preferences

- Travel survey
- Mode choice model

Transport performance by OD pair and mode

- Travel times by mode

Probability of trip production / attraction

- Land use data (Grid)
  - Population
  - Employment
  - Amenities (POIs)
  - Building footprint

Synthetic mobility dataset

- Household characterisation
  - (Residential location, family profile)

- Individual data
  - (age, education level)

- Mobility data
  - (trip sequence, each trip (origin, destination, schedule, purpose, transport mode))

Transport demand & supply scenarios

Demand (Scenario specification)
- Private car trips
  - (% modal shift to SM)
- Bus trips (% modal shift to SM)

Supply (Scenario specification)
- Private car (allowed: Yes/No)
- Conventional Bus (preserved: Yes/No)
- BRT (preserved: Yes/No)
- Walking & biking (preserved: Yes)
- Rail and Ferry (preserved: Yes)
- Low Emission Zone (active: Yes/No)

Focus group and stated preference analysis

- Willingness to shift to SM

SM mode selection
- Shared-Taxi
- Taxi-Bus
- Feeder service to rail, ferry or BRT

Simulation (Outputs)

- Service quality
  - Waiting time
  - Detour time

- Operational Performance
  - Average vehicle occupancy
  - Fleet requirements
  - Costs

- Society (Sustainability)
  - Emissions
  - Congestion
  - Accessibility indicators
  - Parking requirements

Legend

- Inputs
- Outputs
Study area and population distribution (2013)

- Grid 500x500 meters
- Includes 1.3 mil. inhabitants of 1.44 mil. inhabitants of the Auckland region
- 4.9 million trips a day
- 86% trips are by a private car
Congestion for each road network link (evening peak, current mobility)
Passenger-kilometres by car, total, current mobility
Passenger-kilometres by car per capita, current mobility
Current modal share and average trip characteristics

- Mode share distribution based on the total number of trips in the Auckland Metropolitan Area, 2013 (%)
- Computed by ITF based on the Household Travel Survey (2011/2012-2013/2014).

<table>
<thead>
<tr>
<th>Travel mode</th>
<th>Total travel time (min)</th>
<th>Travel distance (km)</th>
<th>Number of transfers</th>
<th>Access + egress time (min)</th>
<th>Waiting time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public transport</td>
<td>47.03</td>
<td>7.81</td>
<td>0.86</td>
<td>11.97</td>
<td>18.02</td>
</tr>
<tr>
<td>Private car</td>
<td>17.77</td>
<td>10.71</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Focus group and stated preferences survey

Mode choice in stated preference survey

Focus group

- Car: 44%
- Bus: 30%
- Rail: 9%
- Bicycle: 9%
- Walk: 6%
- Shared Transport: 2%

Panel respondents

- Car: 58%
- Bus: 23%
- Rail: 7%
- Bicycle: 6%
- Walk: 5%
- Shared Transport: 1%
Focus group and stated preferences: findings of the discussion

• Mostly positive attitudes towards shared mobility modes

• Willing to share vehicles with more travellers, rather than fewer but some would be willing to pay slightly more for being alone in a vehicle

• PT users, younger and older people, those living far from center and women are the most likely earlier adopters of shared services

• The PT users: strong willingness to use the shared modes

• Many PT users: shared modes as feeder services to rail and ferry would be of a great interest
Focus group and stated preferences: findings of the discussion

• Price is the most important attribute
• Majority of the respondents expect the cost to be
  – not higher than that of current PT modes (for Taxi-Bus)
  – cheaper than of conventional taxi or private car (for Shared Taxi)
• Around ¾ willing to substitute their car trips with shared mobility services
• One third of respondents that own a car stated they would sell one of more cars if shared mobility services were available
• Car users tend to perceive the travel cost only as the out-of-pocket cost of the fuel
• This should be taken into account when setting
  – the fare of the new services
  – related policies
  – informational campaigns
## Scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Bus</th>
<th>Cars</th>
<th>Rail + Ferry + BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100% Replacement</td>
<td>100% of trips replaced</td>
<td>Keep</td>
</tr>
<tr>
<td>2</td>
<td>Keep</td>
<td>100% of trips replaced</td>
<td>Keep</td>
</tr>
<tr>
<td>3</td>
<td>100% Replacement</td>
<td>50% of trips replaced</td>
<td>Keep</td>
</tr>
<tr>
<td>4</td>
<td>100% Replacement</td>
<td>20% of trips replaced</td>
<td>Keep</td>
</tr>
<tr>
<td>5</td>
<td>Keep trips where bus with headway &lt;5 min</td>
<td>100% of trips replaced</td>
<td>Keep</td>
</tr>
<tr>
<td>6</td>
<td>Keep trips where bus with headway &lt;5 min</td>
<td>20% of trips replaced</td>
<td>Keep</td>
</tr>
<tr>
<td>7</td>
<td>100% Replacement</td>
<td>Large low emissions zone (LEZ) with all private car traffic constrained during all day</td>
<td>Keep</td>
</tr>
<tr>
<td>8</td>
<td>100% Replacement</td>
<td>Large LEZ with all private car traffic constrained during peak hours</td>
<td>Keep</td>
</tr>
<tr>
<td>9</td>
<td>100% Replacement</td>
<td>Small LEZ with all private car traffic constrained during all day</td>
<td>Keep</td>
</tr>
<tr>
<td>10</td>
<td>100% Replacement</td>
<td>Small LEZ with all private car traffic constrained during peak hours</td>
<td>Keep</td>
</tr>
</tbody>
</table>
Road, public transport and potential shared mobility networks (all scenarios)
Scenarios with keeping frequent bus trips
Low emission zone scenarios

• Small LEZ
  • 13 stations:
    – 4 are existing railway stations;
    – 1 is a BRT station;
    – 8 serve the new shared mobility modes only.

• Large LEZ
  • 13 stations:
    – 6 are existing railway stations;
    – 1 is a BRT station;
    – 1 is a ferry terminal;
    – 5 serve the new shared mobility modes only.
### Changes in vehicle-kilometres, CO₂ emission and congestion compared with the baseline (%)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Vkm</th>
<th>CO₂</th>
<th>Congestion</th>
<th>Motorised vehicle fleet (equivalent private car vehicles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-51.4</td>
<td>-54.4</td>
<td>-49.1</td>
<td>-92.8</td>
</tr>
<tr>
<td>2</td>
<td>-50.6</td>
<td>-53.3</td>
<td>-49.8</td>
<td>-92.9</td>
</tr>
<tr>
<td>3</td>
<td>-21.5</td>
<td>-22.7</td>
<td>-17.1</td>
<td>-31.7</td>
</tr>
<tr>
<td>4</td>
<td>-14.0</td>
<td>-14.6</td>
<td>-7.8</td>
<td>-11.1</td>
</tr>
<tr>
<td>5</td>
<td>-50.9</td>
<td>-53.9</td>
<td>-48.2</td>
<td>-92.9</td>
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<tr>
<td>6</td>
<td>-14.1</td>
<td>-14.7</td>
<td>-8.0</td>
<td>-11.3</td>
</tr>
<tr>
<td>7</td>
<td>-12.9</td>
<td>-13.3</td>
<td>-6.1</td>
<td>-3.4</td>
</tr>
<tr>
<td>8</td>
<td>-13.7</td>
<td>-14.1</td>
<td>-6.8</td>
<td>-1.4</td>
</tr>
<tr>
<td>9</td>
<td>-7.5</td>
<td>-7.9</td>
<td>11.6</td>
<td>-1.8</td>
</tr>
<tr>
<td>10</td>
<td>-2.8</td>
<td>-3.2</td>
<td>17.7</td>
<td>-0.2</td>
</tr>
</tbody>
</table>
## Passenger-kilometres (thousands)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Shared Taxi</th>
<th>Taxi-Bus</th>
<th>Car</th>
<th>Bus + BRT</th>
<th>Ferry</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-</td>
<td>-</td>
<td>43 391</td>
<td>974</td>
<td>28</td>
<td>148</td>
</tr>
<tr>
<td>1</td>
<td>28 517</td>
<td>35 722</td>
<td>-</td>
<td>236</td>
<td>102</td>
<td>1 492</td>
</tr>
<tr>
<td>2</td>
<td>28 493</td>
<td>33 707</td>
<td>-</td>
<td>1 168</td>
<td>100</td>
<td>1 473</td>
</tr>
<tr>
<td>3</td>
<td>8 391</td>
<td>15 570</td>
<td>26 742</td>
<td>86</td>
<td>42</td>
<td>515</td>
</tr>
<tr>
<td>4</td>
<td>3 204</td>
<td>6 258</td>
<td>34 412</td>
<td>57</td>
<td>41</td>
<td>361</td>
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<tr>
<td>5</td>
<td>28 395</td>
<td>34 721</td>
<td>-</td>
<td>369</td>
<td>93</td>
<td>1 469</td>
</tr>
<tr>
<td>6</td>
<td>3 195</td>
<td>5 928</td>
<td>34 371</td>
<td>186</td>
<td>40</td>
<td>335</td>
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<tr>
<td>7</td>
<td>1 785</td>
<td>5 310</td>
<td>35 915</td>
<td>68</td>
<td>41</td>
<td>452</td>
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<tr>
<td>8</td>
<td>2 269</td>
<td>5 956</td>
<td>35 250</td>
<td>77</td>
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<td>424</td>
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<tr>
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<td>2 522</td>
<td>5 514</td>
<td>37 860</td>
<td>85</td>
<td>45</td>
<td>602</td>
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<tr>
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<td>1 661</td>
<td>3 657</td>
<td>40 702</td>
<td>69</td>
<td>43</td>
<td>454</td>
</tr>
</tbody>
</table>
Motorised mode shares

- Shared Modes
- Ferry+Rail
- Bus+BRT
- Car
Mode share between shared modes

- Taxi-Bus
- Shared Taxi
Congestion per time of day
Effective PT access to employment, (a) baseline and (b) potential of the full adoption scenario.
Operational performance

- Estimates for number of vehicles and occupancy

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Average occupancy (pax)</th>
<th>Number of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shared Taxi</td>
<td>Taxi-Bus 8</td>
</tr>
<tr>
<td>1</td>
<td>2.35</td>
<td>3.92</td>
</tr>
<tr>
<td>2</td>
<td>2.34</td>
<td>3.88</td>
</tr>
<tr>
<td>3</td>
<td>2.32</td>
<td>3.77</td>
</tr>
<tr>
<td>4</td>
<td>2.09</td>
<td>3.80</td>
</tr>
<tr>
<td>5</td>
<td>2.34</td>
<td>3.90</td>
</tr>
<tr>
<td>6</td>
<td>2.09</td>
<td>3.82</td>
</tr>
<tr>
<td>7</td>
<td>2.02</td>
<td>4.03</td>
</tr>
<tr>
<td>8</td>
<td>2.05</td>
<td>4.23</td>
</tr>
<tr>
<td>9</td>
<td>1.98</td>
<td>4.22</td>
</tr>
<tr>
<td>10</td>
<td>1.88</td>
<td>4.09</td>
</tr>
</tbody>
</table>
Changes in congestion compared with the baseline (evening peak)

- Scenario 1
- Full replacement of bus and car trips with the shared modes
Changes in congestion compared with the baseline (evening peak)

- Scenario 6
- Bus trips with headway <5 min are kept
- 20% of car trips are replaced
Changes in congestion compared with the baseline (evening peak)

- Scenario 10
- Full replacement of bus and car trips with the shared modes within the small LEZ, during peak hours
- 20% of car users start using shared modes already from the trip origin, the others: park and share
Parking requirements for the shared modes

- Distribution of depot stations (scenario 1)
Parking requirements for the shared modes

- Distribution of depot stations (scenario 6)
Park and ride stations

- Distribution of depot stations (scenario 10)
Share of empty kilometres for shared mobility services in three scenarios
Prices of Shared Taxi and Taxi-Bus services as percentage of current taxi and public transport fares (with driver operation)

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Shared Taxi (NZD/km)</th>
<th>Taxi-Bus (NZD/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average taxi trip</td>
<td>PT cost for user</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>169</td>
</tr>
<tr>
<td>6</td>
<td>22</td>
<td>186</td>
</tr>
<tr>
<td>10</td>
<td>28</td>
<td>240</td>
</tr>
</tbody>
</table>
Total commuting cost per day and km of car ownership vs Shared Taxi (scenario 1)
Impacts on present mobility key findings

- Substantial improvements (reduction of CO2, congestion, etc.).
- Large increase of access in non-private modes: spatial and social equity.
- PT users: increase in connectivity.
- Car users: increase in flexibility (i.e. freeing users from needing to drive and maintaining vehicles during their daily travels) at the price of a small penalisation of waiting and detour time.
- Potential to considerably increase rail, ferry and BRT ridership.
- Introduction of a too narrow operation area for shared mobility solutions can compromise the benefits of sharing.
- The affordability of shared mobility services is affected by the scale of adoption.
Electric vehicle fleet

Number of additional electric vehicles required compared with combustion engine vehicles (%)

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Shared Taxis</th>
<th>Taxi-Bus</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.31</td>
<td>1.10</td>
<td>1.66</td>
</tr>
<tr>
<td>6</td>
<td>7.35</td>
<td>2.38</td>
<td>3.99</td>
</tr>
<tr>
<td>10</td>
<td>10.29</td>
<td>0.32</td>
<td>4.22</td>
</tr>
</tbody>
</table>

Variation of full operational costs compared with combustion engine vehicles (%)

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Shared Taxis</th>
<th>Taxi-Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-8.84</td>
<td>-5.97</td>
</tr>
<tr>
<td>6</td>
<td>-5.52</td>
<td>-0.45</td>
</tr>
<tr>
<td>10</td>
<td>-1.33</td>
<td>3.28</td>
</tr>
</tbody>
</table>
## Scenarios for year 2046

Changes in vehicle-kilometres, CO2 emission and congestion compared with the baseline (2046) scenario (%)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Vkm</th>
<th>CO₂</th>
<th>Congestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-62.5</td>
<td>-65.1</td>
<td>-60.8</td>
</tr>
<tr>
<td>6</td>
<td>-15.1</td>
<td>-16.0</td>
<td>-9.1</td>
</tr>
<tr>
<td>10</td>
<td>-4.9</td>
<td>-6.0</td>
<td>12.2</td>
</tr>
</tbody>
</table>

Passenger-kilometres (thousands)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Shared Taxi</th>
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<th>Car</th>
<th>Bus + BRT</th>
<th>Ferry</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-</td>
<td>-</td>
<td>53 622</td>
<td>3 759</td>
<td>5</td>
<td>688</td>
</tr>
<tr>
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<td>37 640</td>
<td>28 130</td>
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<td>79</td>
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<td>1 895</td>
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<td>11 211</td>
<td>43 143</td>
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<td>136</td>
<td>1 002</td>
</tr>
<tr>
<td>10</td>
<td>2 752</td>
<td>9 548</td>
<td>48 619</td>
<td>34</td>
<td>147</td>
<td>1 222</td>
</tr>
</tbody>
</table>
Congestion by the time of day

[Graph showing congestion levels by time of day with different lines representing various categories like BL2013, BL2046, S1, S6, and S10.]
Impacts on future mobility key findings

• Substantial improvements to the city and its transport system
• The reductions in all the future scenarios are greater than the corresponding reductions in the present scenarios.
• The larger population density will lead to a more efficient operation of shared mobility services
• The congestion levels will increase in 2046, especially for the peak hours
• Introduction of shared mobility can largely increase rail, ferry and BRT ridership
• Higher and denser mobility demand in the future produces greater operational efficiency for shared mobility services
Recommendations

• Consider integrating shared mobility services into Auckland’s existing transport offer
• Use shared services as feeder service for train, ferry and bus rapid transit services to increase use of public transport
• Ensure shared mobility services are provided in a large enough area of Auckland
• Target shared mobility services for potential early adopters
• Integrate land use and transport policies to limit urban sprawl and support the uptake of shared mobility services
• Create a legal and regulatory framework focused on delivering societal benefits from uptake of shared mobility services
Further research needs

• Model assumes static demand patterns. Does not take into account changes induced to travel behaviour.

• In the simulation there is no dynamic analysis into the effects shared mobility might have on the soft modes.

• A more dynamic and flexible mobility offer will have to be accompanied by equally flexible public space policies.

• Business models of the new services.

• A complete toolbox including economic, infrastructure, regulatory and procurement tools is required to manage the transition to the digital age mobility services.
Thank you