



# Pedestrian and Cyclist Safety



# Vulnerability of pedestrians and cyclists

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**We are all pedestrians every day!**

**There is great diversity within each group**

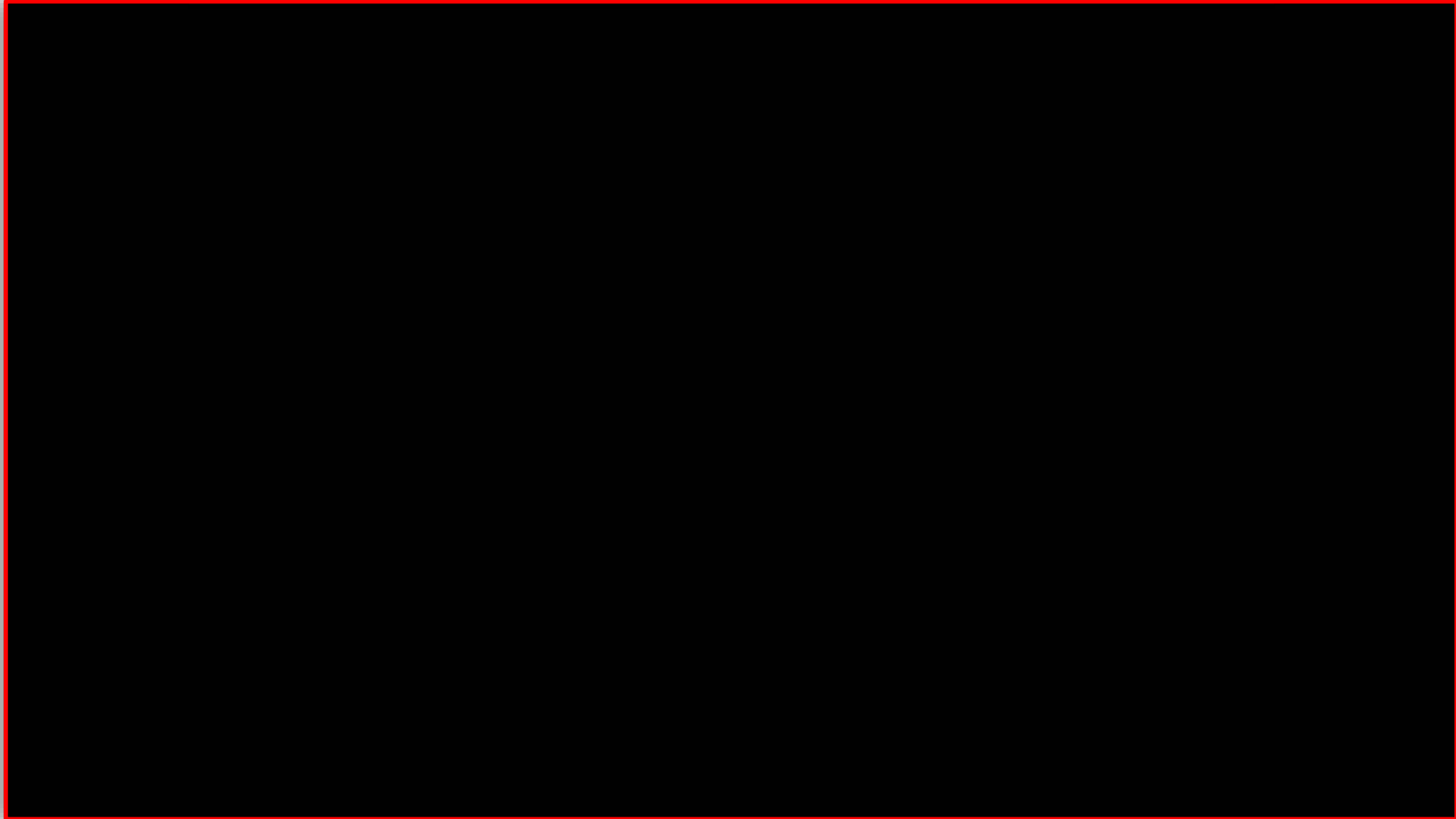
- A large mass differential between struck pedestrians/cyclists and striking motor vehicle
  - Pedestrian/cyclist undergoes greater acceleration and hence greater risk of injury
- A large speed differential between struck pedestrians/cyclists and striking motor vehicle
  - Striking vehicle is often moving much faster and hence crash forces are likely to be large
- Unlike a car occupant, pedestrians and cyclists have little or no protection in the advent of a crash
  - The full force of the crash will be absorbed by the pedestrian/cyclist

# Human threshold to injury

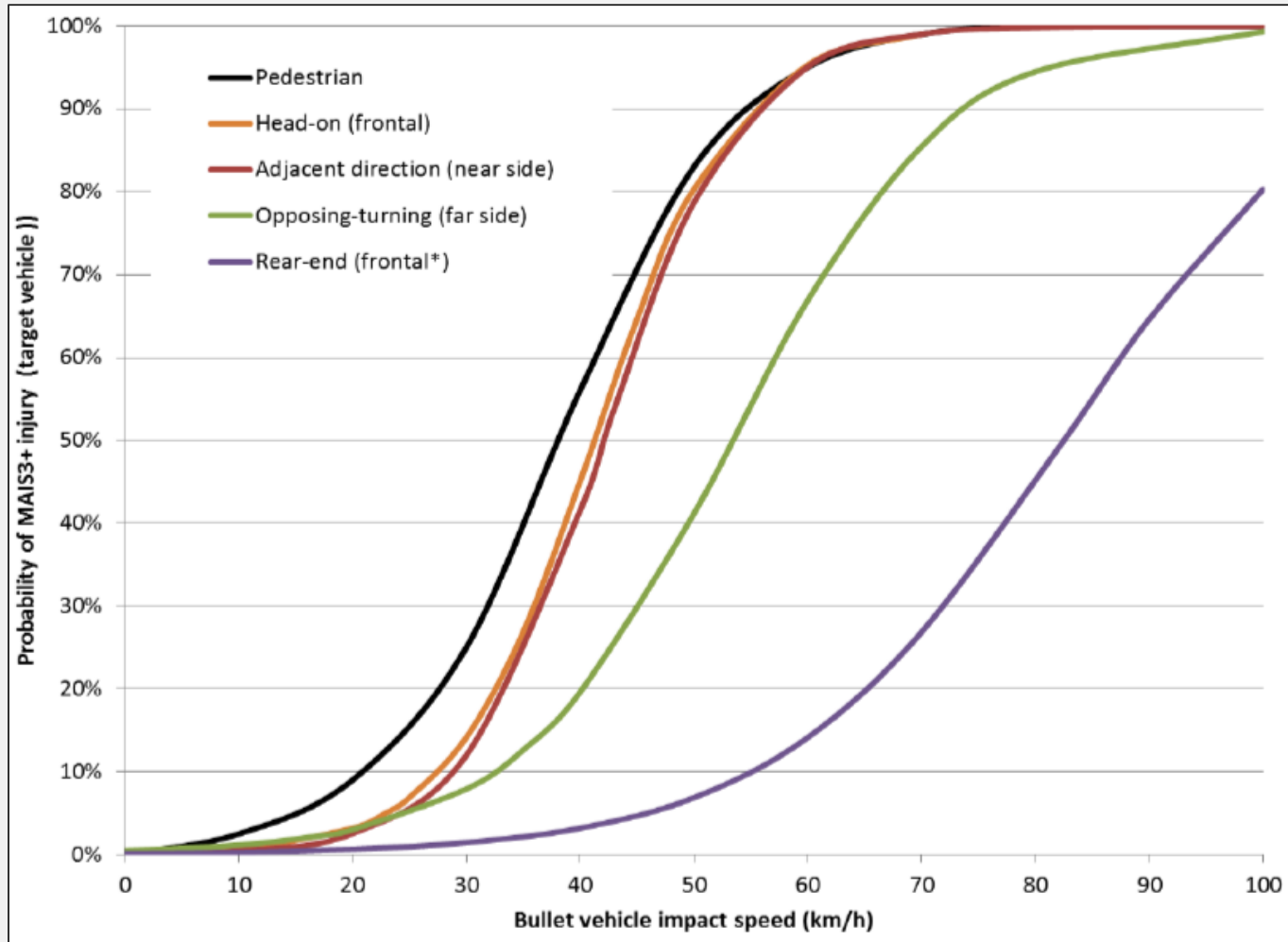


# Human threshold to injury

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# Vulnerability



Sourced from Jurewicz et al. (2015)

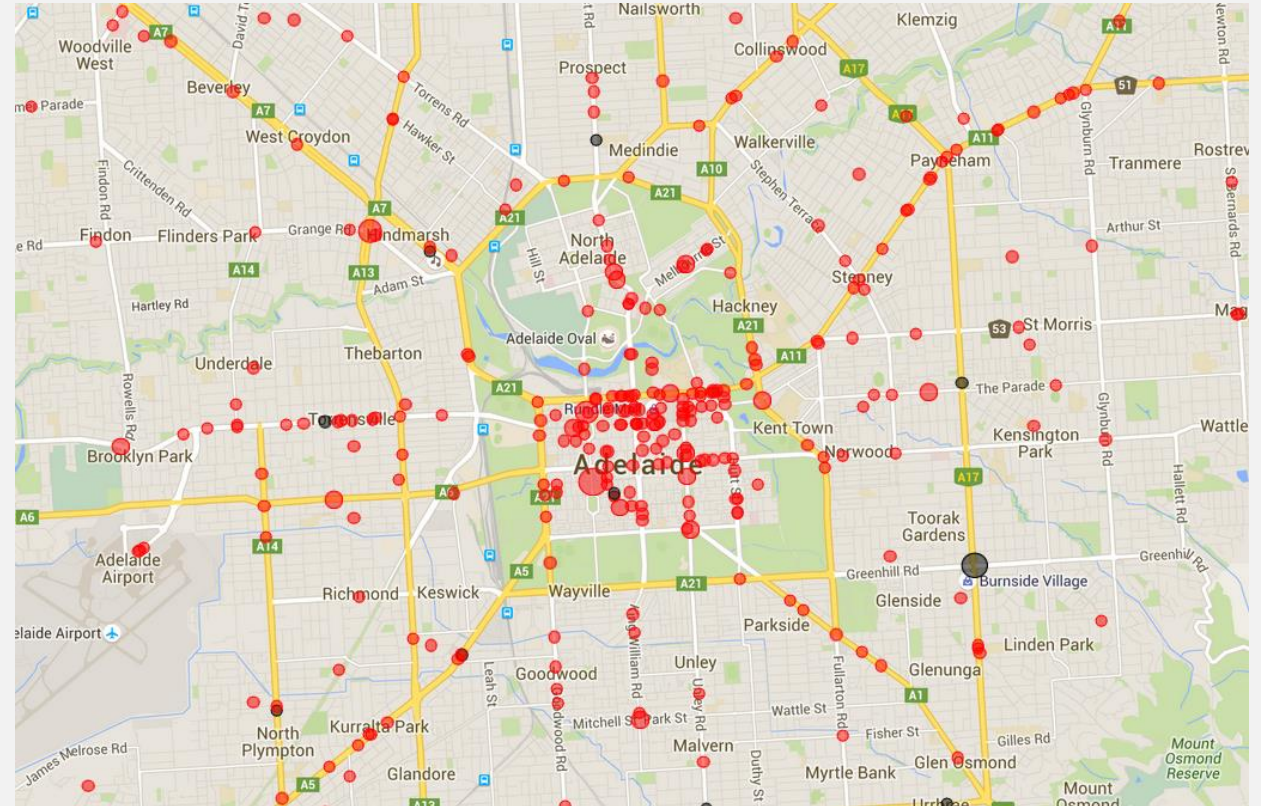
# Pedestrian Safety



# Pedestrians

## Locations of pedestrian crashes

- Concentration of injury crashes in high pedestrian activity areas and along arterial roads (high traffic volumes and speeds)
- Crashes occur along the midblock (uncontrolled crossing) but are often clustered around intersections



**Pedestrian crashes requiring hospital treatment 2012 – 2015 in Adelaide, South Australia**

# Pedestrian protection vs workzone protection





# Intoxicated pedestrians

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## Intoxicated pedestrian issue -> need for more forgiving environments

A study of intoxicated pedestrian crashes in South Australia by Hutchinson et al (2011) found:

- A disproportionate amount of crashes occur on Fridays and Saturdays
- Some 85% of high BAC involved pedestrian crashes occur between 6pm and 4am
- Most crashes occurred midblock, with no (pedestrian related) traffic controls present and speed limits of 50 and 60km/h
- About 15% of crashes occurred within 1km from the Adelaide CBD
  - For both zero BAC and non-zero BAC cases
- Most pedestrians were male, with 71% being 20 to 49 years of age
- 2003-2007: 39% (Fatalities BAC 0.149 9%; BAC >0.15 30% - 91% cases BAC recorded)

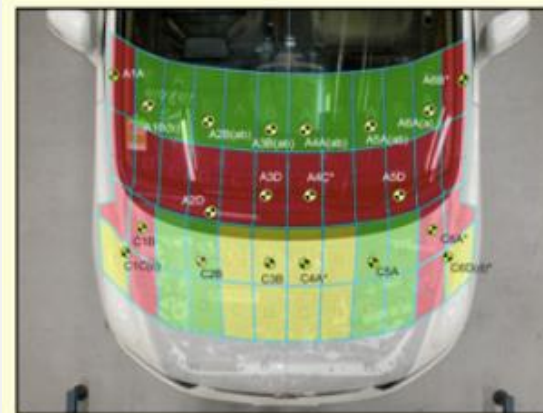
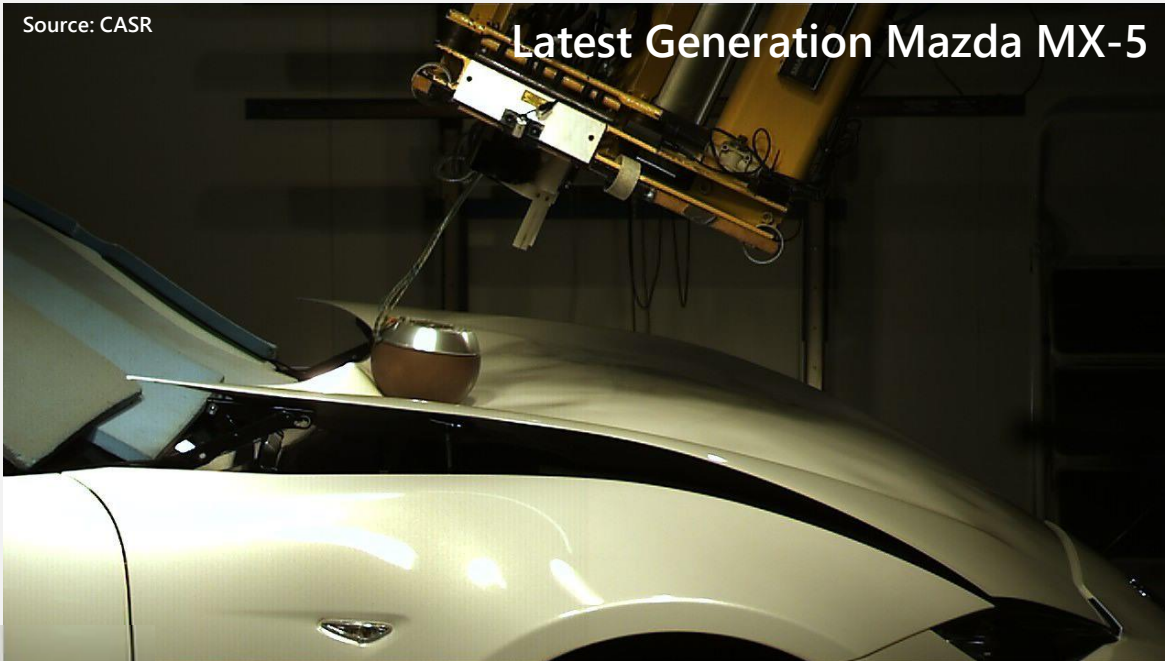
# Vehicle pedestrian protection

## Vehicle passive safety

- Vehicles becoming more pedestrian friendly
- ANCAP requirement to obtain good star ratings

Source: CASR

### Latest Generation Mazda MX-5



Child and adult head impact



Adult leg impact (upper and full legforms)

fair

marginal

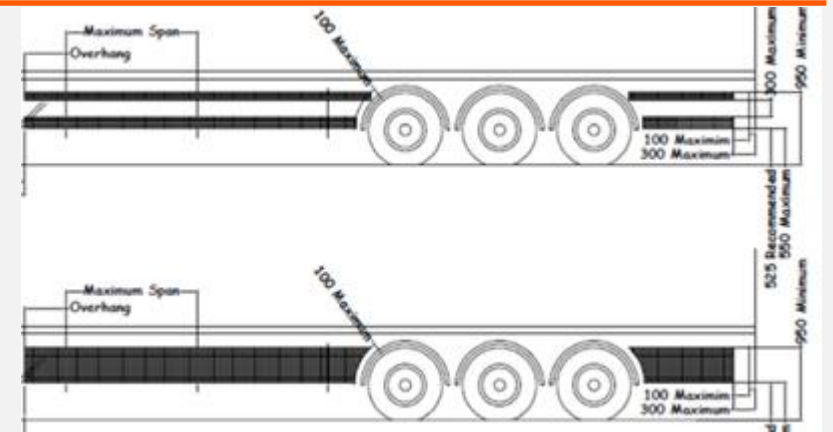
poor

Sourced from CASR <http://casr.adelaide.edu.au/impactlab/ancaptesting/>

# Heavy Vehicles



- Side under-run protection



- Driver assistance systems



# Vehicle pedestrian protection

## Vehicle active safety

### Autonomous emergency braking (AEB)

- 2013 study estimated casualty reduction for then current technology and for best technology thought feasibly possible at present (Edwards et al 2014)
  - 2.9 to 6.2% reductions in fatalities (current)
  - 9.9 to 19.9% reduction in fatalities (best technology)
  - 4.2 to 4.6% reductions in serious injuries (current)
  - 13.6 to 15.8% reductions in serious injuries (best technology)
  - Figures for Great Britain and Germany with entire fleet equipped



Sourced from euroncapcom <https://www.youtube.com/watch?v=FTKxCE5qmQM>



# Pedestrians - Safe System approach

| Hierarchy   | Treatment  | Influence<br>(E = exposure<br>L = likelihood<br>S = severity) |
|---|--|---|
| Safe System options<br>(‘primary’ or<br>‘transformational’<br>treatments)                     | <ul style="list-style-type: none"> <li>• Separation (footpath)</li> <li>• Separation (crossing point)</li> <li>• Very low speed environment, especially at intersections or crossing points.</li> </ul>                      | E<br>L<br>L, S  |
| Supporting treatments<br>(compatible with future<br>implementation of Safe<br>System options) | <ul style="list-style-type: none"> <li>• Reduce speed environment/speed limit</li> <li>• Pedestrian refuge</li> <li>• Reduce traffic volume.</li> </ul>  | L, S<br>L<br>E, L   |
| Supporting treatments<br>(does not affect future<br>implementation of Safe<br>System options) | <ul style="list-style-type: none"> <li>• Pedestrian signals</li> <li>• Skid resistance improvement</li> <li>• Improved sight distance to pedestrians</li> <li>• Improved lighting</li> <li>• Rest-on-red signals.</li> </ul> | L<br>L<br>L<br>L<br>L, S                                      |
| Other considerations  | <ul style="list-style-type: none"> <li>• Speed enforcement.</li> </ul>   | L, S  |

Sourced from Austroads (2016)

# Pedestrians - treatments

## Activity centers

- Focus on promoting walkability
- Better urban design through safe pedestrian design
- A combination of lower speed limits and innovative treatments to guarantee safe interaction speeds
- Emphasis on changed road environment through removal of delineation between pedestrian and motor vehicle areas
- Enlarged pedestrian areas and increased pedestrian comfort



Sourced from Government of South Australia (2012)

# Pedestrians - treatments

## Shared zones

- Emphasis on pedestrian movement over motor vehicle traffic
- Very low speed zones managed by lower speed limits and visual cues
- Vibrant environment promotes pedestrian comfort
- Visually different to motor vehicle prioritised roads to discourage high motor vehicle speeds (ie facility not just for motor vehicles)



Sourced from Government of South Australia (2012)



# Pedestrians - treatments

## At-footpath-grade pedestrian crossings

- Vertical deflection discourages higher than appropriate speed by creating driver discomfort
- Visually different to surrounding road to promote change of priority



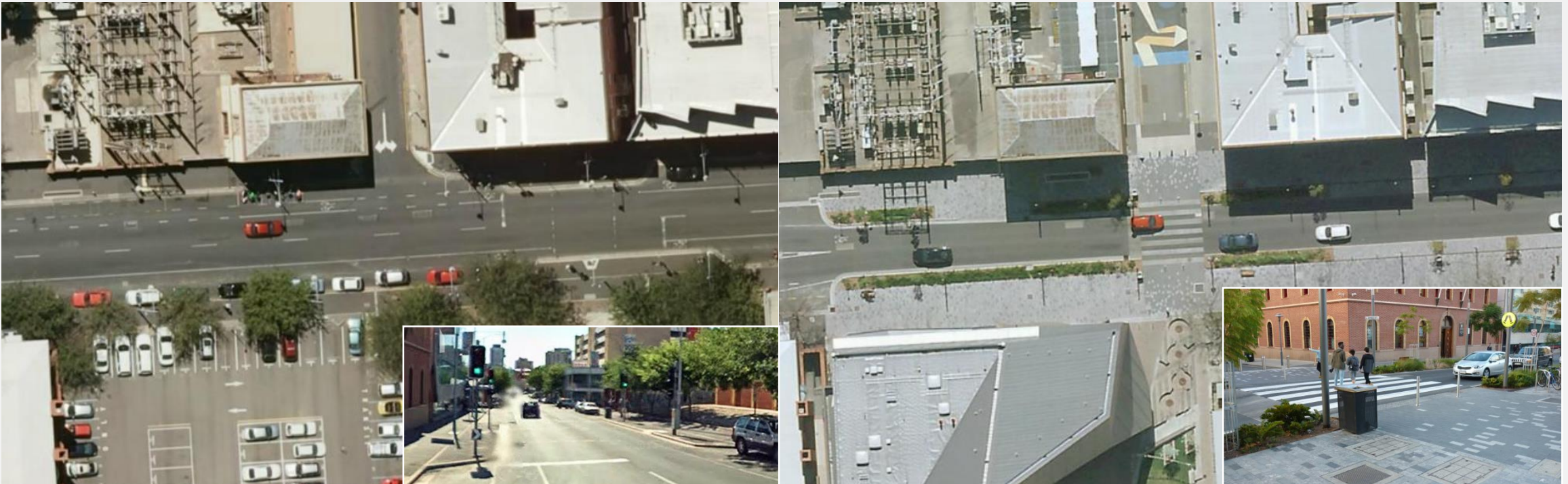


# Pedestrians - treatments

## At-footpath-grade pedestrian crossings

Before

After



Sourced from Aerometrics Metro Maps (2016) and Google Maps (2016)

# Pedestrians - treatments

## Scramble crossings

- Useful in high pedestrian volume areas
- No motor vehicle movements on pedestrian phase
  - Eliminates conflict
- Presents an opportunity for cyclists to cross as well



Source: CASR



# Pedestrians - treatments

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# Pedestrians - treatments

## Grade separation

- Provides physical separation and a safe crossing point for pedestrians
- Suitable for situations where safe interaction speeds cannot be guaranteed
- Not preferential from a livability perspective – access issues for the elderly and disabled





# Pedestrians - treatments

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## Dwell on red

- All approaches remain on a red phase until “called” by a vehicle or pedestrian
- Beneficial at times of low traffic volume
- Especially beneficial where intoxicated pedestrians are encountered
- A study of Melbourne CBD application found some reduction in 85<sup>th</sup> percentile vehicle through speeds (Archer et al 2008)



# Cyclist Safety

# Conflicts

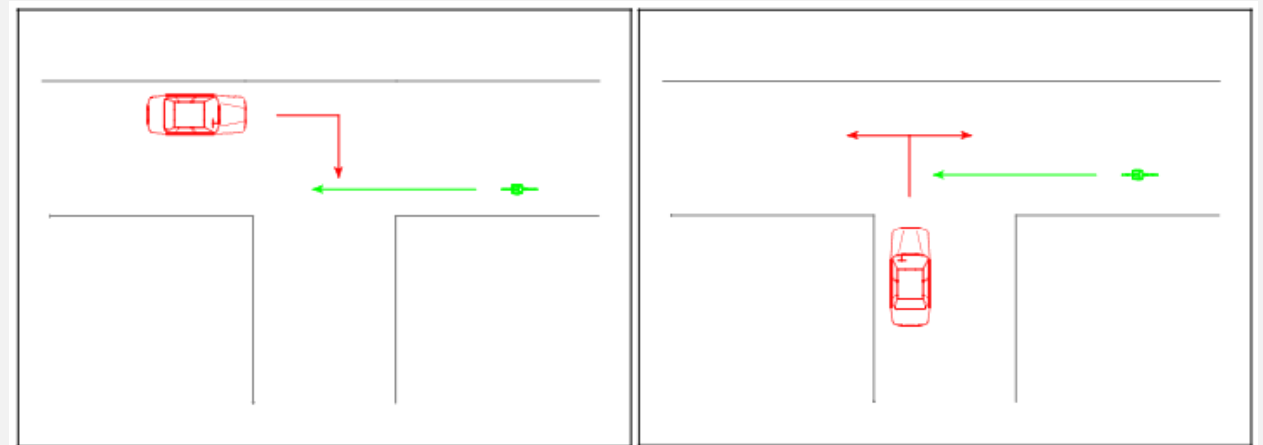
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# Characteristics of Cycling Crashes

## 2013 study of cyclist crashes in Adelaide (Lindsay 2013)

- Most cycling crashes occurred within 10km of the cyclist's home, with almost half being within 2km
- Over half had more than 2 years experience on bicycles and rode more than 5000 km per year
- Males between 36 and 55 years of age were the most common group to be involved in crashes
- Most commonly reported speeds prior to crash were between 20 and 40km/h
- Most crashes occurred between cyclists intending to go straight and turning motor vehicles
- Right turning motor vehicles posed the greatest threat to cyclists, especially when turning over multiple lanes (Right Turn Against)





# Cyclists

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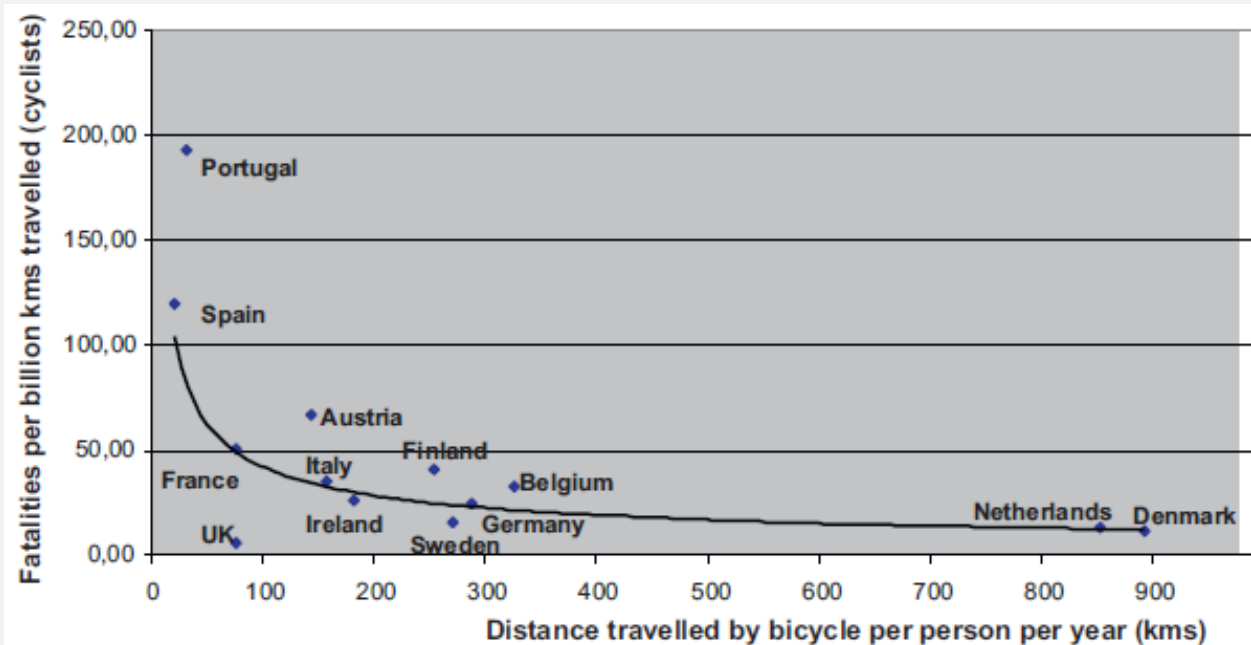
## Gaps in knowledge

- Even in The Netherlands – arguably one of the most advanced safe cycling countries – FSI still occur
  - 2012 – 200
  - 2013 – 184
- Associating impact speed with injury outcomes
- Solo cyclist crashes also lead to serious injuries
  - Limited research is available
  - Public road network and public spaces (parks, bike paths, etc.)
- No single database can provide a complete picture

# Critical Mass

Increased rate of cycling leads to reduced personal risk

- Infrastructure provision -> context where cycling is the “norm”



Sourced from Wegman et al (2012)



# Safety in Numbers

## Not a Safe System solution!

<http://www.theage.com.au/news/sport/doctors-hold-back-news-on-cyclist/2005/07/20/112112002026.html>



<http://www.abc.net.au/cgi-bin/common/printfriendly.pl?news/australia/vic/ballarat/200507/s1418001.htm>



# Cyclists - Safe System approach

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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*




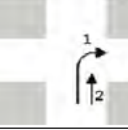
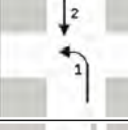
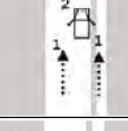
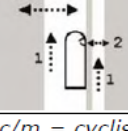
# Cyclists - treatments

## Physical separation

Still no perfect solutions



- Increased bicycle/moped traffic by 20% and decreased motor vehicle traffic by 10% (Jensen 2008)
- Decrease of most cyclist / motor vehicle crashes but increase in non-motor vehicle involved crashes
  - Decrease in car into cyclist crashes, car rear-ended cyclist crashes and cyclist vs parked car crashes (Jensen 2007)
  - Increase in cyclist vs cyclist crashes, cyclist vs pedestrian crashes and turning car into cyclist crashes (Jensen 2007)
  - Rates and injury severity not presented however

| Typical accident situation  | Specific type of accident and manoeuvre | Results   |          |
|---|---|-----------|----------|
|   |   | Accidents | Injuries |
|    | car against c/m in the same direction   | -63 %     | -68 %    |
|   | c/m against c/m in the same direction   | +120 %    | +201 %   |
|    | car against right-turning car           | +70 %     | +177 %   |
|   | right-turning car against c/m           | +129 %    | +161 %   |
|   | right-turning car against pedestrian    | +77 %     | +84 %    |
|    | left-turning car against c/m            | +48 %     | +61 %    |
|   | left-turning c/m                        | -41 %     | -45 %    |
|    | c/m against parked car                  | -38 %     | -56 %    |
|  | entering and exiting bus passengers     | +1951 %   | +1762 %  |
|   | c/m against pedestrians                 | +88 %     | +63 %    |

c/m = cyclists/moped riders. NB the category of mopeds in Denmark confined to driving on cycle tracks is limited to a top speed of 30 kph.

Sourced from Jensen (2007)

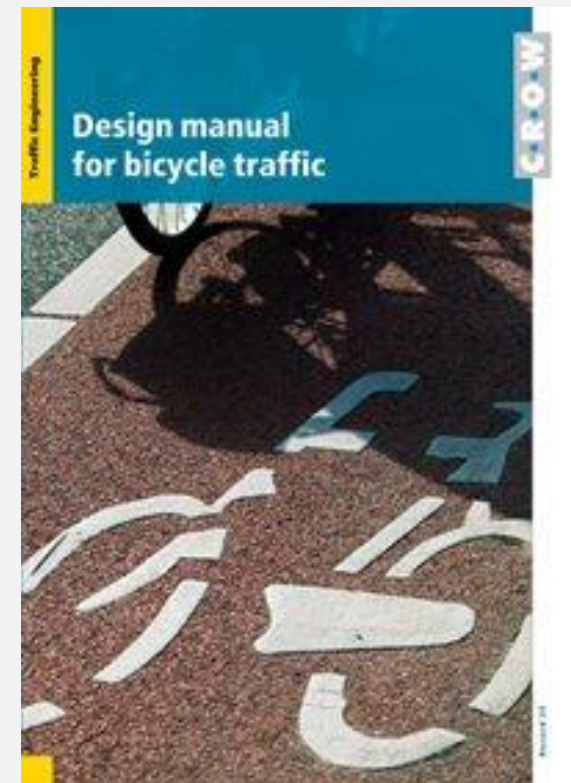
# Cyclists - Safe System approach

| Hierarchy   | Treatment   | Influence<br>(E = exposure<br>L = likelihood<br>S = severity) |
|---|---|---|
| Safe System options<br>(‘primary’ or<br>‘transformational’<br>treatments)                     | <ul style="list-style-type: none"><li>• Separation (separate cyclist path)</li><li>• Very low speed environment, especially at intersections.</li></ul>                   | E<br>L, S   |
| Supporting treatments<br>(compatible with future<br>implementation of Safe<br>System options) | <ul style="list-style-type: none"><li>• Shared pedestrian/cyclist path</li><li>• Cyclist lane</li><li>• Reduce traffic volumes.</li></ul>                                 | E<br>L<br>E, L  |
| Supporting treatments<br>(does not affect future<br>implementation of Safe<br>System options) | <ul style="list-style-type: none"><li>• Separate cyclist signals at intersections</li><li>• Cyclist box at intersections</li><li>• Skid resistance improvement.</li></ul> | L<br>L<br>L   |
| Other considerations  | <ul style="list-style-type: none"><li>• Speed enforcement</li><li>• Enforcement of other regulations.</li></ul>   | L, S<br>L   |

# Dutch cycling infrastructure treatments

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[bicycledutch.wordpress.com](http://bicycledutch.wordpress.com)



# Key Design Aspects

## Vehicle setbacks



[www.fhwa.dot.gov](http://www.fhwa.dot.gov)

[lcc.org.uk](http://lcc.org.uk)





## Junctions



# Key Design Aspects

## Roundabouts





# Key Design Aspects

## Bus Stops



# Cyclists - traditional approach

Dedication of road space to vehicles leads to significant compromises

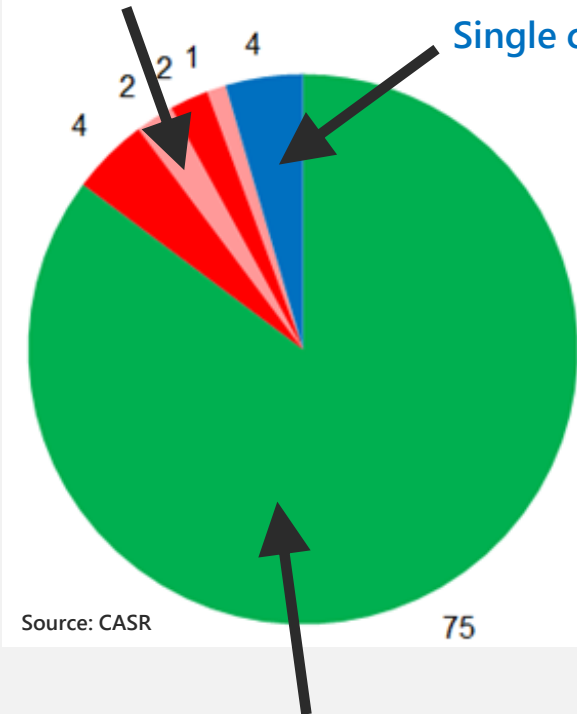


Source: CASR

## Crashes at roundabouts

Vehicle in circulation  
vs. entering cyclist

Single cyclist crash



Source: CASR

Cyclist in circulation vs. entering vehicle



# Cyclists - treatments

## Very low speed environments

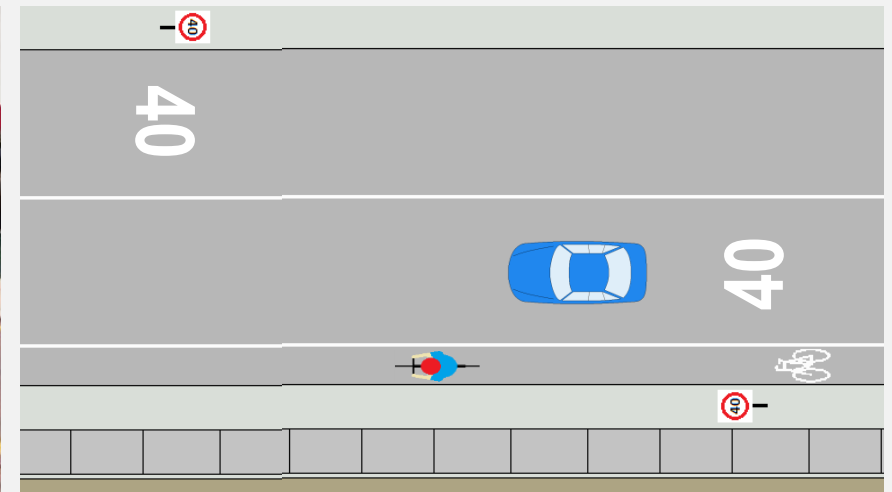
- Mixing of bicycle and motor vehicle traffic at or below the Safe System threshold of ~30 km/h
- Especially beneficial where cyclist traffic volumes are high and motor vehicle traffic volumes are low
- Low speed environments (~40km/h) are beneficial but may still require delineation of traffic streams



Source: Kenn Beer



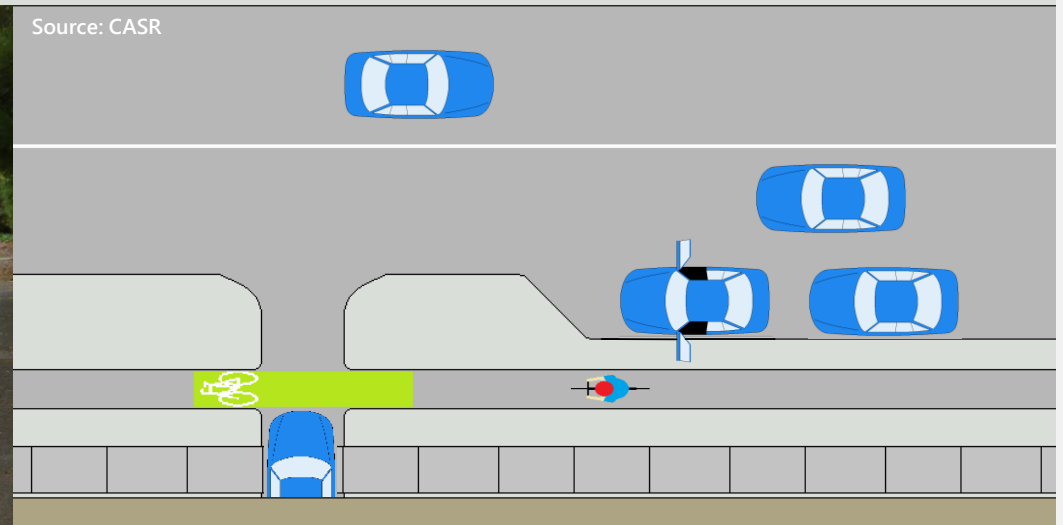
Sourced from Government of South Australia (2012)



# Cyclists - treatments

## Physical separation

- Can provide near Safe System performance when well designed and integrated into the road environment
- Intersections are still a major challenge – grade separation is the only way to continue full separation of traffic streams





# Cyclists - treatments

## Physical separation



*Two-way bicycle paths in Sydney*

Sourced from Austroads (2014)

# Cyclists - treatments

## Physical separation



*Separated bicycle lanes in Melbourne CBD (left) and Adelaide CBD (right)*



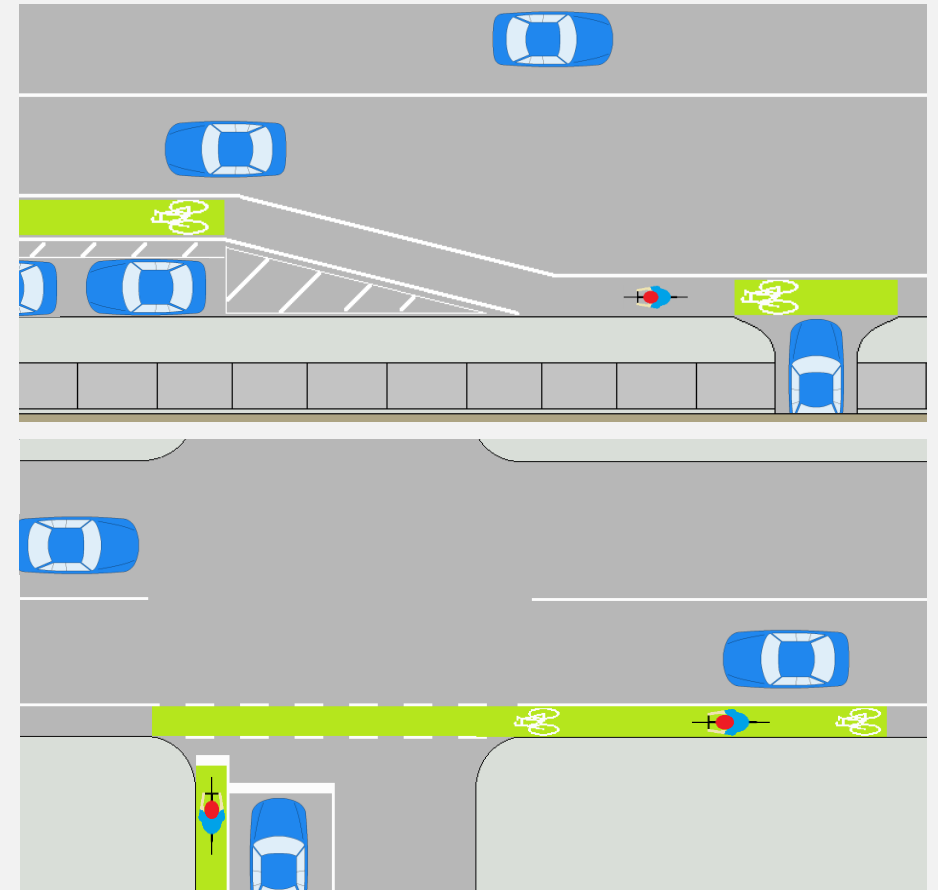
# Cyclists - treatments

## Improved delineation (painted bicycle lanes, buffered bicycle lanes)

- Provide greater conspicuity of bicycle spaces
- May improve recognition of cyclists at intersections – yet to be scientifically tested
- Buffered bicycle lanes give additional room between cyclists and parked vehicles/traffic streams



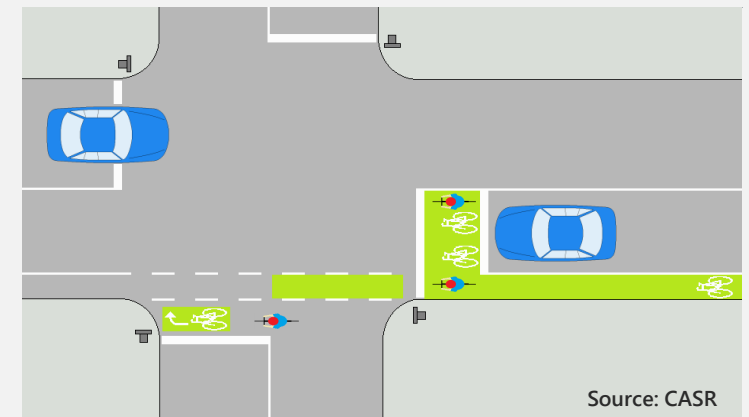
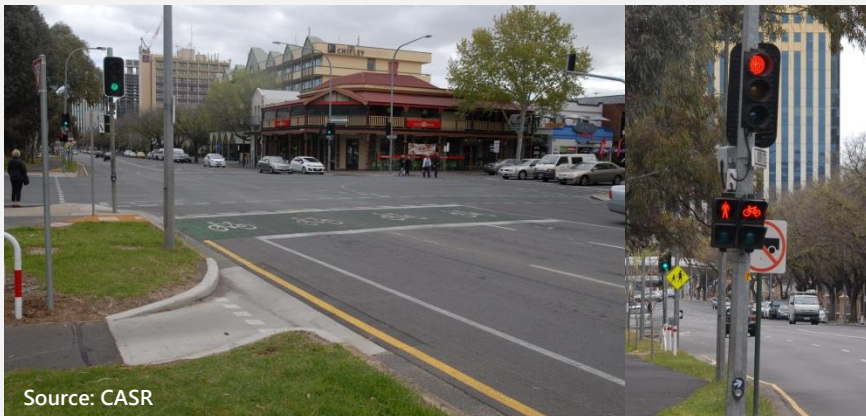
<https://www.bicyclenetwork.com.au/general/policy-and-campaigns/646/>



# Cyclists - treatments

## Bicycle boxes and hook turns (signalised intersections)

- Provide priority for bicycles at intersections
- Encourages cyclists to place themselves in a position where drivers are more likely to see them
- Can be combined with a separate signal phase for cyclists
- Hook turns allow cyclists to perform right turns in two stages without the need to cross traffic lanes

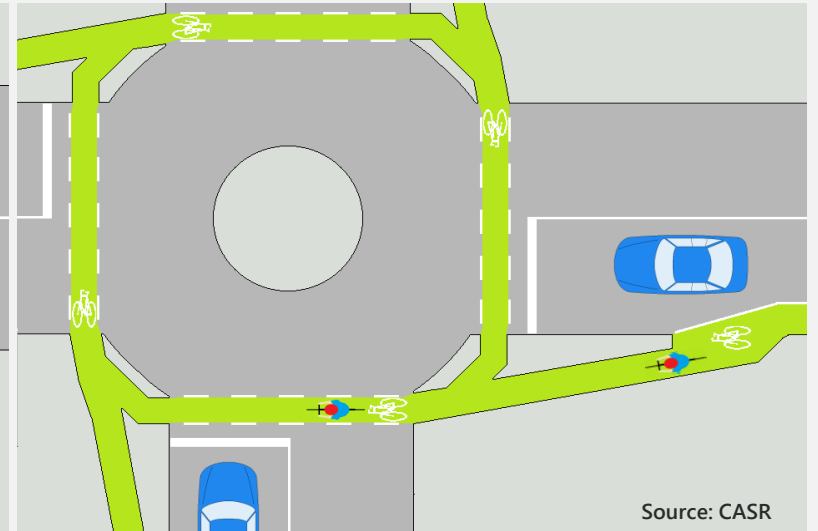
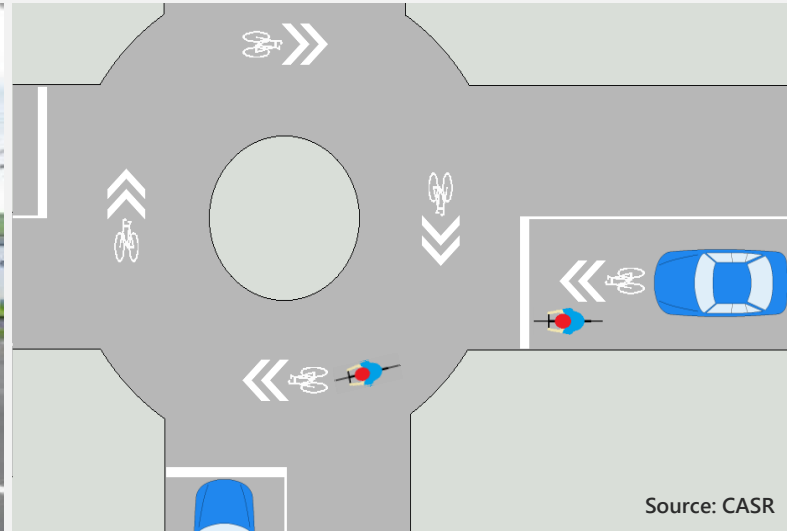


# Cyclists - treatments

## Roundabouts

- Cyclist involved FSI crashes over-represented at roundabouts (>30%) compared to other intersection types (Austroads 2014)
- Encouraging mixing of traffic where speeds can be managed to at or below 30 km/h
- Provision of separate bicycle paths where speeds cannot be managed to appropriate levels
- Evidence to suggest that circulating bicycle lanes decrease cyclist safety (Austroads 2014)

Source: Austroads (2014)



# **Accommodating the Active Travel Modes**



# Promotion of active travel modes

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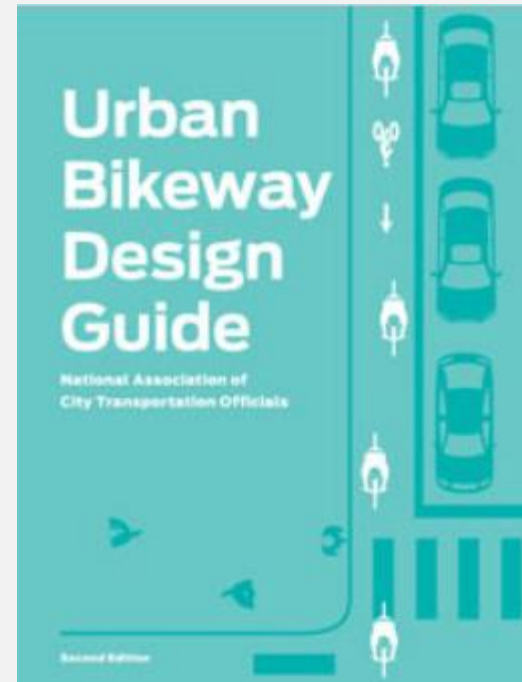
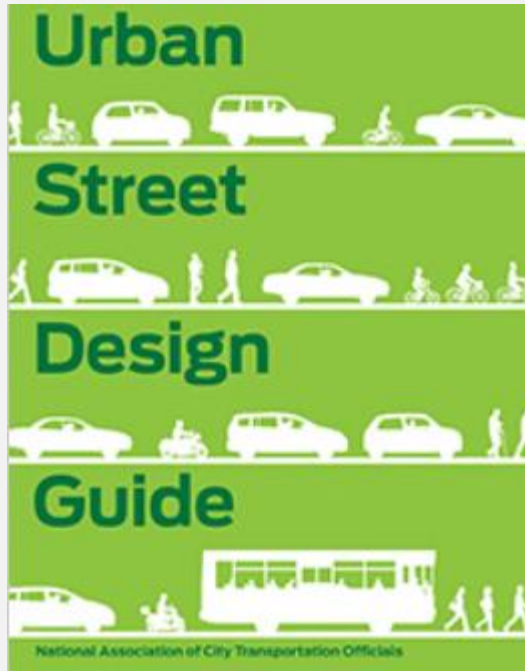


## Promotion of walking and cycling as alternative travel modes

- National and international policies are encouraging active travel modes over conventional private motor vehicle use
  - Increase in walking and cycling
  - Increased combined trip modes - public transport use combined with walking/cycling
  - Promotion of active travel for population health and wellbeing
- Link and place approach
  - Acknowledging link functions but creating places where people are comfortable to undertake their activity
  - Road's social function as well as its transport function
- Move towards vibrant cities
  - Increased social function of public spaces leading to more active travel

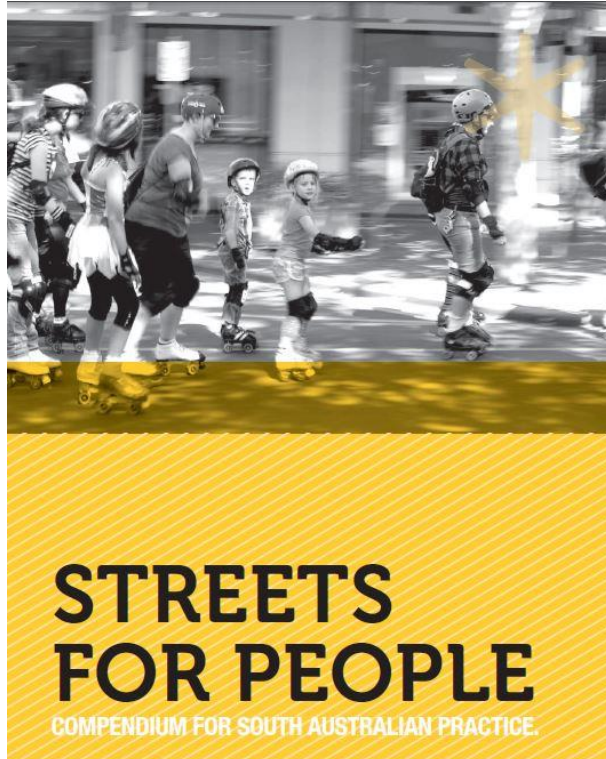
# Promotion of active travel modes

## Example – NACTO Urban Street & Urban Bikeway Design Guides



All images sourced from NACTO <http://nacto.org>

# Promotion of active travel modes



<http://eaactivelivingcoalition.com.au>

**CITY OF SYDNEY**

Cycle Strategy and Action Plan

2007 – 2017



*city of villages*



Ministry of Transport  
TE MANATU WAKA

Raising the Profile  
of Walking and Cycling  
in New Zealand

A GUIDE FOR DECISION-MAKERS



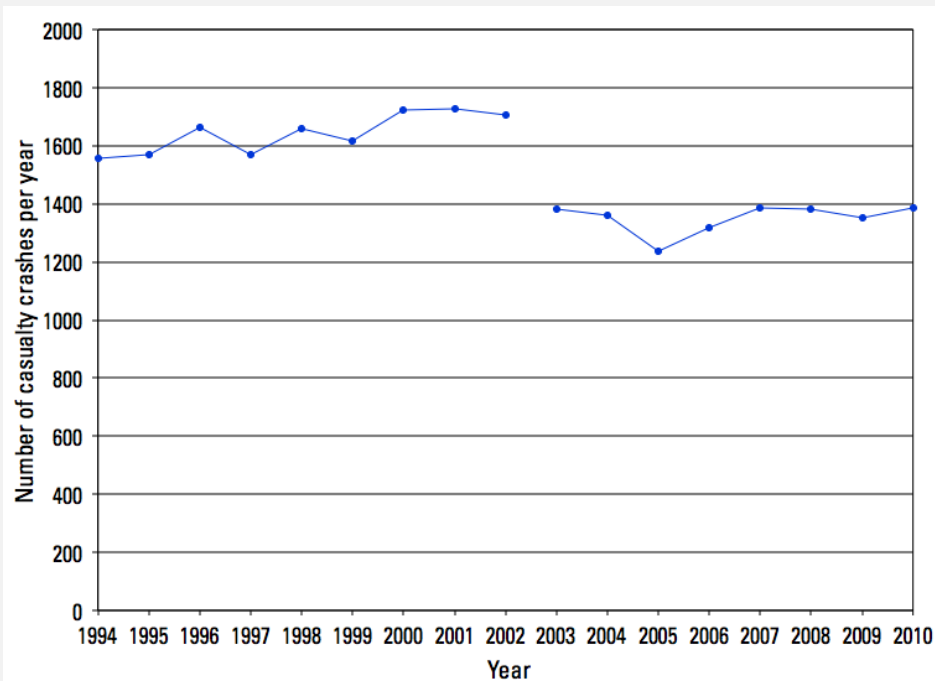
BICYCLE PLAN

2016-2020



# Speed management

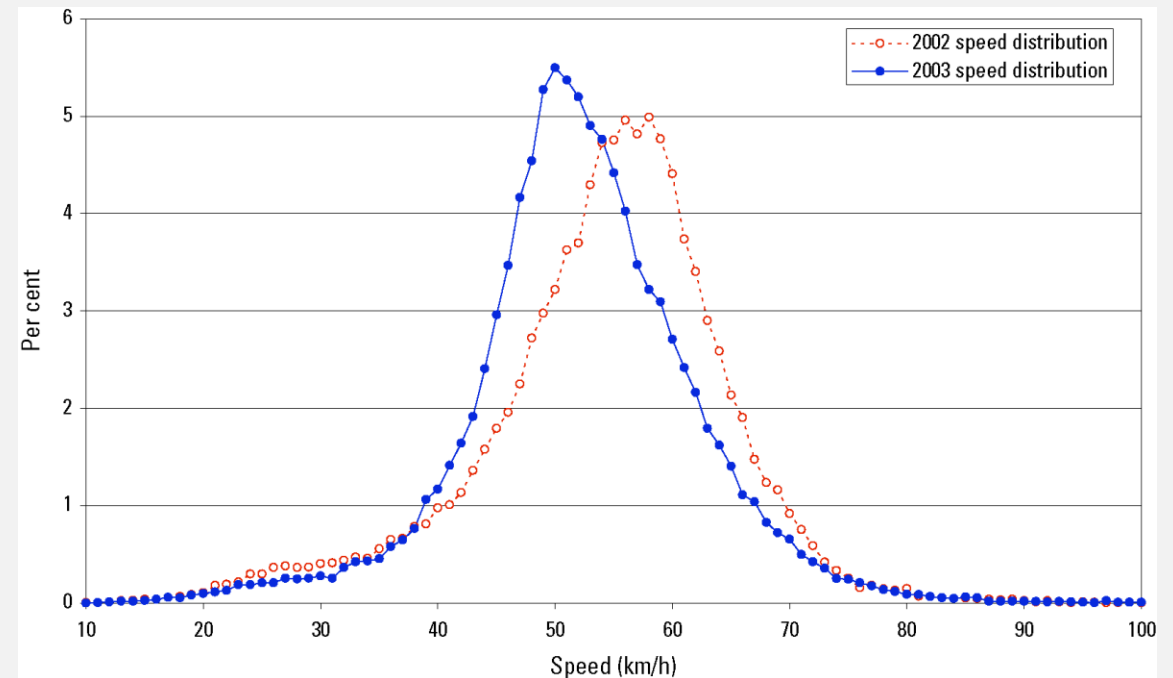
## Safe System speeds are key to increasing pedestrian and cyclist safety



Sourced from Kloeden et al. (2011)

**Average number of casualties before/after  
introduction of 50km/h default urban speed limit in  
SA**

## Urban collector road speed distributions before/after introduction of 50km/h default urban speed limit in SA

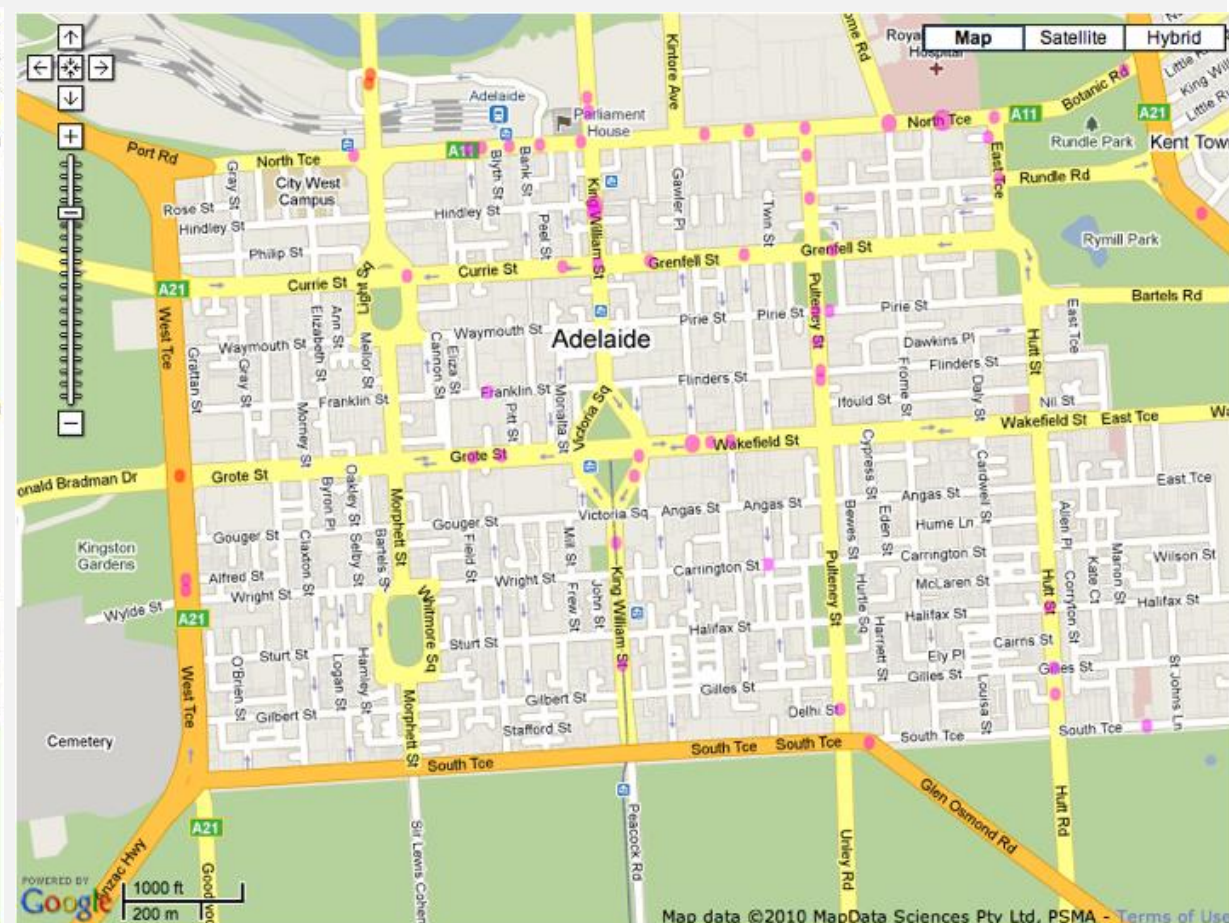
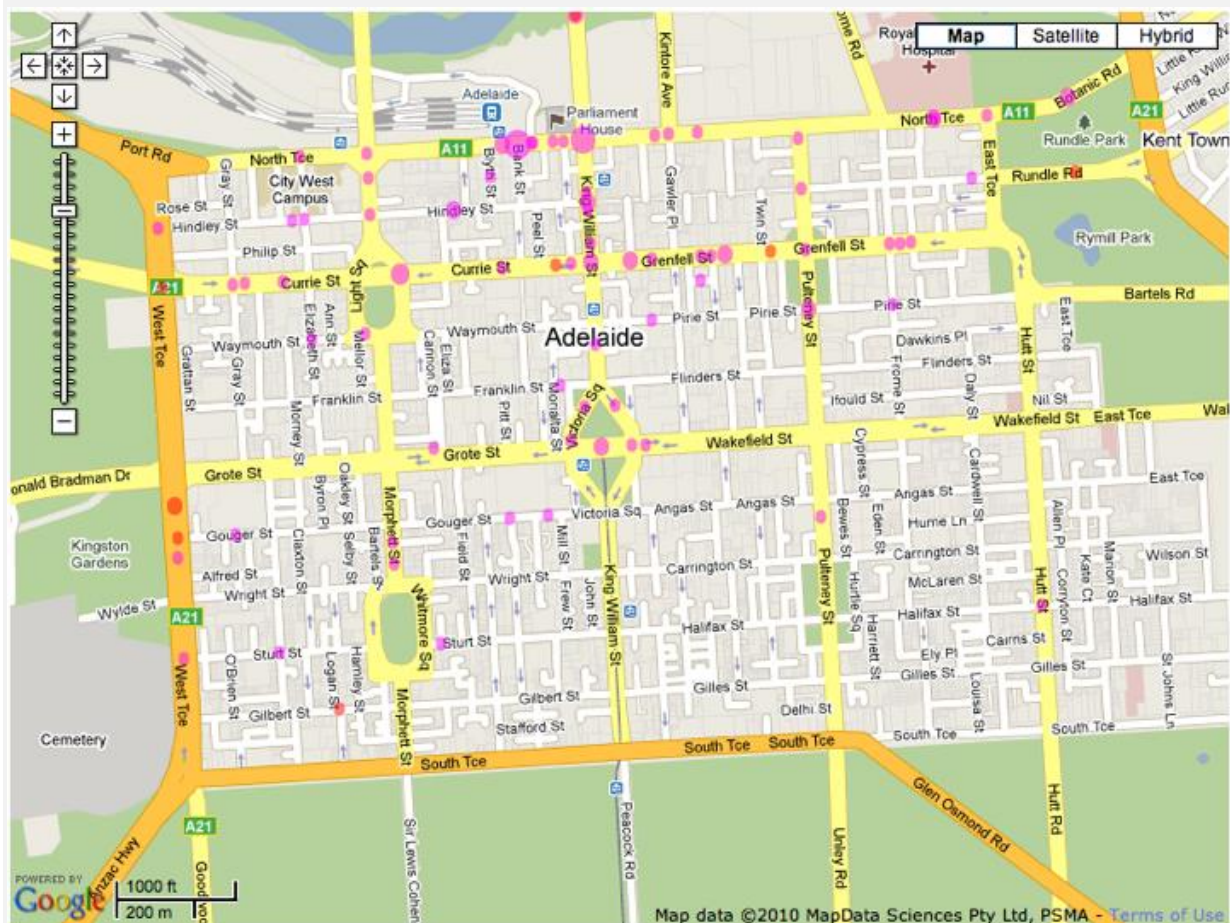


Sourced from Kloeden et al. (2004)



# Speed management

## Default Urban Speed Limit Adelaide CBD – 5 years before and after 60 → 50km/h



# Wrap-up

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## Conclusions and key points

- Safe interaction speeds must be achieved where segregation cannot be achieved
  - Think about how we use infrastructure to guarantee this
- Exposure is likely to increase for these groups into the future
  - We must compensate for this somehow or else absolute numbers of FSI will increase
  - As vehicle occupant safety increases, pedestrian and cyclist injury will become increasingly larger proportion of road safety problem
- Use the place making / vibrant city emphasis to assist you
  - Good examples exist elsewhere
- We still need to innovate and trial different treatments
  - Hard conversations on taking away motorised vehicle space

**Thank you**



Austroads. (2014). "Cycling infrastructure: selected case studies." Austroads, Sydney, Australia.

Government of South Australia. (2012). "Streets for people."

Austroads. (2016). "Safe system assessment framework." Austroads, Sydney, Australia.

Hutchinson, T., Kloeden, C., Lindsay, V. (2011). "Intoxicated pedestrians: accident data from South Australia". *Transport Engineering in Australia*, 13(1), 41-48.

Jensen, S., Rosenkilde, C., and Jensen, N. (2007). "Road safety and perceived risk of cycle facilities in Copenhagen." *Presentation to AGM of European Cyclists Federation*,

Lindsay, V. (2013). "Injured cyclist profile: an in-depth study of a sample of cyclists injured in road crashes in South Australia." 1921645504, Centre for Automotive Safety Research, University of Adelaide, Adelaide, Australia.

Prato, G., Kaplan, S., Rasmussen, T., and Hels, T. (2015). "Infrastructure and spatial effects on the frequency of cyclist-motorist collisions in the Copenhagen Region." *Transportation Safety & Security*, 1-15,