Workshop on Low Carbon Mobility: Greening Suburban Travel

Plant 1 Bowden, 16 Park Terrace, Bowden South Australia
Thursday 8 December 2016 (9:00 am – 4:00 pm)

This workshop is part of a research project currently being undertaking for the CRC for Low Carbon Living. The aim of the workshop is to share knowledge and insights about case studies, initiatives and on-going research relating to improving mobility and reducing transport emissions for low density suburban areas that are currently car dependent.

Thursday 8 December 2016

09.00am–10.30am	**Session 1** **Welcome and workshop opening** *Professor Wasim Saman, University of South Australia* **Keynote address: A snapshot of active transport usage in Melbourne** *Professor Michael Taylor, University of South Australia* **Infrastructure Victoria 30 year strategy: implications for low carbon mobility** *Jeremy Whiteman, Infrastructure Victoria* **Modelling transport mode choices for the Monash National Employment Cluster** *Stephen Cook, CSIRO* **What would make SNAMUTS go green in Melbourne's south-east?** *John Stone and Jana Perkovic , University of Melbourne*
10.30am–11.00am	**Morning tea**
11.00am–12.30pm	**Session 2** **Applying Intelligent Transport Systems to low density areas for low carbon living** *Philip Blake, Department of Planning, Transport and Infrastructure, South Australia* **Travel demand analysis – data collection update** *Sekhar Somenahalli, University of South Australia* **Barriers and opportunities for greening suburban travel** *Karen Wright, Swinburne University of Technology* **Synthesis of CRC Low Carbon Living Research – University of South Australia** *Stephen Berry, University of South Australia* **Bowden's sustainable transport solutions** *Andrew Bishop, Renewal South Australia*
12.30pm–01.00pm	**Lunch**
01.00pm–02.30pm	**Session 3** **When will electric vehicles start to reduce our transport emissions?** *Alan Richards, Low Carbon Economy Unit, Department of the Premier and Cabinet, South Australia* **Sustainable low carbon transport - current situation, trends and best practices** *Callum Sleep, University of South Australia* **Bus-based TOD: Challenges & opportunities for car dependent cities** *Munshi Nawaz, University of South Australia* **Higher density developments in Adelaide: Residents' perceptions in rail corridors** *Li Meng, University of South Australia* **Shared mobility and self-driving vehicles: Shaping the future of suburban travel** *Hussein Dia, Swinburne University of Technology*
02.30pm–03.00pm	**Afternoon tea**
03.00pm–04.00pm	**Session 4** **Hydrogen mobility and economy: opportunities for personal, public & freight transport** *Scott Nargar (Hyundai) and Mario Filipovic (Toyota)* **Demonstrations of hydrogen fuel cell vehicles**
04.00pm	**Closing**

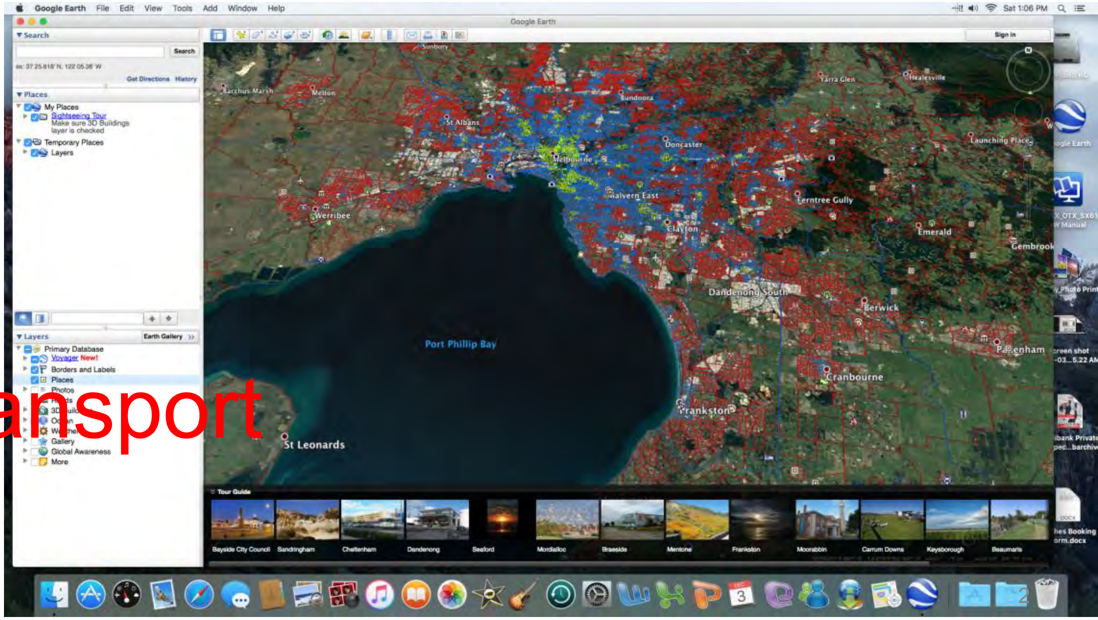
A snapshot of active transport usage in Melbourne

Michael A P Taylor
School of Natural & Built Environments
University of South Australia

8 December 2016

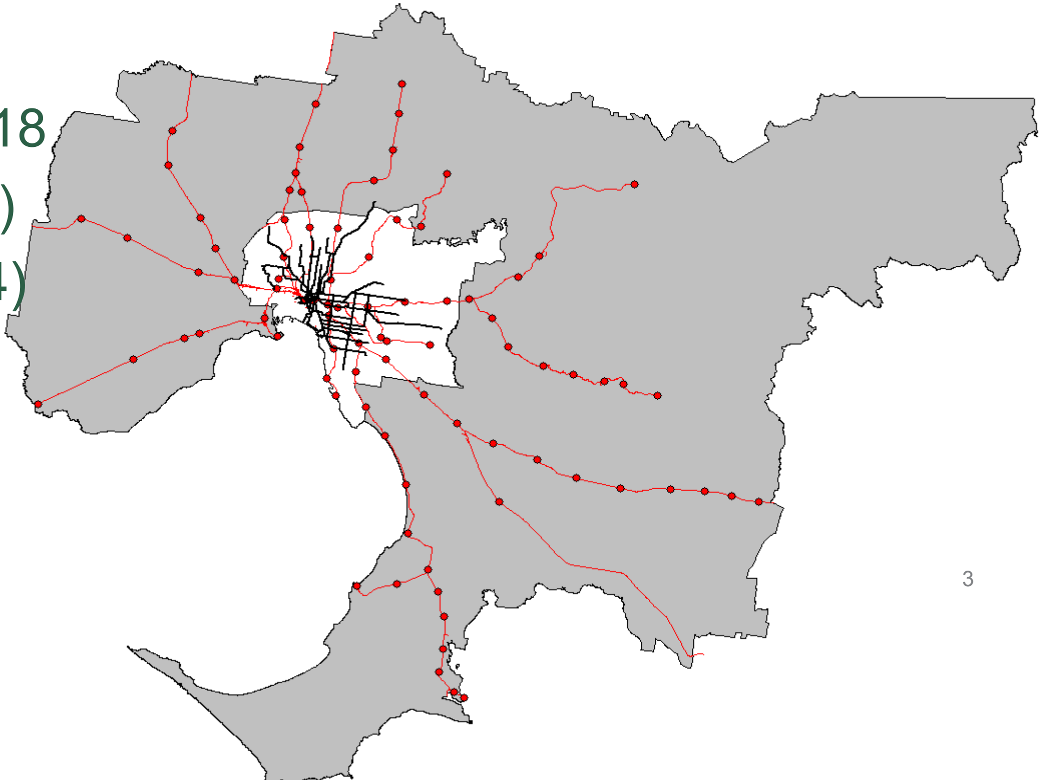
Overview

- CRC LCL project RP2015 (carbon reductions and co-benefits)
- Analysis of VISTA 2010 data for Melbourne (MSD)
  - 3.544M people
  - 1.358M households
  - 19.27 VKT/day pc
  - 0.61 VHT/day pc
  - 31.70 PKT/day pc
  - 1.16 PHT/day pc
- Focus on active transport



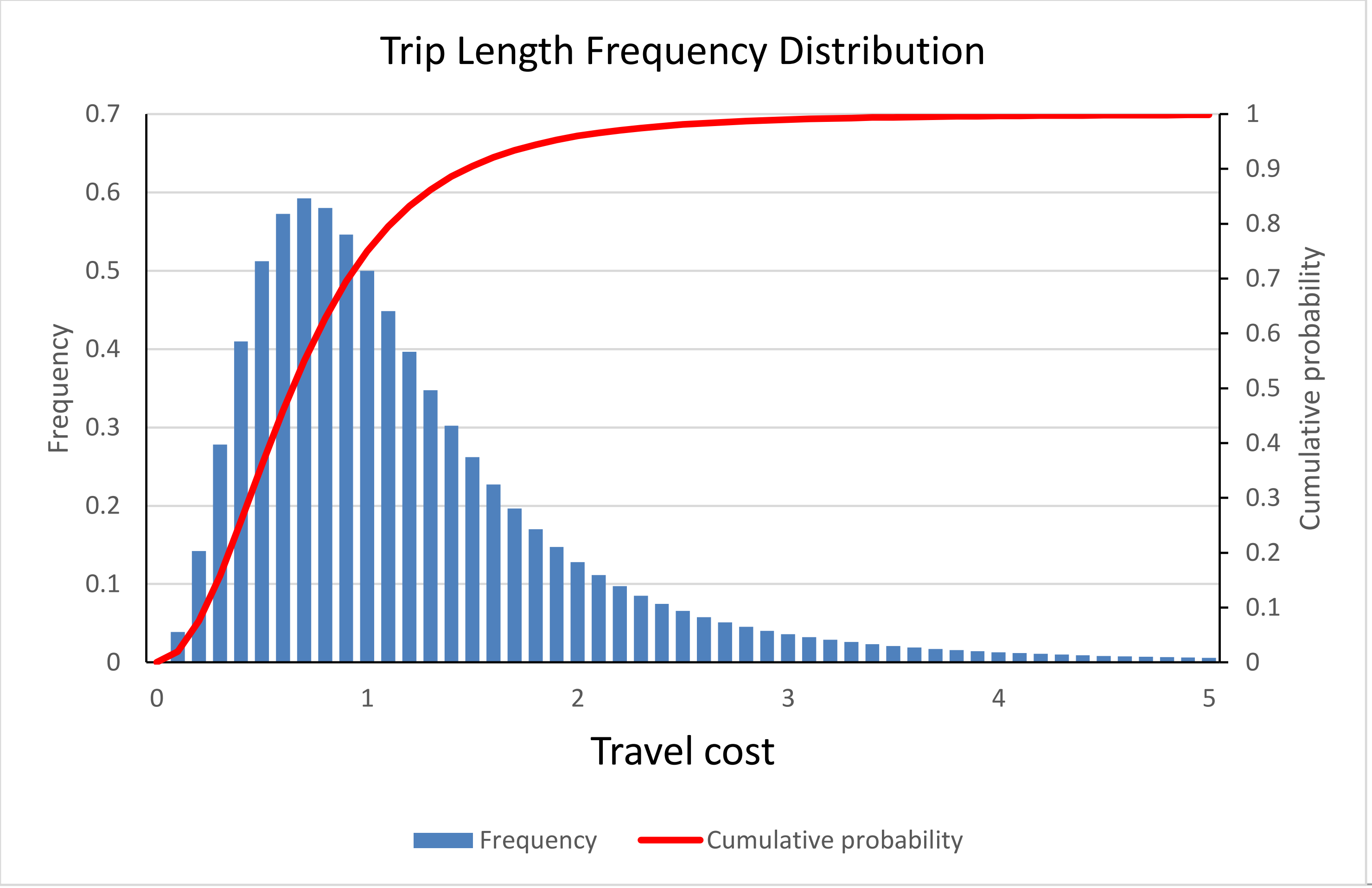
PTAL: Public Transport Accessibility Levels

- PTAL index developed by Transport for London, considers
  - Walking time to access
  - Reliability of services
  - No of available services
  - LoS at access point (av waiting time)
- Melbourne – 2 distinct regions (*on LGA basis*)
  - Inner & Outer
    - Metro average PTAL =3.18
    - Inner min 3.46 (max 7.27)
    - Outer max 2.88 (min 0.64)



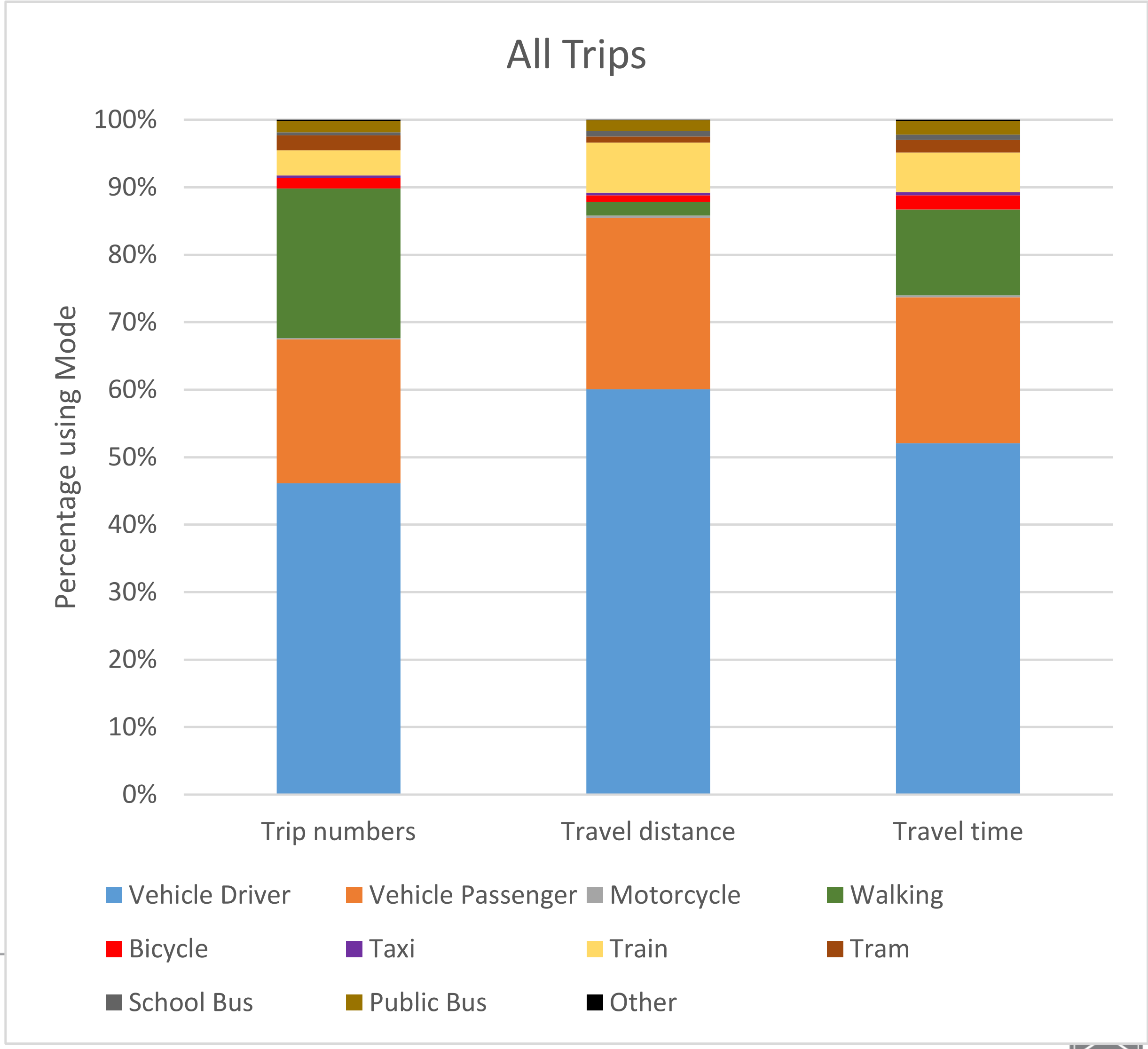
TLFD = Trip Length Frequency Distribution

- A useful summary of travel behaviour
- Indicates distribution of travel in terms of travel cost



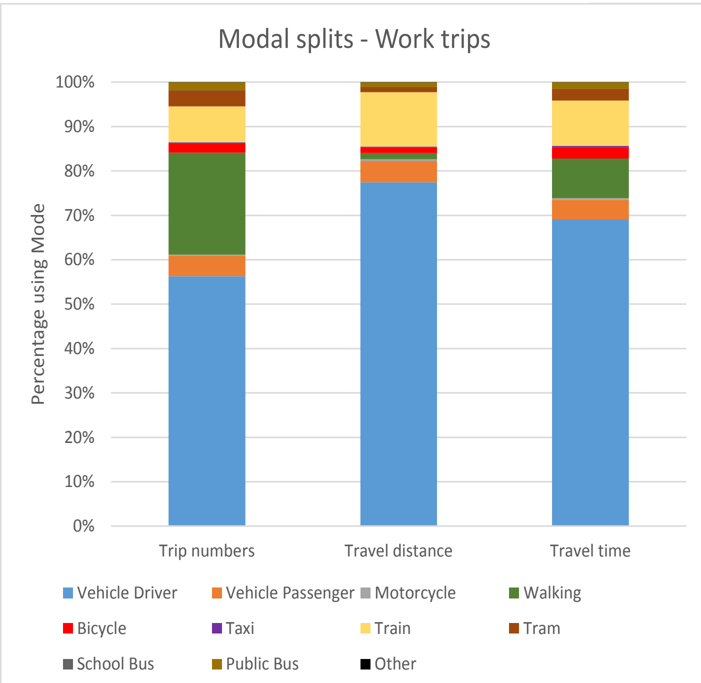
Travel in Melbourne 2010: modal splits

Trip numbers (stops) = decisions   PKT (distance) = effort   PHT(time) = exposure

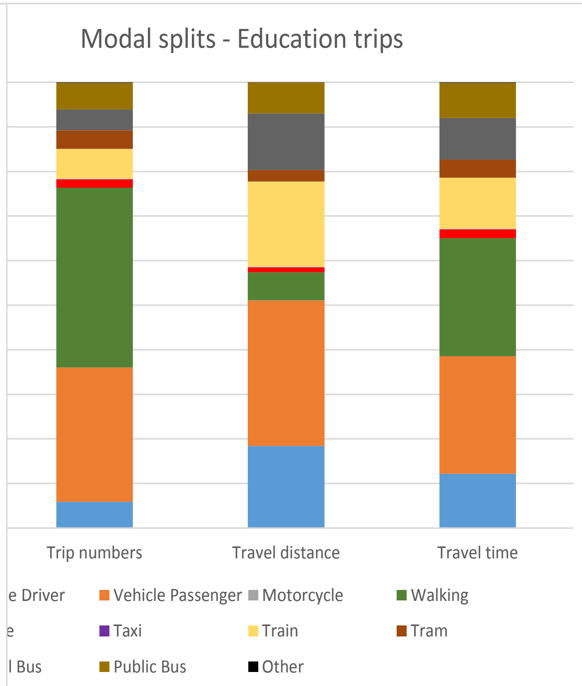


Travel in Melbourne 2010: modal splits for some trip purposes

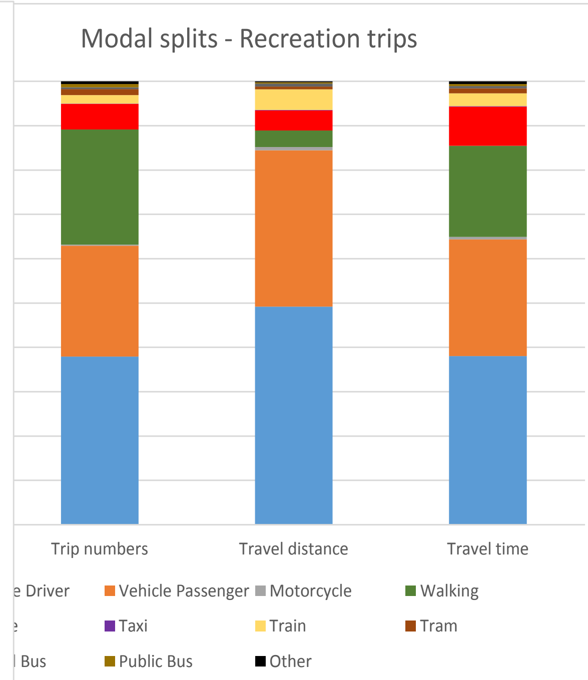
Trip numbers (stops) = decisions   PKT (distance) = effort   PHT(time) = exposure



Work



Education



Recreation

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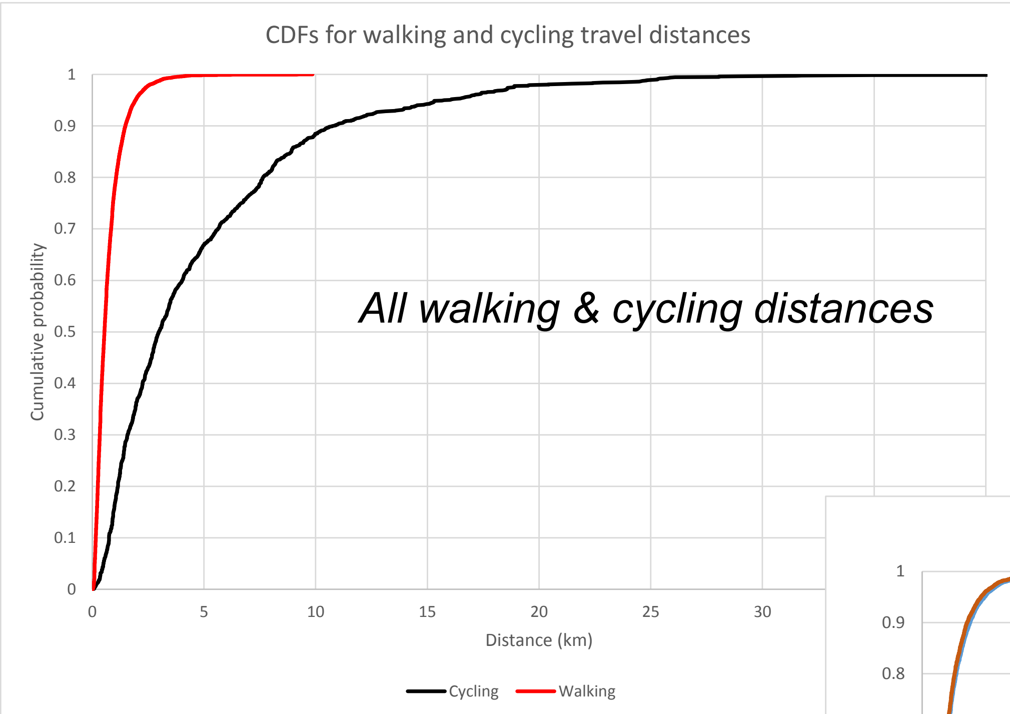
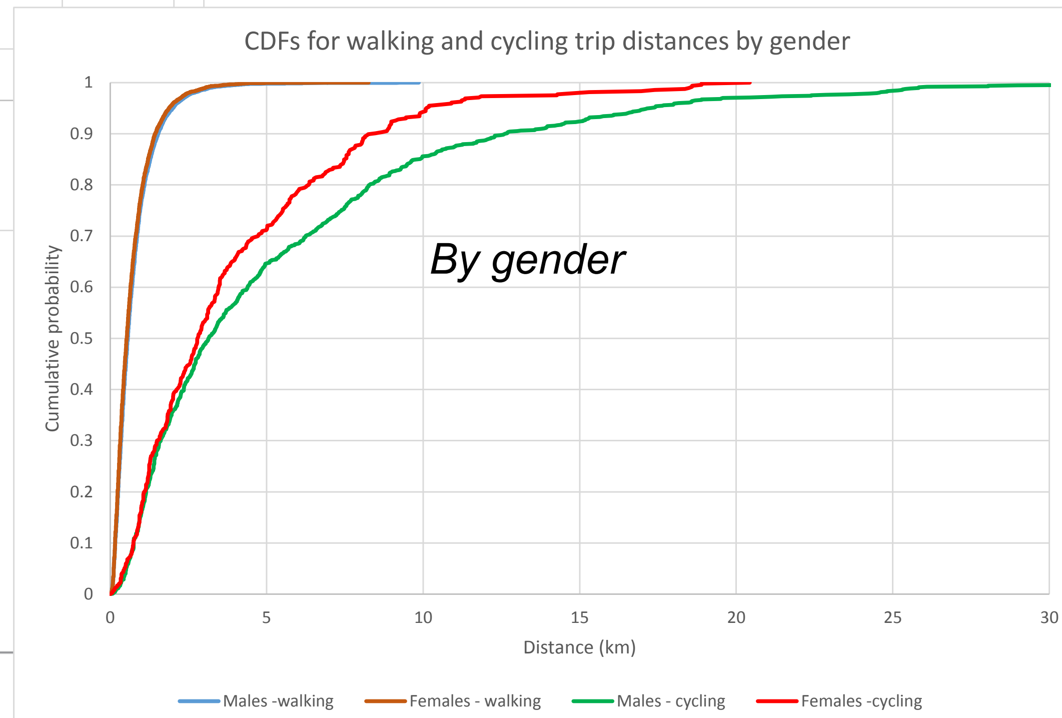
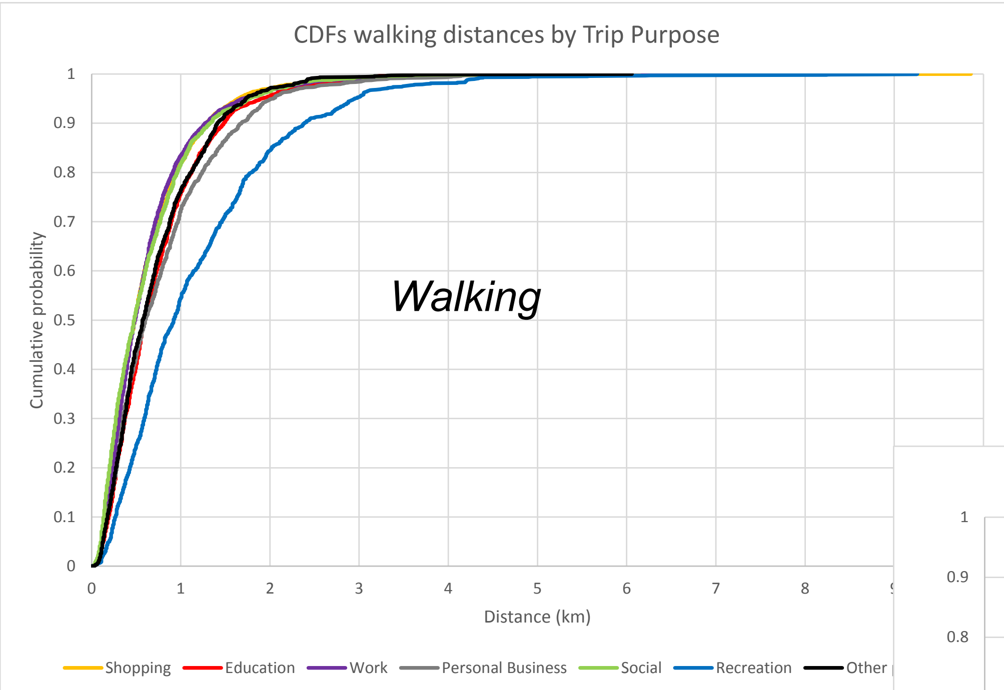
TLFD: walking & cycling



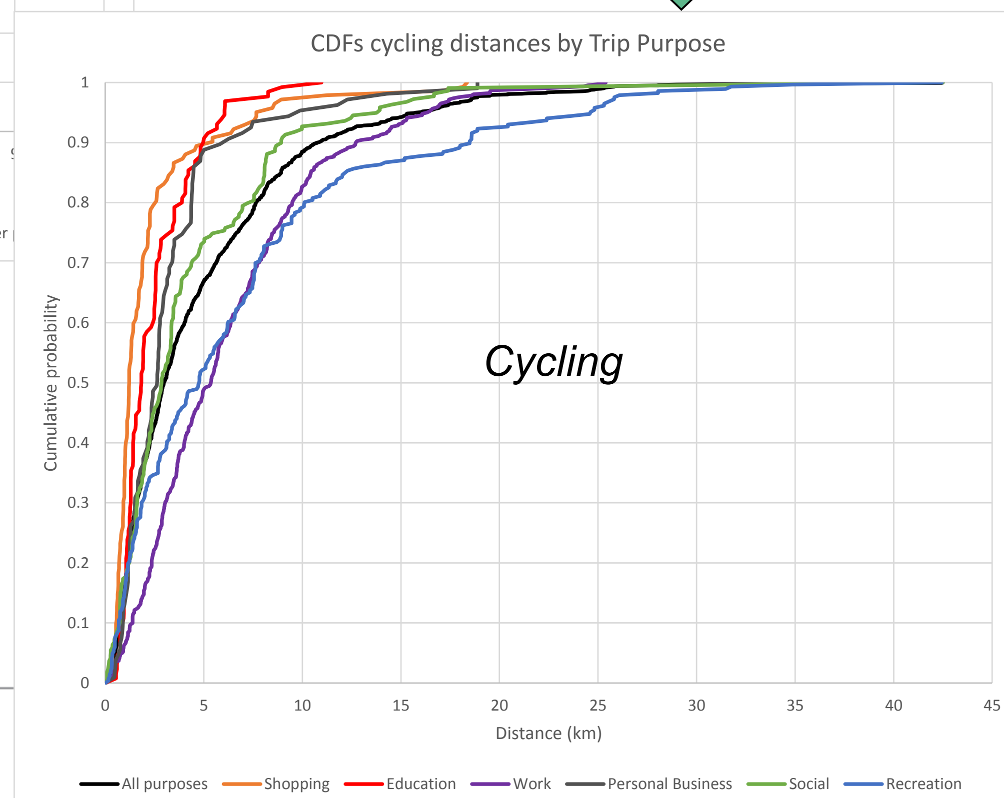


TLFD: walking & cycling by trip purpose



Shopping
Education
Work
Personal business
Social
Recreation
Other

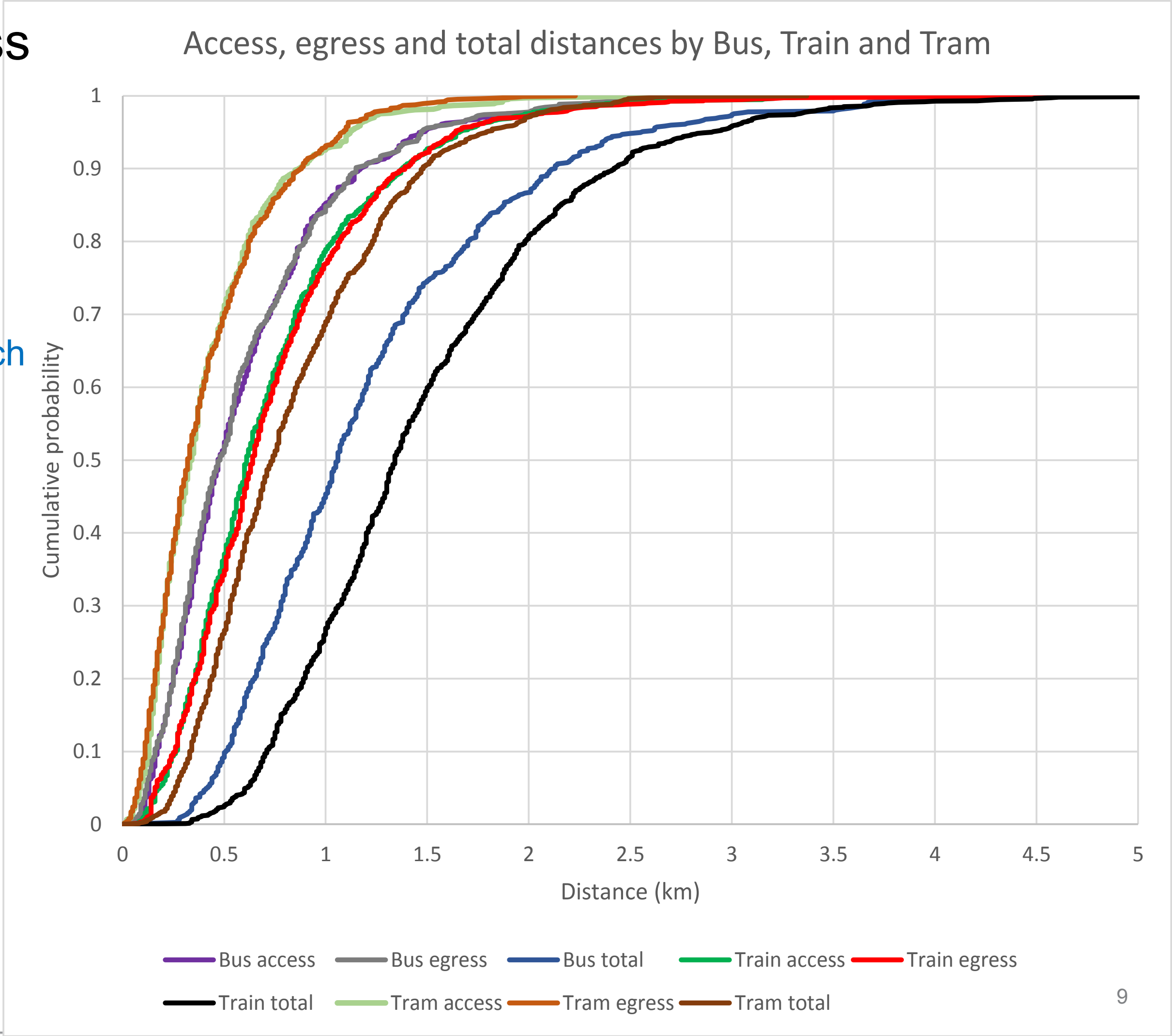
All
Shopping
Education
Work
Personal business
Social
Recreation



Public transport access

A key component of active transport

- Pedestrian access, egress & total walking distances
- For train, tram and public bus modes
  - tram < bus < train
  - similar access & egress for each mode



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Public transport access: percentile walking distances (km)

Comparing all walking trip segments with transit access segments

Percentiles	All walking	Public transport					
		Train		Bus		Tram	
		Access	Egress	Access	Egress	Access	Egress
25th	0.29	0.39	0.30	0.29	0.28	0.19	0.18
median	0.54	0.61	0.64	0.47	0.48	0.34	0.32
75th	0.93	0.94	0.96	0.81	0.80	0.56	0.56
85th	1.24	1.19	1.21	0.99	1.02	0.71	0.73
90th	1.48	1.30	1.30	1.17	1.17	0.86	0.87

10,000 steps? … Contributions to healthy activity …

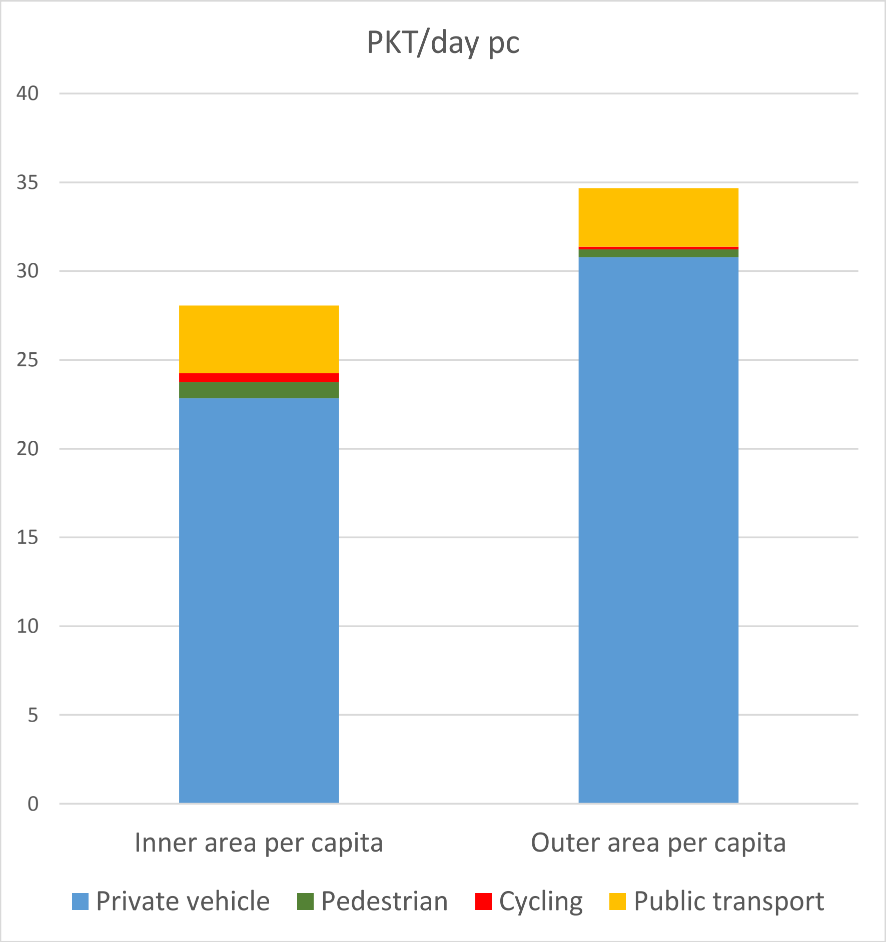
Daily walking activity: accessing public transport, and all walking (daily travel)

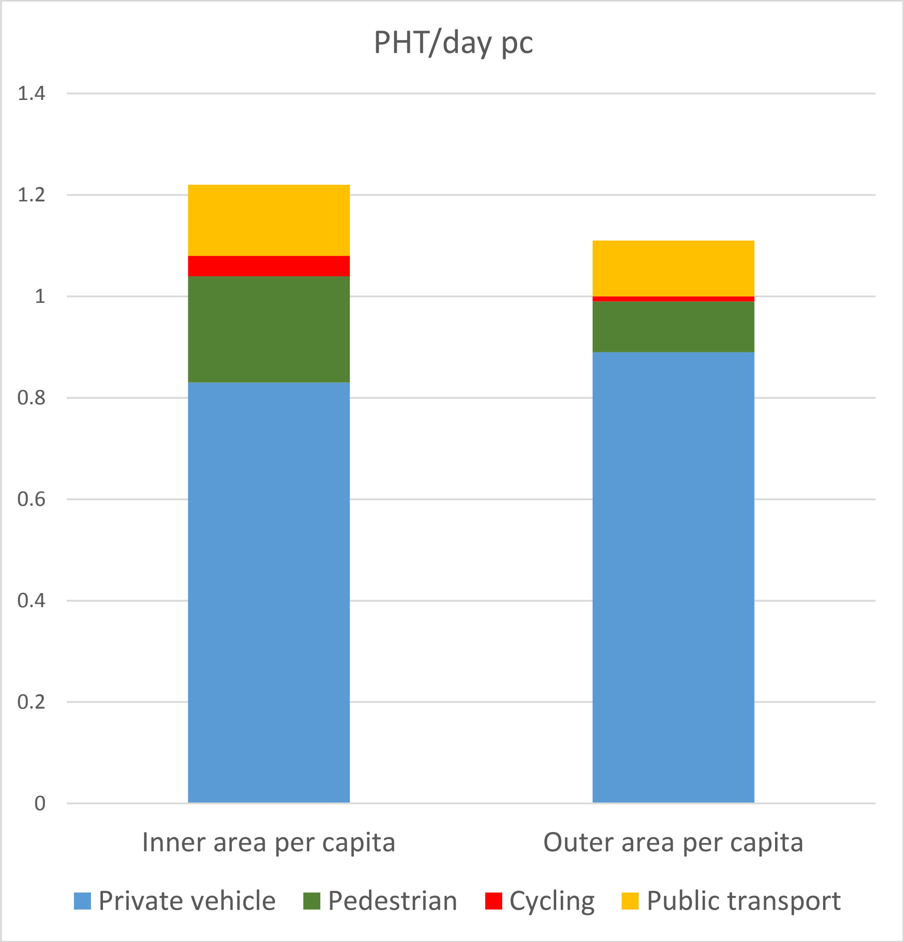
	Train		Tram		Public bus	
	Distance (km)	Steps	Distance (km)	Steps	Distance (km)	Steps
Median	1.34	1828	0.74	1010	1.06	1446
75th percentile	1.87	2552	1.11	1515	1.52	2074
90th percentile	2.42	3302	1.48	2019	2.12	2893

Travel descriptor	Walking (person-km/day)	Walking (person-steps/day)	Walking time (person-min/day)
Summary statistics			
Sample size	6393	6393	6393
Mean	2.25	3070	31.0
Standard deviation	1.77	2415	23.3
Coeff of variation	78.9%	78.7%	75.3%
Mode	0.50	682	20.0
Percentiles			
10th	0.53	723	10.0
15th	0.69	941	10.0
25th	1.00	1364	15.0
50th (median)	1.82	2483	25.0
75th	2.97	4052	40.0
85th	3.79	5171	50.0
90th	4.47	6099	60.0
100th (maximum)	18.51	25255	240.0

Step stride parameters from Morency, C, Trepanier, M & Demers, M (2011). Walking to transit: an unexpected source of physical activity. *Transport Policy 18*, pp.800–806

PTAL and Melbourne regions: PKT and PHT pc





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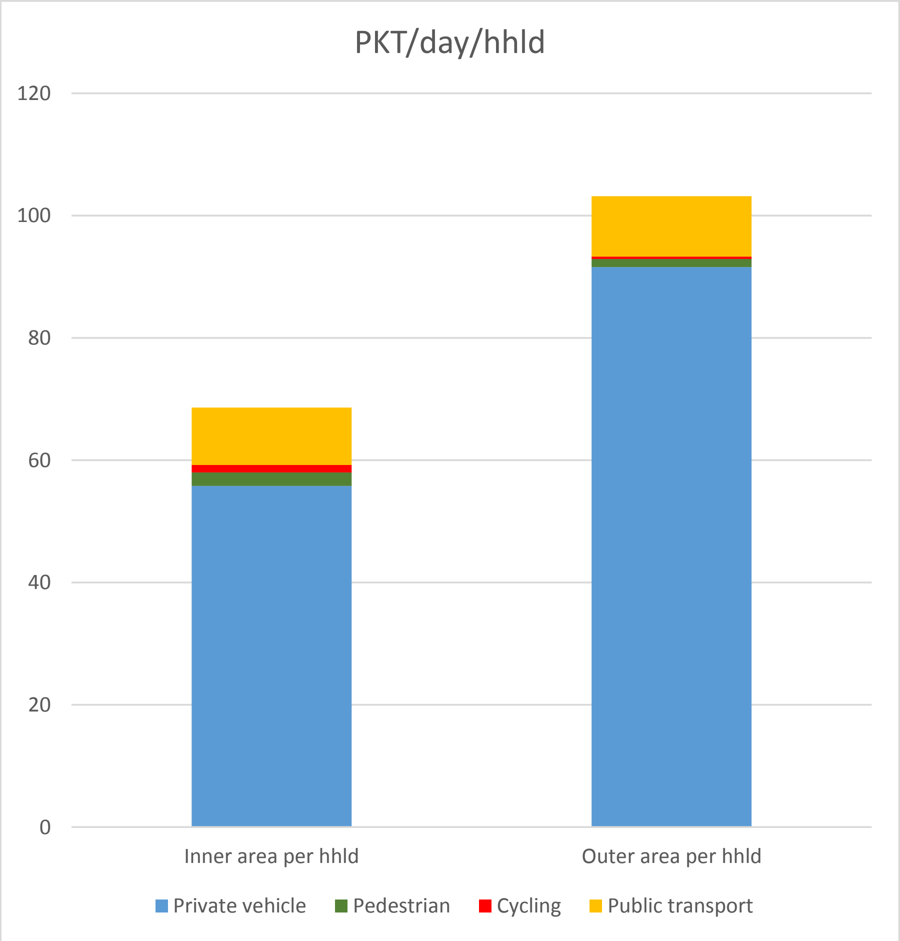
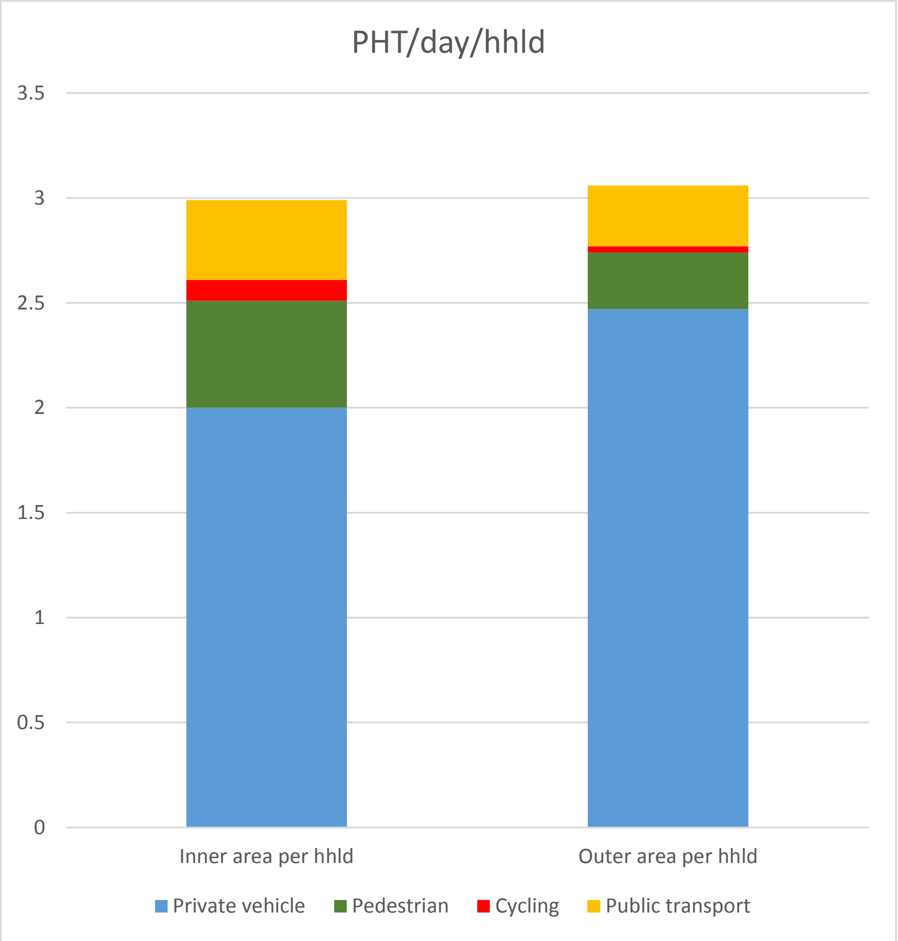
PTAL and Melbourne regions: *and* PKT and PHT per hhld





Thank you

Reference: at the CRC website, report
RP2015: Carbon Reductions and Co-benefits: Final Report – Part II An analysis of current levels active transport usage in Australia – towards a measure of baseline activity

To find out more, contact:

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Infrastructure Victoria's 30 year strategy: Implications for low carbon mobility

Jeremy Whiteman

WHAT DOES INFRASTRUCTURE VICTORIA DO?

1. 30-year infrastructure strategy
2. Independent advice to government
3. Research

INFRASTRUCTURE VICTORIA

SOLUTIONS FOR CHALLENGES


Deloitte.
Infrastructure Capability Assessment
Transport
Infrastructure Victoria
aurecon
KPMG
ARUP JAC
Preliminary Demand Modelling and
The Current and Future State of Victoria: a spatial perspective
Advice to Infrastructure Victoria
AECOM pwc
Technical Report
Infrastructure Victoria's Draft 30-Year Infrastructure Strategy
Assessment 3
Advice to Infrastructure Victoria
23 September 2016
Infrastructure Victoria Regional Citizen Jury Report
Our view of what we should do to meet Victoria's infrastructure needs
Cultural, civic, sporting, recreation and tourism
Education and training
Energy
Information and communications technology
Health and human services
Justice and emergency services
Science, agriculture and environment
Transport
Water and waste
Recommendations for consideration for Victoria's 30-year infrastructure strategy
30 July 2016
Regional Citizen Jury report
1
CITIZEN JURY
METROPOLITAN
Infrastructure Recommendations

Integrated land use and transport

- Apply planning provisions that enable medium density residential development on land near existing infrastructure, such as public transport (**UDC**)
- Prioritise transit-oriented development in and around National Employment Clusters, such as Latrobe, Sunshine and Monash, major regional employment centres & Metropolitan Activity Centres (**STO**)

Promoting Active Transport

- Design measures and supporting infrastructure to promote walking and cycling in established neighbourhoods (e.g. retrofitting walk & cyclability) (**AEA**)
- Develop a stronger high-quality, dedicated strategic cycling network (**BWP1-3**)
- Improve end-of-trip facilities (**ALR**)

A better integrated, multimodal transport system

- A variety of options improving and expanded on-road public transport (e.g. buses and trams)
- Major network rail improvements beyond Melbourne Metro 1 (e.g. Melton electrification, station upgrades, HCS, etc.)
- Introduction of a network pricing regime to manage demand and reform cost recovery within 15 years (**TNP**)

Preparing for advanced & emerging transport technologies and services

- Removing regulatory barriers to trialling and deployment of ADAS, connected and automated passenger and freight vehicles, including the development of national standards (**ACT**, **ADA**, **DFV**)
- Removing regulatory barriers to the development of Mobility-as-a-service models (**MAS**) to widen transport options and reduce the need for private car ownership

Keep in touch

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INFRASTRUCTURE VICTORIA

Modelling transport mode choices for the Monash National Employment Cluster

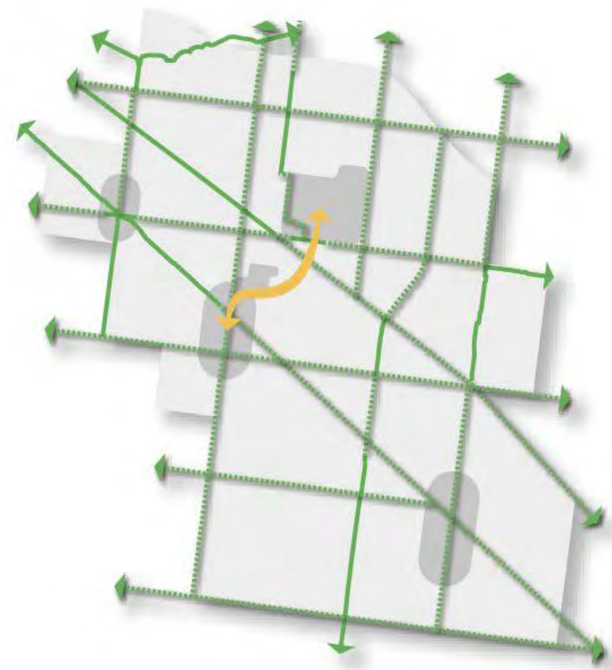
Greening Suburban Transport

Stephen Cook, Sorada Tapsuwan and Magnus Moglia

CSIRO

Research Question

How can we model the uptake of low carbon transport modes in a suburban context under different investment options in a way that considers realistic models for commuter behaviour, and their responses to both demand and supply interventions?



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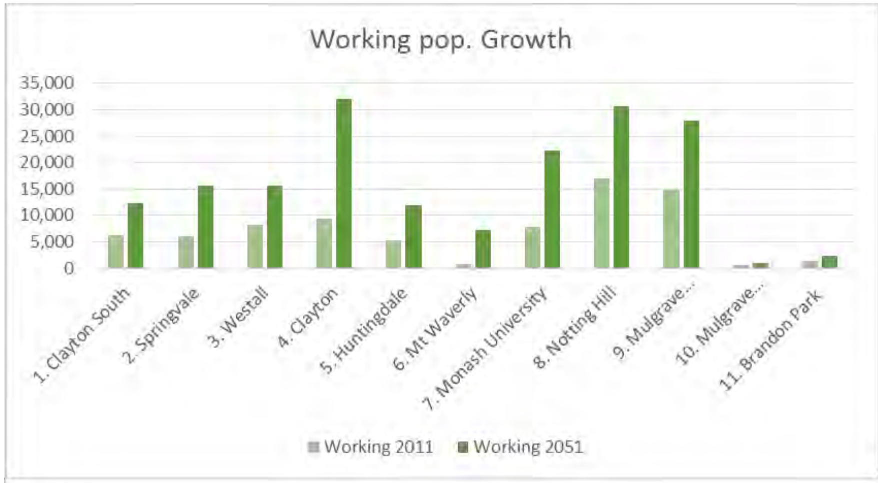
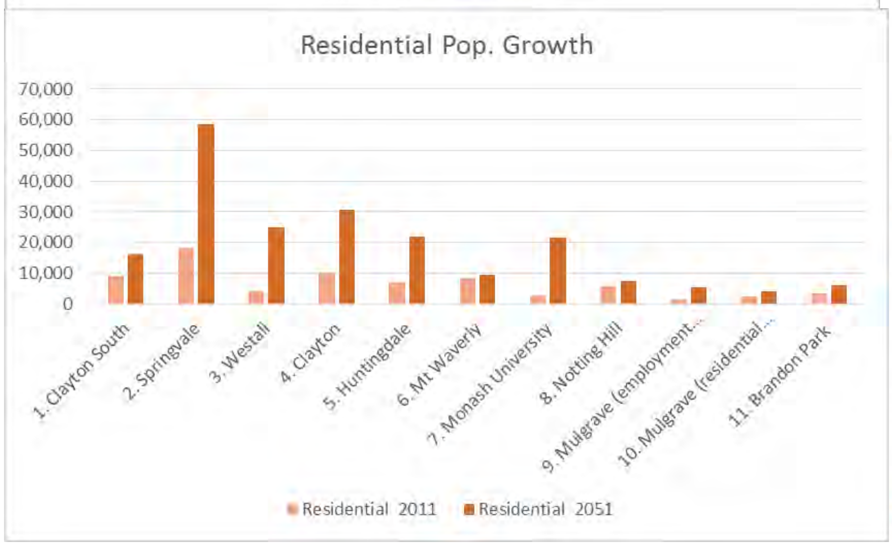
Project activities

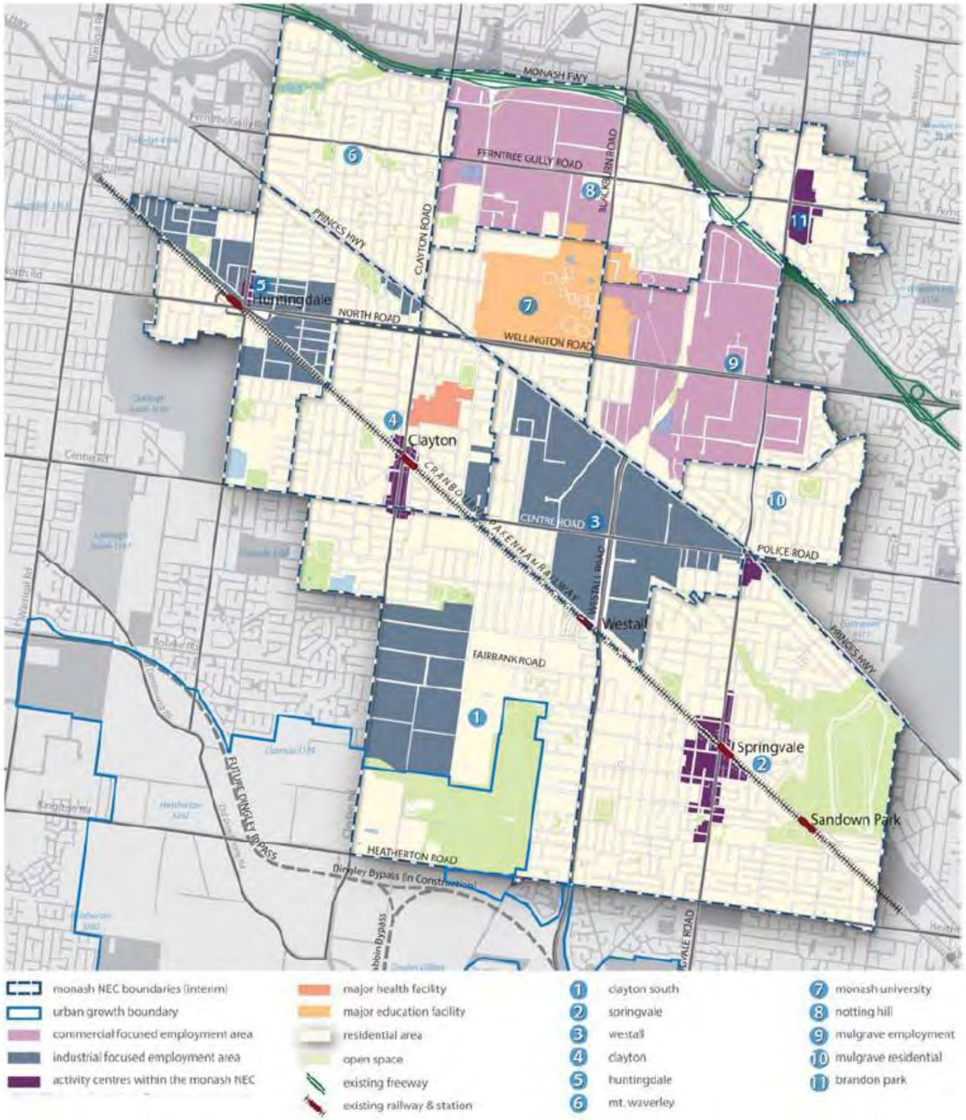
- Literature review
  - Review of international best practices and trends for the adoption of low carbon transport modes in suburban contexts
  - Identify theoretical and modelling frameworks to better understand and simulate travel mode choice
- Case Study
  - Monash National Employment Cluster (data analysis and stakeholder engagement)
- Decision Framework
  - Adaptive choice-based conjoint analysis
  - Agent based model

Case Study – Monash National Employment Cluster

Monash NEC – Current profile and projected growth by precinct







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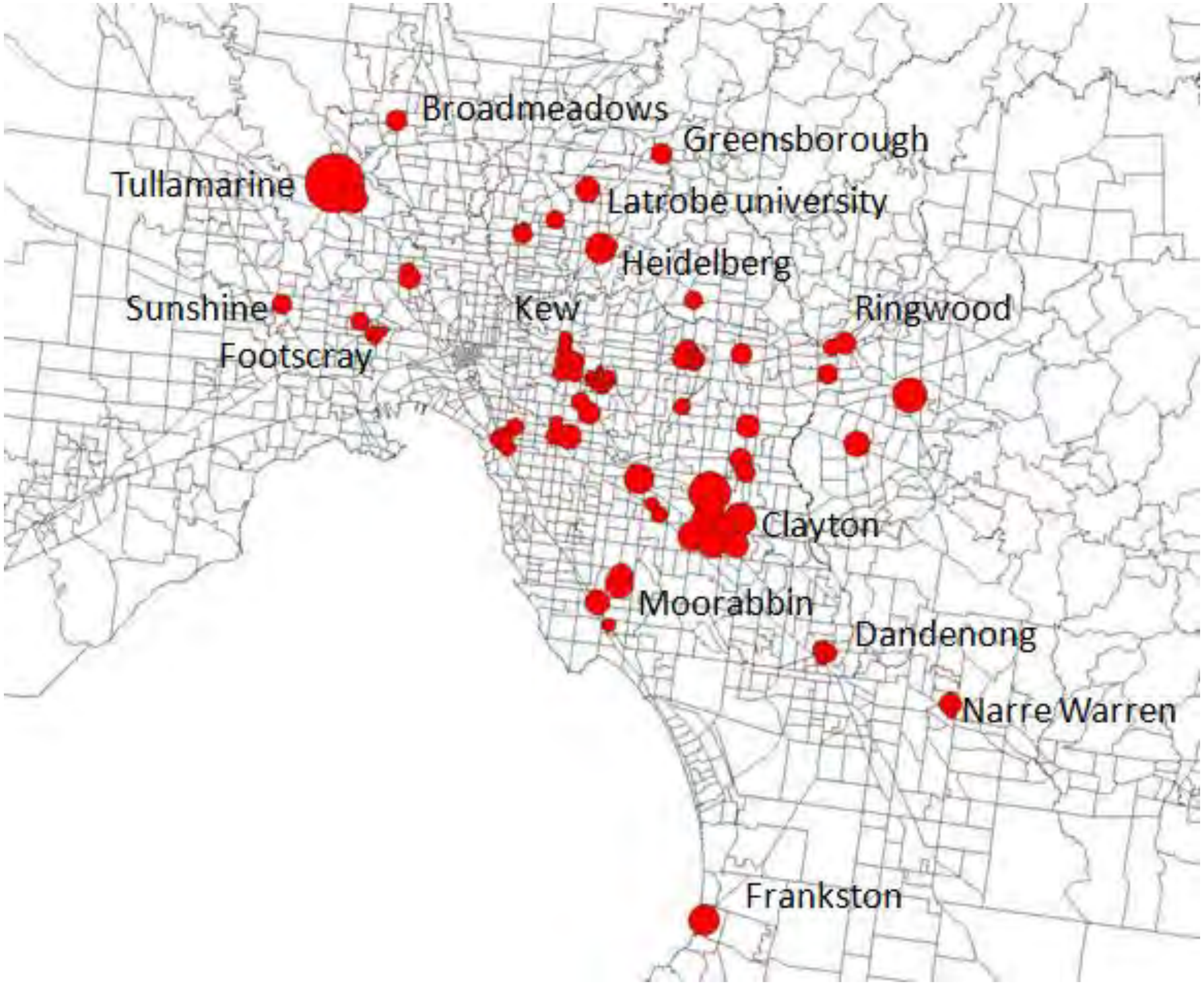
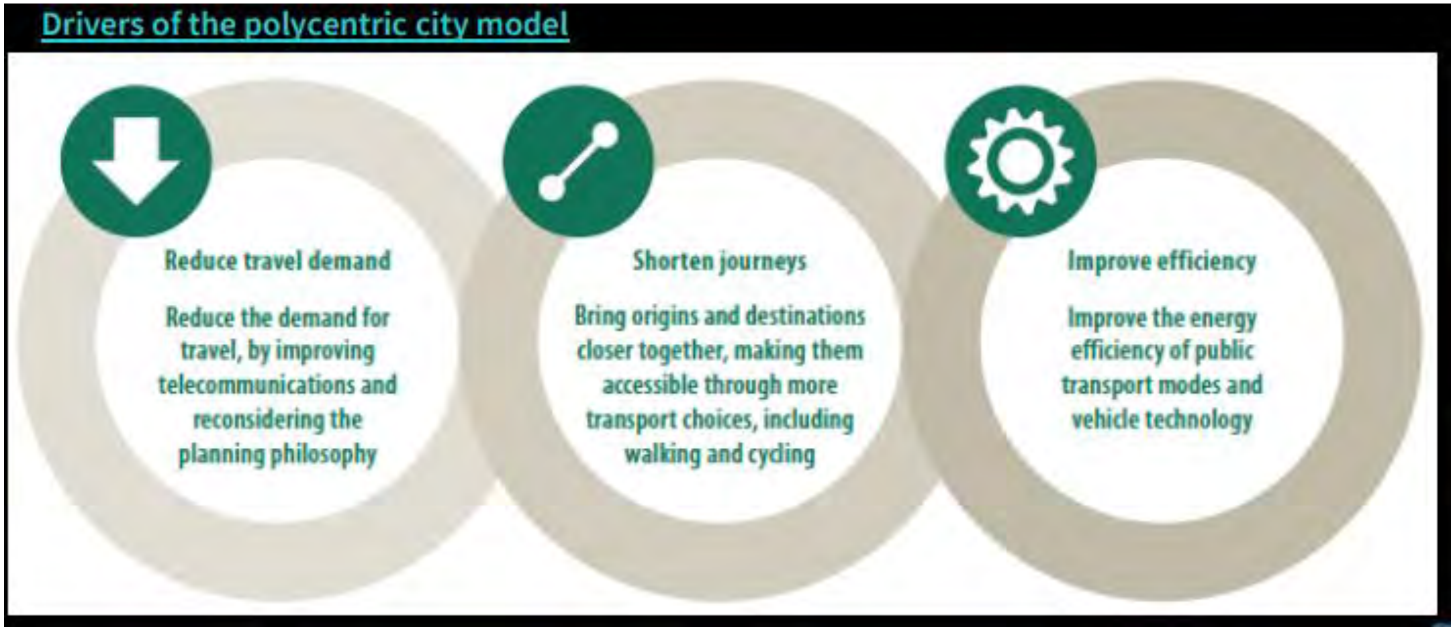
Suburban Employment Clusters – Vision for a Polycentric Melbourne



Source: https://melbourneurbanist.com/category/employment/page/2/

Transport Drivers for Polycentric City



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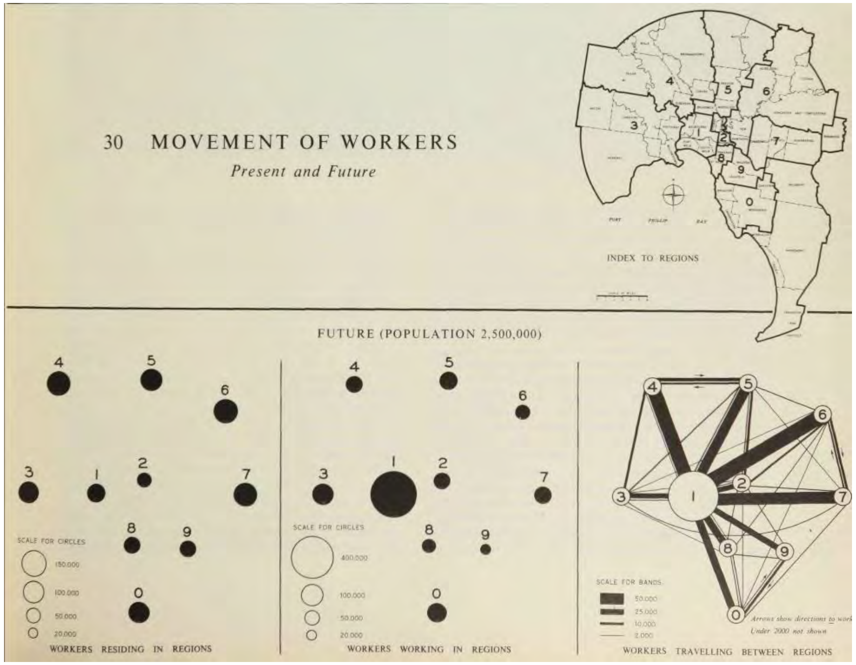
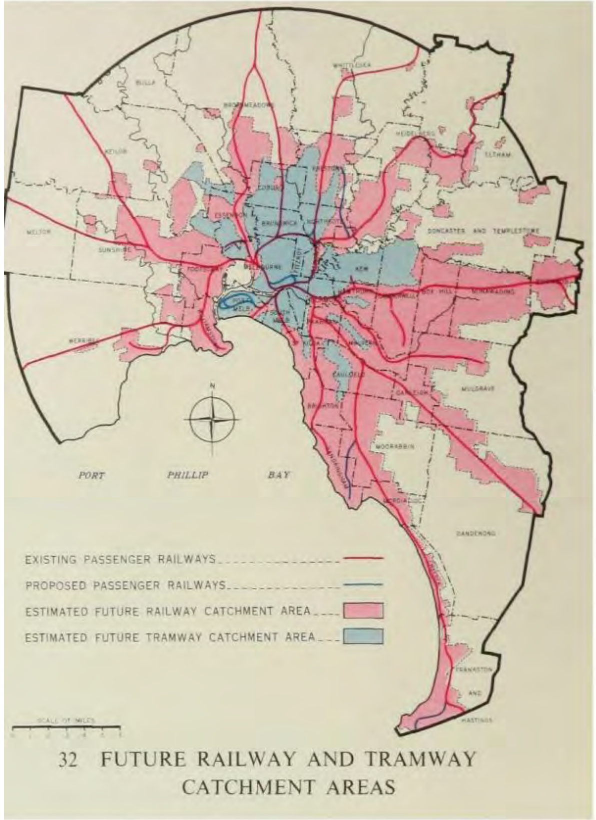
1 – Dunn, S. (2016) Delivering a polycentric city, PIA Congress, Metropolitan Planning Authority

History repeating – Melbourne Metropolitan Planning Scheme 1954

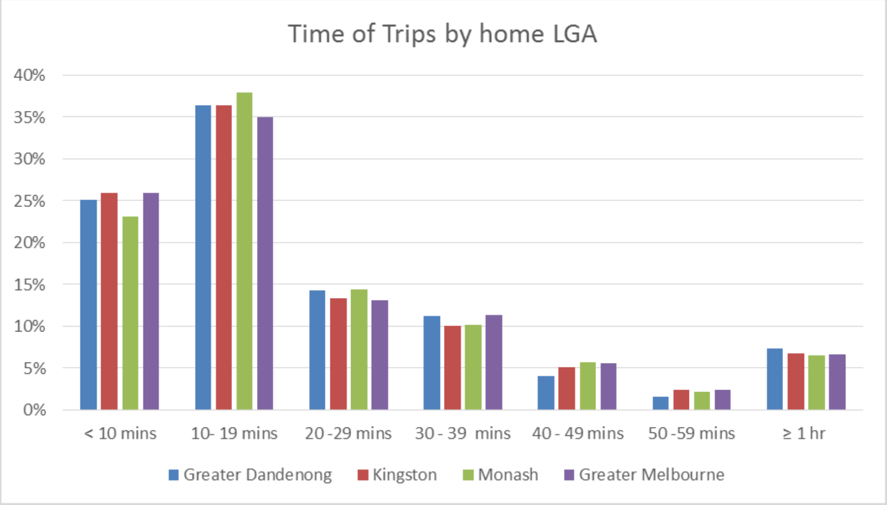


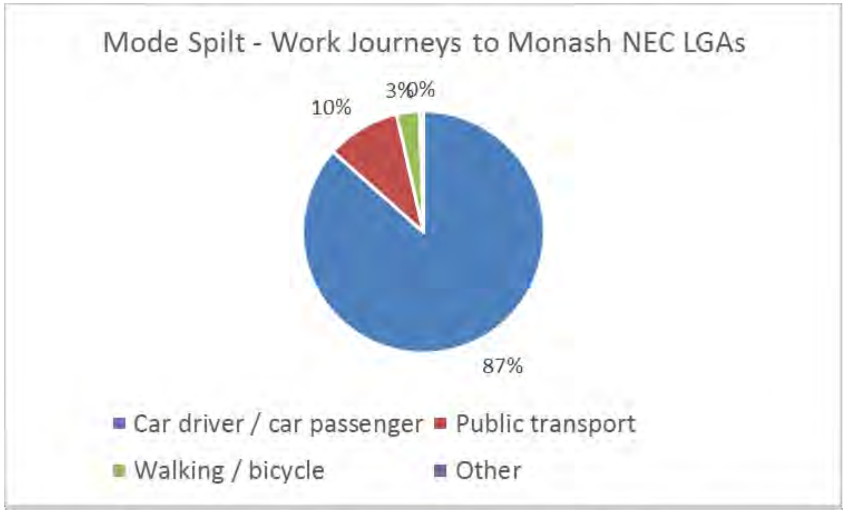


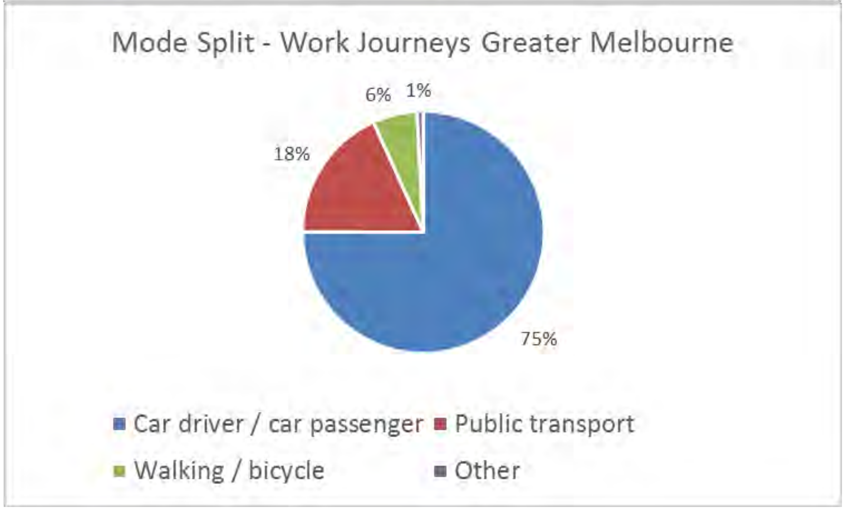
http://www.dtpli.vic.gov.au/planning/plans-and-policies/planning-for-melbourne/melbournes-strategic-planning-history/melbourne-metropolitan-planning-scheme-1954

Monash NEC – Current travel patterns

- Around 33% of workers in the Monash NEC travel from intersecting LGAs (Dandenong, Monash & Kingston)







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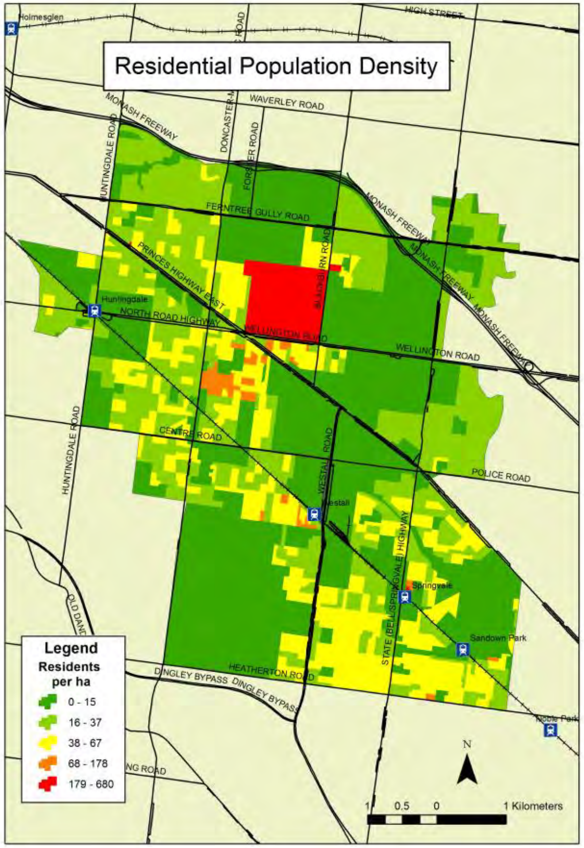
Current impediments to adoption of low-carbon transport modes

- Traffic congestion
- Lack of rapid public transport options
- Lack of active transport connectivity
- Low residential population density
- Lack of mixed land use



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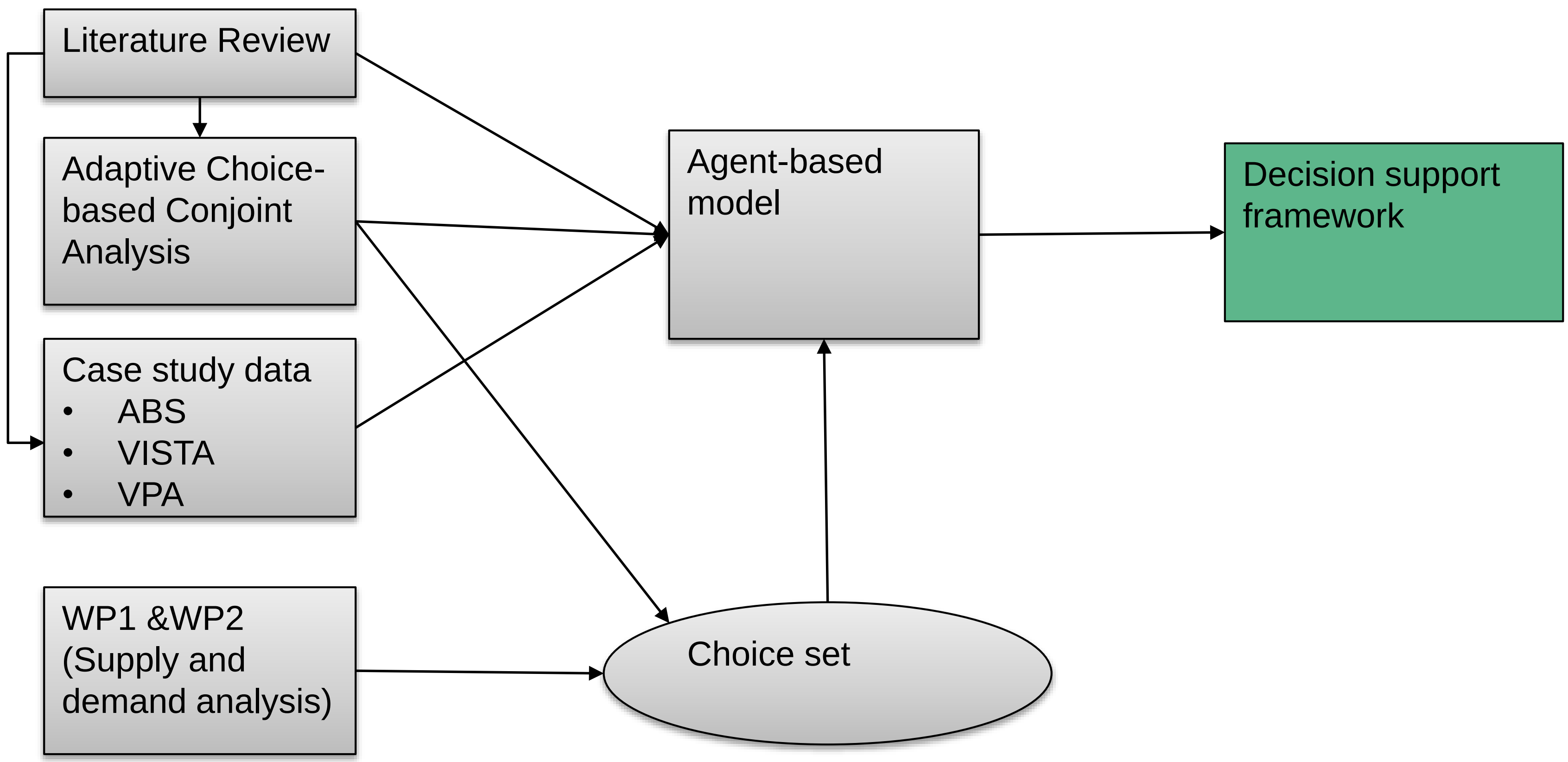
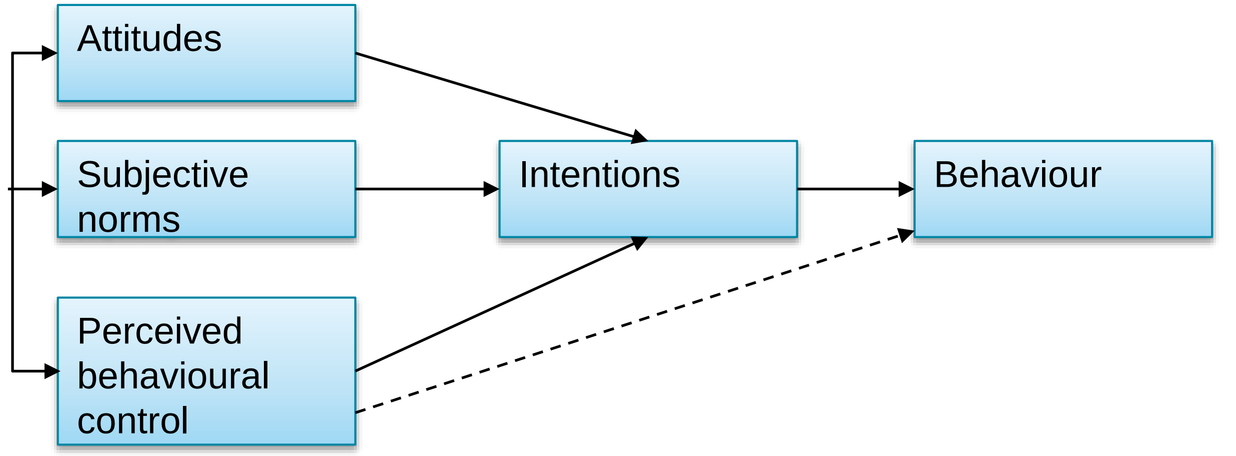
Modelling adoption of low carbon transport modes

Method overview



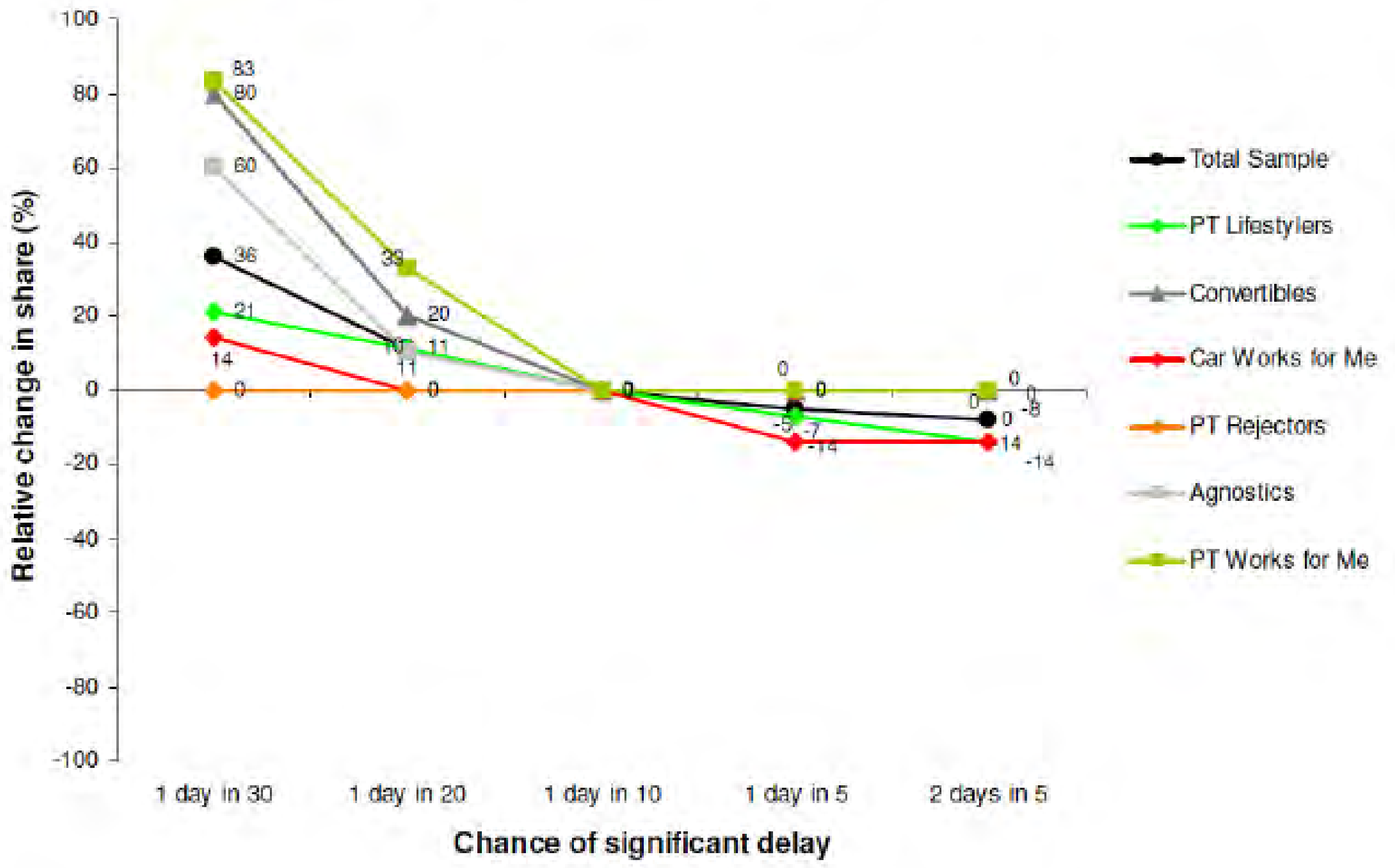
Need for modelling framework to represent influence of values and attitudes on transport mode choice

- Studies have shown importance of attitudes on mode choice
- Identify what segments are potentially receptive to shifting to sustainable transport modes
- Utility functions will vary across segments



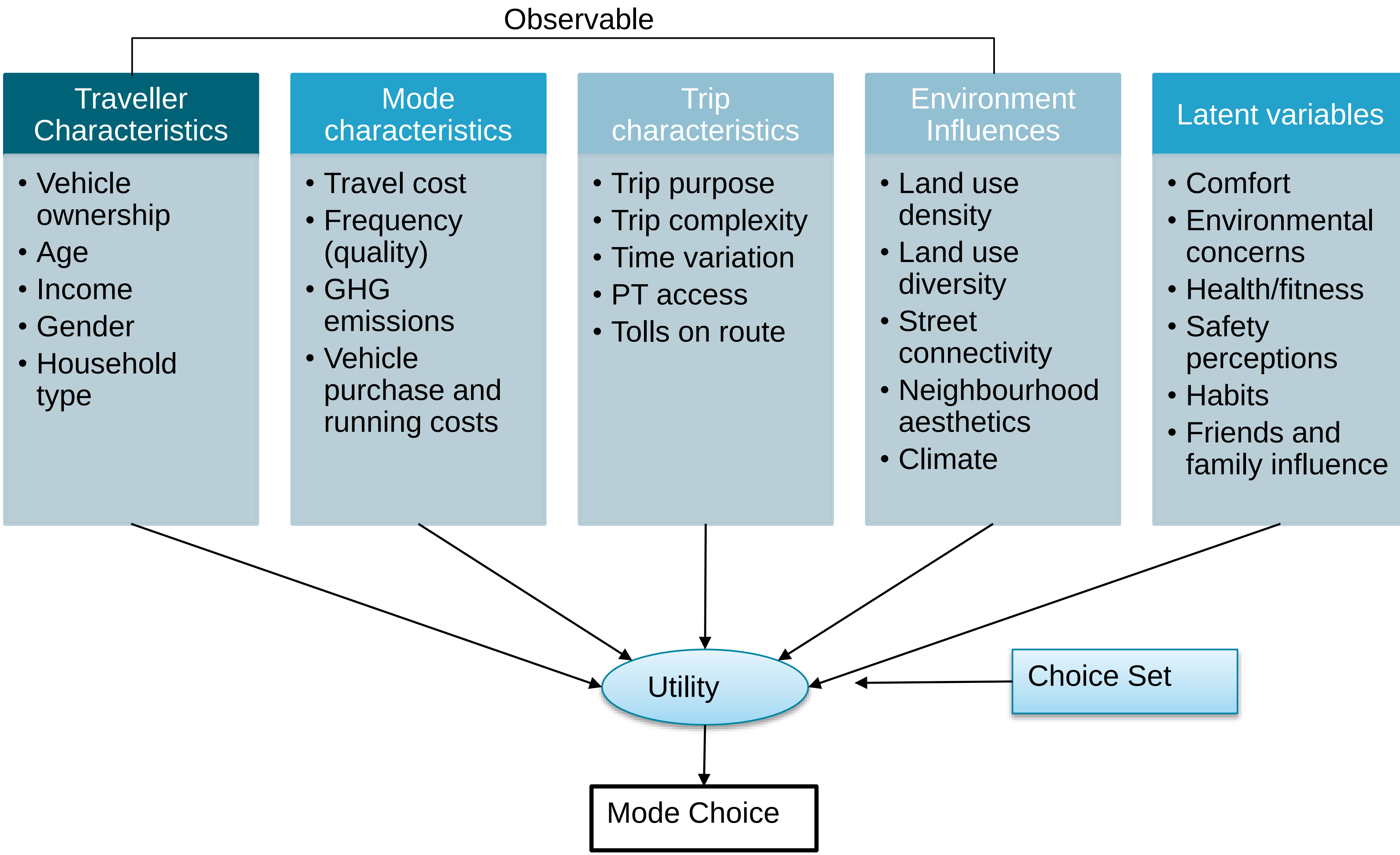
Influence of attitudes on shift to sustainable transport

Figure 8: Change in preference for bus as preferred mode as a function of changing travel reliability by segment (holding all other variables constant)



Source: Gaymer, S, (2010) Quantifying the impact of attitudes on shift towards sustainable modes, Australasian Transport Research Forum 2010 Proceedings

Explanatory variables for travel mode choice



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Adaptive choice-based conjoint analysis

- Expands upon traditional choice based approach to explore non-compensatory rules as well as trade-offs
- Enables segmentation and targeted questions once non-compensatory rules have been identified
- Suited to smaller sample sizes
- Engages participants through more relevant questions
- Implemented and analysed using commercial software
- Target survey to selected anchor tenants from Monash NEC precincts

Sawtooth Software

Stages of Adaptive Choice-based Conjoint Questionnaire

Respondent builds their most ideal scenario for transport → Respondent establishes acceptable and unacceptable variations → Respondent selects most preferred characteristics of varying set

What can the adaptive choice-based conjoint analysis tell us?

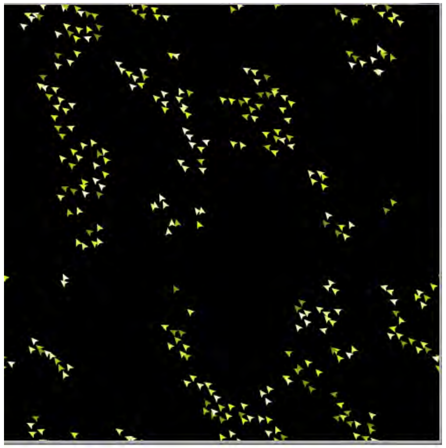
- Segmentation of travellers
- Establish thresholds and non-compensatory rules for travel (must-haves, unacceptable, conjunctive requirements, etc.)
- Then for potentially suitable options explore marginal rates of substitution – e.g. trade-offs between goods (comfort, reliability, travel time. Cost, etc.)
- Cross-elasticities of demand between modes - e.g. how much would congestion (and travel time) have to increase for someone to shift from private vehicle to PT?
- Provides rigour when defining behaviour and dynamics in ABM

Agent based model

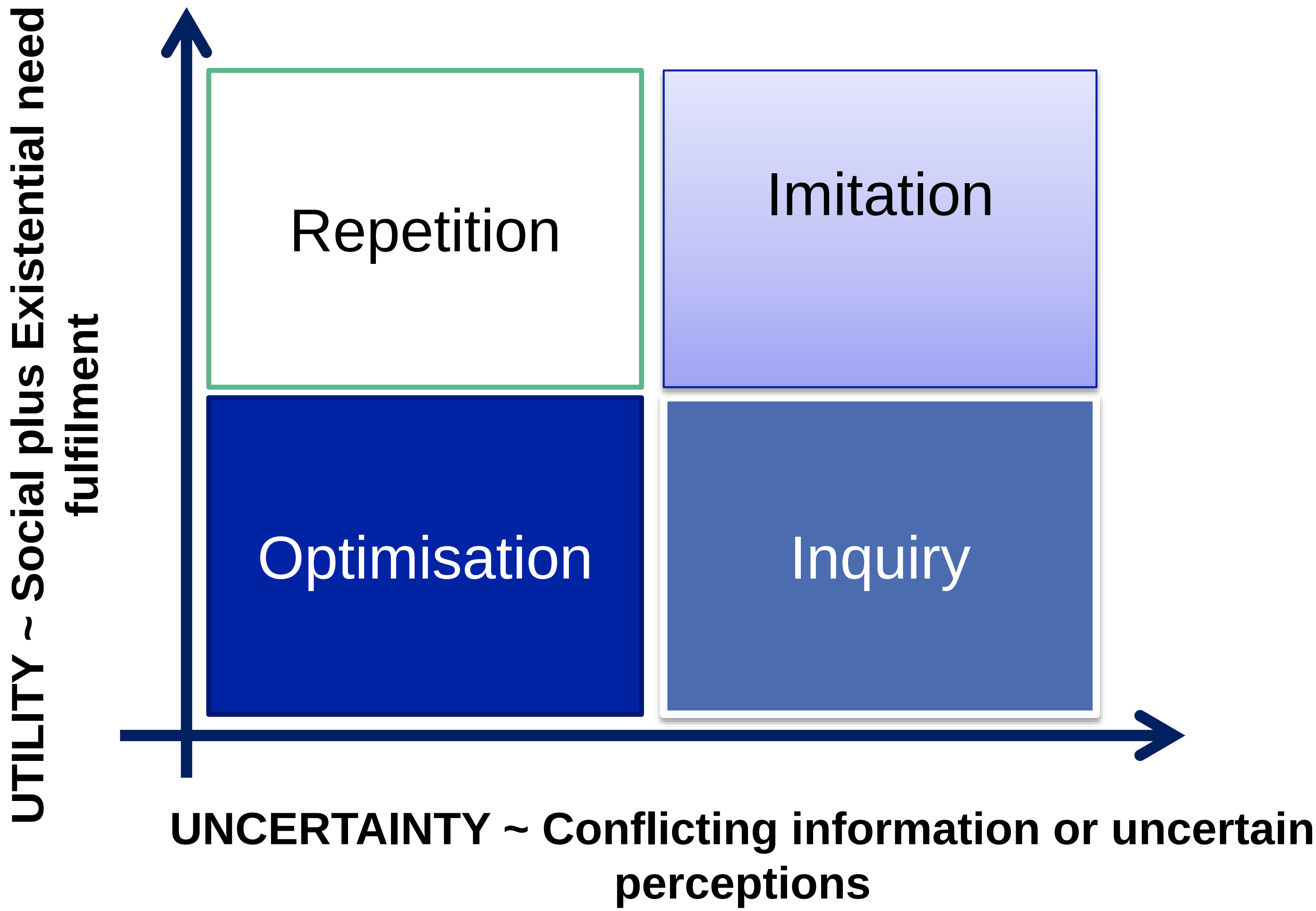
Agent-based model

- Describes individual decision making based on beliefs, desires and intentions
- Can describe interactions between agents and emergent behaviour
- Ideal for exploratory modelling because easy to change and evaluate assumptions

Will and can never have perfect information, but discussion about assumptions, parameterisation and calibration helps make models realistic and useful



Consumat Framework for simulating agent behaviour



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Next Steps

1. Finalise literature review on factors that influence travel mode choice in suburban contexts, and suitable modelling frameworks to support decisions
2. Finalise profile of case study based on available data and reports
3. Ensure integration with WP1& WP2 of this project, and incorporate any feedback
4. Engage with case study stakeholders, and identify suitable anchor tenants for adaptive choice based survey
5. Develop prototype of ABM

Thank you

To find out more, contact

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2015/16 **PARTICIPANTS**

What would make SNAMUTS go green in Melbourne's South-East?

DR JOHN STONE & JANA PERKOVIC

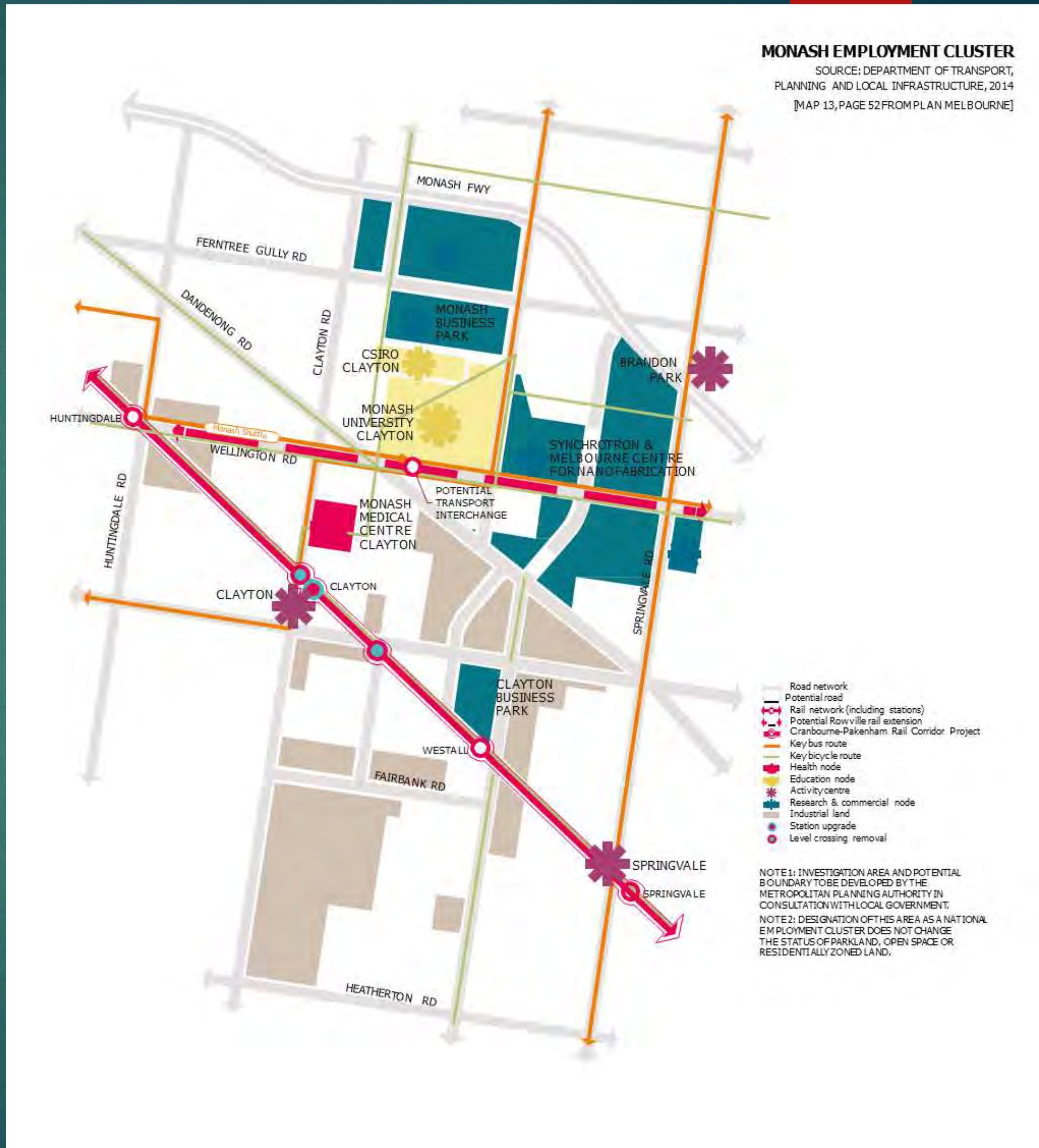
UNIVERSITY OF MELBOURNE

1. Monash National Employment Cluster

- 18kms south-east of the Melbourne CBD
- approximately 38km2
- 3 local government areas: Cities of Monash, Kingston and Greater Dandenong
- 1 of 6 National Employment Clusters identified in Plan Melbourne
- 1 of 3 existing; other 3 are ‘emerging’
- Existing NEC: place that can, or have the potential to, provide high job concentrations in suburban locations, due to their number of businesses, institutions and high levels of employment

Monash NEC: now

- Melbourne's largest established employment cluster
- 58,500 jobs
- largest concentration of employment outside the central city
- critical mass of leading education, health, research and commercialisation facilities including: Australia's largest university (Monash University), the Australian Synchrotron, the Melbourne Centre for Nanofabrication, Monash Medical Centre, CSIRO's largest site in Victoria, Monash Business Incubator and the Monash Enterprise Centre
- "cluster's mix of education, research and commercial facilities creates a unique environment for innovation and world-leading research"
- Key partners include City of Monash, City of Kingston, City of Greater Dandenong, Monash University, Monash Medical Centre, the Australian Synchrotron, CSIRO, Monash Business Incubator, the Monash Enterprise Centre and Chadstone Shopping Centre



Travel to Monash NEC: now

- Notoriously congested
- Bus links to rail system improved in recent years but still relatively uncompetitive
- Long-standing recognised need for improved transit, due to activity mix (residential and business)

Monash NEC: future?

JOBS

- Eastern and South-Eastern subregions together are expected to grow by 550,000 to 700,000 between 2011 and 2031
- the government has recently invested in a new Monash Children's Hospital at Clayton, to be completed in 2016

POLICY

- "The Metropolitan Planning Authority, in consultation with local government, will undertake a rapid pre-assessment and make recommendations to the Minister for Planning about each National Employment Cluster"

DELIVERING?

- Effective connectivity to support economic growth?

TABLE 1 PROJECTED NEC RESIDENT AND EMPLOYMENT GROWTH (MPA SCENARIO)

		Resident Population			Working Population			
Precinct		2011	2051	% growth p.a.	2011	2051 (lower)	2051 (higher)	% growth p.a. (higher)
1	Clayton South	9,300	16,300	1.4%	6,200	8,250	12,350	1.7%
2	Springvale	18,100	58,550	3.0%	6,000	10,400	15,600	2.4%
3	Westall	4,200	24,800	4.5%	8,200	10,400	15,600	1.6%
4	Clayton	10,200	30,500	2.8%	9,300	21,350	32,050	3.1%
5	Huntingdale	7,100	21,950	2.9%	5,300	7,900	11,900	2.0%
6	Mt Waverley	8,400	9,450	0.3%	900	4,900	7,300	5.4%
7	Monash University	2,850	21,500	5.2%	7,900	14,700	22,300	2.6%
8	Notting Hill	5,800	7,400	0.6%	17,000	20,400	30,600	1.5%
9	Mulgrave - employment	1,350	5,600	3.6%	14,800	18,550	27,850	1.6%
10	Mulgrave - res	2,450	3,950	1.2%	600	700	1,100	1.5%
11	Brandon Park	3,300	6,100	1.5%	1,300	1,600	2,400	1.5%
Total		73,100	200,800	2.6%	77,500	119,150	179,050	2.1%

Source: MPA 2015

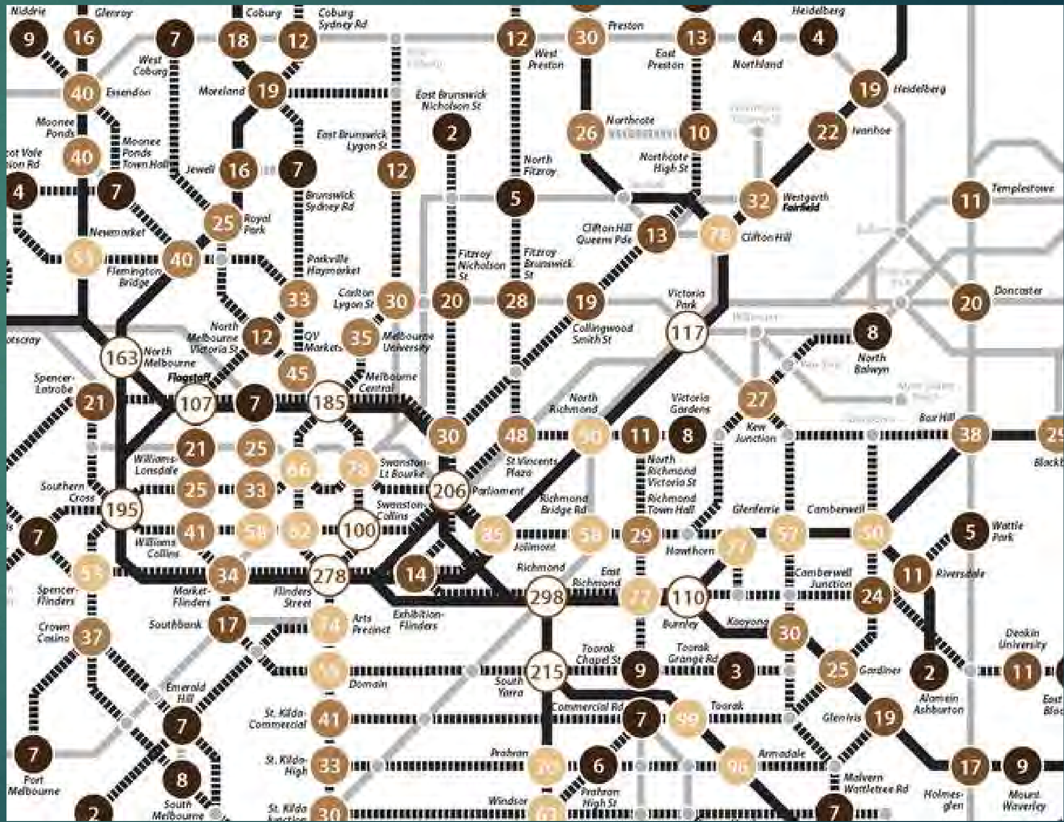
How do we plan for economic growth?

How do we plan TRANSIT SERVICES to enable this economic growth?

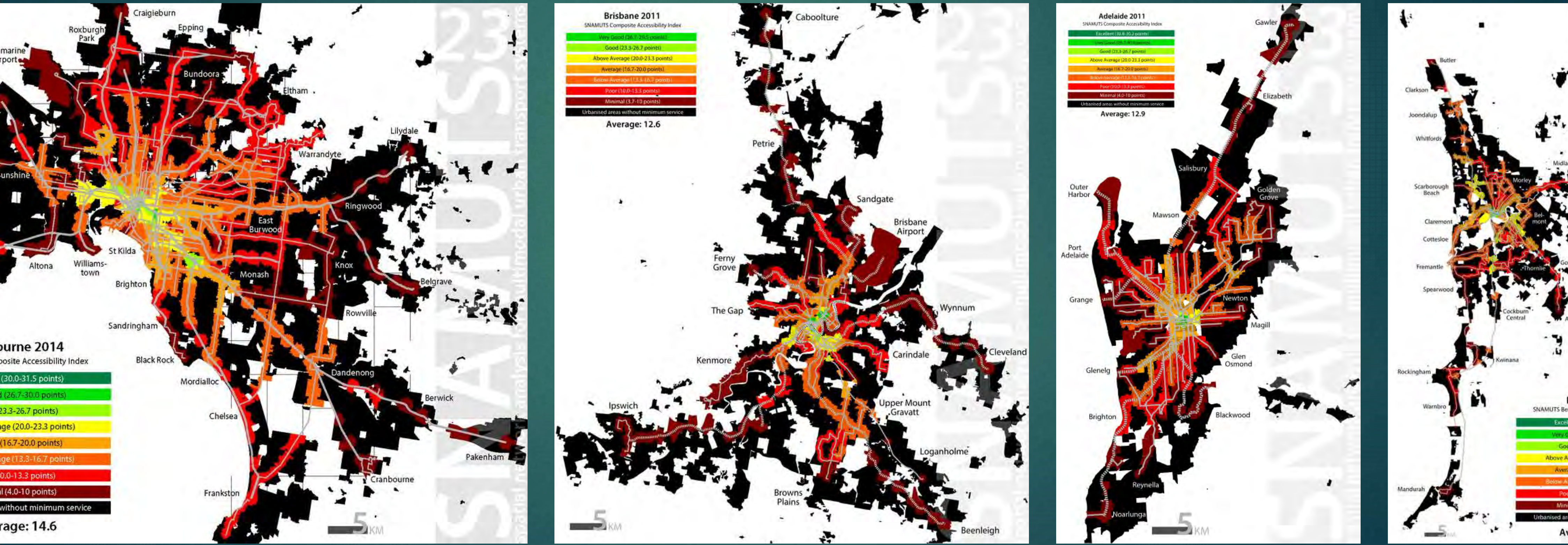
2. SNAMUTS

(Spatial Network Analysis for Multimodal Urban Transport Network Systems)

- Developed by Carey Curtis (Curtin University) and Jan Scheurer (RMIT, Curtin)
- Tool for assessing accessibility by public transport. Interactive capability.
- Assesses current state of PT supply, but also models impacts of changes to supply
- Designed to find answers:
  - How effectively is PT network performing?
  - How well is PT network connecting residents to jobs?
  - What are the weak spots in the network?
  - What changes to the network would most effectively improve network performance?
  - What changes to land use would improve network performance?



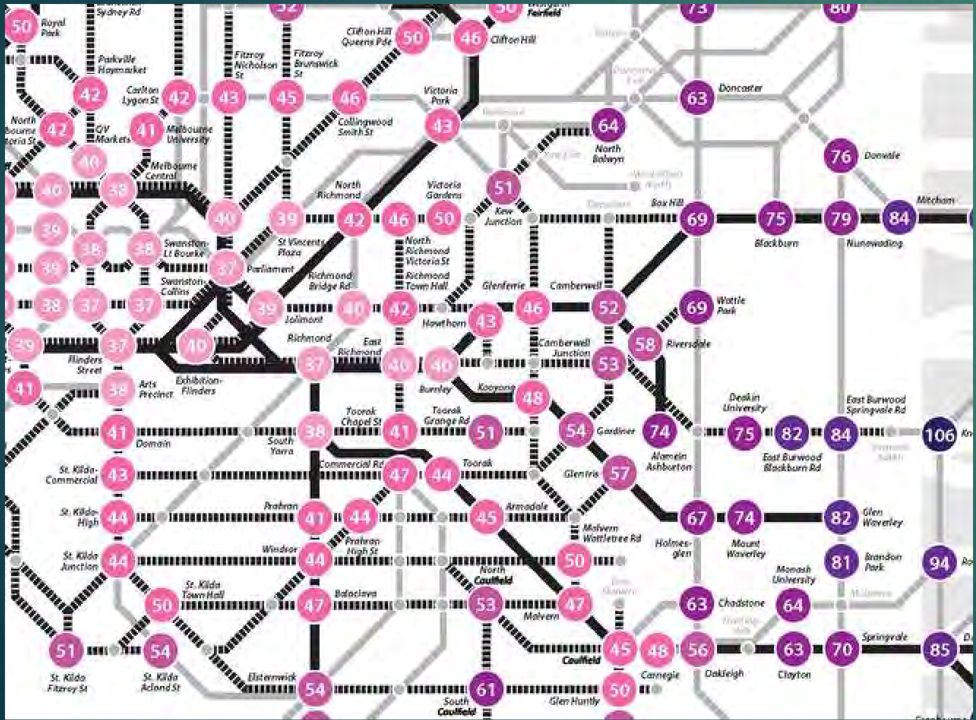
Composite Accessibility Index



Service intensity: two metrics

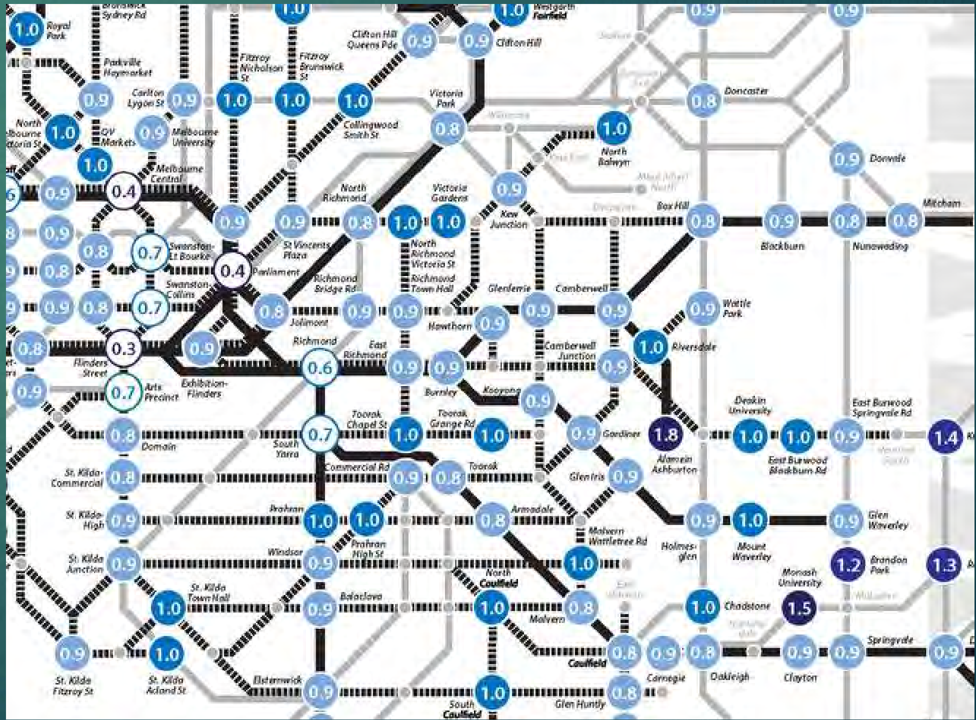
Closeness Centrality

average travel time to get somewhere else in the network



Degree Centrality

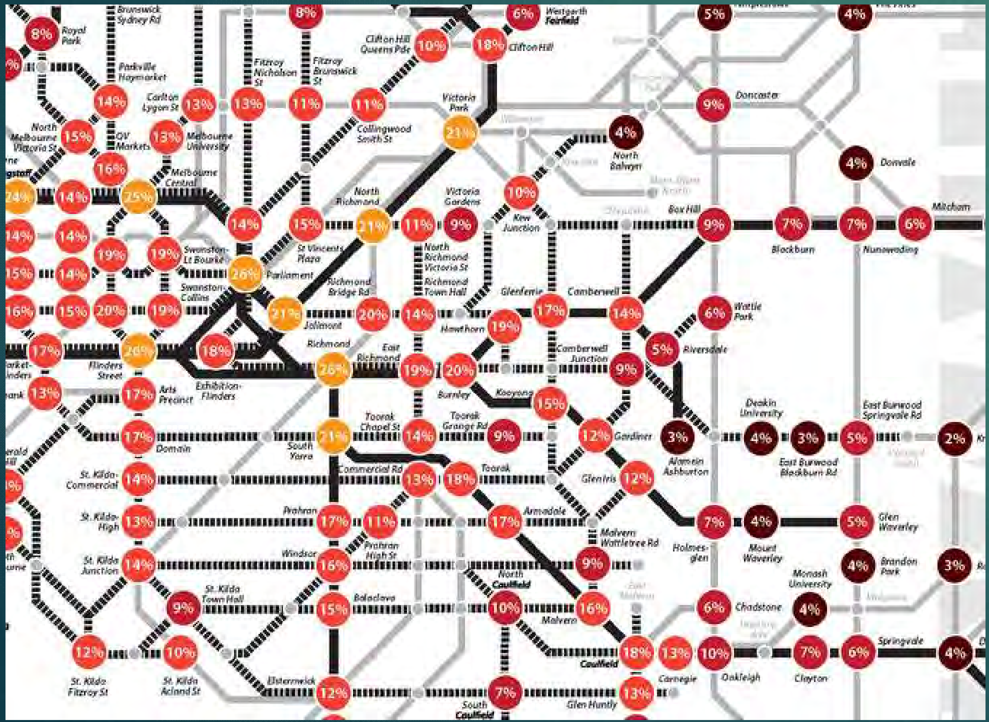
average number of transfers to get somewhere else in the network



Network coverage

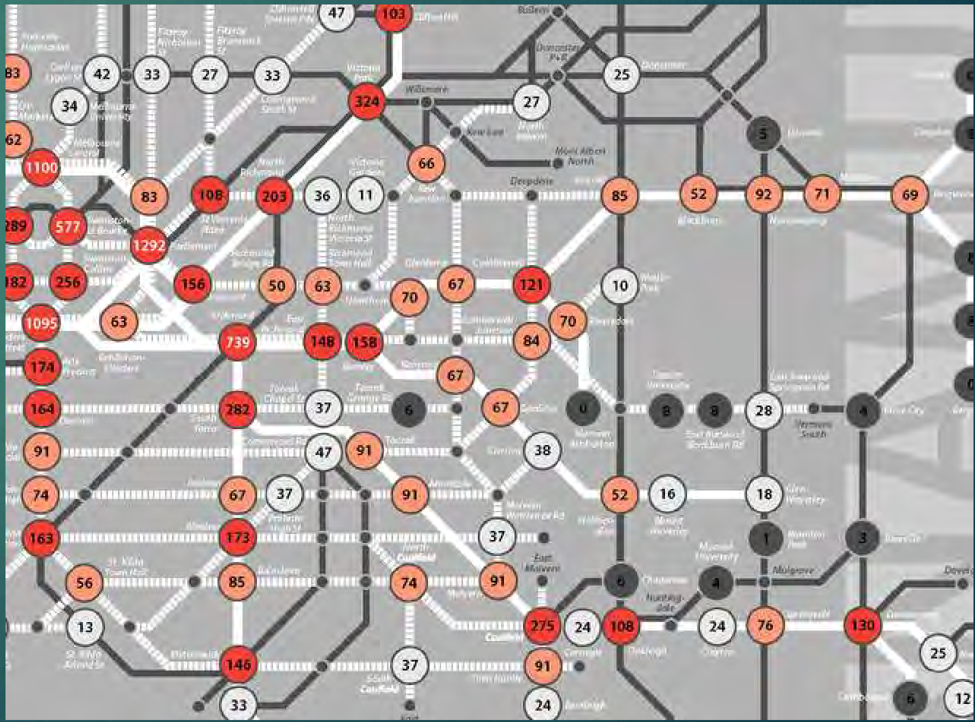
30-min Contour Catchments

Proportion of total metropolitan residents/jobs that can be reached from the station in 30 min



Nodal Connectivity

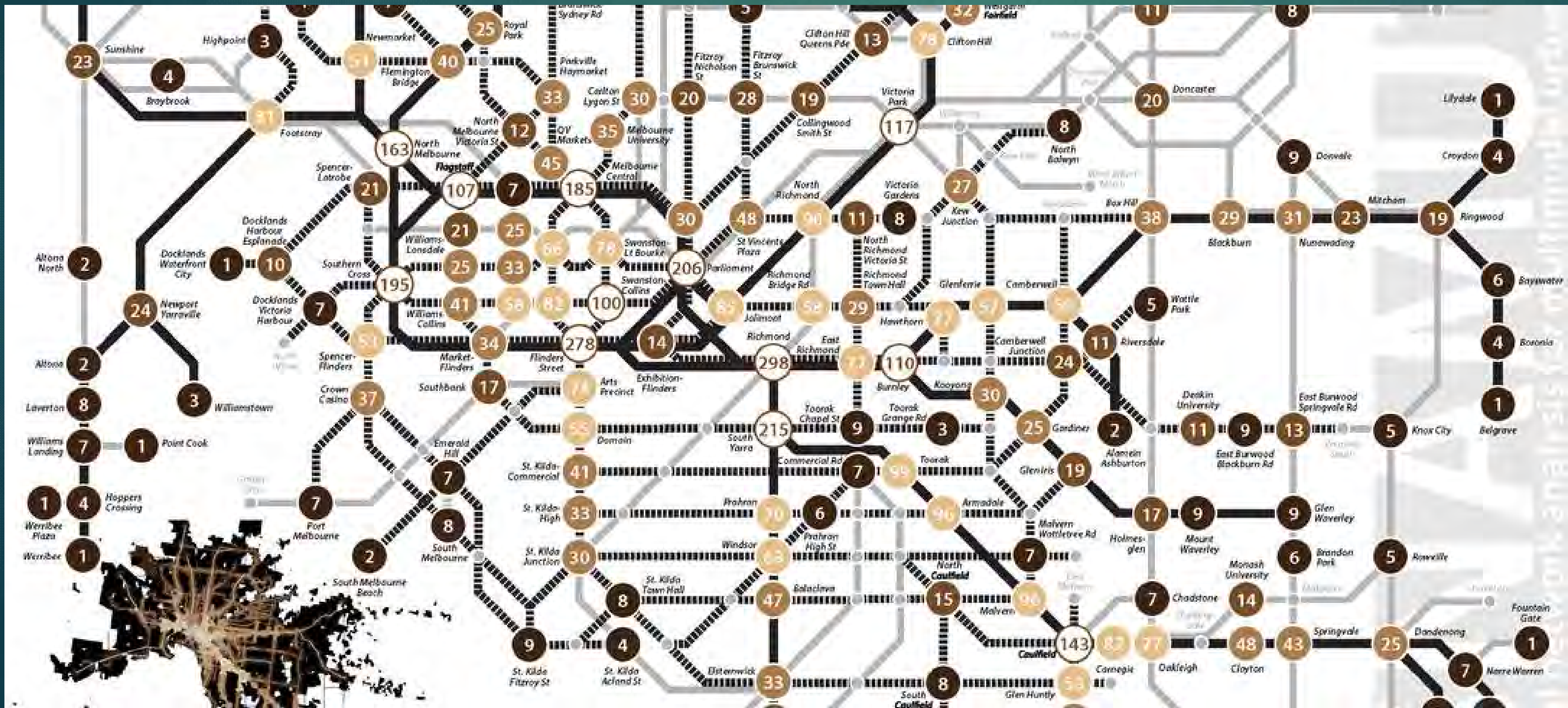
Composite: service frequency and connectedned at each node. Shows how well a node is integrated into the network, and so, how suitable it is for TOD.



Composite: Betweenness Centrality

Betweenness Centrality

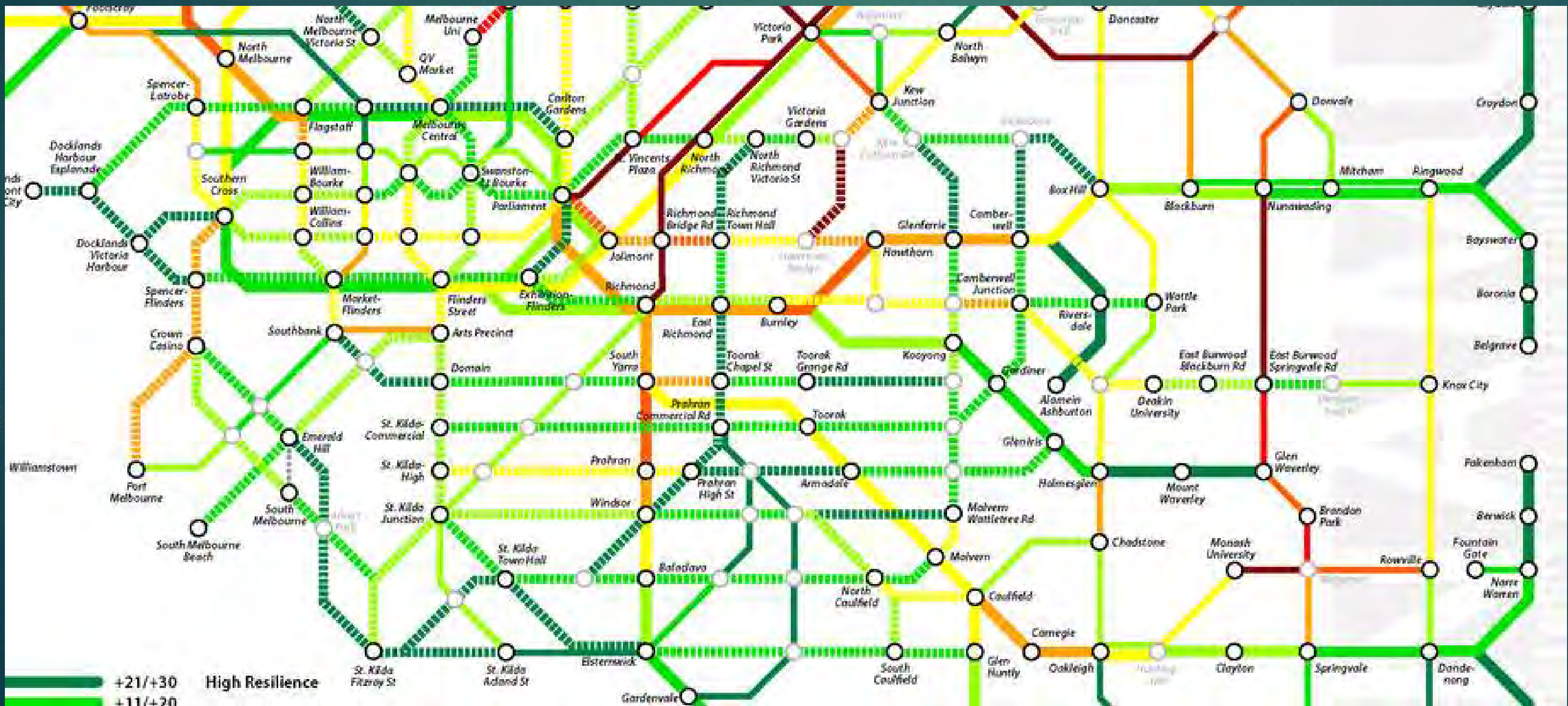
PT supply properties / travel opportunities at each node: service levels (number of network segments passing through the node) and land use



Composite: Network Resilience

Segmental and Network Resilience

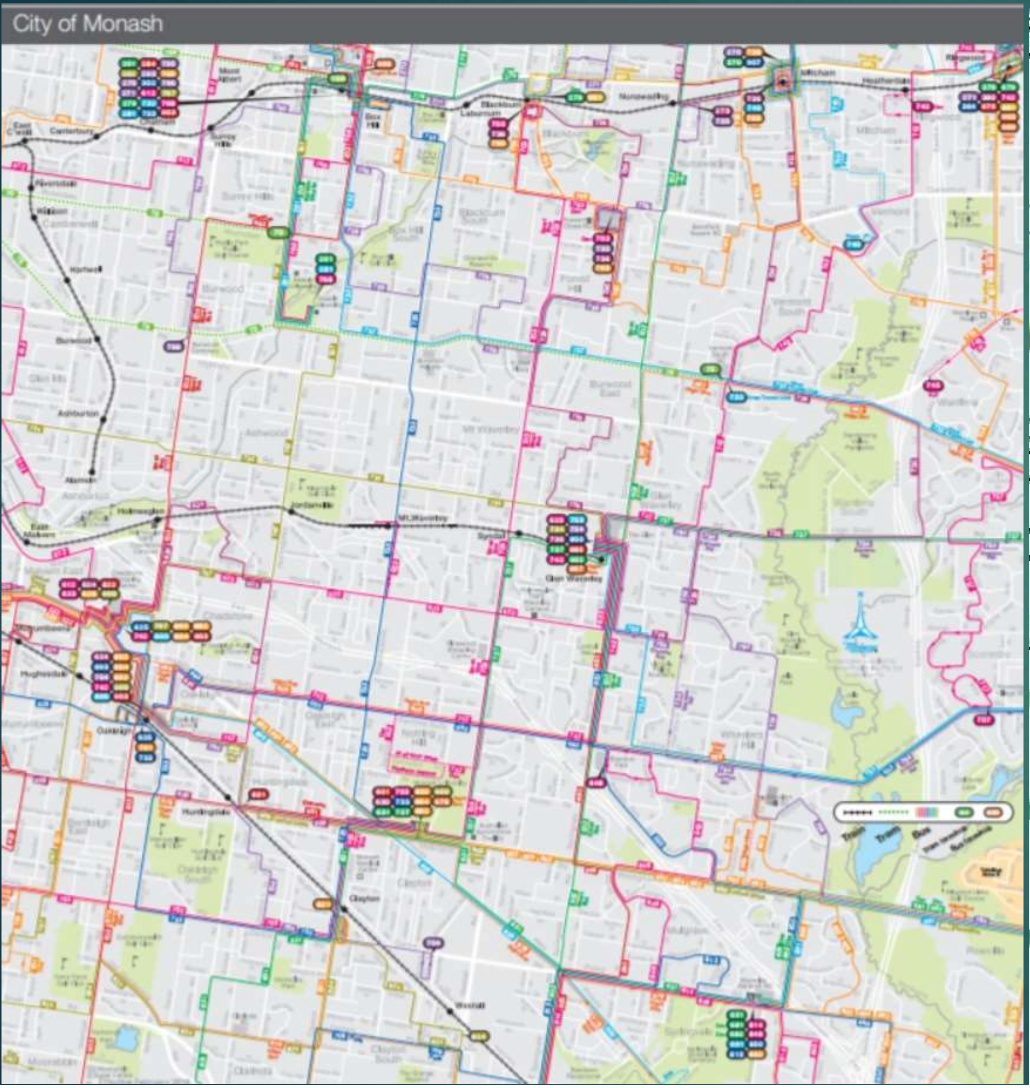
Composite indicator: ratio between segmental betweenness centrality (number of network segments) and actual passenger capacity. When balanced, the segment/node is resilient. When not, it indicates latent demand.

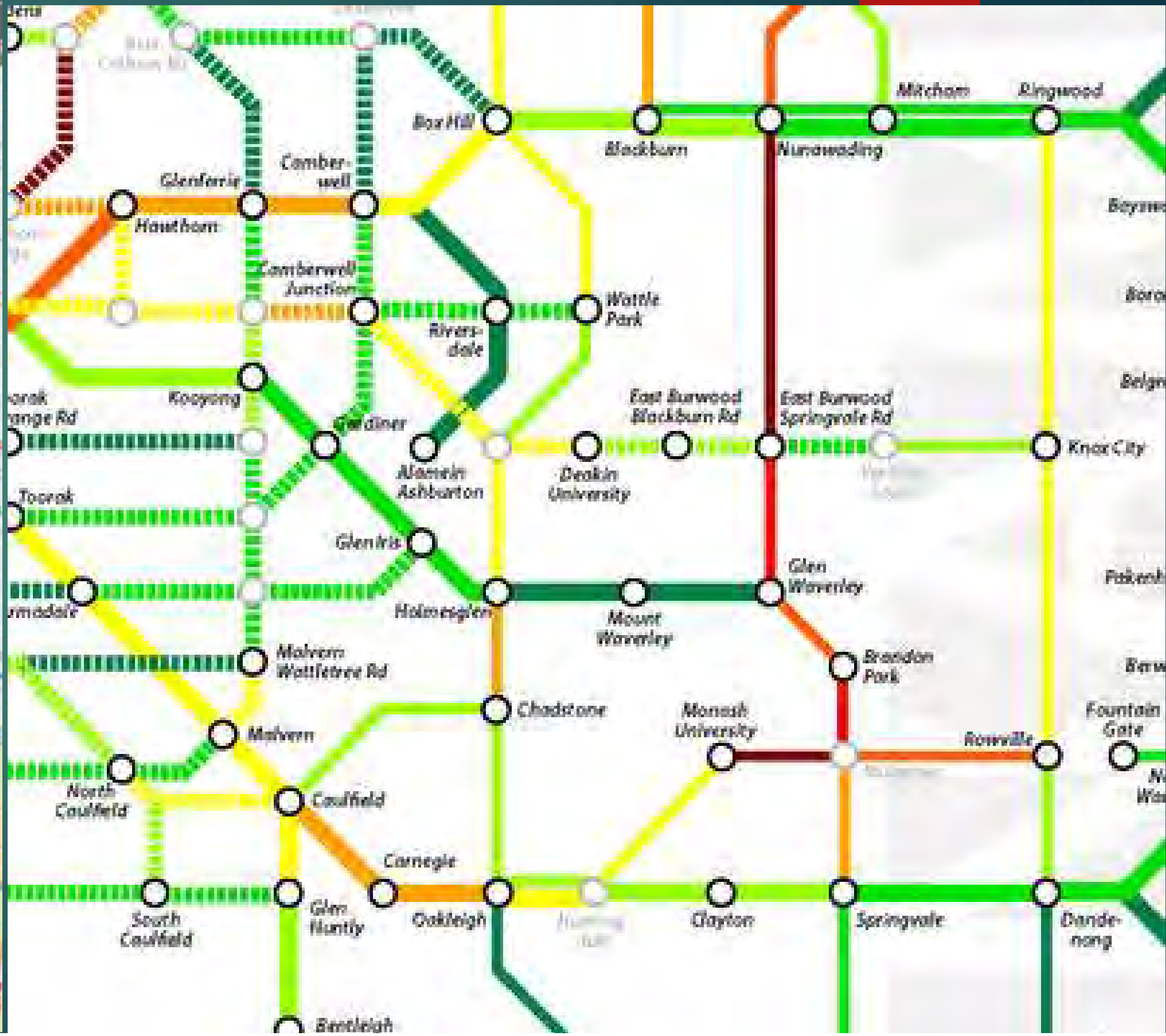


How can this be used in planning urban regeneration?

- NODAL CONNECTIVITY: shows existing quality of a transport node, indicating areas presently suitable for transit-oriented development.
- SEGMENTAL RESILIENCE: indicates where PT supply should be strengthened.
- BETWEENNESS CENTRALITY: indicates good/poor integration of PT/land use.
- Scenarios can be tested, including changes to
  - Land use (local and metropolitan)
  - Population levels (local and metropolitan)
  - PT service levels (local and metropolitan)
  - Network structure
- Visually simple: offers easy overview of options

Current transit supply: much is below network threshold





3. Our research

- Testing scenarios for Monash NEC through SNAMUTS
  - Transit network improvement scenarios (local)
  - Job growth scenarios (local and metropolitan)
  - Population growth scenarios (local and metropolitan)
- Testing application of SNAMUTS in strategic policy-making
  - When & how can SNAMUTS be used for generating and discussing strategic options?
  - How can it be useful for policy makers? Infrastructure planners? Residents?

- Data sources:
  - JOBS & POPULATION GROWTH as predicted by VPA
  - PTV future service plans for rail
  - Bus supply scenarios based on affordable network improvements

Additional Perspective: International Comparison

- Jana’s MPhil:
  - How can SNAMUTS be used to plan regeneration and reindustrialisation?
  - Opportunity to use SNAMUTS in London (UK), Brussels (BE), and Randstad (NE), in modelling reindustrialisation strategy scenarios
  - When, where, and how can visualising PT supply scenarios best serve long-term strategic planning of urban growth, economy, and land use?

Team & Roles

- Dr John Stone, UMelb
  - Team Leader
- Jana Perkovic, UMelb
  - MPhil
- Prof Carey Curtis & Dr Jan Scheurer & Dave, Curtin
  - SNAMUTS modelling team

Deliverables

- January 2017:
  - AV literature review working paper
  - Define initial modelling scenarios (by March)
- April – May 2017: SNAMUTS outputs. New interactive capabilities in place?
- August 2017: interactive workshops with PTV, VPA, local government,major employers community groups
- November 2017: ATRF
- December 2017: SOAC (Adelaide)

Applying Intelligent Transport Systems to low density areas for low carbon living

Philip Blake

Department of Planning, Transport and Infrastructure, South Australia

Low density areas

- Longer distant trips
- Lower public transport share
- Use of Park and Rides
- Lower active transport use
- Multiple car households

Integrated Transport and Land Use Plan (ITLUP)

- Goal 1: Healthy, safe, affordable and connected communities
  - liveability
- Goal 2: A strong, diverse and growing economy
  - prosperity
- Goal 3: Thriving natural and built environments
  - Sustainability – resiliance, emissions, impacts

Traffic Management

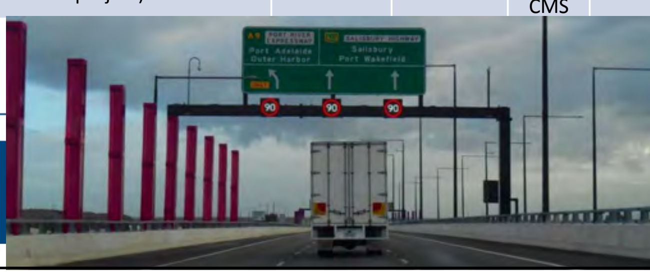
- Safety
- Traffic Flow
  - Congestion
    - Recurrent – demand exceeds supply / capacity
    - Non-recurrent incidents, events, roadworks, etc

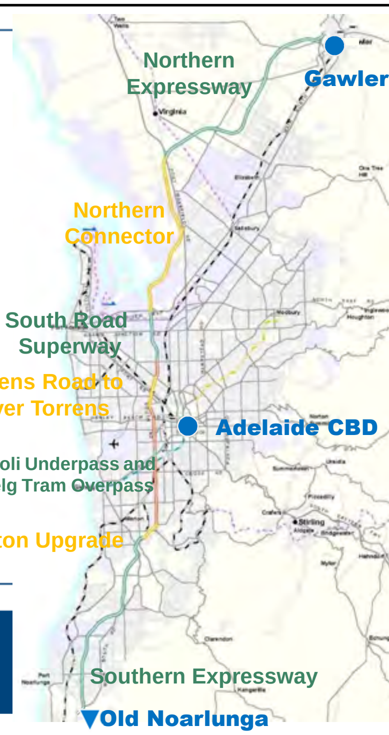
Traffic Management

- Managed motorway infrastructure
- Traffic signals system / SCATS
- Extensive CCTV network - fully digital
- SCADA / PLC network
  - Tunnels
  - Opening road and rail bridges

Government of South Australia
Department of Planning, Transport and Infrastructure

Section / Major project	Status	Detection	Signs	LUMS	Other
Northern Expressway	Open	Loops Bluetooth	VMS CMS		
Northern Connector	Funded	Loops Bluetooth	VMS VSS		
North-South Motorway (South Road Superway project)	Open	Tirtl VIDS Bluetooth	VMS CMS	LUMS	
North-South Motorway (Torrens Road to River Torrens project)	Funded	Loops IR-IDS Bluetooth	VMS	LUMS	
Gallipoli Underpass and Glenelg Tram Overpass	Open	Bluetooth			
Darlington Upgrade	Funded	Loops IR-IDS Bluetooth	VMS CMS	LUMS	
Southern Expressway (duplication project)	Open	Loops Bluetooth	VMS VSS CMS		Weather station





Traffic Management Centre

- 24/7
- Incidents, events, roadworks,
- 1800 018 313 calls
- Statewide

December 2016

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Public Transport

- Xerox contactless card system
- Simple fare structure
- GPS
- Transnet

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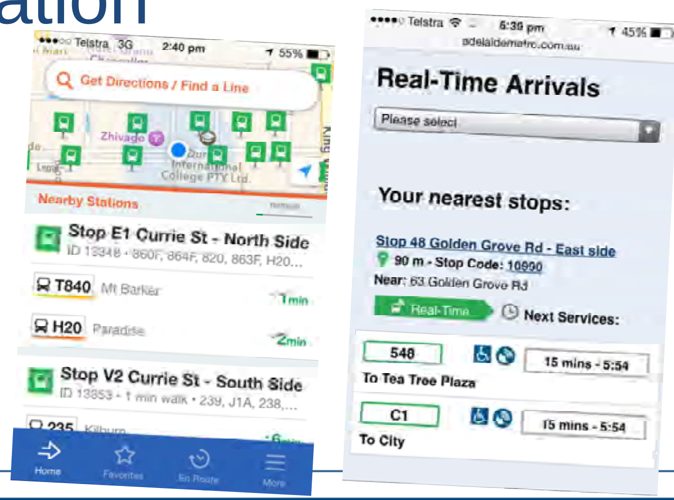
Department of Planning, Transport and Infrastructure

Traveller information

Public Transport

- Open Data
  - General Transit Feed Specification (GTFS)
  - Creative commons licence



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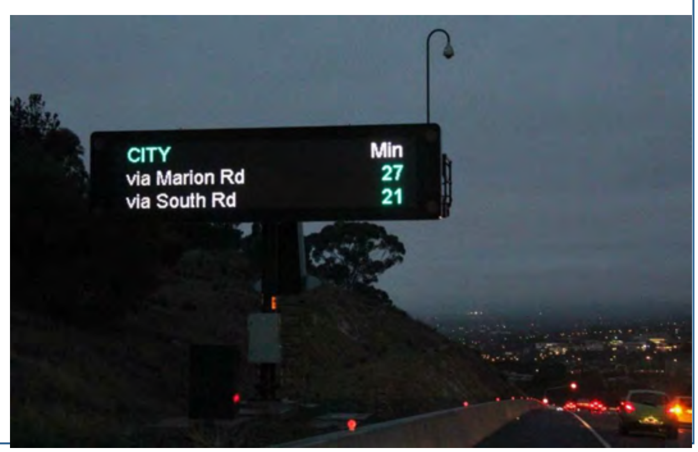
Addinsight

- Bluetooth network
- Real-time travel times and delays
- Travel time signs
- Planning tool



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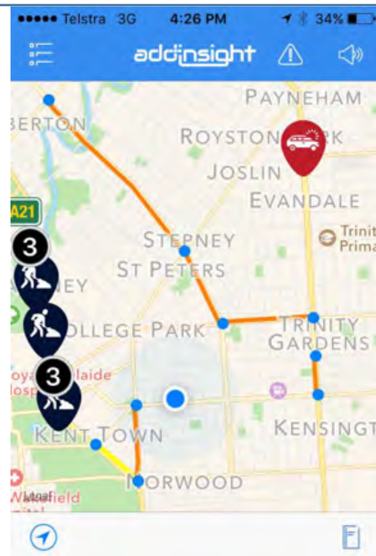
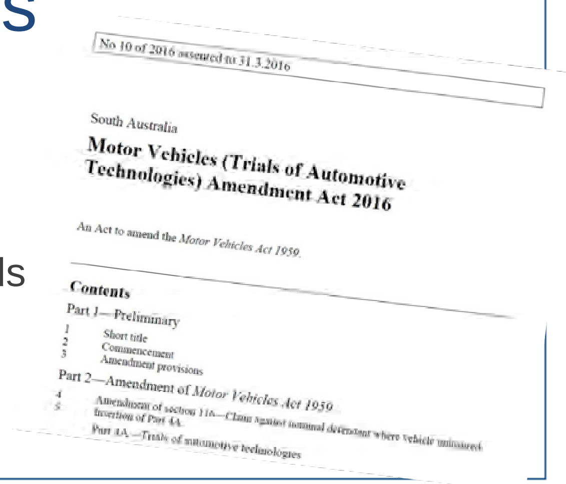
Addinsight app

- Audio traffic alerts
- General messages soon
- >15,000 downloads
- Avoid unusual delays



Autonomous vehicles

- International Driverless Cars Conference
- Demonstration
- Legislation for trials on public roads
- Future Mobility Lab Fund


No 10 of 2016 assented to 31.3.2016

South Australia

Motor Vehicles (Trials of Automotive Technologies) Amendment Act 2016

An Act to amend the *Motor Vehicles Act 1959*.

Contents

Part 1—Preliminary
1 Short title
2 Commencement
3 Amendment provisions

Part 2—Amendment of *Motor Vehicles Act 1959*
4 Amendment of section 116—Claim against nominal defendant where vehicle uninsured
5 Insertion of Part 4A
Part 4A—Trials of automotive technologies

Looking Ahead

- Adelaide - carbon neutral city
- Adelaide - smart city 'Lighthouse city'
- Open data as a virtual infrastructure
- C-ITS / DSRC
- L3, L4, L5 autonomous vehicles
- New mobility business models
- Internet of Things

December 2016

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Looking Ahead

- Transport / Land use / housing and buildings?
- Strategic linkages for low carbon living?




Workshop on Low Carbon Mobility: Greening Suburban

LOW CARBON LIVING CRC

Travel demand analysis – data collection update

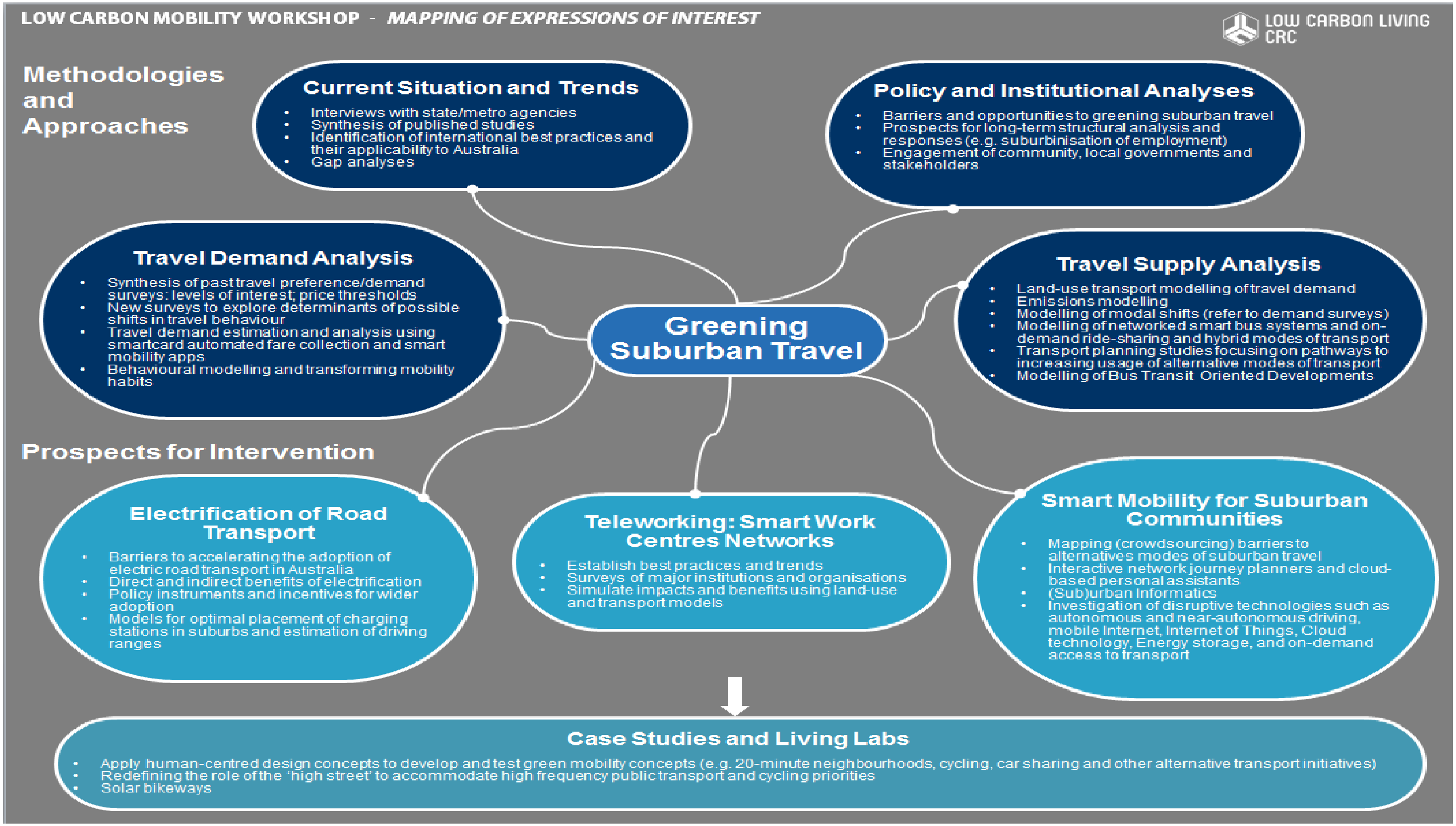
Dr. Sekhar Somenahalli

Senior Lecturer, School of NBE

8th December 2016

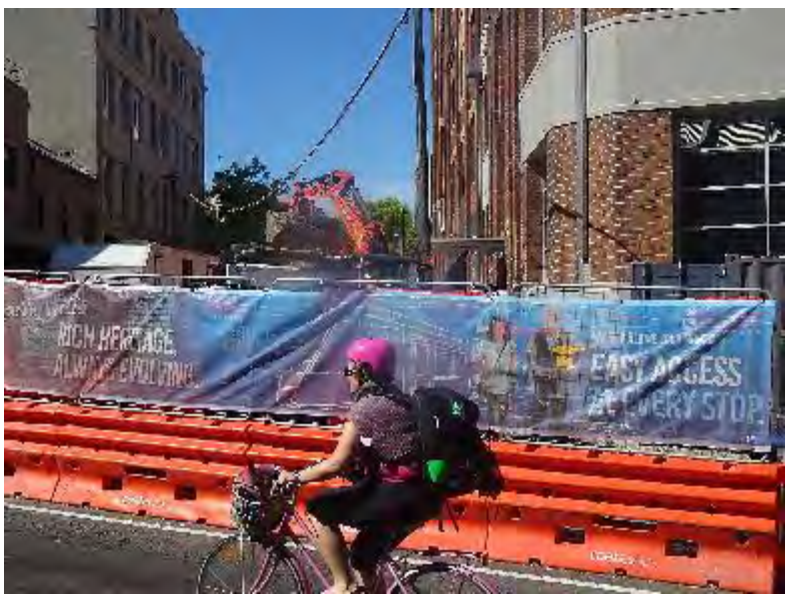
University of South Australia

Introduction



Stated Preference surveys

Or…



Main reasons for using Stated Preference Surveys

- They can predict travel behaviour of study area under various hypothetical travel scenarios proposed in the transport polices for the study area

- They can ensure the current transport planning reflects all the essential attributes of the travelling modes used in the study area

- They can detect the relative importance of qualitative or latent variables such as comfort, convenience, safety etc., which may be inaccurately estimated in RP data (Ortuzar 1996)

LOW CARBON LIVING CRC

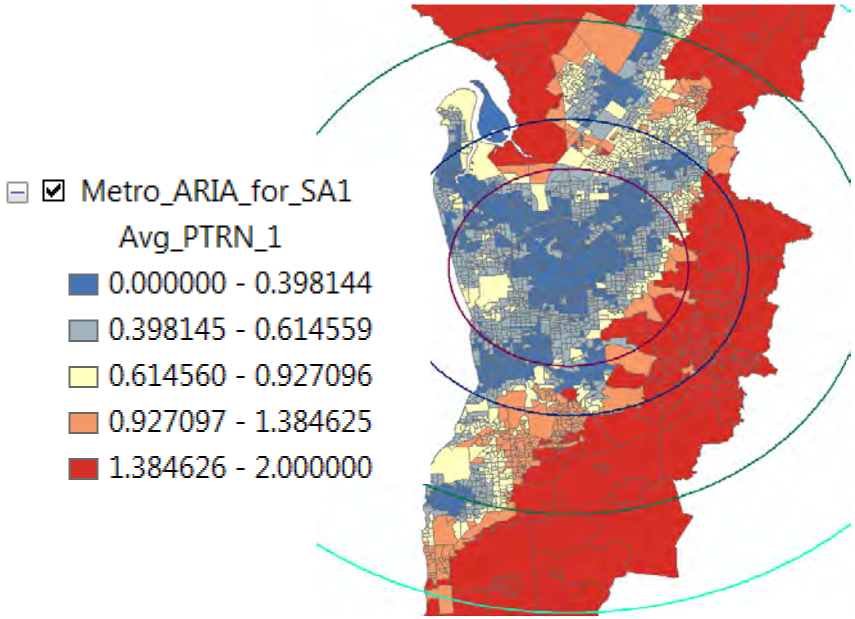
Proposed survey instrument framework

- *personal information* module related to the data on household characteristics (age-group, household size, etc.);
- *revealed preference* (RP) module related to the questions regarding the attributes of the current travelling mode of the respondent; and
- *stated preference* (SP) module related to the mode choice games showing orthogonal comparison scenarios between the attributes of the current travelling mode and the hypothetical travelling alternative perceived by the respondent.

Criteria for suburb selection for SP and RP surveys

- Distance to CBD
- Population density
- Car usage to work
- PT accessibility Index
- Bicycle Usage (for inner suburbs) for work

Public transport Accessibility Index



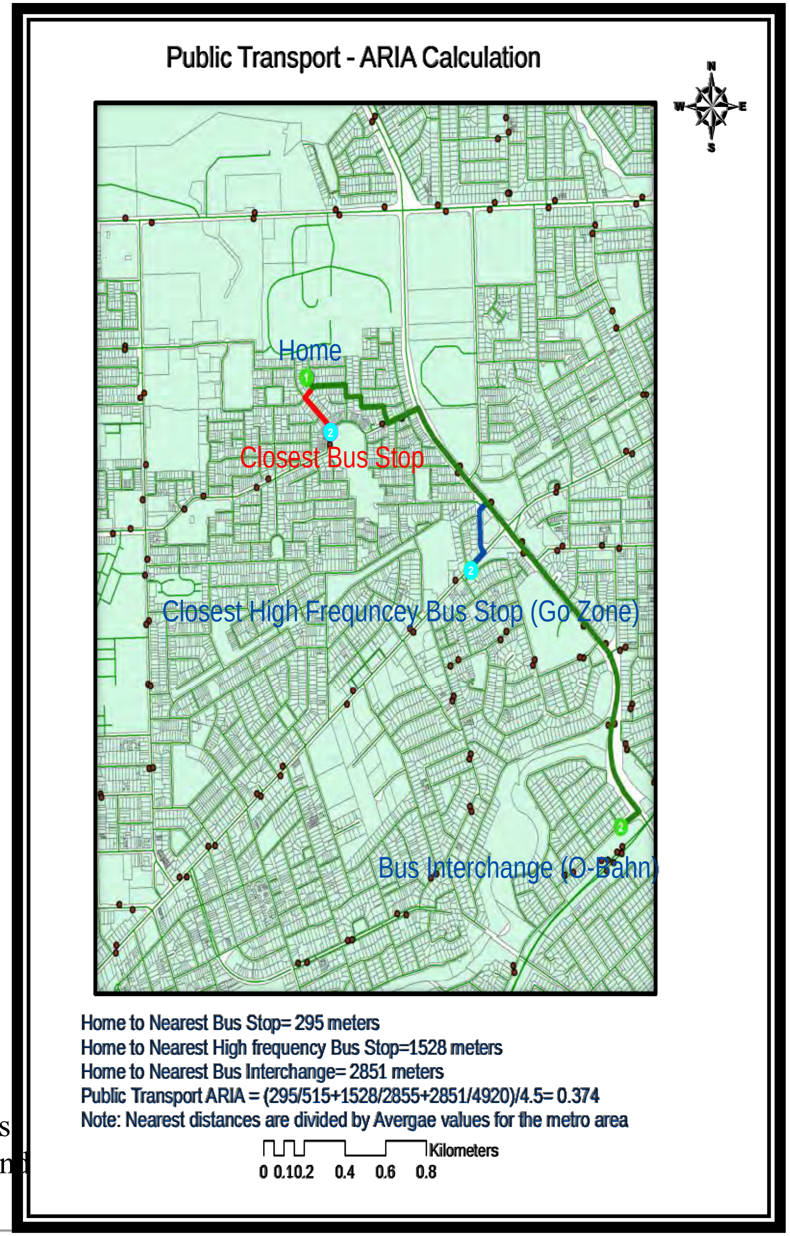
$$ARIA_{iL} = \sum_{L} \min\{3, \frac{x_{iL}}{\bar{x}_L}\}$$

$$ARIA_{iL} = \sum_{L} \min\{3, \frac{x_{iL}}{\bar{x}_L}\} + \sum_{L} \min\{2, \frac{y_{iL}}{\bar{y}_L}\}$$

i = parcel location and L is the service type

x_{iL} = distance to the nearest service from each parcel for Health and Shopping services

y_{iL} = distance to the nearest service from each parcel for Education, Public Transport and 'Financial& Postal' services

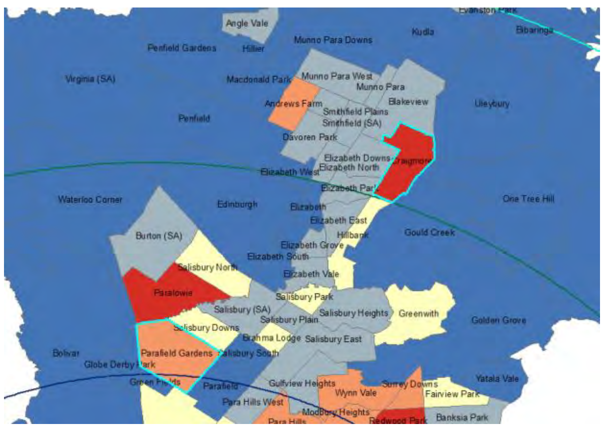


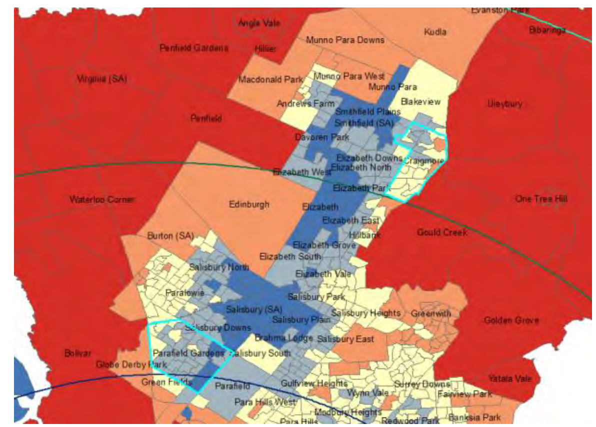
LOW CARBON LIVING CRC

Shortlisting (Draft) of Suburbs

Two Outer Northern Suburbs :Parafield gardens & Craigmore– medium to high car usage for work trips, medium to high density 15 to 35 km away, &Low to medium income with varying PT access.

Scenario type: Bus/Train





Suburbs_Census_data
CarAsDrive / AREA_SQKM
- 0.000 - 177.3
- 177.4 - 413.6
- 413.7 - 593.5
- 593.6 - 757.7
- 757.8 - 1064

Suburbs_Census_data
Total_Persons_Persons / AREA_SQKM
- 0.00000000 - 468.244651
- 468.244652 - 1333.80054
- 1333.80055 - 1984.82833
- 1984.82834 - 2544.08265
- 2544.08266 - 3618.57158

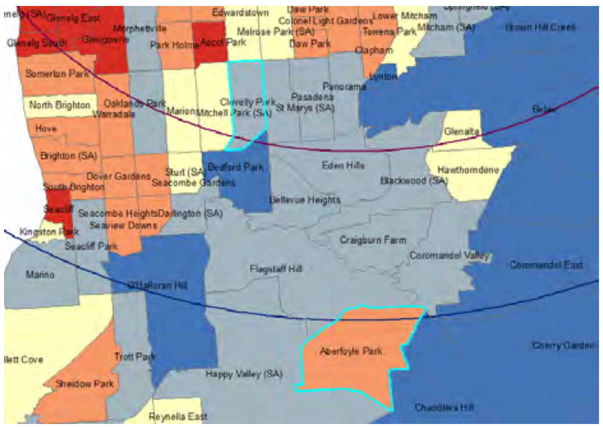
Metro_ARIA_for_SA1
Avg_PTRN_1
- 0.000000 - 0.398144
- 0.398145 - 0.614559
- 0.614560 - 0.927096
- 0.927097 - 1.384625
- 1.384626 - 2.000000

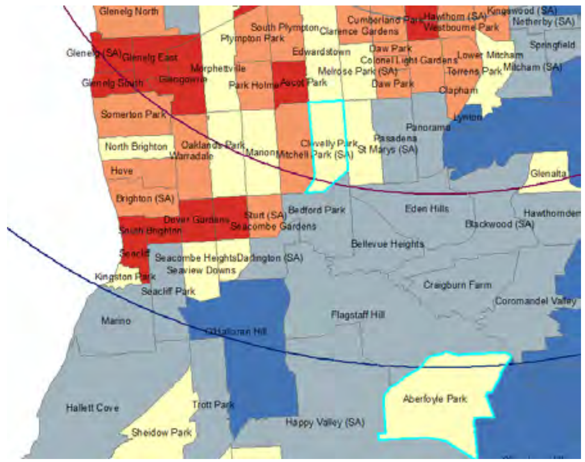
Shortlisting (Draft) of Suburbs …

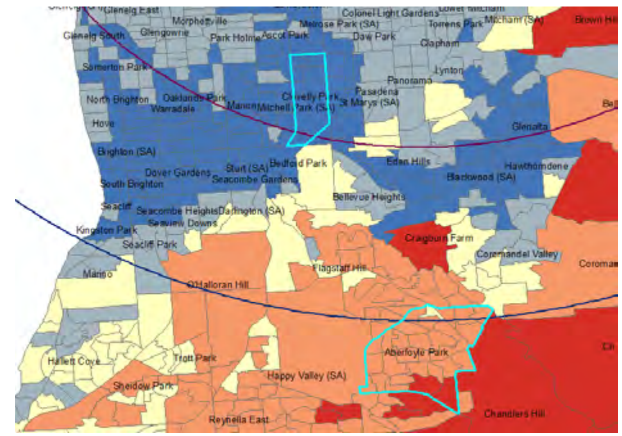
Two Outer Southern Suburbs :Aberfoyle Park–medium to high car usage for work trips, medium to high population density , 10 to 25 km away, &Low to medium income with varying PT access,

Clovelly Park is picked due to upcoming living laboratory location of Tonsley

Scenario type: Bus scenarios for Aberfoyle and Bus/Train scenarios for Clovelly park.







Suburbs_Census_data

CarAsDrive / AREA_SQKM

- 0.00000000 - 177.262358
- 177.262359 - 413.642774
- 413.642775 - 593.548479
- 593.548480 - 757.658112
- 757.658113 - 1064.27106

Suburbs_Census_data

Total_Persons_Persons / AREA_SQKM

- 0.00000000 - 468.244651
- 468.244652 - 1333.80054
- 1333.80055 - 1984.82833
- 1984.82834 - 2544.08265
- 2544.08266 - 3618.57158

Metro_ARIA_for_SA1

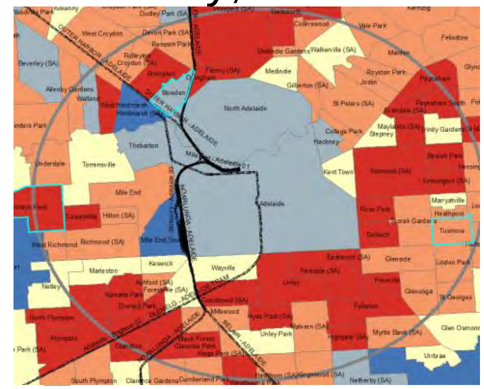
Avg_PTRN_1

- 0.000000 - 0.398144
- 0.398145 - 0.614559
- 0.614560 - 0.927096
- 0.927097 - 1.384625
- 1.384626 - 2.000000

LOW CARBON LIVING CRC

Shortlisting (Draft) of Suburbs … (for encouraging Active Transport)

Two inner Suburbs :Brooklyn Park (Western suburb), Tusmore (Eastern suburb) & Bowden (Central) –low to medium Bicycle usage for work trips, medium to High Car usage, medium to high population density, low to medium walk trips to work within 5 kms from CBD,

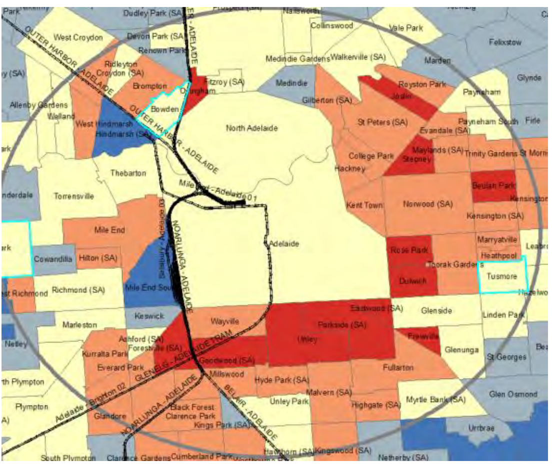


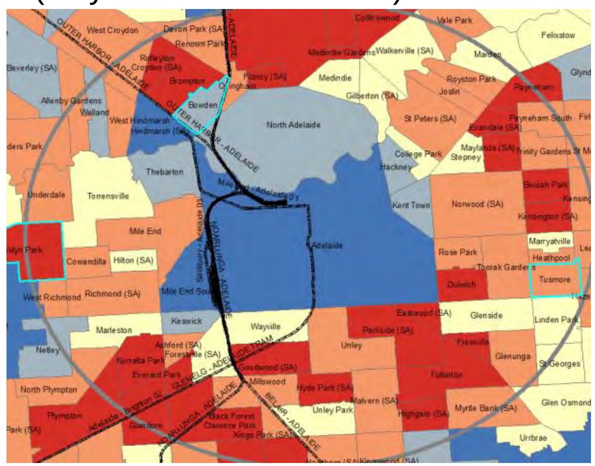
Suburbs_Census_data

Total_Persons_Persons / AREA_SQKM

- 0.00000000 - 468.244651
- 468.244652 - 1333.80054
- 1333.80055 - 1984.82833
- 1984.82834 - 2544.08265
- 2544.08266 - 3618.57158

Scenario type: Active Transport (Bicycle and Walk modes)





Suburbs_Census_data

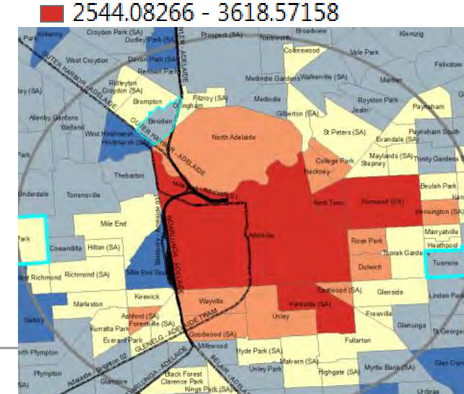
Bicycle / AREA_SQKM

- 0.00000000 - 6.23264030
- 6.23264031 - 16.4741301
- 16.4741302 - 30.2335790
- 30.2335791 - 51.0989584
- 51.0989585 - 93.1566189

Suburbs_Census_data

CarAsDrive / AREA_SQKM

- 0.00000000 - 177.262358
- 177.262359 - 413.642774
- 413.642775 - 593.548479
- 593.548480 - 757.658112
- 757.658113 - 1064.27106



- 14.2296117 - 35.2148848
- 35.2148849 - 68.3360472
- 68.3360473 - 119.030777
- 119.030778 - 218.477385

RP Survey Module – Possible questions

- Age,
- Gender
- Ethnicity ??
- Are you a student or other concession holder? How far do you live from work?
- How far do you live from your preferred supermarket?
- Do you use PT regularly for work or shopping?
- How long do you spend on an average commute?
- How long do you spend on average to get to the shops
- do any of your regular PT trips require you to transfer?
- Where does this take place?
- Do you drive a car regularly? (perhaps approx kms a week)

<u>Which of the following would most entice you to catch PT more often?</u>

- Frequency improvements
- improved safety
- cleaner vehicles and stops
- closer stops to origin/destination
- a reduction/elimination of required transfers
- Would you use PT if you could get a taxi/Uber to/from the local interchange or train station if that meant paying a small surcharge ($2)?
- PT Transfer required, binary yes/no
- Mode Bus, Train or Bus & train (needed??)

Draft questionnaire for Clovelly Park

Given the following information please select from the following commute options

Your commute is 12 kms to King William St in the cbd

This journey will take 35 mins by car, fuel and parking costs $20 a day

Walking to the nearest bus stop the journey takes 50 mins and costs $7 return,
There is a bus every 10 mins

There is a train station 1.5 kms away. From here you can be at work in 30 mins
there is a train every 30 mins and a 1000 space carpark

Travel to the Station:
you can walk taking 20 mins for a total trip of 50 mins and a total cost of $7 daily
By Uber will take 5 mins for a total of 35 mins to work and cost $15 daily (Uber and train fare)
driving yourself will take 10 mins if you find a park (80% chance) and will cost $0.50 in fuel.
If you don't get a park (20% chance) you have to drive 35 mins (total 45 mins) to work at a cost of $21

A. walk to the local bus

B. Walk to the train station

C. access the station with your own car

D. Drive to Work

E. Access the station by Uber/Taxi

This journey will take 40 mins by car, fuel and parking costs $30 a day

Walking to the nearest bus stop the journey takes 65 mins and costs $5 return,
There is a bus every 15 mins

There is a train station 1.5 kms away. From here you can be at work in 35 mins
there is a train every 20 mins and a 1000 space carpark

Travel to the Station:
you can walk taking 20 mins for a total trip of 55 mins and a total cost of $7 daily
By Uber will take 7 mins for a total of 42 mins to work and cost $20 daily (Uber and train fare)
driving yourself will take 10 mins if you find a park (70% chance) and will cost $1.00 in fuel.
If you don't get a park (30% chance) you have to drive 40 mins (total 55 mins) to work at a cost of $32

A. Catch the local bus

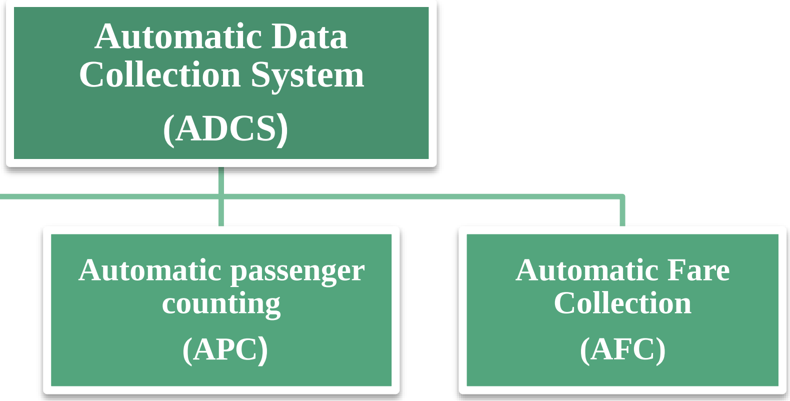
B. Walk to the train Station

C. access the interchange with your own car

D. Drive to Work

E. Access the interchange by Uber/Taxi

Automatic Data Collection System- Smart Card



metroCARD OD data analysis –some challenges

- Non availability of exit reader data
- Paper tickets do not have unique identifier.
- Duplication of Some of records
- Some commuters forget to swipe their card at the train in Adelaide railway station.
- One-pass card data cannot be pursued

LOW CARBON LIVING CRC

Sample data structure from metroCARD

	Collected from smart card use	
Card number	✓	
Cardholder name and address	✗	
Cardholder age	✗	
Cardholder gender	✗	
Trip origin (stage borded)	✓	
Trip destination (stage alighted)	✗	
Time of trip (origin)	✓	
Date of trip	✓	
Trip purpose	✗	
Product purchase time and date	✗	
Product purchase location	✗	
Type and price of product	✗	
Service number boarded	✓	

VALIDATION_ID Unique validation identifier

MEDIA_TYPE The type of physical ticketing media. M = Metrocard, T = Magnetic Ticket

MEDIA_CODE Encoded Metrocard identifier

VALIDATION_ID	MEDIA_TYPE	MEDIA_CODE	FARE_TYPE	TRANSPORT _MODE	FARE	DTHR_VALIDATION	STOP_CODE	STOP_LABEL	STOP_LATITUDE	STOP_LONGITUDE	ROUTE_CODE	TRIP _DIRECTION	VALIDATION _TYPE	PREVIOUS _MODE	EQU_NUMBER	NB_PASSENGERS
1581327288	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	260	1/08/2015 1:06	8129	Belair IN	-34.998108	138.632404	BEL	2	1		3002	1
1581326884	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	250	1/08/2015 0:42	8071	Rundle Mall OUT	-34.922566	138.599515	Tram	1	1		108	1
1581324450	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	520	1/08/2015 0:10	769	Entertainment Centre IN	-34.907292	138.575041	Tram	1	1		103	1
1581324460	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	520	1/08/2015 0:24	8071	Rundle Mall OUT	-34.922566	138.599515	Tram	1	1		103	1
1581324464	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	520	1/08/2015 0:25	8071	Rundle Mall OUT	-34.922566	138.599515	Tram	1	1		103	1
1581324470	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	250	1/08/2015 0:28	8073	Vic Sq OUT	-34.929029	138.599288	Tram	1	1		103	1
1581324474	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	250	1/08/2015 0:29	8073	Vic Sq OUT	-34.929029	138.599288	Tram	1	1		103	1
1581324482	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	4	520	1/08/2015 0:31	8074	City South OUT	-34.932543	138.600253	Tram	1	1		103	1
1581320992	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	520	1/08/2015 0:23	8131	Coromandel IN	-35.025127	138.613981	BEL	2	1		3113	1
1581320250	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	260	1/08/2015 0:02	8095	Kilburn OUT	-34.859289	138.578279	GAWC	1	1		3140	1
1581320264	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	260	1/08/2015 0:27	8105	Elizabeth OUT	-34.717596	138.664455	GAWC	1	1		3140	1
1581319080	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	520	1/08/2015 0:00	8094	Islington OUT	-34.875058	138.58175	GAWC	1	1		3139	1
1581319085	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	520	1/08/2015 0:03	8095	Kilburn OUT	-34.859289	138.578279	GAWC	1	1		3139	1
1581314413	T	94EE4036B299CA651DA0D6F4E4BC61A3C7638AFB	TICKETS	5	520	1/08/2015 0:17	6737	Ethelton IN	-34.848532	138.494932	OUTHA	2	1		3112	1

Thank you!

For more information contact:

Research Node for Low Carbon Living
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Low Carbon Mobility

Greening Suburban Travel

Barriers and opportunities for low carbon travel

Karen Wright Masters Researcher
8 December 2016

Literature review focus

- Barriers and opportunities to shifting to lower carbon transport options.
- Determinants of travel mode shift, particularly from private vehicles to public transport and active transport.
- International best practice for low-emission transport options in suburban communities.

Car dominated travel

LOW CARBON LIVING CRC

Suburban Cartopia

- Low density and primarily residential
- Separation of land uses
- Lack of connected active transport networks
- Public transport infrequent, low relative speed

LOW CARBON LIVING CRC

Suburban transport options

- Traditional – walking, cycling and public transport
- Multimodal – walk and ride, bike and ride, park and ride
- Transition – energy efficient vehicles
- Emerging – bikeshare, carshare, electric bikes and electric vehicles
- Disruptive – rideshare (Uber, Lyft), autonomous vehicles

Barriers to traditional transport modes

Transport mode	Barriers
Walking	Time/speed & distance (max.3-6km/day)
	Infrastructure - maintenance/connectivity/safety
	Travel habits and lifestyle
Cycling	Time/speed & distance (5-12km/day)
	Infrastructure – safety and connectivity
	Self-efficacy / confidence
Public transport (Mass transit)	Accessibility
	Relative speed compared to other transport modes
	Reliable, regular services
	Orbital / cross-city connections

Barriers to multimodal travel

Transport Mode	Barriers
Walk and ride	Must be within reasonable walking distance (10 min walk for express direct service or 5 min walk for a local service)
Bike and ride	Bike and ride facilities should be located within a 10 min ride (2-3 kilometres) of homes
	Lack of cycling infrastructure connecting to bike and ride facility
	Lack of end of trip facilities such as secure bike parking, lockers and repair facilities.
Park and ride	Free parking at final destination operates as a disincentive

LOW CARBON LIVING CRC

Barriers to emerging transport modes

Transport mode	Barriers
Bike share	Bike share specific – proximity to docking station (convenience)
	General bike use concerns i.e. safety and distance
Car share (Go-get, Flexi car, Greenshare)	Existing car ownership
	Accessible car share (space on street or within a development)

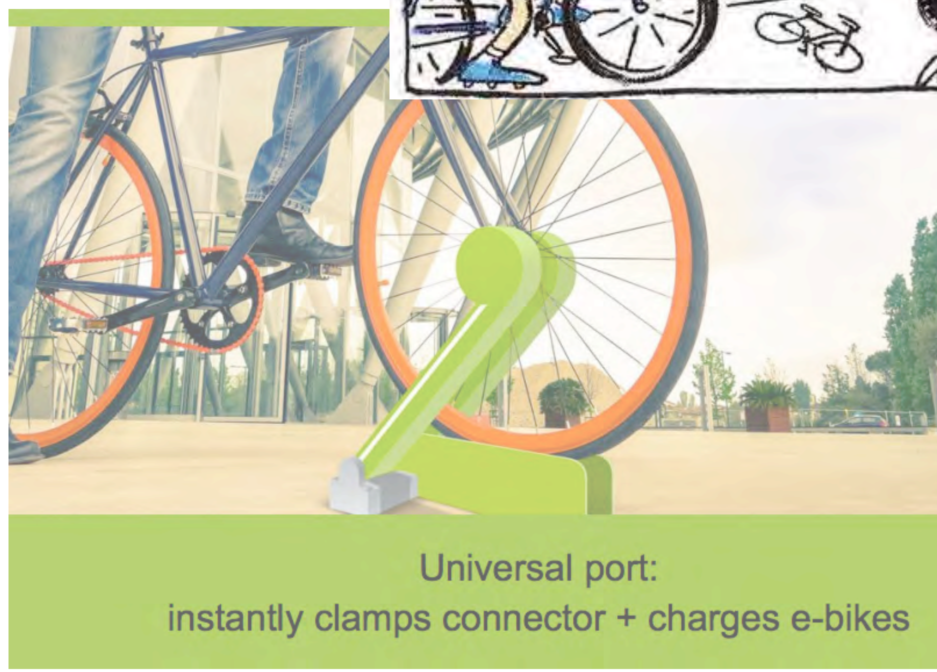
Barriers to emerging and disruptive transport modes

Transport mode	Barriers
Electric bikes	Cost
	Security and availability of end of trip facilities
Electric vehicles	Cost
	Lack of knowledge, availability and choice of models
	Reduced journey range
	Lack of charging facilities
Ride share (Uber, Lyft)	Relative cost, availability
Autonomous vehicles	Rigid regulatory frameworks
	Lack of supporting infrastructure (both cyber and roadside)

LOW CARBON LIVING CRC

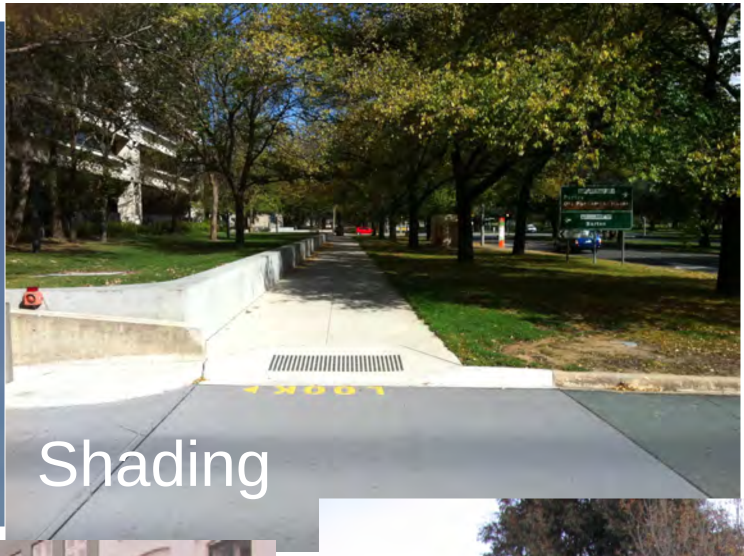
Opportunities for low carbon travel

- Infrastructure
- Safety
- Knowledge
- Relative speed
- Accessibility
- End of trip facilities
- Innovation!



Opportunities for local walking trips

Way-finding

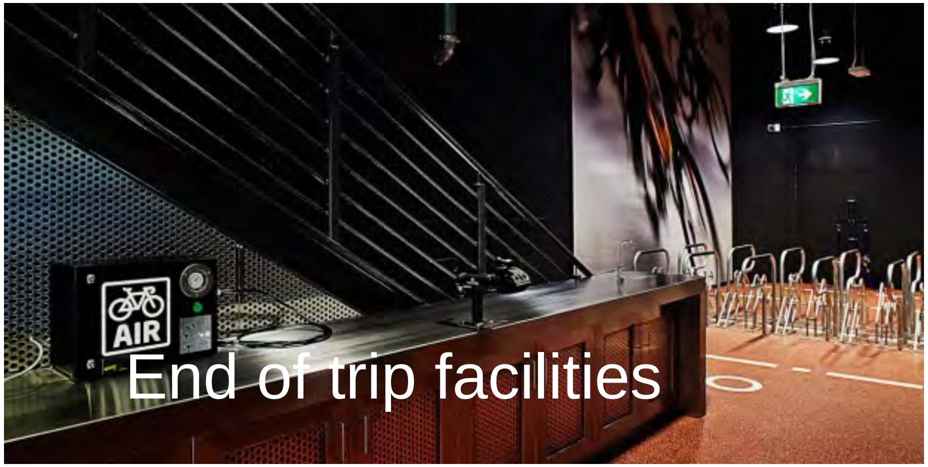

Shading


Improve Connectivity


Destinations and density

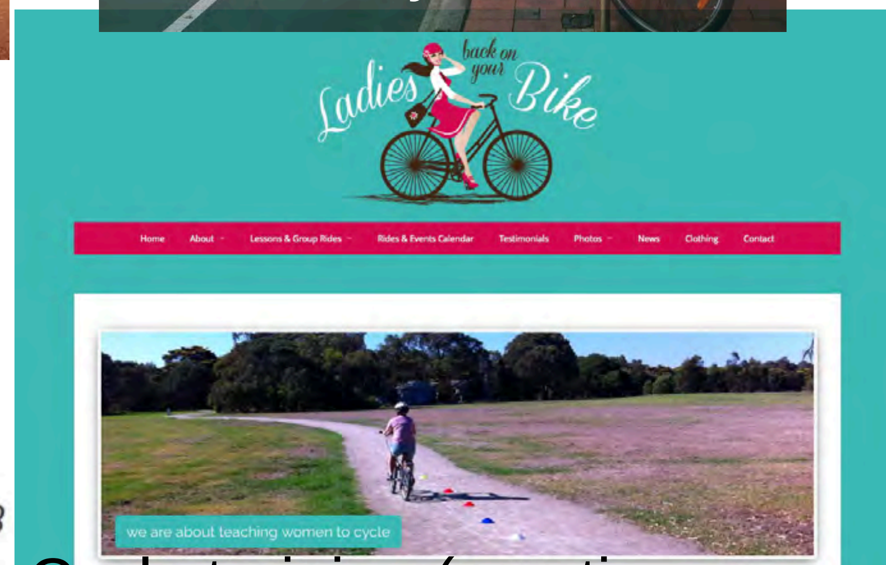

Remove obstacles and trip hazards

Opportunities for cycling trips



End of trip facilities

Improve travel time and safety



Cycle training (creating confident riders)

User Profile

Bold and fearless	<1%
Enthused and confident	10%
Interested but concerned	60%
'Non cyclists'	30%

Source: Cycling Super Highways, Rachel Smith, 2008

Opportunities for public transport

- Increase reserved (right of way) public transport routes
- Create green waves through traffic lights for on-road public transport such as buses or trams
- Increase service frequency
- Improve transfers and interchange facilities
- Behaviour change programs for new infrastructure or services
- Ticketing system that encourages committed users with annual passes

perthnow Sunday Times

WA News

Cars twice as fast as public transport for morning commutes in Perth

Kent Acott, PerthNow
December 1, 2016 4:45pm

TRAVELLING by car can be more than twice as fast as buses and trains on many Perth routes.

An analysis of morning journey times found public transport was particularly uncompetitive when commuters needed to cross the Swan River or travel through the CBD.

Opportunities for multimodal travel

- Increase express direct public transport services within a 10 minute walk/ride of homes
- Direct and easy cycle routes to public transport stops (that all ages and abilities can safely use)
- Bike facilities at public transport stops including bike parking, lockers and repair facilities

Opportunities for emerging transport options

Transport mode	Opportunities
Bike share	Improve cycle infrastructure such as segregated cycle routes
	Increase density of docking stations
	Electric bikes (increase speed and extend distance)
Car share	Provision of dedicated spaces for shared vehicles (either in new developments and/or on street).
	Can result in members forgoing car ownership or selling their second car (Martin 2010, Cervero and Tsai 2004)
	Introduce more electric and hybrid vehicles

Electric bikes and electric vehicles

Opportunities for disruptive transport modes

Transport Mode	Opportunities
Ride share (Uber, Lyft)	Provide incentives for electric or hybrid vehicle use
Autonomous vehicles	Policies to support autonomous on-demand-mobility for use as public transport feeder services
	Reduced demand for car parking facilities

Further research:

- Employee and visitor behaviour for significant trip attractors in suburban areas such as hospitals.
- Measures to extend the cycle catchment of railway stations and rapid bus stops in middle to outer suburbs.
- Explore how shared/autonomous/electric vehicles could be utilised for first/last kilometre trips.
- Evaluate before and after of introducing new active and public transport infrastructure in combination with behaviour change programs.

LOW CARBON LIVING CRC

Implementation Opportunities

1. Increase **infrastructure** for traditional modes (walking, cycling and public transport). **Pilot ideas** and see what sticks.

2. Ensure **parking** is priced to reflect land value, restrict parking in inner city areas.

3. Integrate **behaviour change** programs with the installation of new infrastructure and services that support low carbon mobility.

4. Ensure **employment and shopping centres** have sufficient density and mix of uses to support walking and cycling.

5. **Improve amenity and incentives for low carbon trips**.

LOW CARBON LIVING CRC

When will EVs reduce Adelaide's Transport Emissions?

Alan Richards

DPC Low Carbon Economy Unit

8 December 2016

Government of South Australia
Department of the Premier and Cabinet

The Low Carbon Economy Unit – purpose

To **drive and coordinate cross-portfolio action** to maximise economic opportunities and job creation associated with South Australia's transition to a Low Carbon Economy.

Focus Areas: Renewables SA, Green Tech, Bioenergy, Transport & Planning (including Low Emission Vehicles) & Carbon Offsets

Energy storage & Hydrogen economy

DEPARTMENT OF THE
PREMIER AND CABINET

Opening of the 51st Parliament, 10 February 2015, Governor Hieu Van Lee speaking for the Government:

We will establish a carbon neutral "Adelaide Green Zone" – to make it the world's first carbon neutral city.

Within a decade, electric and hybrid vehicles will be the preferred form of transport within Adelaide's Central Business District.

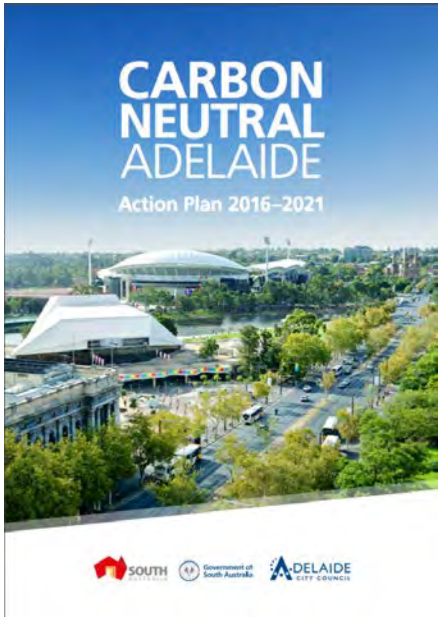
Government of South Australia
Department of the Premier and Cabinet

DEPARTMENT OF THE PREMIER AND CABINET

Carbon Neutral Adelaide Action Plan

Low and Zero Emission Vehicles are Preferred form of Motorised Travel in the City:

- Increase Hybrids & EVs to 15% of new registrations by 2021 and to at least 30% by 2025
- Increase publically accessible EV charging points in the city to 250 by 2020
- Increase Low Emission Vehicles in Fleet SA and the ACC fleet to at least 30% by 2019
- 10,000 registered car share service (eg GoGet) members by 2021



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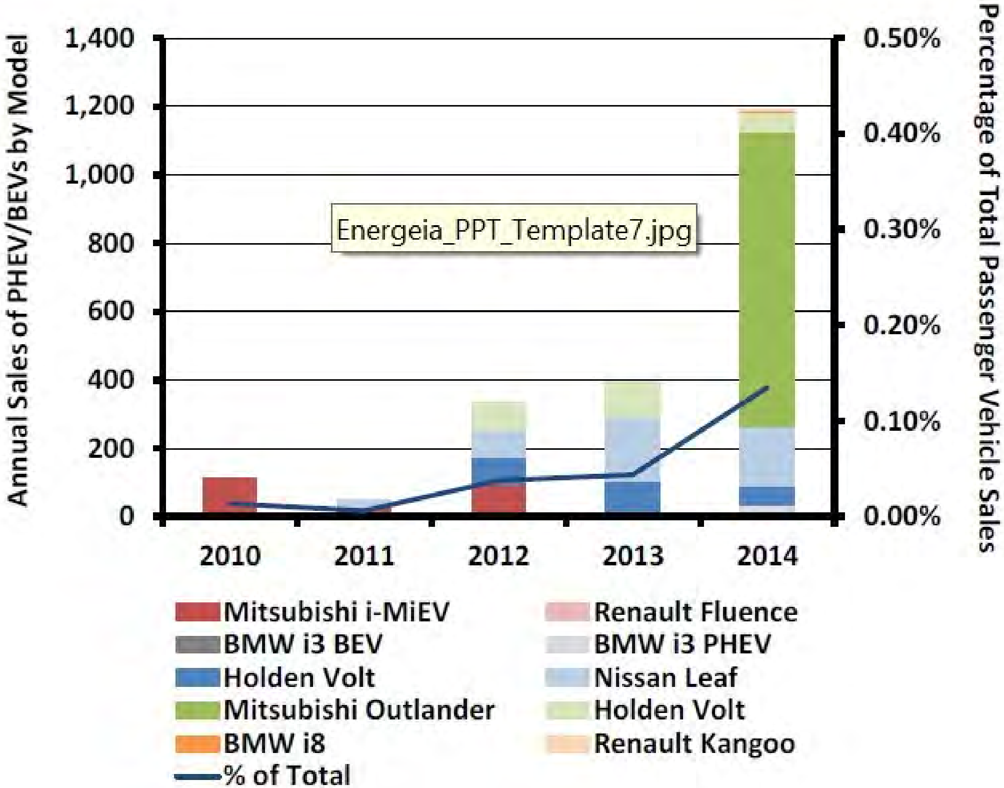
Department of the Premier and Cabinet

Current Status

- Approx. 150 EVs (including about 35 Tesla S and 50 converted vehicles)
- Approx. 300 PHEVs (mostly Outlanders)
- Approx. 5,550 Hybrids (mostly Prius, Camrys)
- Total Fleet: Approx. 1.3 million light vehicles (1.05m passenger, 0.25m light commercials)
- Fleet turnover: +7% new registrations pa, -5% retirements pa

Australian EV Sales to Date – A Drop in the Ocean



A few ripples in the market

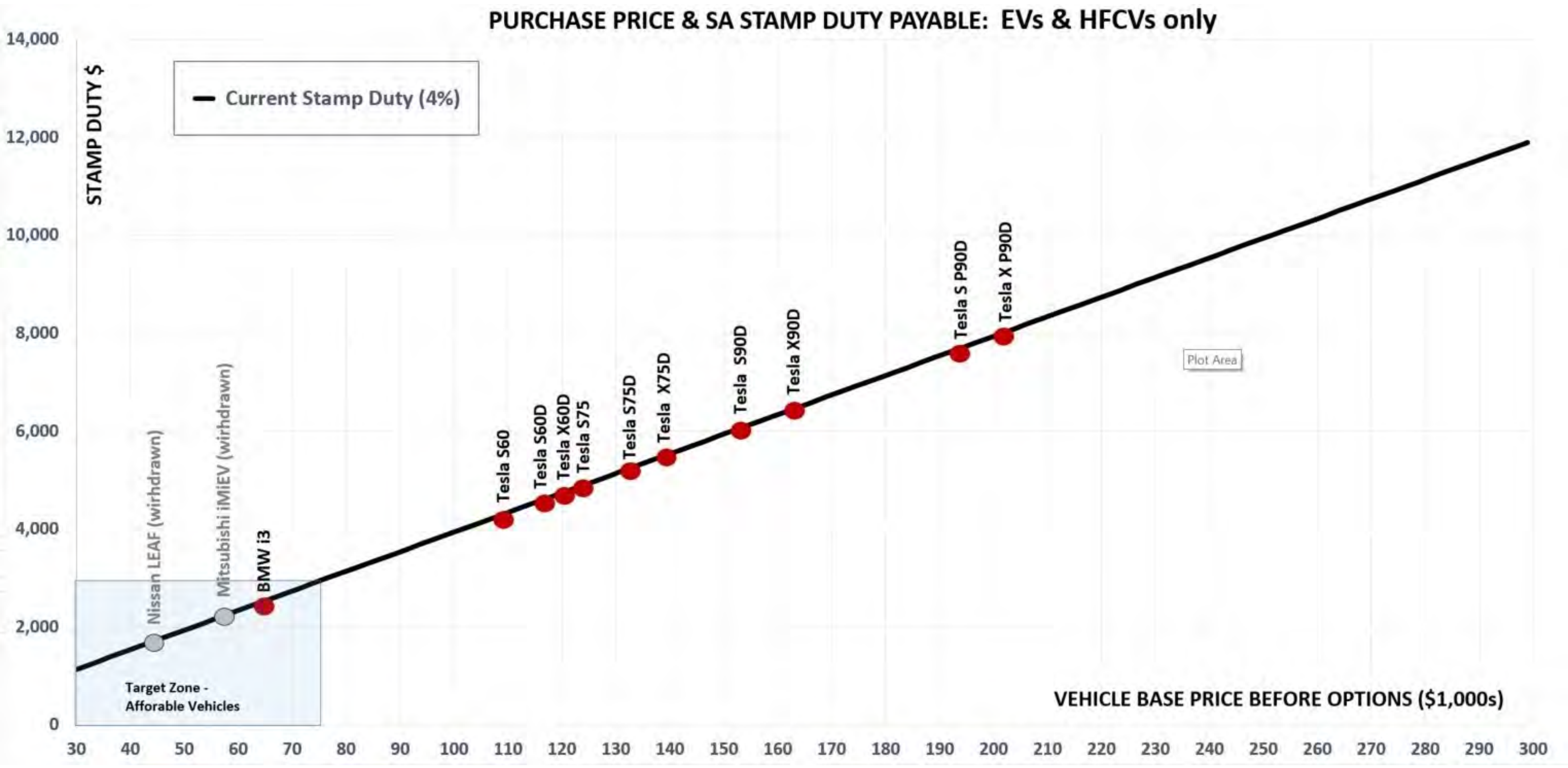
- Australian 2014 EV sales quadrupled off very low base
- 22% of new car sales in Norway are EVs (June 2015)
- Commercial sector was largest buyer, attracted by green credentials, O&M savings
- Outlander accounted for 75% of sales in its 1st year of release
- Leaf sales stagnant and Volt has fallen below expectations
- BMW i3 and i8 models made minor sales (36) in 2014
- Tesla sales data not available

Source: Federal Chamber of Automotive Industries VFacts Sales database

ENERGEIA

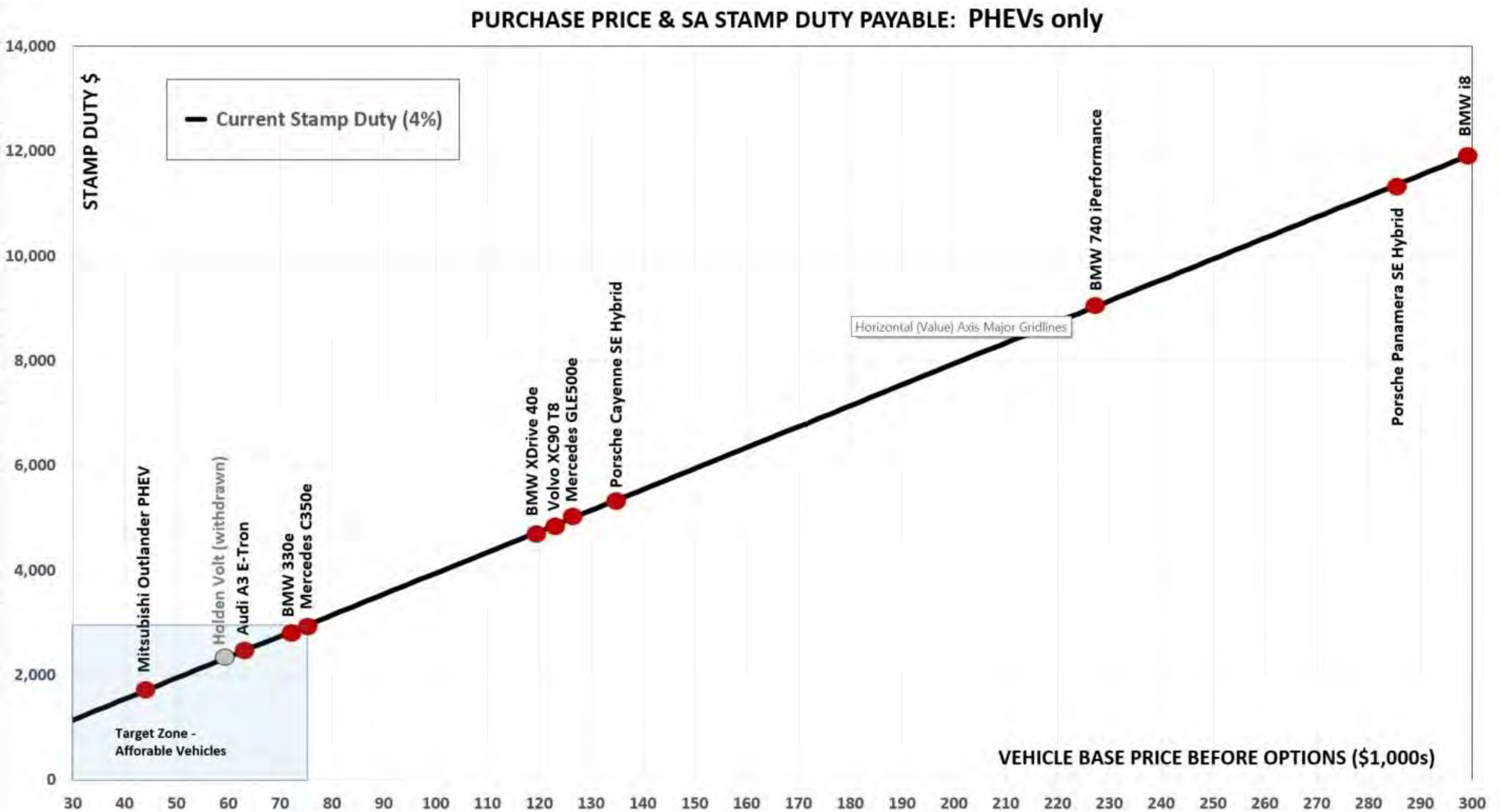
What is there to buy?

EVs



What is there to buy?

PHEVs



What makes people buy EVs?

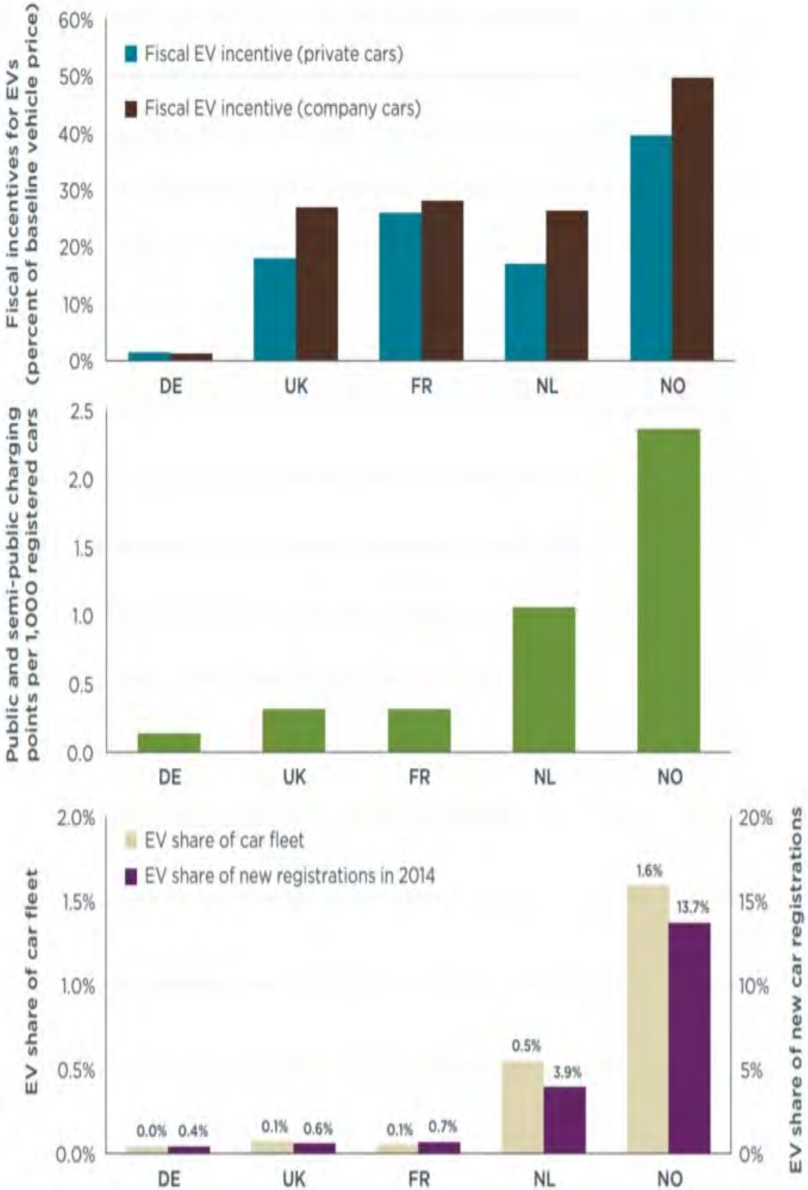


Figure 26. EV market and incentives in five European countries. Top: comparison of fiscal incentives for a medium-sized BEV. Middle: density of public and semi-public charging infrastructure. Bottom: comparison of EV shares of new registrations (2014) and car fleet.

Germany

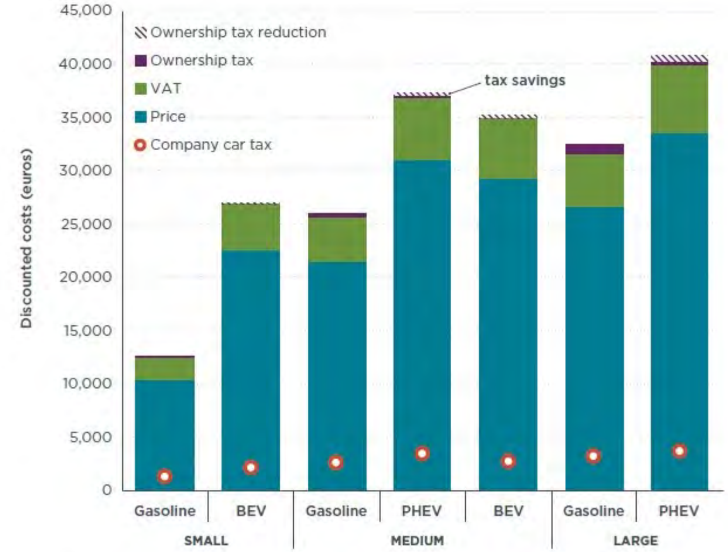


Figure 7. Summary of direct EV incentives in Germany for different vehicle sizes and powertrains.

Norway

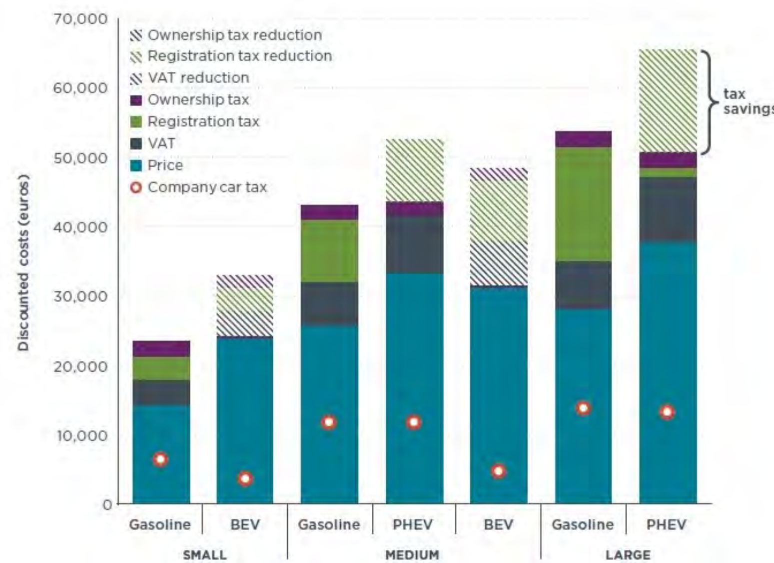


Figure 24. Summary of direct incentives for different vehicle sizes and powertrains.

SOUTH AUSTRALIA

Government of South Australia
Department of the Premier and Cabinet

Australia - The Bad News

- Luxury Car Tax – 33% for vehicle value over $75,375
- Fringe Benefits Tax – 20% on business use (incl novated lease)
- GST – Business claims limited to $57,466
- State stamp duties 4% in SA
- No grants, ADR compliance, RHD
- Seen as ‘EV Unfriendly’

Australia - The Good News

- New Fleet Fuel Efficiency Standard (with EV incentive?)
- CSIRO Futures Low C Roadmap
- Electricity Distributors (eg Electranet, SA Power Networks planning & investing for EV future
- Tesla charging infrastructure provision
- Potential for coalition of State, local governments re procurement

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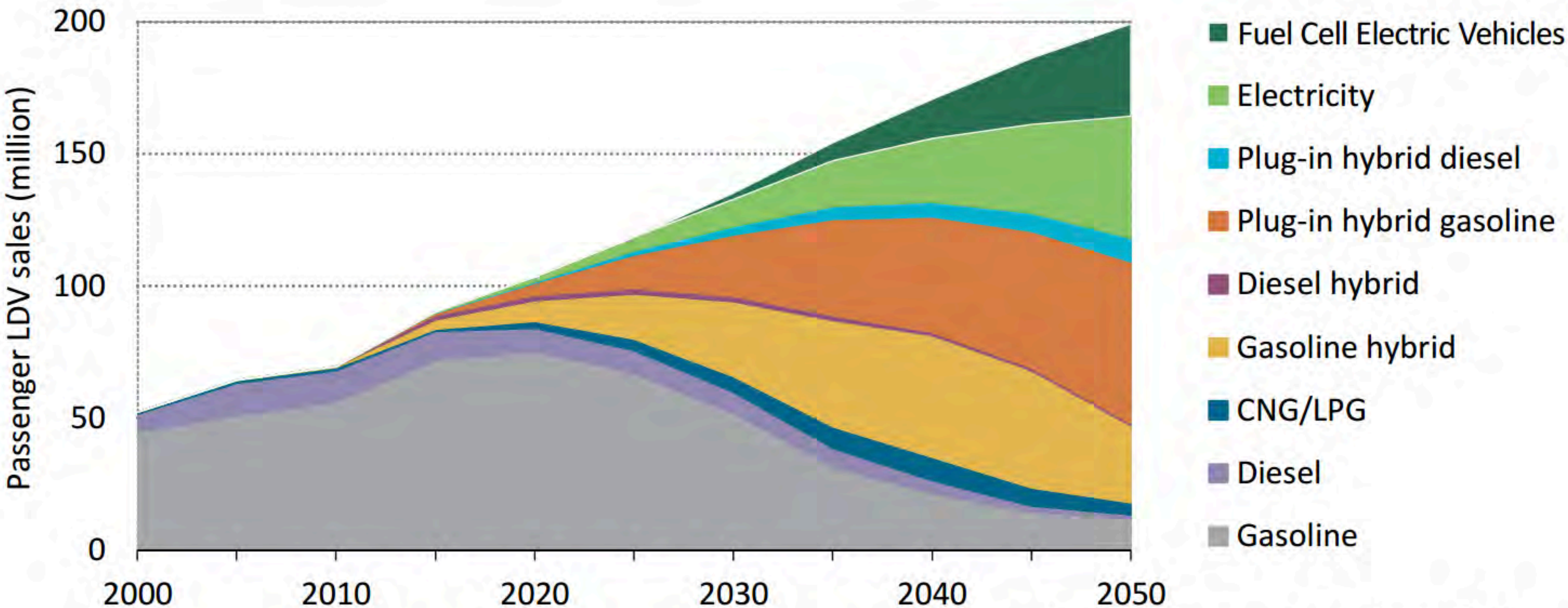
Internationally - The Good News

Countries

- ZEV Alliance (UK, NO, DL, NL, US (part), CAN (part) – all EV by 2050
- German EV production from 2K to 1m (2020) to 5m (2030)
- India 100% EV by 2030
- China 5m EVs by 2020
- Korea 200,000 EVs by 2020
- NZ: Double EV number pa to 2021

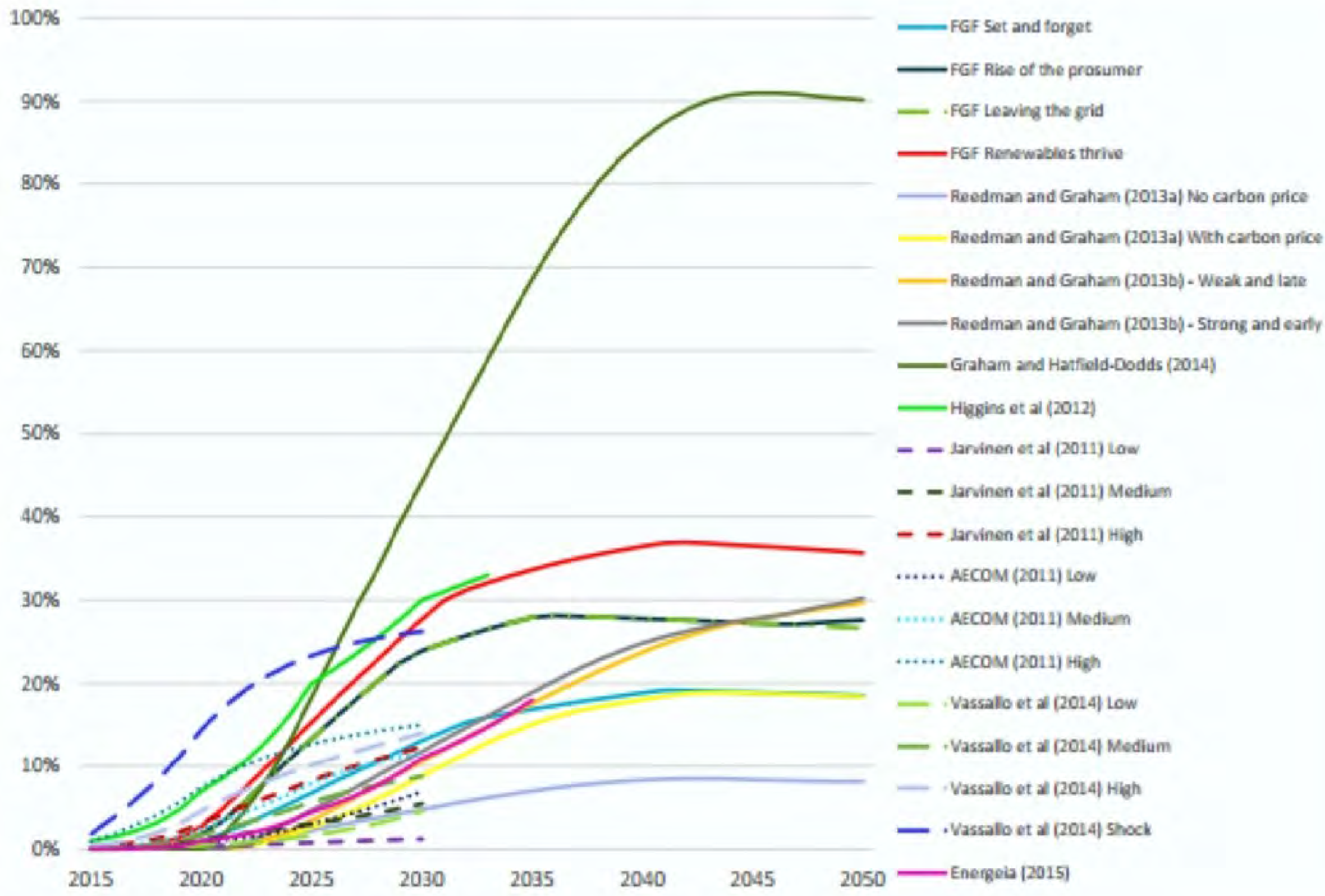
Auto manufacturers

- VW: 30 all new EVs by 2020
- M-B: 10 new EVs by 2025
- BMW: EV 3 series, X4 and Mini
- Toyota EVs for 2020
- Ford Gas2: 2030 tipping point where EVs predominate
- Affordable models - $US35 and 200 mile range: Bolt, Tesla Model 3,



(IEA / ETP (Energy Technology Perspectives) 2012)

Figure 4: Projections of electric vehicle fleet shares in Australia

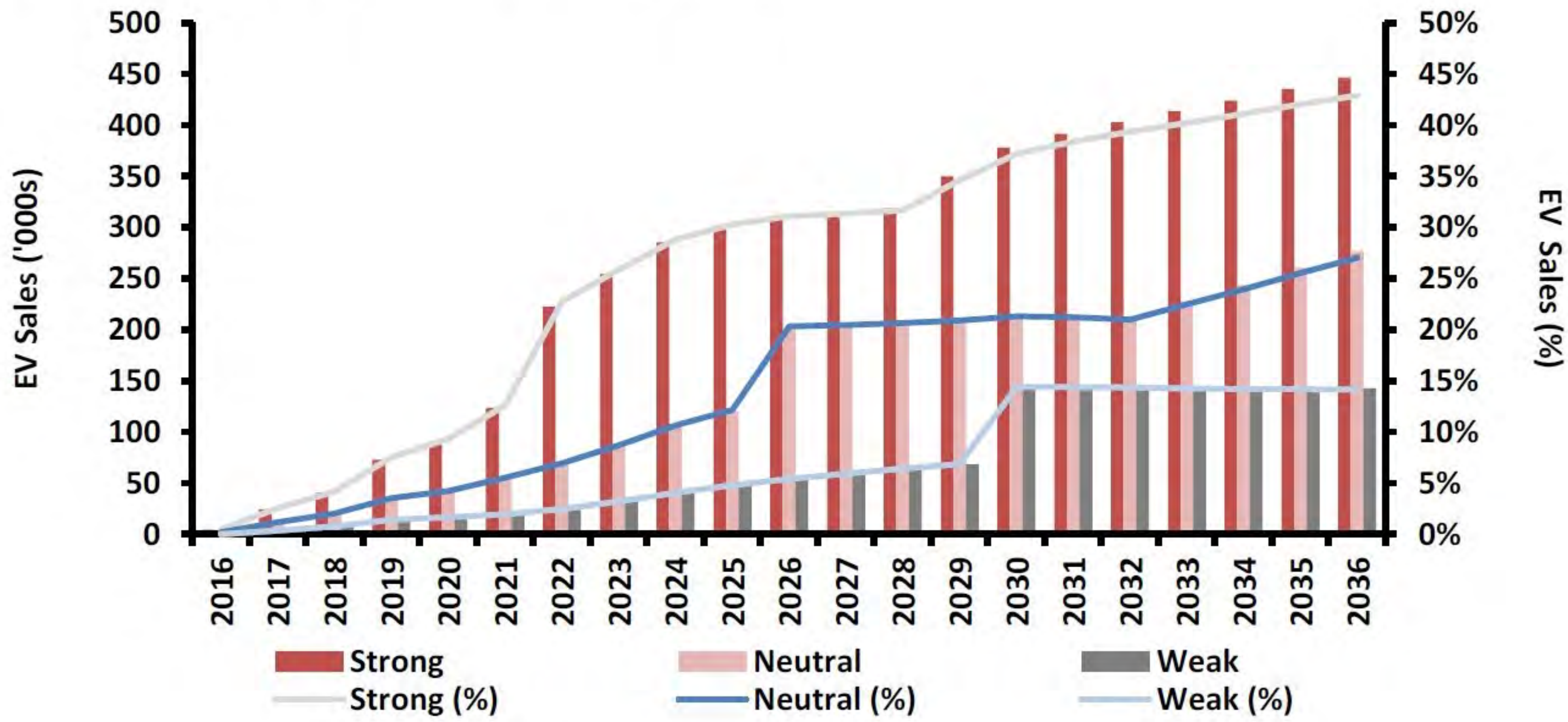


Source: Energy Network Association and CSIRO (2015)

ENERGEIA EV PROJECTIONS (August 2016)

Projected Annual Sales (NEM States)

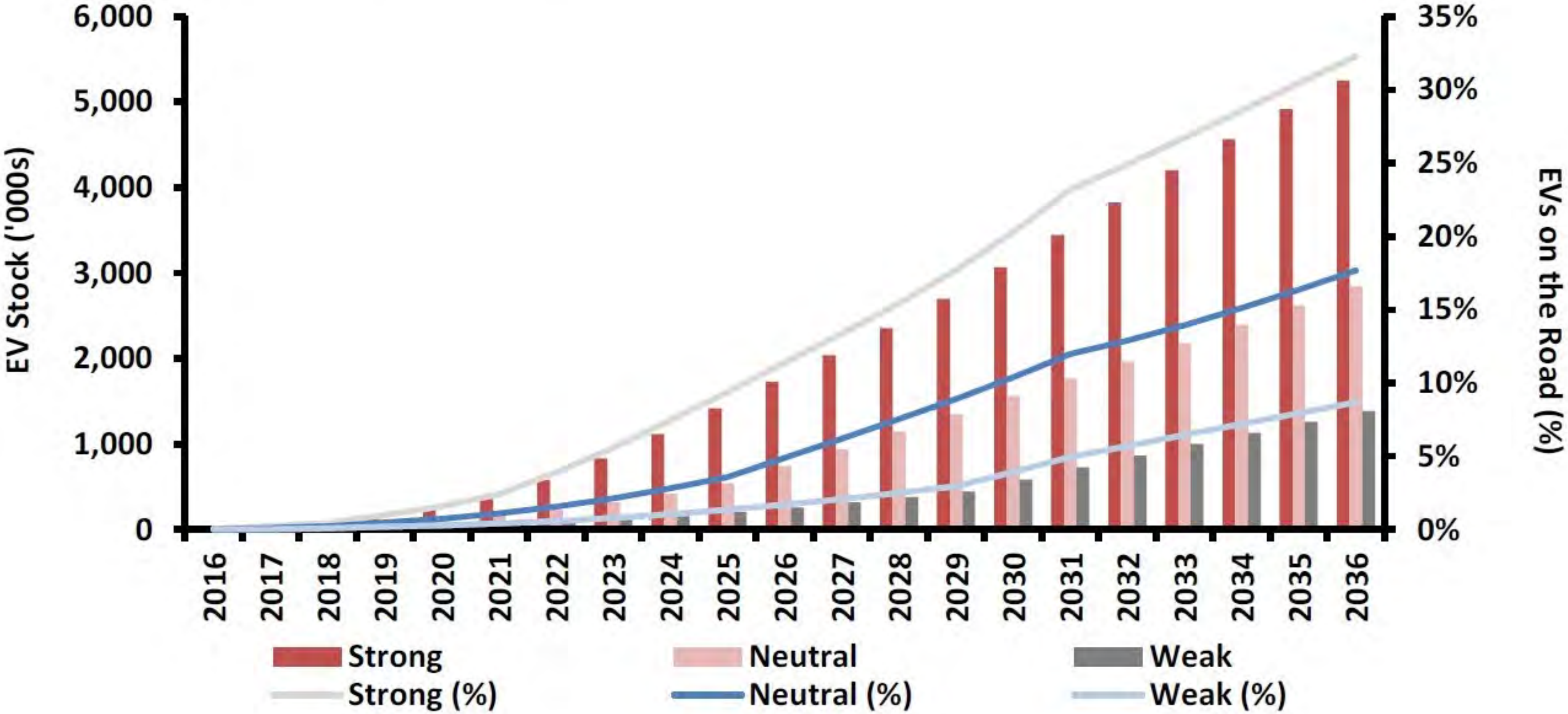
Figure 10 – EV Annual Sales by Sensitivity (NEM)



ENERGEIA EV PROJECTIONS (August 2016)

EVs Cumulative Fleet Impact (NEM States)

Figure 11 –EV Uptake by Sensitivity (NEM)



National Greenhouse Accounts Factors - August 2016

Table 5 : Indirect (scope 2) emission factors for consumption of purchased electricity from the grid

Sources: National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1) and Department of the Environment and Energy.

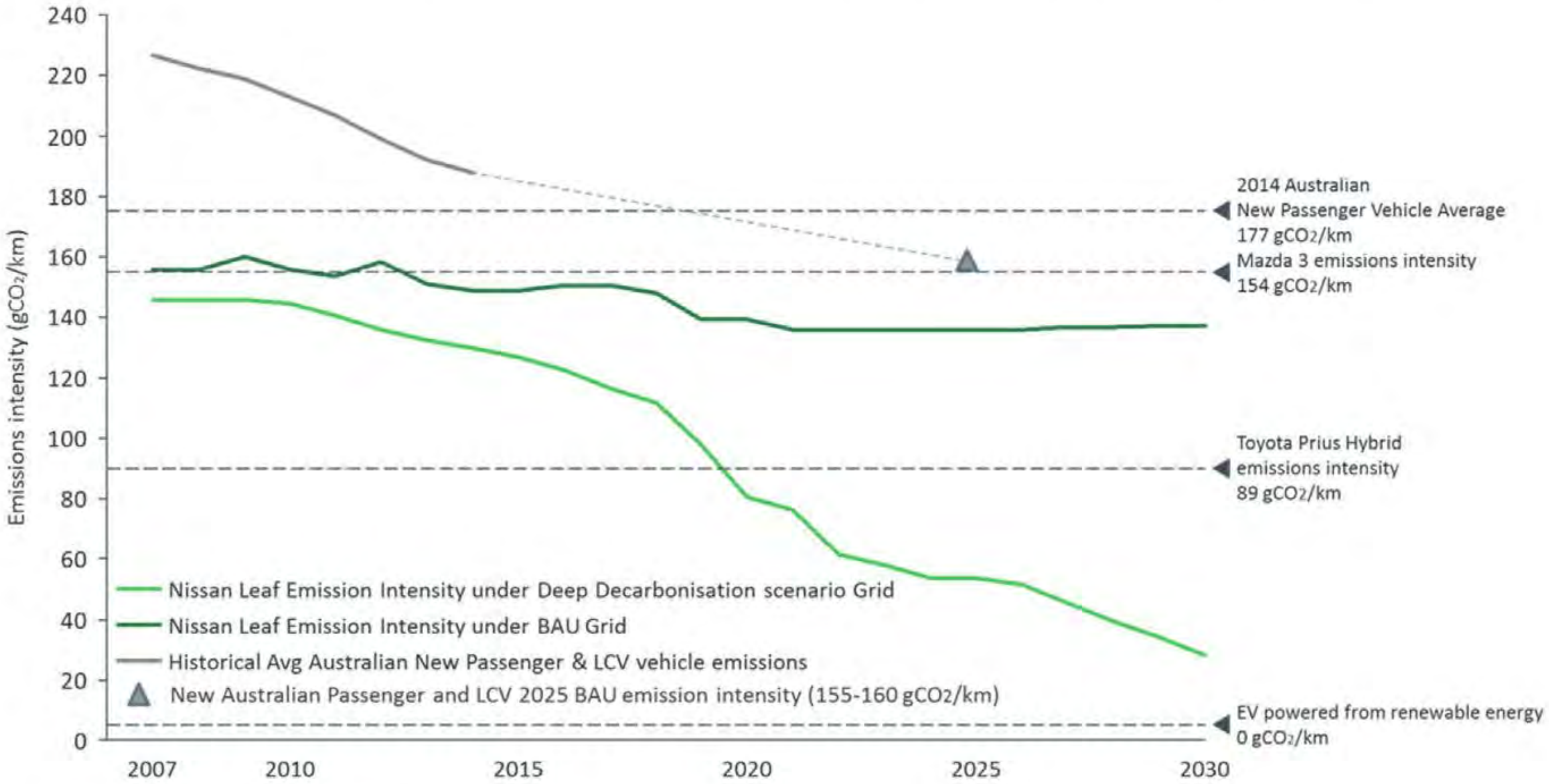
State or Territory	Emission factor kg CO_2-e/kWh	Nissan LEAF EV g CO2e / km	Nissan Pulsar 1.8L g CO2e / km
Tasmania	0.12	25.2	180.2
South Australia	0.53	111.3	180.2
Northern Territory (Darwin-Katherine)	0.56	117.6	180.2
Western Australia (NW Interconnector)	0.64	134.4	180.2
Northern Territory	0.67	140.7	180.2
Western Australia (SW Interconnector)	0.72	151.2	180.2
Queensland	0.78	163.8	180.2
New South Wales and ACT	0.84	176.4	180.2
Victoria	1.09	228.9	180.2

Relative energy efficiency (based on US EPA Fuel Efficiency figures rather than EU NEDC)

Nissan LEAF: 21 kWh per 100km

Nissan Oulsar / Sentra 1.8L: 7.8L/100km

Figure 8: Emissions intensity of electric vehicles based on Australian grid emissions forecasts



Source: ClimateWorks Australia analysis

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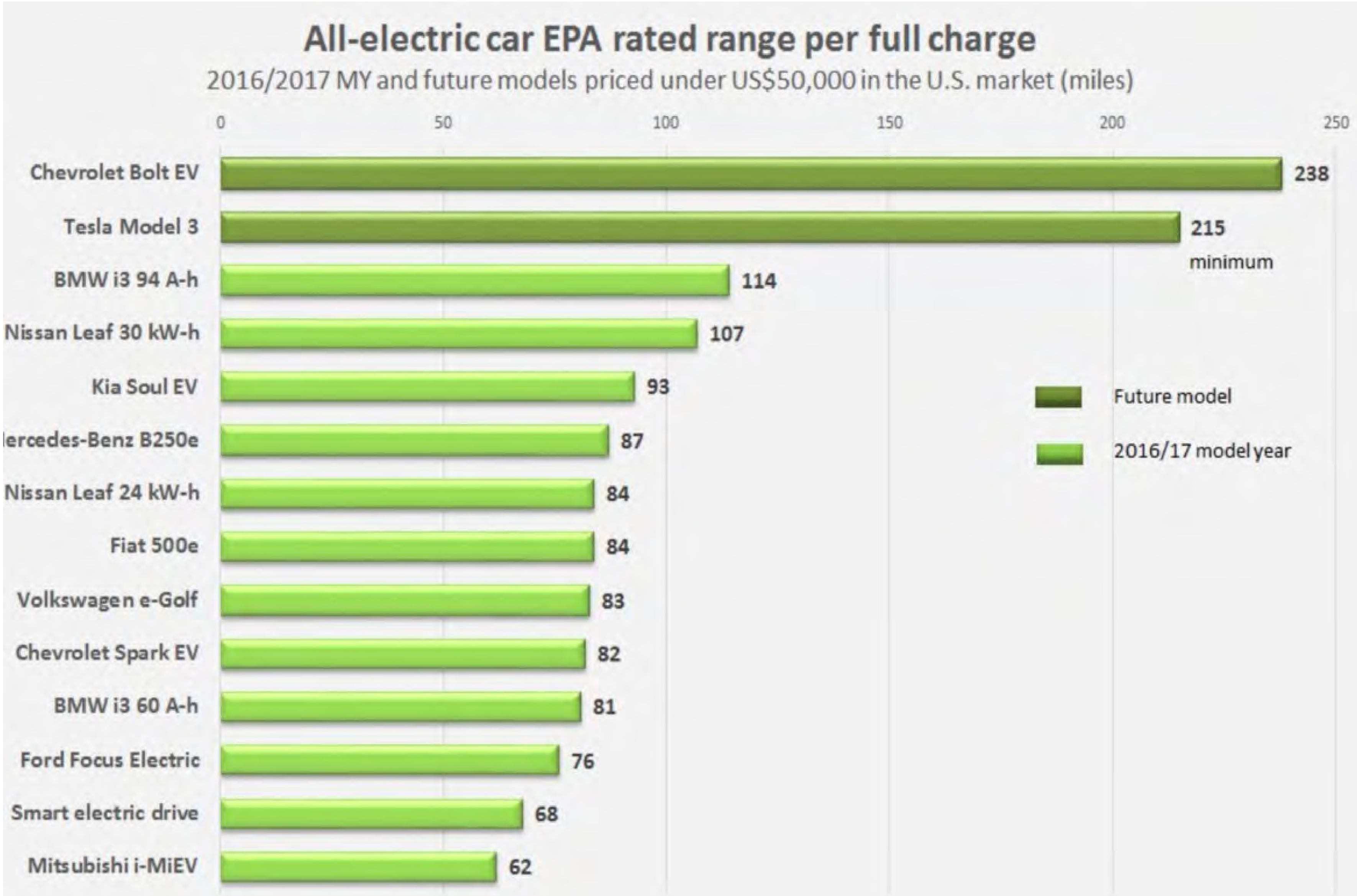
DEPARTMENT OF THE
PREMIER AND CABINET

Electric Vehicles Policy (EVs)

- Progress the Government's goal for *hybrids & electric vehicles*
- Revise SALEVS 2012-16 to focus on ZEVs. Strategies to :
  - Markedly Improve availability and affordability
  - Leadership through the SA Government Fleet
  - Provide opportunities for people to experience EVs
  - Foster private provision of recharging infrastructure including E-Highways
  - Managing impacts on the grid of vehicle recharging
  - Attract EV & HFCV industries and services
  - Integration with complimentary technologies (eg DV & smart home energy management systems)

Electric Vehicles Summary

- Needed for deep long-term cuts in emissions – net zero 2050.
- Emission reductions limited by current Australian grids, but will improve over the on-road life of the EV.
- EV uptake to spike from 2020, be significant by 2025 and predominate by 2035. HFCVs also from 2035
- However, Australia very likely to lag badly if penalty taxes remain and incentives not introduced
- Need to provide charging infrastructure to encourage uptake
- Need to achieve co-benefits (eg better grid utilisation and stabilisation) to reduce net EV costs and/or new ownership models.
- Alignment to Autonomous Vehicles.



All-electric car EPA rated range per full charge
2016/2017 MY and future models priced under US$50,000 in the U.S. market (miles)
0
50
100
150
200
250
Chevrolet Bolt EV
238
Tesla Model 3
215
minimum
BMW i3 94 A-h
114
Nissan Leaf 30 kW-h
107
Kia Soul EV
93
ercedes-Benz B250e
87
Nissan Leaf 24 kW-h
84
Fiat 500e
84
Volkswagen e-Golf
83
Chevrolet Spark EV
82
BMW i3 60 A-h
81
Ford Focus Electric
76
Smart electric drive
68
Mitsubishi i-MiEV
62
Future model
2016/17 model year

Greening Suburban Travel
Current situation, trends and best practices

LOW CARBON LIVING CRC

Callum Sleep
UniSA NBE

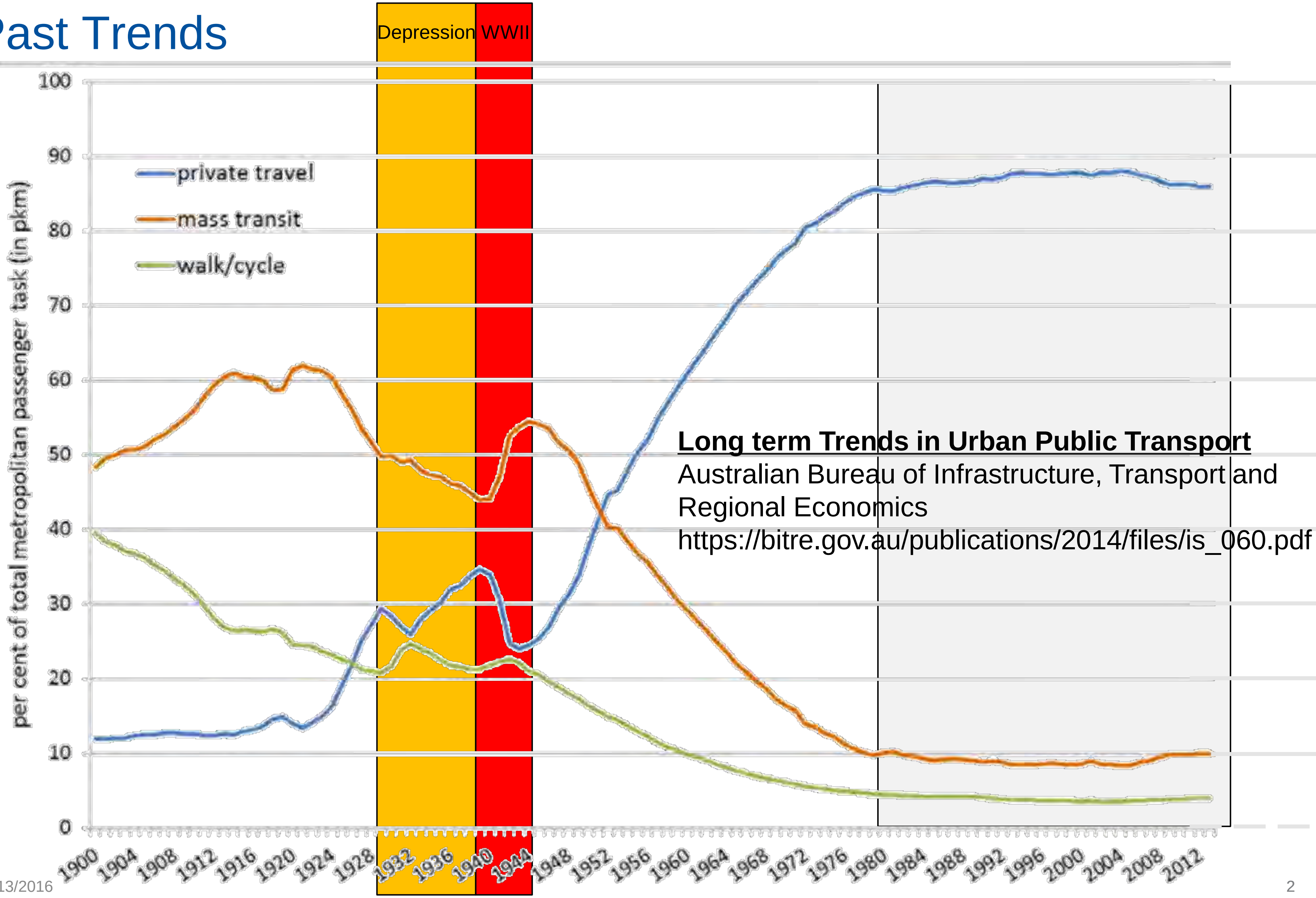
7th December 2016

University of South Australia

RenewalSA people partnerships progress

Government of South Australia

Past Trends

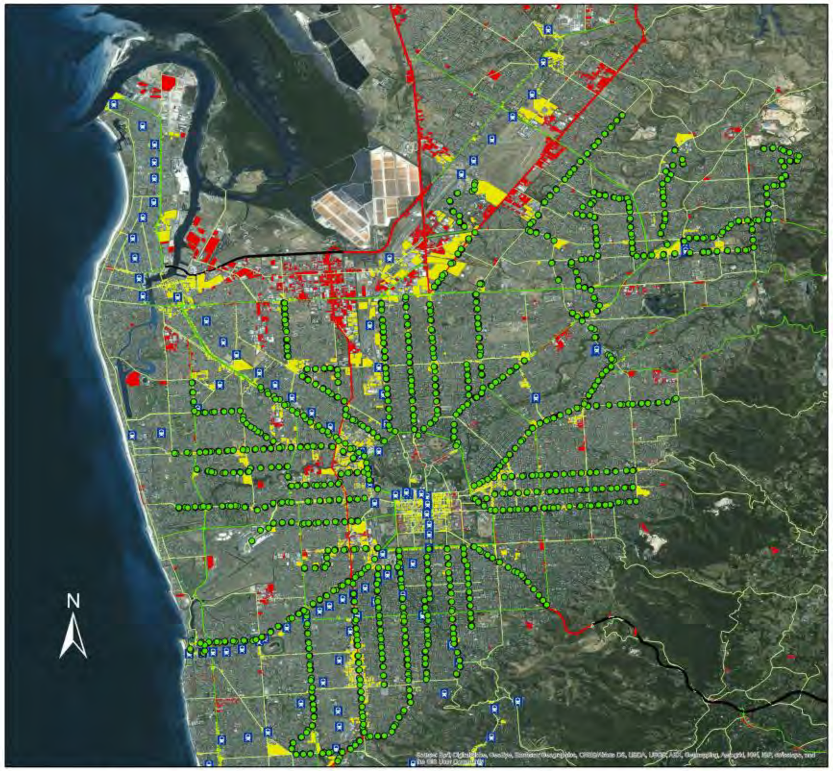


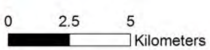
Long term Trends in Urban Public Transport
Australian Bureau of Infrastructure, Transport and Regional Economics
https://bitre.gov.au/publications/2014/files/is_060.pdf

Urban design

Road based planning

Adelaide Commercial Distribution

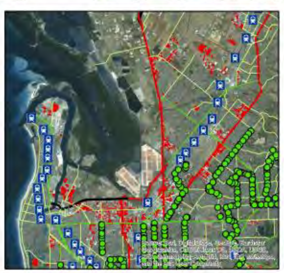




These PT Inaccessable businesses are over 20% of the total in Metro Adelaide.

then it depends where your coming from

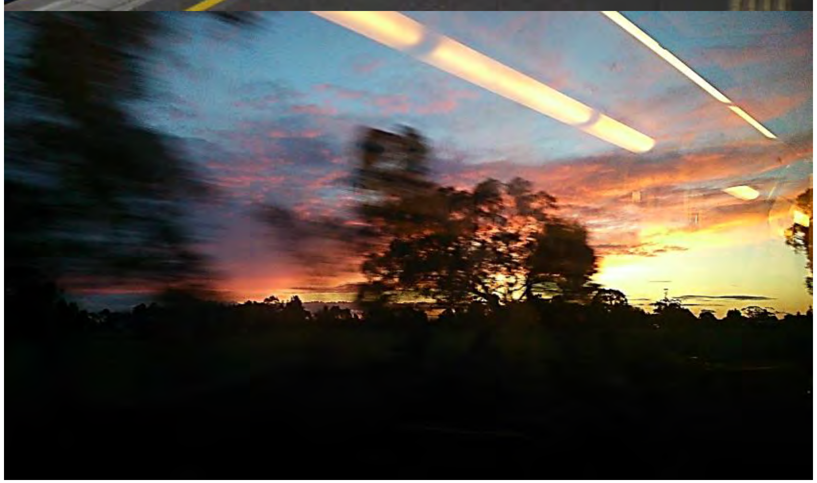
Of those PT inaccessable it can be seen that they are generally near a main road the inset highlights this in the north region



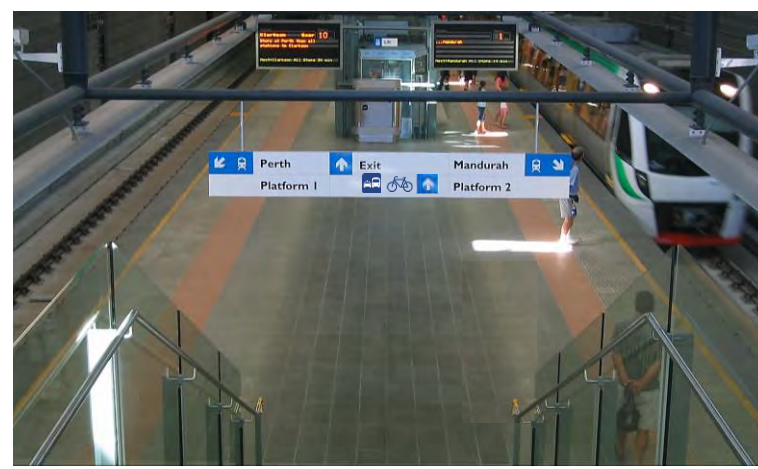
University of South Australia

LOW CARBON LIVING CRC

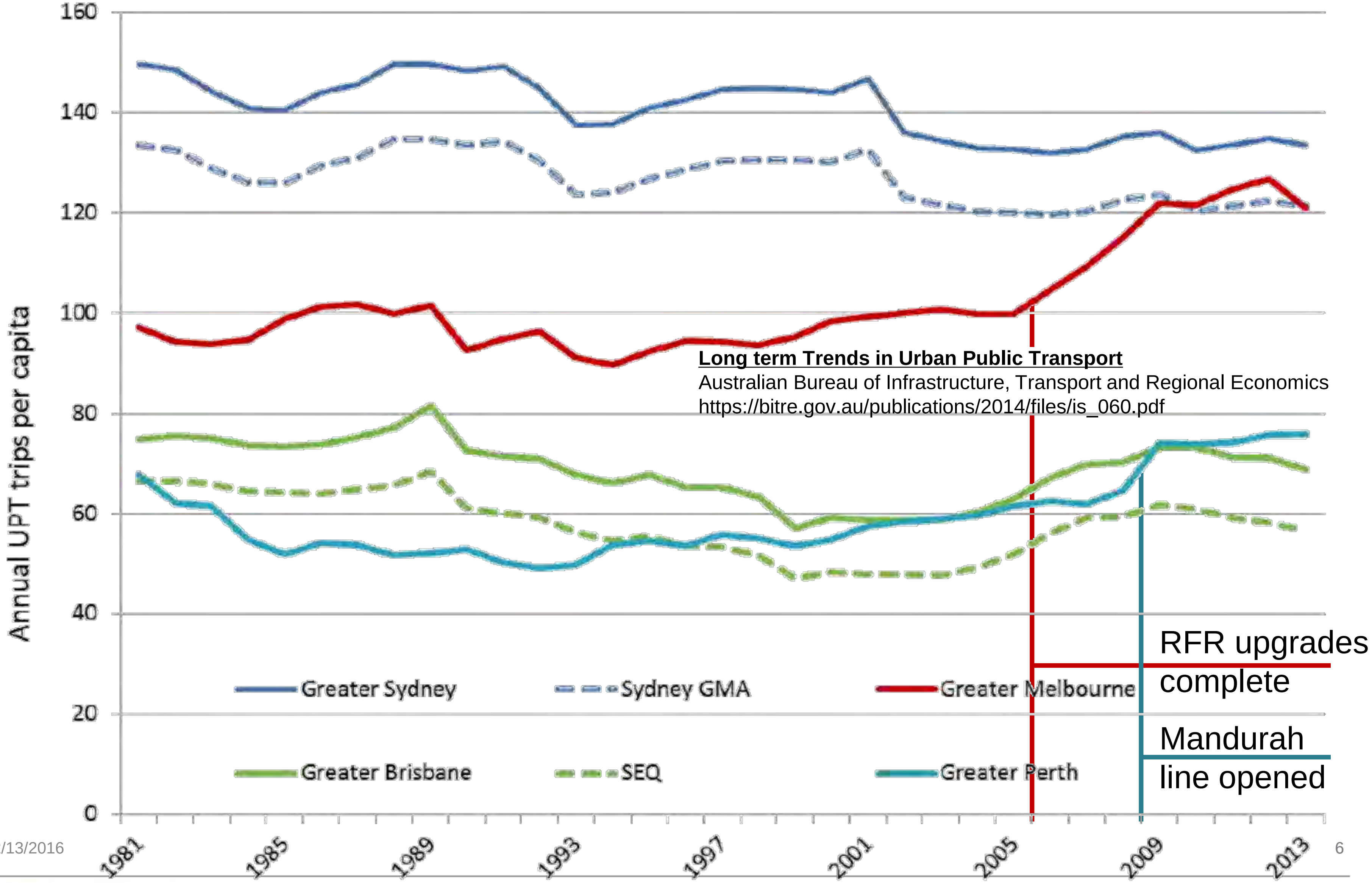
Practices Melbourne & Perth



https://upload.wikimedia.org/wikipedia/commons/e/ef/Mitchell_Freeway_100_N_Stirling_Civic_with_train.jpg
https://upload.wikimedia.org/wikipedia/commons/3/34/Transperth_Esplanade_Station_platform.jpg

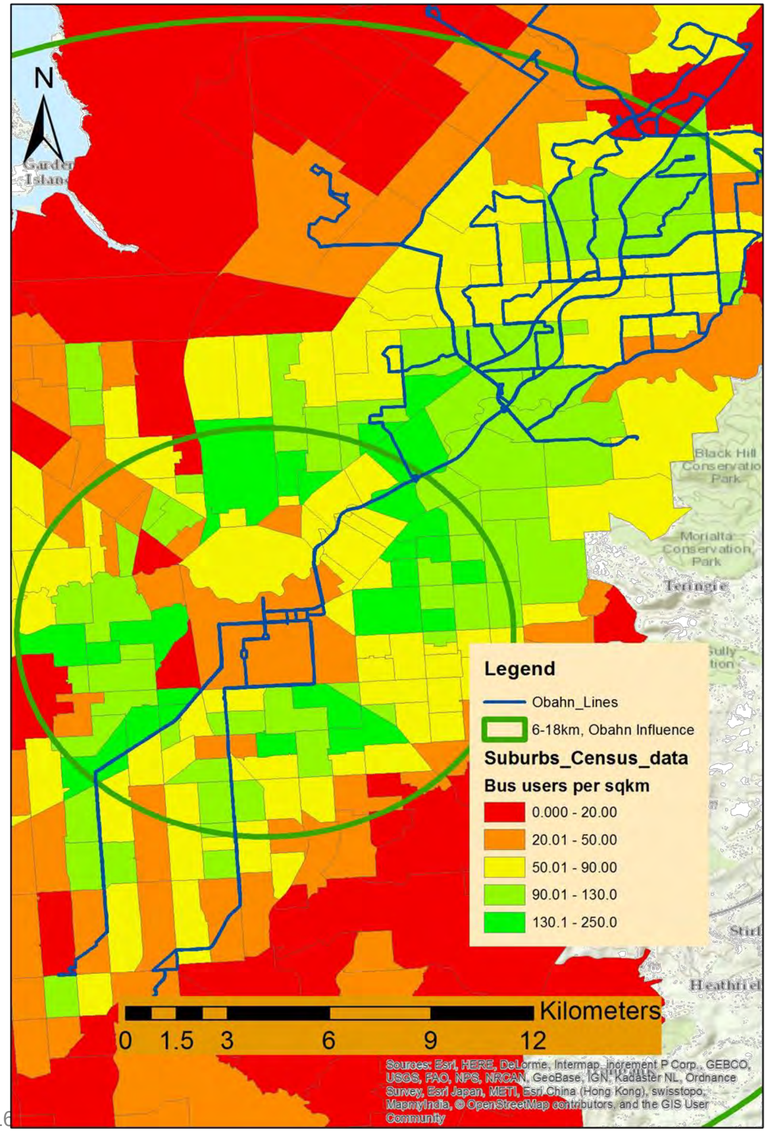


City Scale



160
140
120
100
80
60
40
20
0
Annual UPT trips per capita
Long term Trends in Urban Public Transport
Australian Bureau of Infrastructure, Transport and Regional Economics
https://bitre.gov.au/publications/2014/files/is_060.pdf
RFR upgrades complete
Mandurah line opened
Greater Sydney
Sydney GMA
Greater Melbourne
Greater Brisbane
SEQ
Greater Perth
1981
1985
1989
1993
1997
2001
2005
2009
2013

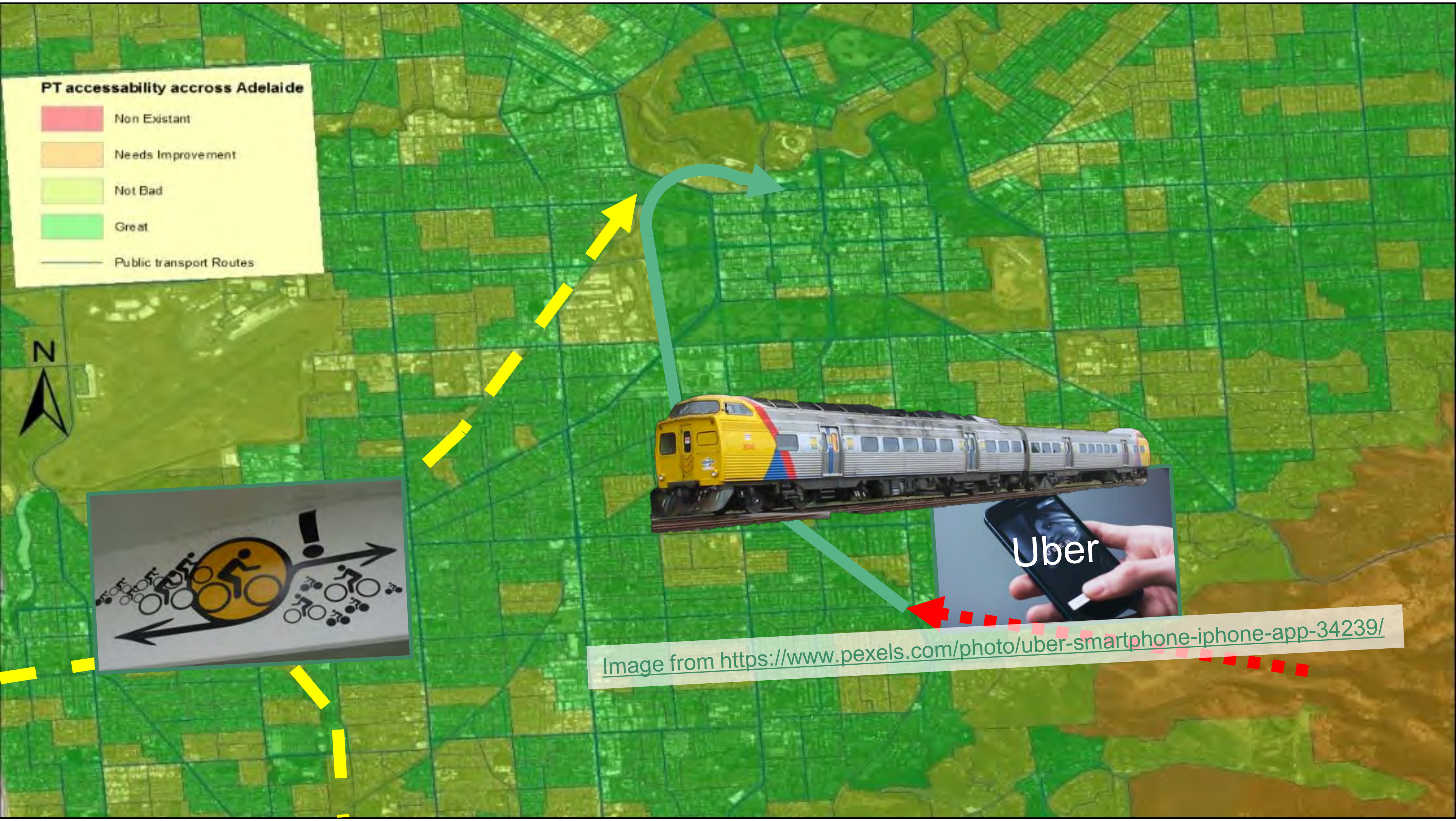
Bus Rapid Transit, dedicated corridor without the transfer



https://upload.wikimedia.org/wikipedia/commons/d/d8/Linear_Park.jpg
https://upload.wikimedia.org/wikipedia/commons/2/2d/Buses_entering_track.jpg

Visible transport lines

Still The First/Last Mile Problem



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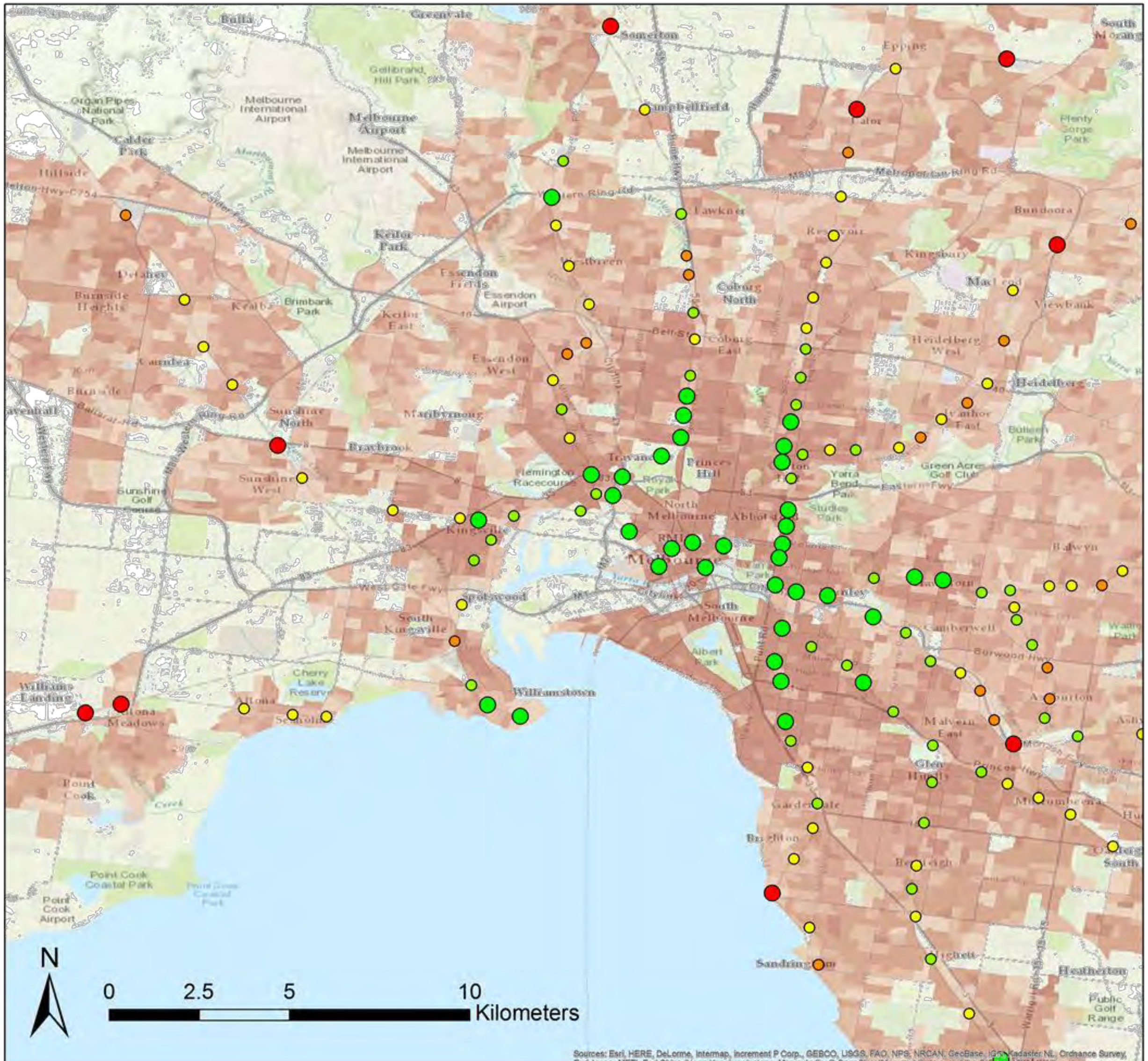
Urban densification and TOD creation

Alternative Access

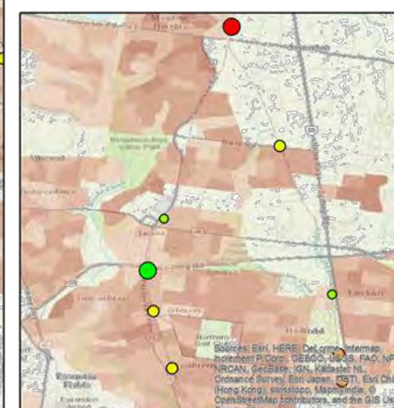
Car Access to Melbourne Stations



Train Stations **Melbourne**

Arrivals By Car	Persons per sqkm (000)
0 - 10%	up to 1
10 - 22.5%	1 - 2
22.5 - 40%	2 - 3
40 - 55%	3 - 4
55 - 85%	greater than 4

With the exception of the Broadmeadows area
(shown in the inset below)
there is a very strong trend towards car access
in the outer suburbs of lower density



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Complimentary modes

https://commons.wikimedia.org/wiki/File:2010_Toyota_Prius_Plug-In_(ZVW35R)_liftback,_GoGet_CarShare_(2015-02-15)_02.jpg

More then just feeder busses!

Thank you!

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University of
South Australia
School of Natural and Built Environments

Bus based transit oriented development (BTOD): Opportunities and challenges for low density, car dependent cities

Prepared by
Munshi Nawaz

Research Supervisor - Dr. Sekhar Somenahalli
Co-Supervisor - Dr. Andrew Allan

What is Transit Oriented Development (TOD)?

TOD is a concept that "refers to dense, mixed-use and pedestrian friendly development oriented to rapid transit" – Higgins and Kanaroglou (2016).

A TOD can also be defined as a mixed use community within an average 400m of transit stops and core commercial areas. - Parker (2002).

A TOD is 'a mixed-use community within walking distance of a transit stop and a core commercial area'. – Calthrope (1993).

Key TOD Principle

The basic principle of TOD can be described as the design of a mixed use relatively higher density development emphasizing on the pedestrian accessibility to a major transit route and reinforcing the use of public transportation.

The key components of TOD can be –

a) a major (rapid) transit route;
b) higher density mixed use development along the route; and
c) appropriate design for increased accessibility.

The concept of TOD is aligned with the principles of Integrated Transport and Land Use Planning

Continued..

How is BTOD different to RTODs and BRTs?

- RTODs are developed along a rail corridor, while BTODs mainly refer to the neighbourhoods that are serviced by bus routes.
- BTODs are supposed to be developed along a corridor similar to a rail corridor, where the corridor may be in form of a dedicated lane within a shared roadway or a track developed only for buses (e.g. Adelaide O-Bahn).
- Bus rapid transit (BRT) concepts as a transport measure can be integrated with the land use planning solutions for the development BTODs along the BRT transit corridor.
- Adelaide O-Bahn is a classic example of a BRT, with a potential to be transformed into a corridor supporting BTODs.

Continued..

TOD's impact on travel behaviour

- People, living within TODs (RTODs), found using public transport more frequently than those living outside
- People living within 800m of a station tend to walk more than frequently than those living farther.
- Reduced frequency of driving is also found for people living within TODs.

- from research of Noland and DiPetrillo (2015)

- The following attributes were found to be the negative factors in attracting increased patronage –
  - Lack of pedestrian and cycling accessibility to the stations;
  - Lack of safety and security in station and onboard;
  - Frequency of services.

- Taylor et al. (2011)

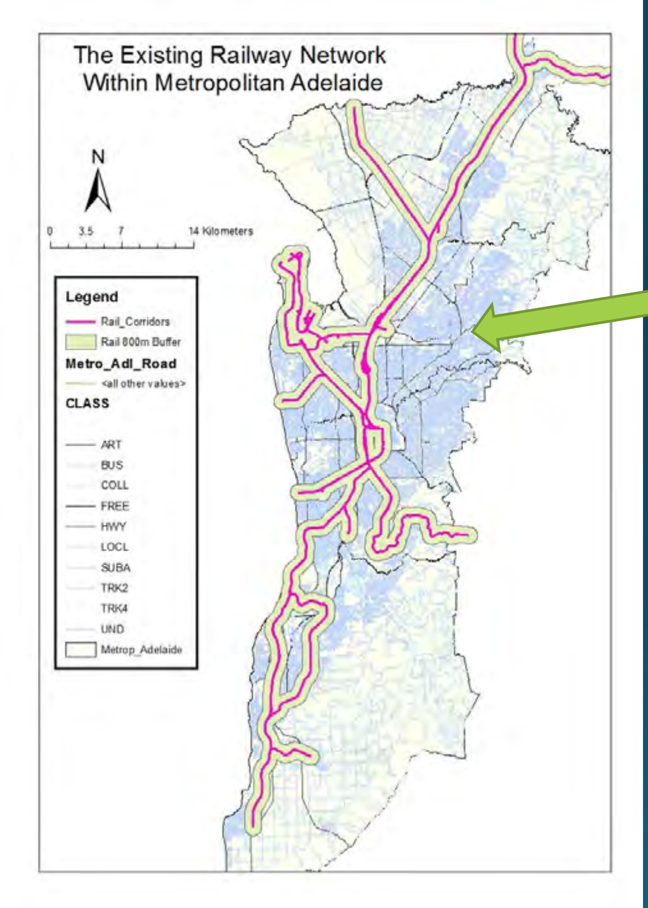
- Consistent with the above, another research found that the travellers would accept to walk an additional distance of 206m to 327m for a 10 minutes improvements in bus frequencies.

- Rose et al. (2013)

Potential for BTODs for low density, car dependent cities

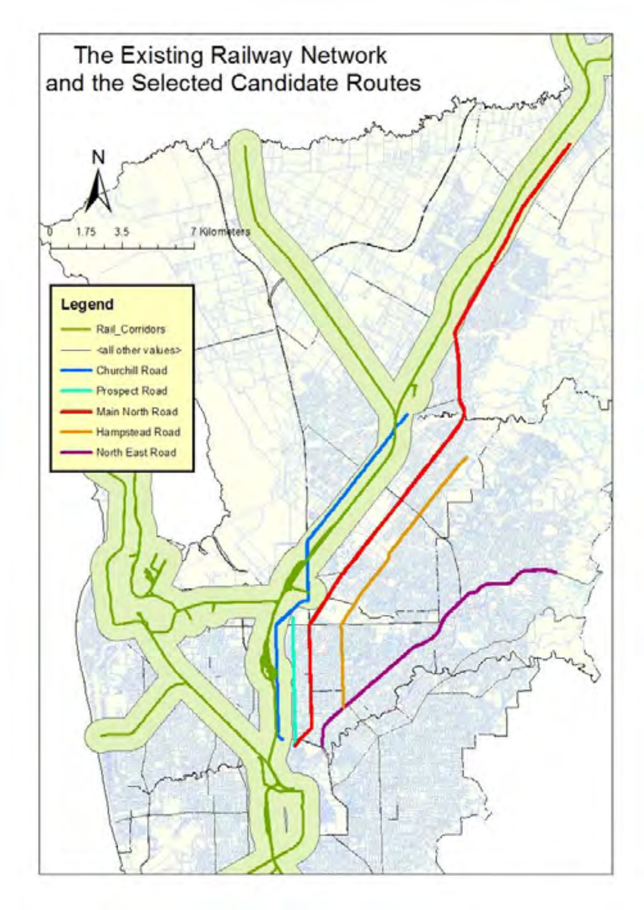
- Development of new rail corridors in existing built-up areas can be constrained.
- Outer suburban areas of Metropolitan Australian cities (such as Adelaide) comprises underutilised services and properties with the potential for future TODs.
- Buses already play a critical role in areas, which are located beyond the catchments of existing railway corridors.
- A bus based service is expected to require lesser patronage to be viable/ sustainable than a rail based service (for rail, recommended density is 35 persons/ ha).
- Bus based transit corridors (TCs) are flexible and can be developed with minimal modifications to the existing infrastructure.
- Costs for developing a bus based TC is significantly lower than developing light rail transits or metro-rail systems (Approx. 4-20 times less than LRT and 10-100 times less than metro-rail system).

Existing Railway Coverage and Potential Bus Transit Corridors



Existing railway network and a 800m Catchment

Existing vast Built up areas located outside rail coverage



Road corridors with potential to be transformed into bus based Transit Corridors

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Continued..

Research Goal

Examination and evaluation of the opportunities and challenges of bus transit oriented development (BTOD), as a form of integrated transport and land use planning, in increasing public transport riderships in the context of low density cities.

Research Objectives

- Critical examination of the potential of TOD principles in the context of the outcome of existing land use and transport patterns.
- Evaluation of the contribution of bus based transit routes in attaining density required for successful TOD along the corridors.
- Development of BTOD models as part of an integrated transport solutions (i.e. networks of BTODs and RTODs).
- Examination of the Impacts of the proposed transit network model on transit adjacent developments in terms of estimated shift from private to the public mode of transport usage.
- An evaluation of travel behaviour as a result of BTOD development.

Continued..

Research Methodology

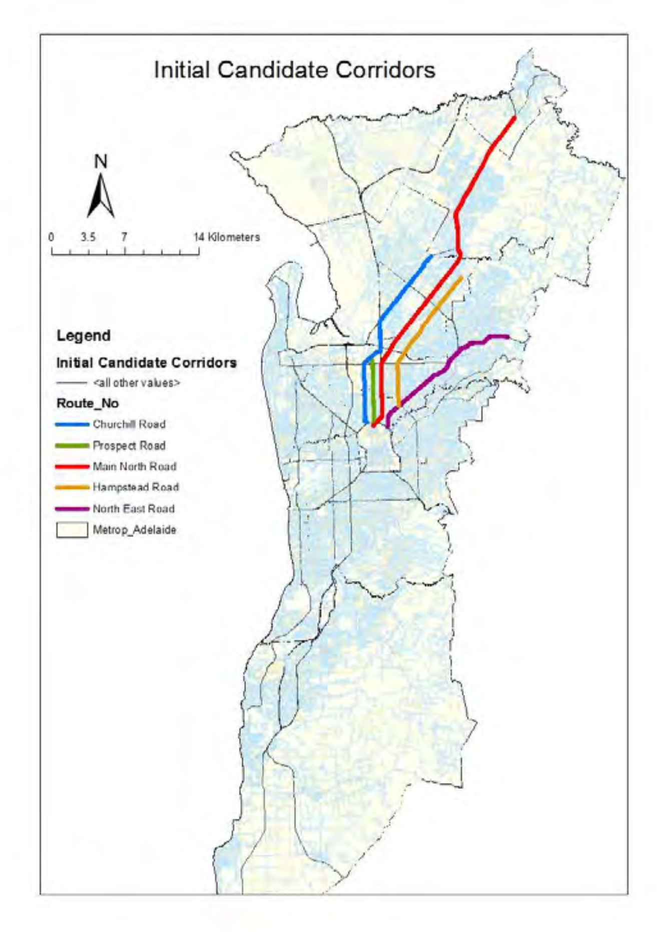
This research is designed to undertake following two (2) major activities–

1. Land Suitability Analysis – to determine the suitability of a corridor adjacent land for the development of future TODs
   - By way of analysing existing land use and demographic data
   - Selection of multiple parameters/ variables
   - Multi-criteria decision analysis methods will be applied at different levels as appropriate

2. Public travel behaviour analysis – to understand the existing mix of dependency on private cars and buses, their stated preferences towards the new transit service and to estimate the preferences to potential growth at the identified transit locations.
   - Designed to validate the findings from Land Suitability Analysis, in terms of population density etc.
   - Household questionnaire survey will be undertaken within the identified TOD locations. The sample size would range from 300-600.
   - A transit passenger questionnaire survey would also be undertaken selecting identified nodes along the corridor. Estimated sample size would range from 80-150.

Minor research projects supporting the overall research

- Selection of the study area and the study route / corridor
  - Metropolitan Adelaide
  - 5 existing bus routes were initially selected as candidate corridors located in the northern region of metropolitan Adelaide
  - Nine (9) parameters were selected; multi-criteria decision analysis techniques were engaged to identify relative importance (weights) of the parameters
  - Final outcome of the analysis showed that Main North Road would be the most suitable route to be considered as the study corridor
  - This method was developed based on relevant literature and can be applied in a selection process of any routes under consideration.



- Evaluation of the Study Corridor (i.e. Main North Road)
  - Assessment of the existing bus routes and services
  - Identification of the existing corridor catchment
  - Analysis of the existing data to identify the frequency and the purposes of the trips made
  - The existing public transport customer survey data -2009 are being analysed for the corridor
  - Other relevant data will be collected and analysed to evaluate the existing performance of the corridor.

- Identification of the design principles required to transform Main North Road into a Transit Corridor
  - Mostly look at the existing infrastructure and services along the corridor
  - On the basis of relevant literature findings, detailed discussion will be provided in terms of the key BRT design features
  - Potential of feeder bus services would also be examined for the northern part of the corridor, i.e. connecting the suburbs of Salisbury, Elizabeth etc.

Continued..

Expected Research Outcomes

- ❑ Development of a BTOD network model (as an interconnected networks of BTODs, RTOD and feeder service routes) –
  - Development of design principles for identification of the suitable BTOD corridor/s
  - Identification of key design principles to develop integrated active transport network (i.e. walking and cycling) for greater accessibility
  - Development of the spatial policy on how the identified suitable land can be developed.

- ❑ Development of a land use analytical model –
  - Development of a methodology for identification of land suitable for supporting future TODs (to attain ‘density’ and ‘diversity’).
  - The analysis are expected to provide a qualitative results in potential growth or density
  - Identification of the relevant parameters and their level of attributes for undertaking land suitability analysis
  - Development of a model based on the identified relationship between all dependent and independent variables.

❑ Understanding of the social perspective on the mode choice preferences

- The household questionnaire survey results will provide important information on the reasons behind their mode choices.
- The survey would also provide participants comments on the theoretical bus corridor.
- A quantitative outcome of the survey result can also be compared with the outcomes of land suitability analysis.

Thank You

University of South Australia

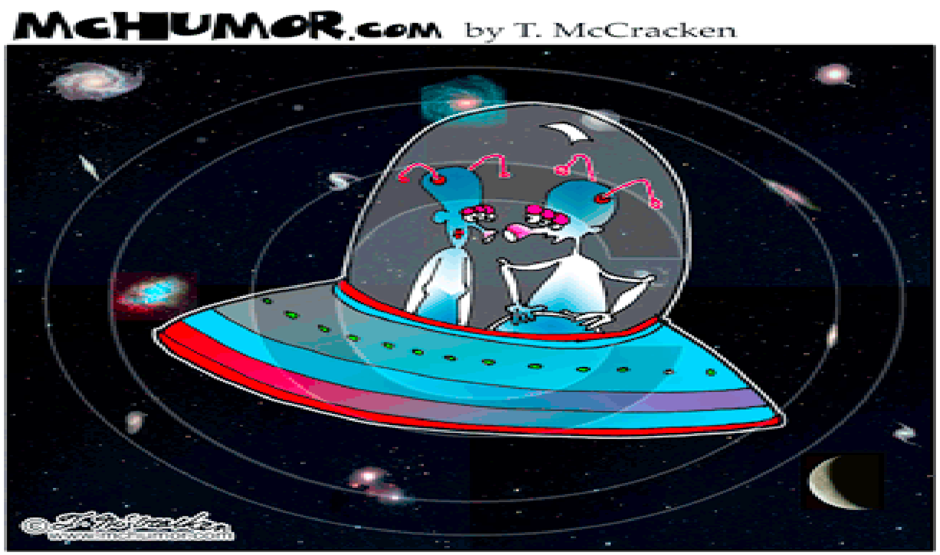
Workshop on Low Carbon Mobility: Greening Suburban Travel

Date:08/12/16

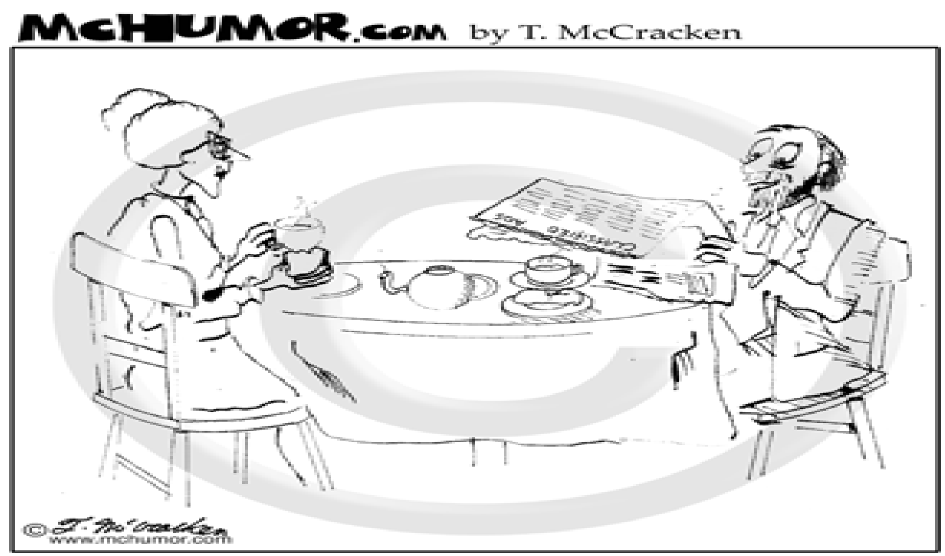
Dr Li Meng

Higher density developments in Adelaide: Residents' perceptions in rail corridors

- How do residents travel to the railway station
- Where and what type of house do residents choose to live



"We've got to move closer to work. These 200 light year commutes are killing me."



"Hmmph. Here's an ad for affordable housing five minutes from downtown. By what means? Learjet?"

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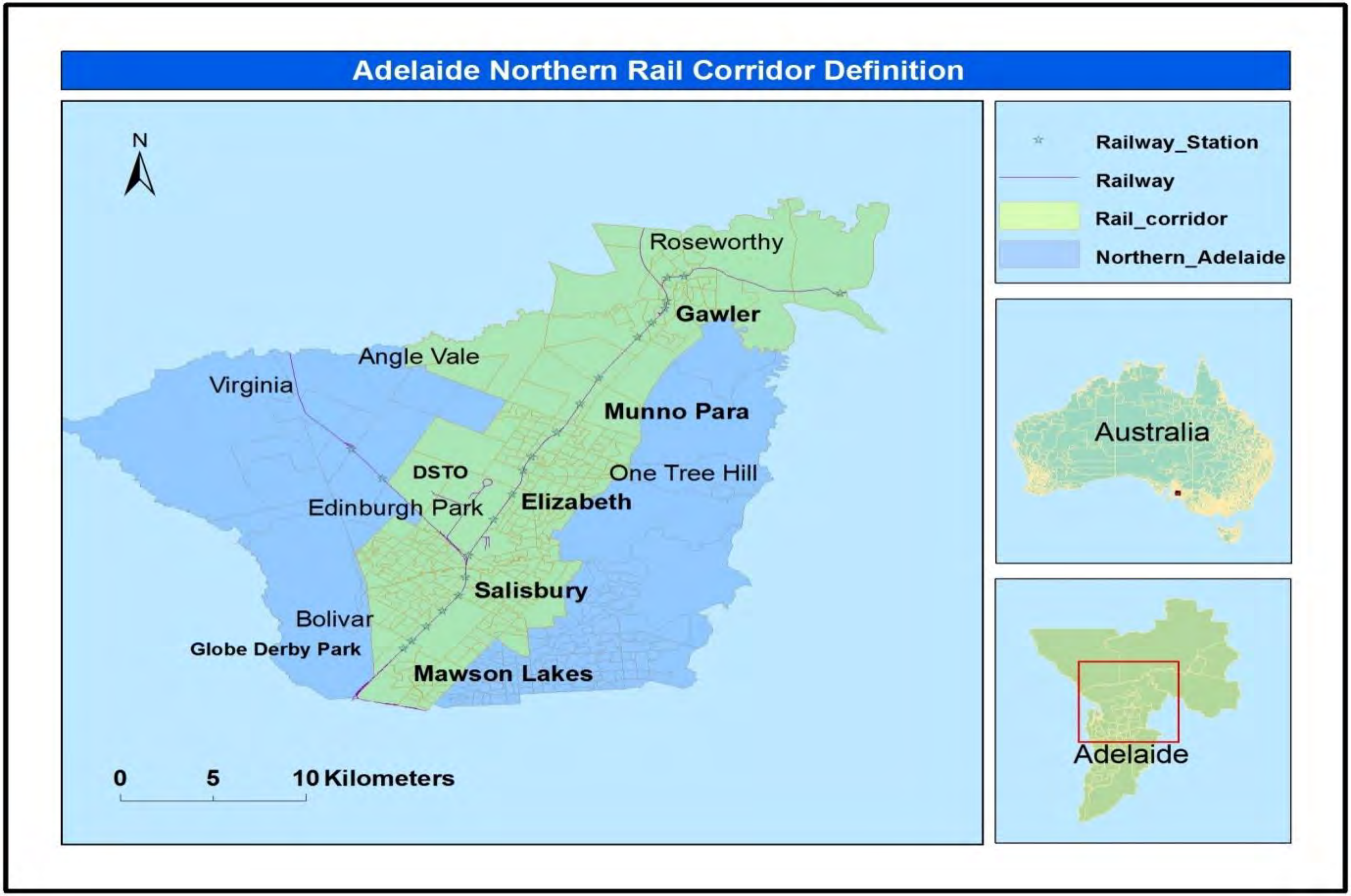

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Discrete Choice Modelling

- $$p_{mi} = \frac{\exp(U_{mi})}{\sum_m \exp(U_{mi})}$$

  p_{mi} – the probability, individual *i* select alternative *m* from a set of alternative choices

- $$U_{mi} = \alpha_r + \sum_j \beta_{mj} X_{ji} + \sum_k \gamma_{mk} Y_{ki} + \sum_l \lambda_{ml} Z_{li}$$

  U_{mi} – utility function
  X_j – alternative specific variables (e.g. transit time, cost)
  Y_k – person-specific variables (e.g. income, family size, gender)
  Z_l – environment-specific variables (e.g walkway, distance to station)

Revealed Preference (RP) data +Stated Preference (SP) data

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Experiment Design Methodology (Stated Preference design)

Fisher information matrix:

$$I_N(\beta|X,y) = -E_y\left[\frac{\partial^2 LL_N(\beta|X,y)}{\partial\beta\partial\beta'}\right]$$

$$\frac{\partial^2 LL(X|\beta)}{\partial\beta_{k1}\partial\beta_{k2}} = \sum_{n=1}^{N}\sum_{s=1}^{S}\sum_{j=1}^{J} X_{jk_1sn}P_{jsn}(X|\beta)\left(X_{jk_2sn} - \sum_{i=1}^{J} X_{jk_2sn}P_{jsn}(X|\beta)\right)$$

The AVC matrix:

$$\Omega_N(\beta|X) = I_N^{-1}(\beta|X)$$

$$\Omega_N(\beta|X) = \begin{bmatrix} \frac{se_1^2}{N} & \cdots & \\ \vdots & \ddots & \vdots \\ & \cdots & \frac{se_k^2}{N} \end{bmatrix}$$

D-error: $D_b - error = \det \Omega^{1/k}$

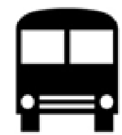
A-error :the trace of AVC matrix

S-estimates: $N \geq \left[\frac{se_1(\beta_k)t^*}{\beta_k}\right]^2$

Station access mode choice model

When choosing please consider that:

- The train station is an environment where you do not feel safe
- It is daytime
- The weather is wet
- You are travelling alone
- Interval between trains is 10 minutes.

	Car	Bus	Walk	Bicycle
				
Travel distance to the train station	1 km	1.5 km	0.5 km	2.5 km
Parking availability at the train station	$2/day parking			
Waiting time for bus to train station		10 mins		
Quality of walking route			Good	
Quality of bicycle route				Good
Which of the mode alternatives would you choose for your journey to the train station?	☐	☐	☐	☐

House location choice model

	House "A"	House "B"	House "C"	None
House type	Apartment/Flat	Apartment/Flat	Semi-Detached/ Townhouse	
House affordability (percent of weekly income spent on loan repayments or rent)	10%	10%	30%	
Travel distance to the train station	0.5 km	3 km	1 km	
Distance to nearest bus stop	0.4 km	0.5 km	0.3 km	
Travel distance to nearest potential employment opportunity from house	1.6 km	1.6 km	1.6 km	
Travel distance to a preferred school	1.5 km	0.9 km	1.5 km	
Travel distance to shops/supermarket	1.8 km	0.3 km	1.2 km	
Travel distance to parks/recreation areas	1.5 km	0.9 km	0.9 km	
Which of the house alternatives do you prefer?	House "A" ☐	House "B" ☐	House "C" ☐	None ☐
If you answered "none" previously and had to choose between House A, B or C, which of these alternatives do you prefer?	House "A" ☐	House "B" ☐	House "C" ☐	

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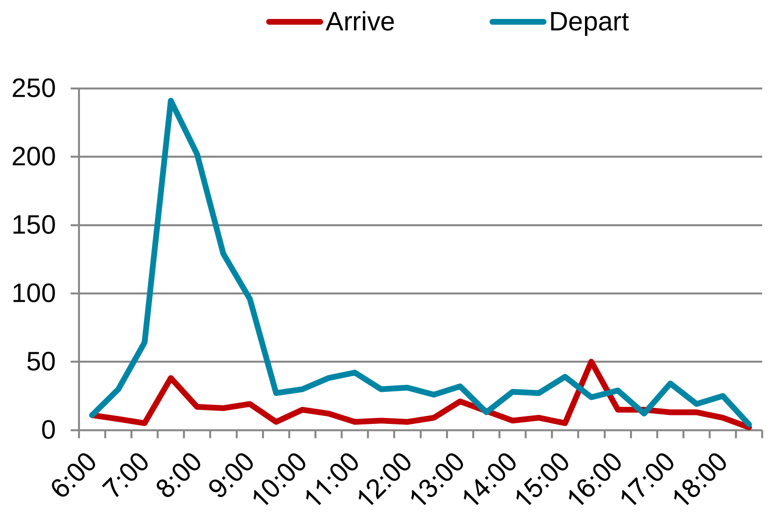
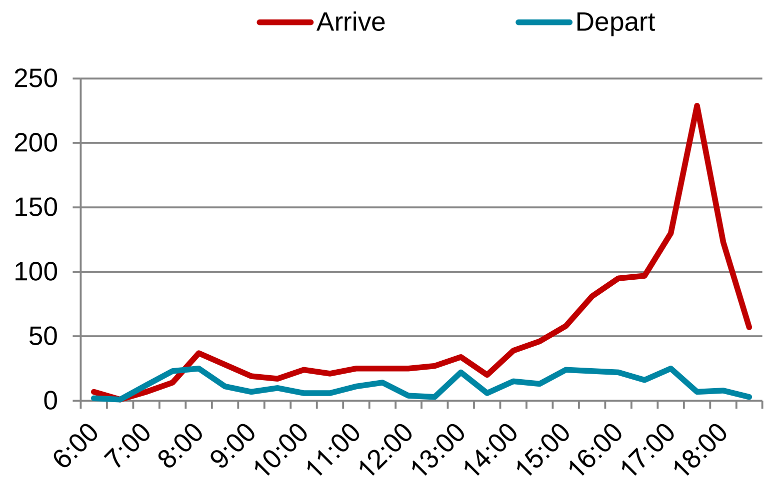
Mawson Lakes Interchange

Train from Gawler to Adelaide City



Train from Adelaide City to Gawler



Quotations of the focus group:

‘school kids/ uni students take up seats with bags and feet and are intimidating sometimes’---- a regular train user

‘Gawler and Gawler Central need toilets. Platforms need to be wheelchair friendly’---- a lady in a wheel chair from Gawler

‘probably we should have buses to the industrial areas of Adelaide such as Wingfield, Port Adelaide’---- a resident from Pooraka

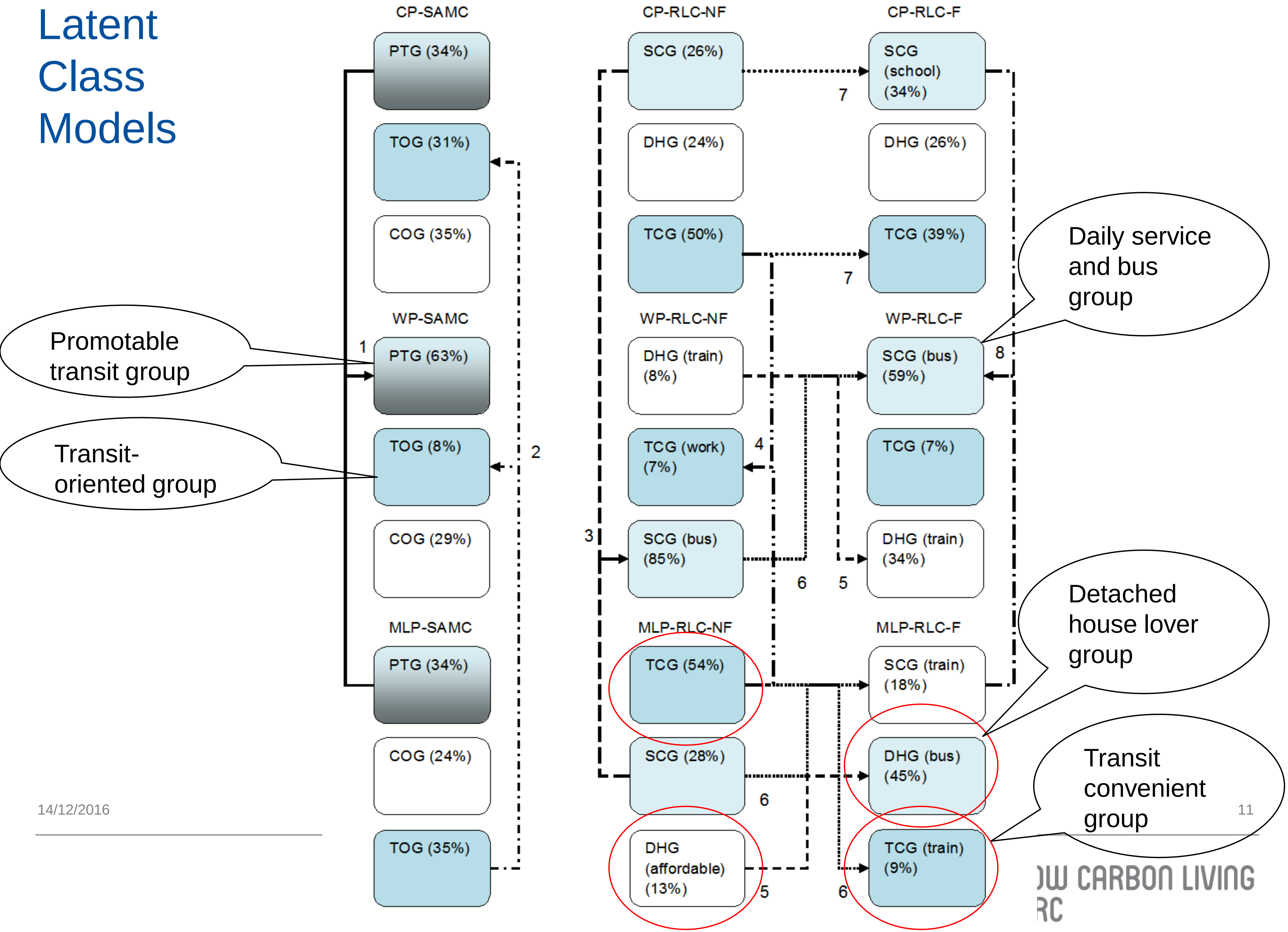
‘work in Mawson Lakes but have to drive 600 km a week for kids going to school to Golden Grove, after school activities to Norwood or Salisbury or city’---- a resident from Mawson Lakes

‘enjoy getting a day train trip with kids on weekend or holidays but the connection is horrible’---- a resident from Elizabeth

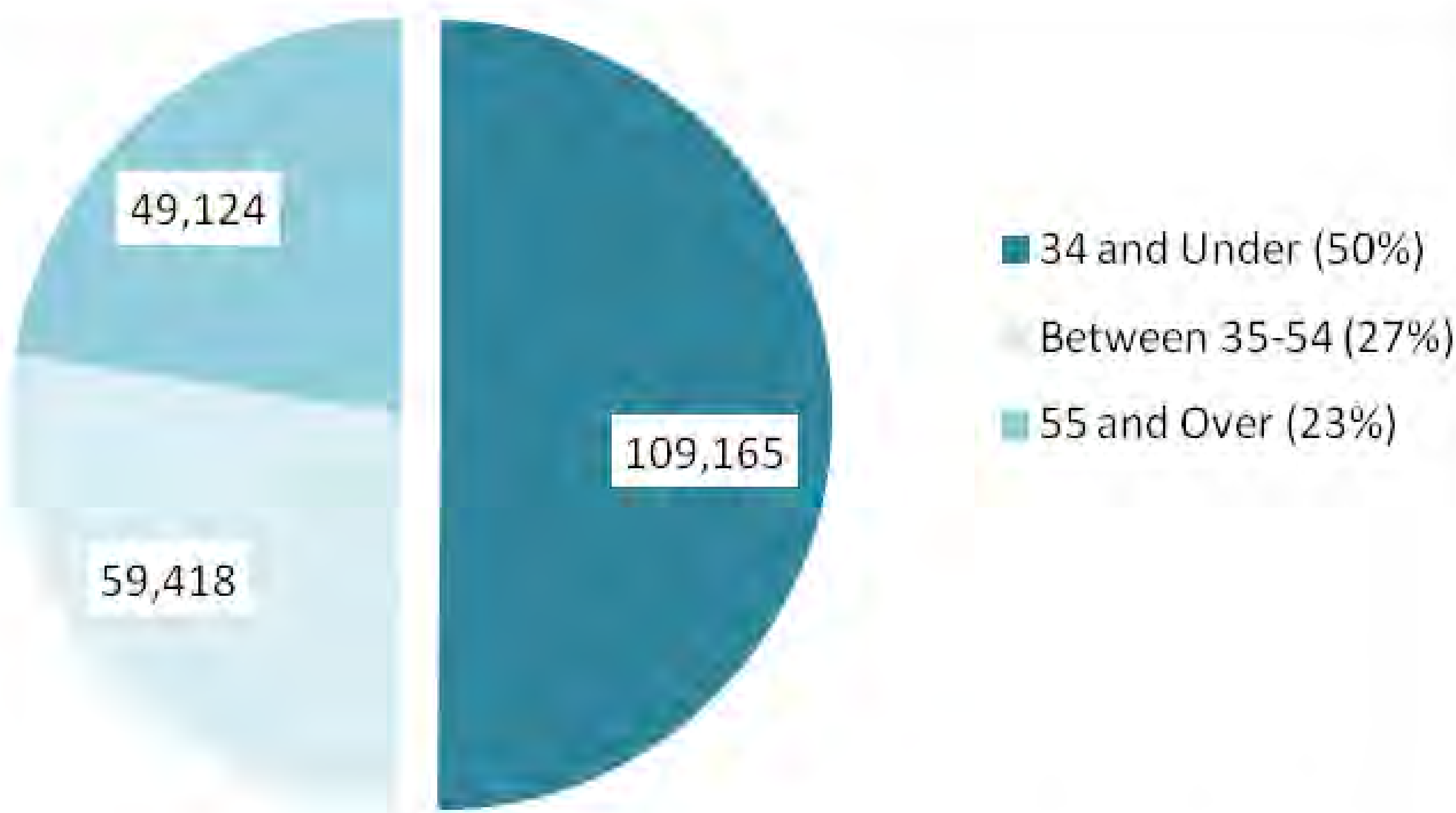
Comparing the Corridor Population with the Mawson Lakes population in railway station access mode choice preference

Corridor Population		Mawson Lakes Population
	Shared important preferences	
car park availability, train frequency, train station access modes, social, age, gender	car, bus travel distance, waiting time for bus, walk distance, travel to work time, travel to work distance, weather	walkway quality, travel to work mode, distance from home to bus stop
	In response to walk distance	
daily activities, time of day		weather, household ownership

Latent Class Models

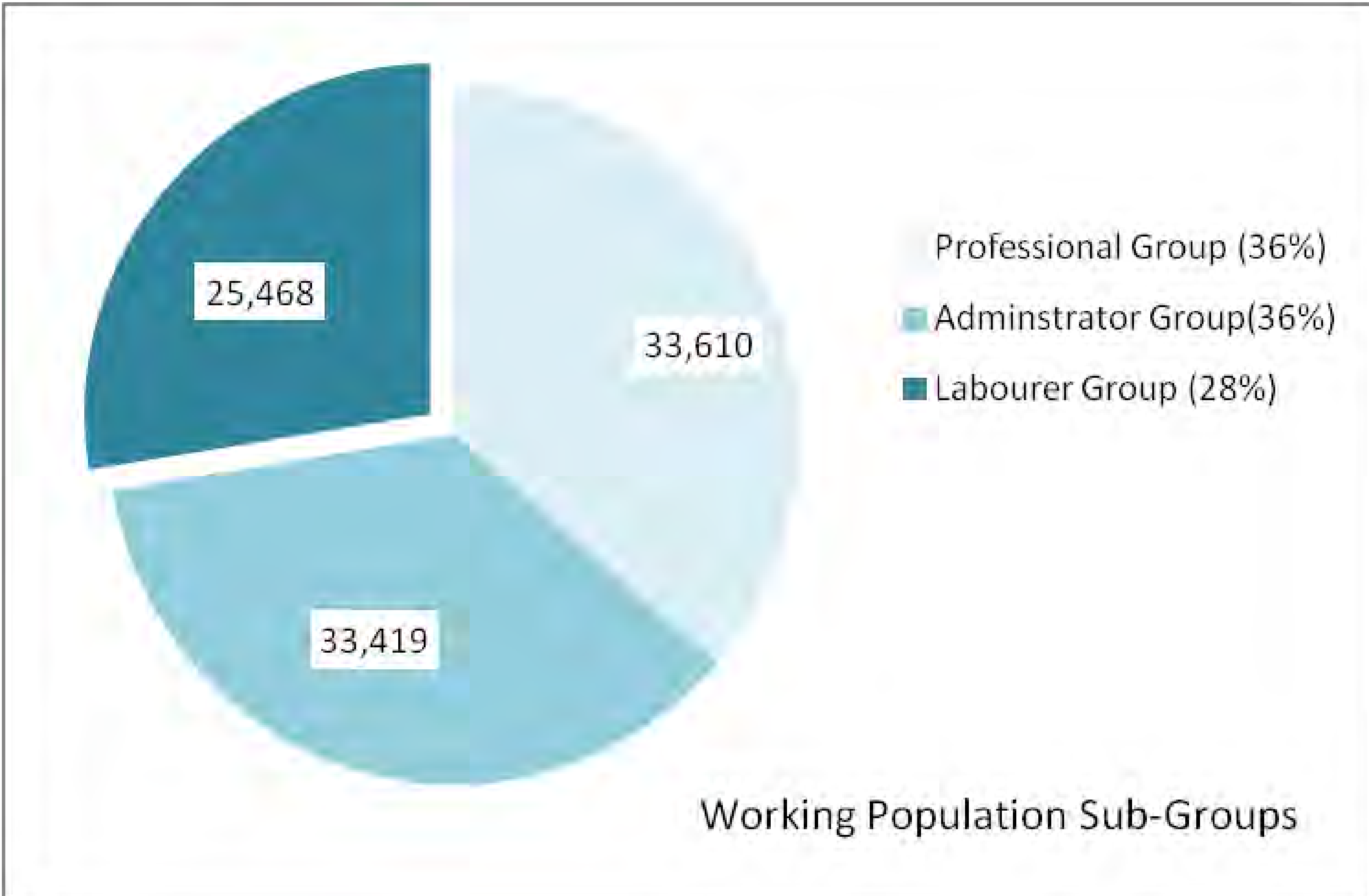


Age groups



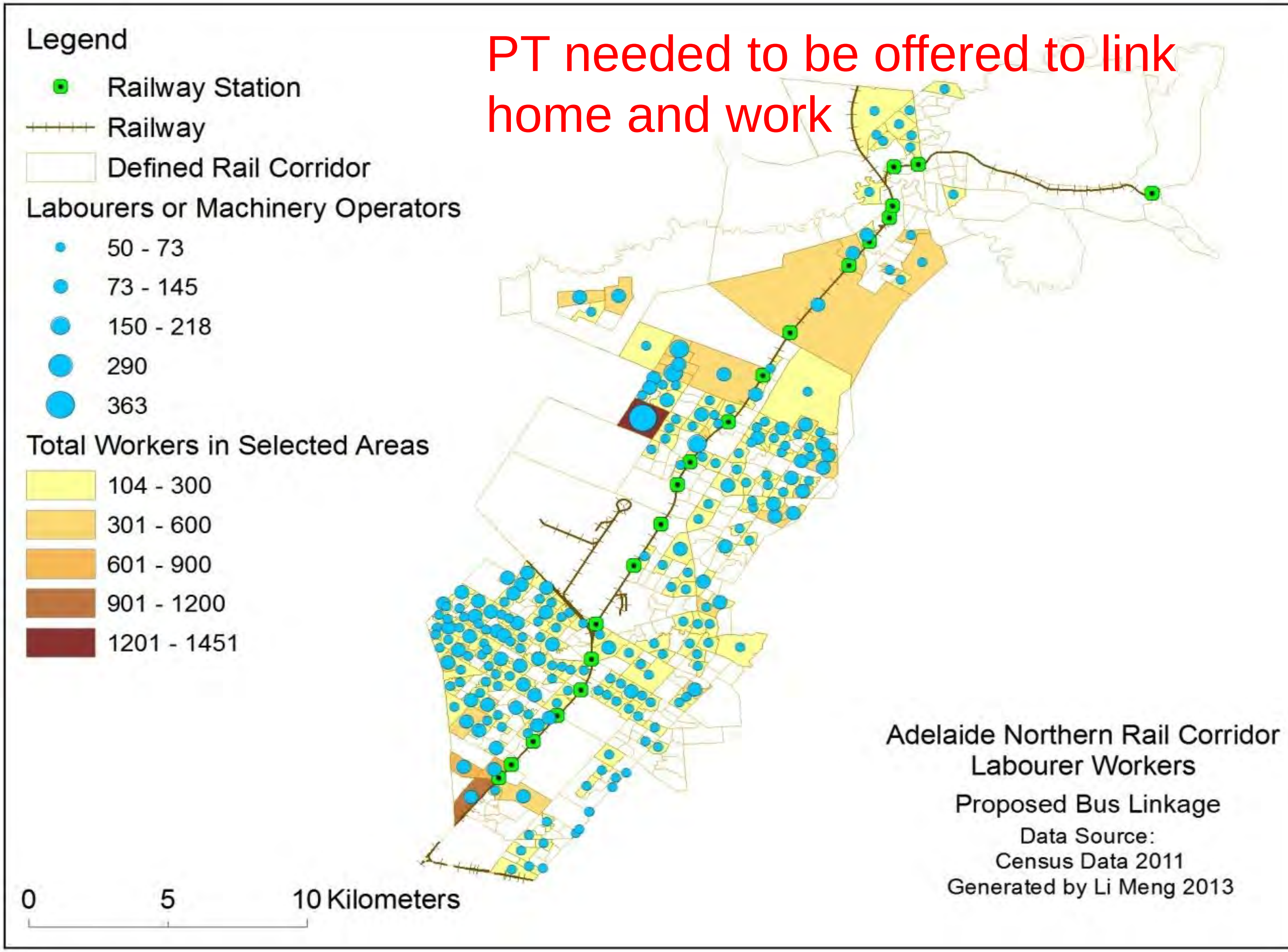
Population age groups in the ANRC

Occupation

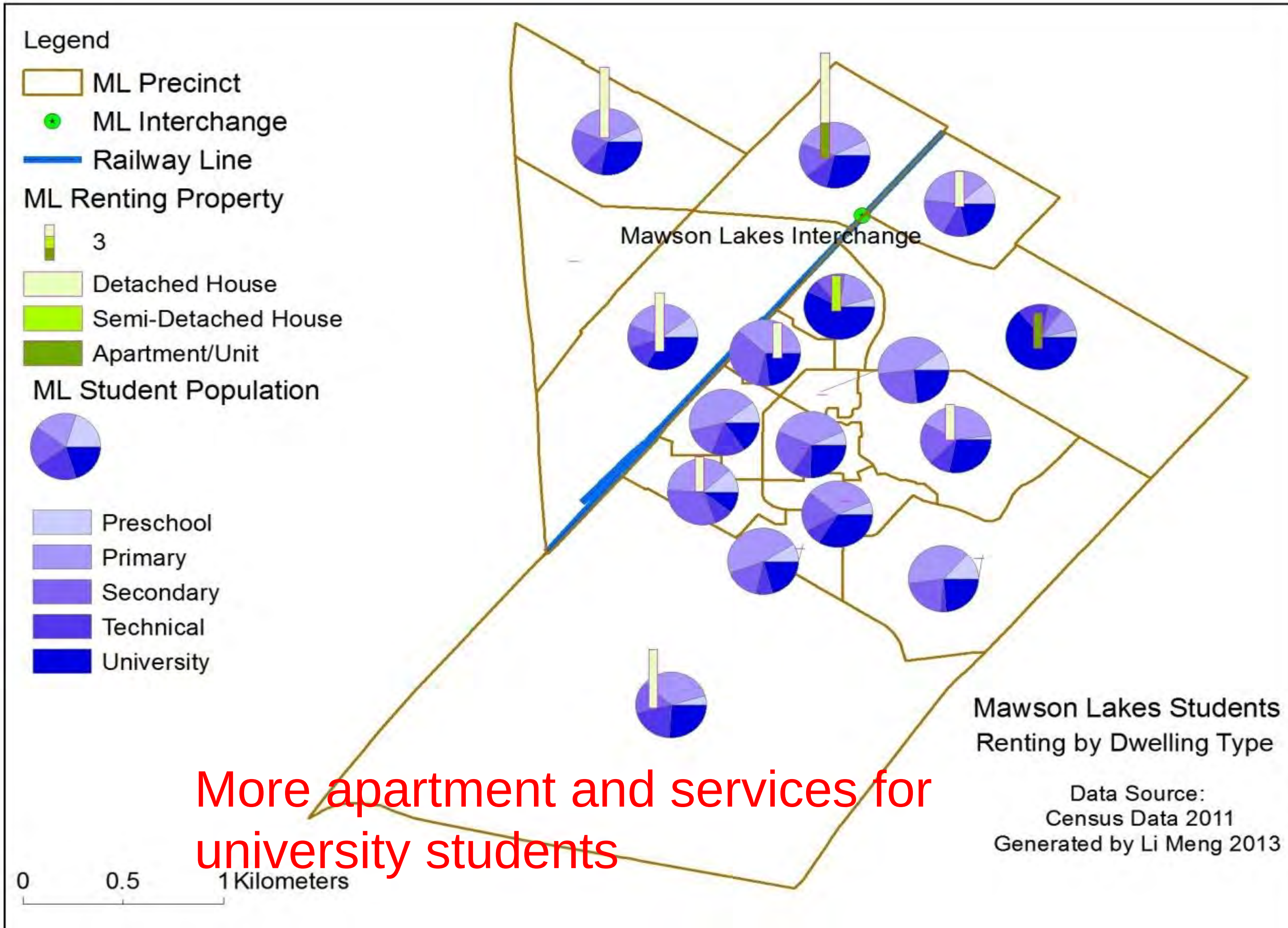


25,468
33,610
33,419
Professional Group (36%)
Adminstrator Group(36%)
Labourer Group (28%)
Working Population Sub-Groups

Bus needed for trip to work--- Labourer workers



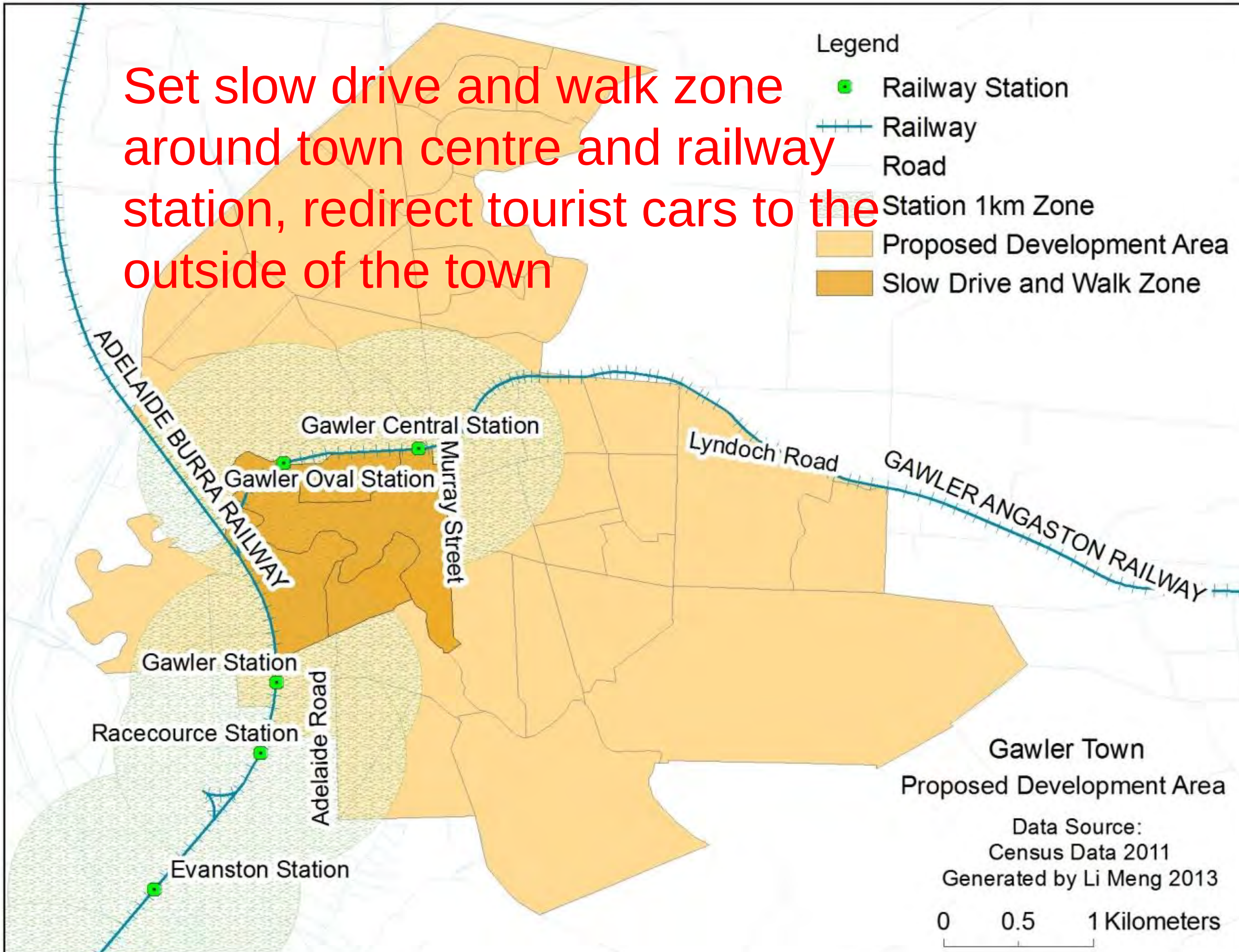
Mawson Lakes



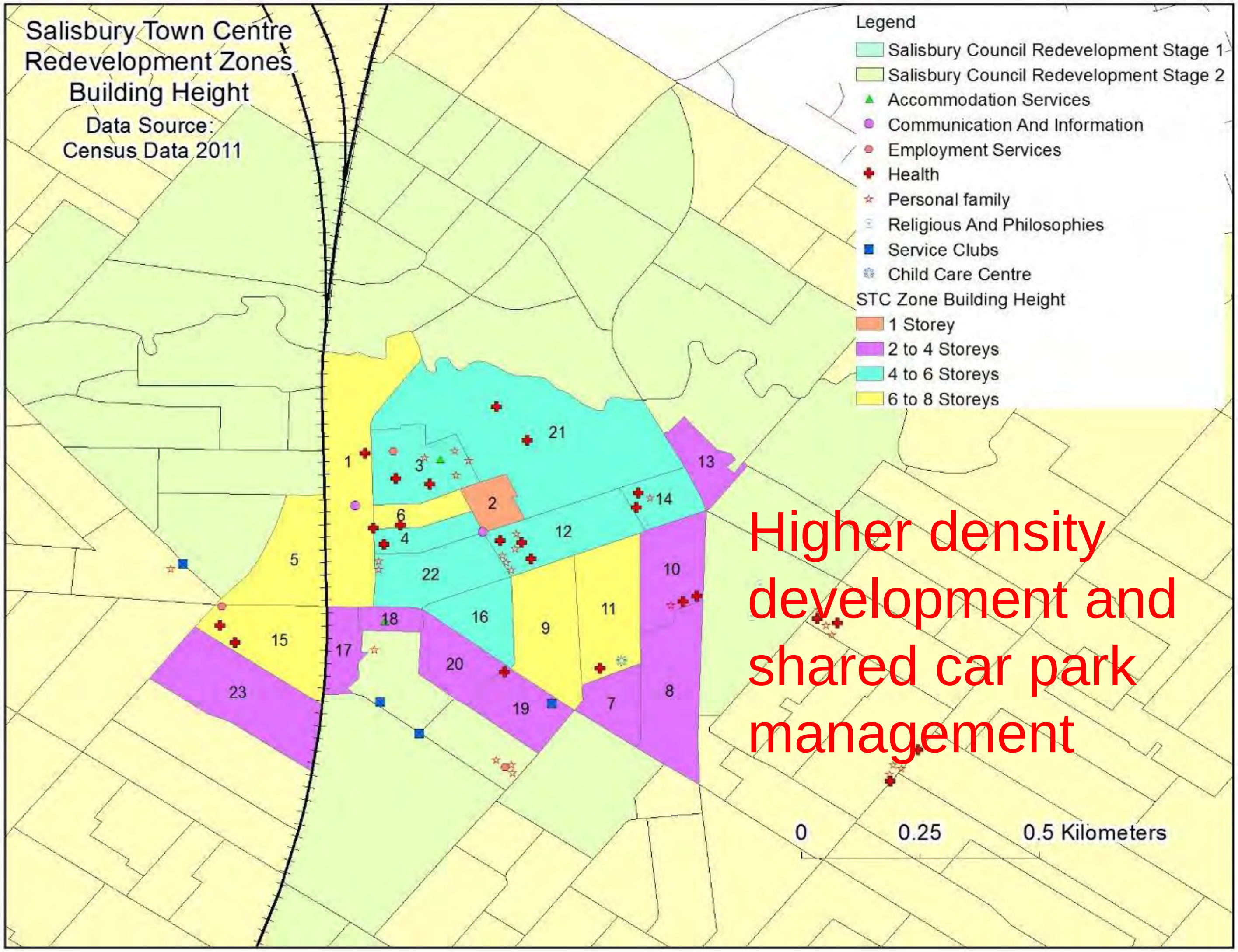
More apartment and services for university students

Gawler

Set slow drive and walk zone around town centre and railway station, redirect tourist cars to the outside of the town



Salisbury Town Centre



Recommended beds and car park plans for Salisbury Town Centre

Number of bedroom and car parks					Dwelling	car park	Shared car park
1=4 bedrooms 2 car parks+ 1 shared car park	10%	20%		75	15	30	15
2=4 bedrooms 2 car parks		20%			15	30	
3=4 bedrooms 1 car park+ 1 shared car park		60%			45	45	45
4=3 bedrooms 2 car parks	40%	10%		300	30	60	
5=3 bedrooms 1 car parks+ 1 shared car park		30%			90	90	90
6=3 bedrooms 1 car park		50%			150	150	
7=3 bedrooms 1 shared car park		10%			30		30
8=2 bedrooms 2 car parks	30%	10%		225	22.5	45	
9=2 bedrooms 1 car parks+ 1 shared car park		20%			45	45	45
10=2 bedrooms 1 car park		60%			135	135	
11=2 bedrooms 1 shared car park		10%			22.5		22.5
12=1 bedrooms 1 car park	20%	40%		150	60	60	
13=1 bedrooms 1 shared car park		60%			90		90
			Total	750	750	690	247.5

1.25 car parks/dwelling

Indications for planning strategies

❖Planned population

Pre-plan transport and service provision for population increase

❖ Planned dwelling

Propose a detailed prescription for medium-rise apartments with affordability and accessibility

❖ Planned jobs

Increase emphasis on trips to work by public transport and create activity zones around work

❖ Planned transport infrastructure

A revision required: overly focused on suburb to CBD link, limited outer suburbs connections

❖ Integration of transport and land use

Create dynamic feedback between transport and land use

2015/16 PARTICIPANTS

Thank you

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SWINBURNE UNIVERSITY OF TECHNOLOGY

Shared mobility and self-driving vehicles:

Shaping the future of suburban transport

Image Credit: Adobe Stock

Image Credit: Adobe Stock

Outline

Background

Shared mobility and on-demand PT

Autonomous mobility on-demand

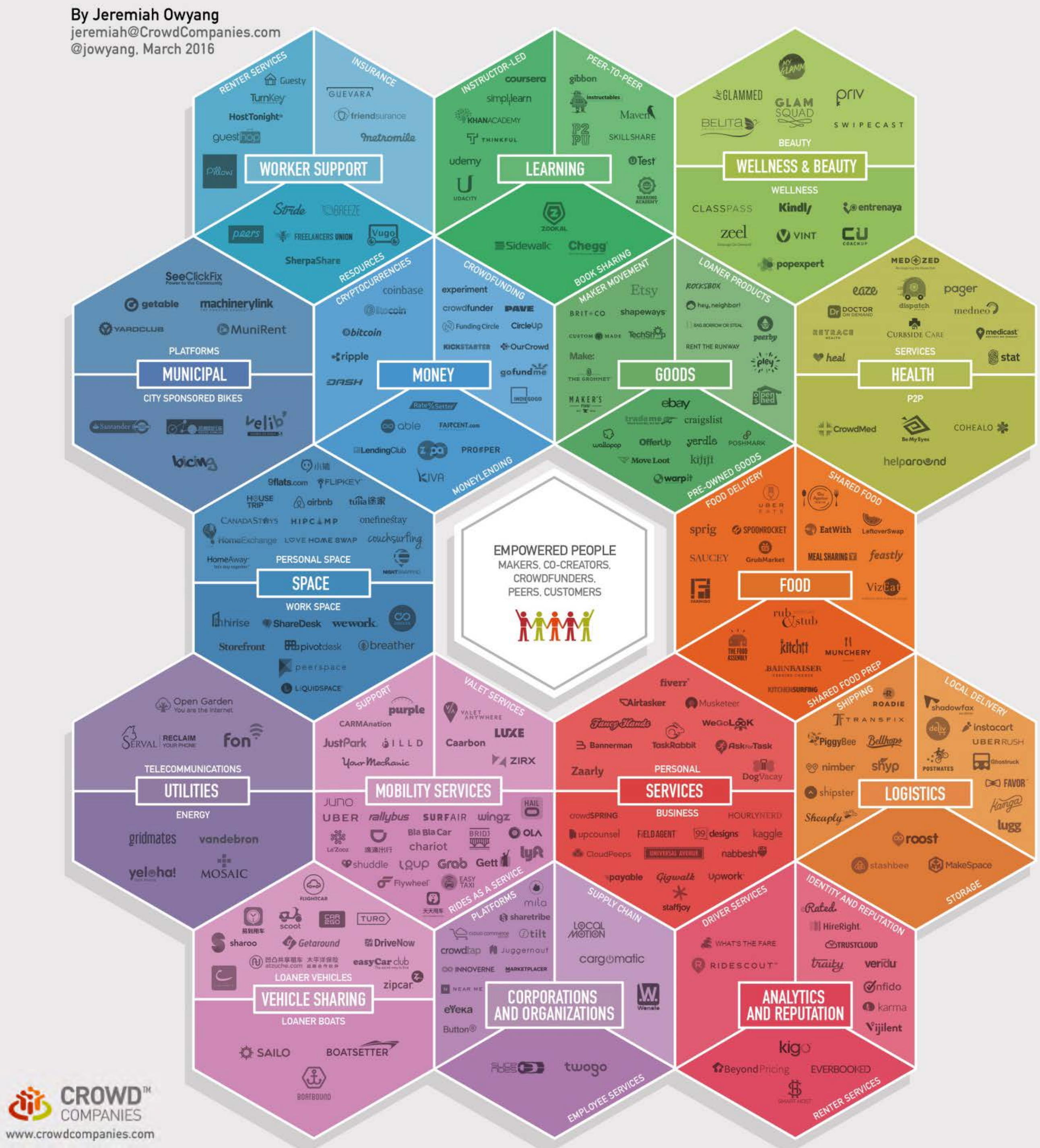
Collaborative Economy

The Collaborative Economy enables people to get what they need from each other.

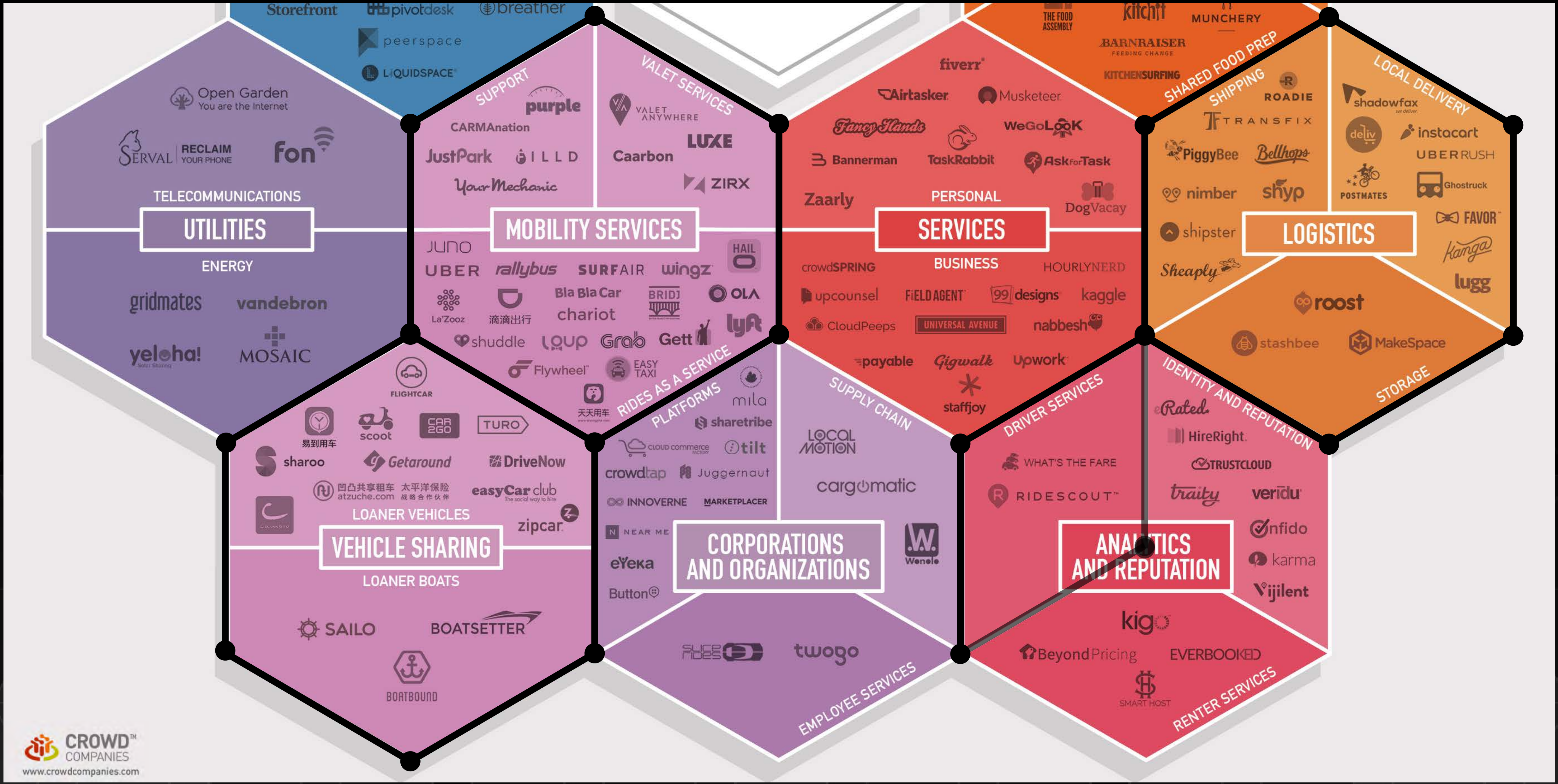
Its market has grown to include new applications in Mobility Services, Vehicle Sharing, Logistics and Analytics

In nature, honeycombs are resilient structures that enable access, sharing, and growth of resources among a common group

Source: Crowd Companies



Collaborative Mobility Services

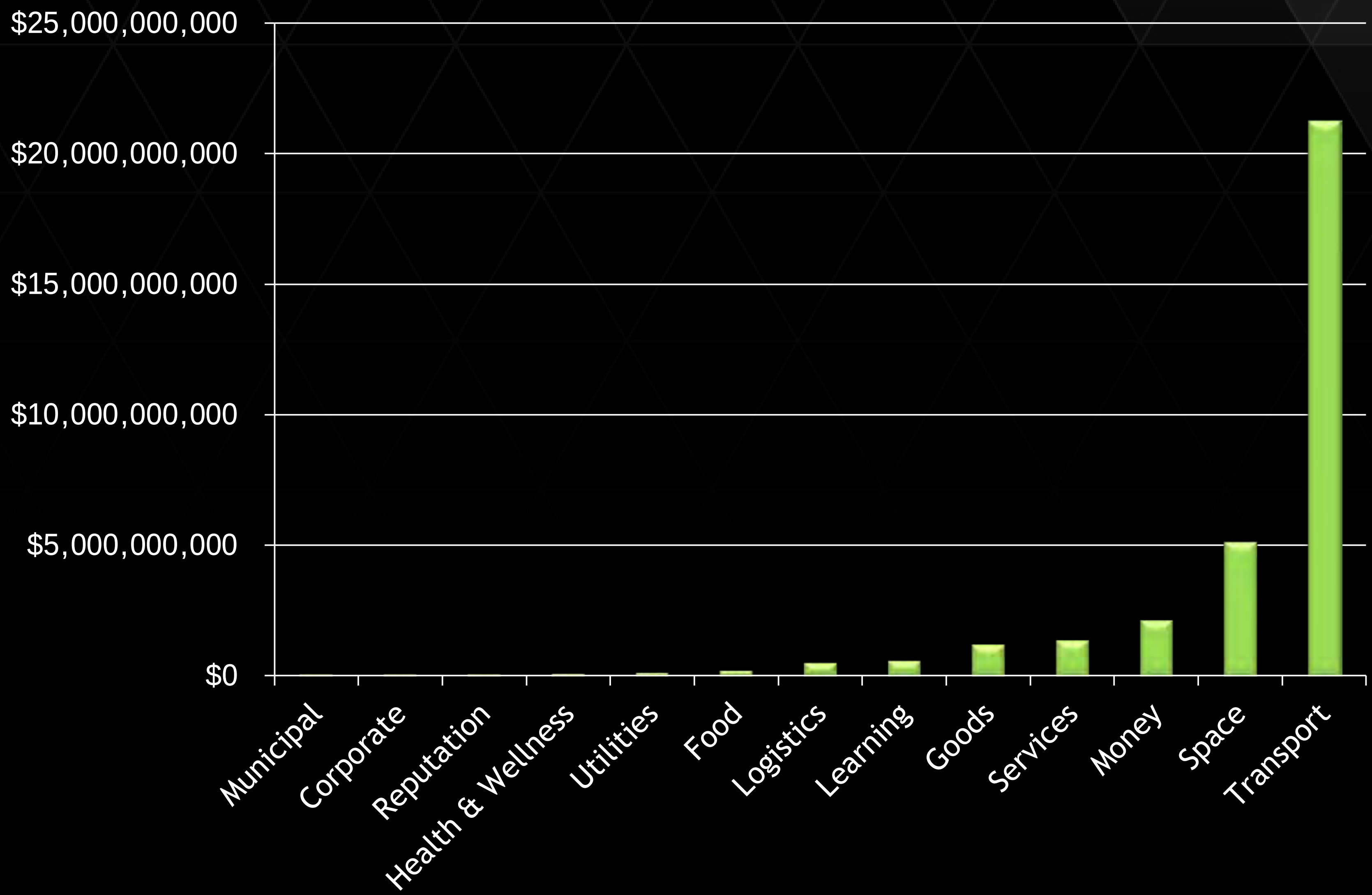


The changing world of urban mobility

	Traditional mobility solutions	New mobility Services	
Individual-based mobility	Private car ownership	Car sharing: peer to peer	A peer-to-peer platform where individuals can rent out their private vehicles when not in use (e.g. Turo)
	Taxi	E-hailing	Process of ordering a car or taxi via on-demand app. App matches rider with driver and handles payment (e.g. Uber, Lyft)
	Rental cars	Car sharing: fleet operator	On-demand short-term car rentals with the vehicle owned and managed by a fleet operator (e.g. GoGet, Car2Go, ZipCar, Getaround)
Group-based mobility	Car pooling	Shared e-hailing	Allows riders going in the same direction to share the car, thereby splitting the fare and lowering the cost (e.g. UberPool, LyftLine)
	Public transport	On-demand private shuttles	App and technology enabled shuttle service. Cheaper than a taxi but more convenient than public transit (e.g. Bridj)

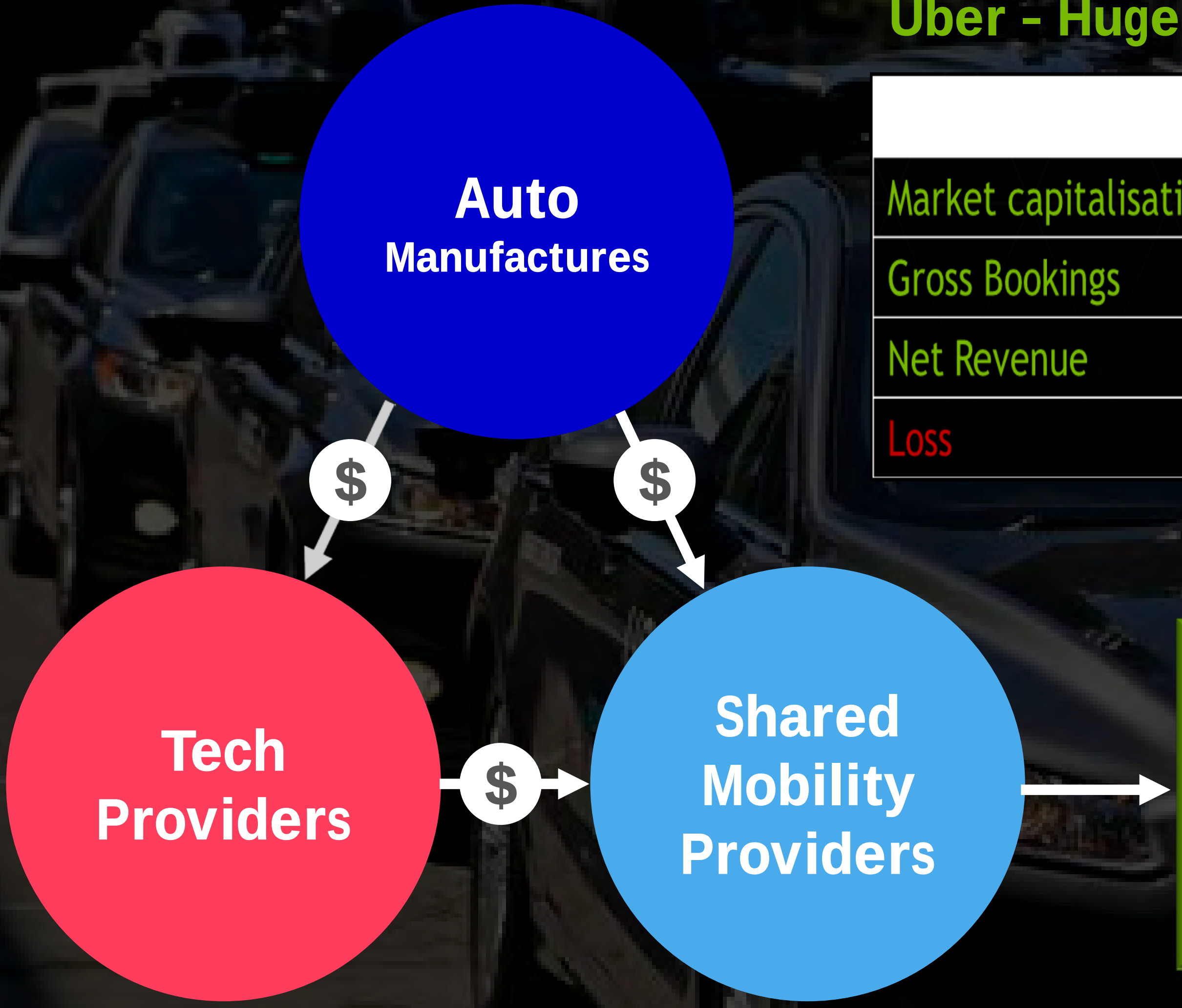
Source: Adapted from Urban mobility at tipping point, McKinsey 2015

Transport is the most funded industry in the collaborative economy



Source: CROWD™ COMPANIES

The merging worlds of technology, vehicles and shared mobility



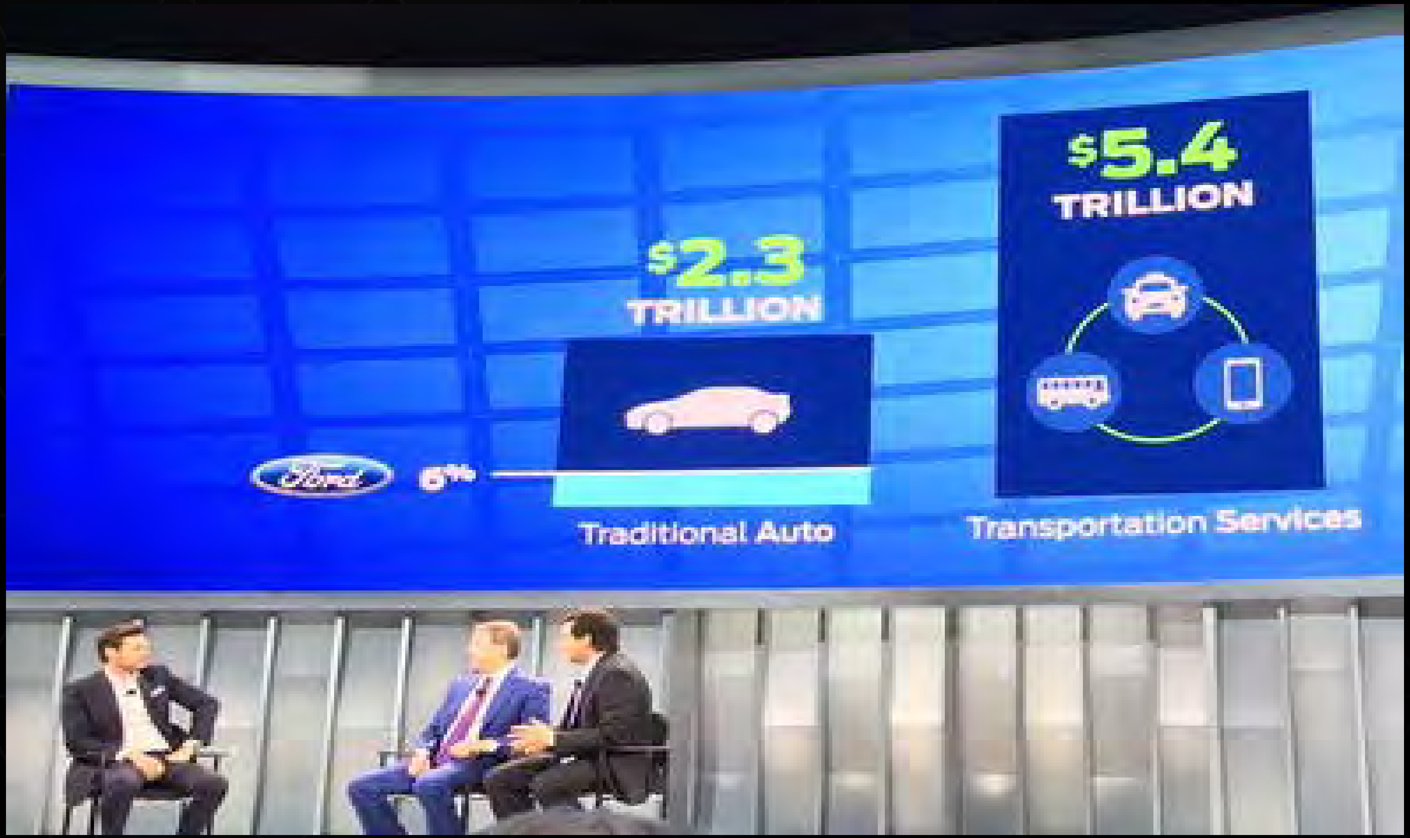
Uber – Huge Growth, Big Losses

	2014	2015	Percent Change
Market capitalisation	$40 billion	$ 63 billion	58%
Gross Bookings	$2.93 billion	$3.63 billion	24%
Net Revenue	$495 million	$663 million	34%
Loss	$671 million	$987 million	47%

Kilometre as a utility

Image Credit: DigitalTrends

New opportunities

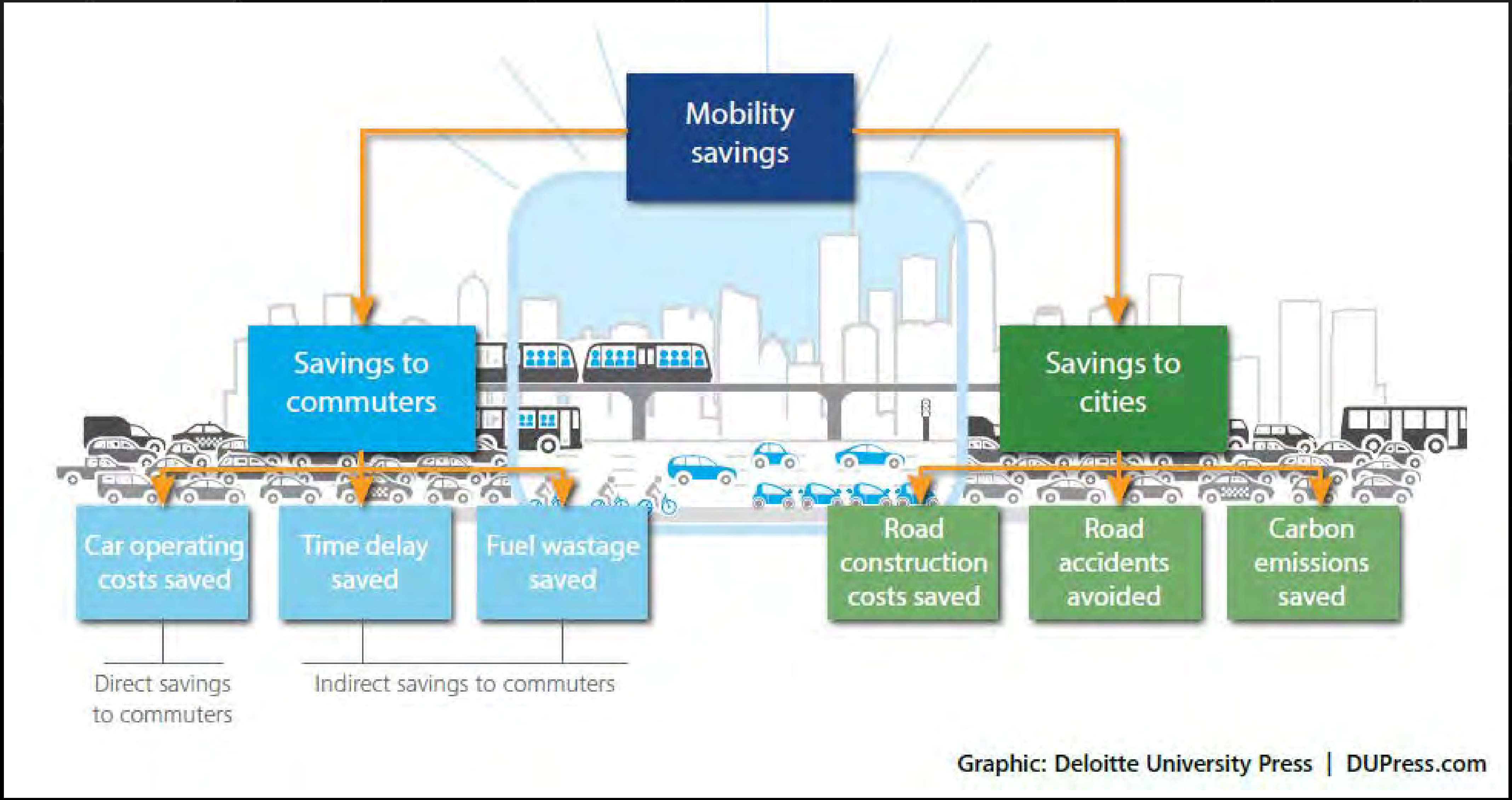


Moving away from sale of independently owned vehicles to on-demand, shared mobility services

Why investors can't get enough?

- Immediate revenue generation with low costs
- Mobility is a means to an end: Access to jobs and services
- Rapid urbanisation
- Rapid global adoption
- An easily shared asset
- Positive sustainability impacts
- Extends value to other industries (e.g. logistics, shipping, storage)
- Private vehicles are costly assets and are under-utilised

The value of collaborative mobility



Estimated benefits of expanded *ridesharing* by metro area and national (USA)

Metro area (MSA)	Ridesharers			Projected annual vehicle miles reduced	Mobility savings to commuters ($ million)			Mobility savings to cities ($ million)				Total annual mobility savings ($ million)
	Current	Potential new	Projected total		Direct annual operating costs savings	Commuter annual fuel savings	Commuter annual delay savings	Road construction cost savings over 25-year period	Annual road construction cost savings	Annual savings from accidents avoided	Annual carbon emission savings	
New York-Newark-Jersey City NY-NJ-PA Metro Area	638,290	908,884	1,547,174	1,438,712,191	805.7	55.4	646.8	2,658.3	106.3	43.1	17.2	**1,674.6**
Los Angeles-Long Beach-Anaheim CA Metro Area	624,743	899,024	1,523,767	1,441,662,615	807.3	56.9	640.5	2,632.2	105.3	43.2	17.3	**1,670.5**
Chicago-Naperville-Elgin IL-IN-WI Metro Area	386,878	663,367	1,050,245	1,134,580,936	635.4	41.5	475.1	1,952.6	78.1	34.0	13.6	**1,277.7**
Dallas-Fort Worth-Arlington TX Metro Area	320,503	612,063	932,566	1,128,969,564	632.2	34.0	441.3	1,813.7	72.5	33.9	13.5	**1,227.4**
Miami-Fort Lauderdale-West Palm Beach FL Metro Area	247,220	570,154	817,374	941,312,738	527.1	32.6	407.2	1,673.3	66.9	28.2	11.3	**1,073.3**
Houston-The Woodlands-Sugar Land TX Metro Area	320,895	540,591	861,486	1,174,462,497	657.7	30.4	396.1	1,628.0	65.1	35.2	14.1	**1,198.7**
Philadelphia-Camden-Wilmington PA-NJ-DE-MD Metro Area	227,149	447,934	675,083	593,746,957	332.5	25.9	314.7	1,293.1	51.7	17.8	7.1	**749.7**
Washington-Arlington-Alexandria DC-VA-MD-WV Metro Area	317,102	428,901	746,003	738,895,120	413.8	24.7	307.4	1,263.2	50.5	22.2	8.8	**827.4**
Atlanta-Sandy Springs-Roswell GA Metro Area	260,974	395,154	656,128	699,080,578	391.5	22.1	283.9	1,166.5	46.7	21.0	8.4	**773.4**
Boston-Cambridge-Newton MA-NH Metro Area	181,851	354,144	535,995	468,027,982	262.1	20.4	248.7	1,022.2	40.9	14.0	5.6	**591.7**
National total	**11,073,639**	**18,739,545**	**29,813,184**	**28,240,874,445**	**15,815**	**870**	**10,704.4**	**44,002.9**	**1,760.1**	**846.9**	**338**	**30,337.3**

Source: Deloitte research

Estimated benefits of expanded *carsharing* by metro area and national (USA)

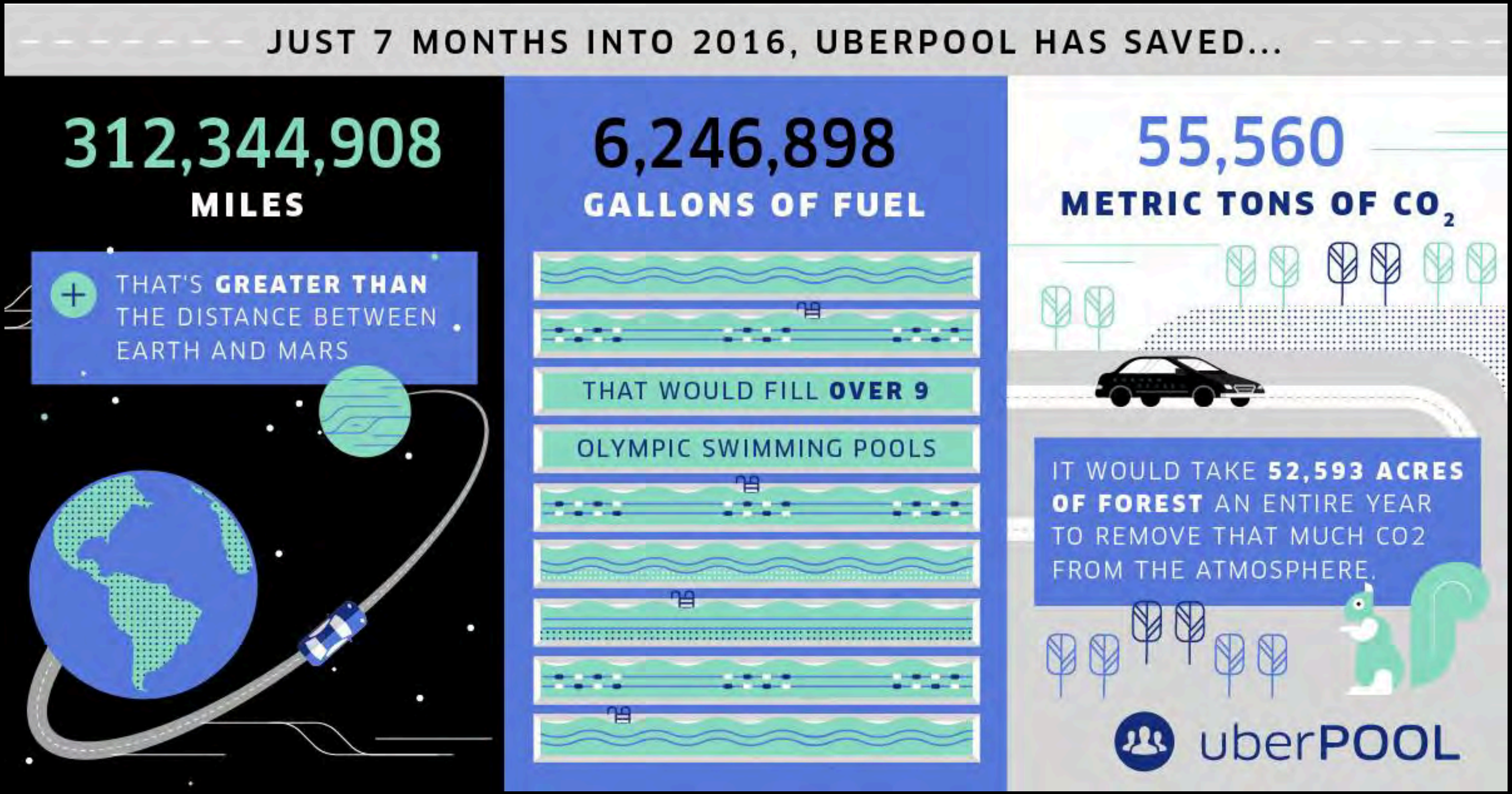
Metro Area (MSA)	Carshare members			Projected annual vehicle miles traveled reduction	Mobility savings to commuters ($ million)			Mobility savings to cities ($ million)				Total annual mobility savings ($ million)
	Total commuters	Potential carshare members	Potential members as % of commuters		Annual direct vehicle operating costs savings	Annual indirect fuel wastage savings	Annual indirect delay savings	Road construction cost savings over 25-year period	Annual road construction cost savings	Annual savings from accidents avoided	Annual carbon emission savings	
New York-Newark-Jersey City NY-NJ-PA Metro Area	8,693,469	1,148,622	13.2%	783,997,428	439.0	65.9	772.5	3,174.6	127.0	23.5	11.1	**1,439.1**
Chicago-Naperville-Elgin IL-IN-WI Metro Area	4,212,913	258,212	6.1%	176,240,786	98.7	15.1	173.7	713.6	28.5	5.3	2.5	**323.8**
Los Angeles-Long Beach-Anaheim CA Metro Area	5,521,388	165,194	3.0%	112,762,418	63.1	9.8	111.1	456.6	18.3	3.4	1.6	**207.3**
Boston-Cambridge-Newton MA-NH Metro Area	2,210,145	161,372	7.3%	110,145,886	61.7	8.9	108.5	446.0	17.8	3.3	1.6	**201.8**
Washington-Arlington-Alexandria DC-VA-MD-WV Metro Area	2,848,122	155,713	5.5%	106,280,787	59.5	8.4	104.7	430.4	17.2	3.2	1.5	**194.5**
San Francisco-Oakland-Hayward CA Metro Area	1,964,152	147,115	7.5%	100,411,840	56.2	8.8	98.9	406.6	16.3	3.0	1.4	**184.6**
Philadelphia-Camden-Wilmington PA-NJ-DE-MD Metro Area	2,655,135	119,845	4.5%	81,805,465	45.8	6.6	80.6	331.2	13.2	2.5	1.2	**149.9**
Atlanta-Sandy Springs-Roswell GA Metro Area	2,309,559	66,013	2.9%	45,055,980	25.2	3.4	44.4	182.4	7.3	1.4	0.6	**82.4**
Miami-Fort Lauderdale-West Palm Beach FL Metro Area	2,402,217	53,714	2.2%	36,661,926	20.5	2.9	36.1	148.5	5.9	1.1	0.5	**67.1**
Seattle-Tacoma-Bellevue WA Metro Area	1,623,998	51,640	3.2%	35,250,750	19.7	2.9	34.7	142.7	5.7	1.1	0.5	**64.7**
National total, 171 combined statistical areas	**108,634,966**	**3,760,851**	**3.5%**	**2,566,986,174**	**1,443**	**185**	**1,585**	**9,138**	**366**	**77**	**36**	**4,329**

Source: Deloitte research

Today’s shared mobility: help or hindrance?

“This is your biggest threat in the commercial bus sector. It’s cheap and it’s even cheaper if there’s more than one person travelling”

Leon Daniels
Managing Director of Surface Transport
Transport for London



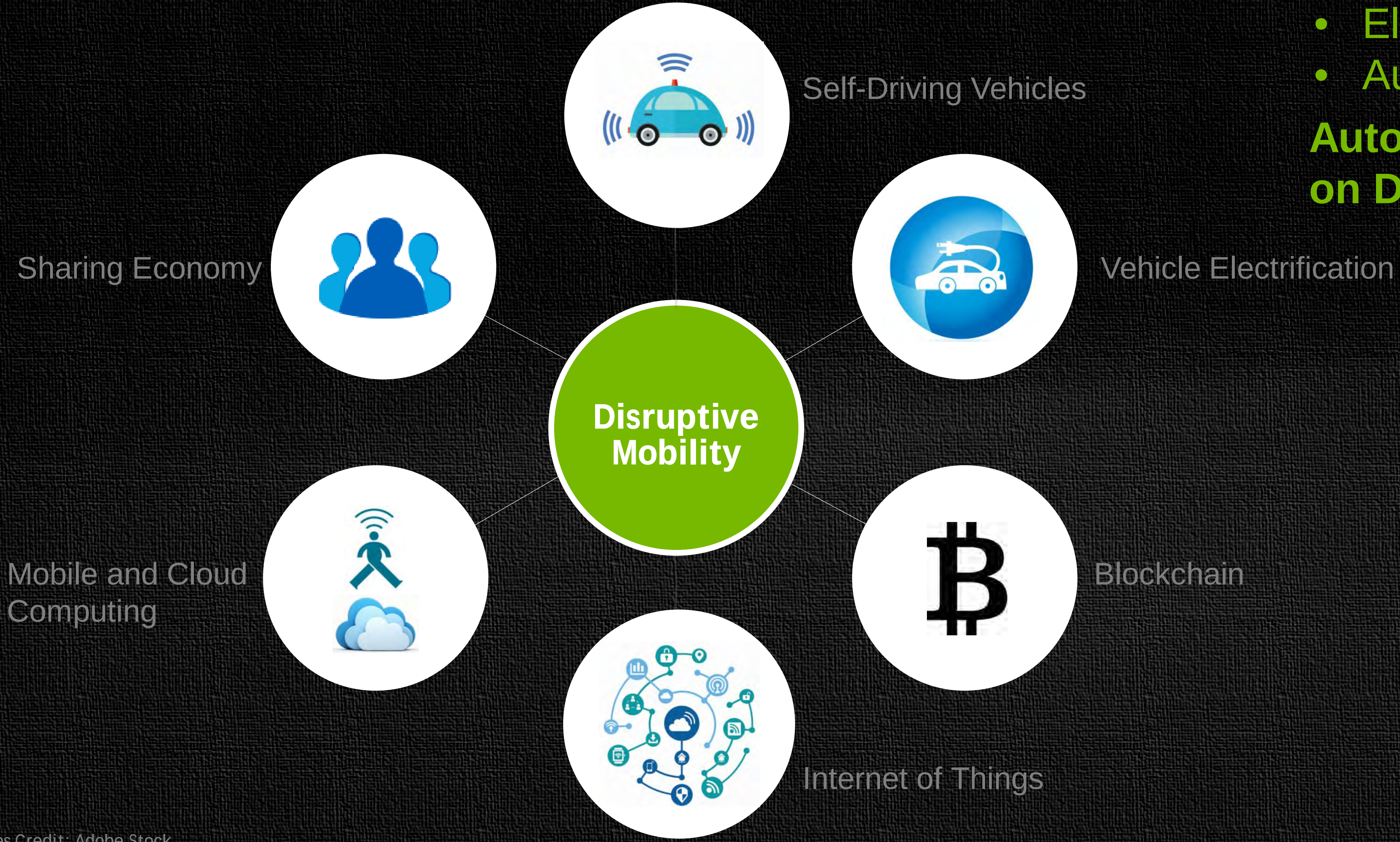
Source: Uber

No ordinary disruption

Future of Mobility

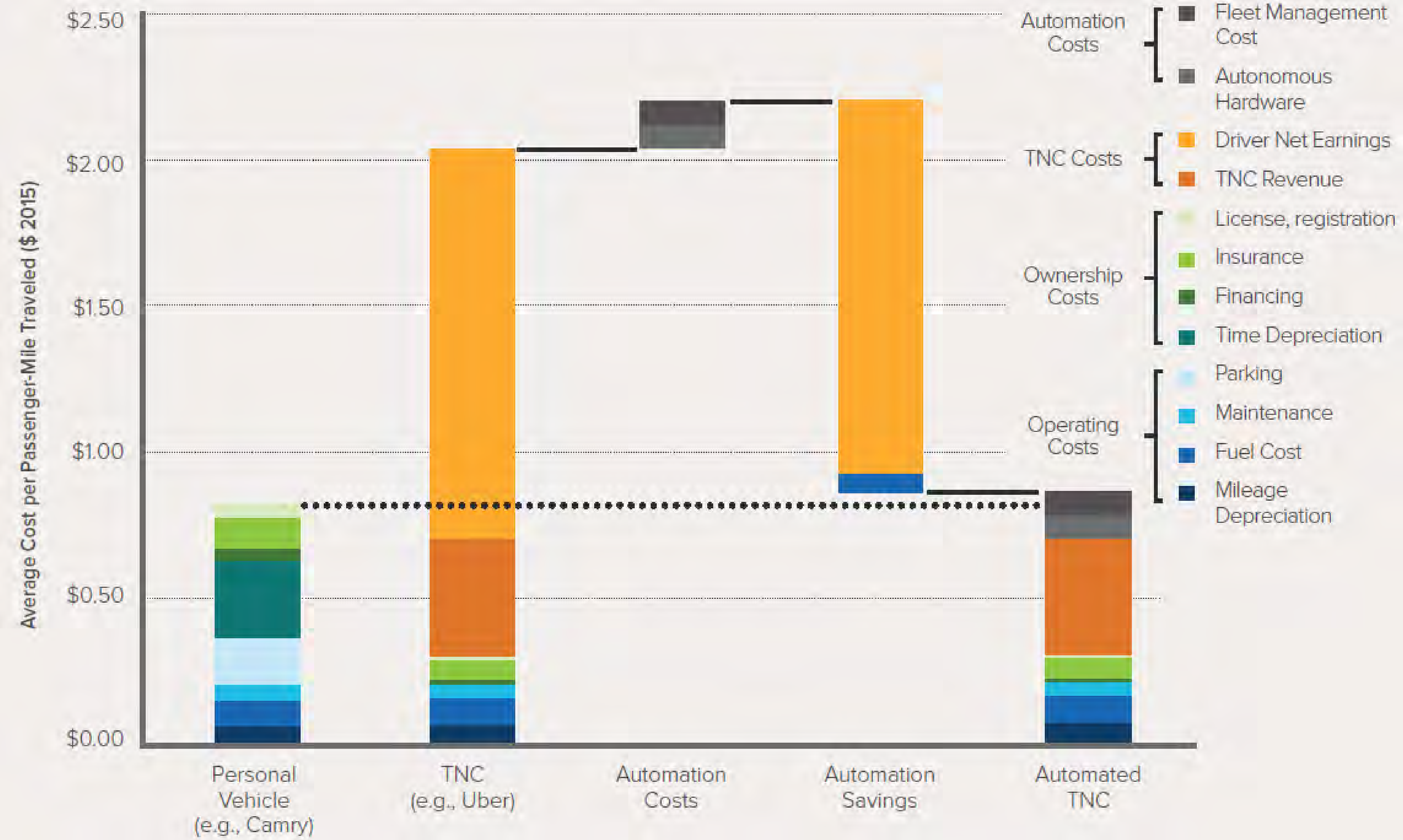
- Shared
- On-demand
- Electric
- Autonomous

Autonomous Mobility on Demand (AMoD)



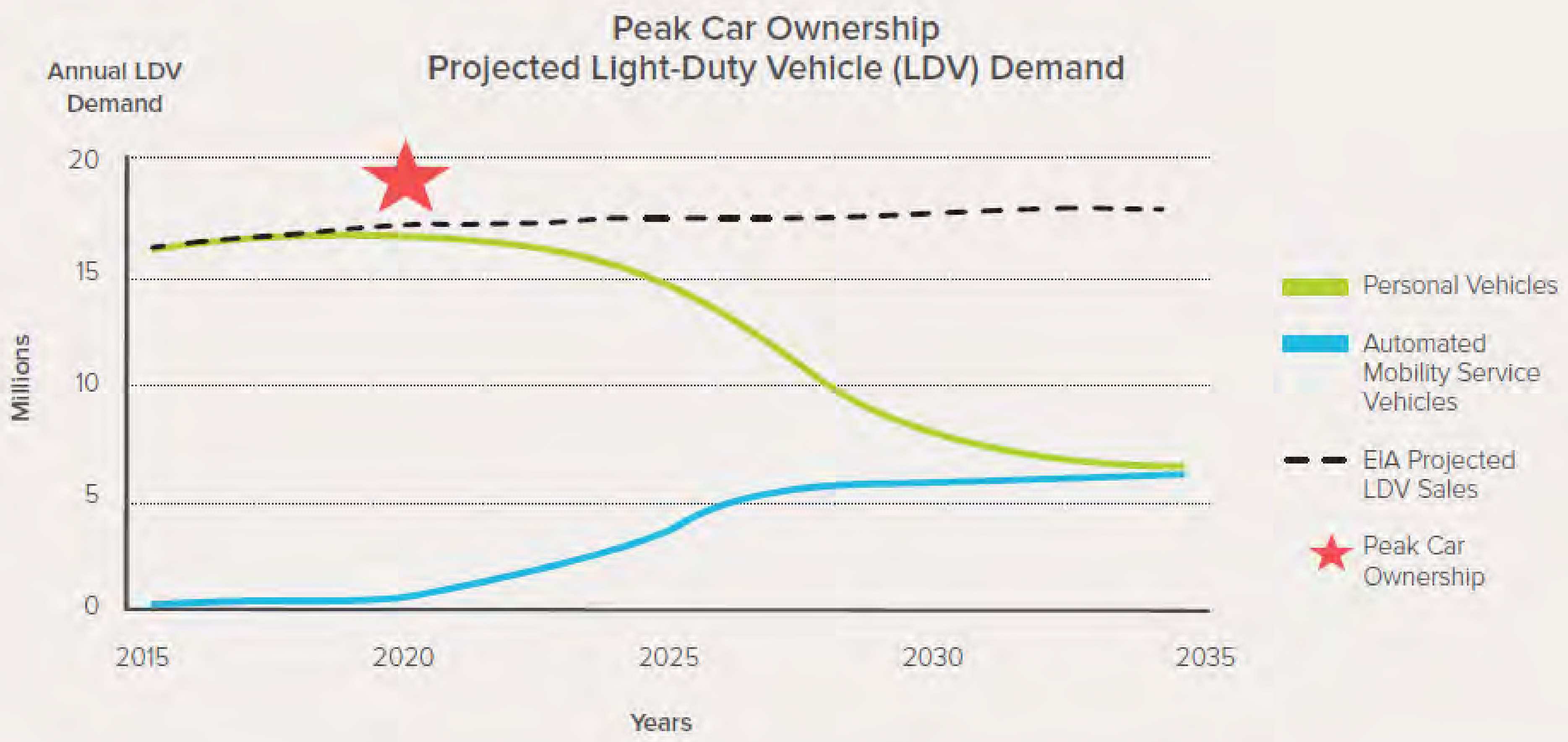
Images Credit: Adobe Stock

Effects of automation on cost per mile of TNC service



MOBILITY TRANSFORMATION

PEAK CAR OWNERSHIP



Peak Car Ownership
Projected Light-Duty Vehicle (LDV) Demand
Annual LDV Demand
Millions
20
15
10
5
0
2015
2020
2025
2030
2035
Years
Personal Vehicles
Automated Mobility Service Vehicles
EIA Projected LDV Sales
Peak Car Ownership

Impact on urban mobility?

- Will they reduce or increase congestion?
- Will they induce more demand for travel?
- How will they impact VKT (per capita)?
- Will they increase or decrease urban sprawl?
- How will they impact urban form?
- What impact will they have on parking?
- Will they reduce or increase emissions?
- How will they impact car ownership?

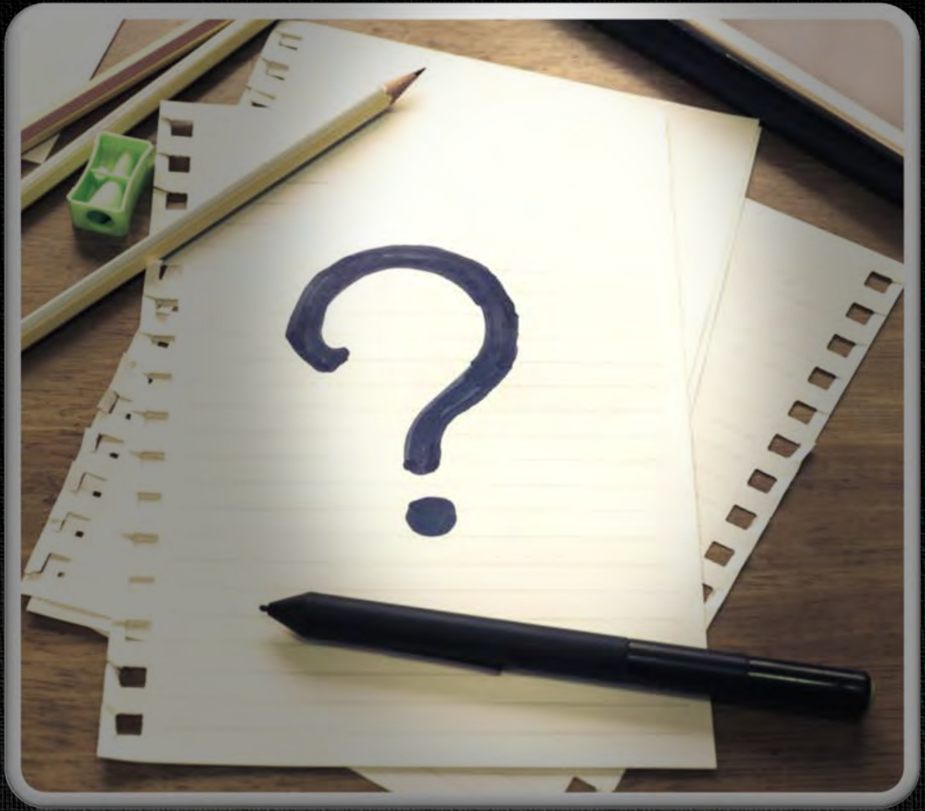
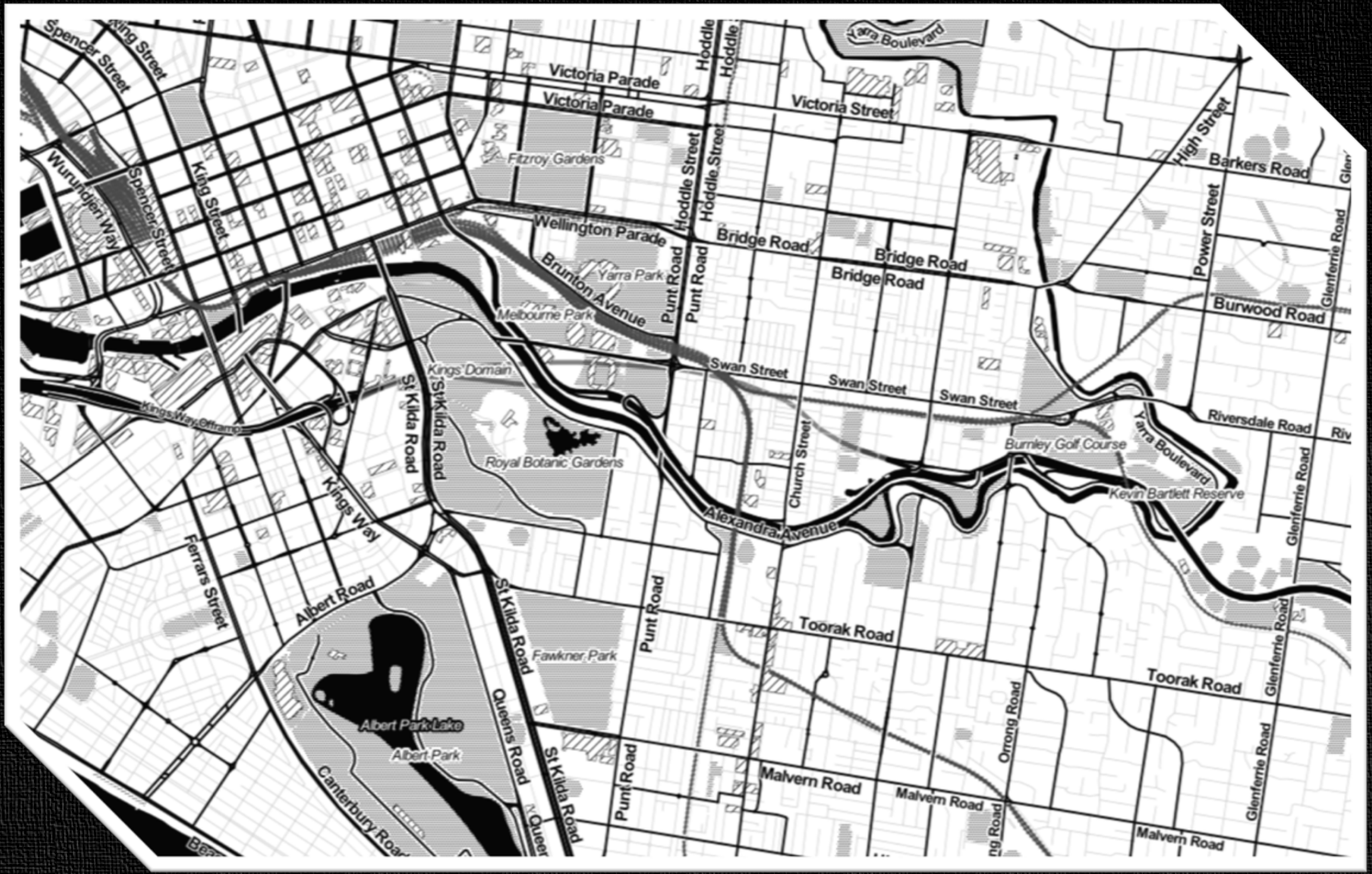


Image Credit: Adobe Stock

Melbourne Pilot Study



AM Peak (7am-9am)

VISTA Data
2,136 trips

Base case scenario

- Existing situation
- All trips are undertaken using single-occupant private vehicles

Image Credit: Adobe Stock

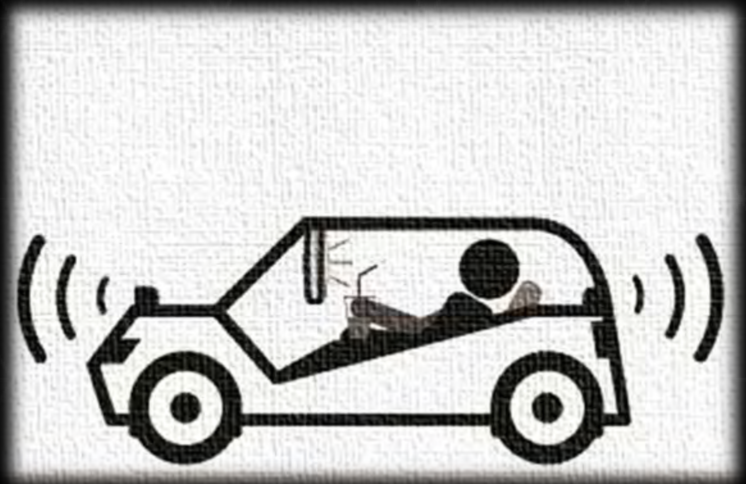
Scenario 1

- Autonomous shared mobility
- Vehicles available immediately for passenger pick-up
- Car-sharing and ride-sharing (capacity 2-4 passengers) options [25:75]

Scenario	Fleet Size (vehicles)	Mean VKT (Km)	Parking Space (m^2)
Base case	2,136	4.04	35,885
Scenario 1	1,217	5.20	15,238
Percent difference	43% decrease	29% increase	58% decrease

Scenario 2

- Autonomous car-shared mobility
- Maximum 5 minutes pick-up waiting time
- Car-sharing only (no ride-sharing)
- Block rebalancing strategy



Scenario	Fleet Size (vehicles)	Total VKT (Km)	Parking Space (m^2)
Base case	2,059	4,660	34,591
Scenario 2	247	5,204	6,048
Percent difference	88% decrease	10% increase	83% decrease

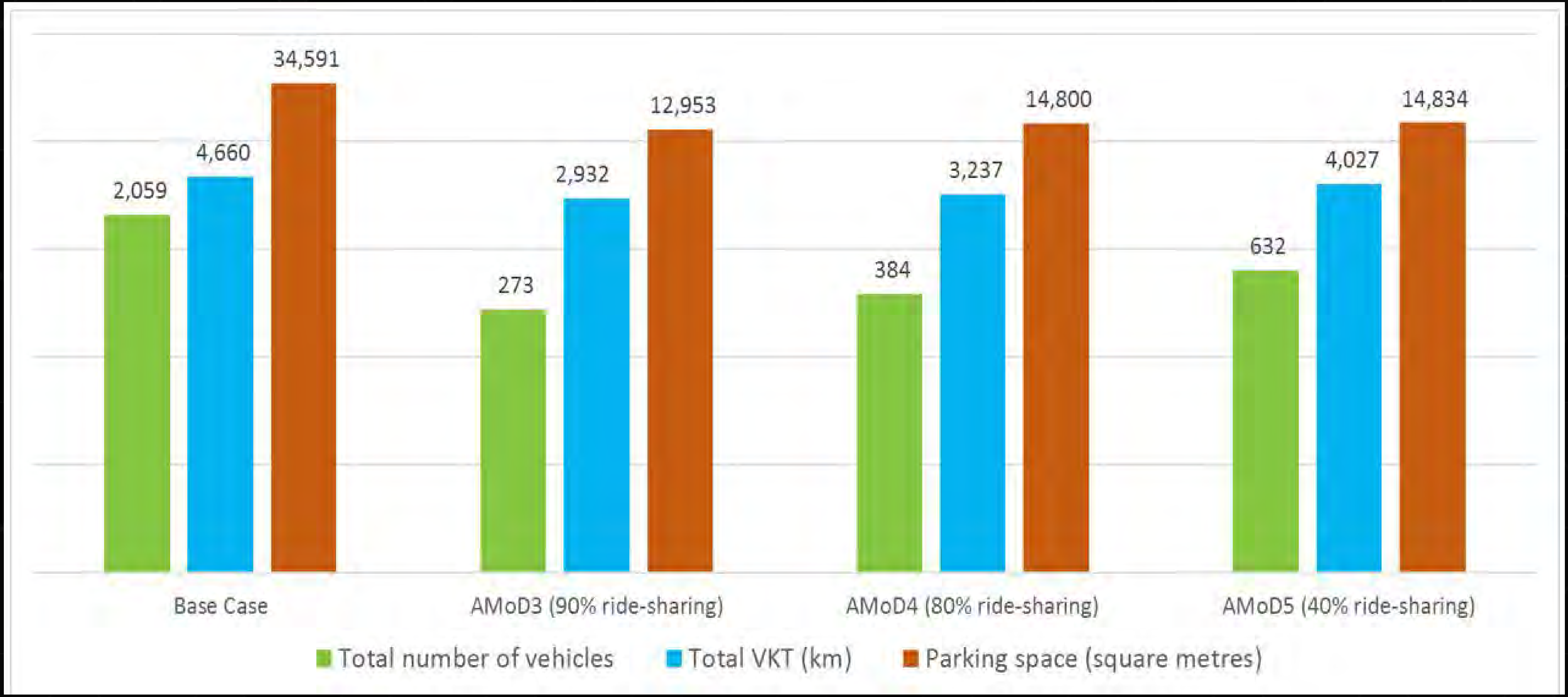
Scenarios 3-5

- Autonomous shared mobility
- Passengers with car-share and ride-share preferences
  - Car-share: Passengers with high values of travel time
  - Ride-share: Passengers with low value of travel time

Scenario	Car-Sharing (Percent)	Ride-Sharing (Percent)		
Capacity	Single occupant	2 passengers	3 passengers	4 passengers
Scenario 3	10%	30%	30%	30%
Scenario 4	20%	20%	30%	30%
Scenario 5	60%		20%	20%

Scenarios 3-5 Results

Impacts of variable proportions of car-share and ride-share



Scenarios 3-5 Results

Interplay between ride-sharing, fleet size and waiting times

Scenario	Ride-sharing (Percent)	Fleet size reduction* (Percent)	Mean waiting time (minutes)	Maximum waiting time (minutes)
Scenario 3	90%	13%	3	10
Scenario 4	80%	19%	2	10
Scenario 5	40%	31%	4	12

* Compared to base case scenario

Future research directions

Dynamic estimation of travel demand

- Machine learning to predict travel demand for shared vehicles
- Short forecasting horizons
- Training deep neural networks using historical data obtained from VISTA

Extend linear programming methods to address the fleet balancing problem

- Include constraints on VKT
- Bounded waiting times

Conclusion

- Modelling provided insights on the interplay between the different parameters and constraints that are likely to influence autonomous shared mobility

- The findings demonstrate that great benefits can be realised from these initiatives, and that sharing is going to be key to their success

- The real challenge will be to convince people to give up their right to drive, and to ride-share

- Not everyone will be excited by the AMoD vision, but the market will ultimately determine whether they can succeed

Conclusion

Number of vehicles required to provide the same trips during peak hours

12%

10% increase in VKT

83% reduction in parking space

Substantial benefits can be realised but sharing is going to be key to their success