Towards Safe System Infrastructure
10 May 2018
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
- Commonwealth Department of Infrastructure and Regional Development
- Australian Local Government Association
- New Zealand Transport Agency
Background and Introduction
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

- Peter Ellis
  RMS NSW

- John Matta
  VicRoads

- Alex Duerden
  DPTI - SA

- David Moyses
  MR WA

- Neil Edgar
  TMR QLD

- Geoffrey Davidson
  TCCS ACT

- Richard Fanning
  VicRoads

- Colin Brodie
  NZTA
New Austroads Compendium
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
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 the book covers?

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?

- 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

Crashworthiness

Pole side impact in lab at 29km/h

Pole side impact on 100km/h rural road

Source: ANCAP

Source: CASR
Safe System Infrastructure Solutions: Roads and Roadsides
Where is the redundancy?
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 Displacements Graph](source: Doecke and Woolley 2011)
Pros and cons of crash barriers types

Flexible  Semi-rigid  Rigid

Clear zones

Barrier treatment of spot hazards

See Section 6

Source: CASR
Rural arterials Historical approach

Historic treatment

Source: CASR
High standard rural roadway
Harm minimisation approach

Proposed treatment

- Continuous lengths of flexible barrier
- High quality terrain unlikely to trigger rollover

Source: CASR
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
Systemic design failures

People are placed in circumstances where failure can be expected
Systemic design failures

People are placed in circumstances where failure can be expected
Systemic design failures

People are placed in circumstances where failure can be expected
Safe System intersections

- 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

See Table 5.2
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

60 km/h

Probability of FSI injury at each conflict point

80 km/h

Assumes a crash will occur at full speed
Roundabout (multi-lane)

Probability of FSI injury at each conflict point

Assumes a crash will occur at full speed
Urban signalised roundabout

Signalised roundabout - conflict points and corresponding Pr(FSI)

Source: Google 2015
Urban signalised with vertical approach deflections

All entry speeds 40 km/h

Divided Arterial Int (40km/h) - conflict points and corresponding Pr(FSI)
Urban signalised with vertical approach deflections

Source: VicRoads
Vehicle activated speed limits

See Section 8
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
Vulnerability – human tolerance to impact forces

Wramborg 2005 – Safe System speeds
Effect of speed on crashes

See Section 4

-50% -40% -30% -20% -10% 0% 10% 20% 30% 40% 50%
Mean speed change
Crash change
Fatal crashes
Serious injury crashes
Minor injury crashes

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

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

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
Key points on speed

- Cost effective
- Immediate benefits
- Proven
- Benefits increase over time
Safe System Infrastructure Solutions: Vulnerable Road Users
Creating liveable, vibrant and healthy cities

Images source: NACTO http://nacto.org

See Section 3
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

# Pedestrians Safe System treatments

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

Source: Safe System Assessment framework, Austroads 2016
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

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

<table>
<thead>
<tr>
<th>Towards zero goal</th>
<th>KPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>For roads without mid- and side-barriers, maximise percent VKT with speed limits of &lt;80km/h.</td>
<td>Percentage of VKT on roads without mid- and side-barriers with speed limits &lt;80 km/h.</td>
</tr>
<tr>
<td>Ensure intersections are designed to achieve minimal conflicts and/or entry speeds not greater than 50 km/h.</td>
<td>Percentage of vehicle movements entering intersections designed at not more than 50 km/h.</td>
</tr>
<tr>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>Ensure walking and cycling become, low-risk, convenient choice for short-medium length journeys.</td>
<td>Increases in safe walking and cycling mode share.</td>
</tr>
<tr>
<td>Ensure residential areas will be limited to and designed for 30 or 40 km/h travel</td>
<td>Percentage of VKT in local streets at or below 40 km/h and at below 30 km/h.</td>
</tr>
</tbody>
</table>

Source: Mornington Peninsula Shire
<table>
<thead>
<tr>
<th>Safe System Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure</strong></td>
</tr>
<tr>
<td>AADT; length of road segment</td>
</tr>
<tr>
<td><strong>Likelihood</strong></td>
</tr>
<tr>
<td><strong>Severity</strong></td>
</tr>
</tbody>
</table>
### Existing Intersection Configuration

#### Table 4.3: Safe System matrix for Safe Roads and Roadsides and Safe Speeds

<table>
<thead>
<tr>
<th></th>
<th>ROR</th>
<th>HO</th>
<th>INT</th>
<th>OTHER</th>
<th>PED</th>
<th>CYC</th>
<th>MIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>3/4</td>
<td>3/4</td>
<td>4/4</td>
<td>2/4</td>
<td>0/4</td>
<td>1/4</td>
<td>2/4</td>
</tr>
<tr>
<td>Product</td>
<td>27/64</td>
<td>36/64</td>
<td>48/64</td>
<td>12/64</td>
<td>0/64</td>
<td>8/64</td>
<td>24/64</td>
</tr>
</tbody>
</table>
Change in Scores across 14 Projects in Victoria, Australia

Average scores of Safe System Assessments of 14 Major Projects in Victoria; worth ~$3.8 billion

Projects Costs increased from 0% to 7%
Other Austroads Documents
Austroads reports


- 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
Thank you