Towards Safe System Infrastructure

10 May 2018

Austroads

Today’s moderator

Eliz Esteban
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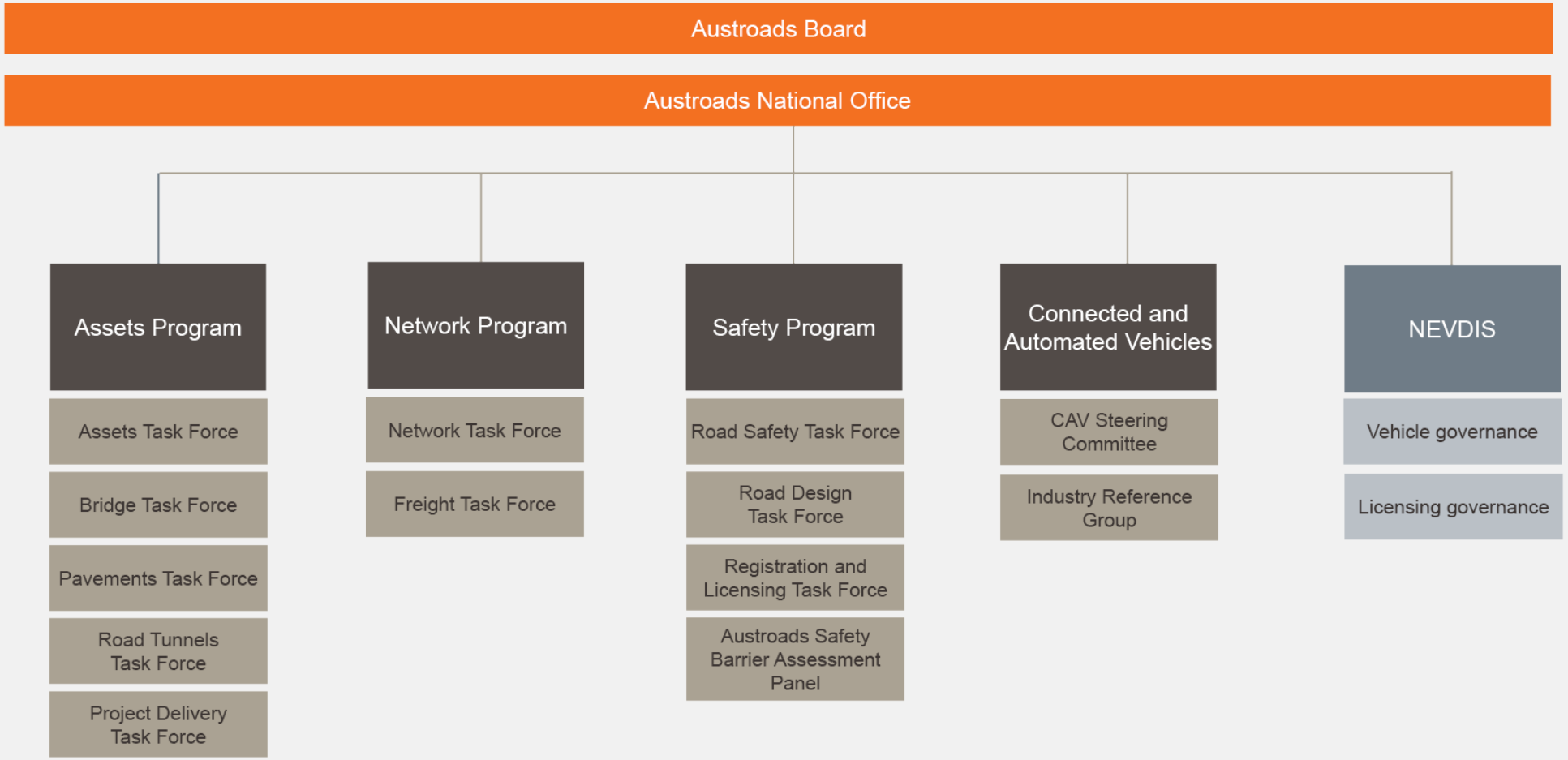
About Austroads

The peak organisation of Australasian road transport and traffic agencies

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Department of Transport and Main Roads Queensland
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Transport Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Department of Infrastructure, Regional Development and Cities
- Australian Local Government Association
- New Zealand Transport Agency

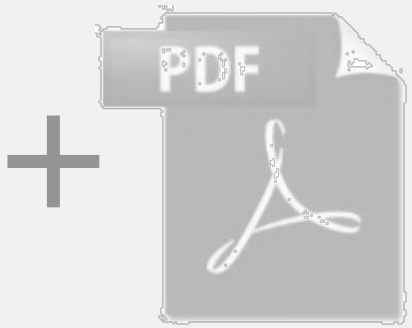
Our structure



Housekeeping

Presentation = 60 mins

Question time = 15 mins



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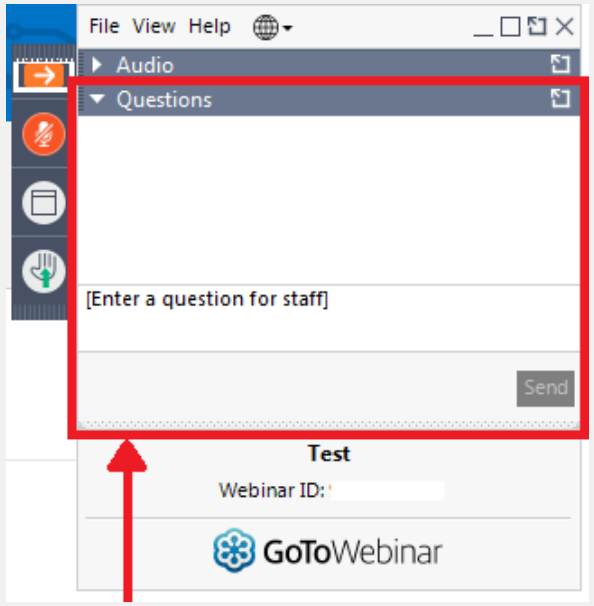
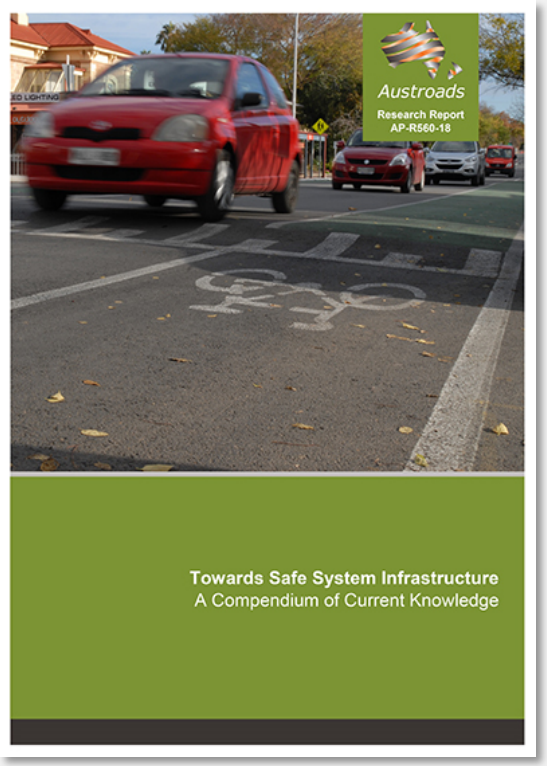


Please type your questions here

Let us know the slide number your question relates to

Austroads report



Download from Austroads Website:

https://www.onlinepublications.austroads.com.au/items/AP-R560-18

Today’s presenters

Dr Blair Turner

National Technical Leader

Australian Road Research Board (ARRB)

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Associate Professor Jeremy Woolley

Director

Centre for Automotive Safety Research (CASR)

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Agenda

Topic	Presenter
Background and Introduction	Blair Turner
The Safe System - Recap	Blair Turner
Overview of New Austroads Compendium	Jeremy Woolley
Safe System Infrastructure Solutions • Roads and Roadsides • Intersections • Speeds • Vulnerable Road Users	Both Presenters
Safe System Tools	Blair Turner
Q&A	Both Presenters

Background and Introduction

Dr Blair Turner

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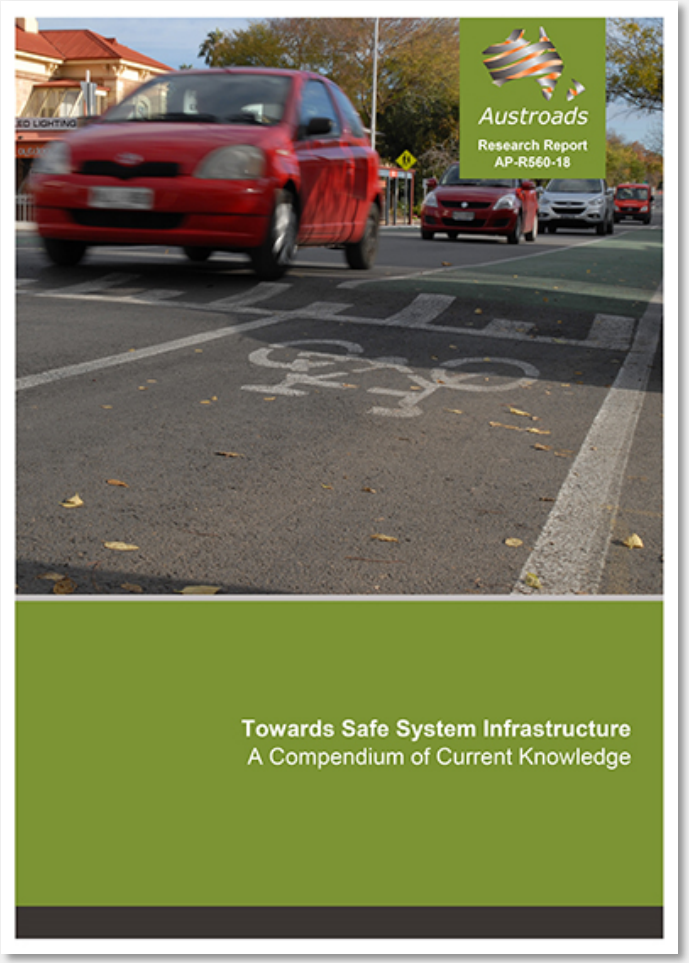
Two Austroads projects

1. Towards Safe System Infrastructure:
   A Compendium of Current Knowledge
2. Safe System Workshops
   - 15 two-day workshops
   - Three one-day workshops



Introduction to team

Project Team

Austroads Project Manager
Colin Brodie
Natalie Lockwood
David Bobbermen

Project Leader
Jeremy Woolley (CASR)
Chris Jurewicz (ARRB)

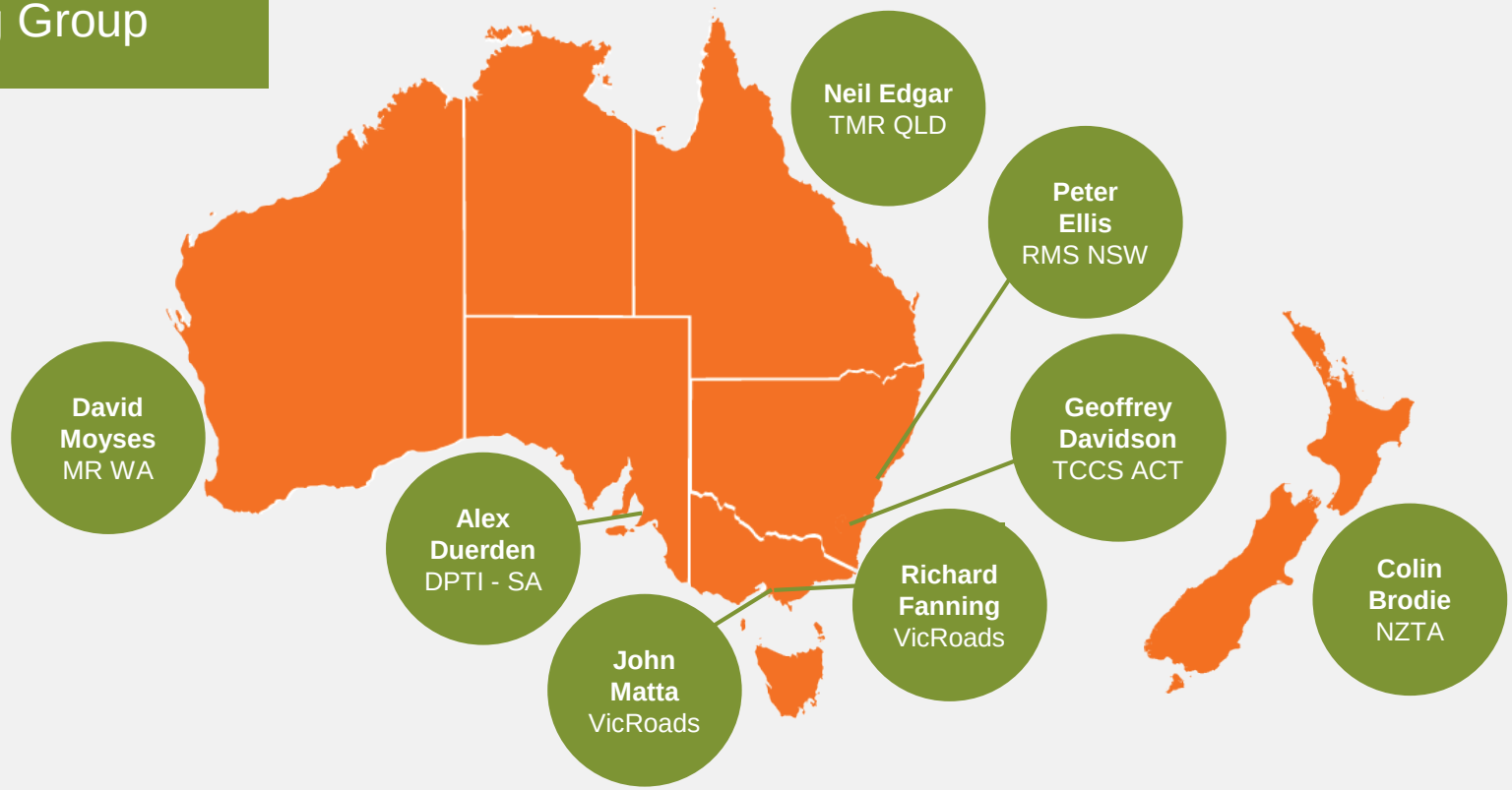
Team Member
Chris Stokes (CASR)
Blair Turner (ARRB)

Review Team

- Austroads Project Steering Group
- Stakeholders- Road and Traffic Authorities
- Austroads Road Safety Task Force
- Austroads Board

The Project Team

Austroads Project Steering Group



The Safe System … in two slides

Dr Blair Turner

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The Safe System

See Section 2

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Principles

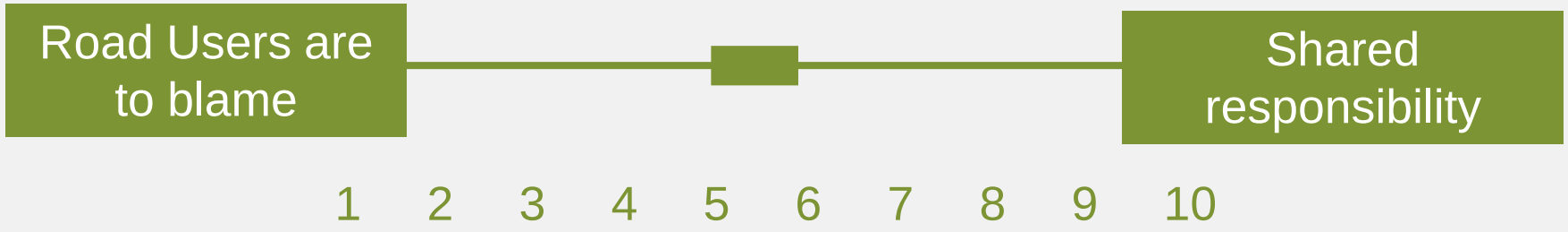
- People make mistakes
- Limited human tolerance to crash forces
- Shared responsibility
- Solutions can be found across all pillars

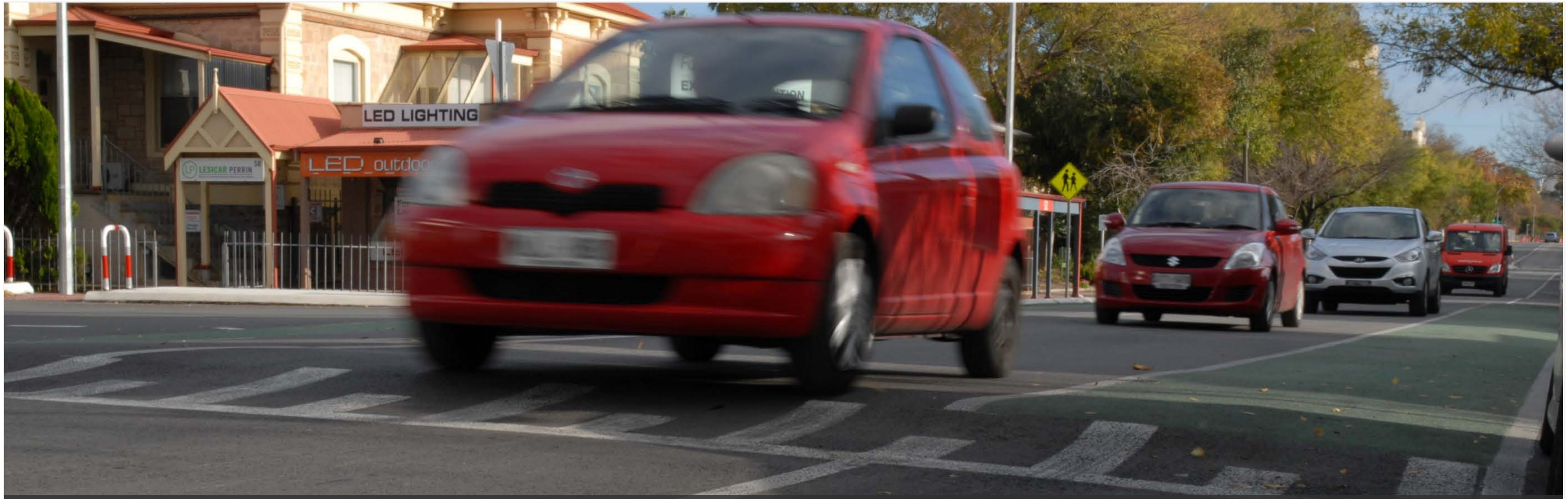
Other elements

- Proactive approach
- Focus on fatal and serious injuries
- A vision – directs interim strategies

Culture shift where are you on the journey?

Blame road users	➔	Shared responsibility
All crashes	➔	Focus on fatal and serious injury
React to crashes	➔	Proactive identification of risk locations
Individual pillars	➔	System





New Austroads Compendium

Associate Professor Jeremy Woolley

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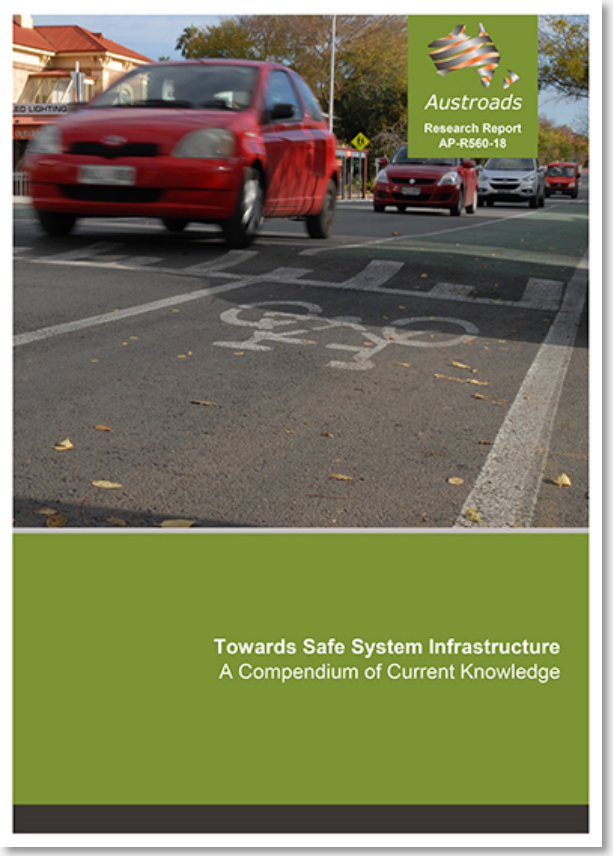
Towards Safe Systems Infrastructure: A Compendium of Knowledge



- A reference document for the latest evidence and commentary
- Aimed at broad range of people including practitioners involved with the planning, design, management and maintenance of the road network; good background information for those in other areas of road safety
- Clarifies practical steps to take things forward

It should be acknowledged that…

See Section 1

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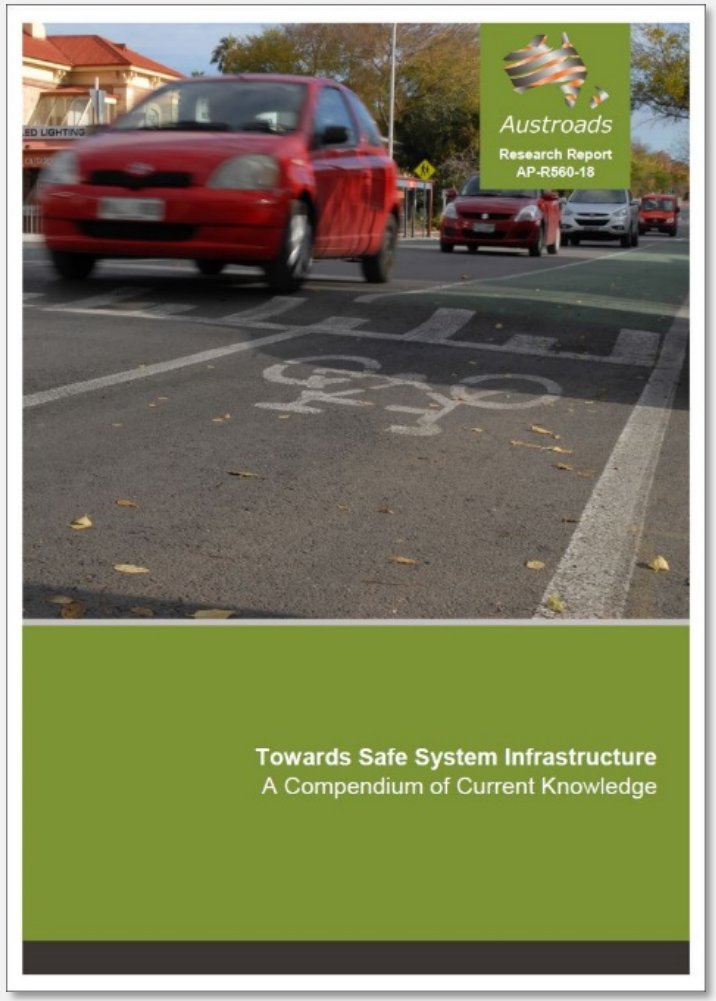
- Knowledge and practice in the area is evolving rapidly
- Must do things differently to the past ➔ innovation is essential
- The focus is on *harm minimisation* - make sure you consider the opportunity to achieve this in your decision processes!
- Infrastructure alone cannot deliver the desired outcomes however there is still not strong alignment to the strengths of vehicle design, human performance or the role of speed and energy in injury outcomes

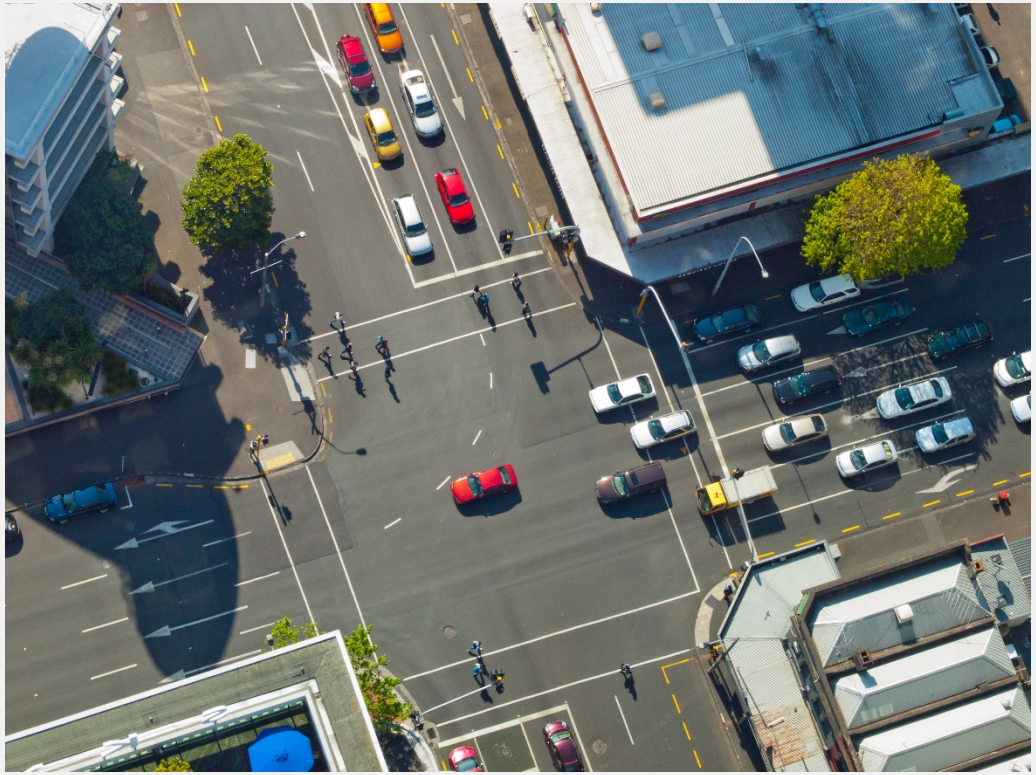
What does the book cover?



It covers

- Introduction
- Safe System explanation
- Influence of the road environment on road user performance
- Role of speed in harm minimisation
- Intersections
- Lane departures
- Specific road user groups (VRUs)
- ITS and CAVs
- Tools and prioritisation approaches
- Resources

Key messages



- Work through a treatment hierarchy
  - Based on ability to eliminate harm
- Consider system redundancy
- Look for differing opportunities to mitigate risk with:
  - Exposure
  - Likelihood
  - Severity

Autonomous vehicles not infrastructure?

See Section 8.2

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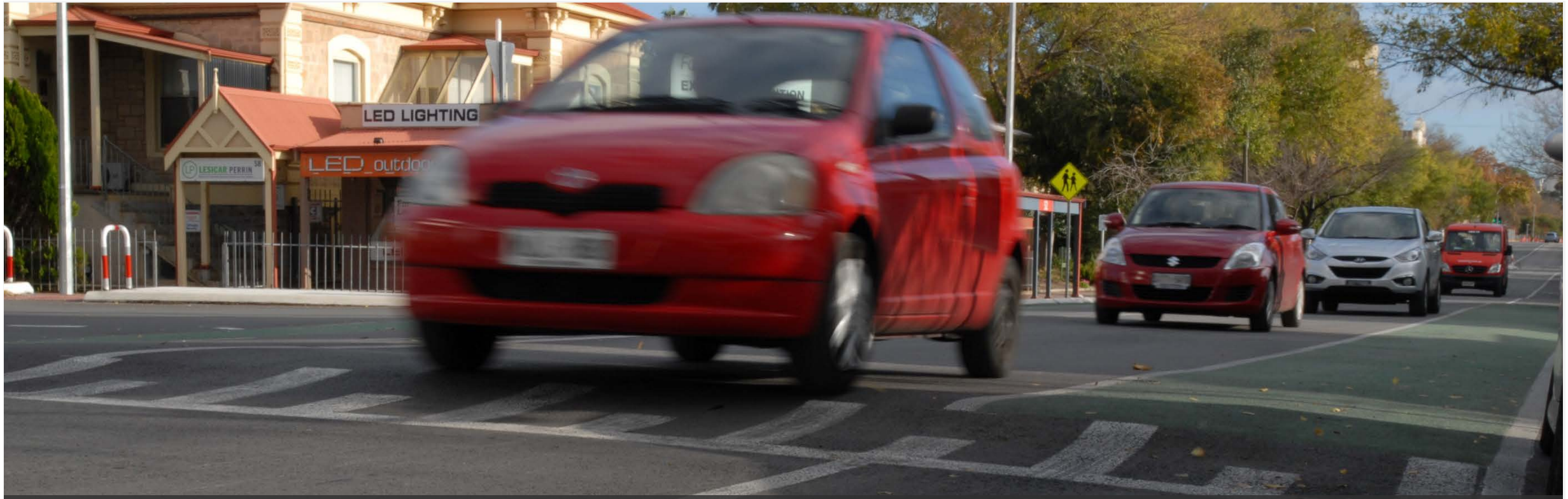
- We need appropriate expectations:
- **Estimates of residual crashes still sit around 30-85% mark**
- Redundancy is required across pillars
- Vehicles need to be able to interpret and interact with roads

Google Street View

Thursday, March 22nd, 2018
(day prior to accident)

Source: https://www.forbes.com/sites/alanohnsman/2018/04/16/tesla-autopilot-fatal-crash-waze-hazard-alerts/#458daec85572



Safe System Infrastructure Solutions: Roads and Roadsides

Associate Professor Jeremy Woolley

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Crashworthiness

Urban 60 km/h

Rural 100 km/h

3.4 times more Kinetic Energy (assuming equal mass)

Source: ANCAP

Crashworthiness

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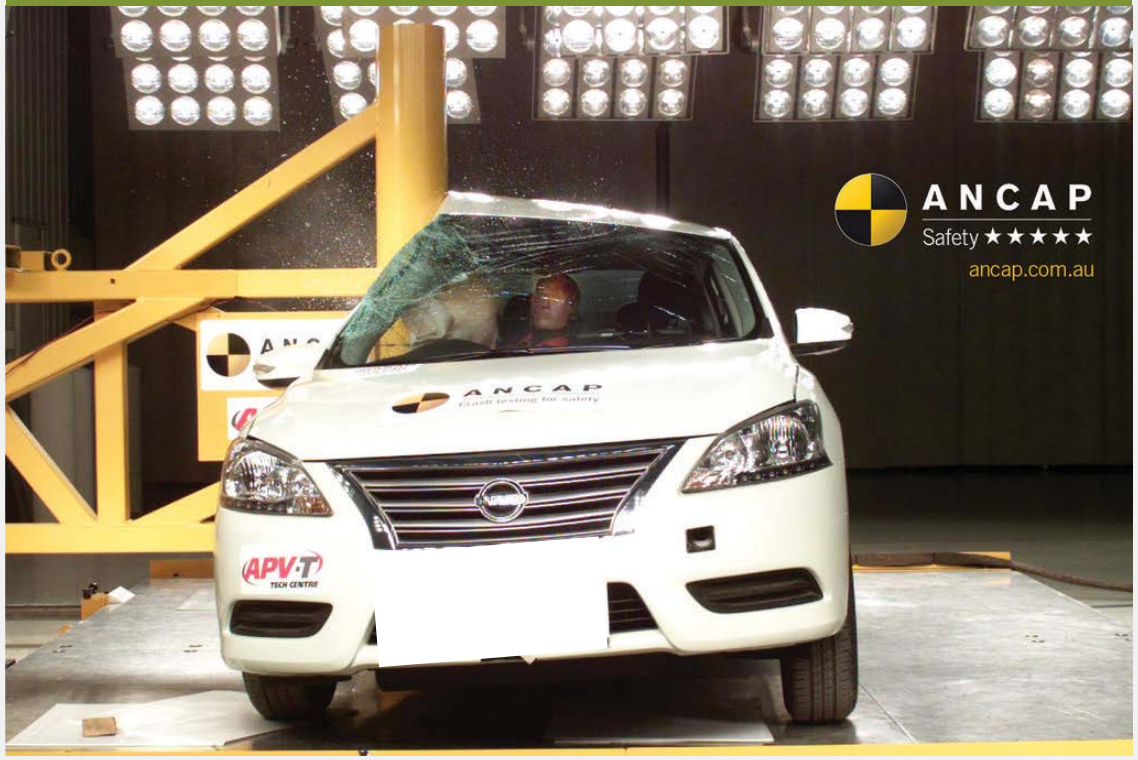
Pole side impact in lab at 29km/h



Source: ANCAP

Pole side impact on 100km/h rural road

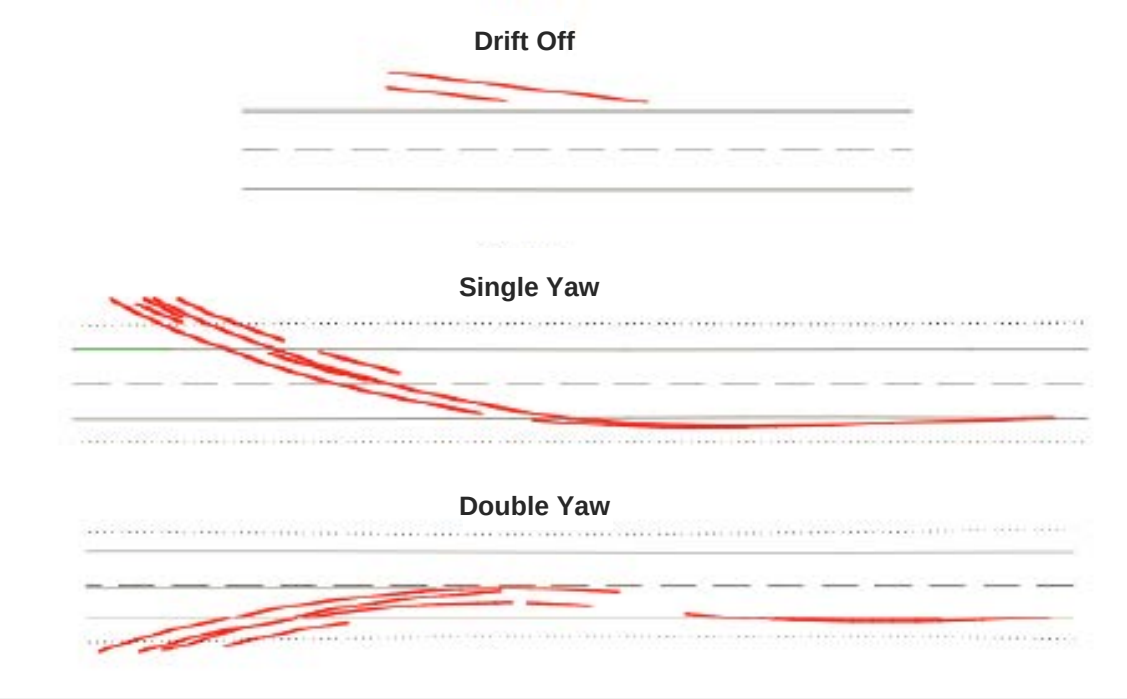
Source: CASR

Where is the redundancy?

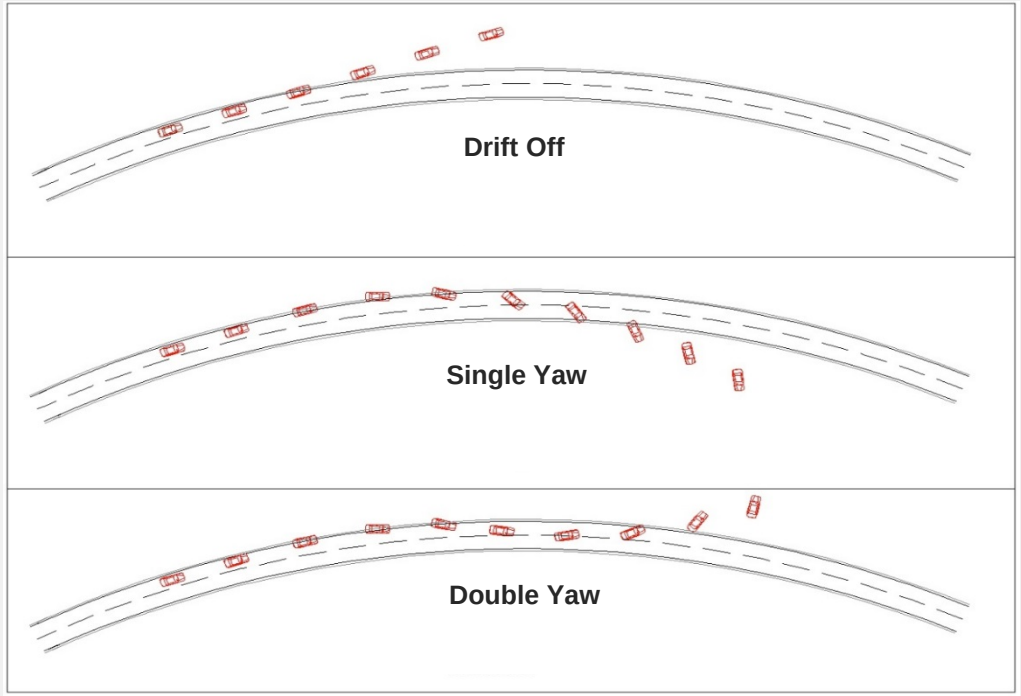
Source: CASR

Road Departure and Head-on Scenarios

Most common types of road departure



Source: Doecke and Woolley 2011

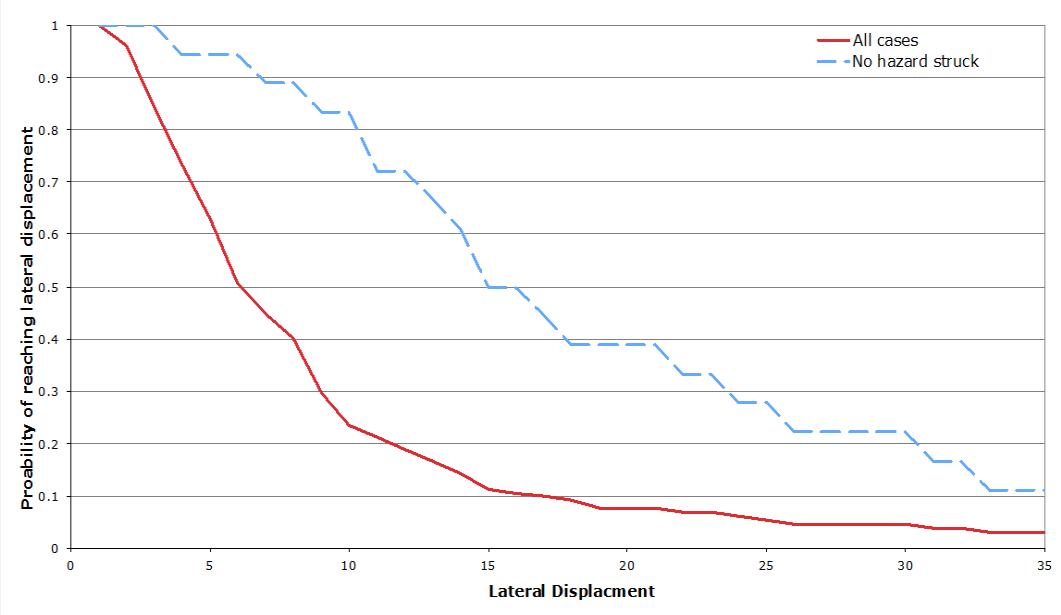


Source: Doecke and Woolley 2012

Lateral Displacements

- Clear zones cannot be relied upon in isolation to achieve Safe System outcomes
- Wide clear zones are often difficult to achieve
- Even wide clear zones do not converge towards zero FSI crashes
- Rollover crashes increase with increasing clear zone width
- Centre barrier can assist with depart right, head-on and depart left crashes involving yaw

Lateral displacement of vehicles after road departure



Source: Doecke and Woolley 2011

Pros and cons of crash barriers types

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Flexible

Semi-rigid

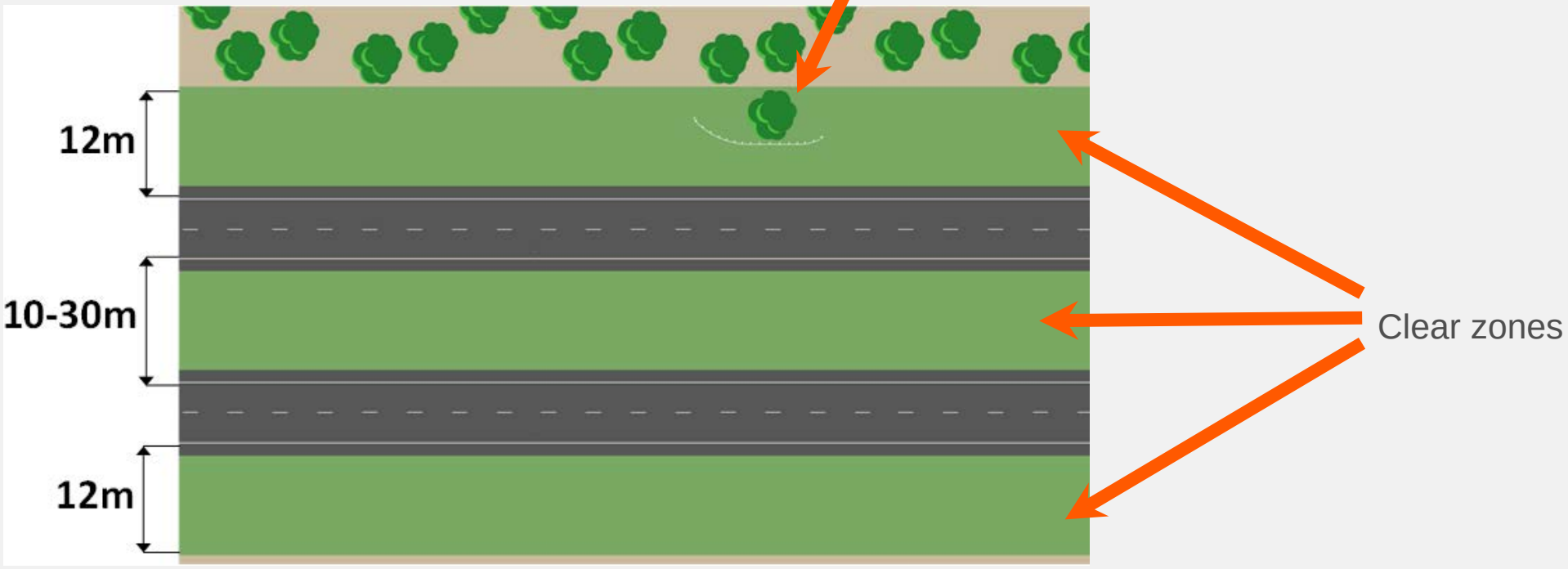
Rigid

Source: CASR and http://www.ingalcivil.com.au/products/road-safety-barriers/guardrail/ezy-guard-smart

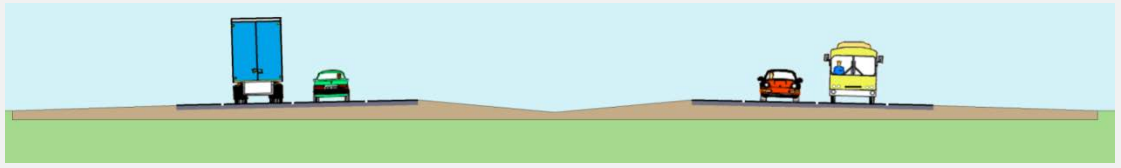
High standard rural roads Historical approach

Clear zones

See Section 6

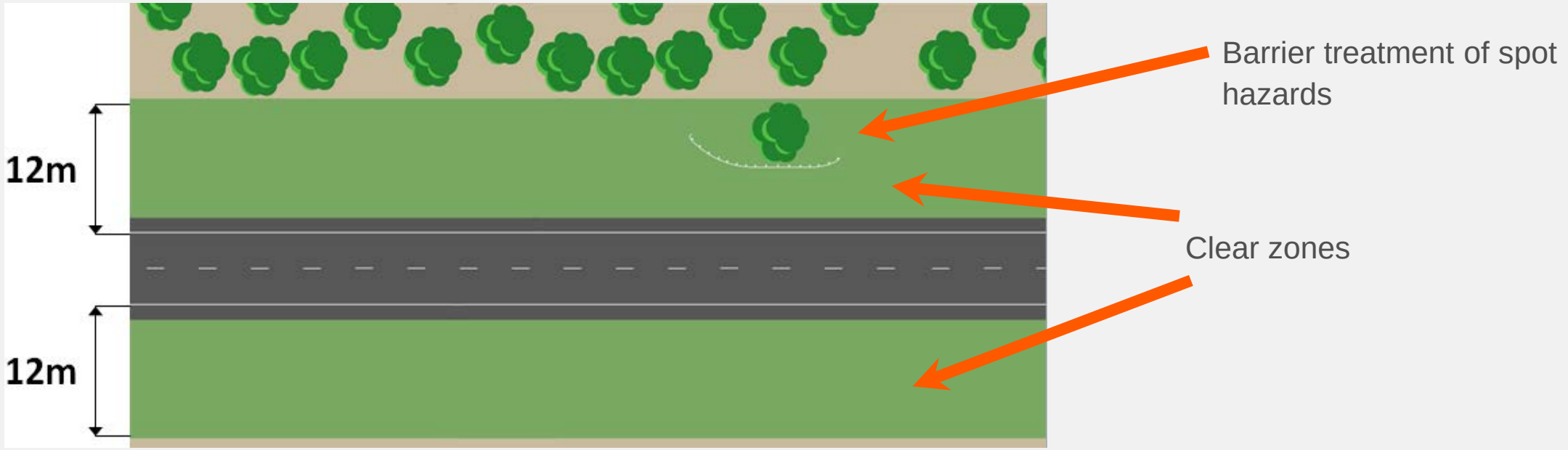


Source: CASR



Rural arterials Historical approach

Historic treatment

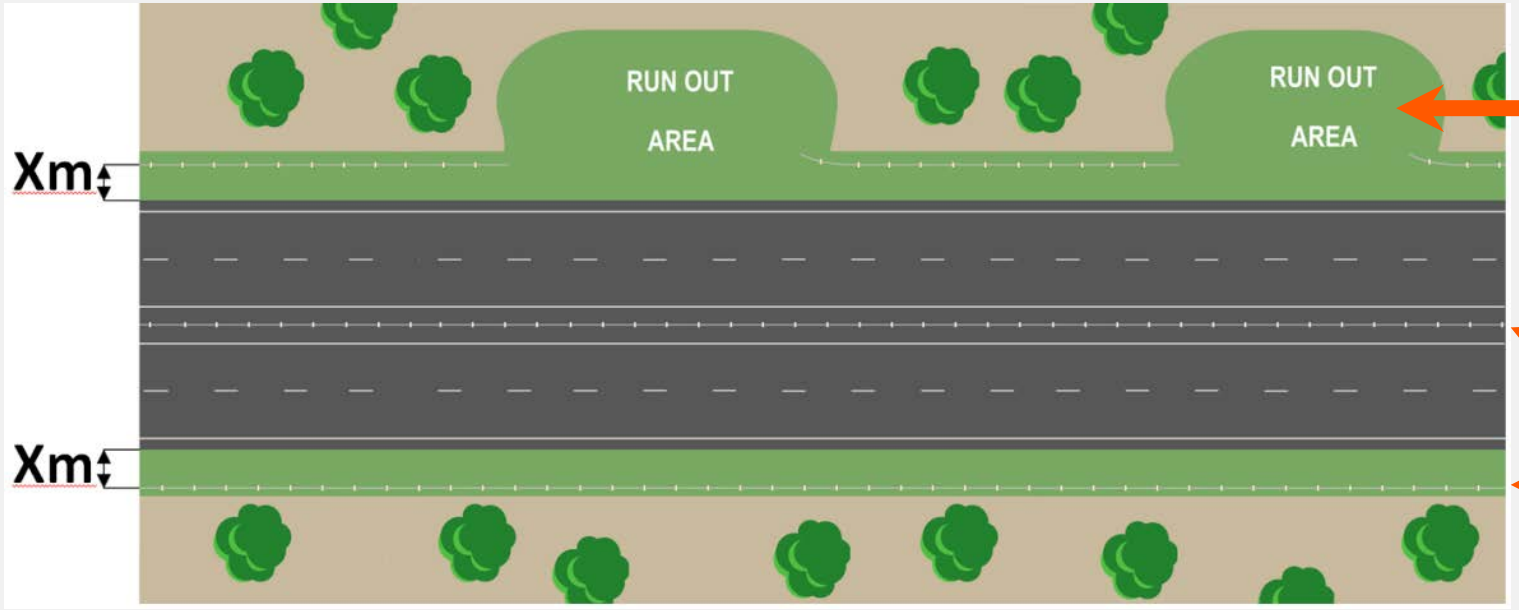


Source: CASR

High standard rural roadway
Harm minimisation approach

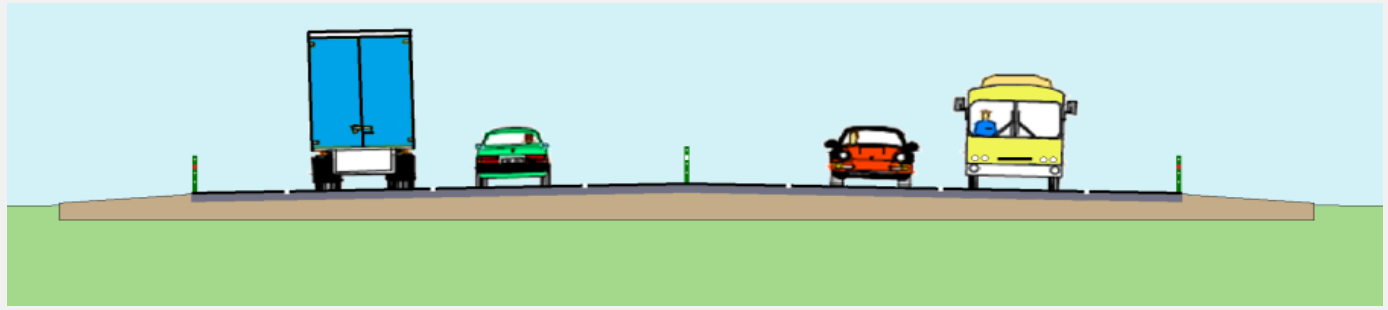
Austroads

Proposed treatment



High quality terrain unlikely to trigger rollover

Continuous lengths of flexible barrier



Source: CASR

Rural Arterial Harm minimisation approach

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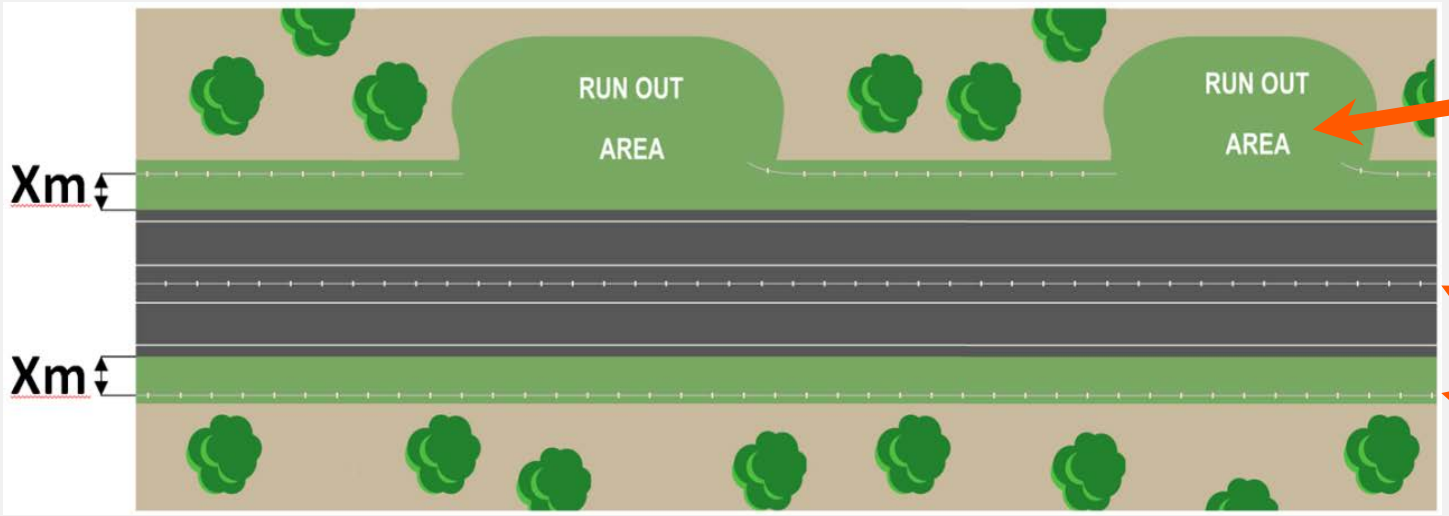
Rural Arterials - Proposed Approach

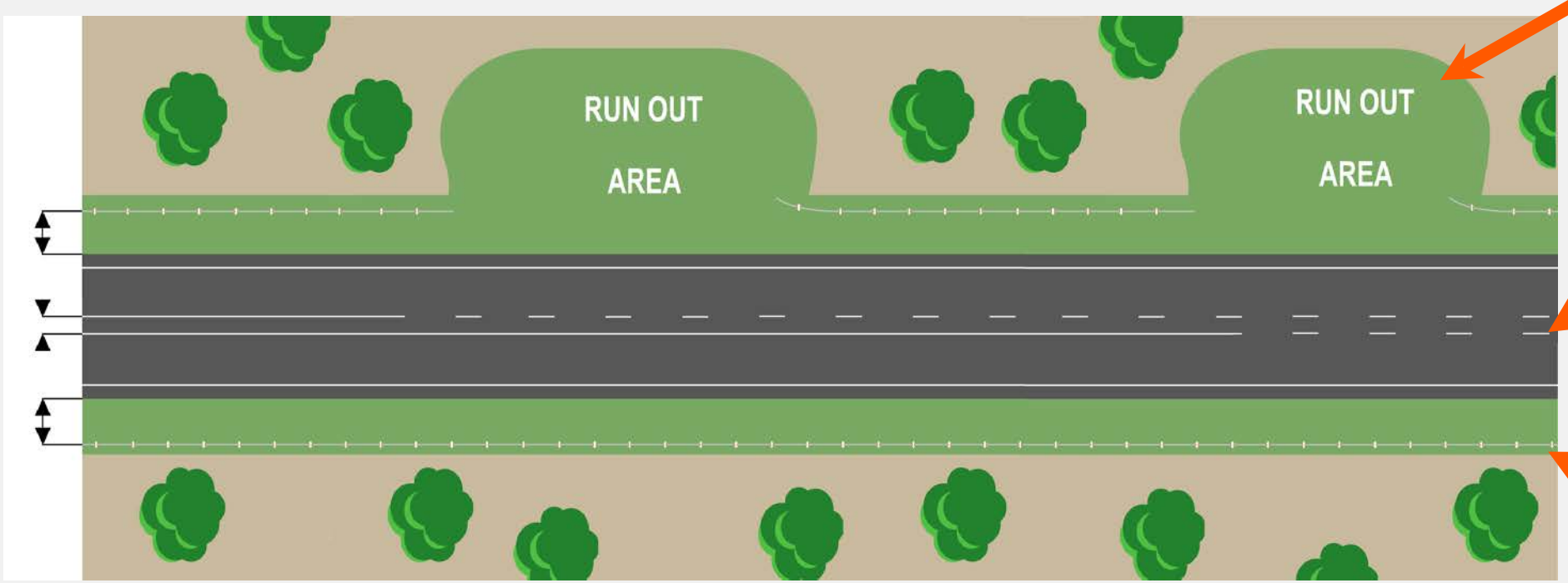


High quality terrain unlikely to trigger rollover

Continuous lengths of flexible barrier

Source: CASR

Rural Arterial Supporting approach



High quality terrain unlikely to trigger rollover

Wide centreline treatment

Continuous lengths of flexible barrier

Safe System Infrastructure Solutions: Intersections

Associate Professor Jeremy Woolley

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Systemic design failures

See Section 2.2

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People are placed in circumstances where failure can be expected

Systemic design failures

See Section 2.2

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People are placed in circumstances where failure can be expected

Systemic design failures

See Section 2.2

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People are placed in circumstances where failure can be expected

Safe System intersections

See Table 5.2

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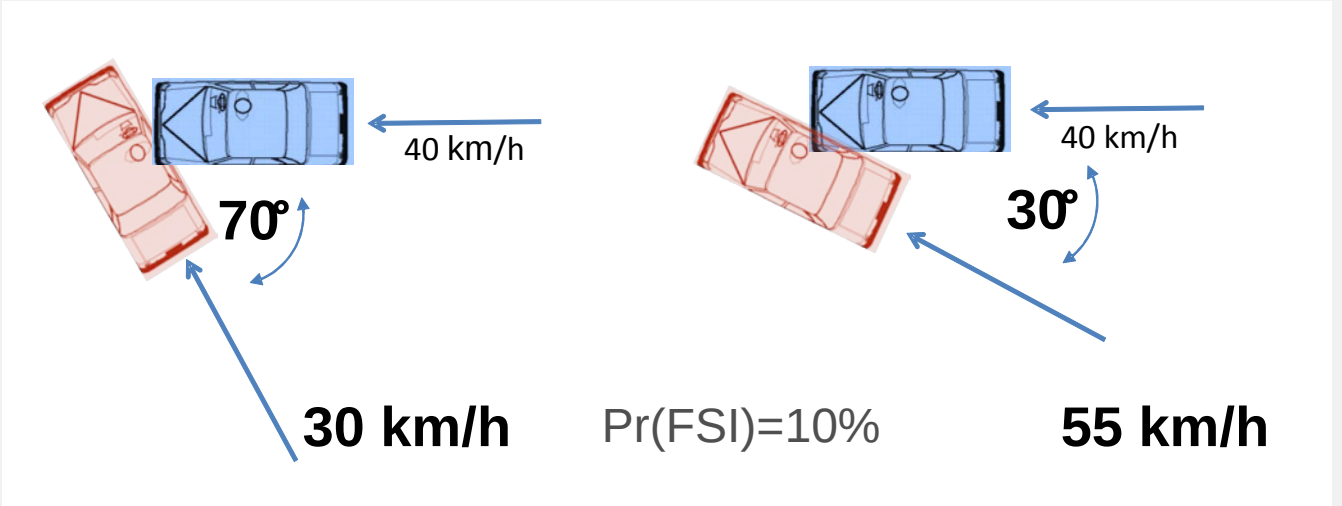
- Design features that guarantee survivable impact speed and configurations
- Default position is protected turns (signals)
- Limit points of conflict and simplify decision making
- Geometry that mitigates consequences of deliberate risk taking or driver error
- Dynamic visual obstruction considered
- Secondary impacts considered
- “Looked but did not see” collisions considered

Key variables regarding collisions

Energy as a function of:

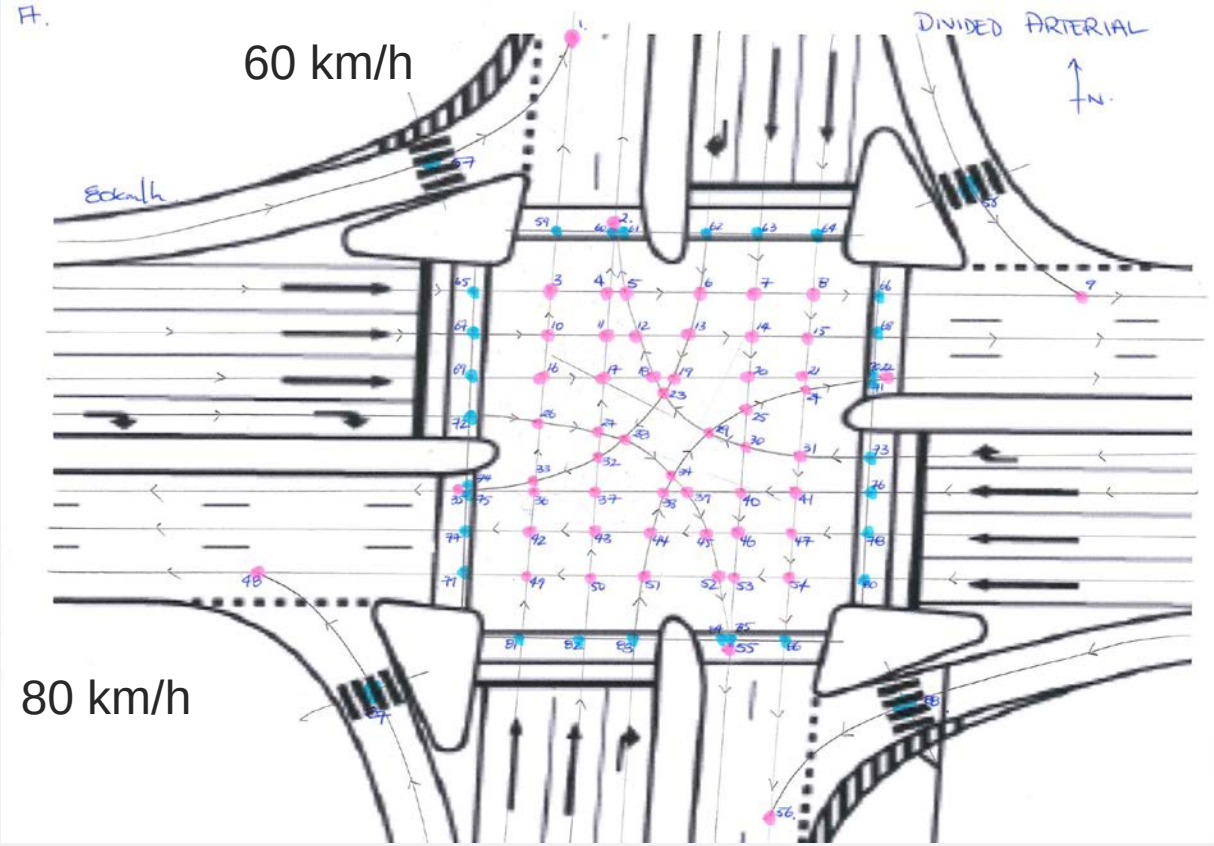
- Speed
- Mass
- Impact configuration



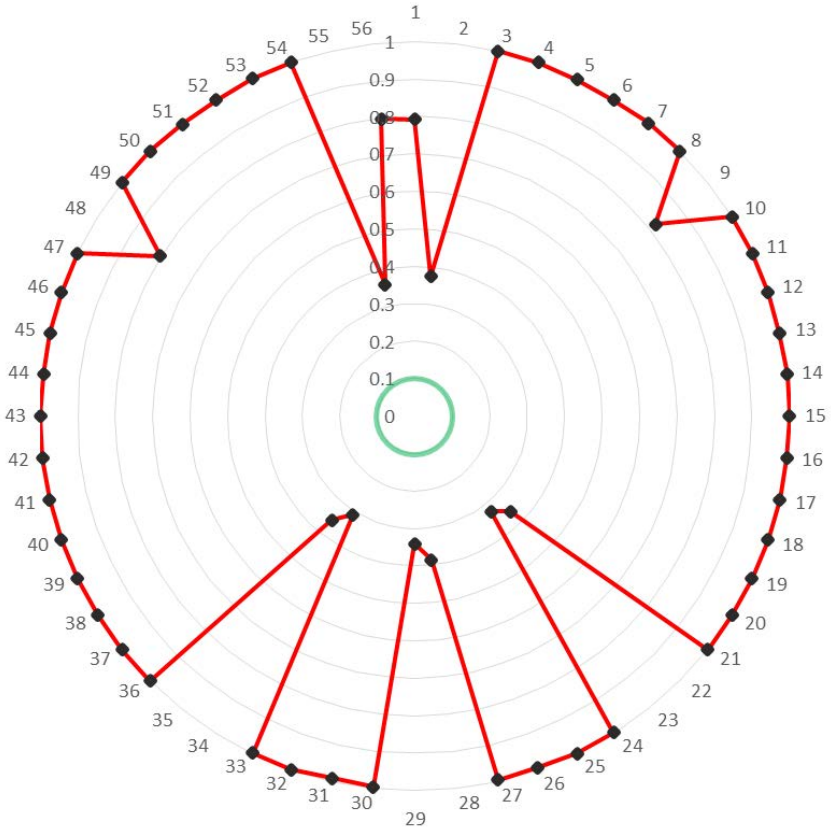
Energy model being developed

- Numerical analysis of relative FSI probabilities for a given impact angle and speed (mass equal)
- X-KEMM-X

X-KEMM-X application examples

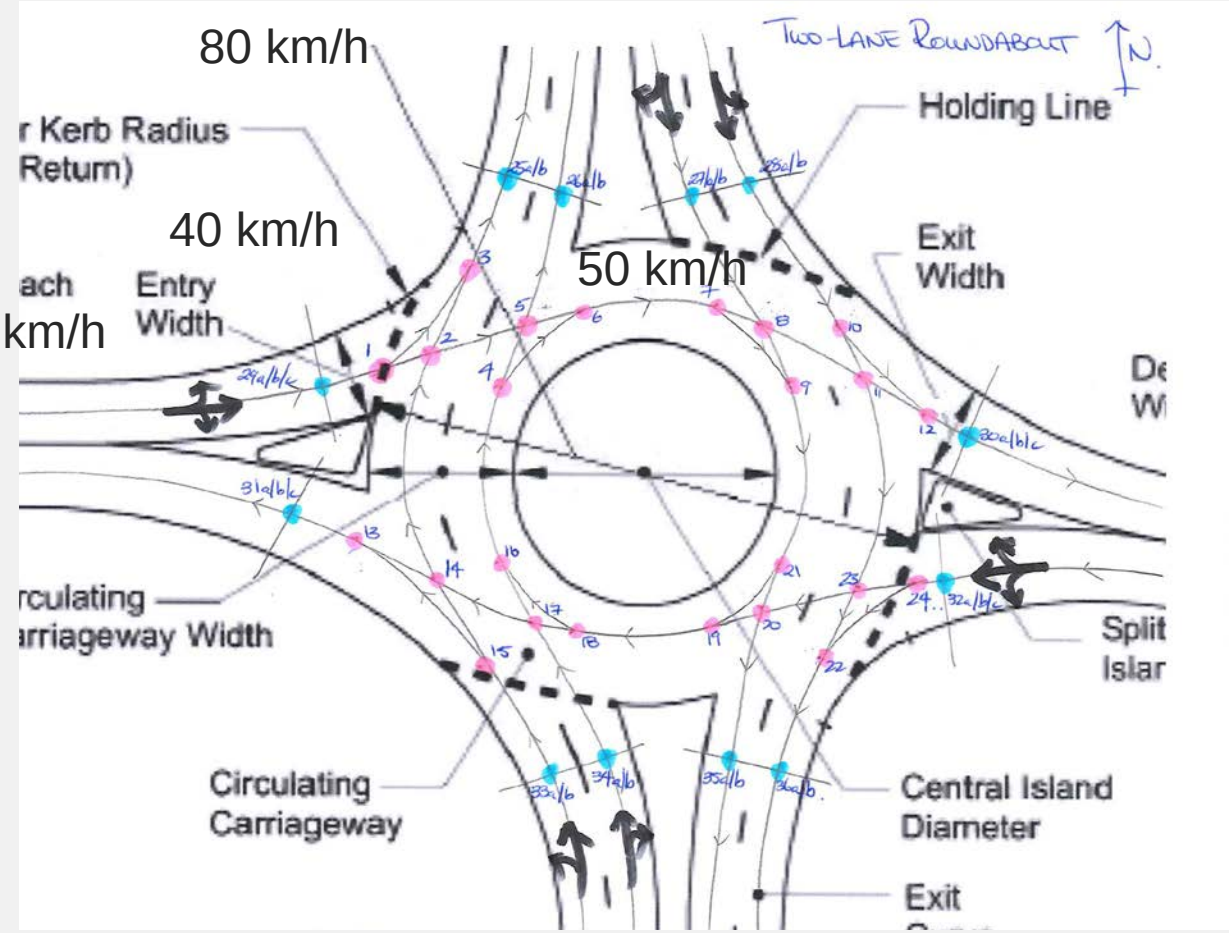


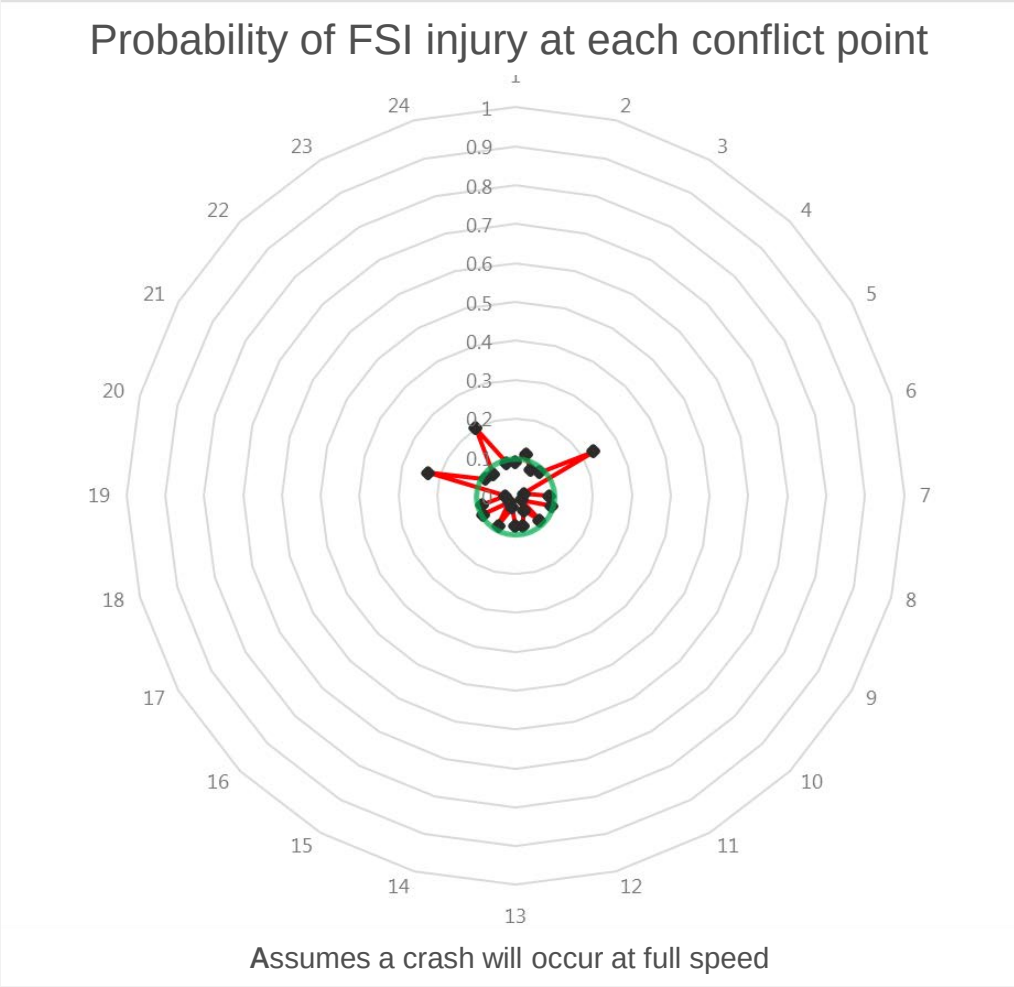
Probability of FSI injury at each conflict point



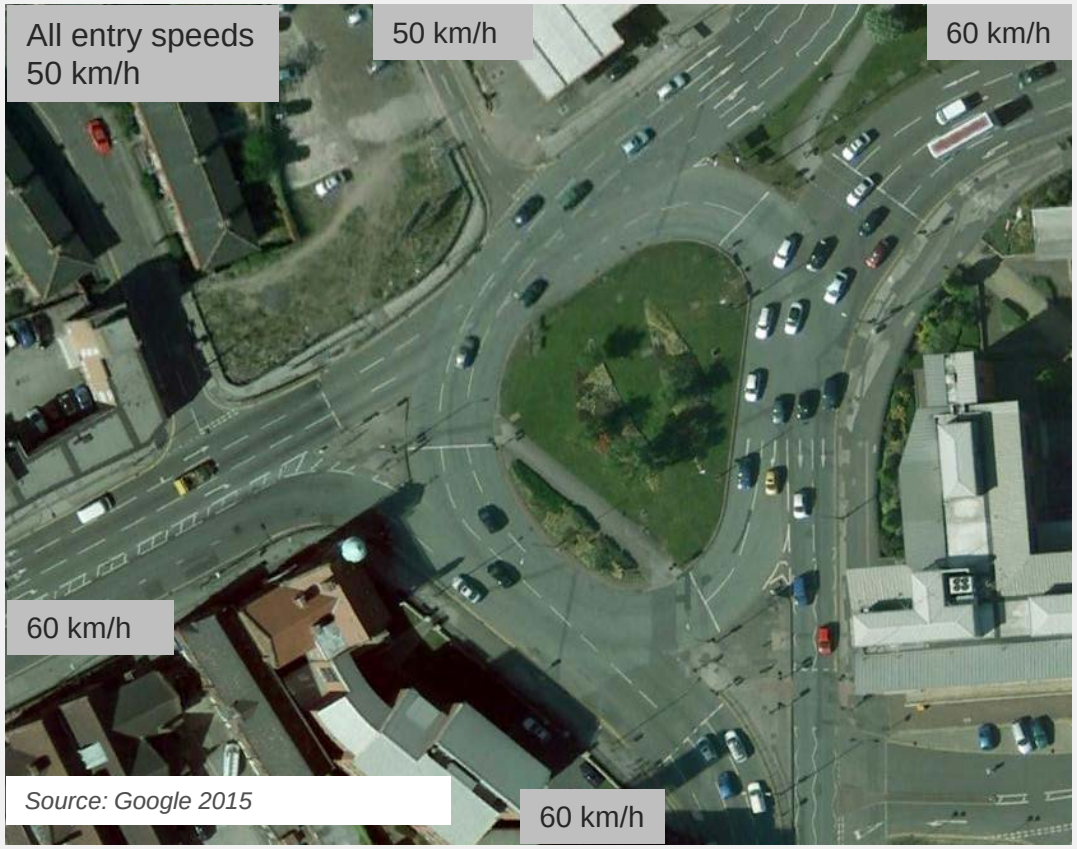
Assumes a crash will occur at full speed

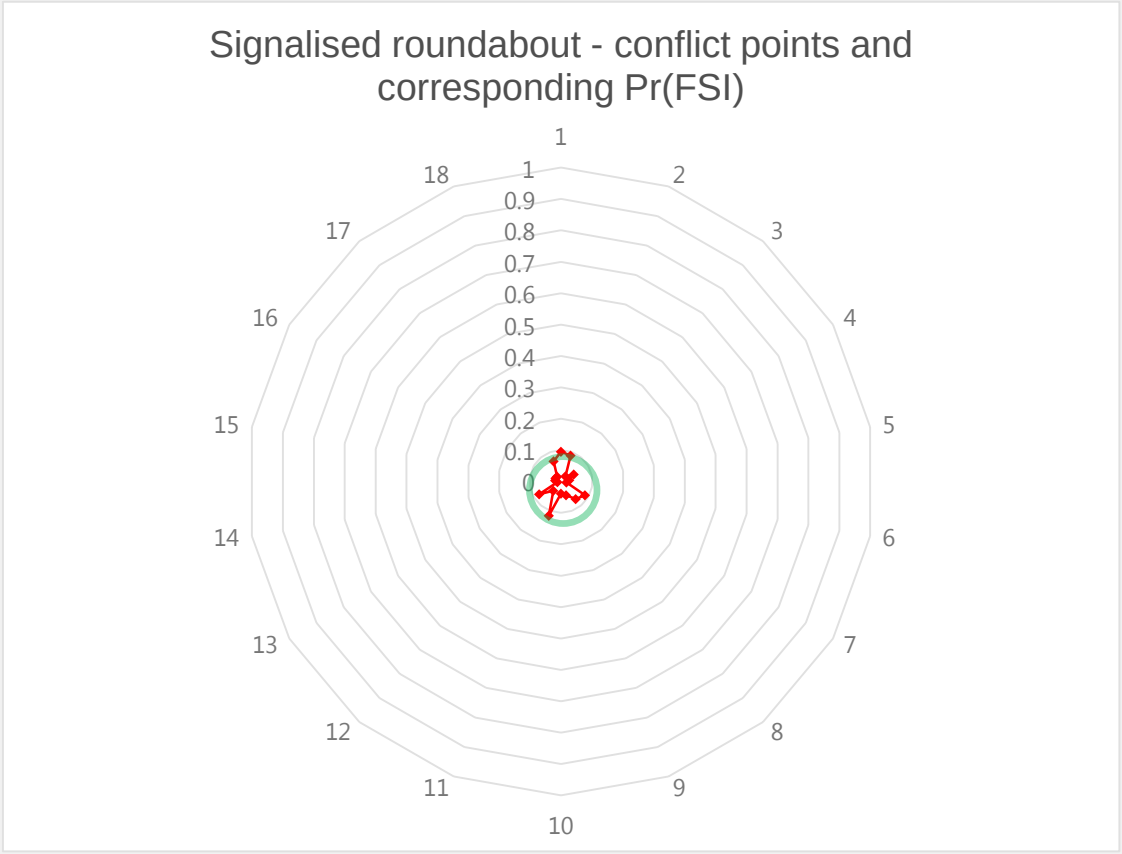
Roundabout (multi-lane)



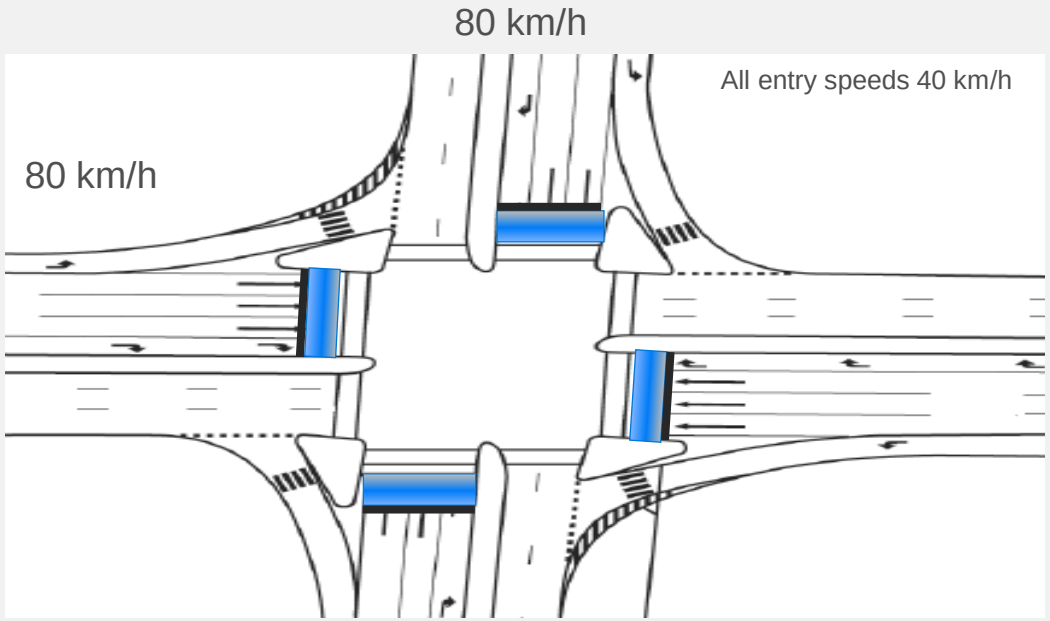


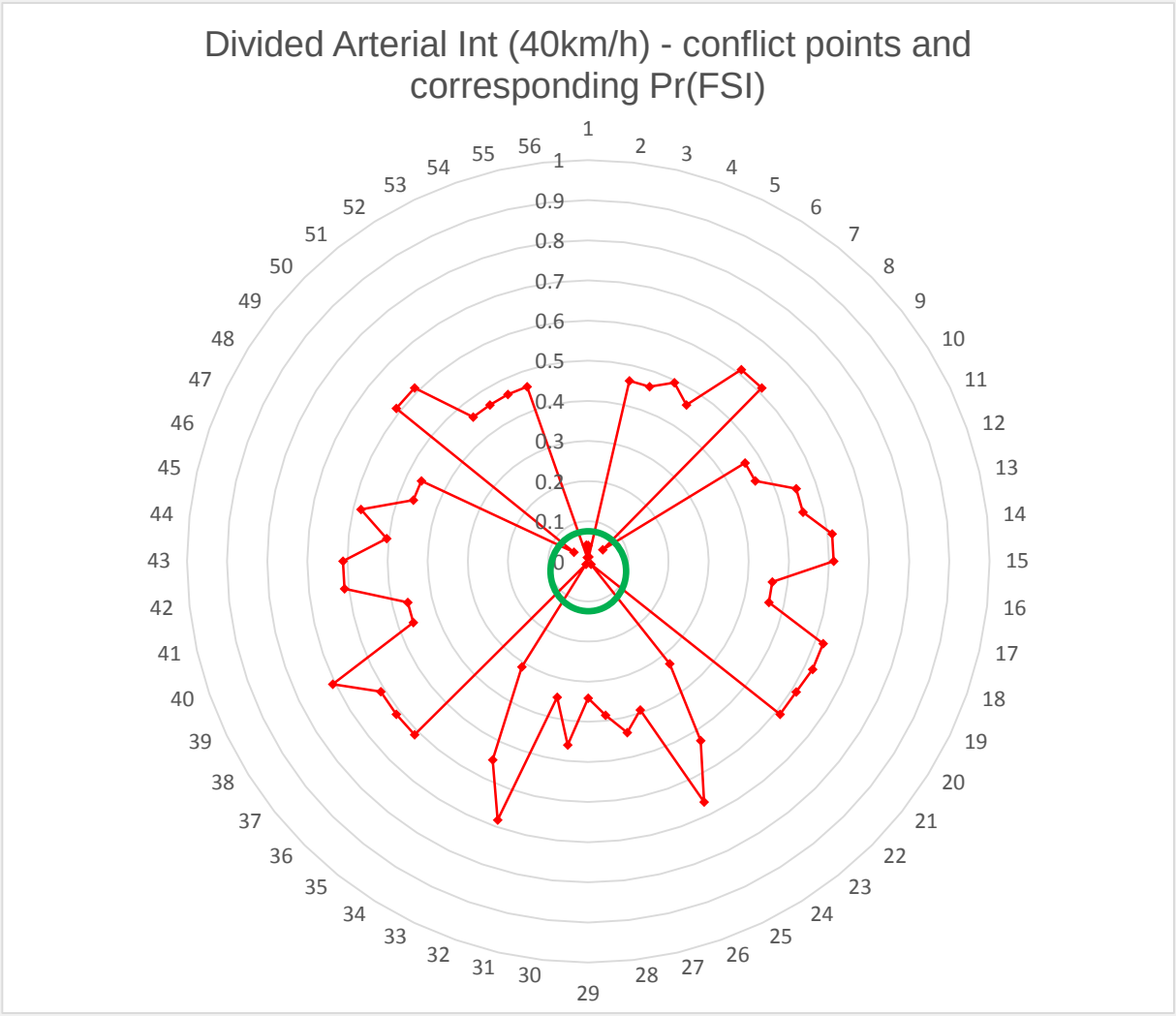
Urban signalised roundabout





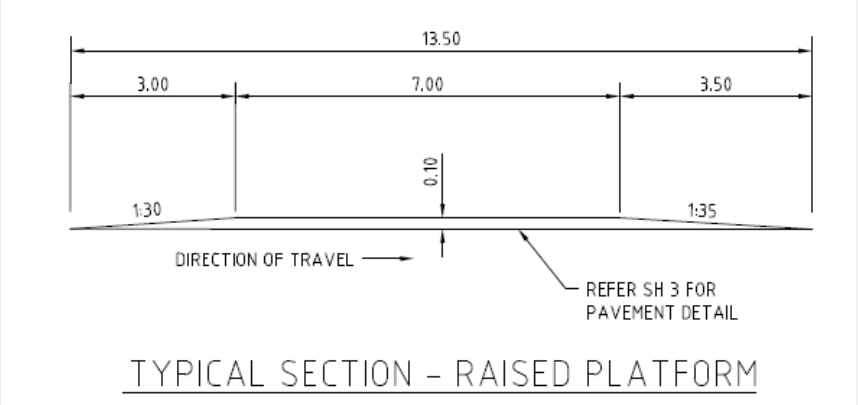
Urban signalised with vertical approach deflections





Urban signalised with vertical approach deflections

Source: VicRoads



Vehicle activated speed limits

See Section 8

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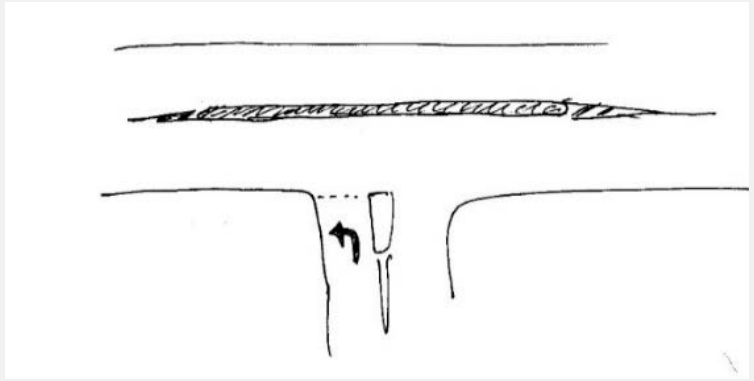
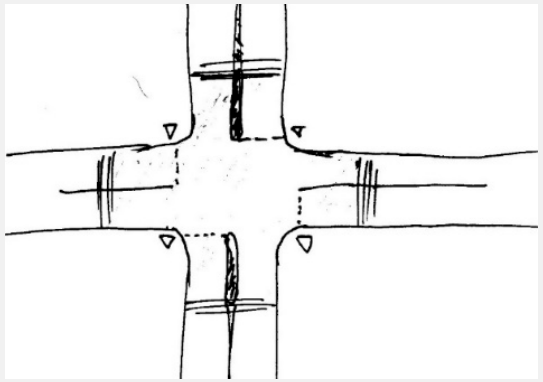
Other low cost ideas?

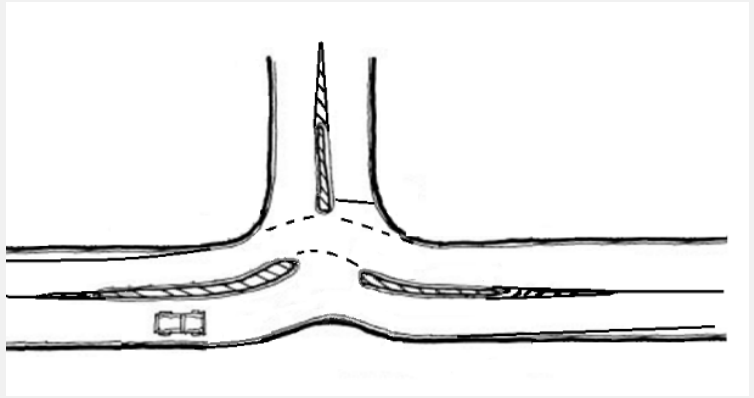
Left-in, left-out



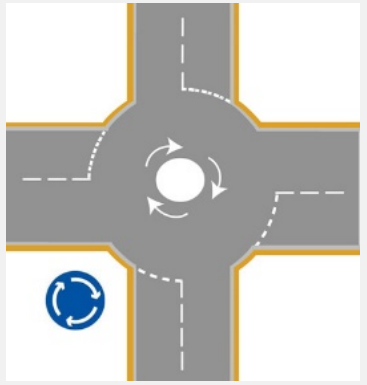
Rural 4-way give way with platforms and rumble strips



Rural Modified-T



Mini-roundabout



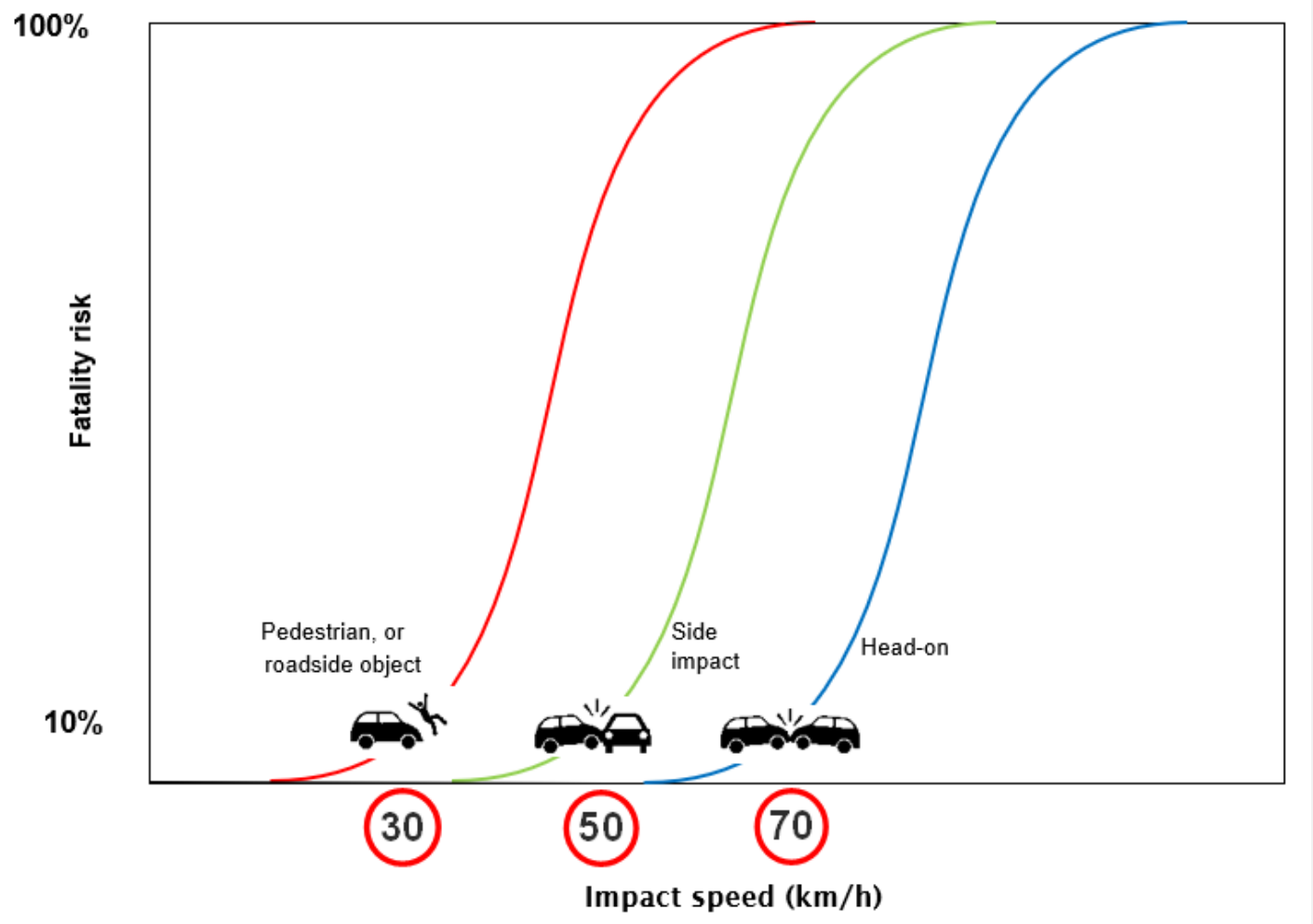
Safe System Infrastructure Solutions: Speeds

Dr Blair Turner

Austroads

Vulnerability – human tolerance to impact forces

Wramborg 2005
Safe System speeds



Effect of speed on crashes

See Section 4

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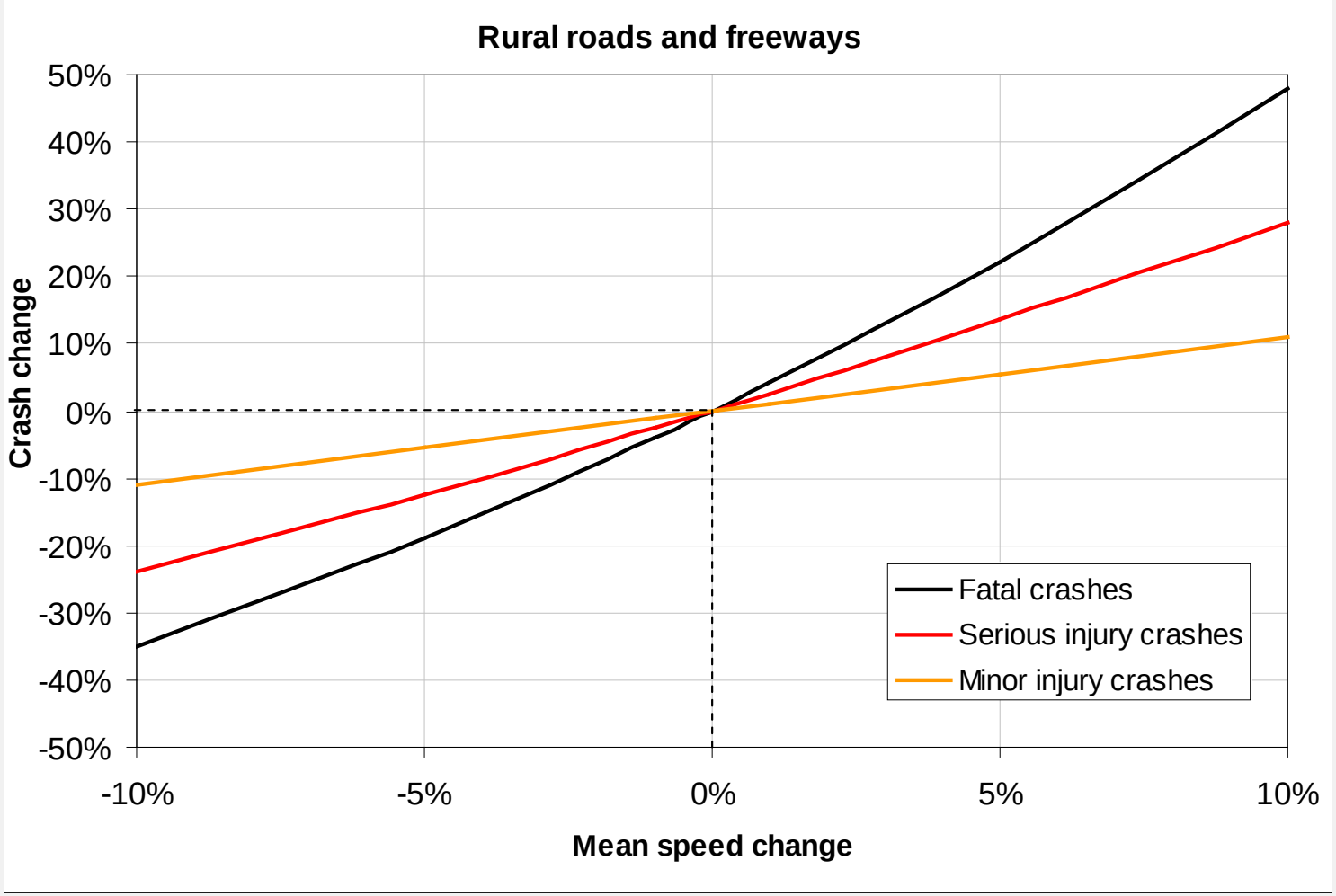

Cost benefit

See Table 4.3

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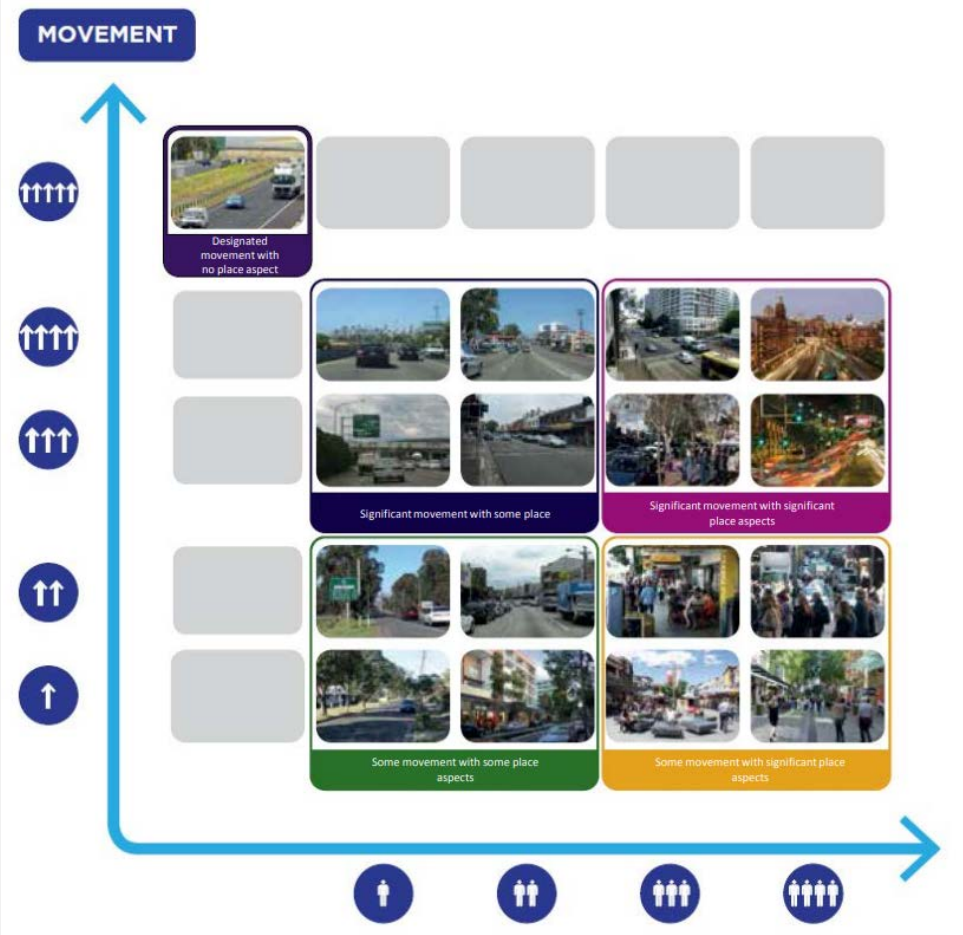
Cost of obtaining reductions on state controlled roads in South Australia with infrastructure changes or speed limits

Speed limit	Treatment option	Serious casualty crash reduction	Cost of treatment ($M)	Cost of 20% serious casualty crash reduction ($M)
100 km/h	10 km/h speed limit reduction	20%	<1	<1
	Shoulder sealing	14%	104	NA
	Roadside barriers	18%	526	NA
	Median barriers	14%	2,142	NA
	Clear zones	9%	545	NA
110 km/h	10 km/h speed limit reduction	20%	<1	<1
	Shoulder sealing	25%	427	338
	Roadside barriers	35%	2,404	1,367
	Median barriers	26%	9,540	7,235
	Clear zones	18%	2,428	NA

Source: Doecke, Kloeden et al. 2011

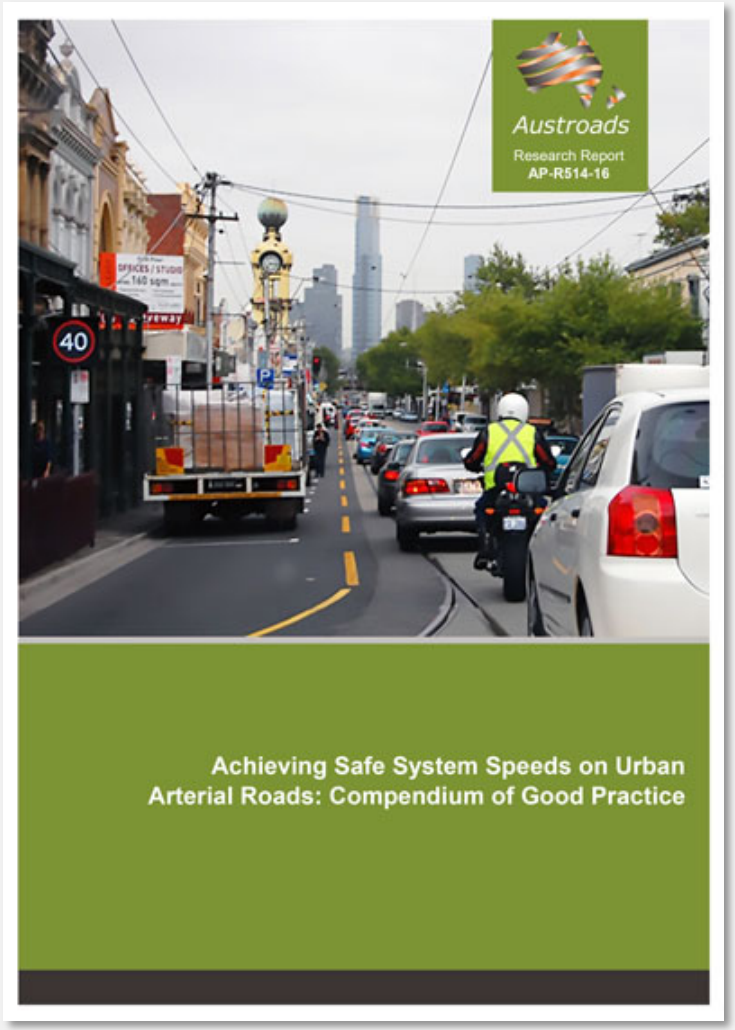
Speed Management in the Safe System

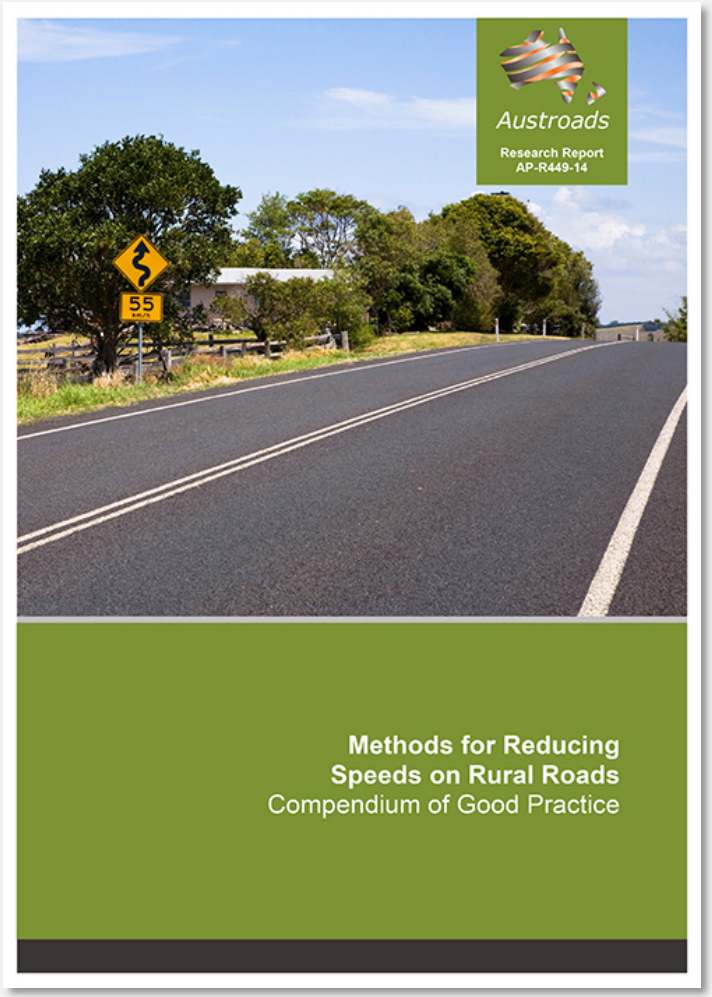
- Importance on road function
- Movement and Place = safety mobility
- Match traffic speeds to road infrastructure, road use and function
  - ‘Engineer up’ if higher speeds are required (including protection/ separation for vulnerable road users)
  - Reduce speed limit where quality of infrastructure is not appropriate for current speed.



Changing the road environment to match the speed limit

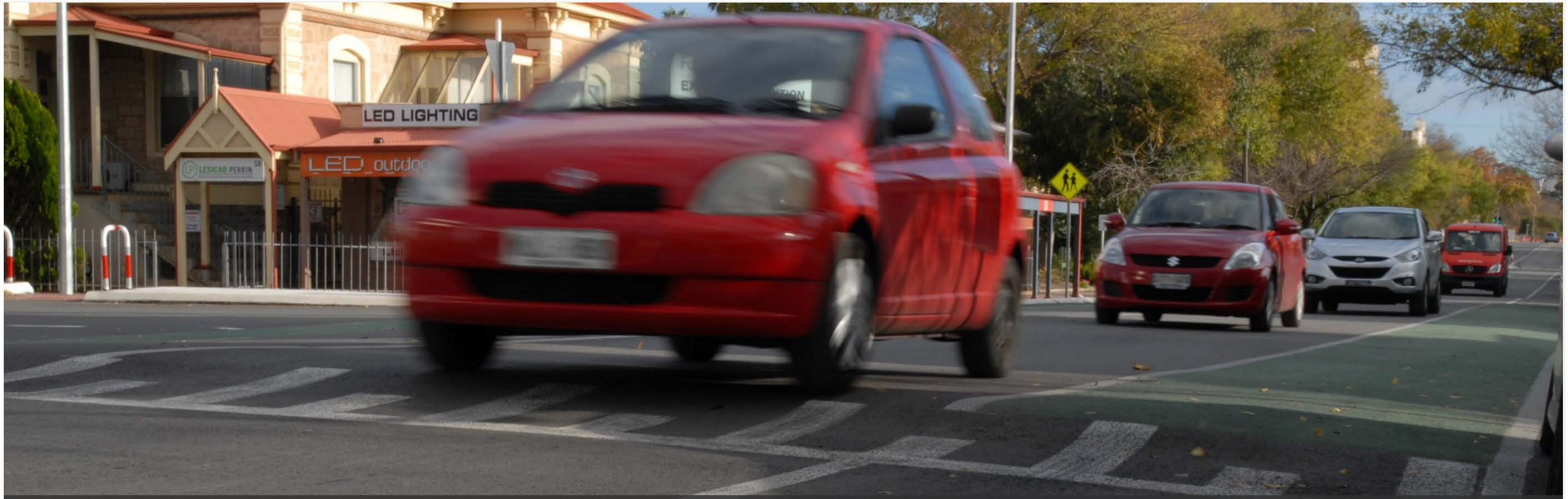
Austroads Reports





Key points on speed

- Cost effective
- Immediate benefits
- Proven
- Benefits increase over time



Safe System Infrastructure Solutions: Vulnerable Road Users

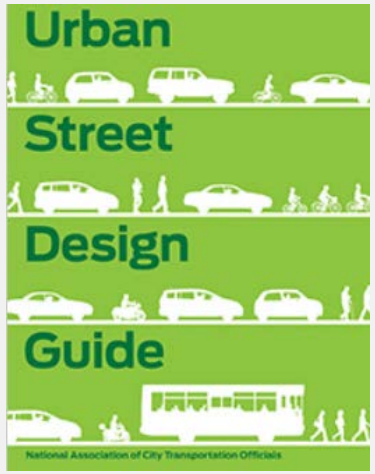
Associate Professor Jeremy Woolley

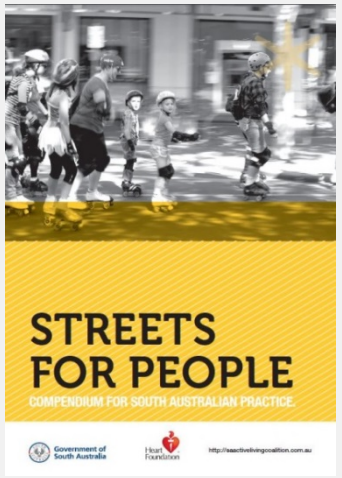
Austroads

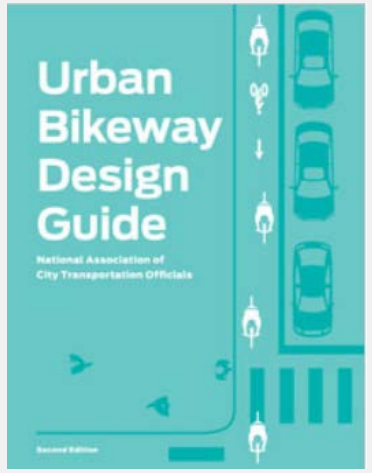
Creating liveable, vibrant and healthy cities

See Section 3

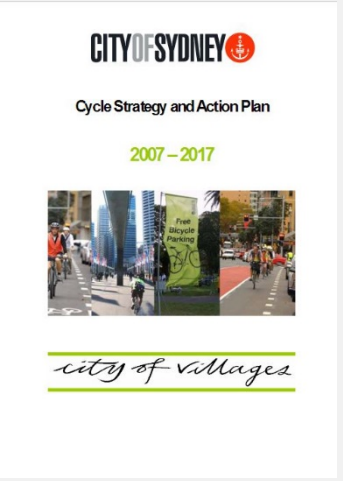
Austroads

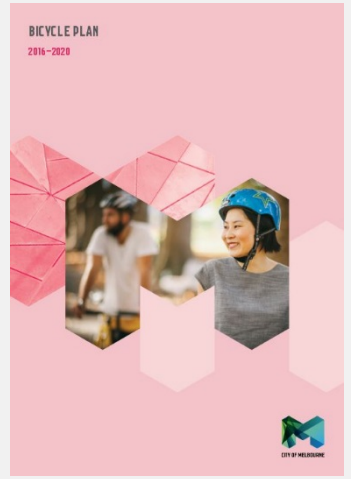






Movement and Place





Images source: NACTO http://nacto.org

Pedestrians Some important considerations

Issues

- Collisions in CBD
- Collisions in high pedestrian activity areas
- Spatially random nature of crashes along arterials
- Intoxication still a significant issue

Treatments

- Lower speed limits
- Vertical deflection
- Dwell on red

Strategically – Long Term

- Movement and Place Framework

Source: http://dpti.sa.gov.au/newconnections/news/?a=145001

Pedestrians Safe System treatments

Hierarchy	Treatment	Influence (E = exposure L = likelihood S = severity)
Safe System options ('primary' or 'transformational' treatments)	• Separation (footpath) • Separation (crossing point) • Very low speed environment, especially at intersections or crossing points.	E L L, S
Supporting treatments (compatible with future implementation of Safe System options)	• Reduce speed environment/speed limit • Pedestrian refuge • Reduce traffic volume.	L, S L E, L
Supporting treatments (does not affect future implementation of Safe System options)	• Pedestrian signals • Skid resistance improvement • Improved sight distance to pedestrians • Improved lighting • Rest-on-red signals.	L L L L L, S
Other considerations	• Speed enforcement.	L, S

Source: *Safe System Assessment framework,* Austroads 2016

Cyclists Safe System approach

It is currently unclear what a Safe System for cyclists looks like if we maintain a car perspective

> *“Mix traffic where speeds are low*
> *Separate traffic where speeds are too high*
> *And introduce targeted speed reduction where pedestrians and cyclists meet motorized traffic flows”*
>
> – Dutch Advancing Sustainable Safety

Learn from others

- Vehicle setbacks
- Protective blisters on corners

Source: www.fhwa.dot.gov

Source: lcc.org.uk

Roundabouts

- There is still scope for much innovation

Source: bicycledutch.wordpress.com

Motorcyclists Safe System treatments

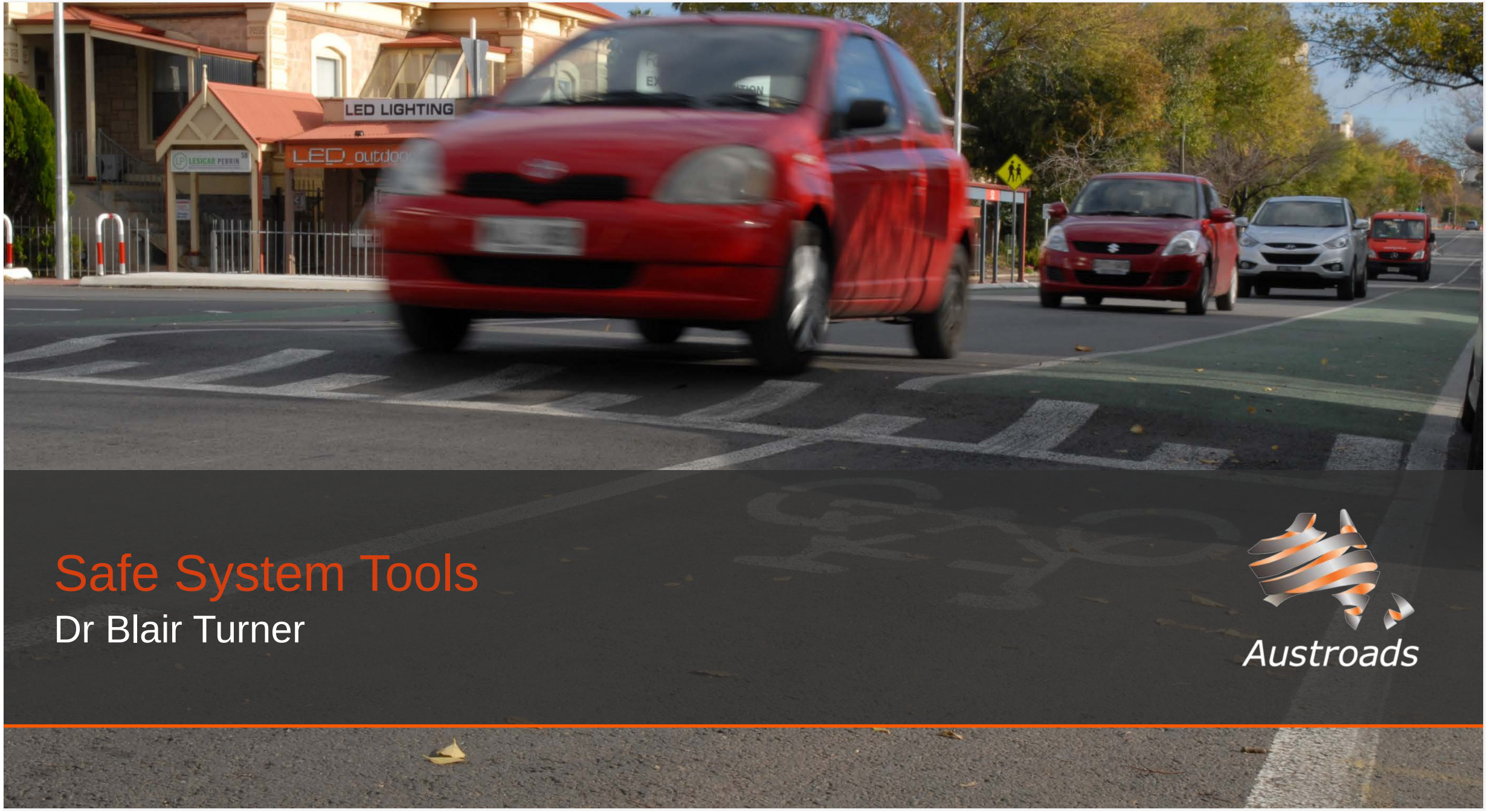
Hierarchy	Treatment	Influence (E = exposure L = likelihood S = severity)
Safe System options ('primary' or 'transformational' treatments)	• Separate motorcycle lane (e.g. on freeways).	E
Supporting treatments (compatible with future implementation of Safe System options)	• Shared motorcycle/bus/taxi lane (e.g. on freeways).	L
Supporting treatments (does not affect future implementation of Safe System options)	• Consistent design along the route (i.e. no out-of-context curves) • Consistent delineation for route • Skid resistance improvement • Motorcycle-friendly barrier systems.	L L L S
Other considerations	• Speed enforcement • Enforcement of other regulations.	L, S L

Source: Austroads 2016a

Motorcycle barrier protection

- Half of all barrier collisions occur with motorcyclist in sliding posture
- Severe injuries can occur at 30 km/h + impacts with barrier post (Bambach and Grzebieta 2015)
- Barriers that are more forgiving are evolving but not Safe System

Source: Dua and Sapkota 2012



Safe System Tools

Dr Blair Turner

Austroads

Performance indicators

See Section 9

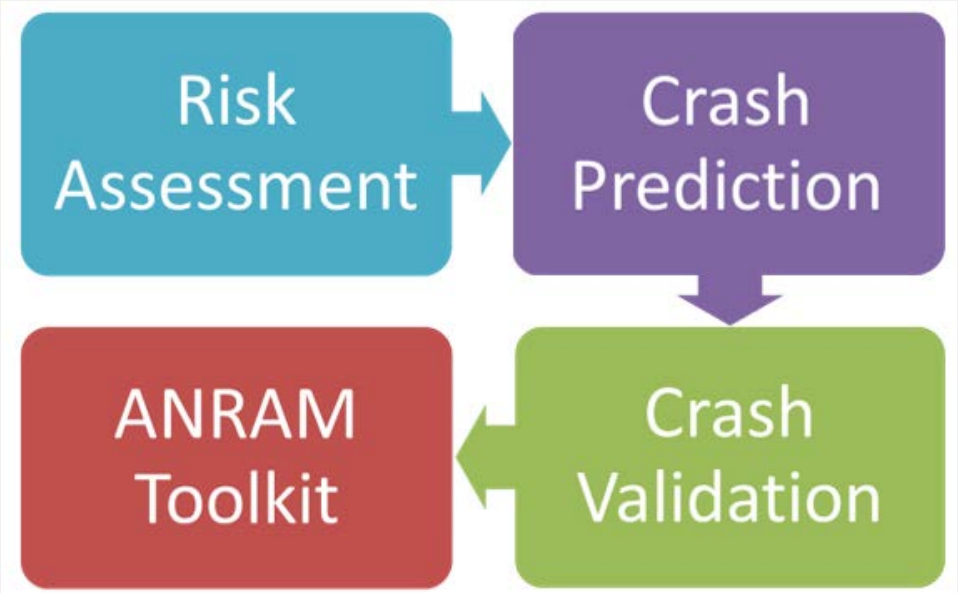
Austroads

Towards zero goal	KPI
For roads without mid- and side-barriers, maximise percent VKT with speed limits of <80km/h.	Percentage of VKT on roads without mid- and side-barriers with speed limits <80 km/h.
Ensure intersections are designed to achieve minimal conflicts and/or entry speeds not greater than 50 km/h.	Percentage of vehicle movements entering intersections designed at not more than 50 km/h.
Ensure traffic speeds in streets used to access schools, or places where children, senior citizens or mobility impaired people live or gather, are limited to and designed for 30 or 40 km/h.	Percentage of vehicles using roads and streets with significant numbers of children, senior citizens and mobility-impaired people that are at or below 40 km/h and at or below 30 km/h.
Ensure walking and cycling become, low-risk, convenient choice for short-medium length journeys.	Increases in safe walking and cycling mode share.
Ensure residential areas will be limited to and designed for 30 or 40 km/h travel	Percentage of VKT in local streets at or below 40 km/h and at below 30 km/h.

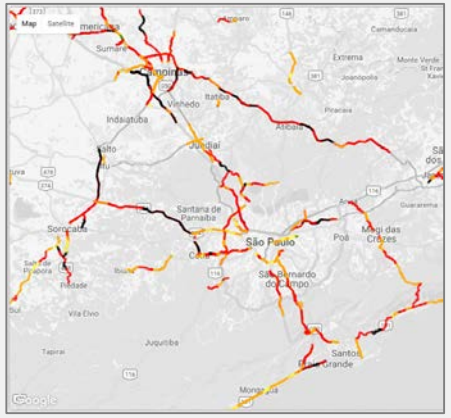
Source: Mornington Peninsula Shire

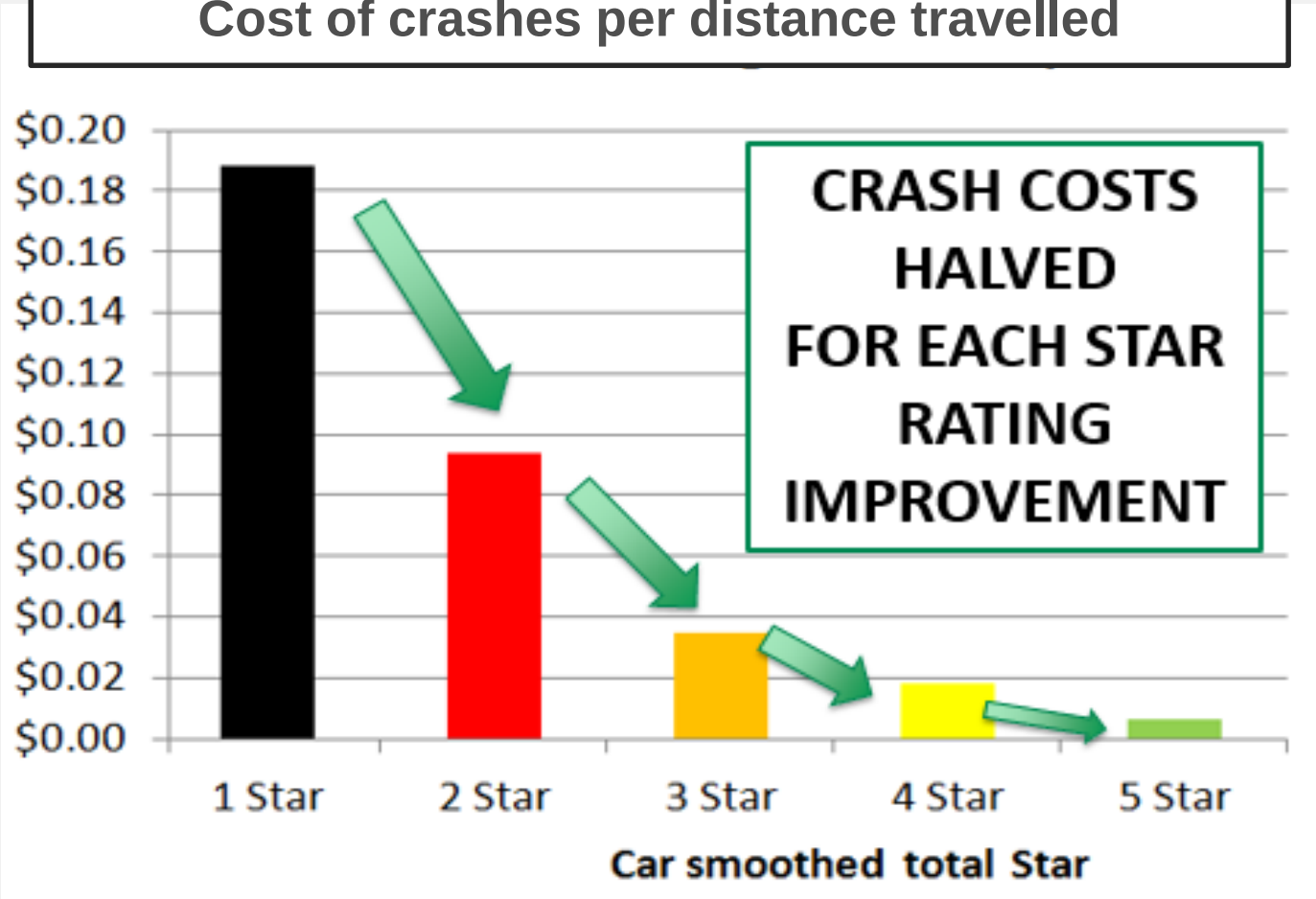
Australian National Risk Assessment Model (ANRAM)

- A consistent method for the whole country (all jurisdictions, state and local government)
- Based on Australian crash data, speeds and traffic
- Safe System:
  - Fatal and serious injury crash focus, proactive and reactive
  - Allows systematic (route or network)
- Outcome of an Austroads research project
- Collaboration between: Austroads, ARRB, AAA and iRAP/AusRAP
- https://www.arrb.com.au/anram



AusRAP / KiwiRAP



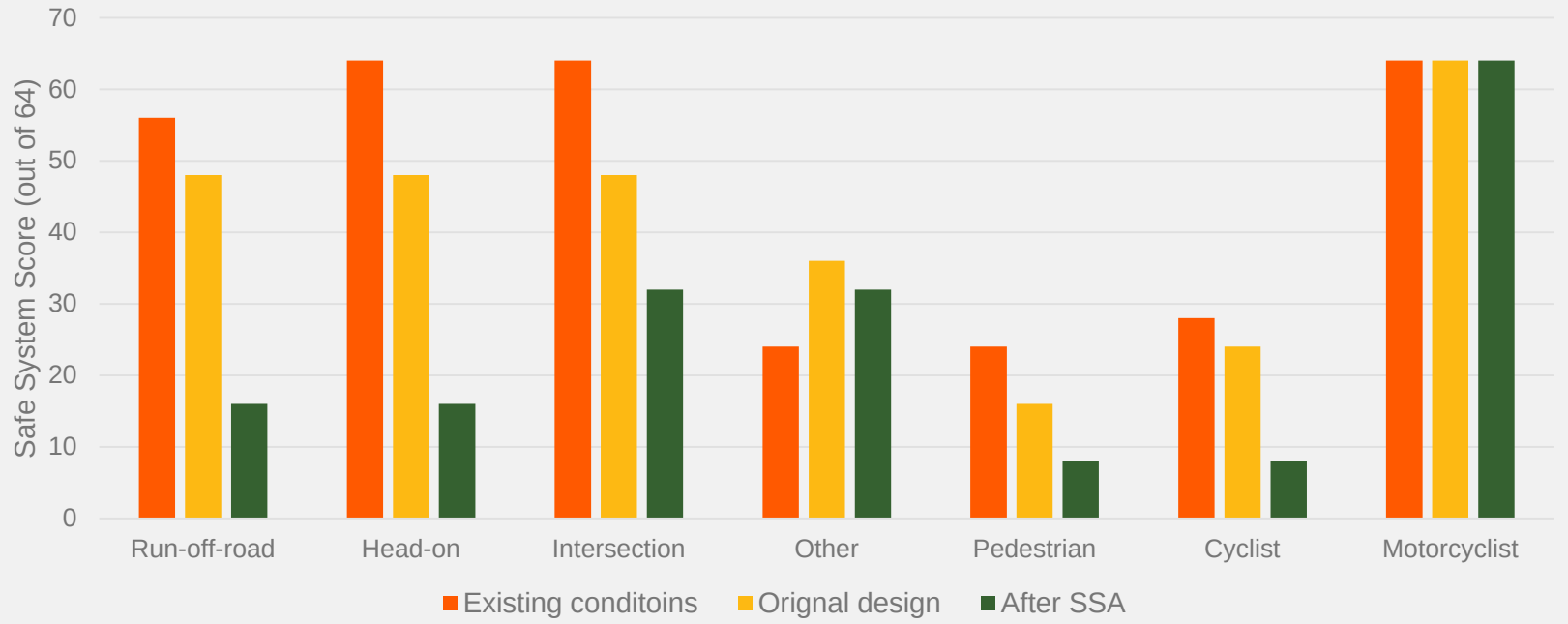


Safe System matrix

Safe system assessment framework for infrastructure projects

	Run-off-road	Head-on	Intersection	Other	Pedestrian	Cyclist	Motorcyclist
Exposure	AADT; length of road segment	AADT; length of road segment	AADT for each approach; intersection size	AADT; length of road segment	AADT; pedestrian numbers; crossing width; length of road segment	AADT; cyclist numbers; pedestrians	AADT; motorcycle numbers; length of road segment
Likelihood	Speed; geometry; shoulders; barriers; hazard offset; guidance and delineation	Geometry; separation; guidance and delineation; speed	Type of control; speed; design, visibility; conflict points	Speed; sight distance; number of lanes; surface friction	Design of facilities; separation; number of conflicting directions; speed	Design of facilities; separation; speed	Design of facilities; separation; speed
Severity	Speed; roadside features and design (e.g. flexible barriers)	Speed	Impact angles; speed	Speed	Speed	Speed	Speed

Safe System Assessment Framework



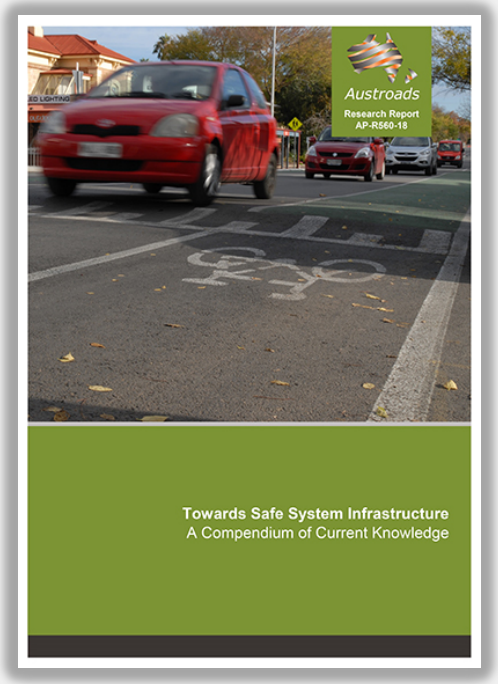
		Safe System Assessment Score	Improvement	Estimated Cost
	Existing conditions	**324** / 448		-
	Original design	**284** / 448	12%	$130M
	After Safe System Assessment	**176** / 448	45% (38% improvement from original design)	$130M

Key References

Dr Blair Turner

Austroads

Austroads reports



Download from https://www.onlinepublications.austroads.com.au/

- Safe System Assessment Framework
- Safe System Infrastructure on Mixed Use Arterials
- Understanding and Improving Safe System Intersection Performance
- Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice
- Safe System Roads for Local Government
- Infrastructure Improvements to Reduce Motorcycle Fatalities

Questions?

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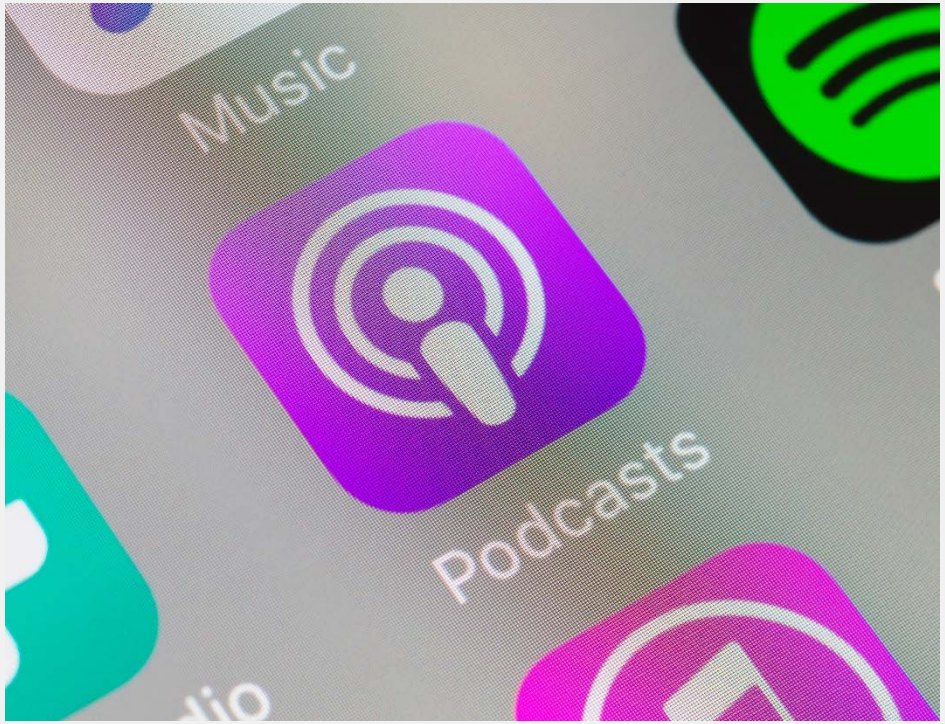
Upcoming Austroads webinars

Topic	Date
Best Practice in Road Safety Infrastructure Programs	15 May
Updated Pedestrian Facility Selection Tool	29 May

Register at http://www.austroads.com.au/event

Webinars now available as podcasts



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