Road Safety Research, Policing and Education Conference 2013

Brisbane Convention & Exhibition Centre

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29 August 2013

Presentation Topic

The influence of road design speed, posted speed limits and lane widths on speed selection :

A literature synthesis

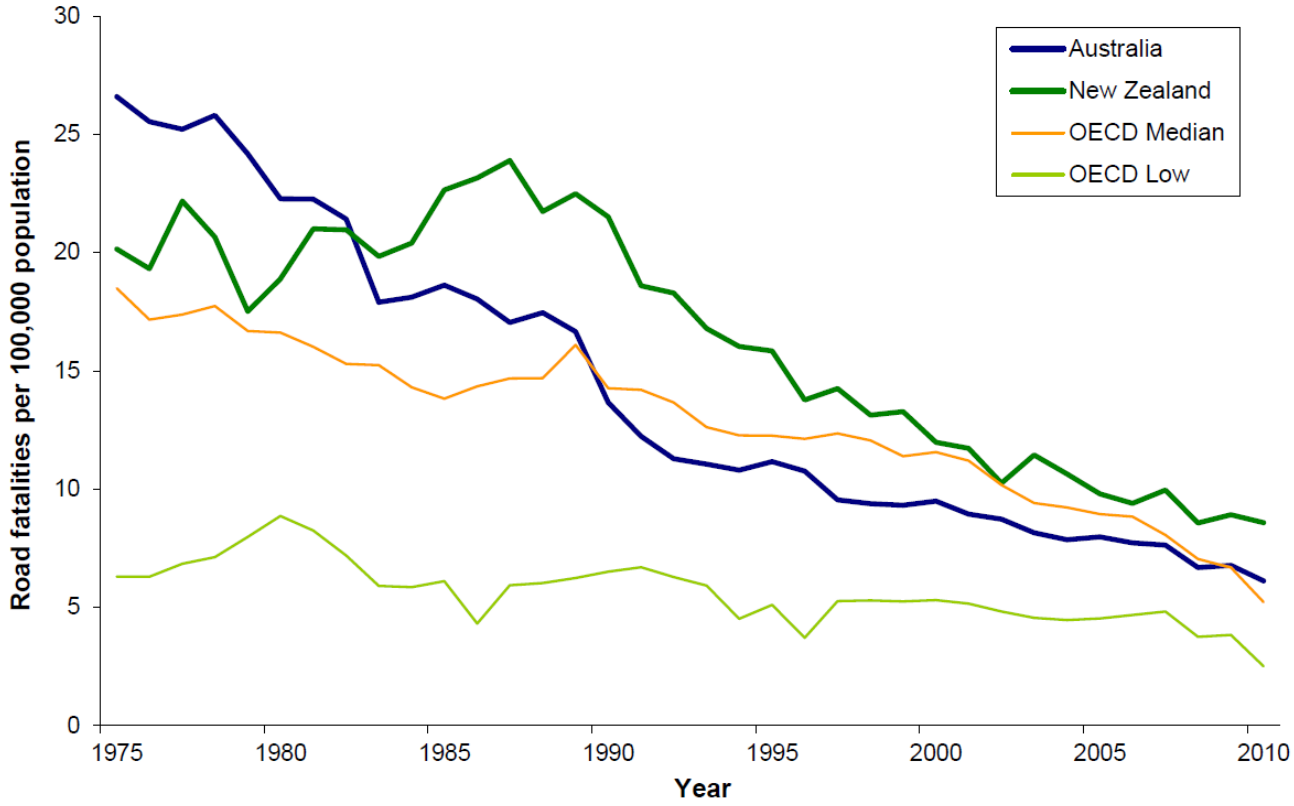
Literature Review

Here's what we know…..

Fatal, Age 52

Fatal, Age 50

Road Crashes

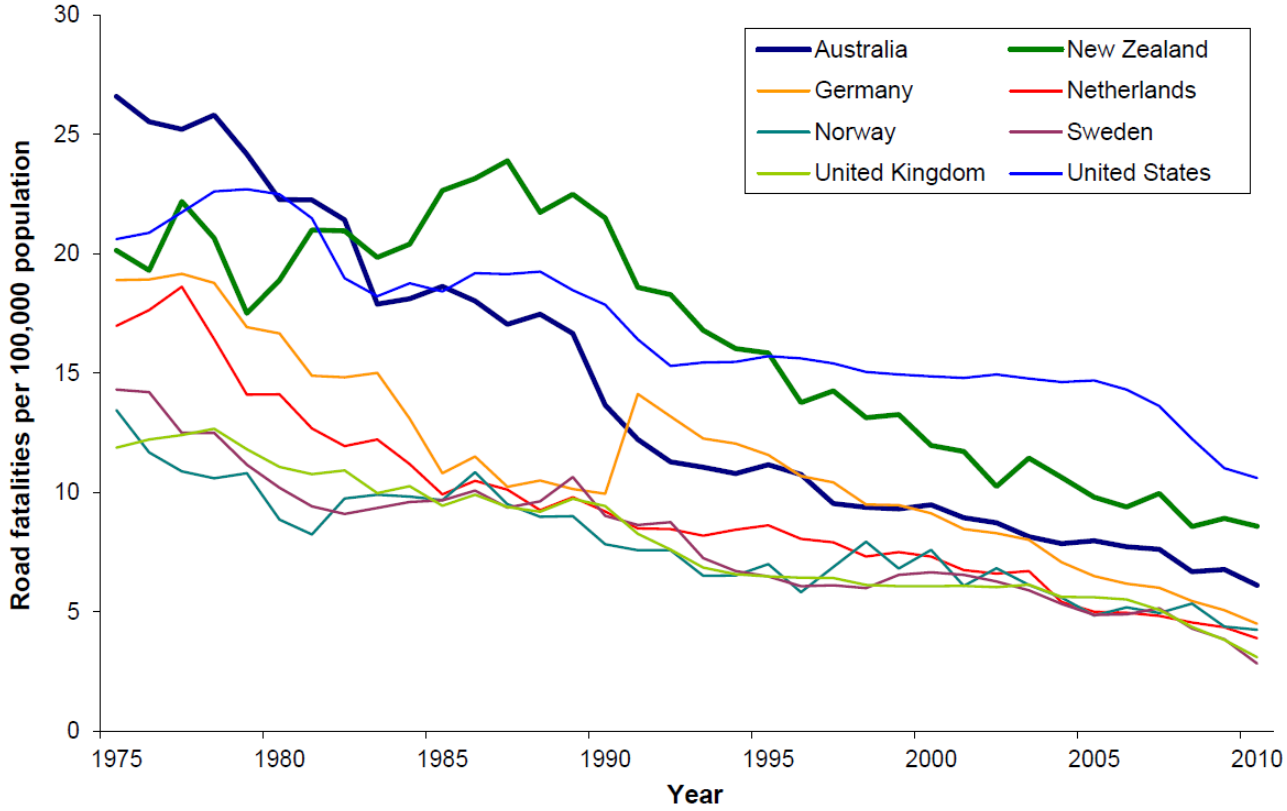


Data sourced from: OECD (2012a), OECD (2012b).

Figure 3.1: Progress in reducing road fatalities per 100 000 population in Australia and New Zealand compared to OECD benchmarks 1975–2010

Source: Austroads AGRS02-13 (2013)

Road Crashes

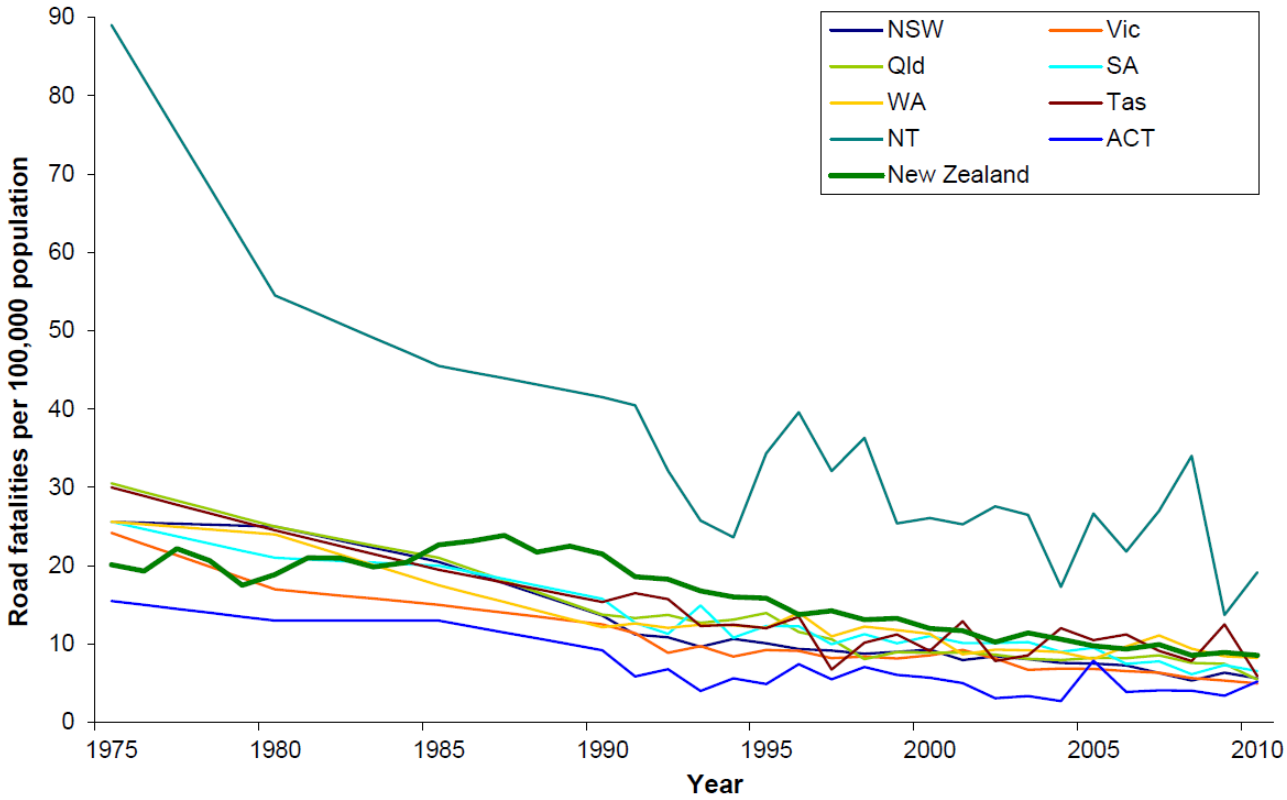


Note: In 1991 there was a change in the coding of fatalities in Germany and this is reflected by the sharp increase in the rate of fatalities per 100 000 population.
Data sourced from: OECD (2012a), OECD (2012b).

Figure 3.2: Road fatalities per 100 000 population in Australia, New Zealand and selected OECD countries 1975–2010

Source: Austroads AGRS02-13 (2013)

Road Crashes



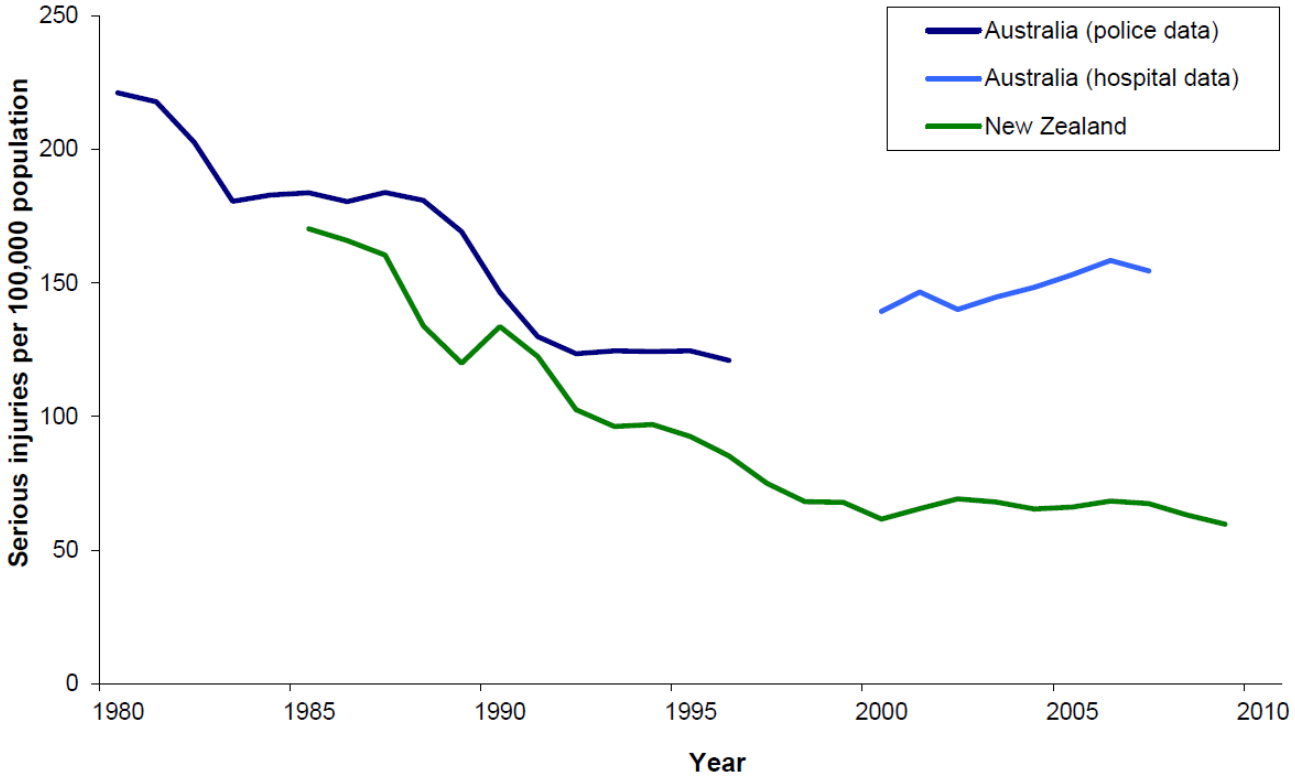
Note: Data was only available at five yearly intervals between 1975 and 1990 for the Australian jurisdictions.

Data sourced from: ABS (2010), DITRDLG (2009b), OECD (2012a), OECD (2012b).

Figure 3.4: Road fatalities per 100 000 population in Australia and New Zealand 1975–2010

Source: Austroads AGRS02-13 (2013)

Road Crashes



Data sourced from: ABS (2010), Henley & Harrison (2011), ATSB (2004), Ministry of Transport (2010b).

Figure 3.6: Serious injuries per 100 000 population for Australia and New Zealand, 1980–2009

Source: Austroads AGRS02-13 (2013)

Road Crashes

- Road crashes are a leading cause of death and injury both in Australia and worldwide
- Countermeasures for some high risk behaviours have reduced deaths and injuries over the past two decades
  - random breath testing
  - speed cameras
- Reductions appear to have essentially plateaued since 2003
- Most injuries are the unintended consequences of individual actions in a risky environment, not due to fate or to problem behaviour.

Sources: Murray Lopez (1997), Edquist et. al. (2009), Connelly Supangan(2006), BITRE(2010), Hedlund(2000)

Excessive Speed

- Speed not only affects the severity of a crash, but is also related to the risk of being involved in a crash
- Mannering(2009) : Without exception, a vehicle that moved (much) faster than other traffic around it, had a higher crash rate
- Excessive speed was assigned as a major factor in fatal crashes more frequently in the 2000s than in the 1990s
  - Averaged 28% of crashes to 33% in 2006.

Sources: Mannering(2009) ,BITRE(2010), Aarts(2005), Jamson(2005), Taylor et.al.(2000),Elvik(2004), Letirand(2004), Hedlund(2000)

Speed Choice
Geometric Design Elements

Speed Choice and Design Elements

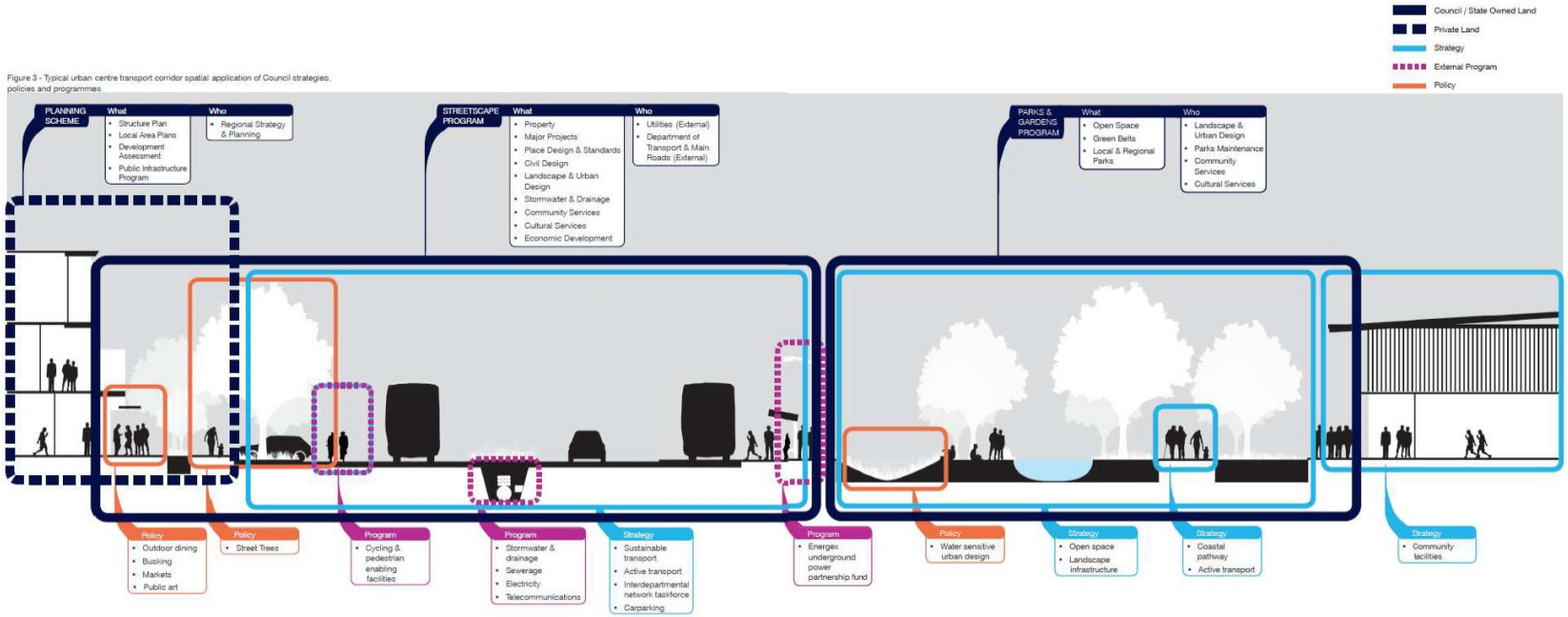
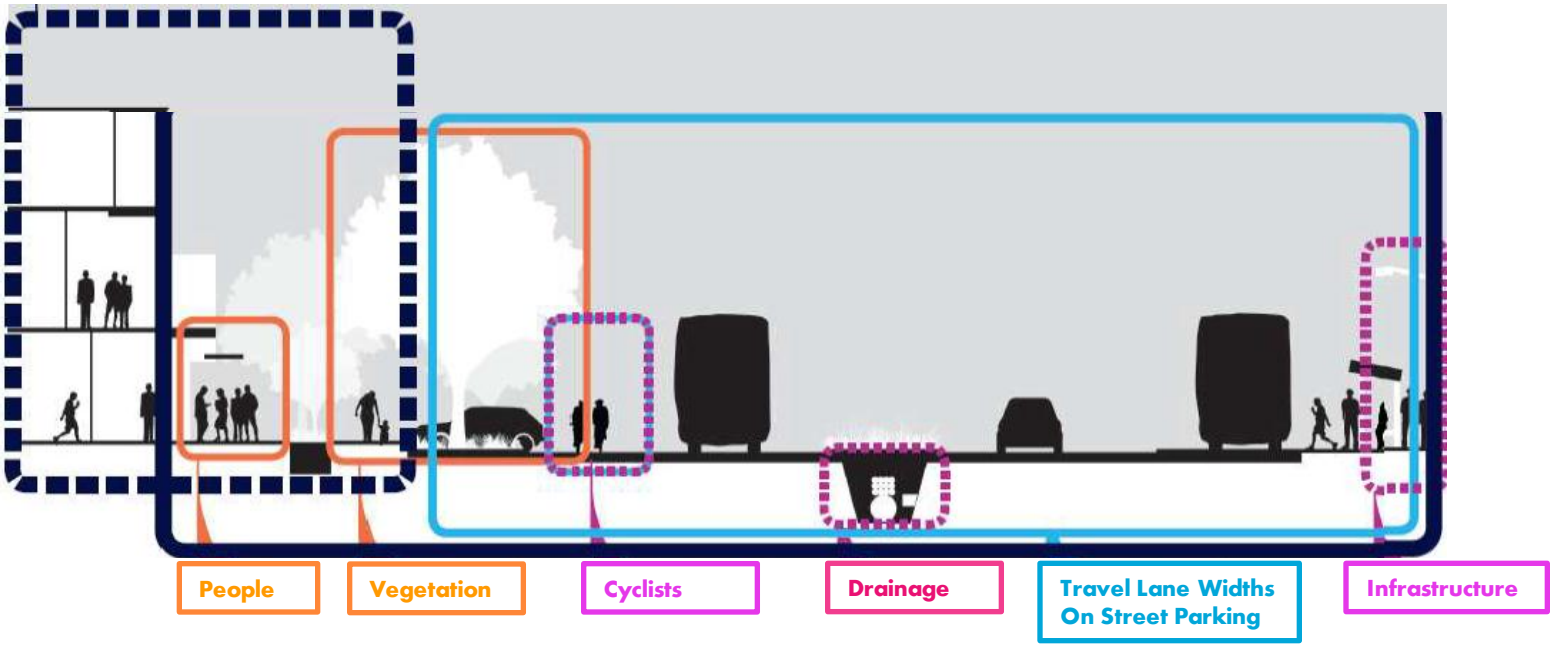


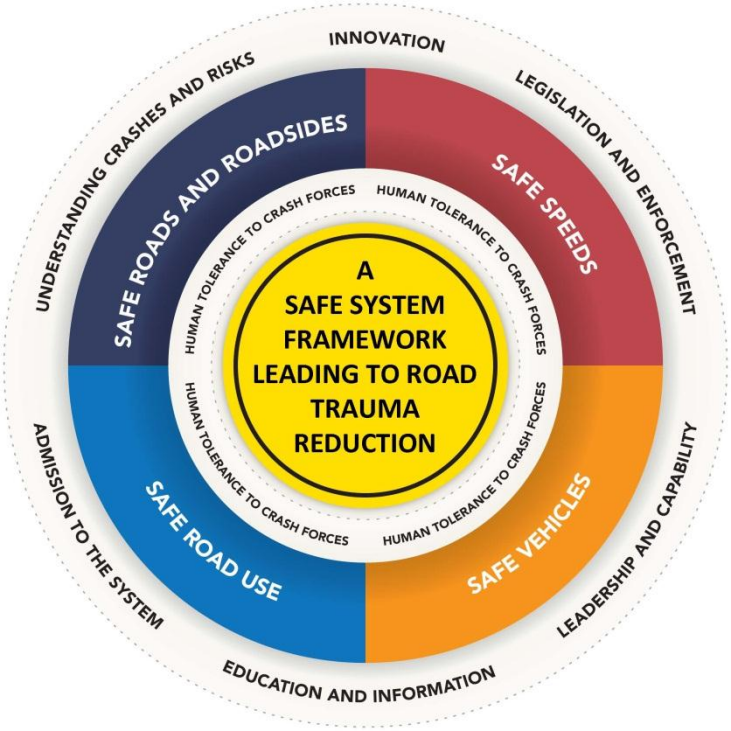
Figure 3 - Typical urban centre transport corridor spatial application of Council strategies, policies and programmes

Speed Choice and Design Elements



Speed Choice and Design Elements

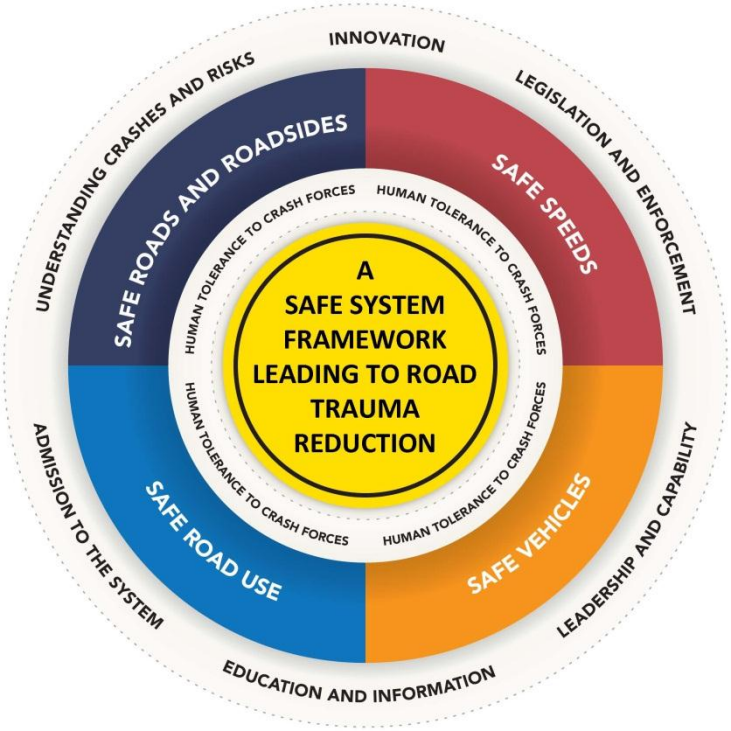
- Safe System Framework
- Based on 3 basic principles
  - People make mistakes
  - Human physical frailty
  - A 'forgiving' road transport system
- Ensure that the forces in collisions do not exceed the limits of human tolerance.



Source: Austroads AGRS02-13 (2013)

Speed Choice and Design Elements

- Safe System Framework
- Speeds must be managed so that humans are not exposed to impact forces beyond their physical tolerance
- Consider Limits of the human body in designing and maintaining roads, vehicles and speeds.



Source: Austroads AGRS02-13 (2013)

Speed Choice and Design Elements

- Context Sensitive Design
- Aims Appropriate Balance
  - Safety
  - Mobility
  - Community needs
  - Environment needs
- Combination of design elements
- Experience and judgment
  - assisted by objective measurement and research.

Source: DTMR2005, Austroads (2006)

Speed Choice and Design Elements

- Geometric design guides generally do not provide quantitative information on the relationships between crash risk and the standard adopted of should be selected for a design element

- As a result, typically decisions regarding the adoption of 'above minimum' standards or a standard less than the recommended value in a constrained situation, have to be made with only a limited appreciation of the safety implications.

Source: Austroads AP-T146-10 (2010)

Speed Choice and Design Elements

- Consistency of design for each type of function in each terrain type regardless of location
  - critical to the reduction in driver decision making uncertainty
- Fildes & Jarvis(1994) emphasise the importance of these changes in road design
  - mixture of sensory and cognitive aspects
- Leads to the concept of a "self-explaining road".

Source: DTMR(2005), Edquist et. al. (2009)
Martins et. al. (1997),Fuller Santos(2002),Shinar Ben-Bassat(2011)

Speed Choice and Design Elements

- "Self-explaining road"
- Drivers make fewer errors
  - at geometric features that conform with their expectations
  - consistent roadway design should ensure that most drivers confidently operate safely
  - desired speed along the entire alignment
- Errors more likely when there is some disparity between what drivers may believe to be a 'safe' speed and the actual speed at which a feature can be negotiated safely.

Source: Martins et. al. (1997), Tate F. Turner (2007)

Speed Choice and Design Elements

- Temporal Effects
  - weather conditions
  - time of day
  - season variations
- Choice of speed may be the result of a number of factors
  - Age
  - Risk of apprehension
  - Attitudes
  - Interaction with each other.

Source: Haglund Aberg(2005)

Speed and Travel Time

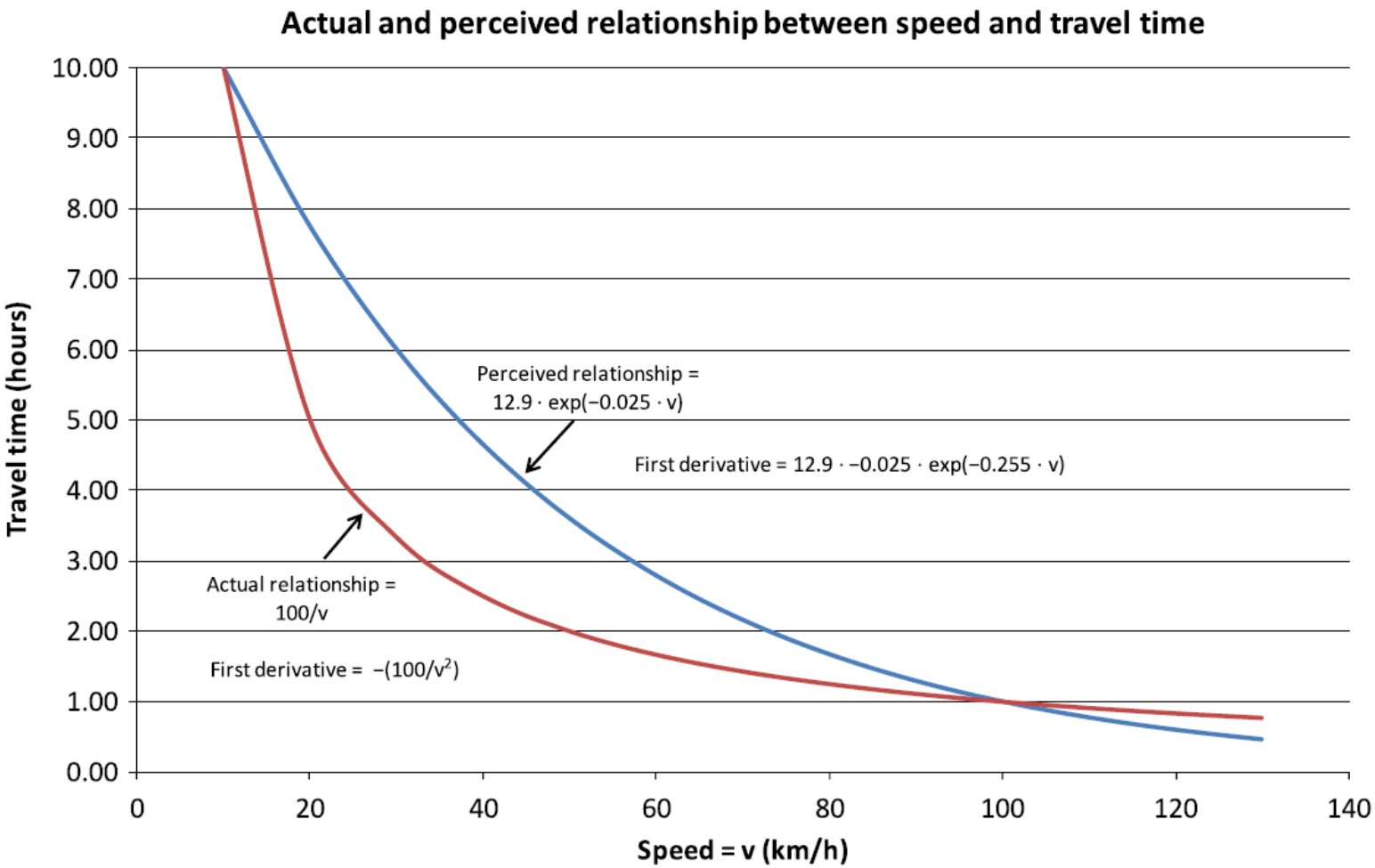


Fig. 1. Actual and perceived relationship between speed and travel time for a given travel distance.

Source: Elvik(2010)

Speed Choice and Design Elements

- Aspects of the actual road infrastructure that influence speed choice:
  - lane and road width, road shoulder width number of lanes
  - radius of road curvature, length of curves
  - delineator type, number, spacing, condition
  - pavement markings, road edge guide posts, signing conventions
  - intersecting roads or driveways, intersection treatments
  - traffic flow, traffic conditions
  - parked cars, roadside environment
  - roadway grade.

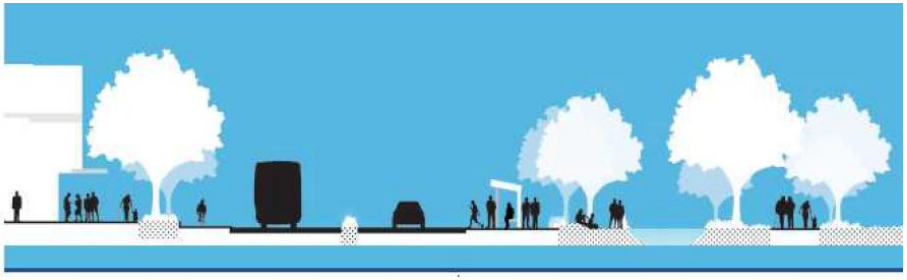
Source: Mannering(2009), Sayed(2004), DTMR(2005), Fildes et. al.(1987)

Speed Choice and Design Elements

- Corridors are thus formed with the following basic design tenants:
  - cross section consistency
  - operating speed consistency
  - driver workload consistency
- Sayed(2004) : little work had been carried out to quantify the safety benefits of geometric design consistency
- Shinar(2011) : only a few studies directly investigated the effect of roadway design on driver behaviour through controlled manipulations.

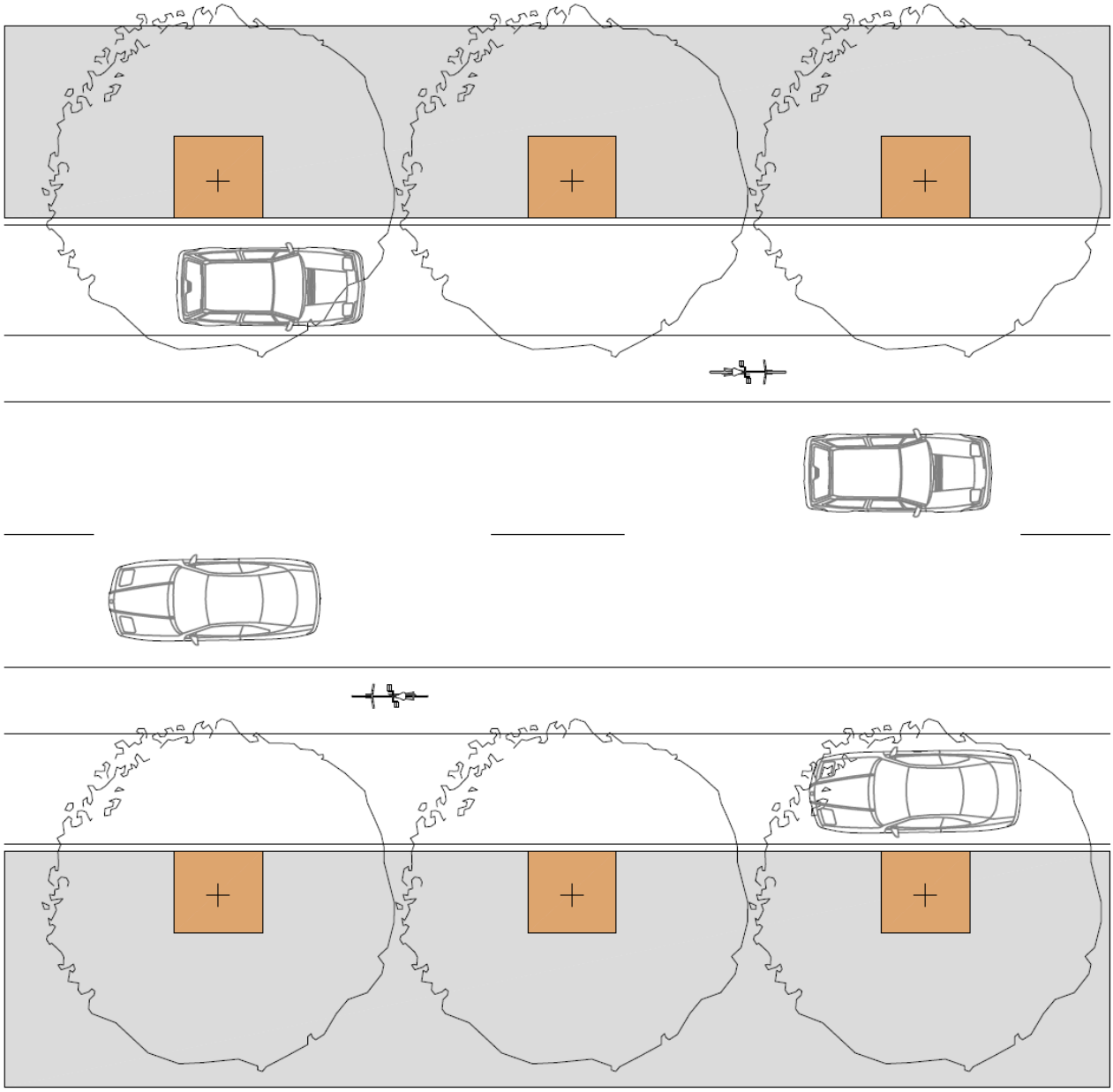
Source: Mannering(2009), Sayed(2004), DTMR(2005), Fildes et.al.(1987)

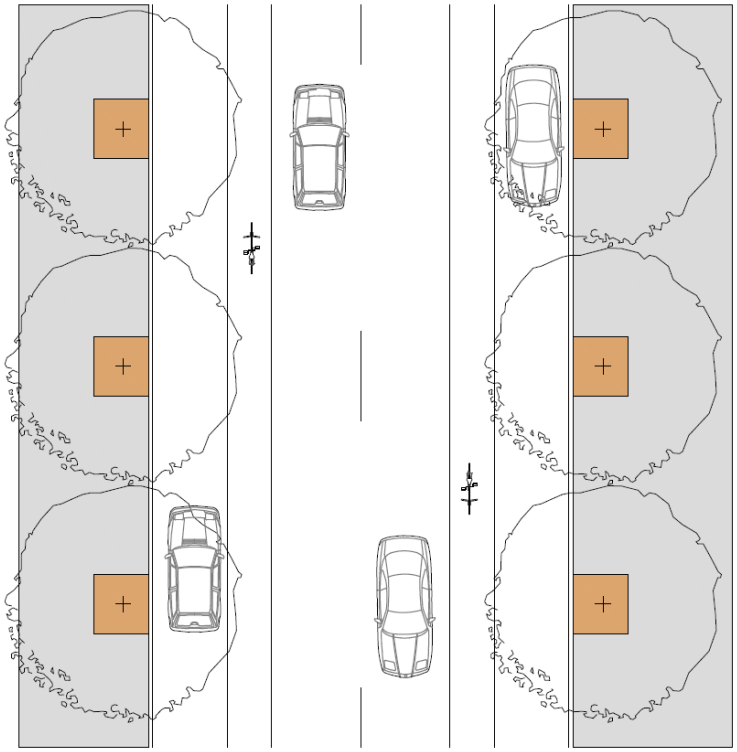
Design Elements



- Each element forms a complete system
  - more than the sum of their parts
  - inter-relationship
- Often shown in a series of cross sections incorporating:
  - travel lanes
  - cycle lanes
  - shoulders
  - verge
  - road reserve.


4.50
2.50
1.50
3.00
3.00
1.50
2.50
5.50
24.00






4.50
2.50
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3.00
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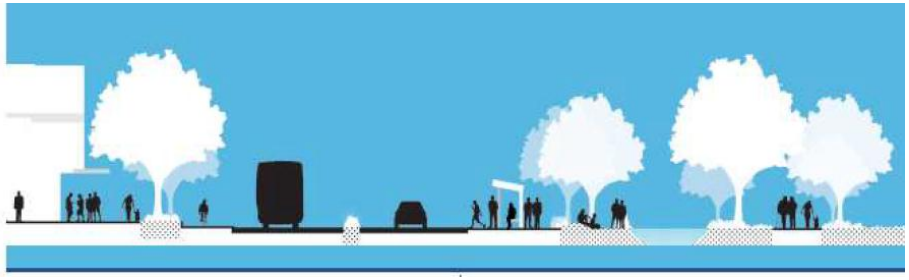
50

Design Elements



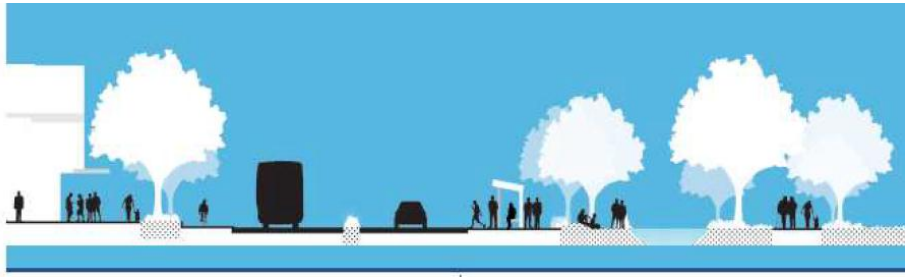
- Aspects of the actual road infrastructure that influence speed choice:
  - lane and road width, road shoulder width number of lanes
  - radius of road curvature, length of curves,
  - delineator type, number, spacing, condition
  - pavement markings, road edge guide posts, signing conventions
  - intersecting roads or driveways, intersection treatments
  - traffic flow, traffic conditions
  - parked cars, roadside environment
  - roadway grade

- Challenge design solution that takes account of the competing alternatives and the trade-offs that might be:
  - mobility and reliability
  - environmental impacts
  - safety
  - loss of consistency of design
  - reduction in the life of the infrastructure
  - capital costs
  - whole of life costs
  - Aesthetics

- Safety System Framework.

Source: Mannering(2009), Sayed(2004), DTMR(2005), Fildes et.al.(1987)

Design Elements



- Haglund(2002) found there was higher consistency in speed choice
  - segments of the road were homogenous
  - consistency in relation to speed limit
  - varied as a function of roads and direction of travel
- Cross-section elements such as the width and the number of lanes had the strongest influence on drivers perceptions of safety and travel speeds
- A narrow, confined cross-section is likely to result in a slower speed of operation than one with similar geometric characteristics but a wide, open cross section.

Source: Rosey et.al.(2009)

Lane and Shoulder Width

Lane and Shoulder Width

- Empirical evidence generally suggests that narrower roads, and narrower lanes on roads, lead to slower travel speeds with more influence of other traffic and of obstacles along the side of the road
- Reducing lane width leads to lower speeds and crash frequency but the effects depend on lane widths and road types
- Martins et. al.(1997) believes with smaller lanes, more effort must be put into lane keeping and steering behaviour and as a consequence, driving speed usually decreases with lane width.

Source: Milton Mannering(1998), Sawalha Sayed(2001), Fildes Lee(1993), DTMR(2005), Godley(1999), Martins et. al.(1997), Shinar(2011)

Lane and Shoulder Width

- Reducing lane width is an effective measure to decrease speed
  - As long as it does not result in an increase in crash rates
- Decreasing lane width beyond a certain point (close to the width of the car) makes driving practically impossible
- Godley(1999) concluded that widening the total sealed road leads to faster speeds
  - for both drivers that were familiar and unfamiliar with the roads
  - wider lanes increase speed more than wider shoulders.

Source: Godley(1999), Martins et. al.(1997), Shinar(2011)

Lane and Shoulder Width

YET…

- Noland(2004) rejects that improved road infrastructure geometric design is beneficial for safety
  - Suggest changes actually led to increased road crashes and fatalities
- Martins et. al.(1997) found extra pavement width, or shoulder does not always have to affect driving speed
- Shinar(2011) found no main effects for the shoulder width
- Auberlet et.al.(2009) concluded lane reduction had no impact on speeds
  - changing of position within the lane
- Literature suggests a change of lane/shoulder widths and crash frequency *(speed-crash relationship)* are inconsistent.

Source: Austorads(2010), DTMR(2005), Godley(1999), Martins et. al.(1997), Edquist et.al.(2009), Auberlet et.al.(2009),Shinar(2011)

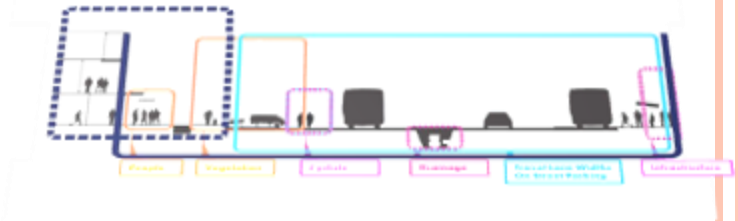
Design, Posted and Operating Speeds

Design and Posted Speed

- Ideally road design creates an environment whereby drivers select <u>appropriate and safe</u> speeds for the road corridor being built
- Design Speed
  - Roadway geometry
  - horizontal and vertical curves (radii)
  - lane widths, shoulder widths
  - sight distances
- Design Speed is taken as the 95%tile speed
  - free-flowing traffic expected to occur
  - function of the adopted design standard.

Source: Austorads(2010), DTMR(2009)

Design and Posted Speed



- Garber and Gadiraju(1989) found that the difference between design speed and (posted) speed limit plays a role crash rates
- Mainly from the lack of geometric design consistency and the associated conformance of geometric characteristics with drivers' expectations
- Changing posted speed without changing the other factors of the road corridor that influence speed choice can lead to an increase of crash risk
- Inconsistency when posted speed exceeds design speed, can raise liability concerns even though drivers can safely exceed the design speed.

Source: Haglund(2002), Fitzpatrick et.el.(1997)

Design and Posted Speed

- In recent decades, it has become more common for speed limits to be set for political reasons rather than for safety reasons
  - resulting in the community increasingly questioning their rationale
- A key motivating factor in drivers' tendency to exceed the speed limit is that they believe that the excess speed does not threaten safety
- Geometric design guides generally do not provide quantitative information on the relationships between crash risk and the standard which should be selected for a design element.

Source: Mannering(2009), TMR(2009)

Design and Posted Speed

- Speed limits are typically determined with the intention that credible limits are established
  - to maintain a balance between a road user's reasonable perception of the speed environment
  - an acceptable level of environmental amenity for all road users and abutting land users
- To achieve this balance, similar to design speed, a number of safety factors and criteria are considered when determining an appropriate speed limit and done within the context of the Safe System.

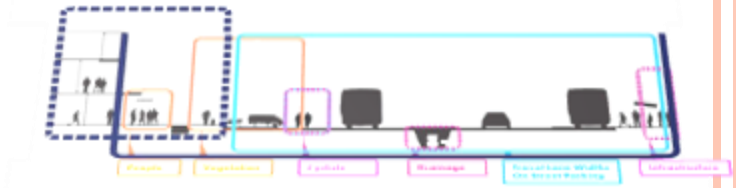
Source: Austorads(2008), DTMR(2009)

Design and Posted Speed

- These factors are not simply a standard or the appearance of a road and include
  - environment in which the road is located
  - pavement, shoulder and lane width
  - horizontal and vertical road alignment
  - traffic volume, activity and prevailing speeds
  - frequency of intersections and property access
  - on-road parking activity
  - type of roadside activities.

Source: DTMR(2009)

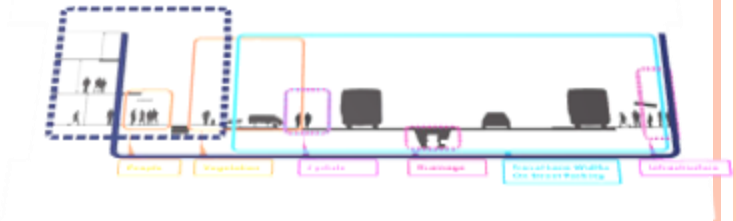
Design and Posted Speed



- These factors are not simply a standard or the appearance of a road and include
  - presence of unsignalised at-grade pedestrian crossings
  - presence of traffic signals
  - magnitude of property setback
  - presence of line marking, channelisation and medians
  - proximity of roadside hazards and standard of protection.

Source: DTMR(2009)

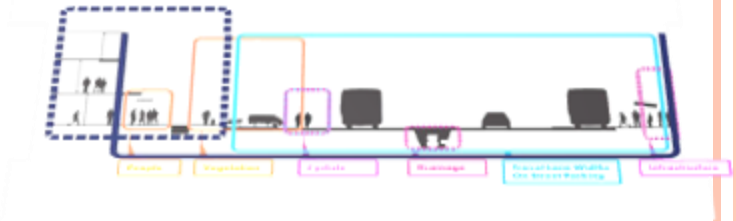
Design and Posted Speed



- One of the most important consideration in review of a posted speed limit should be the determination of the crash rate of the road.

Source: DTMR(2008)

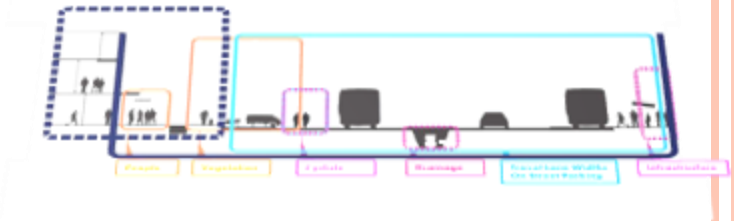
Operating Speed



- Identification of the operating speed is fundamental to the development of any roadway facility
- Used <u>to determine</u> an appropriate design speed of a road section
- Often Operating Speed is taken as the V85
  - speed at, or below, which 85% of vehicles are observed to travel under free flowing conditions
- Operating speed is a common and simple measure of design consistency
- Design speed should not be less than the intended operating speed
- Where operating speed varies, design speed must vary accordingly

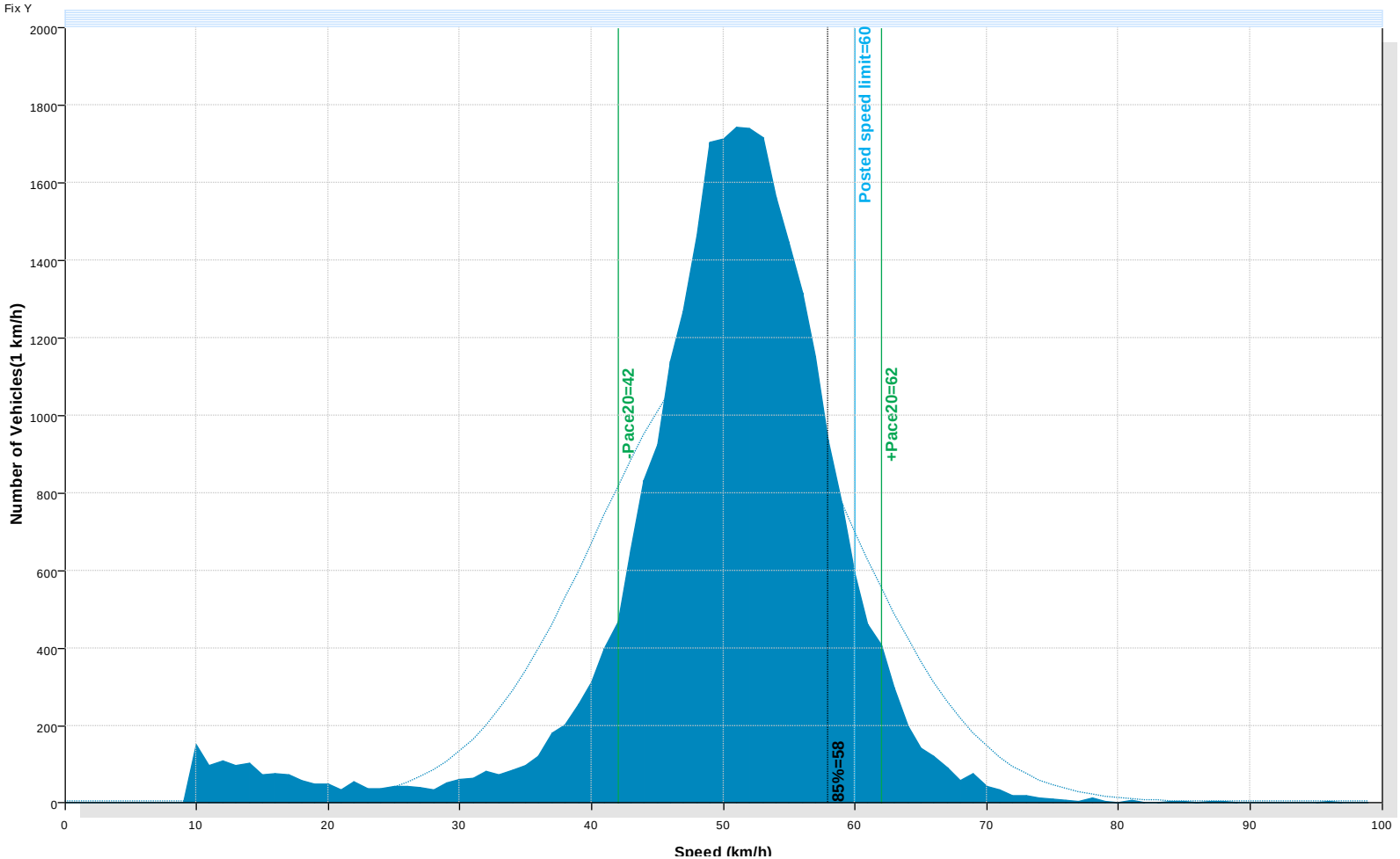
Source: Jamson(2005), Finch et.al.(1994)
Sayed Ng(2004), DTMR(2009), Ausroads(2009)

Operating Speed



Speed Histogram

SpeedHist-3 (Metric) **Site:**158006.0.0EW
Description: Sippy Downs Dve 100m East of University Way<60>
Filter time: 0:00 Wednesday, 21 July 2010 => 9:00 Tuesday, 27 July 2010
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,100) Headway(>4)
Scheme: Vehicle classification (AustRoads94)



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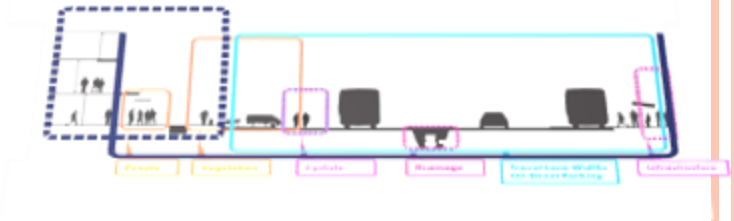

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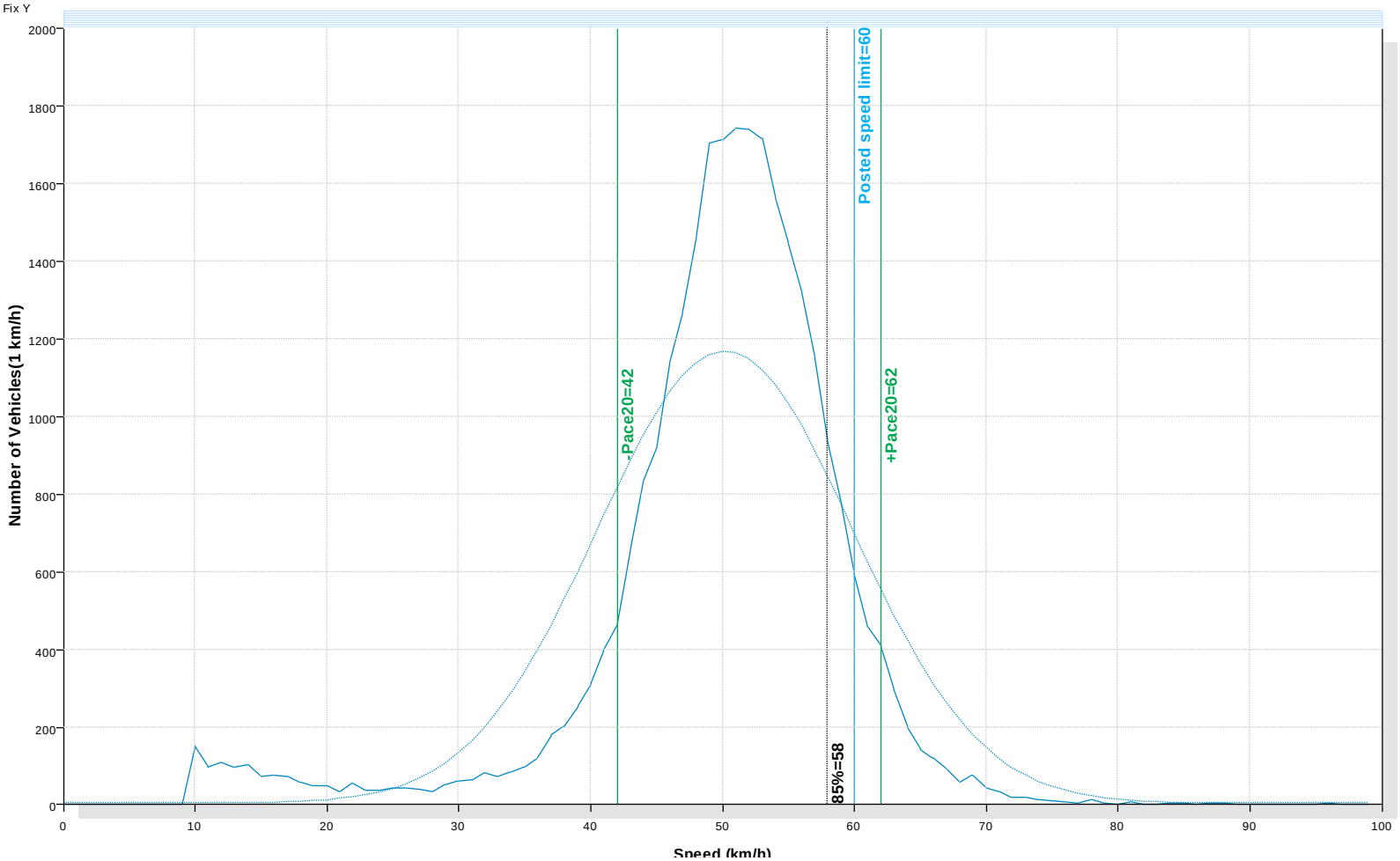
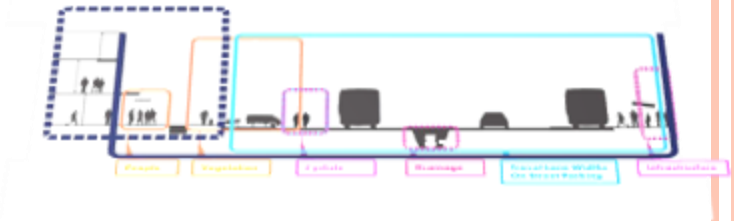
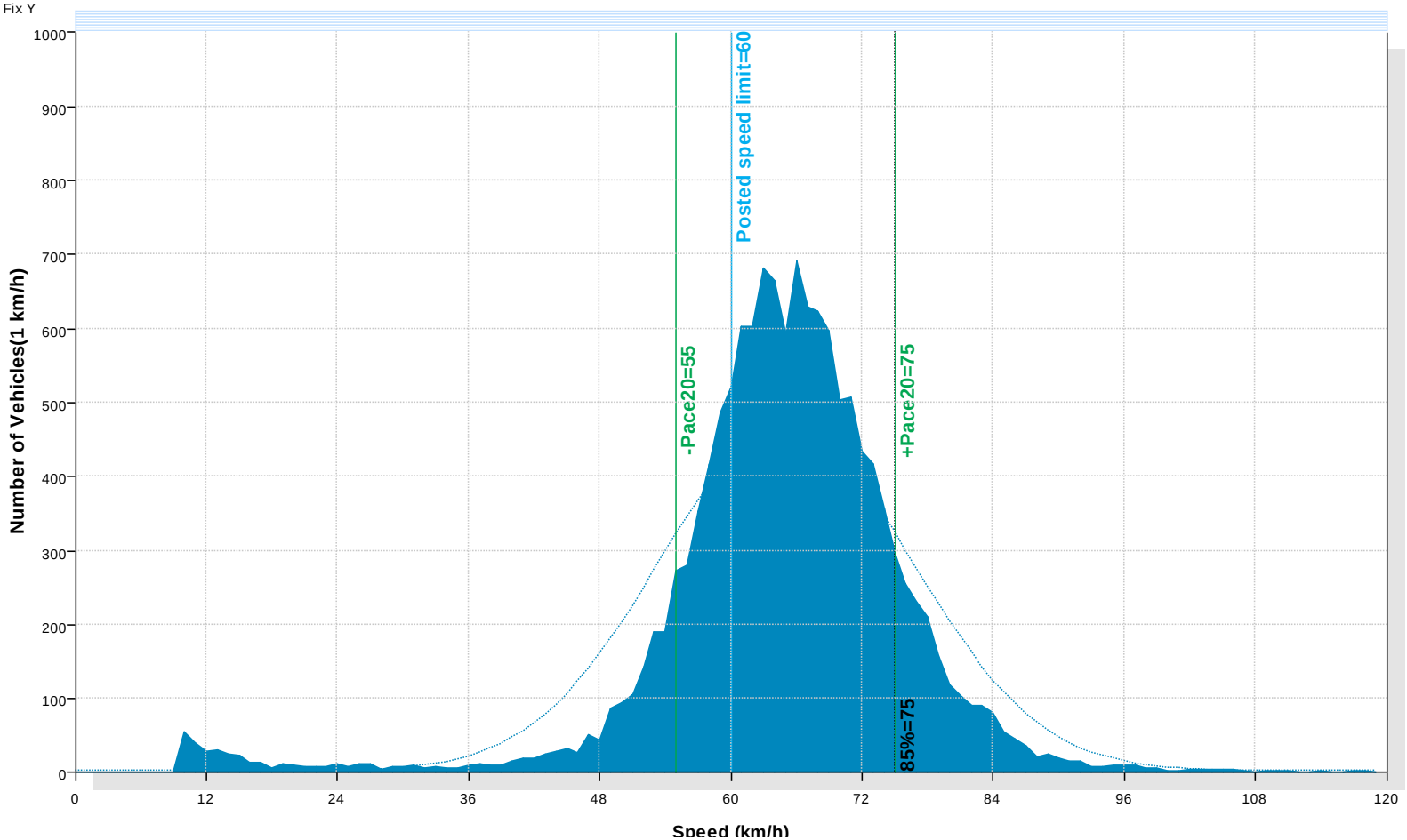


Operating Speed



Speed Histogram

SpeedHist-4 (Metric) **Site:**2200.0.0EW
Description: Sippy Downs Dr - 200m East of Stringybark Rd
Filter time: 12:00 Thursday, 17 July 2008 => 15:43 Tuesday, 22 July 2008
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,120) Headway(>4)
Scheme: Vehicle classification (AustRoads94)



Operating Speed

Speed Histogram

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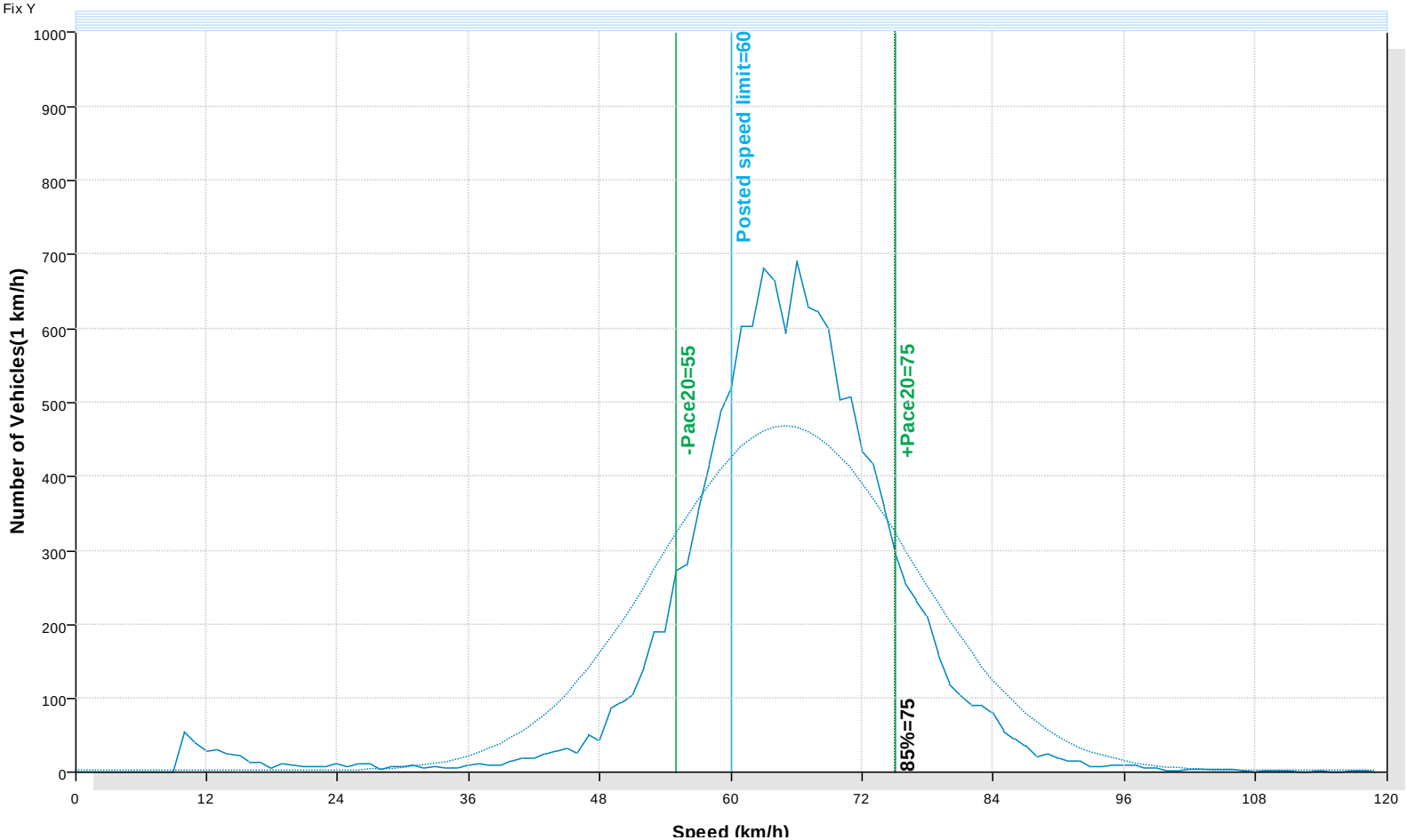
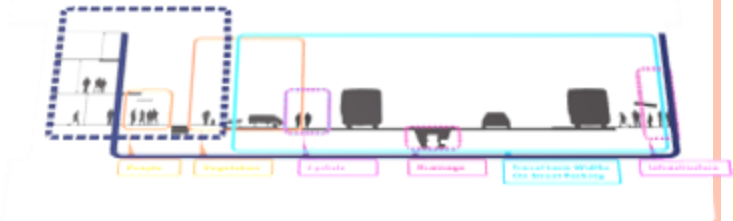
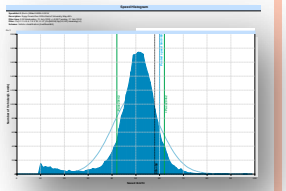


Operating Speed

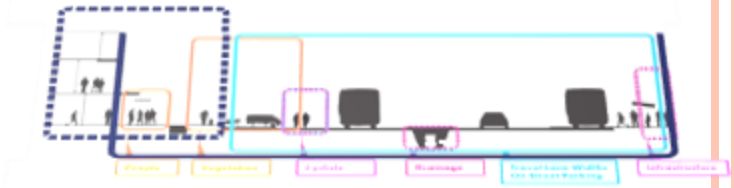


- The view that limits should be set at or close to the V85 speed dates back to the early 1940s in the USA
- 3 main arguments put forward and repeated over the years:
  1. The collective wisdom argument
  2. The speed dispersion argument
  3. The enforcement practicality argument.



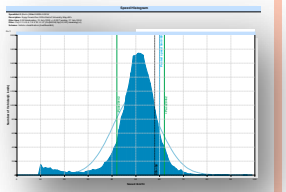
Source: Austroads(2008), Transportation Research Board SR254(1998)

Operating Speed



1. Collective Wisdom Argument

- V85 provide an objective basis for determining 'maximum safe speeds'
- The theory was that that most drivers are capable of making good judgments about 'safe' driving speeds
- Drivers will chose to drive at 'safe' speeds
- Posted speed role is to limit the speeds of the small minority of drivers who are incompetent or irresponsible.



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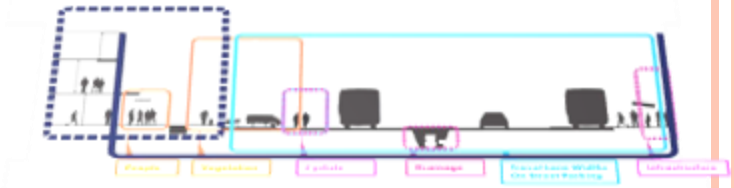
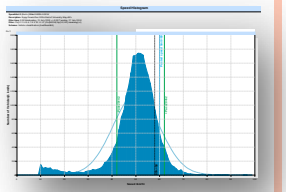


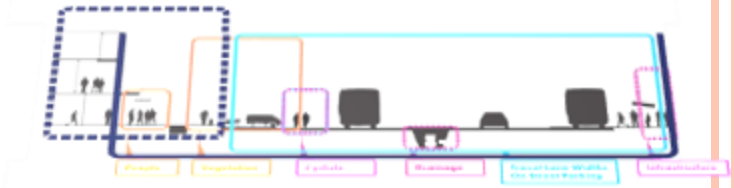
2. Speed Dispersion Argument

- Speed limits near the V85 will minimise the variance of the speed distribution
- Minimising the speed variance will minimise opportunities for vehicle conflict and therefore minimise the number of crashes
- An important element of this argument is the proposition that setting speed limits lower than the V85 will lead to greater speed dispersion and in doing so will offset any benefits of lower speeds, and may actually increase crash rates.



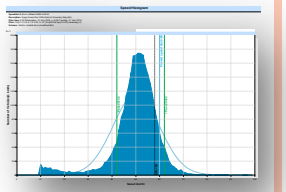
Source: Austroads(2008), Transportation Research Board SR254(1998)

Operating Speed



3. Enforcement Practicality Argument

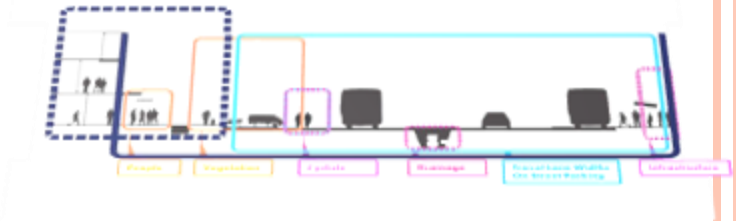
- V85 limits have 'appeal' from an enforcement perspective, and represent a reasonable and realistic benchmark for enforcement



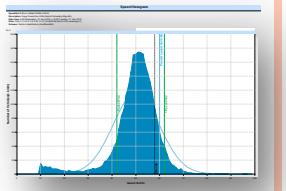
- Alternatively, this argument is that enforcing speed limits below the 85th percentile requires a level of enforcement intensity and expense that has proven difficult to sustain.

Source: Austroads(2008), Transportation Research Board SR254(1998)

Operating Speed



- Where the operating speed cannot be determined through speed measurement an operating speed 10 km/h higher than the posted speed limit is often adopted
- Apart from the direct evidence that safety can be improved by setting limits below V85, the three arguments around the use of V85 in setting speed limits remains controversial.



Source: Austroads(2008), Austroads(2009)

Operating Speed

- Road corridors must be designed to ensure <u>appropriate</u> speed choices are made
- Important characteristics
  - road grade
  - cross-section
  - surface conditions
- Insufficient research to accurately understand impact on
  - speed choice
  - associated design
  - posted speed.

Source: Austroads(2009)


STOP
CROSS TRAFFIC
DOES NOT STOP
COMMERCE
PAYNE

042976

Some Key Issues

- Safe System Framework / Context Sensitive Design
- Further research / investigation on speed choice influences from:
  - effect of geometric road design consistency (or inconsistency)
  - change in shoulder, lane and road widths
  - inconsistency between design and posted speeds.


LOCK IT
OR
LOSE IT
CAR
PARK
9
40