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Yarra Trams – Monash Research Selection

Prof Graham Currie
Public Transport Research Group
Monash Institute of Transport Studies
Monash University

PTRG PUBLIC TRANSPORT RESEARCH GROUP

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SEPT-GRIP – YARRA TRAMS

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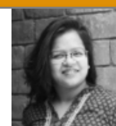
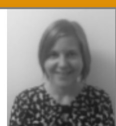
Laura Aston


2. Big Data & Visualisation
Homayoun Rafati

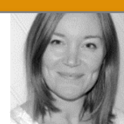

3. Network Synchronisation
Rejitha Ravindra


4. Shared Mobility
Taru Jain


5. Changing Travel Behaviour
Laura McCarthy


6. Tourism & Public Transport
Victoria Radnell


7. Reliability Engineering Approaches in Best Practice Railways
Maryam Nawaz


8. Improving Gender Diversity in the Public Transport Workforce
Rachel Mence


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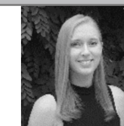
9. Future Train
Lisa Fu


10. Designing Urban Rail to Reduce Vandalism
Amy Killen


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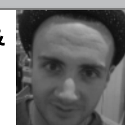
11. Bus & Tram Priority Implementation
James Reynolds


12. Simulating Bus & Tram Priority
Samithree Rajapaksha


13. Placemaking & Street Redesign
Matthew Diemer


14. Passenger Falls in Trams
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15. Transit Network Design
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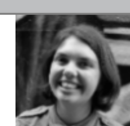
16. Future Bus
Sarah Roberts


17. The New Bus Rider
Prudence Blake


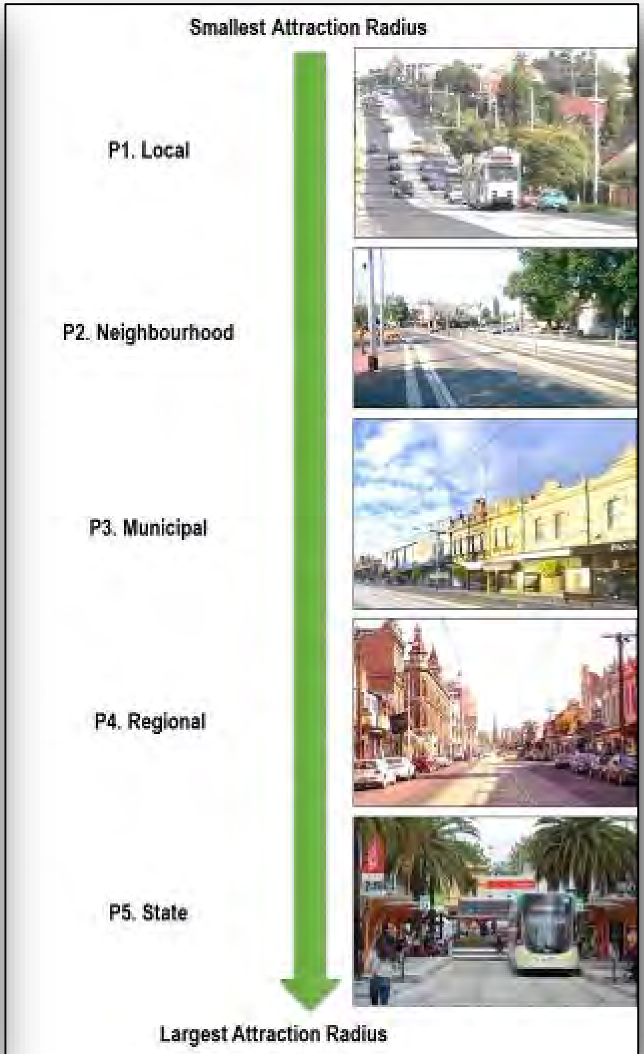
18. Road Safety Impacts of Bus Safety Inspections
Jianrong Qiu


BusVic

A Movement and Place Framework for Trams

Street Types for London' – Transport for London's Movement & Place Matrix

Source: Transport for London (2016)



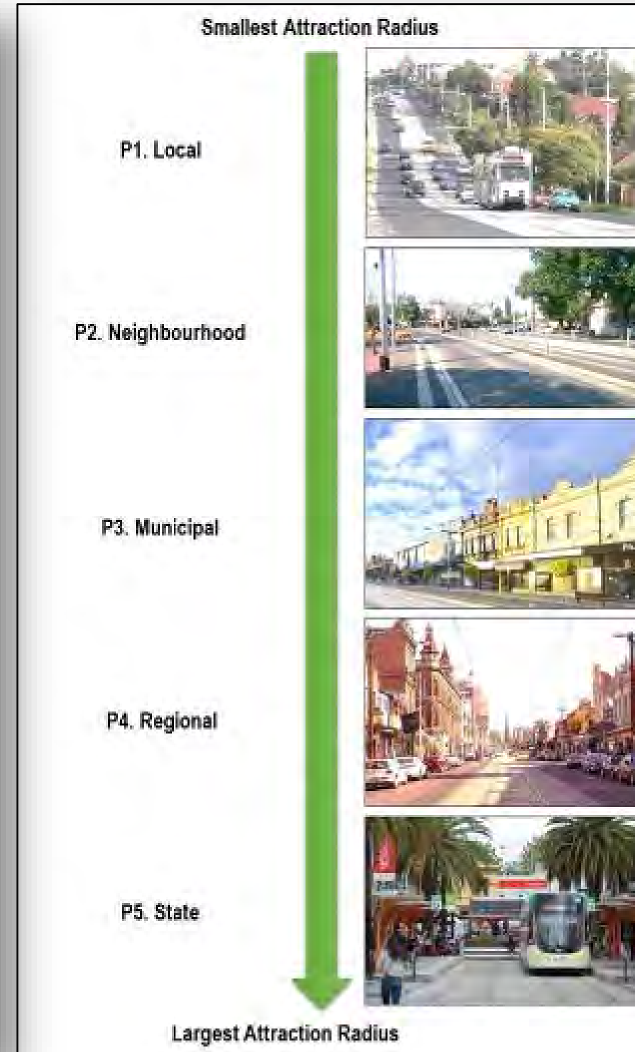
A Movement and Place Framework for Trams

Key:
- M1 (No Separation)
  - 57%
- M2 (Peak-Hour Lane)
  - 2.4%
- M3 (Pedestrianised Space)
  - 0.6%
- M4 (Visible Separation)
  - 15.4%
- M5 (Physical Separation)
  - 24.6%

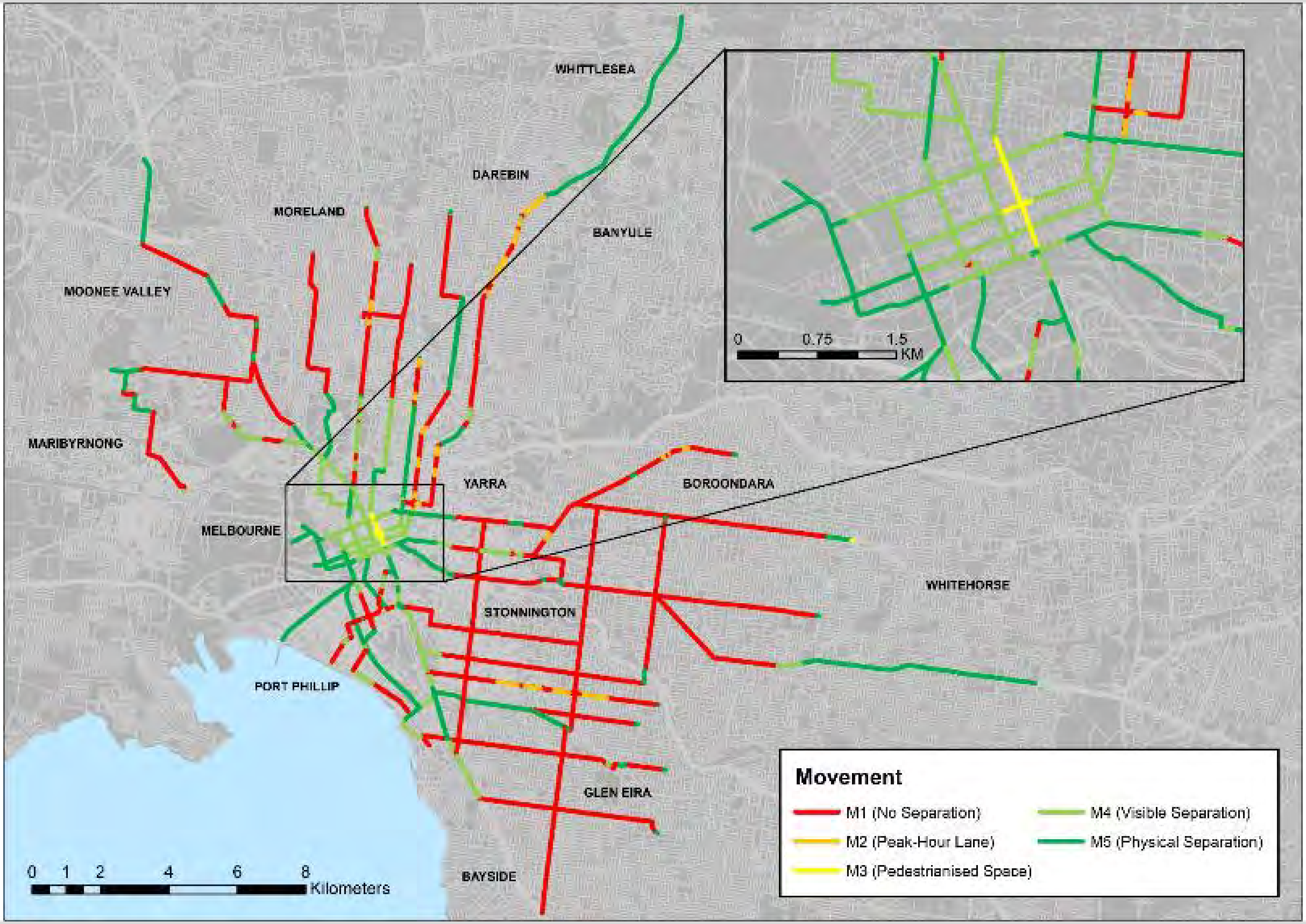
Movement Classification

Key:
- P1 (Local)
  - 23.3%
- P2 (Neighbourhood)
  - 31.3%
- P3 (Municipal)
  - 33.3%
- P4 (Regional)
  - 8.6%
- P5 (State)
  - 3.4%

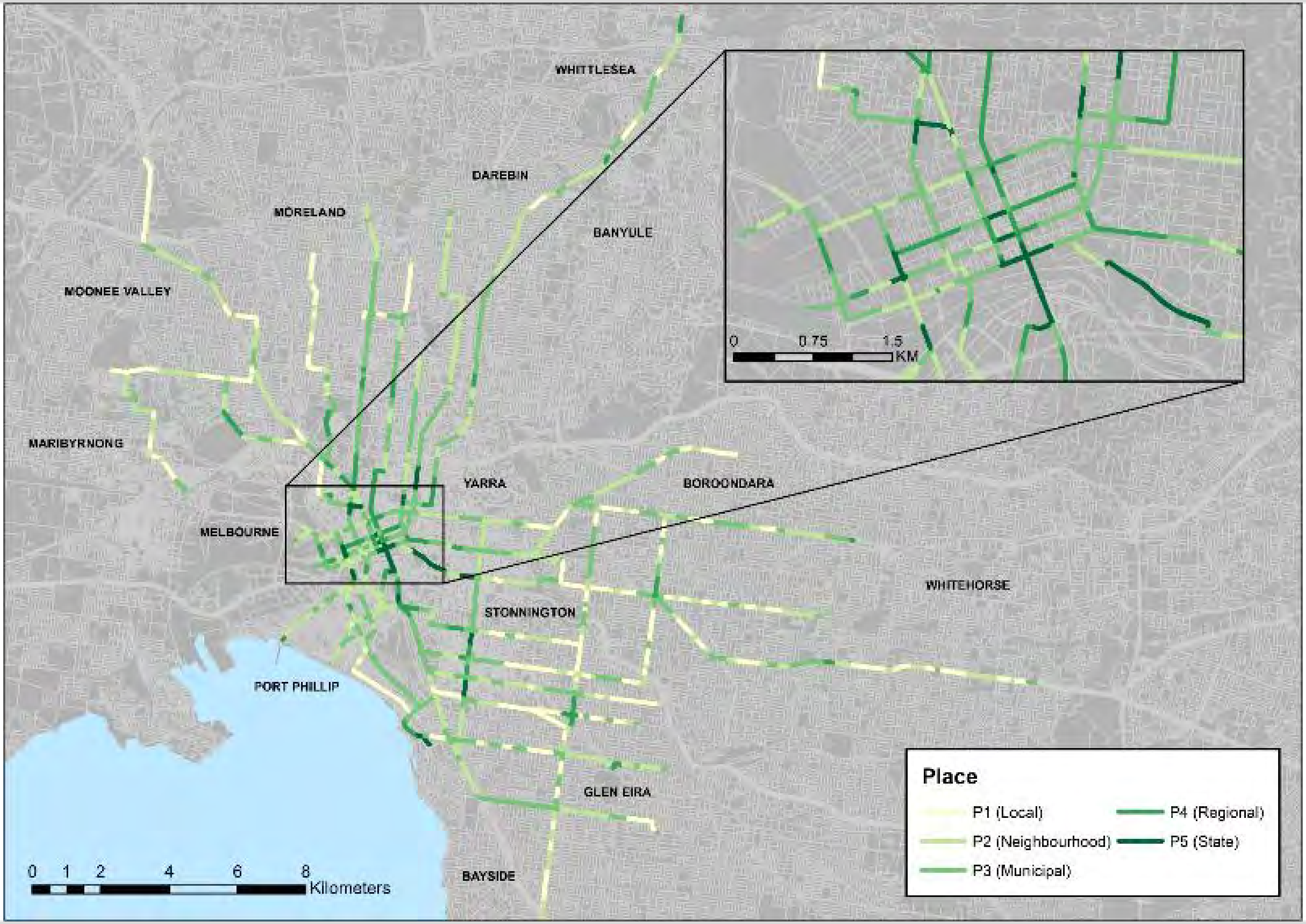
Place Classification



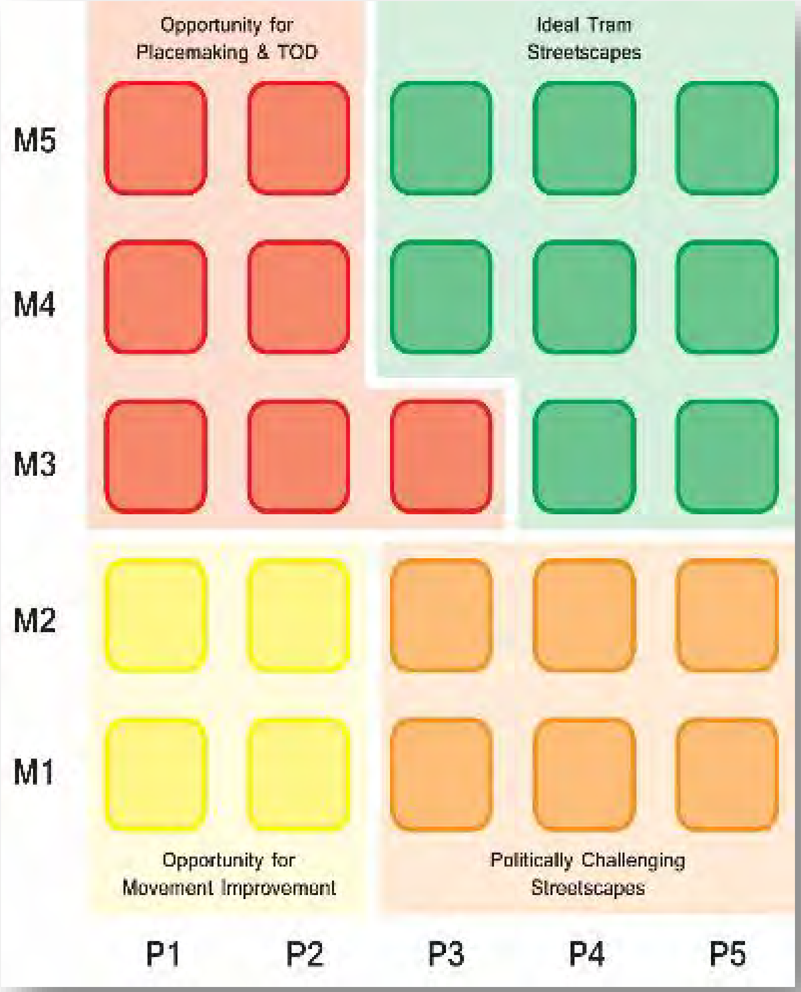
Movement Classification

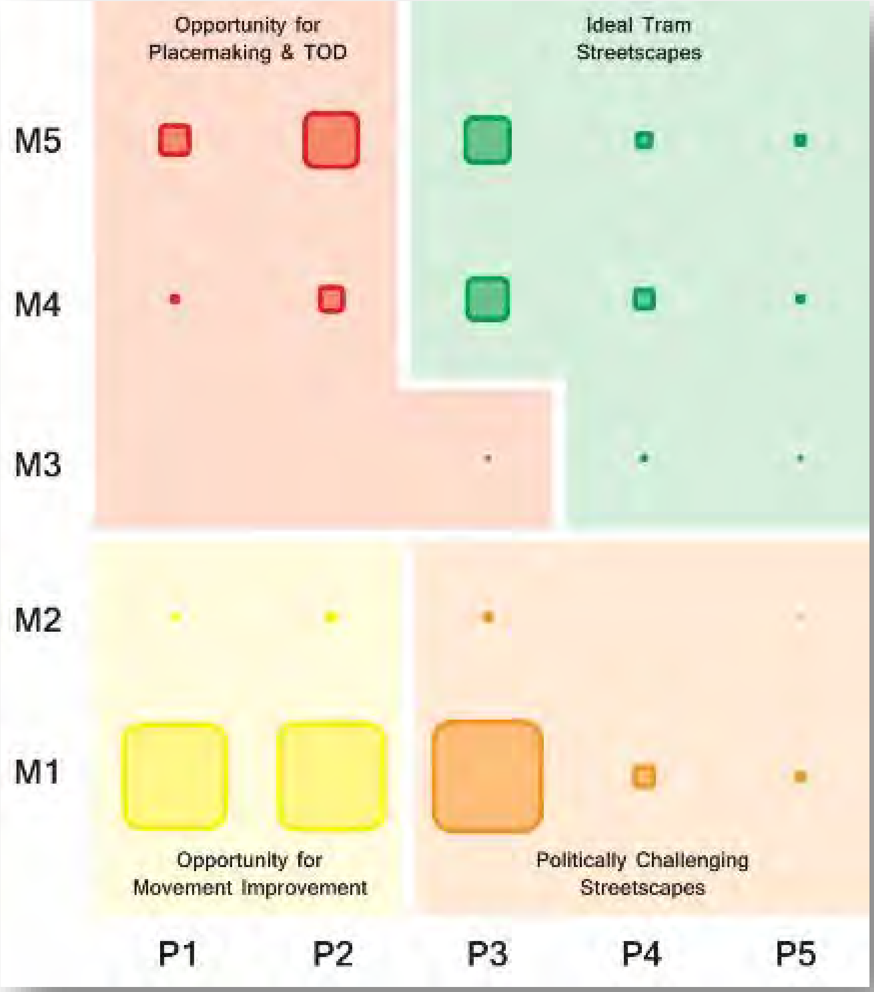


Place Classification

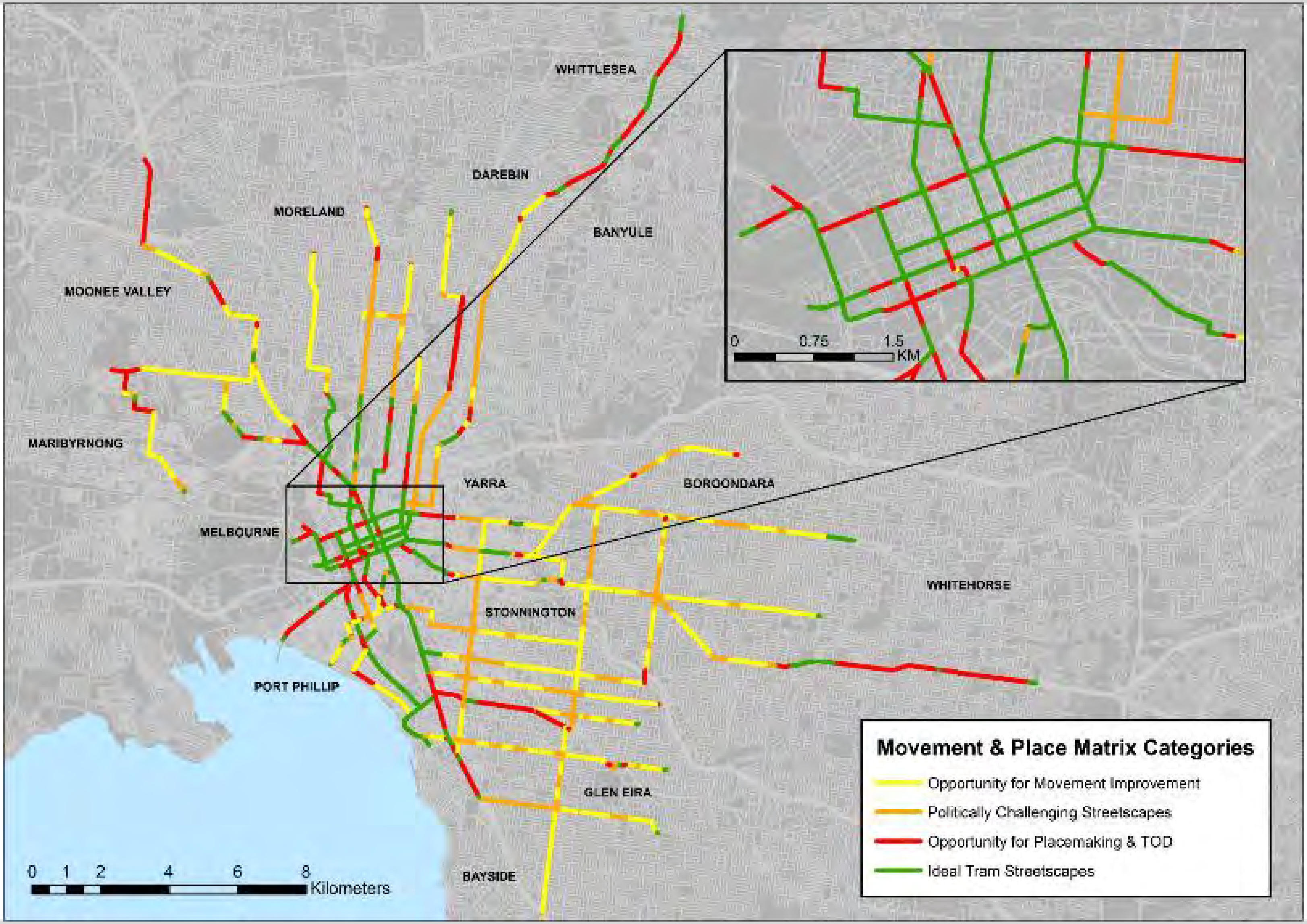


Movement Place Framework for Tram Development Actions





M&P Tram Framework – Key Target Areas and Strategies



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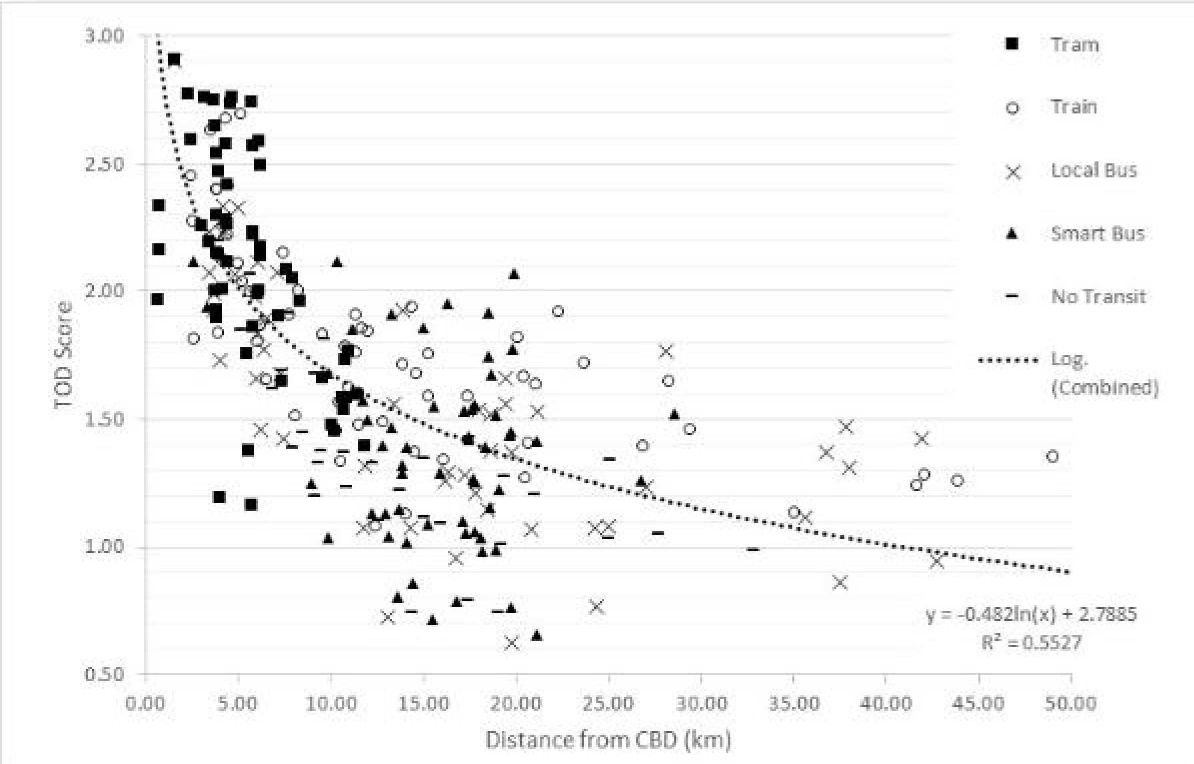


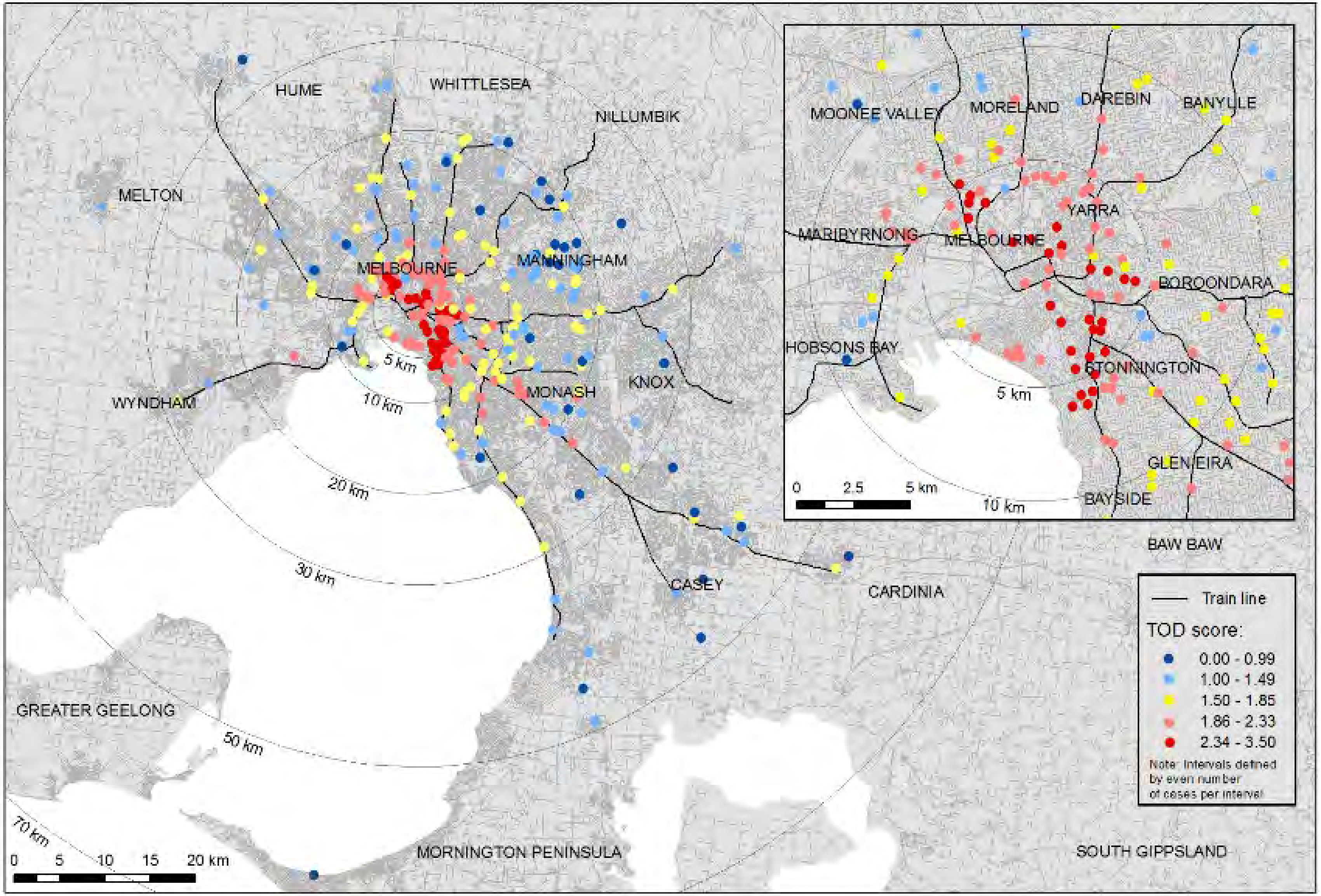
Relationship Between TOD Score and Distance from the CBD

TOD Score

Population **density**
Land use entropy - **Diversity**
Walk score - **Design**

TOD Score:	2.13	1.74	1.49	1.34	1.32

TOD score and Location



MONASH University

Transportation Research Board 96th Annual Meeting
Walter E. Washington Convention Center, Washington D.C
8-12th January 2017

17-05635: Streetcar safety from the tram driver perspective

Farhana Naznin, Graham Currie and David Logan

Public Transport Research Group
Institute of Transport Studies
Monash University

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Research Method

Approach: Tram driver focus groups

Focus groups format :

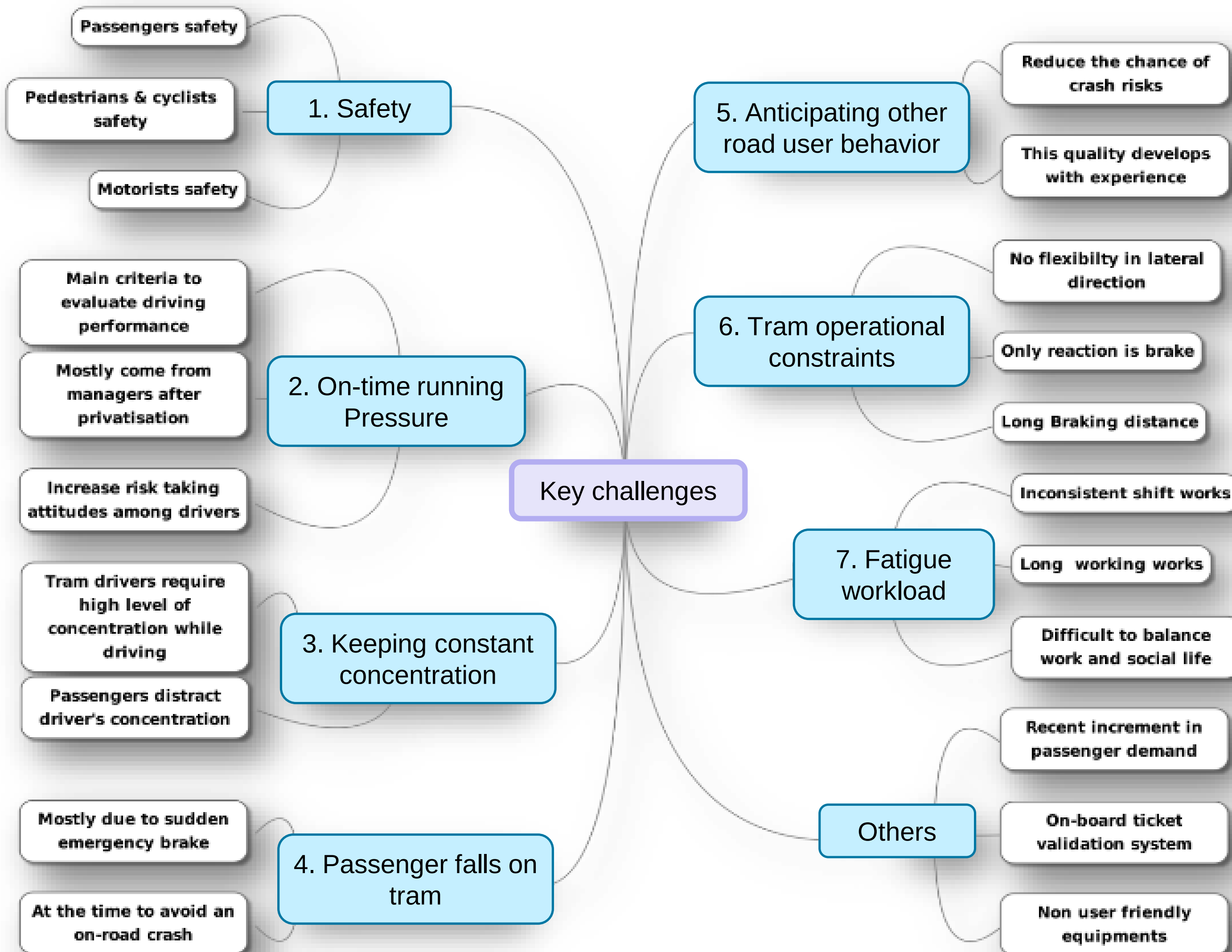
- 5 focus groups (1 hour each) at 3 tram depots (Kew, Southbank and Preston) involving 30 tram drivers
- Most of the groups had 6-7 participants
- 26 male and 4 female tram drivers
- Participants age 29~63 years, with an average age of 47.6 years (Stdv 10.1years)
- Participants age tram driving experience 1.17~31 years, with an average experience of 12.5 years (Stdv 10.2 years)
- Predefined discussion guide
- Audio-recorded

Results

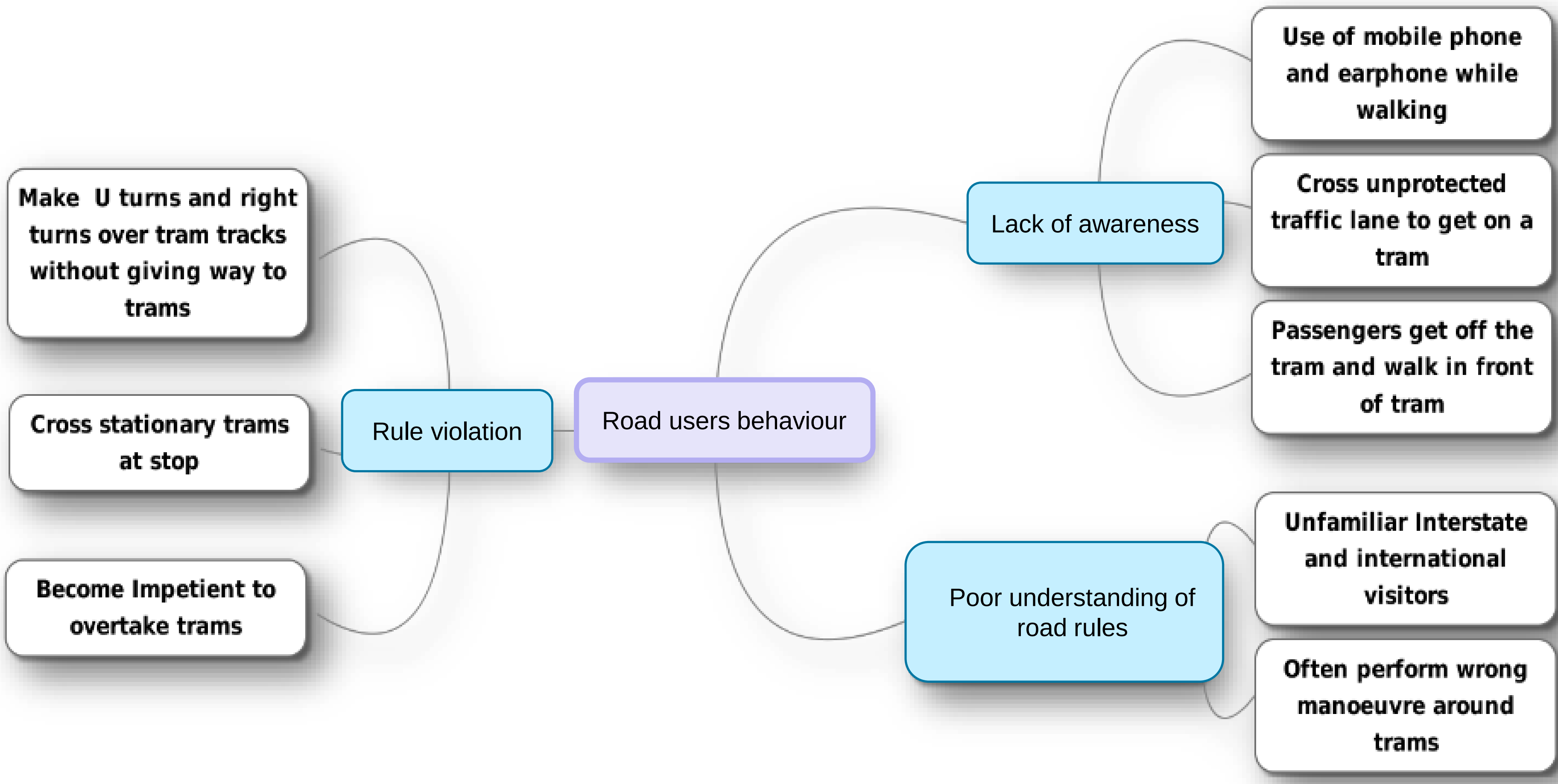
Key outcomes from tram driver focus groups:

1. Key challenges in tram driving
2. Key factors affecting safe tram driving (Road user behavior)
3. Tram driver safety perception for different
   a) Tram lane configurations
   b) Signal settings
   c) Stop configurations
4. Suggestions to improve tram road safety

Results - 1. Key challenges in tram driving



Results - 2. Key challenges in safely driving trams

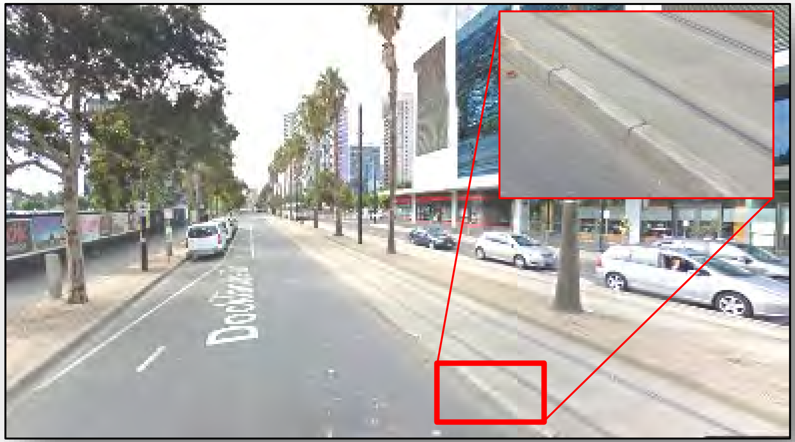


Results - 3. Tram driver safety perception of different tram lane, signal and stop priority features

a) Safety perceptions on alternative tram route sections:

- '<u>There is no safe route section</u>'; Tram drivers do not perceive any route section as safe.

- However, any <u>traffic measure that separates trams from general traffic</u> was considered as safer
    - *Raised tram tracks*
    - *Tramways with raised yellow kerbing beside tracks*



Raised tram track

Yellow kerbing

Results - 3. Tram driver safety perception of different tram lane, signal and stop priority features

- Light rail tracks were perceived as safe. However, perceived as unsafe mostly at night due to low light as well as when passenger cross the tracks.

- Full-time and part-time tram lanes were not believed to have any road safety benefit due to lack of road rules compliance by road users

Light rail track

Part-time tram lane

Full-time tram lane

Results - 3. Tram driver safety perception of different tram lane, signal and stop priority features

b) Safety concerns at intersections:

- Most tram drivers stated the positive road safety benefits of ‘hook turns’; some were found to be concerned about unfamiliar motorists which are unsafe
- Tram drivers appreciated the presence of ‘T’ light for trams, as it improves tram travel time, but could not see any road safety benefits
- ‘No right turn’ signs were perceived to be ignored by motorists

Hook turn

Tram ‘T’ light

Turn bans

c) Road safety issues at tram stop:

- ‘Platform tram stops’ were clearly identified as the safest type of tram stop for passengers by almost all tram drivers
- Tram drivers perceived ‘Easy access stop’ as the most dangerous type of stop
- Tram drivers perceived the risk of passengers being hit by cars while boarding and alighting at ‘kerbside stops’
- ‘Safety zone stops’ are perceived to have risk of passengers being struck by trams at the narrow waiting area.

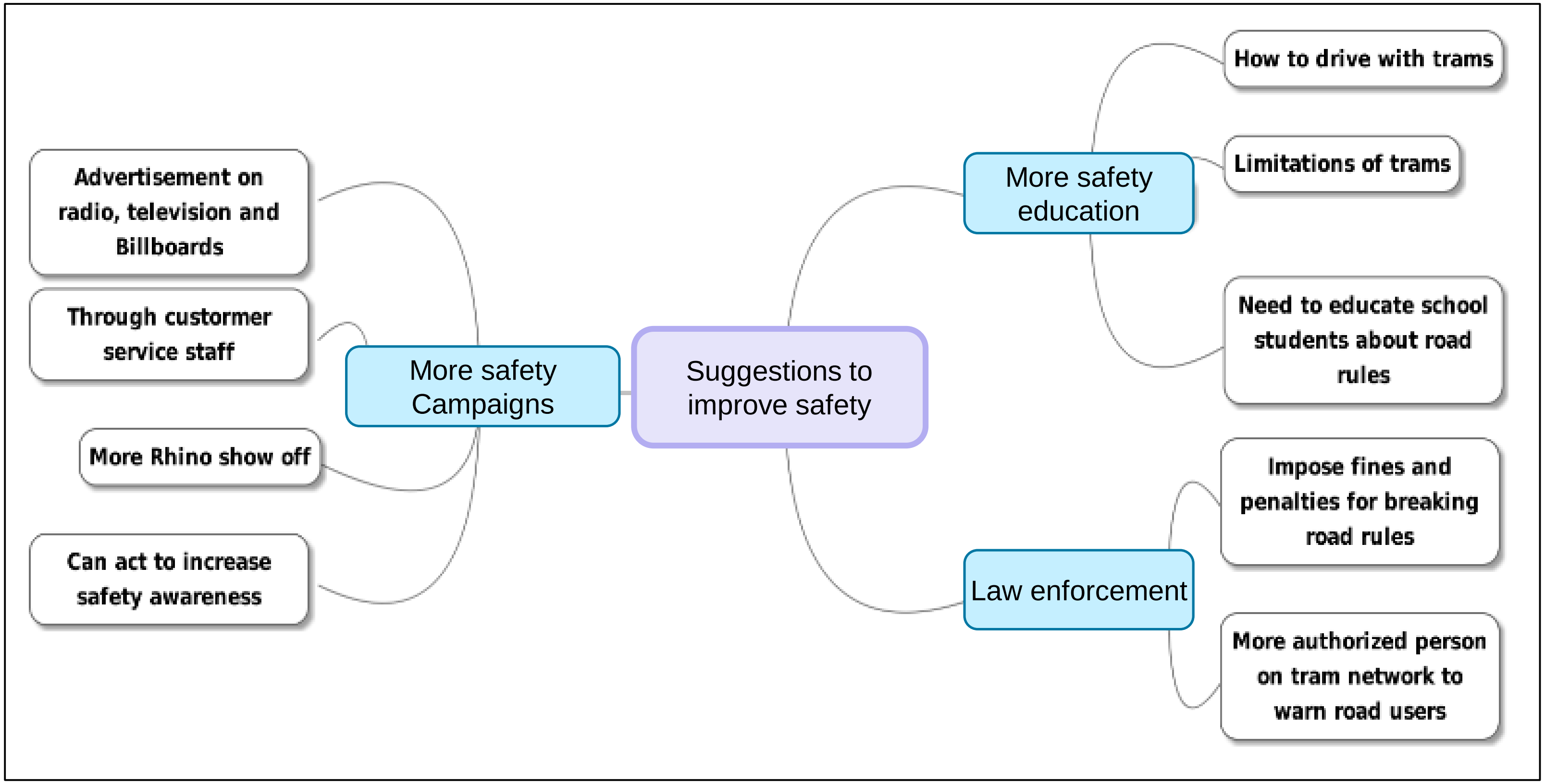
Platform tram stop

Easy access stop

Safety zone stop

Kerb side stop

4. Suggestions to improve road safety



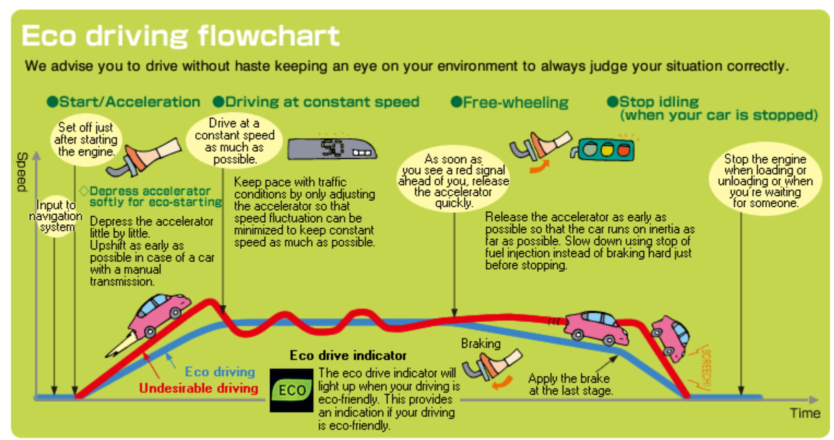
Eco-driving for Melbourne Trams: a Preliminary Study using Yarra Trams E-Class Tram Driving Simulator

Graham Currie
Long Truong

Public Transport Research Group
Monash Institute of Transport Studies
Monash University, Australia

Eco-driving

- Eco-driving is driving that minimises energy use and contributes to emission reduction
  - while not compromising safety (and on-time performance for PT)
- Eco-driving initiatives
  - Eco-driving training/ assistance devices
  - Vehicle maintenance
  - Eco-routing



Eco-driving effectiveness

- Reported reductions in fuel consumption and CO_2 emissions range from 5% to 40% across various jurisdictions and initiatives (Alam&McNabola 2014)
- In Australia
  - Car: 11% fuel saving (simulated experiment – Qian&Chung 2011)
  - Truck: 27% fuel saving (field experiment – Symmons&Rose 2009)
- PT vehicles
  - Bus: 2% to 10% fuel saving (Xu et al 2016)
  - Train: 5% to 10% energy saving (Gonzalez-Gil et al 2014)
- Other potential effects?
  - Reduced intersection capacity (increased fuel consumption at the network level)
  - Crash risks (distractions associated with assistance devices)

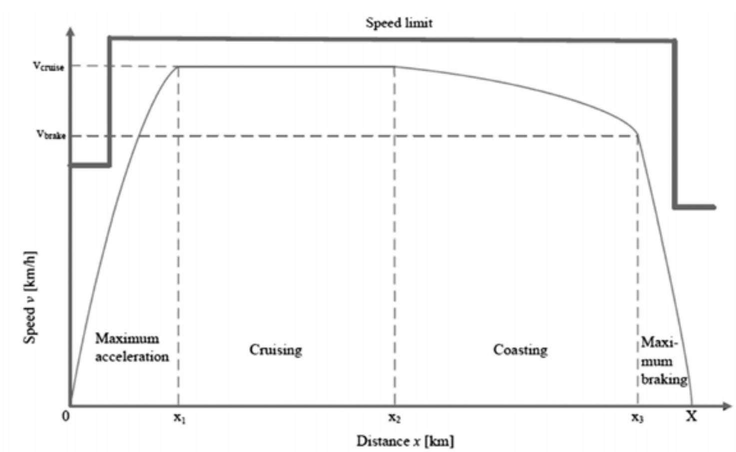
Eco-driving for Trams

- Limited research has been conducted
  - 3% energy saving in Leipzig and Brno (ACTUATE 2015), but unclear if regenerative braking is utilised
- Substantial cost savings given energy represents 15 to 20% of the operation expenditures of a light rail network (http://www.uitp.org/)

5 GOLDEN RULES FOR SAFE ECO-DRIVING OF CLEAN VEHICLES:

1) *acceleration should be quick*
2) *the "steady state" on the throttle /accelerator should be avoided*
3) *the rolling ratio should be as high as possible, while ensuring compliance with the schedule*
4) *unnecessary braking should be avoided and usage of wear-free electric brakes for energy recuperation should be optimised*
5) *conscious use of the heating, air conditioning and ventilation system*

(ACTUATE 2015)



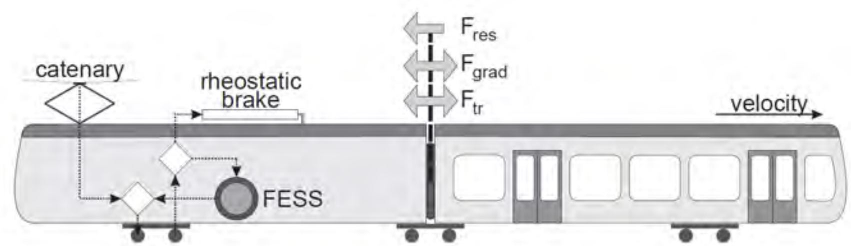
Luijt et al 2017

Eco-driving with Yarra Trams E-Class Tram Driving Simulator

- How the Yarra Trams E-Class Tram Driving Simulator can be used to monitor eco-driving for trams?
  - Drive cycles can be extracted from the simulator’s performance data outputs.
  - Drive cycles would be improved by eco-driving principles
  - Energy consumption can be estimated from drive cycles
    - a new energy estimation model is developed

Energy estimation model using drive cycles

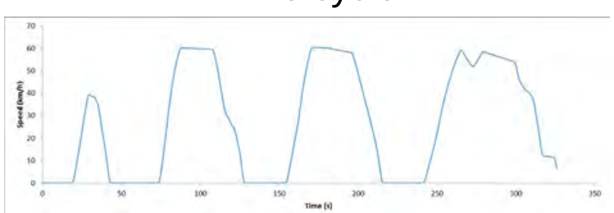
- Train/tram dynamics
  - Tractive force F_{tr}
  - Track resistance F_{res}
  - Force due to track gradient F_{grad}



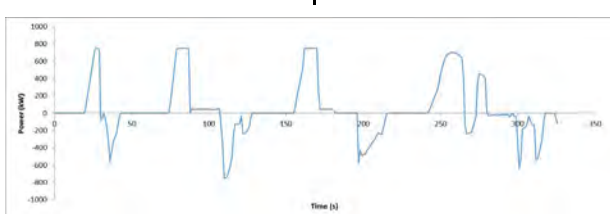
$$F_{tr} - F_{res} - F_{grad} = M_{train}^{eff} a = F_a$$

- Instantaneous electrical power requirement is determined from the tractive power
  - Regenerative breaking is considered
- Energy consumption is then determined from power requirement

Drive cycle



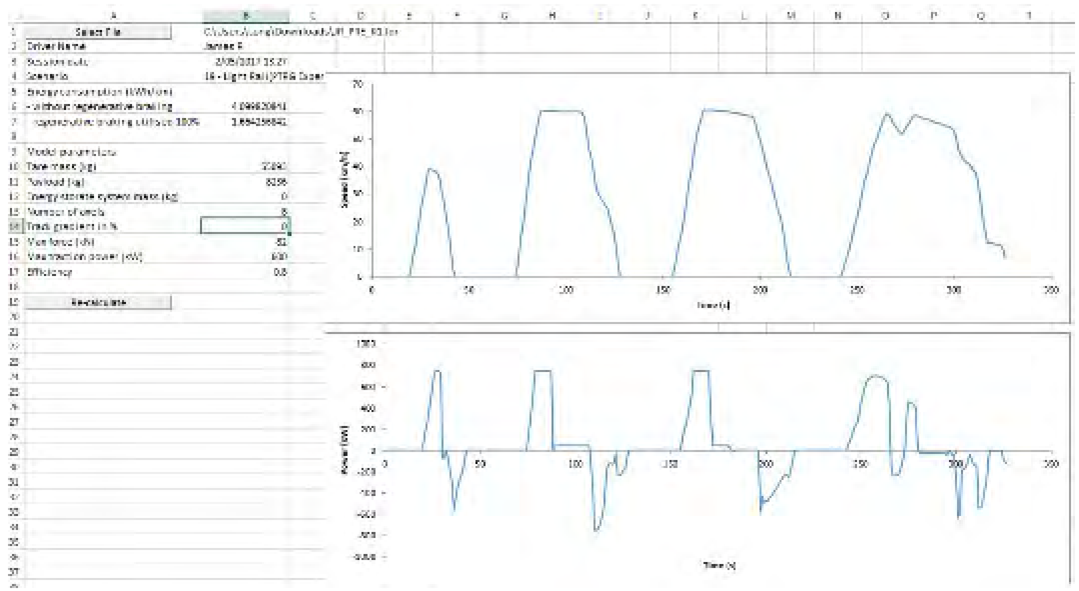
Power requirement



Energy consumption

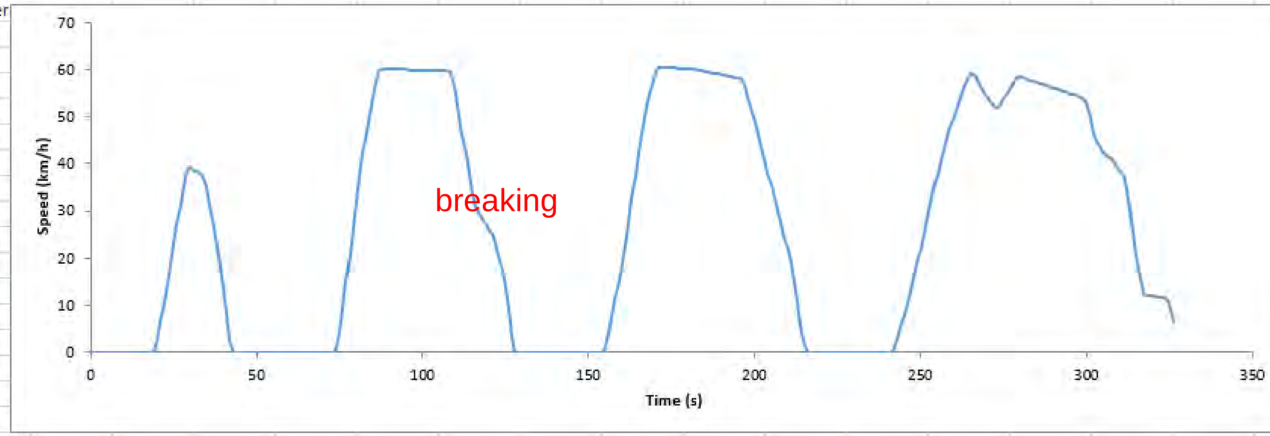
Excel VBA tool for energy estimation (1)

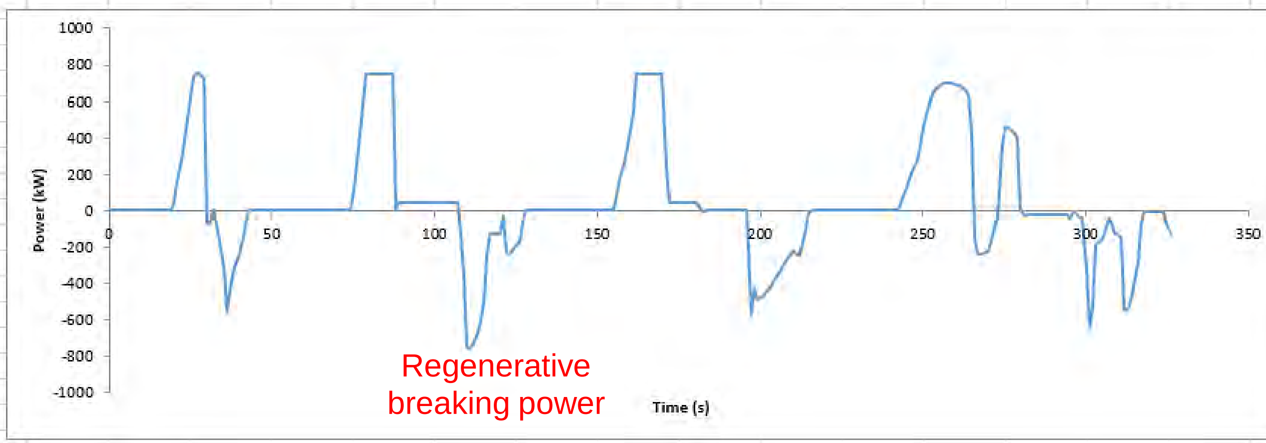
- Inputs:
  - Drive cycle (driving record file from the simulator can be read directly)
  - Model parameters: tare mass, payload, number of axels, track gradient, max force, max traction power, efficiency etc
    - These parameters can be calibrated specifically for E-Class trams
- Outputs:
  - Power requirement
  - Energy consumption



Excel VBA tool for energy estimation (2)

	A	B
1	Select File	C:\Users\Long\Downloads\JR_PRE_R1.ldr
2	Driver Name	James R
3	Session date	2/05/2017 13:27
4	Scenario	19 - Light Rail(PTRG Exper
5	Energy consumption (kWh/km)	
6	- without regenerative braking	4.099820841
7	- regenerative braking utilised 100%	1.664256842
8		
9	Model parameters	
10	Tare mass (kg)	55093
11	Payload (kg)	8236
12	Energy storate system mass (kg)	0
13	Number of axels	8
14	Track gradient in %	0
15	Max force (kN)	82
16	Max traction power (kW)	600
17	Efficiency	0.8
18		
19	Re-calculate	





Tram Driving Simulator Experiments (as part of a Final Year Project)

- 6 Participants (including 2 controls)
- 1 Scenario (Light Rail Only)
- 4 Stages
  - Training (10-15 minutes)
  - Pre eco-driving training (3 runs)
  - Eco-driving training (for 4 participants)
  - Post eco-driving training (3 runs)

Summary of Energy Consumption

Participant No.	Average Pre-Eco (kWh/km)	Average Post-Eco (kWh/km)	Change in Energy (%)
P1	3.735	3.917	4.87
P2	4.532	3.966	-12.49
P3	4.284	3.730	-12.93
P4	4.306	4.188	-2.76
P5	3.083	2.790	-9.52
P6	3.479	3.997	14.89
(P1-P4)	4.21	3.95	-6.27
(P5-P6 - Controls)	3.28	3.39	3.42

Potential energy savings of around 6%

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