



Intersections



Austroads

Introduction



- **Current design forms – key issues in the Safe System context**
- **What is a Safe System intersection?**
- **Safe System analyses, investigations and innovative solutions**

Traditional responses...



...can't help if people don't pay attention.

...it was well-designed, complied with the guidelines.

...limited budget, can't goldplate everything.

...must maintain intersection capacity.

...these crashes are very rare.

Still... a clear contribution of road infrastructure to a serious injury outcome.

What do we learn from current approaches?



- Capacity and delay nr. 1 traditional concern for intersections
- Concept of 'safe' or 'safer' = following guidelines and standards
- Vague and complex guidance on intersection control,
 - Excellent detailed technical standards (e.g. size of lanterns)
 - Priority back to front
- Engineering tradition of reactive upgrades over time.
- Always trailing, never achieving the safest intersection for the existing conditions

Current
AGTM Part 6

Type of control	Key traffic and safety selection factors	References
Road rules only	<ul style="list-style-type: none"> Applied in the absence of intersection traffic control devices. Is common practice at T-intersections between local streets where traffic control devices may not be provided. Cross roads generally have traffic control devices, however, they need not be provided on very low-volume roads in remote areas where a major/minor road hierarchy does not exist (note that New Zealand requires all cross roads to be controlled). 	See Australian Road Rules and New Zealand Land Transport Rules.
<i>Give way</i> lines only (Not in New Zealand)	<ul style="list-style-type: none"> May be used at local street T-intersections to reinforce priority although an appropriate sign (<i>stop</i> or <i>give way</i>) may be required in these circumstances. Not common practice. 	See Australian Road Rules and Parts 4 and 10 of the <i>Guide to Traffic Management</i> ⁽¹⁾⁽²⁾ and AS1742.2.
<i>Stop</i> signs and <i>give way</i> signs	<ul style="list-style-type: none"> Used at intersections other than those controlled by roundabouts or traffic signals. Used to reinforce road rules or to assign priority. <i>Stop</i> signs must only be used when warrant is met. Advance warning signs may be necessary where there is a high approach speed or where approach sight distance is limited. 	See Part 10 of the <i>Guide to Traffic Management</i> ⁽²⁾ and AS1742.2.
Roundabout	<ul style="list-style-type: none"> Can be used at a wide range of sites and improve safety by simplifying conflicts, reducing speeds and providing clear indication of priority. Are useful where there is a high proportion of right-turning traffic. Perform best when traffic flows are balanced. Cyclists (especially when turning right) and pedestrians find it more difficult to negotiate multi-lane roundabouts. An off-road facility may be required for cyclists in some cases. 	See Parts 4 and 10 of the <i>Guide to Traffic Management</i> ⁽¹⁾⁽²⁾ and AS1742.2.
Traffic signals	<ul style="list-style-type: none"> Used where unsignalised intersection has a poor crash record or excessive delays for traffic using minor roads, and a roundabout is an unsuitable alternative to traffic signals. Are suitable for high pedestrian movement including people who have an impairment. Numerical warrants may apply (see signalised intersections in Table 2.4). 	See Section 5 and Parts 9 and 10 of the <i>Guide to Traffic Management</i> ⁽³⁾⁽²⁾ .

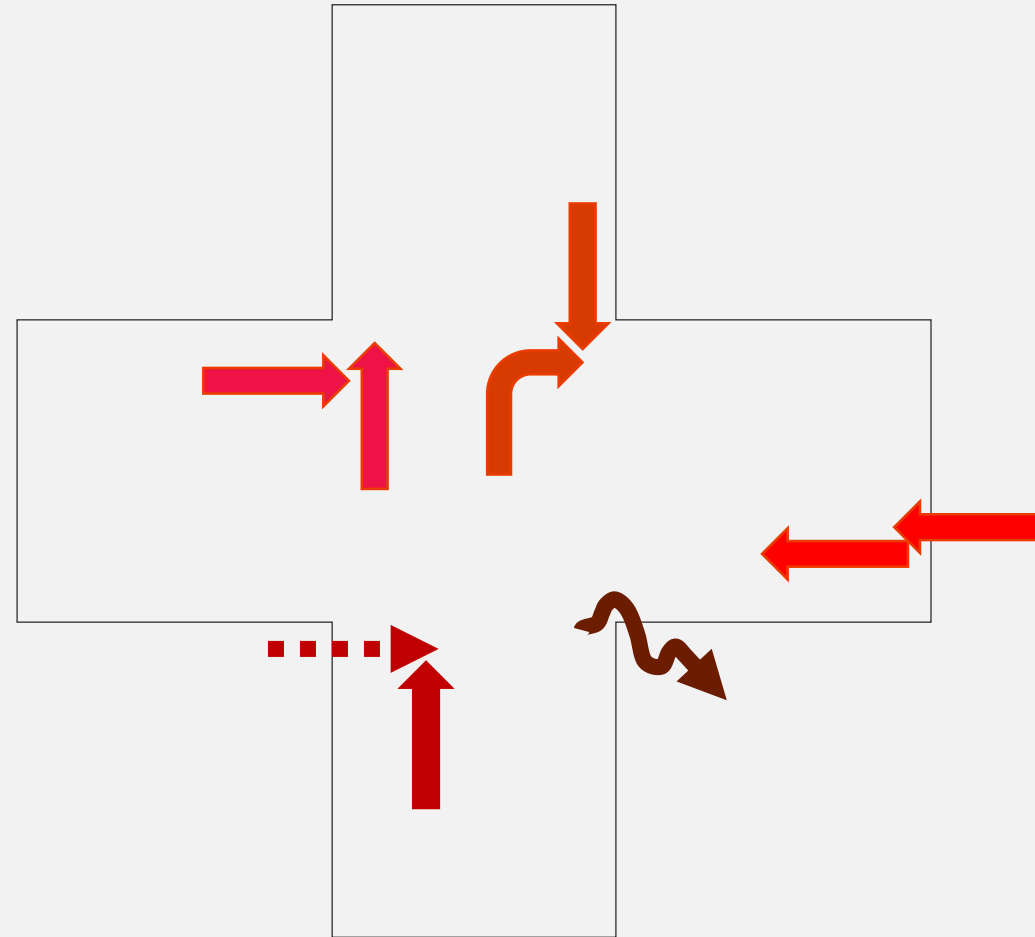
The worst
safety
record

The best

Moderate

Key Safe System issues

Most common intersection FSI crash types:



Based on NZ and Vic crash data, Austroads project SS1960

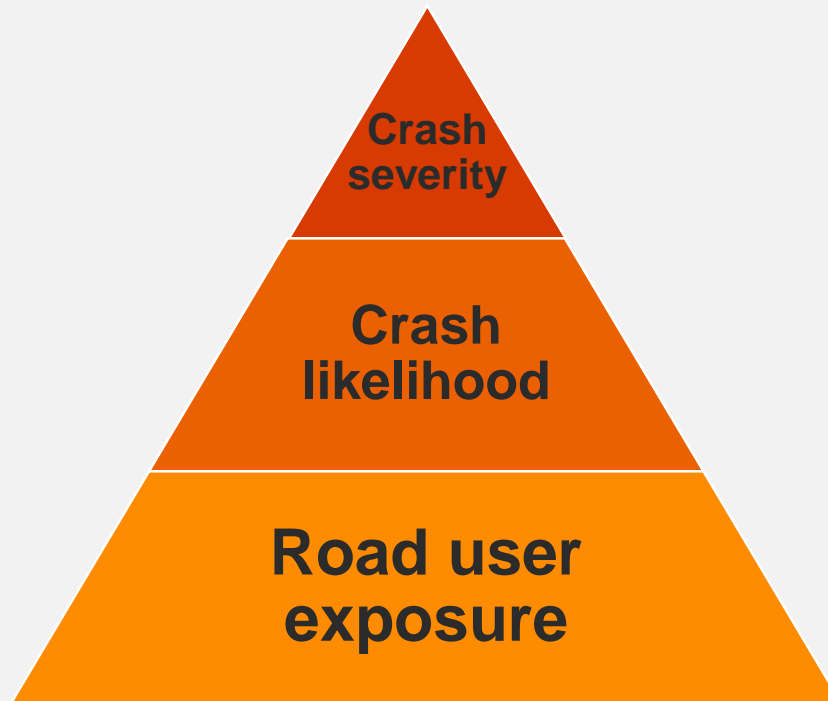
What is a Safe System intersection?

A guiding principle:

At-grade intersection design needs to accommodate frequent human error and physical frailty in order to minimise fatal and serious injury.

What is a Safe System intersection?

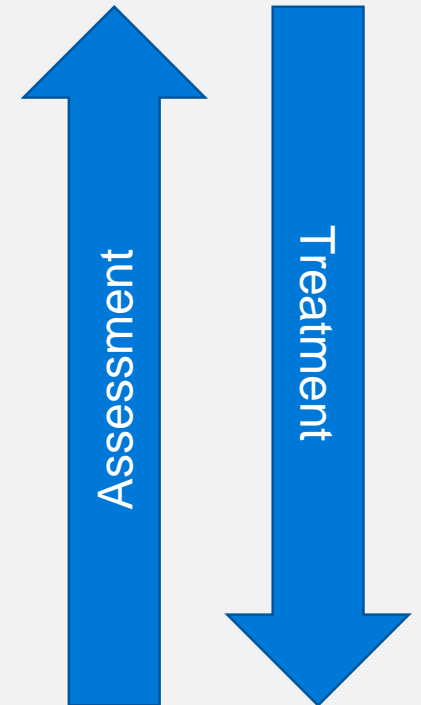
Safe System Assessment Framework



Probability the crash will result in fatal or serious injuries

Probability a user will crash

Number of relevant road users

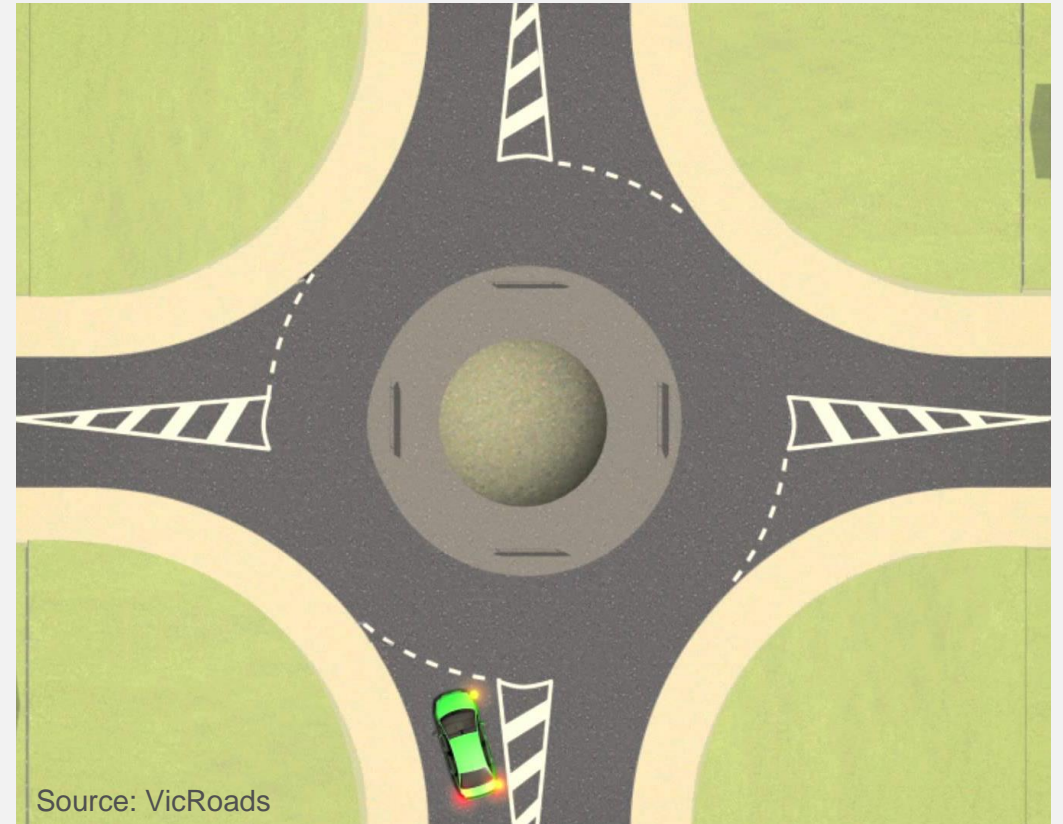


Source: Austroads (2016)

What is a Safe System intersection?

- Minimise conflict points
- Remove or simplify road user decisions
- Minimise impact angles
- Minimise impact speeds

FOR ALL ROAD USERS



What is a Safe System intersection?



Safe System intersection design principles:

Design principle	What it means:
1. Consider all relevant road users and their numbers	<ul style="list-style-type: none">• Can intersection be avoided?• Who and in what numbers has to use it?
2. Minimise likelihood of a crash for each user (rates of system failure, human error)	<ul style="list-style-type: none">• Minimise no. of conflict points, separate.• Movement control, regulation.• Give more time (reduce approach speeds).• Simplify road user decision making.• Provide guidance.• Warn (...last resort).
3. If crash occurs, minimise probability of fatal and severe injury outcome (minimise KE and it's transfer)	<ul style="list-style-type: none">• Minimise impact speeds.• Minimise impact angles.• Consider incompatible vehicle mixes (mass).• Redesign roadside environment.• Provide for effective emergency access.
4. Build-in system redundancies	<ul style="list-style-type: none">• Synergies from multiple supporting solutions.

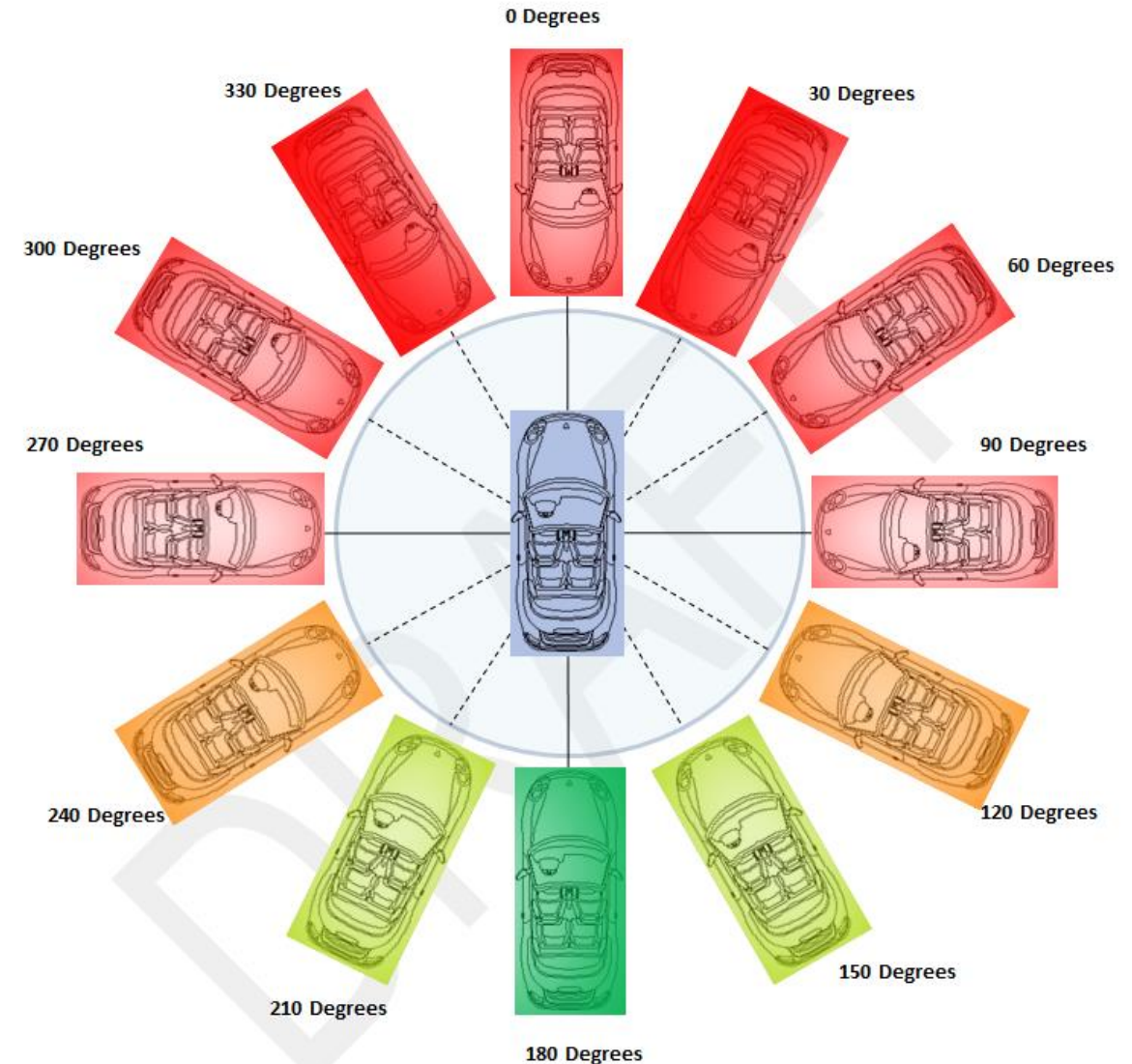
Can we design Safe System intersections?



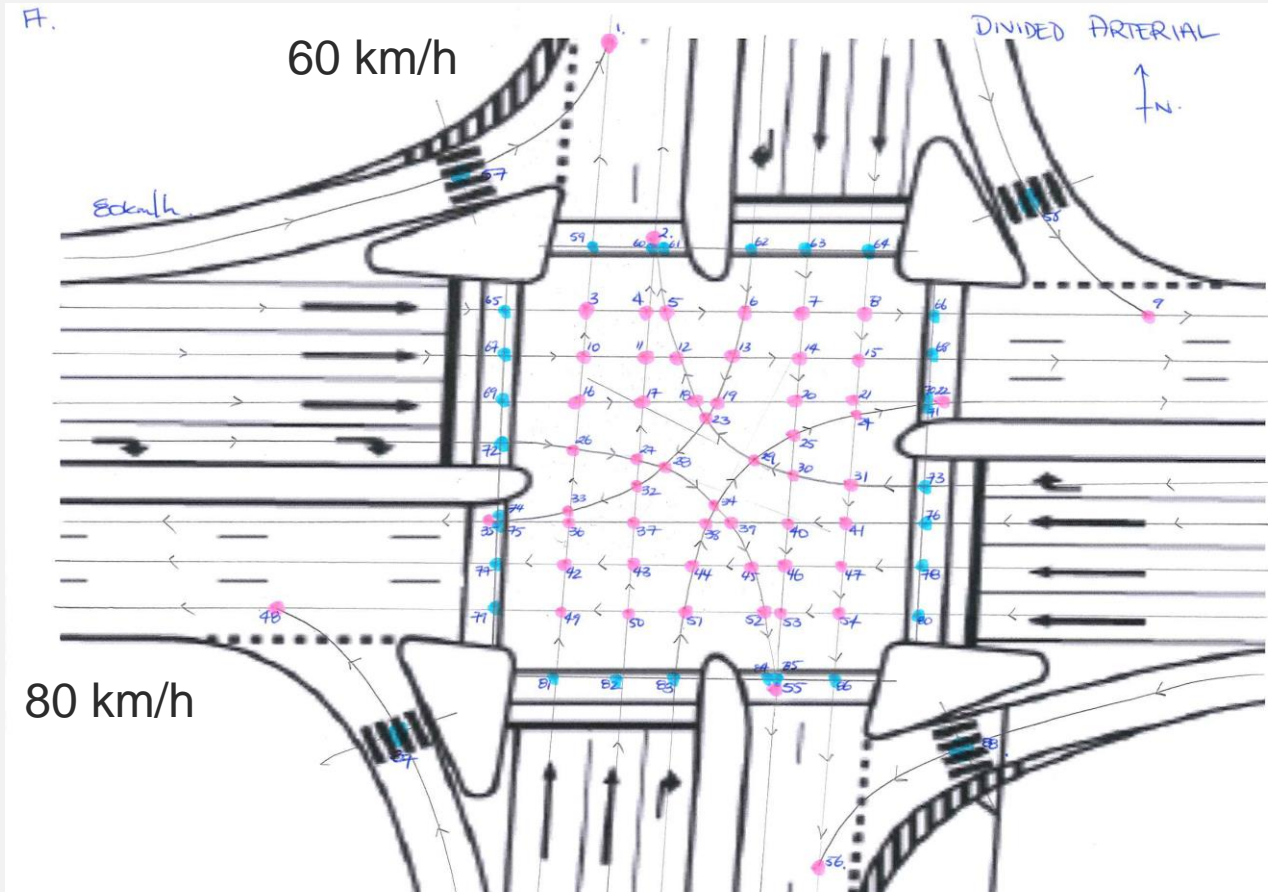
- Not every design can be made 100% Safe System... BUT
- Can we make existing designs more Safe System-aligned?
- New intersection forms?
- We can now rate intersection designs on their alignment with the Safe System objectives.

X-KEMM-X Method

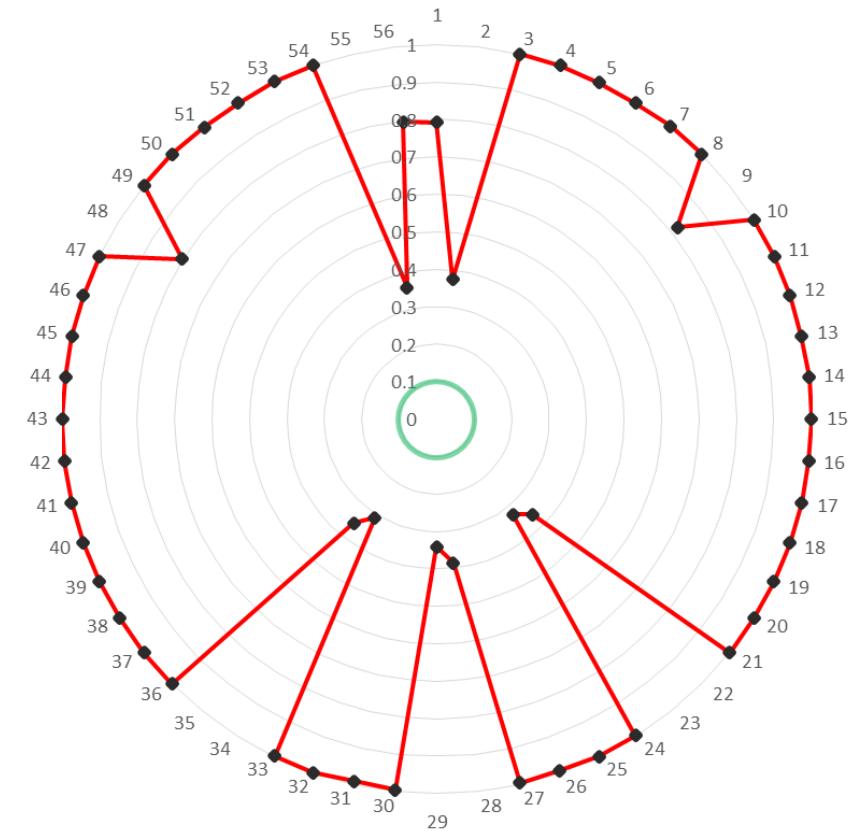
- Numerical analysis of relative FSI probabilities for a given impact angle and speed
- High level of Safe System alignment if total $P(\text{FSI}) \leq 10\%$
- Assesses existing and innovative designs



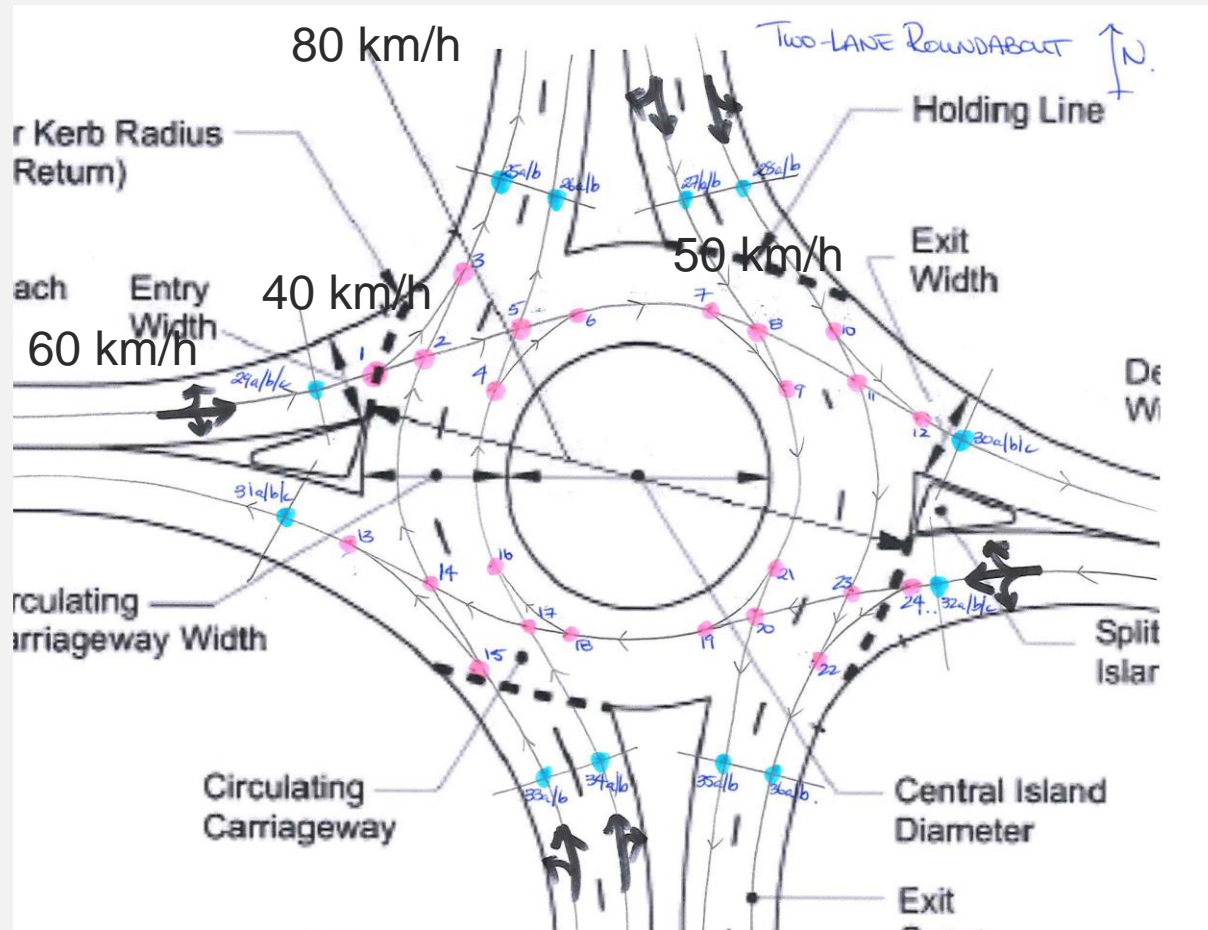
X-KEMM-X application examples



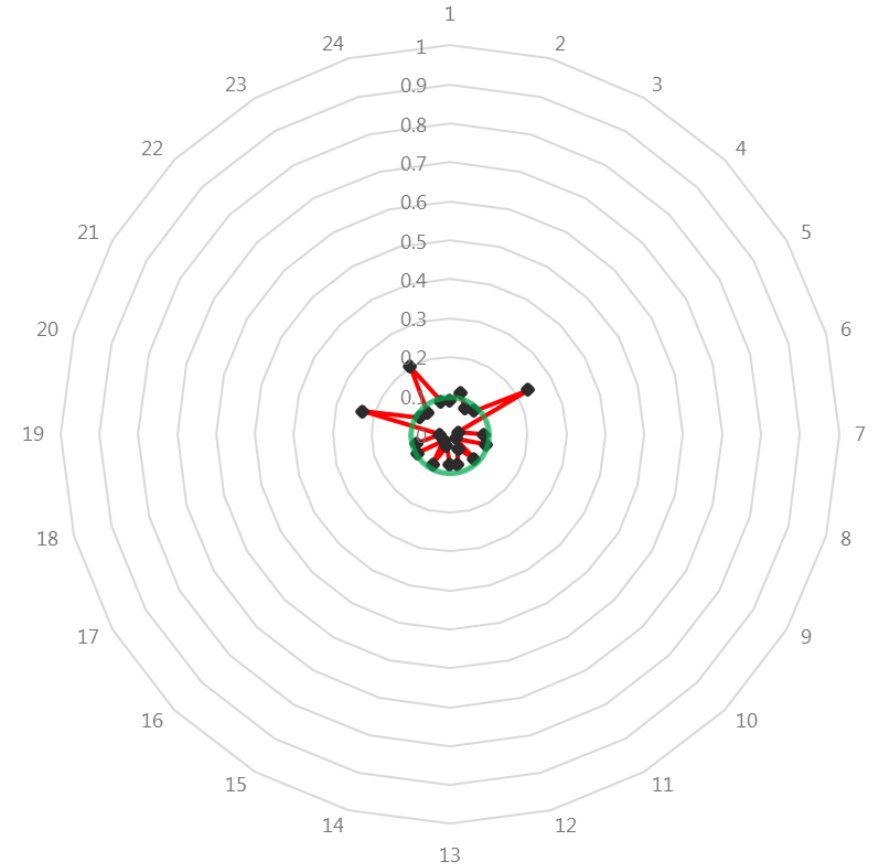
Divided Arterial Int - Conflict points and corresponding Pr(FSI)



Roundabout (multilane)



Two-Lane Roundabout - Conflict points and corresponding Pr(FSI)



Proposed Safe System treatment hierarchy



Hierarchy	Treatment	Influence (E = exposure L = likelihood S = severity)
Safe System options (‘primary’ or ‘transformational’ treatments)	<ul style="list-style-type: none"> • Grade separation • Close intersection • Low speed environment/speed limit • Roundabout • Raised platform. 	L, S E L, S L, S L, S
Supporting treatments (compatible with future implementation of Safe System options)	<ul style="list-style-type: none"> • Left-in/left-out, with protected acceleration and deceleration lanes where required • Ban selected movements • Reduce speed environment/speed limit. 	L, S E L, S
Supporting treatments (does not affect future implementation of Safe System options)	<ul style="list-style-type: none"> • Redirect traffic to higher quality intersection • Turning lanes • Vehicle activated signs • Improved intersection conspicuity • Advanced direction signage and warning • Improved site distance • Traffic signals with fully controlled right turns • Skid resistance improvement • Improved street lighting. 	E L L L L L L L L
Other considerations	<ul style="list-style-type: none"> • Speed cameras combined with red light cameras. 	L, S

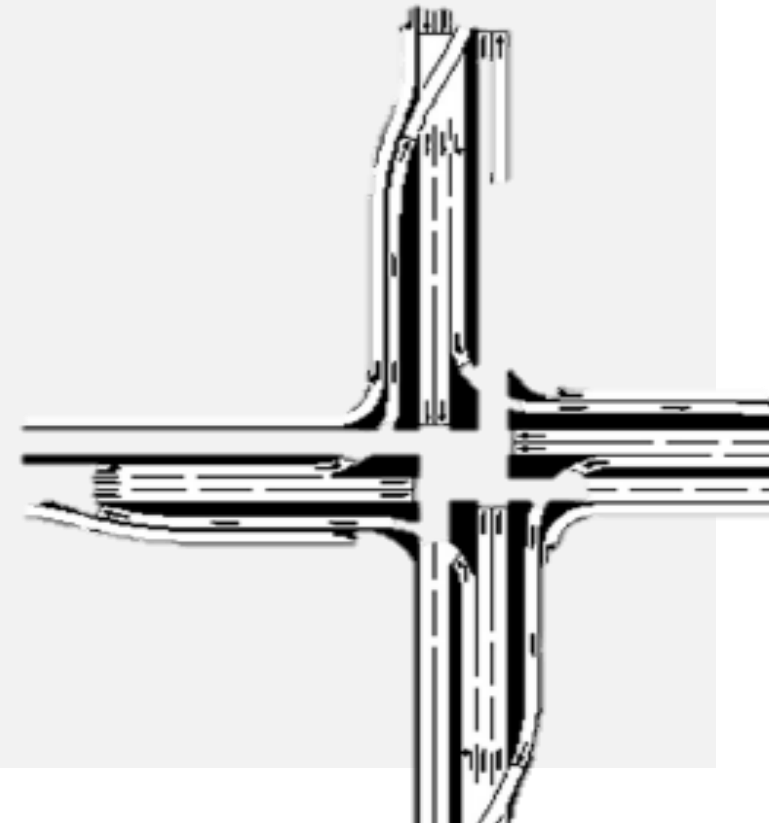
- Safe System Assessment Framework
- Based on CRF/CMFs
- Some assessed with X-KEMM-X
- Design detail plays role

We know what does not work well in Safe System



- Traffic signals
- Staggered-T's
- Warning signs
- Complex, over-managed design schemes

Intersection design requires new analytical approach





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Examples of Innovative Safe System Intersections

Examples of Innovative Safe System Intersections



Case studies chosen for:

- High–moderate level of Safe System alignment
- Addressing the key FSI crash issues
- Greenfield and retrofit potential (low cost)

1. Urban signalised roundabout



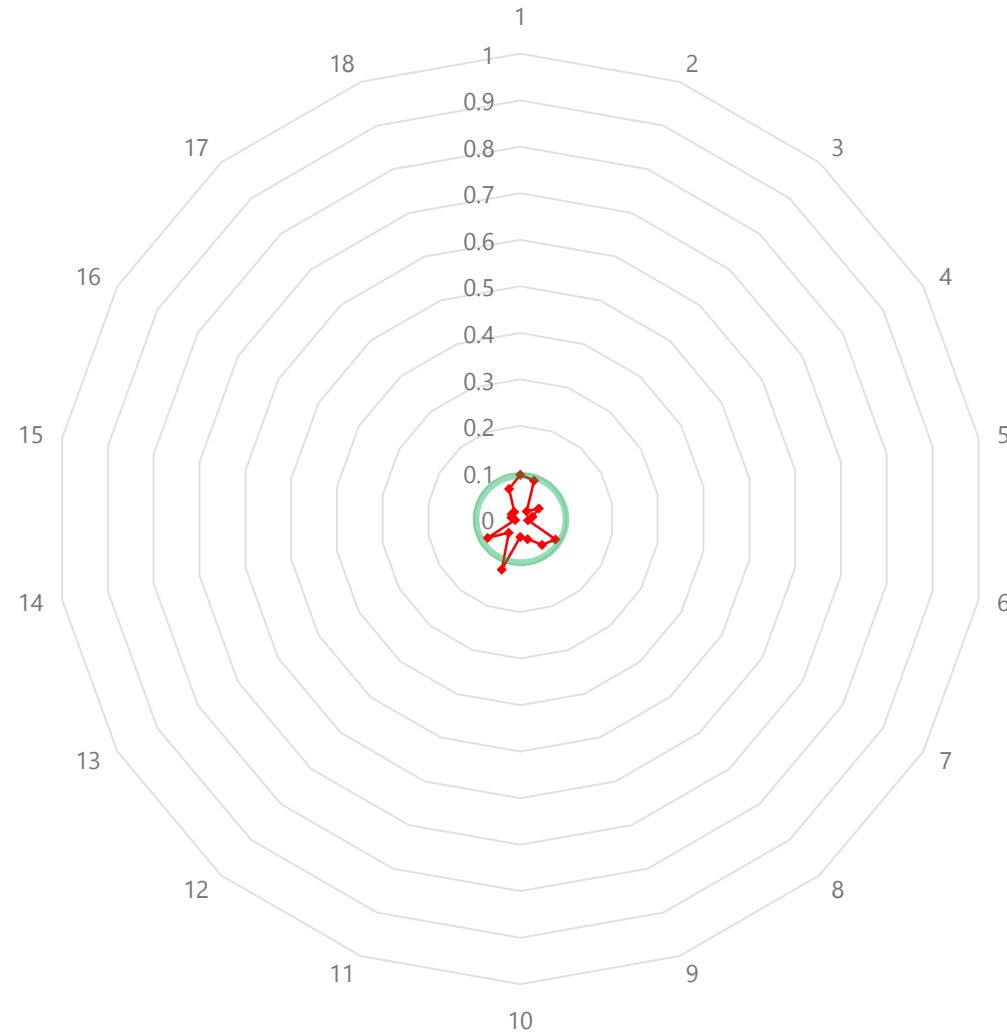
60 km/h

60 km/h

60 km/h

1. Urban signalised roundabout

Signalised roundabout - conflict points and corresponding Pr(FSI)

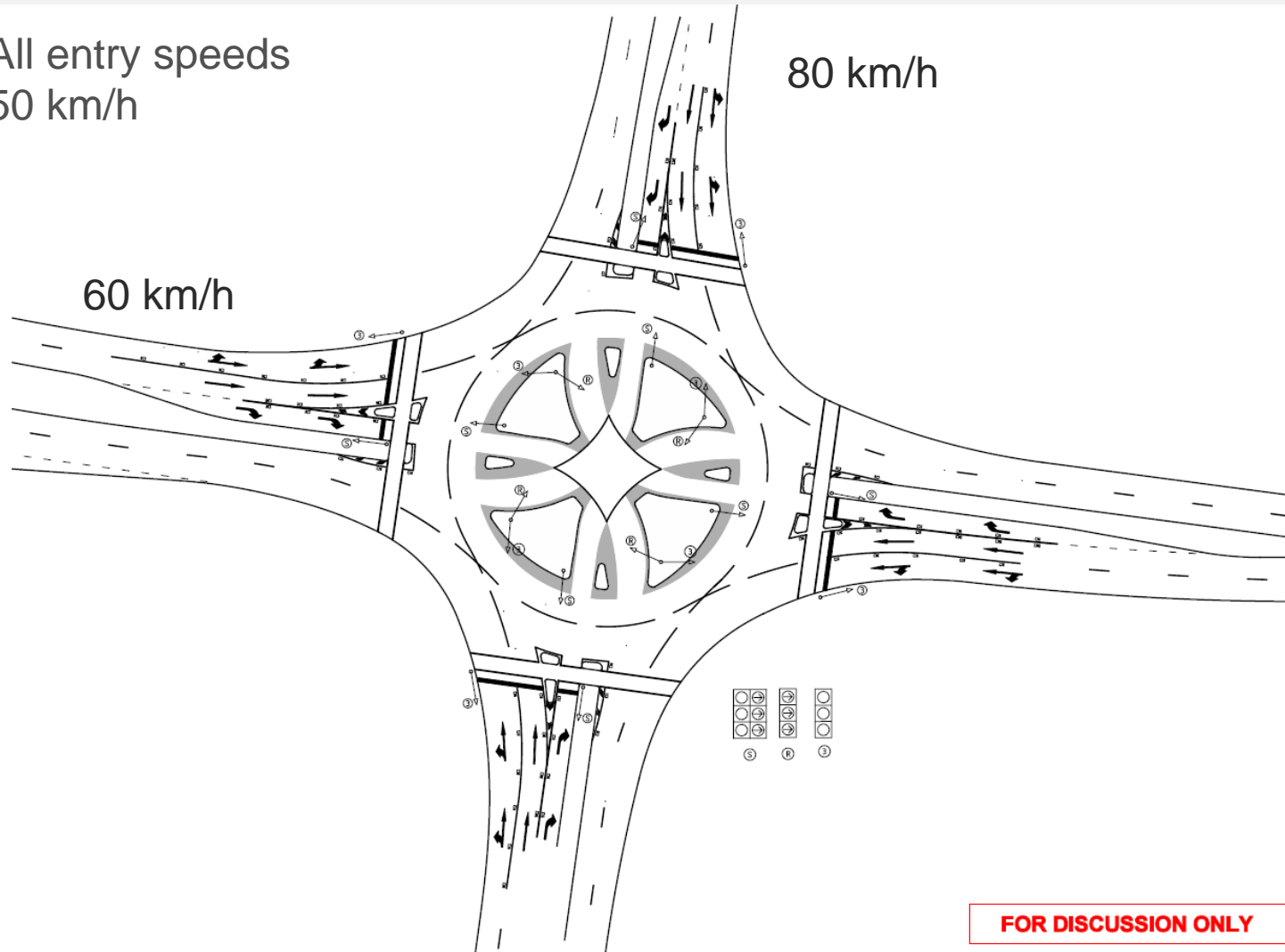


2. Urban signalised with horizontal approach deflections



“Cut-through”

All entry speeds
50 km/h

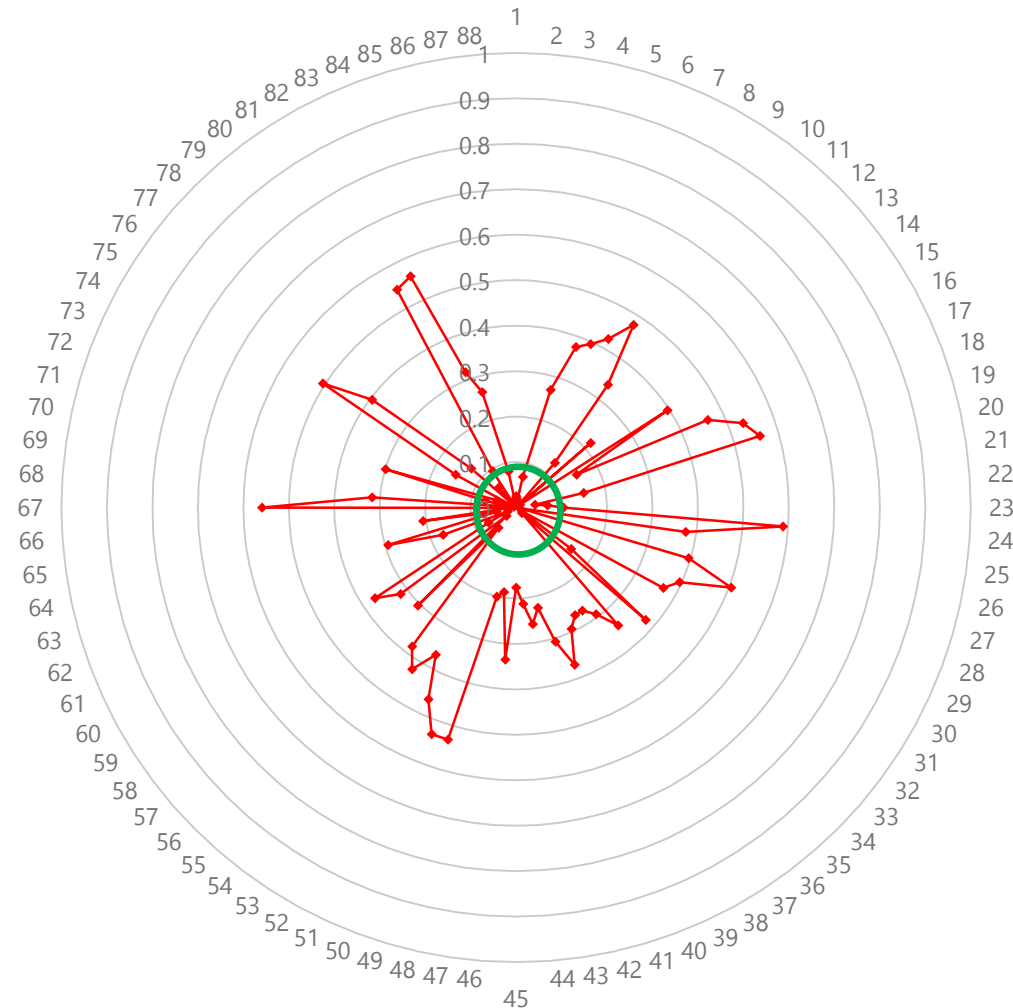


FOR DISCUSSION ONLY

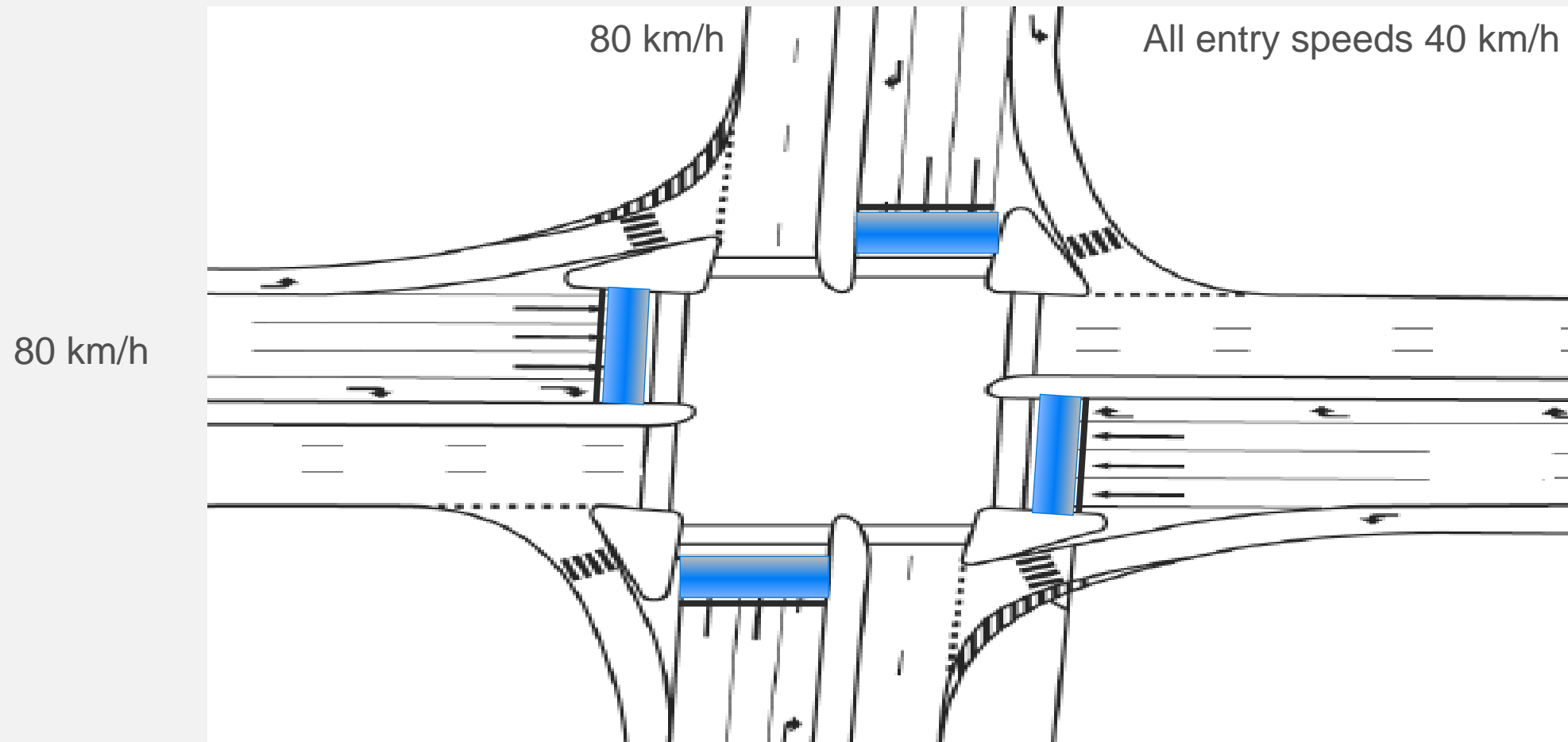
2. Urban signalised with horizontal approach deflections



Cut - Through Roundabout - conflict points and corresponding Pr(FSI)

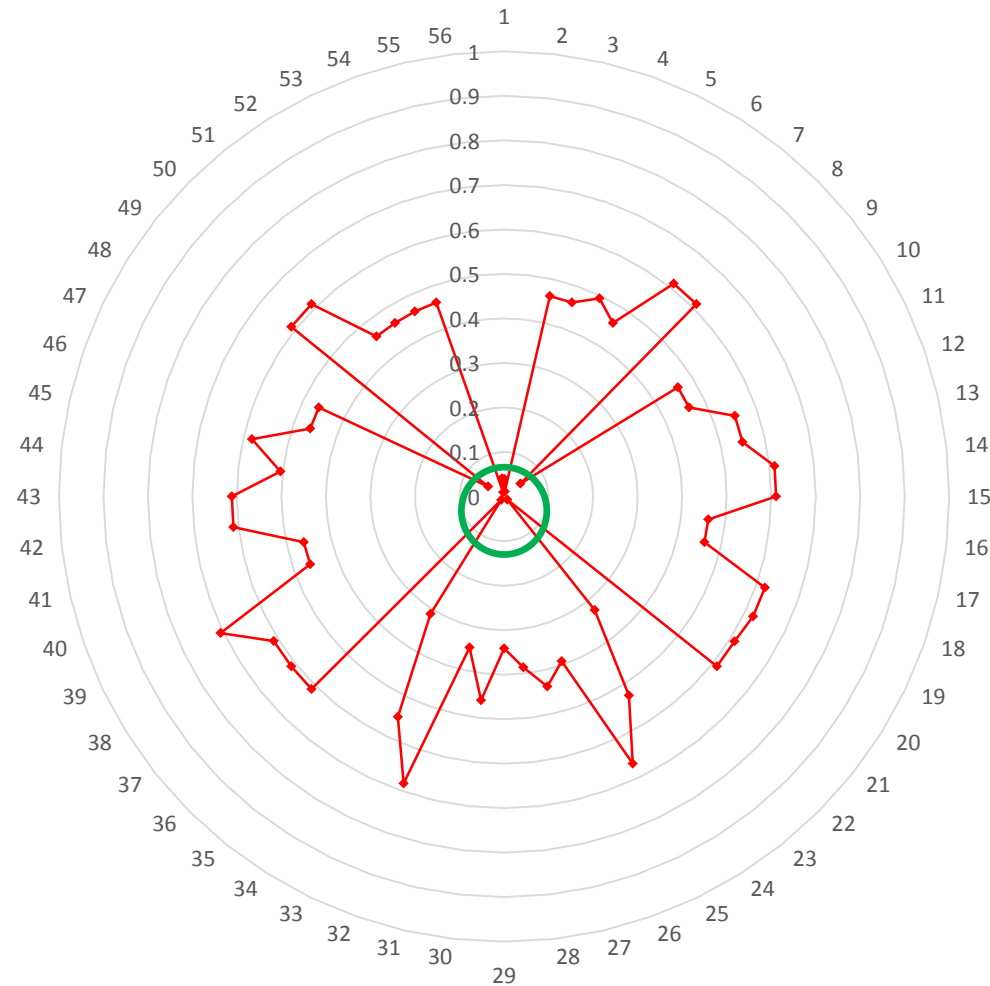


3. Urban signalised with vertical approach deflections



3. Urban signalised with vertical approach deflections

Divided Arterial Int (40km/h) - conflict points and corresponding Pr(FSI)



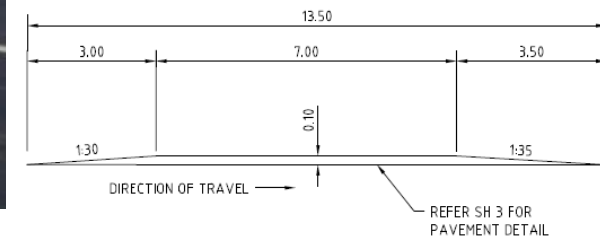
3. Urban signalised with vertical approach deflections



3. Urban signalised with vertical approach deflections



Source: VicRoads

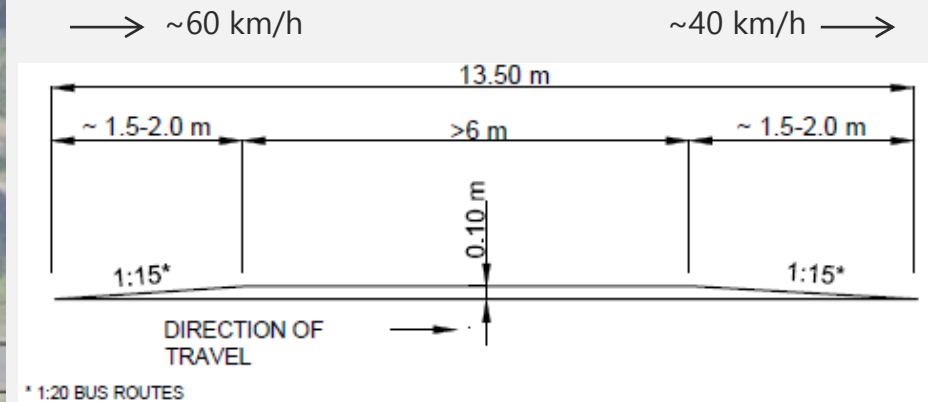


TYPICAL SECTION - RAISED PLATFORM

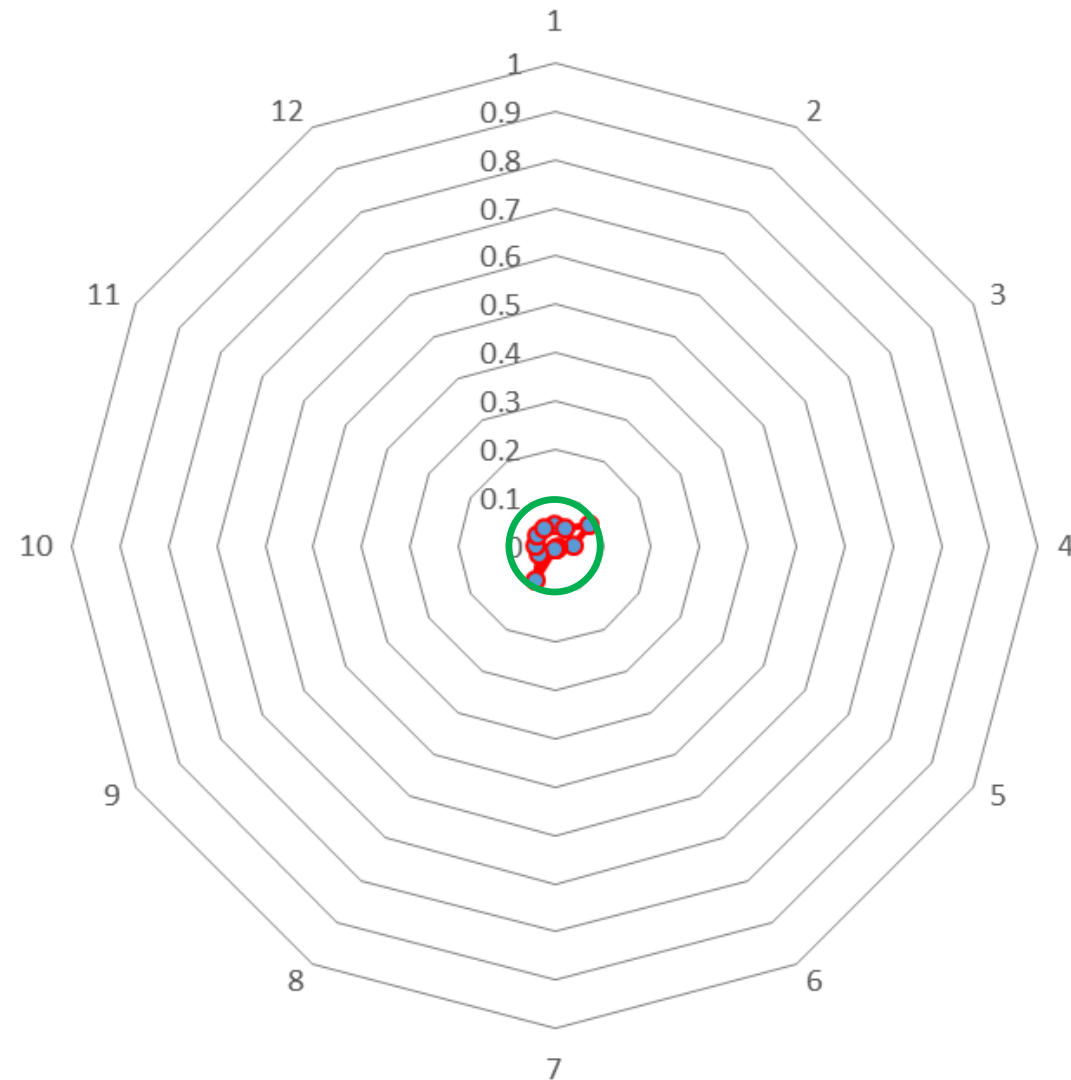
4. Urban compact roundabout vertical approach deflections



Low-cost solution



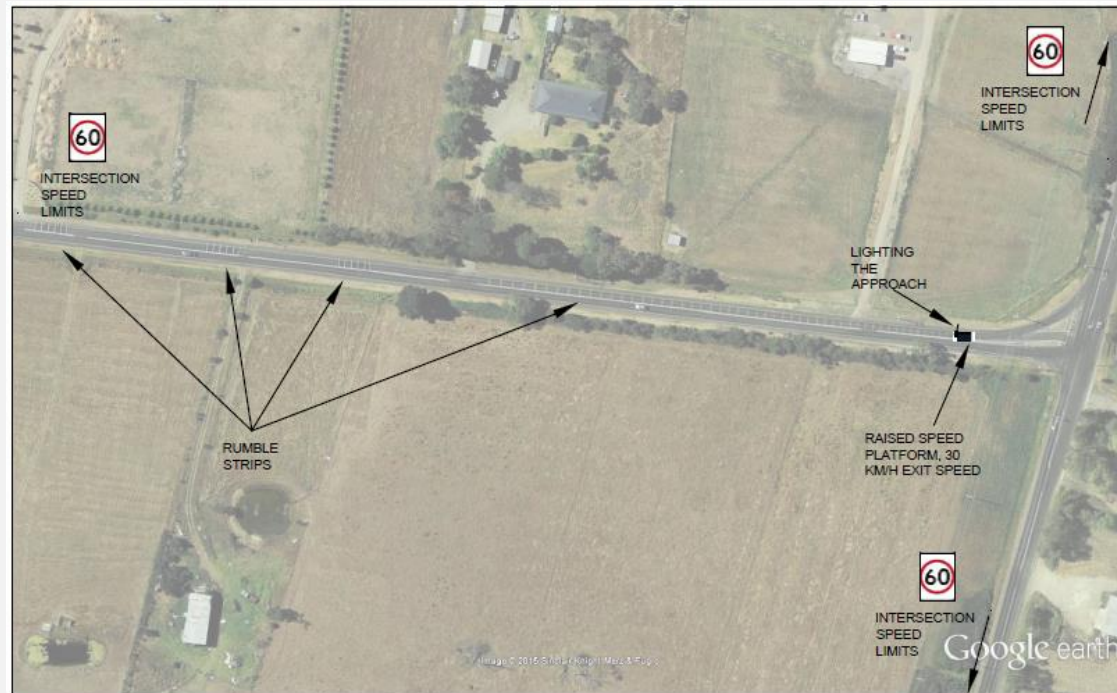
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4. Urban compact roundabout vertical approach deflections

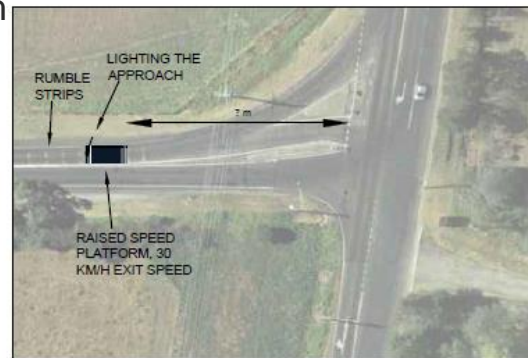
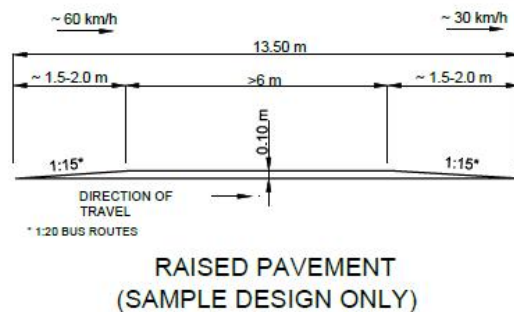


5. Rural priority vertical approach deflection retrofit combination



- Reduced approach speed limits
- Rumble strips
- Raised pavement platform
- Can be applied on X-intersections

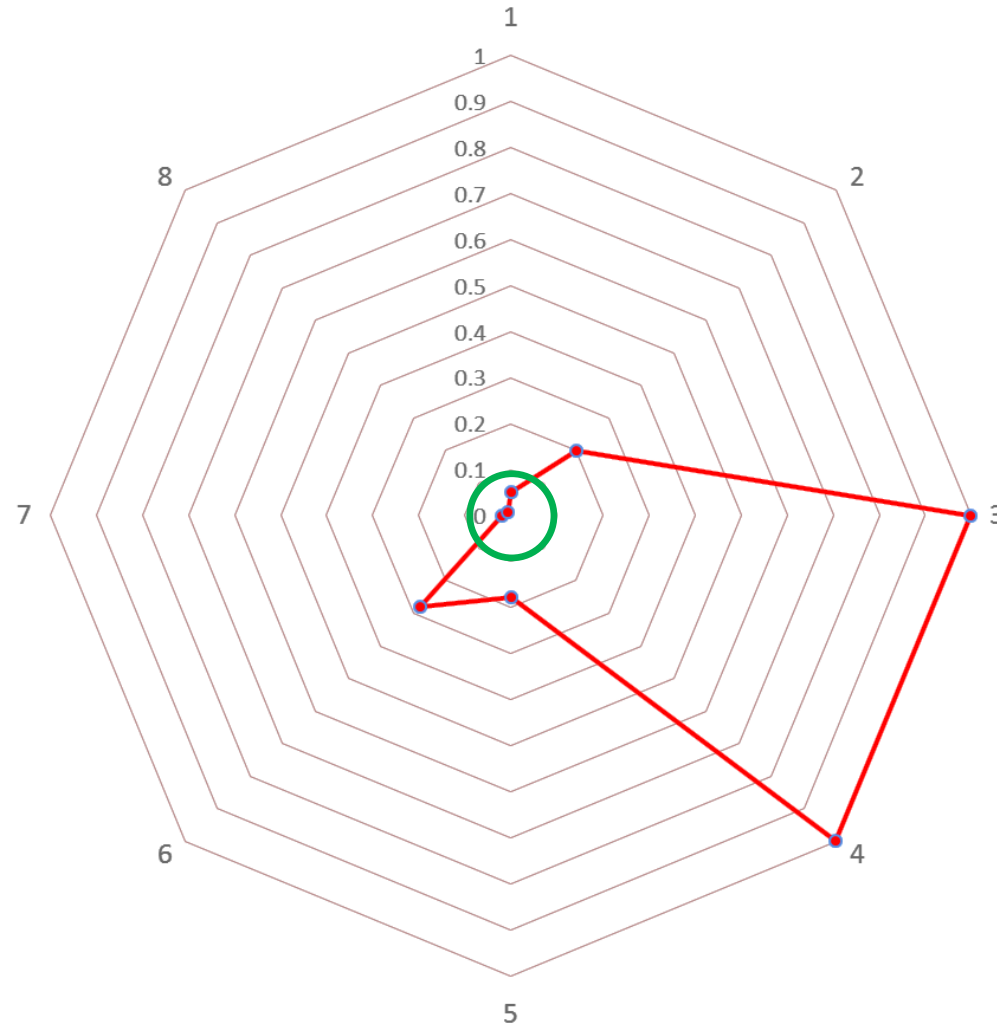
Entry speeds 60 km/h and 30 km/h



5. Rural priority vertical approach deflection retrofit combination

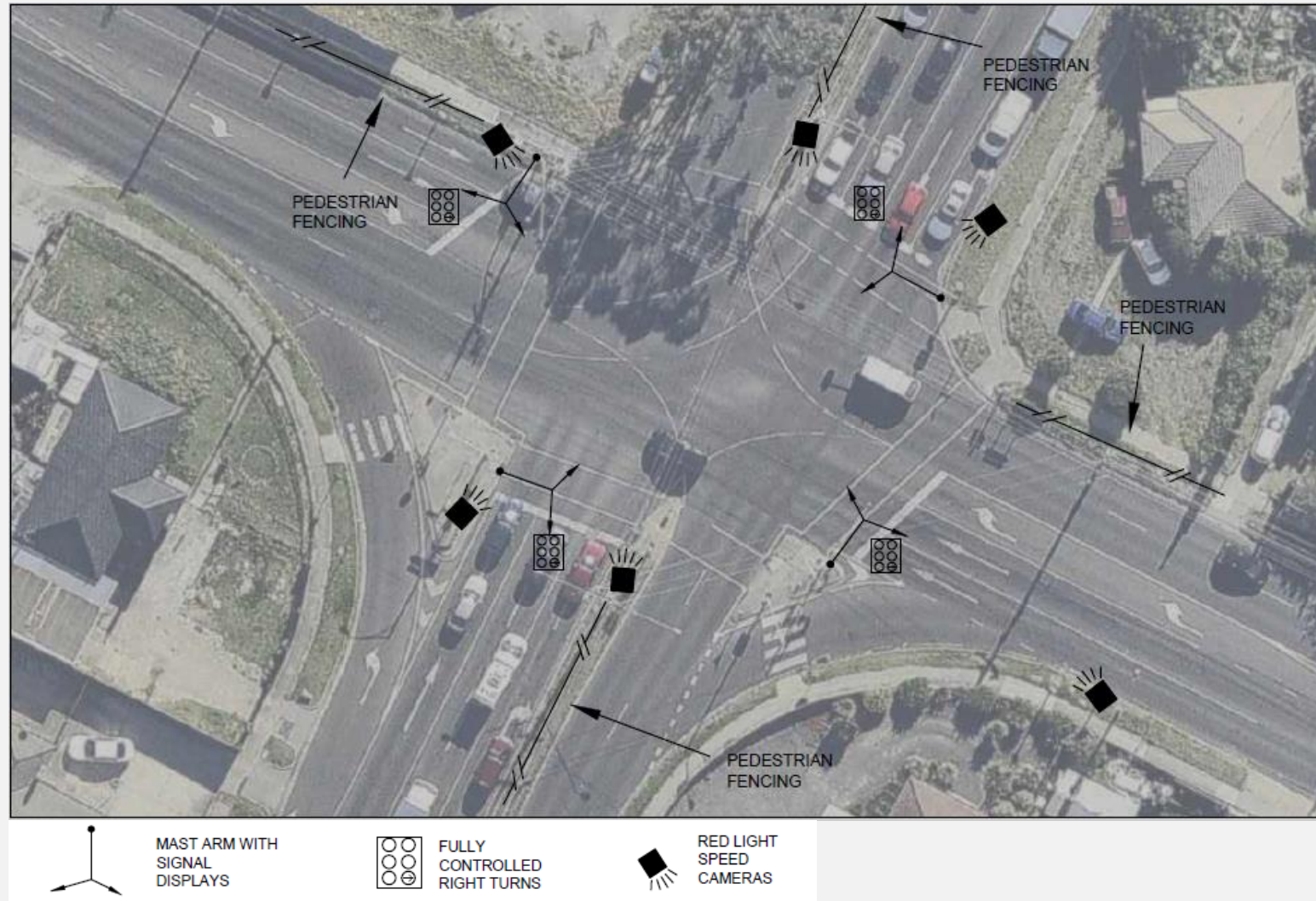


T- Intersection with Minor Rd - Conflict points and corresponding Pr(FSI)



- Reduced average severity, but...
- Increased alertness
- Reduction in driver error at give way, reduction in crash likelihood
- Potential improvements?

6. Urban signalised retrofit combination treatment

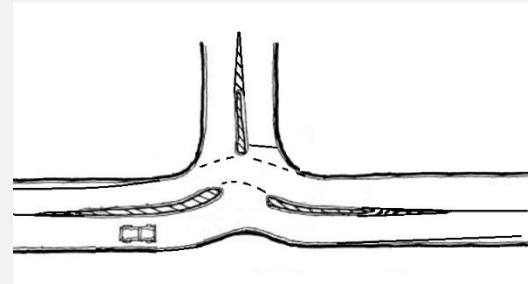
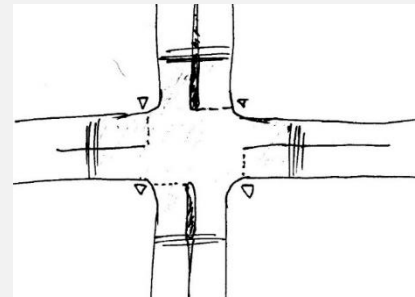
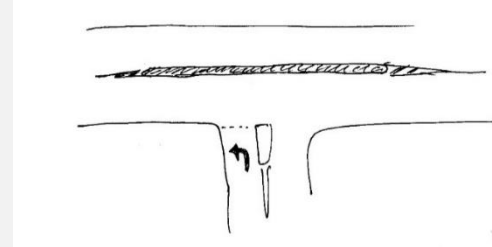


6. Urban signalised retrofit combination treatment

- Severity unchanged
- Reduction in system failures/road user error:
 - Fully controlled RTs – 60% right turn against, 45% crossing casualty CRF (Austroads 2012), up to 93% of right turn against casualty crashes (Bui, Cameron & Foong 1991).
 - Red-light speed cameras – 44% FSI CRF for crossing & right turn against (Budd, Scully & Newstead (2011)
 - Mast arms – varied 7-35%, all crashes CRF (ST1767 literature review)
 - Ped fencing – 20% casualty CRF pedestrians
- Estimated transition to Safe System – 40-50% FSI reduction???

Other low-cost ideas?

- Left-in, left-out
- Rural 4-way give way with platforms and rumble strips
- Modified-T
- Mini-roundabout



Thank you