MONASH University

Australian Institute of Transport Planning and Management
DEDJTR Theatrette , Level 5, 121 Exhibition Street,, Melbourne, VIC
Tuesday 27th September 2016

Monash University Research Program on the Road Safety Impacts of Public Transport Priority.

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

PTRG PUBLIC TRANSPORT RESEARCH GROUP

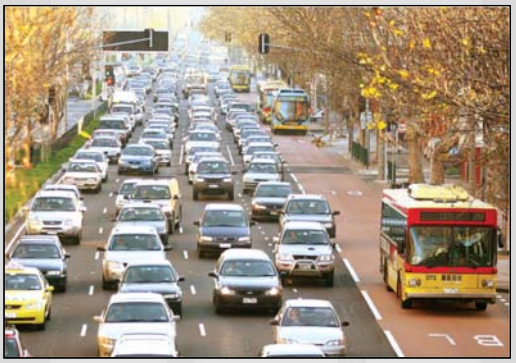
GROUP OF EIGHT AUSTRALIA

ITS (Monash)

Institute of Transport Studies (Monash)
The Australian Research Council Key Centre in Transport Management

MONASH University

- Introduction
- Bus Priority
- Tram Priority
- Next Steps



PTRG PUBLIC TRANSPORT RESEARCH GROUP

This paper presents an overview of a series of research programs exploring road safety and bus services……

Background:

- Bus Road Safety:
  - Project started as a study of bus safety
  - Found important effects of bus priority (signal and lane priority) on bus crashes so explored wider effects on all traffic
  - Found BIG impacts so the question was why?
  - Undertook a series of studies to identify why
- Tram/Streetcar Safety
  - Exploring bus issues in a tram context
  - Explored reasons for effects

…all research is published in a series of research papers

Bus

Factors Affecting 'At Fault' Bus- Involved Accidents (Including Bus Priority)

•Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Factors Affecting the Probability of Bus Drivers Being At-Fault In Bus-Involved Accidents' ACCIDENT ANALYSIS AND PREVENTION Volume 66, May 2014, Pages 20-26

Exploring Road Safety of Bus Routes With/Without Priority

•Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Bus Accident Analysis of Routes With/Without Bus Priority' ACCIDENT ANALYSIS AND PREVENTION Volume 65, April 2014, Pages 18-27

Before/After Effects of Bus Priority on Road Safety

•Goh K, Currie G, Sarvi M and Logan D (2013) 'Road Safety Benefits from Bus Priority? – An Empirical Study' TRANSPORTATION RESEARCH RECORD, No. 2352, Transportation Research Board of the National Academies, Washington,D.C., 2013, pp. 41–49

Road Safety, Bus Priority and Experimental Micro-Simulation

•Goh K, Currie G, Sarvi M and Logan D (2014) 'Experimental Micro-Simulation Modelling of Road Safety Impacts of Bus Priority' TRANSPORTATION RESEARCH RECORD, Volume 2402 / Truck and Bus Safety; Roundabouts 2014, pp 9-14

Tram

Before/After Effects of Tram Priority on Road Safety

•Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97 .

•Naznin F, Currie G, Logan D (2016) 'Exploring the impacts of factors contributing to tram-involved serious injury crashes on Melbourne tram route' ACCIDENT ANALYSIS AND PREVENTION Volume 94, September 2016, Pages 238-244

• Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

•Naznin, F., Currie, G., Logan, D., Sarvi, M (2016) 'Safety impacts of platform tram stops on pedestrians in mixed traffic operation: A comparison group before-after crash study' ACCIDENT ANALYSIS AND PREVENTION ,86 pp. 1 - 8

•Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

•Currie G, Reynolds J, Naznin F and Law J (Under review) 'Exploring the Safety Performance of Tram Roundabouts' 96th Annual Meeting of the Transportation Research Board, Washington DC

Tram Stops and Road Safety

•Currie, G., Tivendale K and Scott R (2011) 'Analysis and Mitigation of Safety Issues at Kerbside Tram Stops' TRANSPORTATION RESEARCH RECORD No 2219 No 4 pp 20-29

•Currie, G., & Reynolds, J. (2010). Vehicle and Pedestrian Safety at Light Rail Stops in Mixed Traffic. TRANSPORTATION RESEARCH RECORD, Vol. 2146, pp. 26-34

Hook Turns and Road Safety

•Currie, G. and Reynolds J (2011) 'Managing Trams and Traffic at Intersections with Hook Turns – Safety and Operational Impacts' TRANSPORTATION RESEARCH RECORD No 2219 No 4 pp 10-19

The research is part of a program funded by the Australian Research Council & partners with a research team including 2 PhD students…

Research Program

Goal

to improve methodologies and guidance to enable the optimisation of design and implementation of public transport priority initiatives

Team

Graham Currie, Majid Sarvi, Research Fellow, 2 PhD Students

ITS (Monash)

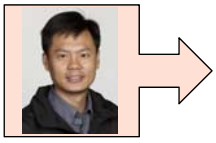
University of Southampton Nick Hounsell

vicroads

PUBLIC TRANSPORT VICTORIA PT

Australian Government
Australian Research Council

PhD Research



Kelvin Goh – PhD Thesis Road Safety Impacts of Bus Priority Measures

Farhana Naznin – PhD Thesis Road Safety Impacts of Tram Priority Measures

Co-supervisors

Dr David Logan – Monash University Accident Research Centre

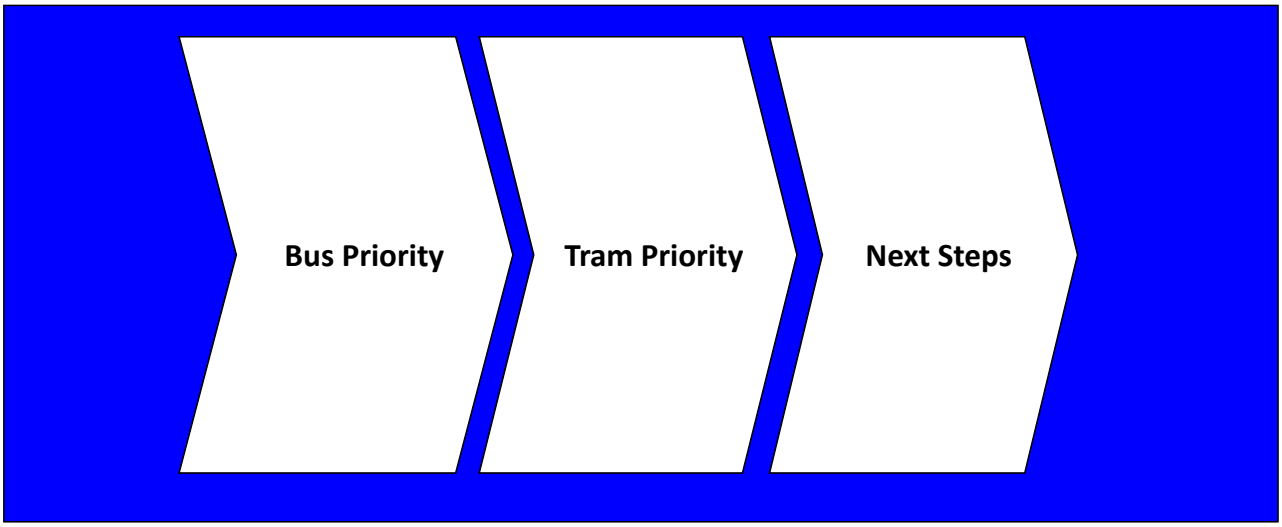
Assoc. Prof Majid Sarvi – ITS (Monash) now Melb Uni

…who have done very well…

2014
Australian Road Research Board – Monash Prize in Postgraduate Transport Research

2016
Australian Road Research Board – Monash Prize in Postgraduate Transport Research

The presentation is structured as follows



Introduction

Bus Priority

Tram Priority

Next Steps

Bus Priority

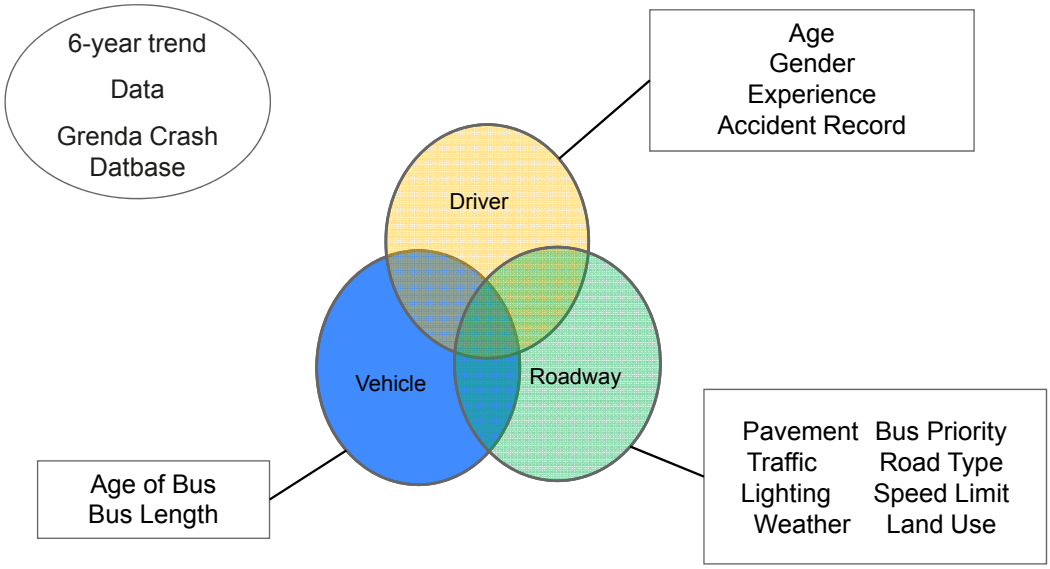
Bus Crash Risk

Bus Crashes With/Without Priority

Traffic Effects?

Traffic Microsimulation

The genesis was a study exploring Bus drivers' probability of being 'at-fault' in bus crashes including road design effects

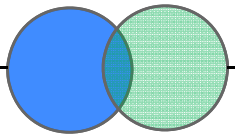


Approach: Mixed Logit Model of driver being at-fault; *16 driver, vehicle, roadway and environment factors*

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Factors Affecting the Probability of Bus Drivers Being At-Fault In Bus-Involved Accidents' ACCIDENT ANALYSIS AND PREVENTION Volume 66, May 2014, Pages 20-26

Two vehicle and 5 road factors were found significant – bus priority dominated road design factors

Age of Bus
Bus Length



Pavement | Bus Priority*
Traffic* | Road Type
Lighting* | Speed Limit
Weather | Land Use

	Factor	Type	β	S.E.	t-Statistic
↑	Bus age - 25 years or more	Fixed	0.273	0.0969	2.82
↓	Bus Length - 12m or less	Fixed	-0.241	0.0415	-5.81
↓	Divided Road	Fixed	-0.427	0.0501	-8.53
↑	Speed Limit - 50kph & below	Fixed	0.313	0.0404	7.73
↓	Traffic - Moderate/Heavy	Random	-0.206 (0.400)	0.0370 (0.0363)	-5.57 (11.03)
↓	Daylight	Random	-0.125 (0.418)	0.0449 (0.0297)	-2.78 (14.05)
↓	Bus Priority	Random	-0.446 (2.26)	0.216 (0.447)	-2.07 (5.05)

Indicative that divided roads and those with bus priority would help bus drivers

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Factors Affecting the Probability of Bus Drivers Being At-Fault In Bus-Involved Accidents' ACCIDENT ANALYSIS AND PREVENTION Volume 66, May 2014, Pages 20-26

Other risk factors were also identified – bus priority is a key mitigation measure

Driver-related

- Above 60 year old - possibly reflecting declining driving skills
  - <2 years working experience - also found in previous study (Tseng, 2012)
- Female driver
- Previous at-fault record - presence of accident prone mentality

Vehicle-related

- Longer / older buses - not surprising given buses are likely to be less responsive and had been subjected to greater wear-and tear

Roadway / Environment

- Undivided / 50kph or lesser roads - indicate space issues faced by bus drivers, especially near bus stops (Wahlberg, 2002)
  - Light traffic - perhaps drivers letting guard down
  - Night time - lesser visibility
  - Lack of bus priority - space issue as highlighted

For road / bus agencies, findings suggest benefits in assigning

✓Longer / older buses to experienced drivers

✓Routes with bus priority and mainly arterial roads to less experienced drivers

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Factors Affecting the Probability of Bus Drivers Being At-Fault In Bus-Involved Accidents' ACCIDENT ANALYSIS AND PREVENTION Volume 66, May 2014, Pages 20-26

Bus Priority

Bus Crash Risk

Bus Crashes With/Without Priority

Traffic Effects?

Traffic Microsimulation

This study aimed to 'predict' bus crashes on routes with/without priority

- Approach:
  - Empirical analysis of bus accident type and frequency analysis to gain a broad understanding of the safety implications of implementing bus priority measures at a bus route-section level
- Data
  - Traffic Incident Management System Grenda Transit (Ventura) – 2009-2011; 1,099 incidents on 99 bus routes

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Bus Accident Analysis of Routes With/Without Bus Priority' ACCIDENT ANALYSIS AND PREVENTION Volume 65, April 2014, Pages 18-27

Raw data suggests an average of about 4 bus crashes/route section p.a. (max 29!/ min zero)

Table 1: Summary Statistics of Variables Used in MENB Model

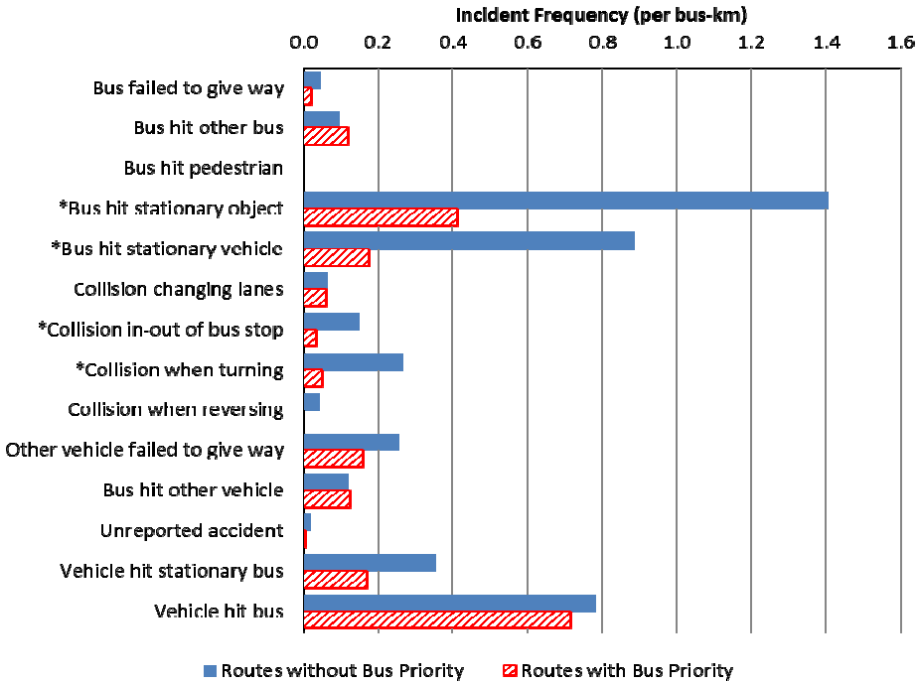
Variable	Min	Max	Mean	S.D.
Accident Frequency (Collisions/year)	0	29	3.68	4.89
Year[a] (2009=1; 2010=2; 2011=3)	1	3	2	0.82
Location[a] (Segment 1 =1 to Segment 99 = 99)	1	99	50	28.58
Length of bus route segment[b] (km)	2.5	55.0	15.94	10.11
Average Annual Daily Traffic (AADT) of segment[c]	1,495	78,433	7,335	6,286
Number of bus services per week	6	314	111.43	87.63
Stop Density (Number of bus stops/km)	0.53	7.33	2.50	0.941
Presence of bus priority (With = 1; otherwise = 0)	0	1	0.15	0.36
Total Observations, n = 297				

Note: [a] *Coded as string variable as required in R software*
[b] *Defined based on bus service route and presence of bus priority*
[c] *The weighted average method is applied to compute the AADT value for segments that comprise more than one road sections*

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Bus Accident Analysis of Routes With/Without Bus Priority' ACCIDENT ANALYSIS AND PREVENTION Volume 65, April 2014, Pages 18-27

The raw data show significant reductions in incident frequency for routes with bus priority

- 70% reduction in accidents with buses hitting stationary objects
- 80% reduction in buses hitting stationary vehicles
- 80% reduction in collisions in-out of bus stops
- Cause hypothesis – Bus Priority facilitates safer bus movements on roads with traffic



Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Bus Accident Analysis of Routes With/Without Bus Priority' ACCIDENT ANALYSIS AND PREVENTION Volume 65, April 2014, Pages 18-27

Risk factors are Rte Length, NO bus priority, Traffic Level, Stop Density & Frequency; bus priority reduces bus accidents by 54%!

- bus accident frequency at the route-section level increases with:
  - traffic volume (AADT),
  - route length and
  - service frequency
- that having more bus stops per route km increases accident risks (p=0.000), while
- the presence of bus priority reduces accident risks (p=0.002).
- the presence of bus priority is associated with a 54% reduction in bus accident occurrence, of all severity levels. *[This data includes all accident types including property – not only police recorded accidents)*

Table 1: MENB Model Results for Bus Accident Frequency

Variable	Estimate	P-value
Intercept	-6.640	0.000
Services per week	0.006	0.000
Ln(AADT)	0.431	0.001
Ln(Route Section Length)	0.773	0.000
Stop Density	0.389	0.000
Bus Priority = Yes	-0.766	0.002
Bus Priority = No	0 (Reference)	
Random Effect:	**Variance**	**Standard Deviation**
Year	0.357	0.598
Location	0.195	0.441
Dispersion parameter, α	0.242	
95% CI for α	[0.169,0.429]	
Log likelihood	-607.205	
AIC	1232.4	
R_α	0.807	

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Bus Accident Analysis of Routes With/Without Bus Priority' ACCIDENT ANALYSIS AND PREVENTION Volume 65, April 2014, Pages 18-27

Models can predict crash rate 'shapes' for risk factors

- Best model had 1 hidden layer with 4 neurons – example outputs

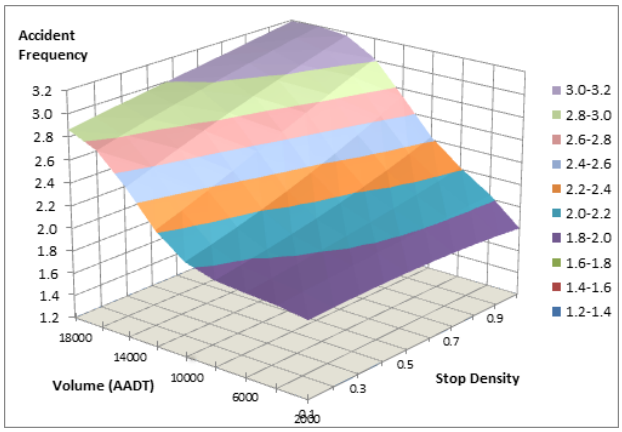


Figure 3: Effect of AADT and stop density on accident frequency (route-section 25)

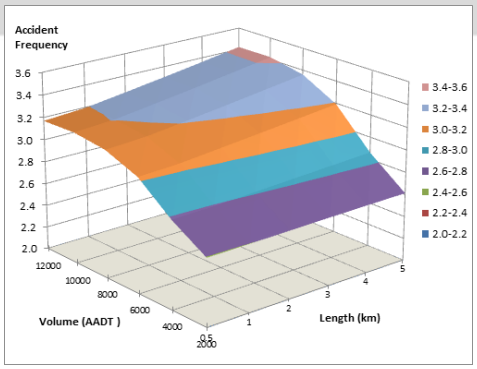


Figure 4: Effect of AADT and route length on accident frequency (route-section 25)

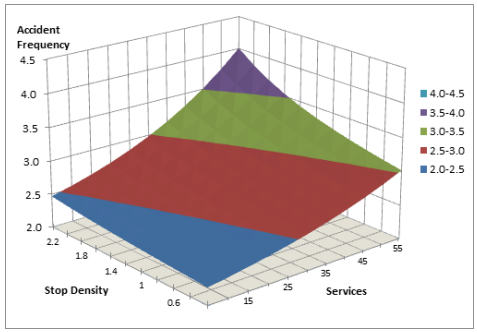


Figure 5: Effect of stop density and service frequency on accident frequency (route-section 25)

Source: Goh, K, Currie, G, Sarvi M and Logan, D (2014) 'Bus Accident Analysis of Routes With/Without Bus Priority' ACCIDENT ANALYSIS AND PREVENTION Volume 65, April 2014, Pages 18-27

Bus Priority

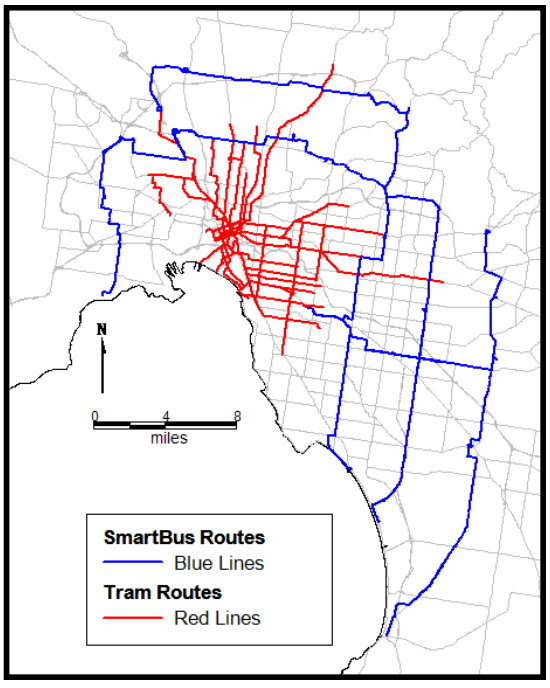
Bus Crash Risk

Bus Crashes With/Without Priority

Traffic Effects?

Traffic Microsimulation

The focus of this study was the SmartBus network; has SmartBus priority affected general traffic crash rates?

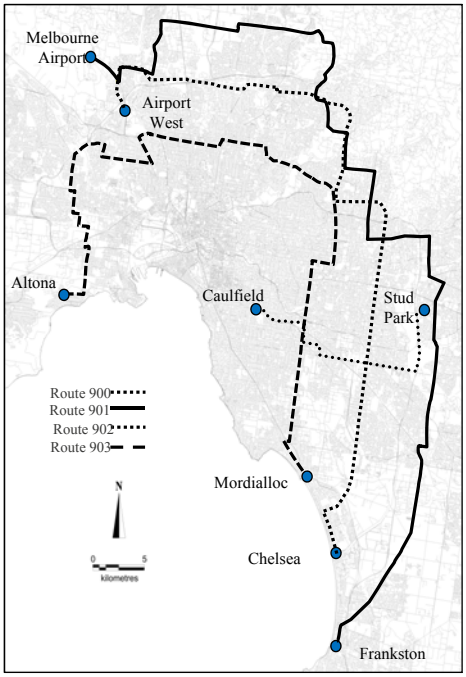


SmartBus

- 8 routes
- 200 buses
- Low frequency; 15 min headway
- Long Routes; Round Trip Time = 238 mins

Source: Goh K, Currie G, Sarvi M and Logan D (2013) 'Road Safety Benefits from Bus Priority? – An Empirical Study' TRANSPORTATION RESEARCH RECORD, No. 2352, Transportation Research Board of the National Academies, Washington,D.C., 2013, pp. 41–49

CrashStats Before/After Data was explored to understand the road safety impacts of BUS priority measures

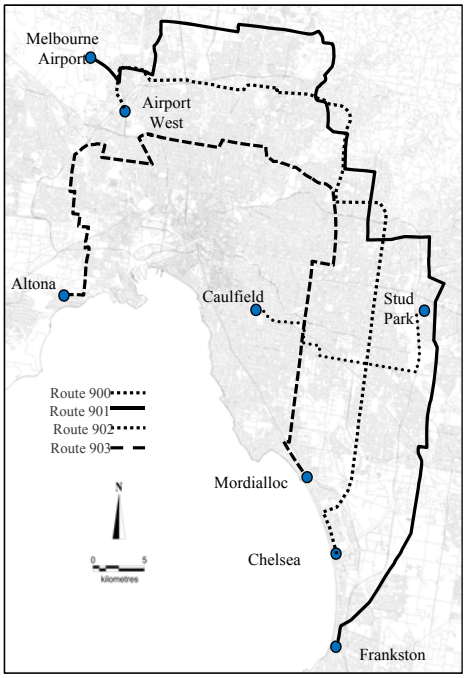


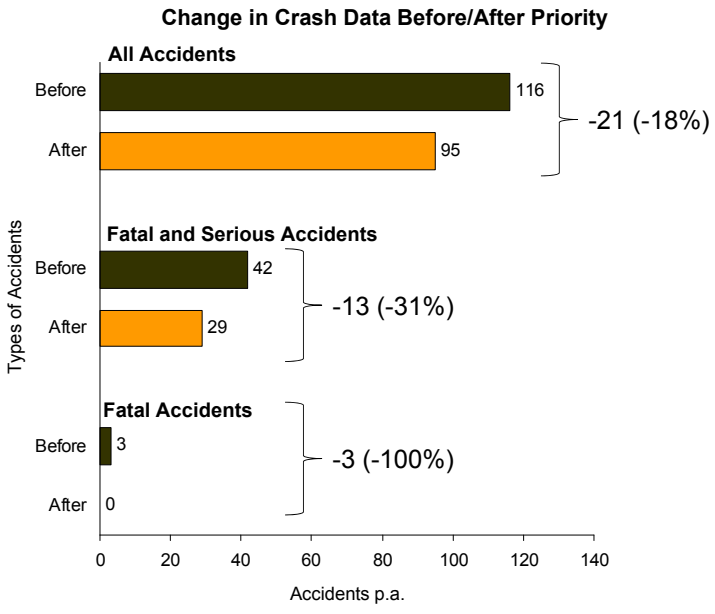
- Extensive implementation of priority measures on routes 900 to 903

Treatment	Type of Measures	Description
Transit Signal Priority (TSP) – 31 locations	Actuated Transit Phase with or without Queue Jump Lane	"B" Signal activated when presence of bus is detected
	Phase Insertion / Deletion / Red Truncation / Green extension	Adjustment of cycle / phase timing when bus is detected
Non-Transit Signal Priority (non-TSP) – 25 locations	Clearways	Restricted parking on kerbside lane to facilitate to bus flows
	Curb Extension	Widening of carriageway to facilitate bus movements
	Full-Time or Part-Time Bus Lane	Dedicated lane for bus use only

Source: Goh K, Currie G, Sarvi M and Logan D (2013) 'Road Safety Benefits from Bus Priority? – An Empirical Study' TRANSPORTATION RESEARCH RECORD, No. 2352, Transportation Research Board of the National Academies, Washington,D.C., 2013, pp. 41–49

Results show BIG general traffic crash reductions particularly in the important FSI group; why?





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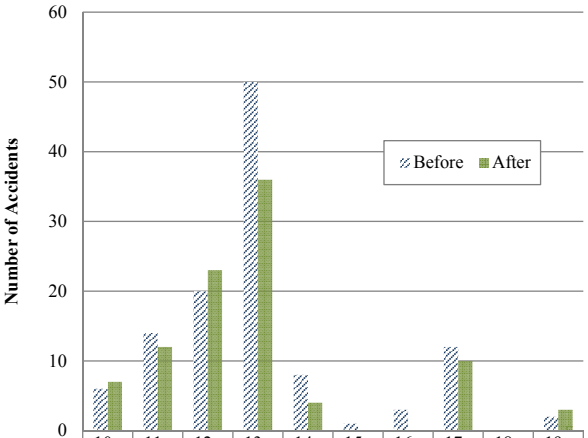
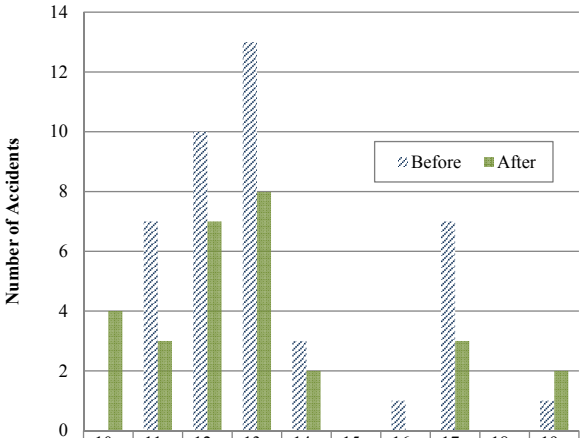
Crash Type analysis suggests causal factors for a bus priority traffic safety effect

(A) All Accidents

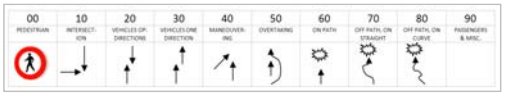


	10x	11x	12x	13x	14x	15x	16x	17x	18x	19x
Before	6	14	20	50	8	1	3	12	0	2
After	7	12	23	36	4	0	0	10	0	3

(B) Fatal and Serious Accidents



	10x	11x	12x	13x	14x	15x	16x	17x	18x	19x
Before	0	7	10	13	3	0	1	7	0	1
After	4	3	7	8	2	0	0	3	0	2



Key Findings:

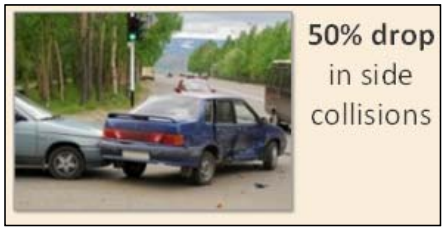
- ✓66% drop in on & off-path accidents
- ✓28% drop in rear-end accidents
- ✓50% drop in side collisions
- ✓31 % drop in FSI accidents (42 to 29)

Source: Goh K, Currie G, Sarvi M and Logan D (2013) 'Road Safety Benefits from Bus Priority? – An Empirical Study' TRANSPORTATION RESEARCH RECORD, No. 2352, Transportation Research Board of the National Academies, Washington,D.C., 2013, pp. 41–49

Crash Type analysis suggests causal factors for a bus priority traffic safety effect

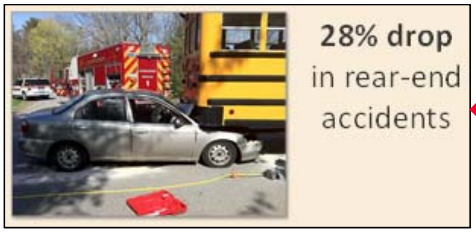
66% drop in on & off-path accidents

Bus Lanes as a Roadside Buffer?



50% drop in side collisions

Bus Lanes as a Roadside Buffer?



28% drop in rear-end accidents

Removing Bus Merges from The Traffic Stream?

Slower Traffic in Lanes & at Intersections?

Source: Goh K, Currie G, Sarvi M and Logan D (2013) 'Road Safety Benefits from Bus Priority? – An Empirical Study' TRANSPORTATION RESEARCH RECORD, No. 2352, Transportation Research Board of the National Academies, Washington,D.C., 2013, pp. 41–49

Analytical impact is a 14% crash reduction; space based priority -18%; time based -11%

- Robust before-after evaluation (Empirical Bayes method) employed
  - Final results show 14% reduction in accidents

Parameter	Types of Treatments		
	Time Based	Space Based	Overall
Number of Locations	31	25	56
Total observed crash counts in the "after" period	94	66	160
Expected crash counts in the "after" period	105.38	80.29	185.7
OR'	0.892	0.822	0.862
OR	0.889	0.818	0.860
SE(OR)	0.11	0.12	0.08
Safety Effect, θ	11.1%	18.2%	14.0%*
90% confidence level	(-7%,29%)	(-1.5%,38%)	(0.8%,27%)

* Significant at 90% level

- Time based measures opposite to those by study in Toronto, Canada (tram) – Likely due to lower bus frequency / pedestrian volume in Melbourne

Source: Goh K, Currie G, Sarvi M and Logan D (2013) 'Road Safety Benefits from Bus Priority? – An Empirical Study' TRANSPORTATION RESEARCH RECORD, No. 2352, Transportation Research Board of the National Academies, Washington,D.C., 2013, pp. 41–49

Bus Priority

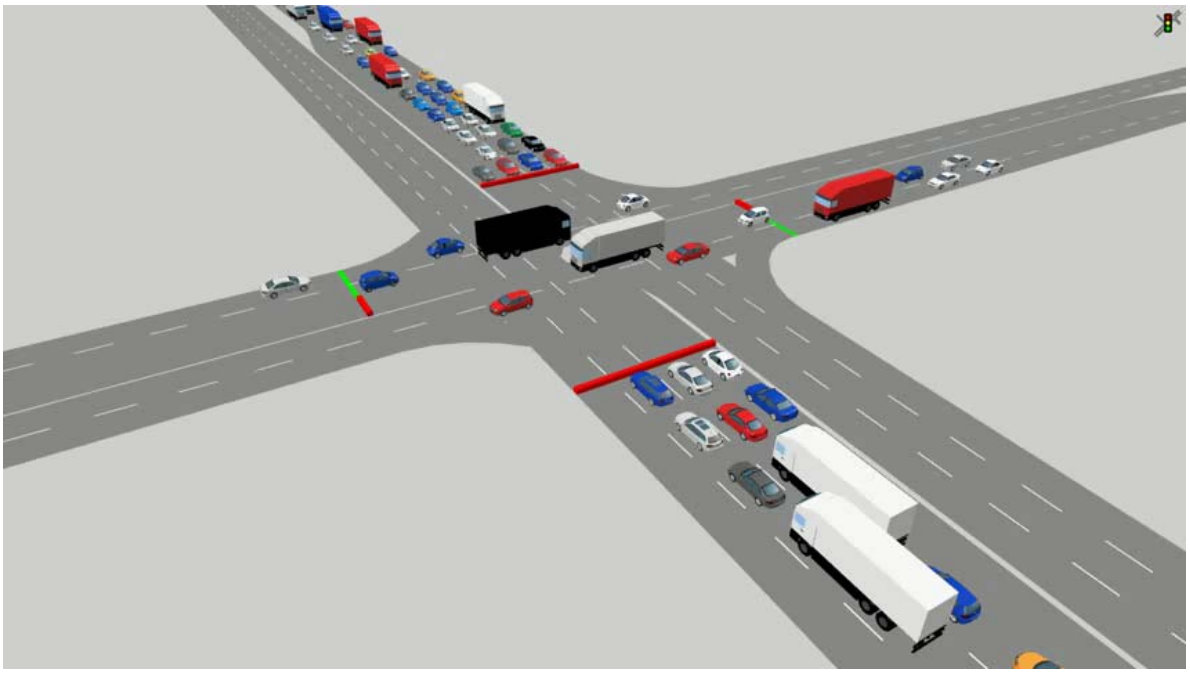
Bus Crash Risk

Bus Crashes With/Without Priority

Traffic Effects?

Traffic Microsimulation

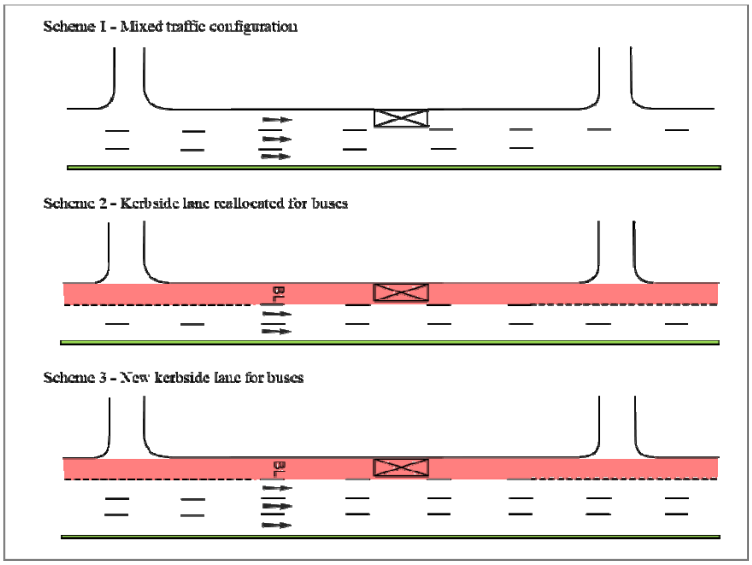
Traffic Micro Simulation (TMS) is now a common tool for road traffic engineering including bus (tram) priority



Source: Goh K, Currie G, Sarvi M and Logan D (2014) 'Experimental Micro-Simulation Modelling of Road Safety Impacts of Bus Priority' TRANSPORTATION RESEARCH RECORD, Volume 2402 / Truck and Bus Safety; Roundabouts 2014, pp 9-14

Monash has been developing SSM/TMS as an experimental tool to explore bus priority and safety using DRAC/CPI metrics

- Surrogate Safety Measures (SSM) in Traffic Micro-Simulation Modelling:
  - DRAC - deceleration rate to avoid the crash
  - CPI – crash potential index
  - Can be used to relate accident risk in traffic
- AIMSUN model adopted to test following configurations >>>>>



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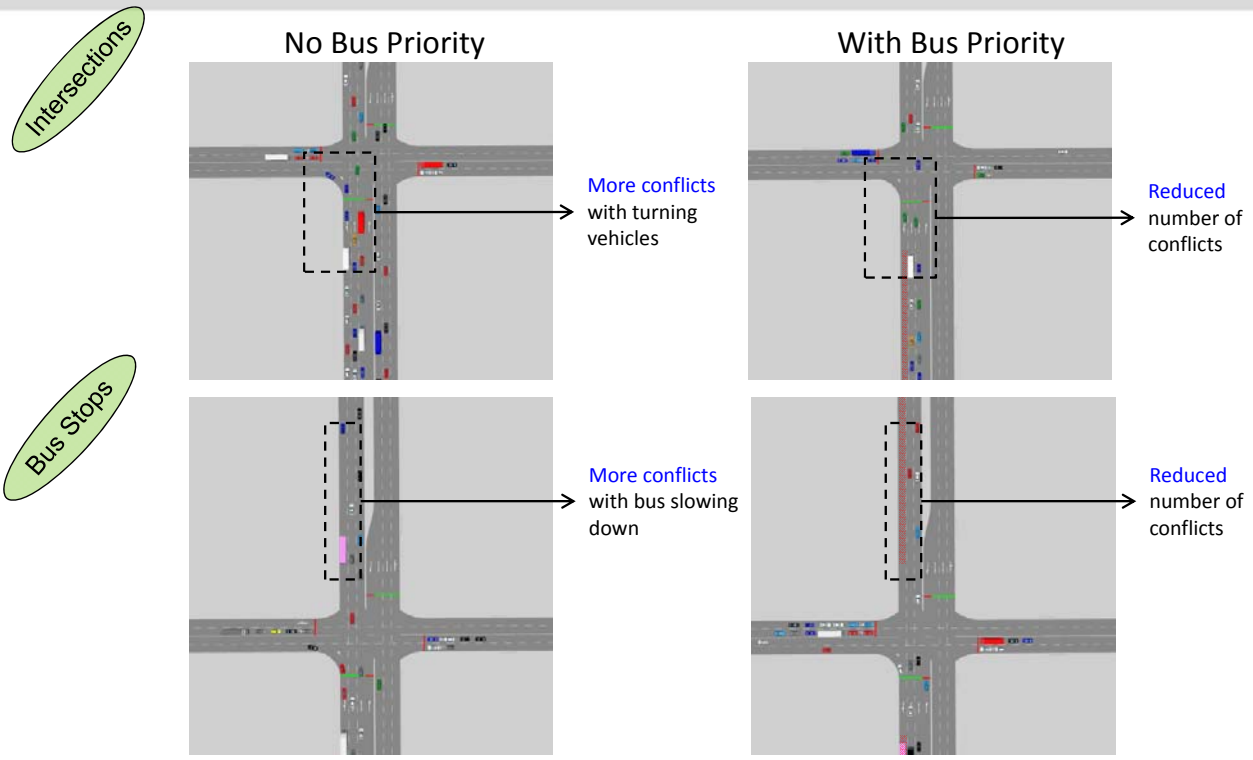
Bus Priority Scheme Effect - Results



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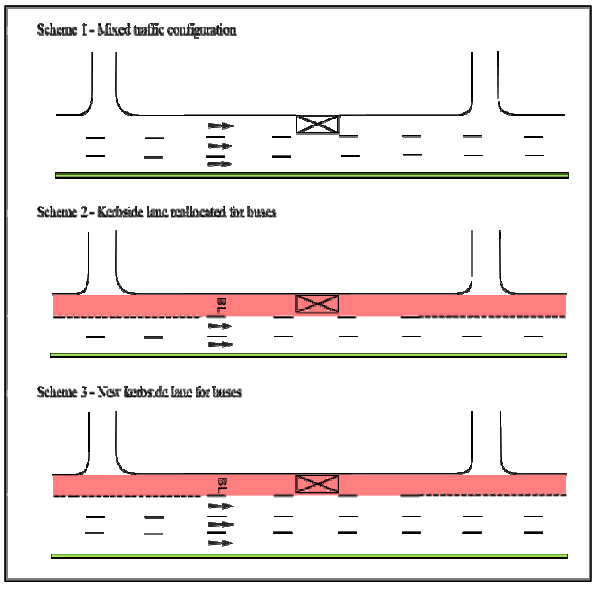
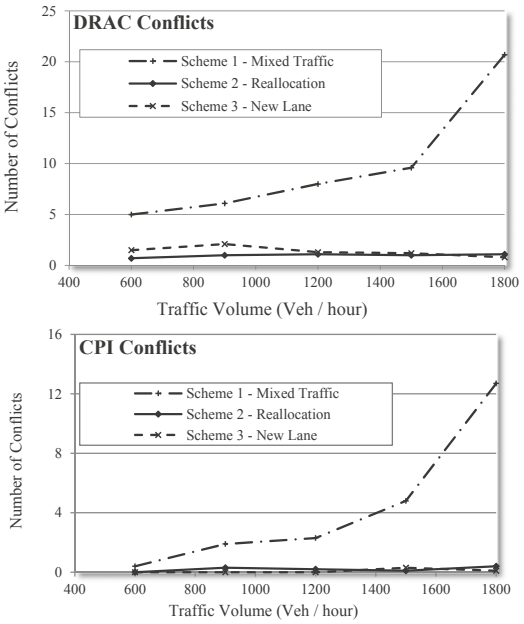
Bus priority schemes 2/3 have less conflicts at intersections…

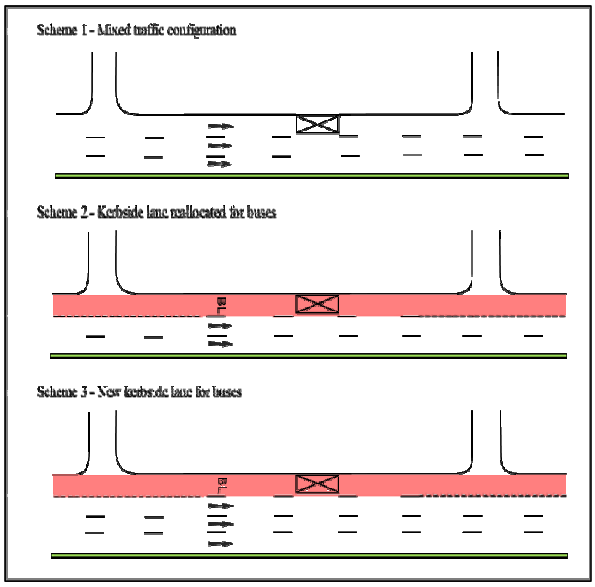


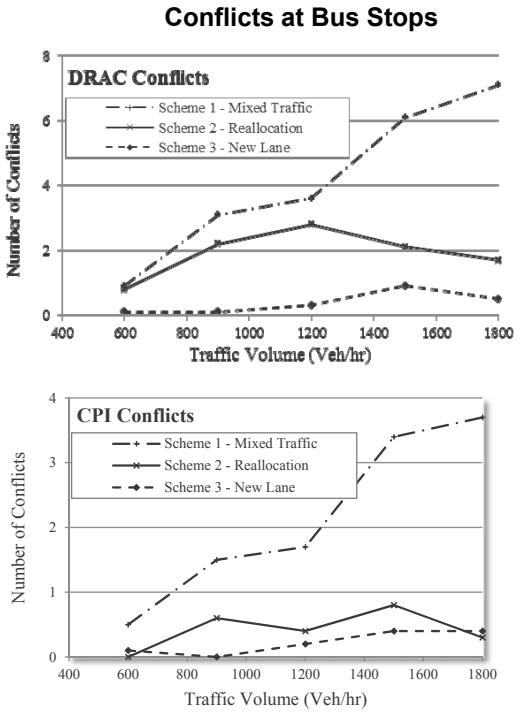
Conflicts at intersections



Source: Goh K, Currie G, Sarvi M and Logan D (2014) 'Experimental Micro-Simulation Modelling of Road Safety Impacts of Bus Priority' TRANSPORTATION RESEARCH RECORD, Volume 2402 / Truck and Bus Safety; Roundabouts 2014, pp 9-14

…and at bus stops; scheme 3 has less conflicts than 2





Source: Goh K, Currie G, Sarvi M and Logan D (2014) 'Experimental Micro-Simulation Modelling of Road Safety Impacts of Bus Priority' TRANSPORTATION RESEARCH RECORD, Volume 2402 / Truck and Bus Safety; Roundabouts 2014, pp 9-14

Introduction

Bus Priority

Tram Priority

Next Steps

Tram Priority

Tram Crash Risk

Traffic Effects?

Tram Stops

Tram Drivers

There are about 3 crashes involving trams a day; causes are not well understood

- Crash Rates
  - 2009 to 2013 ; 4,482 tram-involved collisions; 1,121 p.a.
- Common crash types are
  - collisions of tram with road vehicles,
  - trams hit person,
  - collisions between trams,
  - trams hit infrastructure
- Research literature
  - factors associated with tram-involved collisions at macro level are still unclear
  - Only 2 other published studies; none consider tram only; none in Melbourne

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

A safety science model (RENB) is applied to 5 years of Yarra Trams Crash Data at 101 tram link route sections …

- Random effects negative binomial model
  - Can account for spatial and temporal variations within observation groups in panel count data structures.
- 5 years of tram-involved crash counts from 7 tram routes in Melbourne which includes 101 tram route sections.
- "Tram Incident Database", Yarra Trams' crash reporting system.

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

…exploring the following predictor variables…

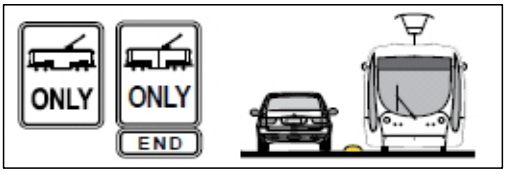
No.	Variables	Min	Max	Average	Stdv.
1.	Traffic volume (AADT) of section	1,100	36,000	9,585	6,001
2.	Section Length (km)	0.1	2.45	0.89	0.61
3.	Service frequency (Number of trams/week)	517	911	671.62	125
4.	Average Speed (Km/hr)	15	17	15.85	0.64
5.	Stop Spacing (km/stop)	0	0.61	0.25	0.09
6.	Platform stop ratio	0	1	0.33	0.42
7.	Presence of tram lane priority (yes= 1, no =0)	0	1	0.62	0.49
8.	Ratio of intersections with tram signal priority	0	1	0.44	0.41

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

...including Lane Priority...

Tram Priority measures explored

Priority type	Forms of priority
Lane Priority	Tramway, Full Time Tram Lane, Part Time Tram Lane,
Signal Priority	Tram Phase 'T', Green Extension, Early Green, Hook Turn, Turn Ban
Stop Priority	Platform tram stops



Tram Lane Priority

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

... Signal Priority...

Tram Priority measures explored

Priority type	Forms of priority
Lane Priority	Tramway, Full Time Tram Lane, Part Time Tram Lane,
Signal Priority	Tram Phase 'T', Green Extension, Early Green, Hook Turn, Turn Ban
Stop Priority	Platform tram stops

"T" Light

Hook Turn


Turn Ban

Tram Signal Priority

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

…and Stop Priority…

Tram Priority measures explored

Priority type	Forms of priority
Lane Priority	Tramway, Full Time Tram Lane, Part Time Tram Lane,
Signal Priority	Tram Phase 'T', Green Extension, Early Green, Hook Turn, Turn Ban
Stop Priority	Platform tram stops

Platform Tram Stops

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

Results show risk factors are; shorter stop spacing, less signal priority, lack of land priority

Results

Variable	Estimated value	P-value
Intercept	-1.92	0.035
Ln(AADT)	0.17	0.026
Ln(Section Length)	0.31	0.000
Services per week	0.004	0.000
Average Speed	0.09	0.036
Stop Spacing	-0.43	0.038
Platform stop ratio	-0.09	0.043
Tram lane priority (yes=1)	-0.148	0.032
Proportion of tram signal prioritised intersection	-0.263	0.015

Source: Naznin F, Currie G, Logan D and Sarvi M (2016) 'Application of a Random Effects Negative Binomial Model to Examine Tram-Involved Crash Frequency on Route Sections in Melbourne, Australia' ACCIDENT ANALYSIS AND PREVENTION Volume 92, July 2016, Pages 15-21

Tram Priority

Tram Crash Risk

Traffic Effects?

Tram Stops

Tram Drivers

Aim is to explore simple before/after impacts of priority implementation then apply a safety science method; empirical bayes…

Approaches

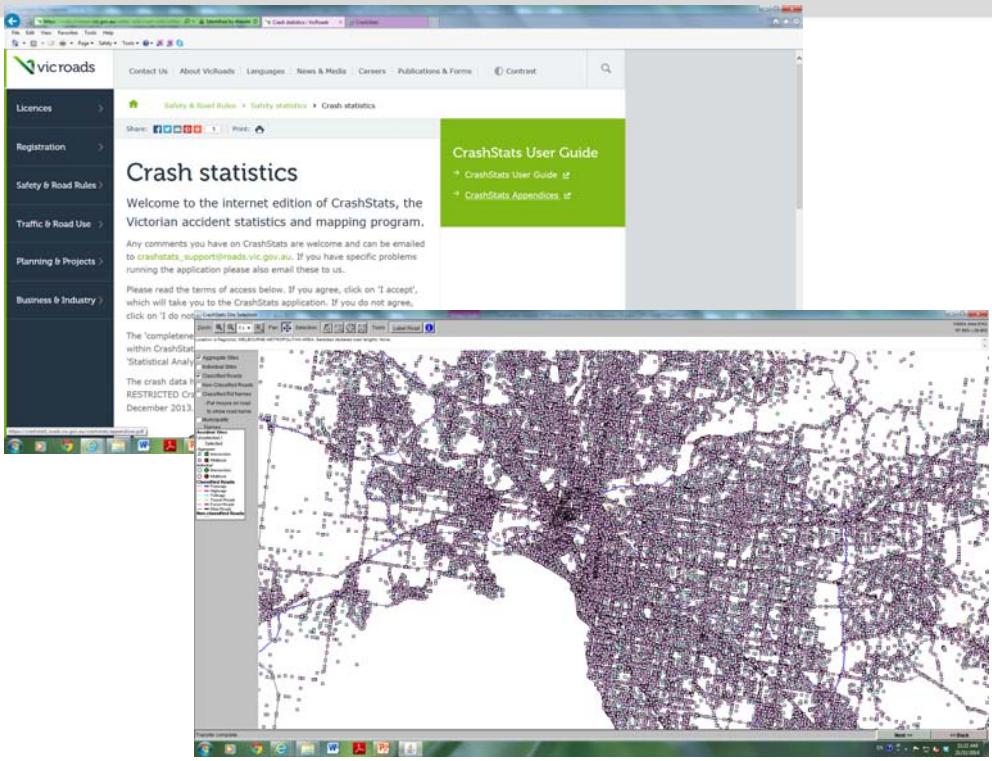
Simple before-after analysis	The Empirical Bayes (EB) before-after analysis (Highway Safety Manual, 2010)
Aggregate Level	Aggregate Level
Disaggregate Level (Following DCA codes)	

Key Features of the Empirical Bayes method

- Consider influencing factors which can effect crash occurrence except treatment.
- Can allow wider trends in crash counts.
- Correct Regression-to-the-mean (RTM) effect
- More accurate estimates of safety impacts

Source: Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97

...using 5/2 years CrashStats data...



Crash data:

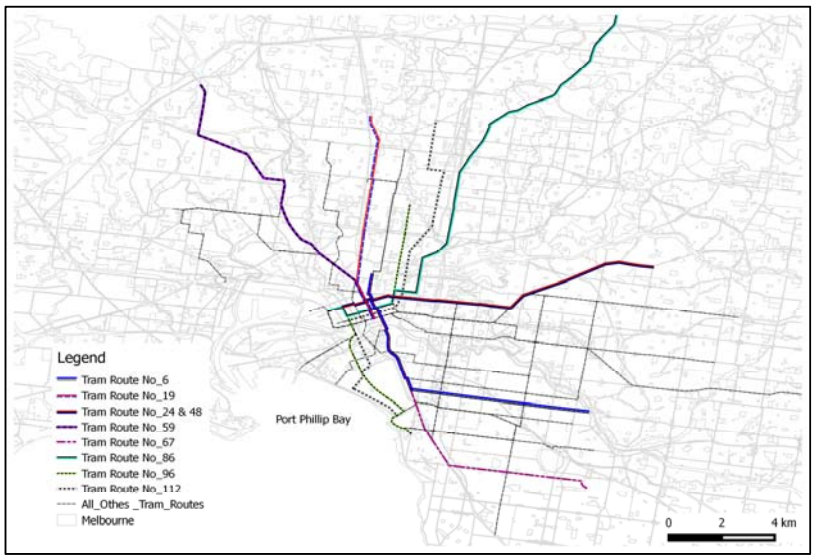
- CrashStats
- Before Period: 5 years
- After Period: 2 Years

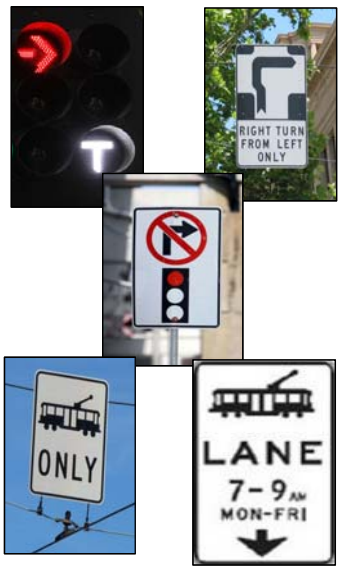
Source: Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97

...on 8 tram routes; 52 priority locations...

Priority Locations:

- Selected Priority Route Number: 6, 19, 24, 59, 67, 86, 96, 112 (Total 8 tram routes)
- Priority Types: Intersection (29 positions) and Lane (23 road sections)



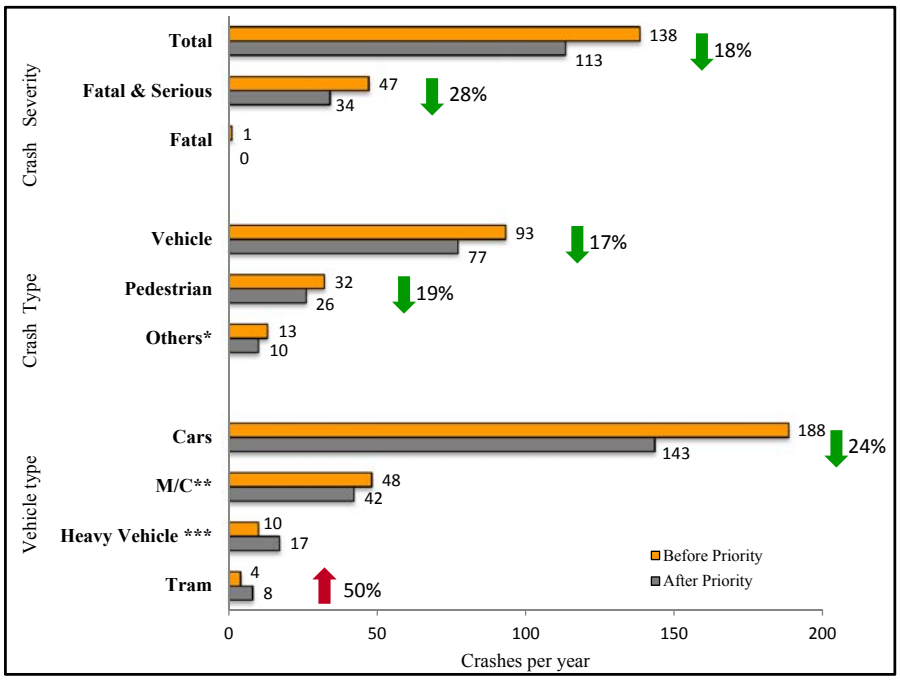


Source: Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97

Aggregate results; -18% all crashes, -24% FSC; ped crash -19%, car -24%. Tram involved crashes increase

Results

Simple Before-After Analysis (Aggregate Level) (an Average one *year before/after priority implementation)*



Key Results

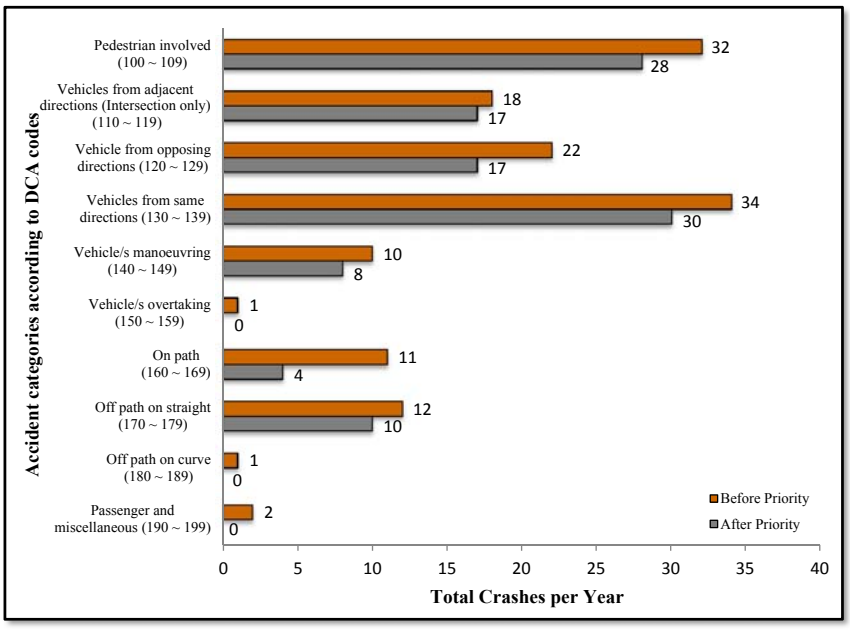
- **-25 (-18%)** All crashes
- **-13 (-24%)** Fatal and Serious crashes
- Total and Fatal & Serious crash reductions are significant by 95% Significant when the **Wilcoxon Signed Rank test** was used
- **-16 (-17%)** Vehicle-involved crashes
- **-6 (-19%)** Pedestrian-involved crashes
- **-45 (-24%)** Car-involved crashes
- 50% increase in tram involved collisions

Source: Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97

Disaggregate results; -64% on path crashes, -23% opposing direction crashes, -20% vehicle manoeuvring crashes

Results

Simple Before-After Analysis (Disaggregate Level) following 'DCA' code by Austroads (an Average one year before/after priority implementation)



Key Results

- **-7 (-64%)** Types 160 to 169- on path crashes
- **-5 (-23%)** Types 120 to 129- Vehicle from opposing directions
- **-4 (-13%)** Types 100 to 109- Pedestrian involved
- **-2 (-20%)** Type 140 to 149- Vehicle/s maneuvring
- **-4 (-12%)** Type 130 to 139- Vehicles from same directions

Source: Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97

Overall EB result; Tram Priority reduces crash risk by 16.4%; lane priority - 19.4% and signal priority 13.9%

The Empirical Bayes Before-After Analysis

Parameters	Type of treatment		
	Signal Treatment	Lane Treatment	Overall
Number of locations	29	23	52
Total observed crash counts in the 'after' period	125	101	226
Total expected crash counts in the 'after' period	145	125	270
Adjusted Odd Ratio (OR)	0.861	0.806	0.836
Standard Error of OR	0.082	0.091	0.061
OR (95% confidence interval)	0.699 ~ 1.022	0.628 ~ 0.984	0.716 ~ 0.956
SAFETY EFFECTIVENESS	**+13.9%**	**+19.4%***	**+16.4%***
** Significant at 95% level*			

Key Results

- **Positive safety effect** of tram priority measures by 16.4%
- **Lane priority** yielded **more positive** safety impacts (19.4%) compared to **signal Priority** (13.9%)

Source: Naznin F Currie G Sarvi M and Logan D (2016) 'An empirical bayes safety evaluation of tram/streetcar signal and lane priority measures in Melbourne;' TRAFFIC INJURY AND PREVENTION Traffic Injury Prevention , 17 (1) pp. 91 - 97

Tram Priority

Tram Crash Risk

Traffic Effects?

Tram Stops

Tram Drivers

What happens to pedestrian safety when…

- to better evaluate pedestrian safety at platform stops through the adoption of a more advanced before–after crash analysis method, the comparison group (CG)method.
- In addition, a modified crash analysis will be conducted to consider differences in passenger volume between new and older design stops, aiming to test the effect of passenger exposure on safety impacts.

Source: Naznin, F., Currie, G., Logan, D., Sarvi, M (2016) 'Safety impacts of platform tram stops on pedestrians in mixed traffic operation: A comparison group before-after crash study' ACCIDENT ANALYSIS AND PREVENTION ,86 pp. 1 - 8

…safety zones are converted to platform stops

Source: Naznin, F., Currie, G., Logan, D., Sarvi, M (2016) 'Safety impacts of platform tram stops on pedestrians in mixed traffic operation: A comparison group before-after crash study' ACCIDENT ANALYSIS AND PREVENTION ,86 pp. 1 - 8

Fig. 1. Old and new tram stops in Melbourne at Spencer street and Collins Street, respectively: (a) a distinctive yellow 'safety zone' traffic island sign at safety zone stop, (b) wide and safe platforms for passengers at platform stop, (c) safety zone stop with narrow waiting area, (d) zebra crossing for pedestrian at the end of platform stop, (e) typical layout of safety zone stop with gap in metal barriers, and (f) platform stops with narrow side traffic lane and on-street parking near platforms.

A treatment/control site method is adopted…crash rates all show decline

Treatment /Comparison Group Stops

Table 2
Descriptive statistics of crash counts, AADT and pedestrian volume for treatment and comparison groups.

Sites	Parameters	Before	After	% Change
Treatment group	Pedestrian-involved all injury crashes per year	17	8	−52.9%
	Pedestrian-involved FSI crashes per year	7	3	−57.1%
	Average AADT per site	14,907	13,600	−8.76%
	Average passenger volume per site per week (2011)	34,503		
Comparison group	Pedestrian-involved all injury crashes	14	12	−14.3%
	Pedestrian-involved FSI crashes	6	4	−33.33%
	Average AADT per site	16,044	14,348	−10.57%
	Average passenger volume per site per week (2011)	26,678		

Source: Naznin, F., Currie, G., Logan, D., Sarvi, M (2016) 'Safety impacts of platform tram stops on pedestrians in mixed traffic operation: A comparison group before-after crash study' ACCIDENT ANALYSIS AND PREVENTION ,86 pp. 1 - 8

Conventional CG method suggests a 43% safety effectiveness; an new method adjusted for pax volume growth suggests >80%

Table 4
Results of before–after crash analysis using the CG method.

Crash types	Crash change factor, $\hat{\theta}$	Standard deviation, $\hat{s}_\theta$	Safety effectiveness
Pedestrian-involved all injury crashes	0.571	0.14	+42.9%*
Pedestrian-involved FSI crashes		Outcomes are insignificant at 95% level	

* Significant at the 95% level.

Table 5
Results of the CG before–after crash analysis using the modified crash counts.

Crash types	Parameters		
	Crash changing factor, $\hat{\theta}$	Standard deviation, $\hat{s}_\theta$	Safety effectiveness
Considering passenger increment			
Pedestrian-involved all injury crashes	0.191	0.076	+80.9%*
Pedestrian-involved FSI crashes	0.142	0.063	+85.8%*
Without considering passenger increment			
Pedestrian-involved all injury crashes	0.193	0.075	+80.7%*
Pedestrian-involved FSI crashes	0.159	0.067	+84.1%*

* Significant at the 95% level.

Source: Naznin, F., Currie, G., Logan, D., Sarvi, M (2016) 'Safety impacts of platform tram stops on pedestrians in mixed traffic operation: A comparison group before-after crash study' ACCIDENT ANALYSIS AND PREVENTION ,86 pp. 1 - 8

Tram Priority

Tram Crash Risk

Traffic Effects?

Tram Stops

Tram Drivers

Tram driver focus groups – understand their key challenges and road safety influences; is priority good for road safety

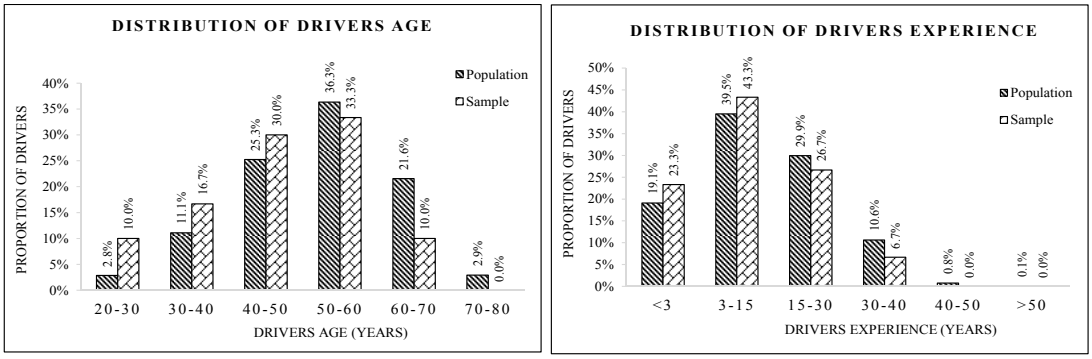


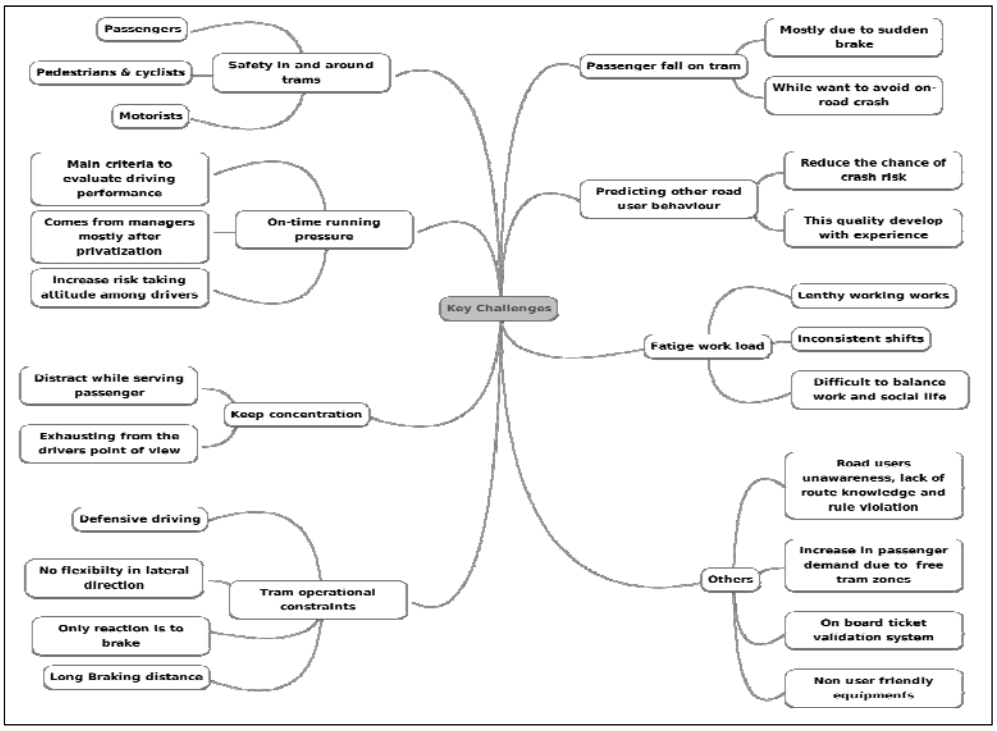
Figure 1 Distribution of Tram drivers' age and years of experience

Table 1: Location and composition of focus group sessions

ID	Number of participants	Gender	Age (years)	Experience (years)	Name of Depot	Mostly driven tram routes
1	6	2 Female, 4 Male	29 - 59	1.17 - 26	Kew	48, 109
2	6	All Male	34 - 56	2 - 20	Southbank	12, 96
3	7	1 Female, 6 Male	29 - 63	2 - 14	Southbank	12, 96
4	7	1 Female, 6 Male	30 - 57	2.5 - 31	Preston	11, 86
5	4	All Male	49 - 62	3 - 31	Preston	11, 86

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

Key overall challenges as a tram driver (unprompted) ; safety was identified as the no.1 challenge



Driver Quotes

The generic answer is to keep everyone safe as much as possible in and around the tram….you just can't take your eyes from the road for a second….. Even a split second.

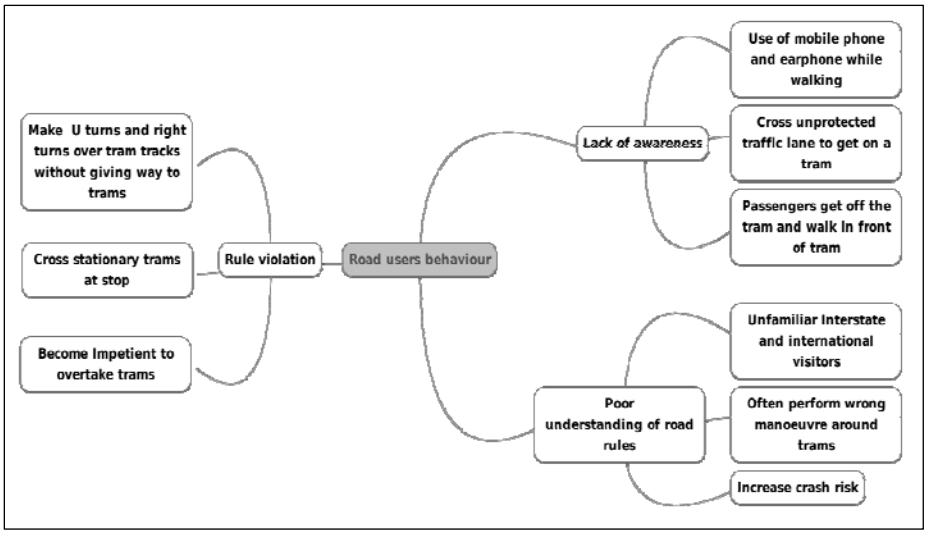
(Tram driver age 34/ 7 years experience)

Whichever angle you look safety comes first anyway.

(Tram driver - age 62/ 28 years experience)

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

Key safety concern driving trams; other road user behaviour and road rule violation



Driver Quotes

The biggest problem we have now is everyone walking the street, crossing the road with ear phones. Today I had two near misses. It is a continuous thing. They are not looking and crossing the street. If we are not alert we will be killing people every day. .

(Tram driver age 62/ 28 years experience)

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

What tram route sections are safer?

"There are no safe route sections"

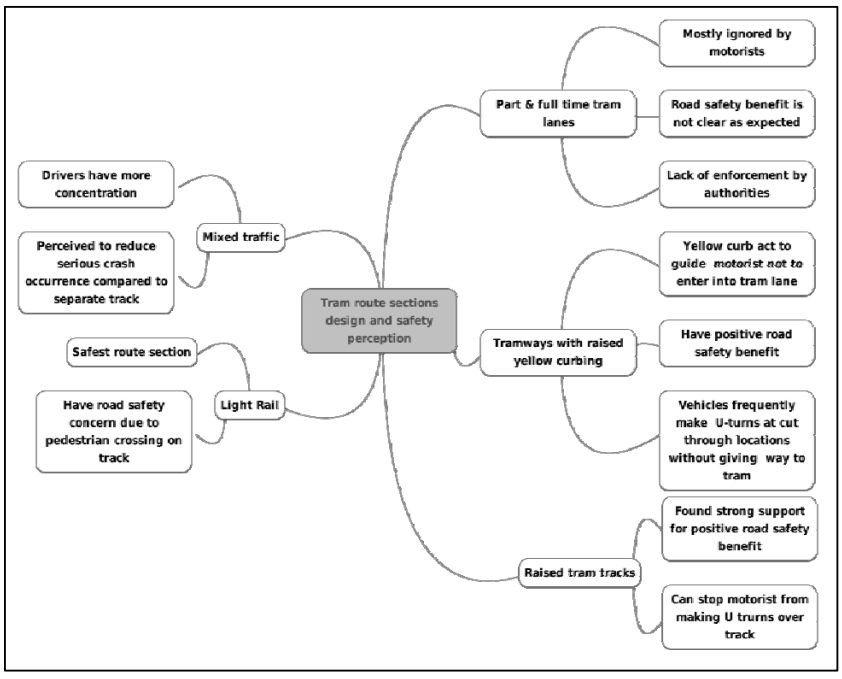
Driver Quotes

There is not such a thing ….this part is safe and this part is unsafe. No no...If we start thinking like that we are in trouble. For us as a tram driver every part of our route is unsafe. We have to think like that. Otherwise ……. you hit someone

(Tram driver age 59/ 26 years experience)

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

What is your view on safety for alternative types of tram route sections



Driver Quotes

One frustration I have is we do have part time tram lanes on some or probably most of the routes in Melbourne during peak hours. There is virtually no compliance

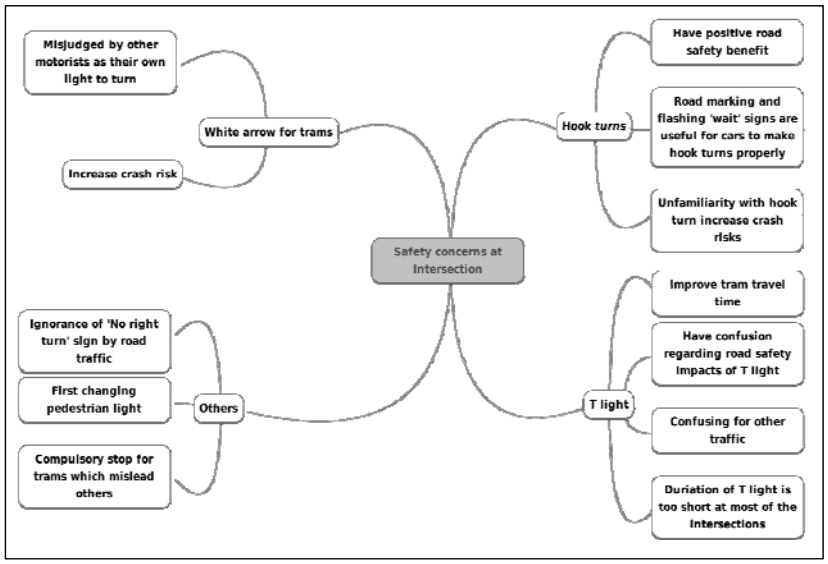
(Tram driver age 36/ 12 years experience)

I give that a tick, the raised yellow curb, it's good. I think people feel it when they (drivers of cars) go over it.

(Tram driver - age 48/ 6 years experience)

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

What is your view on safety for alternative types of tram intersections



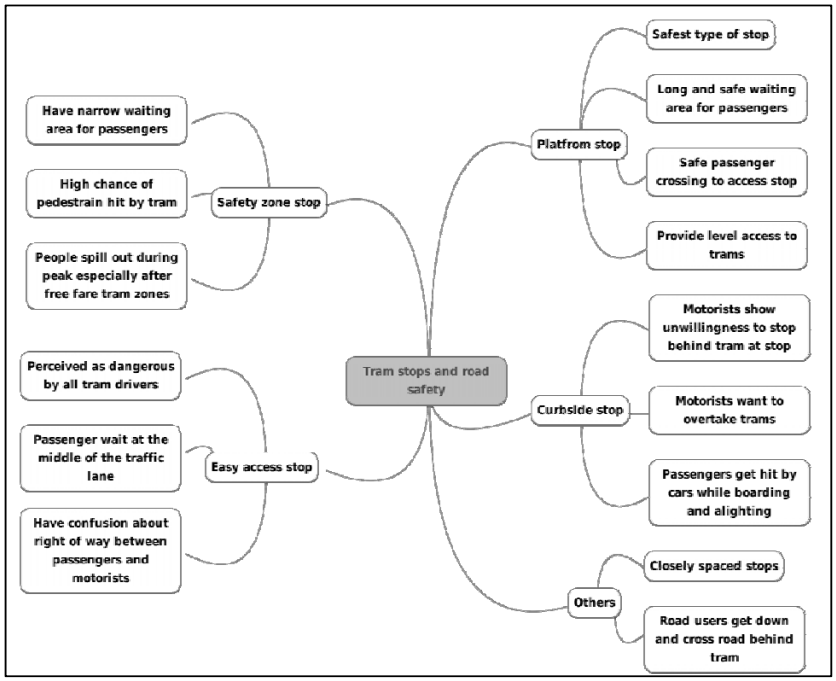
Driver Quotes

One thing is that we get white arrow and white T. I don't believe we should get white arrow. Because too many car drivers misconstrued the arrow for them to turn. ……when they see a white arrow and they don't know whether the light faded or not green anymore and attempted to go. It happens all the time. *(Tram driver age 55/ 2 years experience)*

Hook turn is fantastic. Nothing goes wrong with hook turn. So far I never see any driver come to me and said that I have problem. *(Tram driver - age 59/ 26 years experience)*

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

What is your view on safety for alternative types of tram stops



Driver Quotes

I think too many trams stops close together. It's probably what frustrates road users…. If they reduce the number of stops, the traffic gonna flow. The trams given priority as well, obviously the trams keep going. The other road users are not going to get frustrated with us because we are not stopping so often.

(Tram driver - age 30/ 2.5 years experience)

Source: Naznin, F Currie G and Logan D (Under review) 'Exploring the key challenges in tram driving and crash risk factors on the Melbourne tram network: tram driver focus groups' Australasian Transport Research Forum 2016

Introduction

Bus Priority

Tram Priority

Next Steps

SEPT-GRIP is one of the largest joint industry-Uni research initiatives in the world

Sustainable and Effective Public Transport – Graduate Research Industry Program

PUBLIC TRANSPORT VICTORIA PT>

PTRG PUBLIC TRANSPORT RESEARCH GROUP

PTRG SEPT-GRIP
(Graduate Research Interdisciplinary Program)

- 18 PhD students
- 6 Faculties plus MUARC

- **World First joint Authority/Uni. Research and Training Initiative**
- **Started March 1st 2015 for 5 years; then continues subject to review**
- **$ 2.5M PTV funding including 4 PhD scholarships**
- **Plus $2M funding Monash and $0.5M Other Industry; $5M total**

There are 18 topics…

1. **Land Use & PT**
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
9. **Future Train** — Lisa Fu
10. **Designing Urban Rail to Reduce Vandalism** — Amy Killen
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** — Luke Valenza
15. **Transit Network Design** — Nora Estgfäller
16. **Future Bus** — Sarah Roberts
17. **The New Bus Rider** — Prudence Blake
18. **Road Safety Impacts of Bus Safety Inspections** — Jianrong Qiu

Sustainable and Effective Public Transport – Graduate Research Industry Program

…with 6 Industry Partners…

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METRO

vicroads

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yarra trams

transdev

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17. **The New Bus Rider** — Prudence Blake
18. **Road Safety Impacts of Bus Safety Inspections** — Jianrong Qiu

BusVic

SEPT-GRIP Project 14. Older Passengers and Falls in Trams

Sangeeta Singh

Student 14

Luke Valenza

Associate Professor Judith Charlton

Associate Director, Behavioural Science for Transport Safety, Monash University Accident Research Centre

Project Outline

Trams have superior ride quality to buses and can also accelerate and decelerate at a quicker rate. This and the frequent need for braking due to traffic interference has been one of the many causal factors said to have generated increasing rates of passenger falls within trams. This a major concern with an aging population and increased use of trams. This project seeks to better understand the extent, conditions and causal influences of incidence of passenger falls in trams by older passengers. Its central aim is to identify and test mitigation strategies to reduce the rates of these incidents and their impact including specific redesign concepts for the interior of trams. This project is paired with project 9 and 16 (which also concern aspects of design for an aging population); these students will work together to identify mitigation strategies for trams.

SEPT-GRIP Project 18. Exploring the Road Safety Impacts of Bus Safety Inspections

Chris Lowe

Student 18

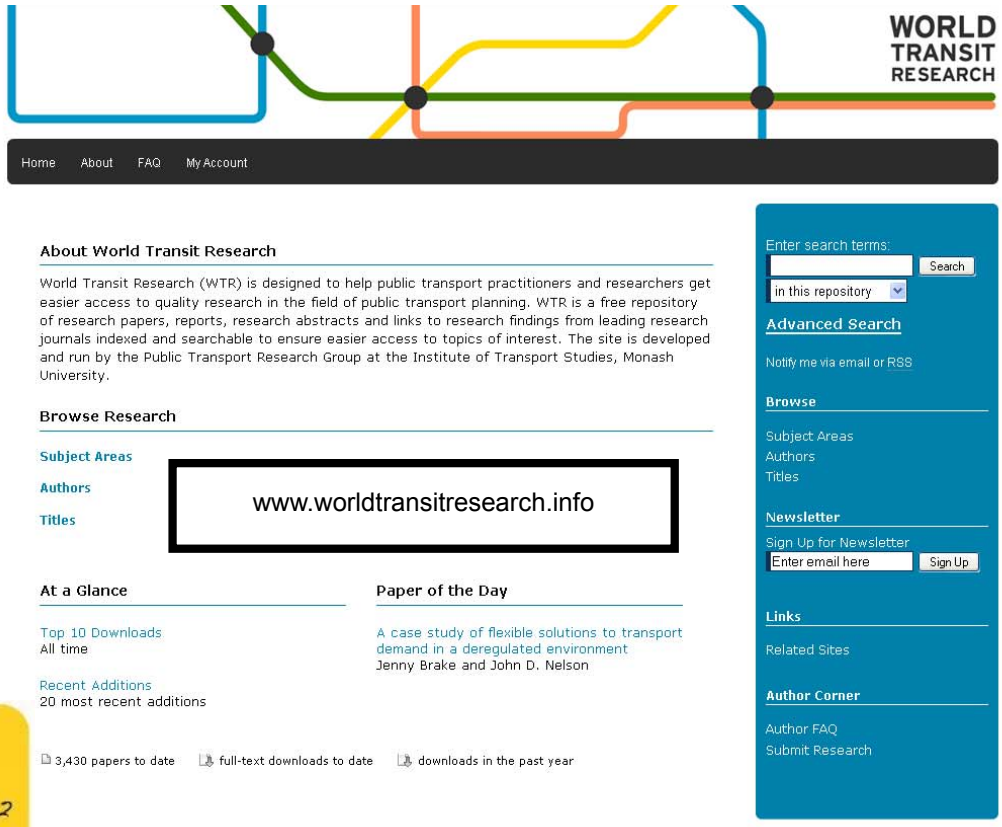
Jianrong Qiu

Dr David Logan

Monash University Accident Research Centre

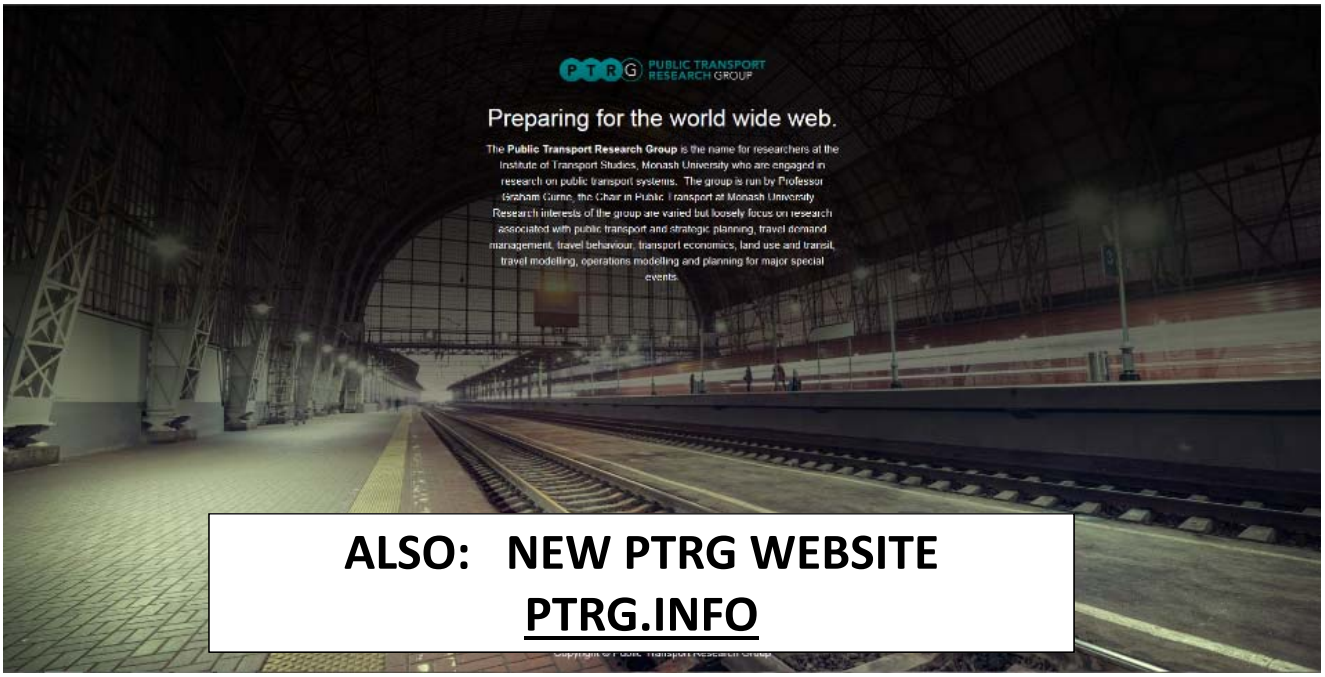
Project Outline

The Victorian bus industry, like other Australian jurisdictions, must meet safety regulation requirements including mandatory bus safety inspections with both annual independent inspections and more regular documented self-inspection processes. This project aims to understand the road safety impacts of these regulatory standards through a review of current crash records and their links to bus safety issues and a comparative analysis of bus safety in other regulatory contexts. The project will contrast bus and coach crash records against those of other transport industries including the Australian truck and heavy vehicle industry who do not have mandatory independent safety inspection regulations. The project will also seek to understand general risk factors for bus crashes to better understand safety standards in the context of other risks. It will also seek to better understand what aspects of safety inspections are having greater impacts on road safety than others.



2025=PTx2

Showcase Award Winner



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