SAFE SYSTEM SOLUTIONS

ROAD SAFETY · AUDITING · ENGINEERING · PROJECT DEVELOPMENT

ROAD DESIGN FOR HEAVY VEHICLES

Summary Report

[redacted]

SAFE SYSTEM SOLUTIONS

Pty Ltd

Specialist Road Safety Consultants

Offices in: Brunswick | Camberwell | Lidköping (Sweden) | Hamilton | Bendigo | Myrtleford | Brisbane

Date: 8 June 2022
Project Number: S20200015
Contact: [redacted]

Trading Name: Safe System Solutions Pty Ltd
Phone: +61 3 9381 2222
Address: 4/35 Hope Street, Brunswick, Vic, 3056
Web: www.SafeSystemSolutions.com.au
Email: info@SafeSystemSolutions.com.au

[redacted]

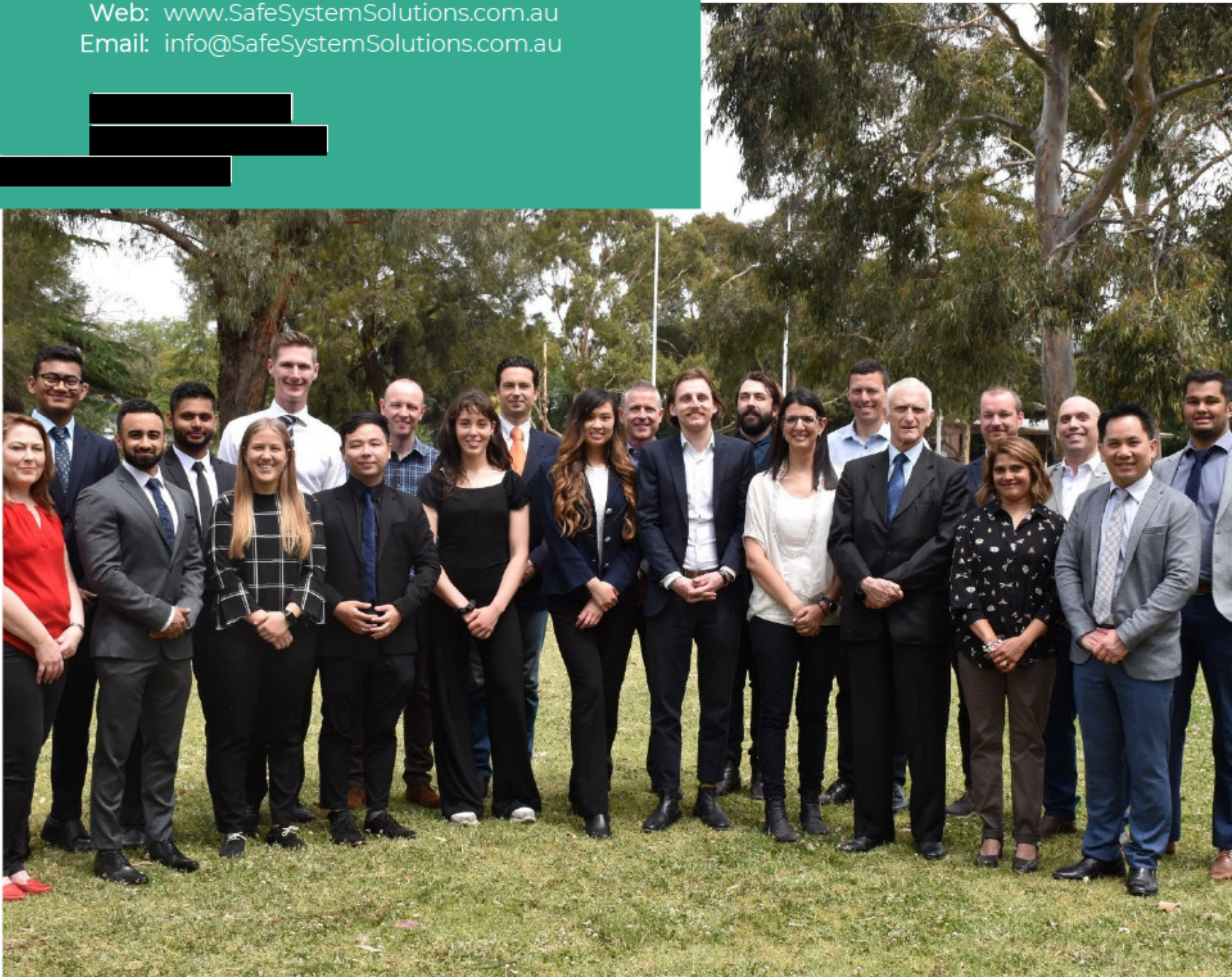


TABLE OF CONTENTS

B A C K G R O U N D

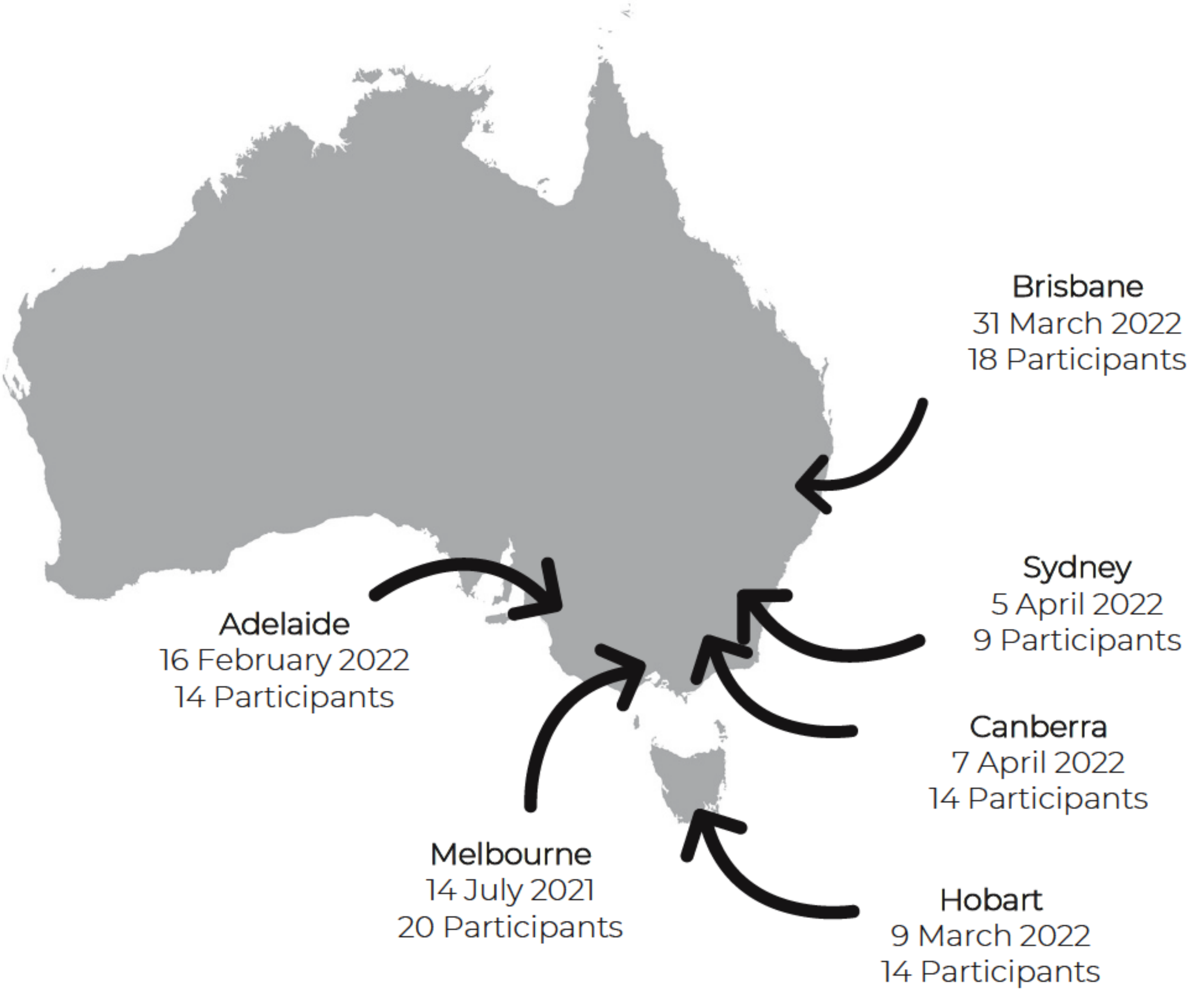
This course examined design standards, traffic engineering and road safety with a focus on the needs of heavy vehicles, from the truck cabin perspective. Safe System Solutions Pty Ltd & the National Heavy Vehicle Regulator (NHVR), with support from the Australian Trucking Association (ATA) offered a unique hands-on practical training program for those working in road design as an introduction for practitioners to consider heavy vehicle needs and how to best manage them on the road network.

The first half of the day explored unique heavy vehicle road design issues including swept paths, sight distances, geometric design elements, rollover prevention and other road safety issues. In the second part of the day a key feature of the course was the practical component which involved course participants sitting in the cabin of a truck whilst a licensed heavy vehicle driver highlighted some common areas of concern. This assisted practitioners to fully appreciate the challenges of driving from a truck driver's perspective which led them to rethink some aspects of road designs for heavy vehicles.

Watch a 2-minute video about the course

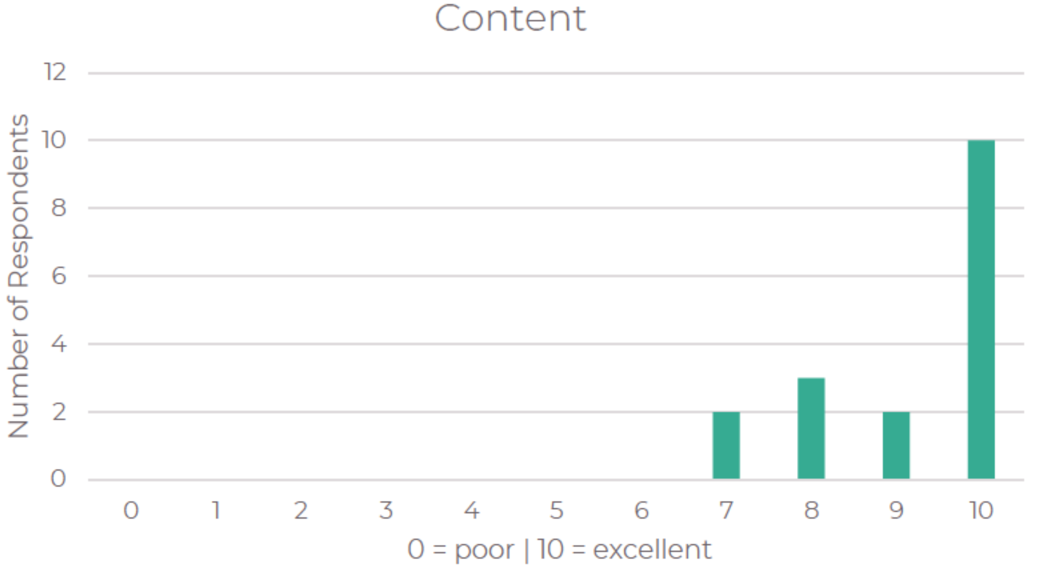
BACKGROUND

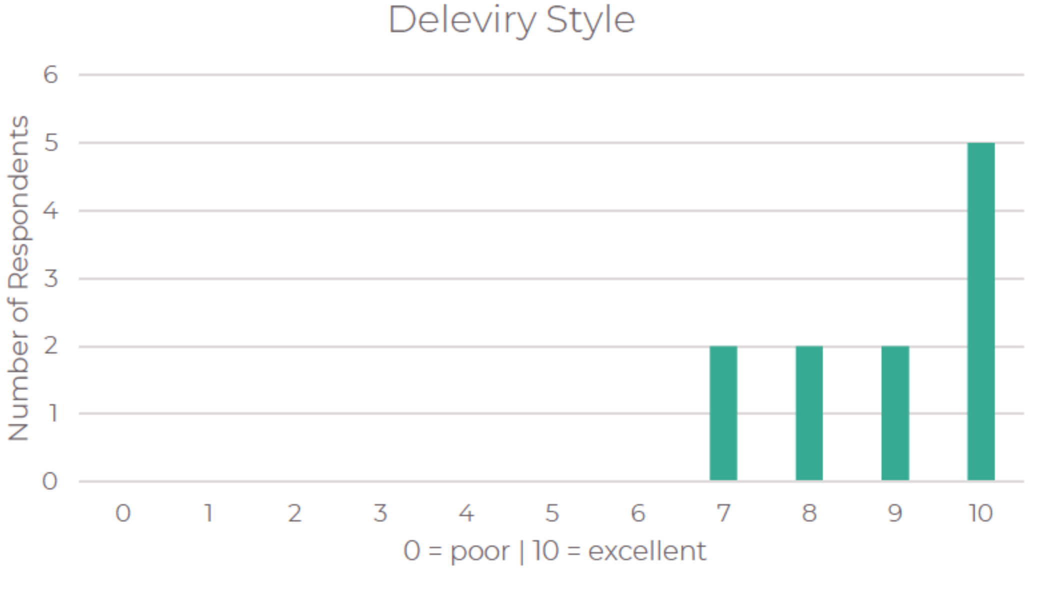
The course rollout was disrupted due to Covid-19, however the agreed six sessions were held in Brisbane, Sydney, Canberra, Hobart, Melbourne and Adelaide.



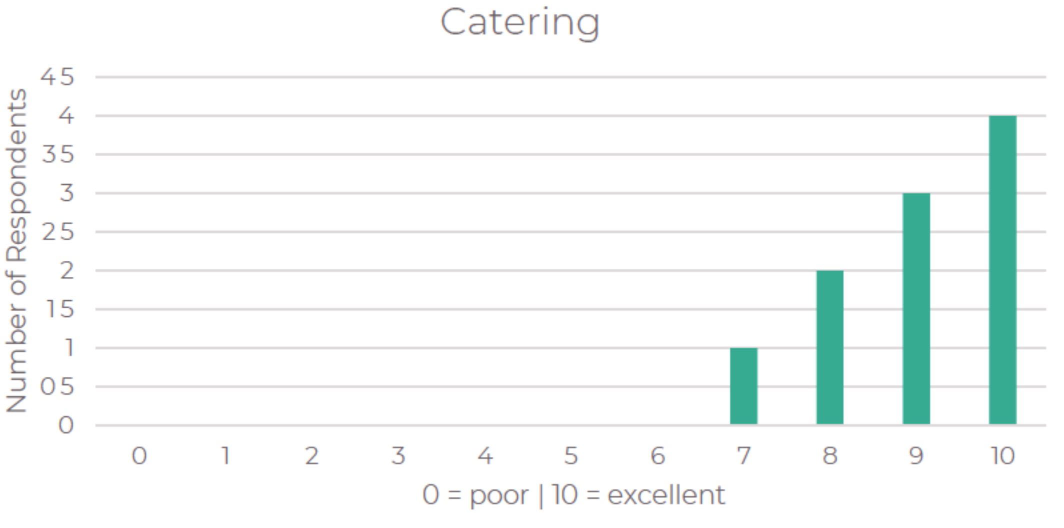
F E E D B A C K

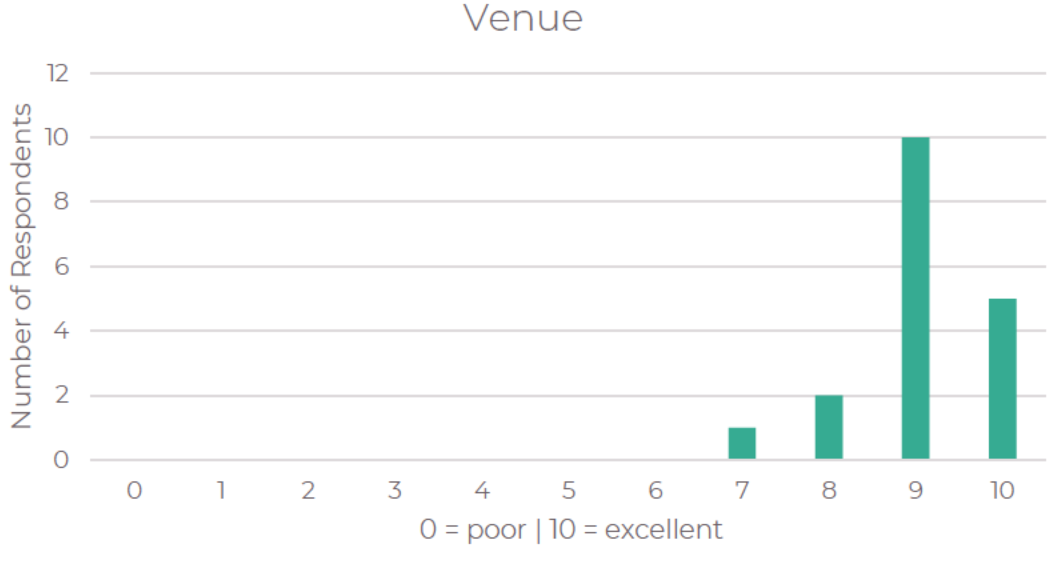
Participant feedback overall was excellent. Participants especially liked the practical nature of the course, the technical content and the delivery style. The venue and cantering were generally well received, with some minor exceptions.





F E E D B A C K


Catering
Number of Respondents
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0 1 2 3 4 5 6 7 8 9 10
0 = poor | 10 = excellent


Venue
Number of Respondents
12
10
8
6
4
2
0
0 1 2 3 4 5 6 7 8 9 10
0 = poor | 10 = excellent


ROAD DESIGN FOR
HEAVY VEHICLES
TECHNICAL TRAINING
Jamie Robertson (BEng (Hons), BSc)
Technical Design Lead
Safe System Solutions Pty Ltd
+61 3 9381 2222, 0429 186 619
Jamie. Robertson@SafeSystemSolutions.com.au
Safe System Solutions Pty Ltd
Office G2, 10 – 14 Hope Street, Brunswick, VIC, 3056
+61 3 9381 2222
info@SafeSystemSolutions.com.au
www.SafeSystemSolutions.com.au
SAFE
SAFE SYSTEM SOLUTIONS

FEEDBACK COMMENTS

"Excellent presentation of material at a good pace. Trainers had a very good understanding of the information they were delivering. Particularly relevant for Local Government road asset management."

"Good content. Interesting course"

"Fantastic mixing theory with the practical element in the afternoon, the truck drive really opened my eyes for things to consider when reviewing design for roads"

"The presenters had a broad range of knowledge and due to the training day being split up into lots of different activities, it kept us all engaged which helped with taking in the information as much as possible."

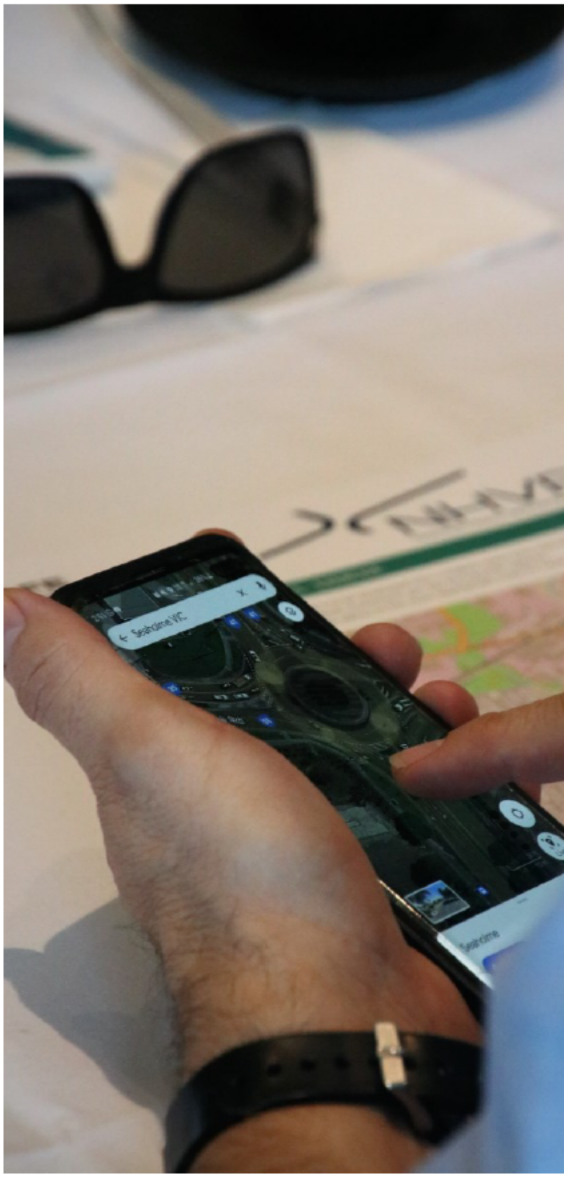
"I was hoping for more in the course about Performance Based Standards and comparisons of how these vehicles are different to other long vehicles."

FEEDBACK COMMENTS

"Some additional information on unsealed roads would have been useful. It was good to see a mix of participants from councils and private industry. The drive in the truck was really useful and interesting to see the new perspective."

"The exercise at the end didn't seem to really involve much of the content covered throughout the day - I think the course and final exercise could be improved by giving more consideration to the audience and specifying if it targeted at road managers vs road designers as the base level of knowledge is different between the two. Other than that, it was a good thought-provoking day for road design for heavy vehicles."

"Consider whether the training session can be offered to the Private Sector via a commercial arrangement. The content is highly suitable for less experienced professionals."



COVID-19 IMPACT

The overall program was delayed due to COVID-19 restrictions, state lockdowns and boarder closures in 2021. Originally the program was scheduled to be completed in August 2021, with initial schedule revisions meant the new program dates were scheduled to conclude in October 2021. However, due to the aforementioned restrictions, state lockdowns and boarded closures, these new dates were not able to be met. Advanced planning for 2022 enabled the full program to be delivered within the revised timeframe and concluded in April 2022.

Due to the venue and truck provider in Canberra having a COVID-19 outbreak the week we were scheduled to deliver the session in that location, they were not able to fulfil their agreed participation in the session. We were able to obtain a new venue, however, we were not able to secure another truck and driver at short notice. Therefore, participants in Canberra didn't have the practical truck experience.

WHAT WORKED?

We engaged Kevin Walsh from Australian Trucking Association to assist us with engaging local transport associations around the country. He put us in contact with the likes of the South Australian Road Transport Association, Heavy Vehicles Industry Australia, and Tasmanian Transport Association, which in turn enabled us to partner with truck providers, Don Watson Transport (VIC), Haulmark (SA) KS Easter Group (QLD), SRT Logistics (TAS), Vellex (NSW) to provide a highly engaging practical learning experience for all participants.

We held the Adelaide session at South Australian Road Transport Association headquarters and had access to their $500,000 truck simulator.

WHAT TO IMPROVE?

Feedback indicates that we could incorporate additional content around unsealed roads as well as targeting the final activity to incorporate more of the day's content and target the activity to different participants roles.

It may also be beneficial to charge a small registration fee. As this was a fully funded program, there was a high number of last-minute registration cancellations along with many participant no-shows in all locations.

CONCLUSION AND NEXT STEPS

Feedback indicates that this program has genuinely contributed to practitioners' professional practice. The topics covered have broad appeal for a range of road design, traffic engineering and road safety roles. In particular, the practical truck experience has enabled participants to completely understand the challenges of driving from a truck driver's perspective which in turn assists them to rethink many aspects of road designs for heavy vehicles resulting in safer outcomes for a range of road users.

The course disruptions associated with Covid-19 significantly impacted on the delivery of the program, and due to scheduling challenges, illness and exposure to Covid-19 there were many practitioners that would have liked to attend the course but were not able.

There is a high level of demand across all locations for another round of sessions.

SAFE SYSTEM SOLUTIONS

ROAD SAFETY · AUDITING · ENGINEERING · PROJECT DEVELOPMENT

APPENDIX A

Promotional Brochure

SAFE SYSTEM SOLUTIONS
ROAD SAFETY • AUDITING • ENGINEERING • PROJECT DEVELOPMENT

NHVR

ROAD DESIGN FOR HEAVY VEHICLES TRAINING

CLICK HERE TO REGISTER

This course examines design standards, traffic engineering and road safety with a focus on the needs of heavy vehicles, from the truck cabin perspective.

Safe System Solutions Pty Ltd & the **National Heavy Vehicle Regulator (NHVR)**, with support from the **Australian Trucking Association (ATA)** are pleased to offer a unique hands on practical training program for those working in road design. This course is an excellent introduction for practitioners to consider heavy vehicle needs and how to best manage them on the road network. The first half of the day explores **unique heavy vehicle road design issues** including swept paths, sight distances, geometric design elements, rollover prevention and other road safety issues.
In the second part of the day a key feature of the course is the **practical component** which will involve course participants sitting in the **cabin of the truck** whilst a licensed heavy vehicle driver will highlight some common areas of concern. This will assist practitioners fully appreciate the challenges of driving from a truck driver's perspective which will lead them to rethink some aspects of road designs for heavy vehicles.

2021 DATES & LOCATIONS - INCLUDING UPDATED DATES DUE TO LOCKDOWNS

MELBOURNE - 14 JULY
BRISBANE - ~~27 JULY~~ 20 OCTOBER
SYDNEY - ~~10 AUGUST~~ 13 OCTOBER
CANBERRA - ~~12 AUGUST~~ 15 OCTOBER
ADELAIDE - 25 AUGUST
HOBART - 2 SEPTEMBER

TRAINER

Jamie Robertson
BEng (Hons) BSc

Jamie is the Road Safety Design Specialist at Safe System Solutions Pty Ltd. Previously Jamie was Technical Leader Traffic Engineering & Design at VicRoads where he worked for 11 years.

His areas of expertise include traffic engineering, road safety, safety barriers, and design, which have seen him work on some of the largest and highest-profile road projects in Australia.

He is a recognised expert in the understanding and application of VicRoads guidelines, Austroads Guides and Australian Standards, and is also one of Victoria's most active Safe System practitioners and Senior Road Safety Auditors.

Jamie holds a Bachelor of Engineering (Civil), is an accredited Senior Road Safety Auditor and a heavy vehicle driver.

THIS WORKSHOP WILL COVER:

- Characteristics of heavy vehicles
- Design principles & design elements
- Intersection design
- Barriers and roadsides
- Common safety issues and treatments
- Practical component in the cabin of a heavy vehicle
- Austroads guidance on designing roads for heavy vehicles

WHO SHOULD ATTEND?

- State and Local government personnel
- Engineers, planners, designers, traffic managers
- Road safety practitioners

COST

The program is fully funded by SSS & NHVR, places are strictly limited and by regsitration only.

FOR MORE INFORMATION

Info@SafeSystemSolutions.com.au +61 3 9381 2222

SAFESYSTEMSOLUTIONS.COM.AU

SAFE SYSTEM SOLUTIONS

ROAD SAFETY · AUDITING · ENGINEERING · PROJECT DEVELOPMENT

APPENDIX B

Workshop Agenda

AGENDA:

ROAD DESIGN FOR HEAVY VEHICLES

0900	WELCOME AND INTRODUCTIONS
0915	Characteristics of Heavy Vehicles
0930	Design Principles
1000	Design Elements
1030	Morning tea
1045	Intersection Design
1115	Barriers & Roadsides
1135	Common Safety Issues & Treatments
1205	Lunch
1250	Driver experience (in small groups) Heavy Vehcile Design Exercise (in small groups)
1530	Participants present Design Exercise
1630	Conclusion & presentation of certificates

SAFE SYSTEM SOLUTIONS

NHVR

www.SafeSystemSolutions.com.au

SAFE SYSTEM SOLUTIONS

ROAD SAFETY · AUDITING · ENGINEERING · PROJECT DEVELOPMENT

APPENDIX C

Full List of Participants

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

SAFE SYSTEM SOLUTIONS

ROAD SAFETY · AUDITING · ENGINEERING · PROJECT DEVELOPMENT

APPENDIX D

Learning Guide

AGENDA:

ROAD DESIGN FOR HEAVY VEHICLES

0900	WELCOME AND INTRODUCTIONS
0915	Characteristics of Heavy Vehicles
0930	Design Principles
1000	Design Elements
1030	Morning tea
1045	Intersection Design
1115	Barriers & Roadsides
1135	Common Safety Issues & Treatments
1205	Lunch
1250	Driver experience (in small groups) Heavy Vehcile Design Exercise (in small groups)
1530	Participants present Design Exercise
1630	Conclusion & presentation of certificates

SAFE SYSTEM SOLUTIONS
ROAD SAFETY • AUDITING • ENGINEERING • PROJECT DEVELOPMENT

NHVR

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

Road Design for Heavy Vehicles

[redacted]

www.SafeSystemSolutions.com.au

Follow: Safe System Solutions Pty Ltd

Check out our recent photos

SAFE SYSTEM SOLUTIONS

1

JAMIE ROBERTSON
TECHNICAL LEAD
SAFE SYSTEM SOLUTIONS PTY LTD
+61 429 186 619
Jamie.Robertson@SafeSystemSolutions.com.au
www.SafeSystemSolutions.com.au

Specialist Presenter

- **Current role:** Technical Lead – Safe System Solutions Pty Ltd
- **Past role:** Technical Lead Traffic and Design - VicRoads
- **Lead trainer:**
  - Road Safety Barriers technical training course
  - Road Design for Heavy Vehicles training course
- **Senior Road Safety Auditor:** Victoria, South Australia, NSW
- **Current lead author:** Austroads Guide to Road Safety Part 2: Roads and Roadsides
- **Areas of expertise:**
  - Road Safety Barriers
  - Safe System Assessments
  - Detailed Design Road Safety Audits
  - Traffic Engineering
  - Lighting, Signage and Traffic Signal Design

2

[redacted]

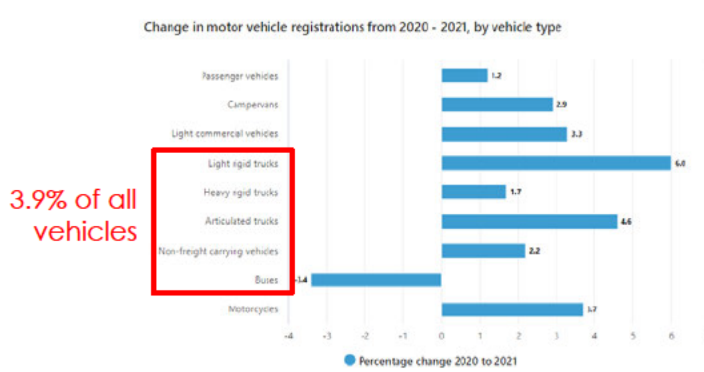
SAFE SYSTEM SOLUTIONS

2

Overview

- Why consider heavy vehicles?
- Design principles
- Road elements
- Intersection design
- Safety issues and treatments

Heavy vehicle activity



Source: ABS

Road Design for Heavy Vehicles

Heavy vehicle activity

Mode	Goods moved billion tonne kilometres	Change since previous year
Road	235.4	↑ 5.6%
Rail	453.1	↑ 1.3%
Coastal shipping	111.9	↑ 0.5%
Air freight	0.3	↓ 9.1%
Total freight task	800.4	↑ 2.4%

www.bitre.gov.au

SAFE SYSTEM SOLUTIONS

5

Road Design for Heavy Vehicles

Moving more with less

- High Performance Freight Vehicles
- Performance Based Standards

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

6

Heavy vehicle crashes

- In 2019 in Australia:
  - 188 people were killed in crashes involving heavy trucks (including 38 deaths from single vehicle crashes)
  - 20 people were killed in crashes involving buses (zero deaths from single vehicle crashes)

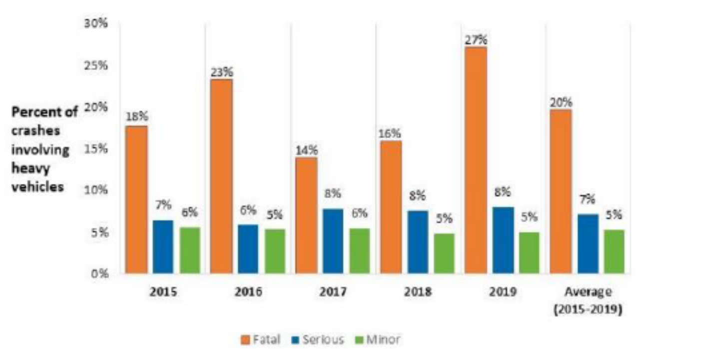
www.bitre.gov.au

➢ **The risk of a fatality in a crash involving a heavy vehicle is approximately 3 times higher than in a crash involving light vehicles only**

www.roadsafety.vic.gov.au

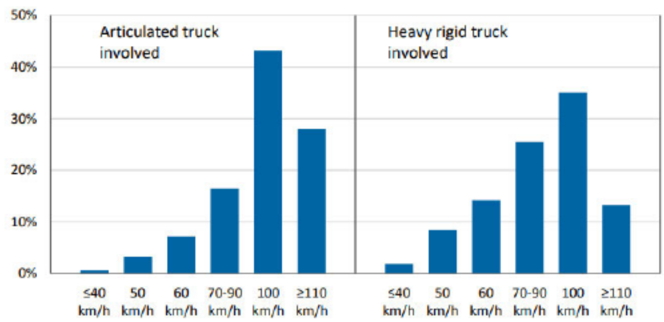
Heavy vehicle crashes

Figure 1: Percent of heavy vehicle crashes as a representative of all crashes by severity and year, South Australia, 2015-2019



Heavy vehicle crashes

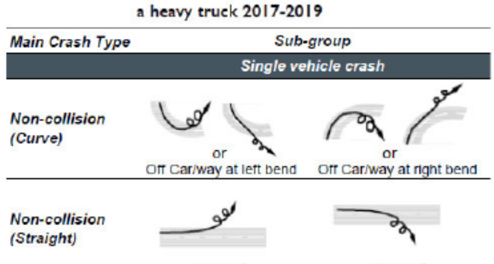
Figure 1.2 **Distribution of deaths (%) across posted speed zones – crashes involving heavy trucks (5 years combined to 2019)**



SAFE SYSTEM SOLUTIONS

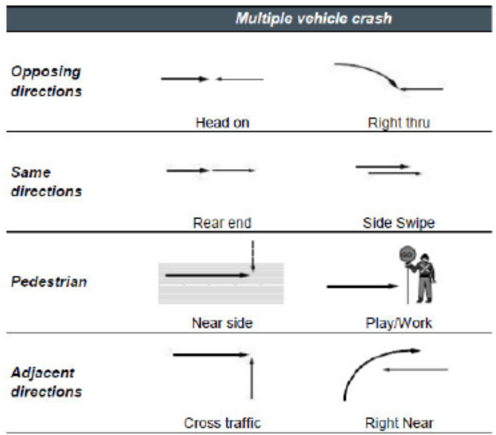
Heavy vehicle crashes

Figure 1.6 **Common crash type (sub-groups) for fatal crashes involving a heavy truck 2017-2019**



SAFE SYSTEM SOLUTIONS

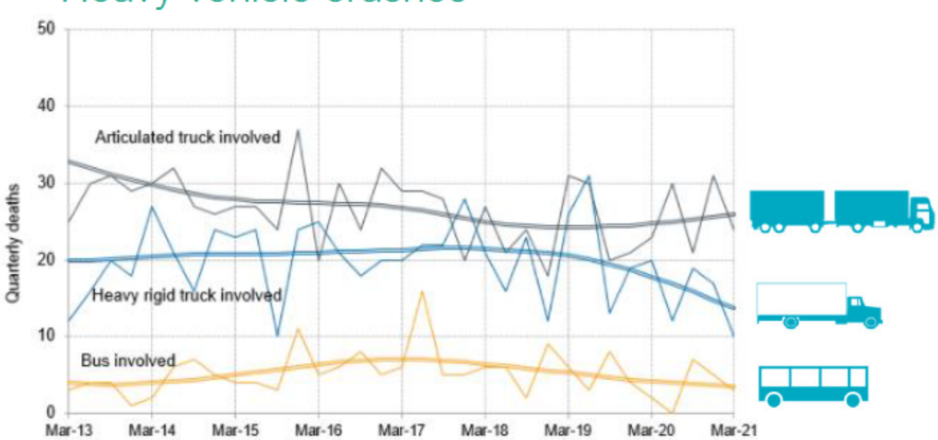
Heavy vehicle crashes



SAFE SYSTEM SOLUTIONS

11

Heavy vehicle crashes



[redacted]

SAFE SYSTEM SOLUTIONS

12

Heavy vehicle crashes

Table D 1: Accident rate comparison per 100 million km travelled between HPVs (survey) and conventional vehicles

		Minor	Moderate	Serious	Major	Total
Conventional	Articulated	21	22	16	13	29
	Rigid Truck	42	34	19	7	26
	Weighted Total	27.5	25.7	16.9	11.1	28
HPV	Articulated	8	2	2	5	7
	Rigid Truck	20	26	4	2	6
	Weighted Total	11.7	9.4	2.6	4.1	6.7
Incident Savings		57%	63%			

Source: Austroads (2014a).

	Crashes per 100 million kilometres	Crashes per 10,000 vehicles
Single semi-trailer	20.6	146
B-double	7.3	121
B-triple	4.3	99

[redacted]

SAFE SYSTEM SOLUTIONS

13

Road Design for Heavy Vehicles

What is a heavy vehicle?

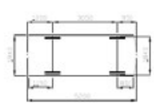


Figure 3.1: Passenger vehicle (5.2 m)

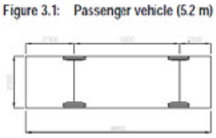


Figure 3.2: Service vehicle (8.8 m)

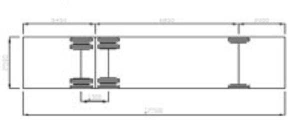


Figure 3.3: Single unit truck/bus (12.5 m)

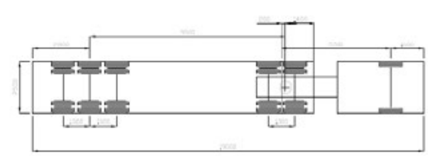


Figure 3.6: Prime mover and semi-trailer (19 m)

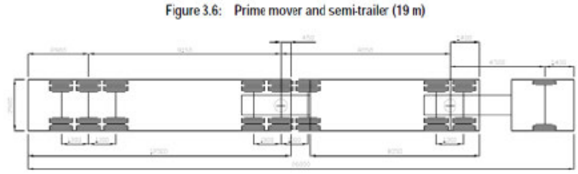


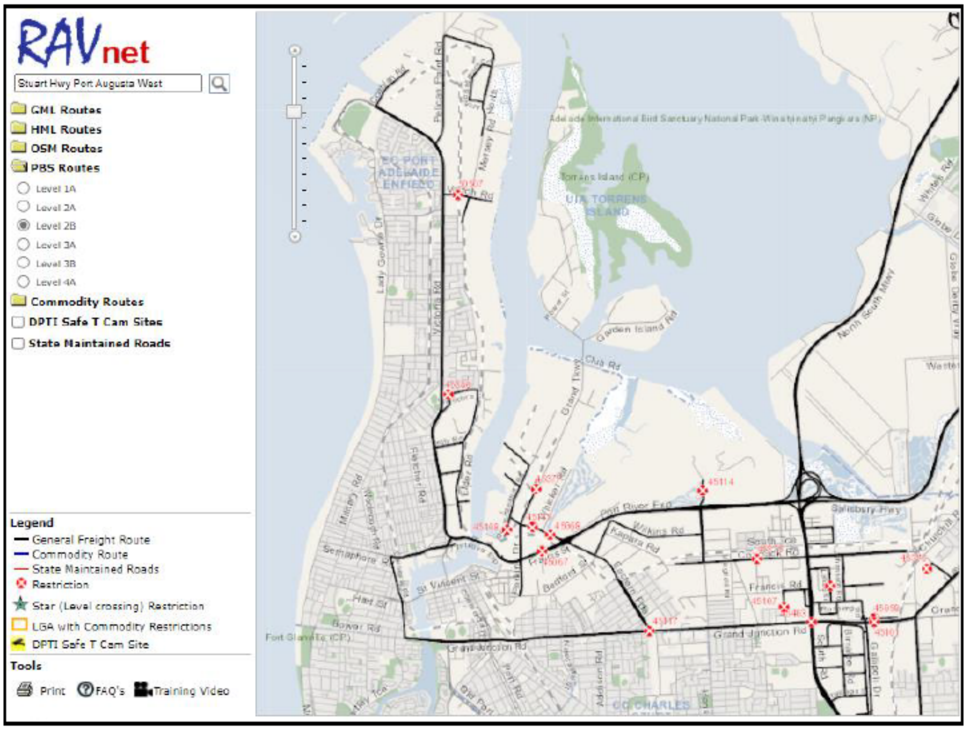
Figure 3.9: B-double (26 m)

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

[redacted]

SAFE SYSTEM SOLUTIONS

14



15

Road Design for Heavy Vehicles

What heavy vehicle is that?

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

NHVR National Heavy Vehicle Regulator
SAFE SYSTEM SOLUTIONS

16

Heavy vehicle characteristics

- Dimensions
  - Length
  - Tracking width
  - Driver eye height
  - Centre of gravity, Static Rollover Threshold (SRT)
- Performance capability
  - Acceleration
  - Deceleration/stopping
  - Operating speed

DESIGN PRINCIPLES

The Design vehicle

The physical and operating characteristics of the largest vehicles using the road control many elements in the geometric design.

Design vehicle:
- 26m B-double
- 19m semi-trailer
- 12.5m rigid truck/bus
- 8.8m service vehicle
- 5m car
- Other?

Checking vehicle

Design speed

Truck operating speed is generally taken as being equal to the posted speed limit for design purposes.

Therefore, truck operating speed is assumed to be:

- the same as car operating speed in urban areas and major rural cities
- 10 km/h less than car operating speed in rural areas

Road Design for Heavy Vehicles

Sight distance

The design of all new roads should cater for the sight distance requirements of trucks

(Austroads)

Driver eye height: HVs = ______

Cars = ______

Braking ability: Cars

HVs

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS

Sight distance

Designers should provide stopping sight distance <u>for both cars and trucks for all roads</u>

(Austroads)

However, in practice, road design is typically based on car performance.

Practitioners should be aware of the different (and generally more stringent) requirements when designing for trucks. Sight distance is a prime example.

Sight distance

Car SSD

Deceleration based on braking on <u>wet</u>, sealed roads

Table 5.5: Stopping sight distances for cars on sealed roads

Design speed (km/h)	Absolute minimum values Only for specific road types and situations(1) based on $d = 0.46$(2),(3)			Desirable minimum values for all road types based on $d = 0.36$			Values for major highways and freeways in flat terrain(7) based on $d = 0.26$	
	$R_T = 1.5$ s(4)	$R_T = 2.0$ s(4)	$R_T = 2.5$ s	$R_T = 1.5$ s(4)	$R_T = 2.0$ s(4)	$R_T = 2.5$ s	$R_T = 2.0$ s	$R_T = 2.5$ s
40	30	36	–	34	40	45	–	–
50	42	49	–	48	55	62	–	–
60	56	64	–	64	73	81	–	–
70	71	81	–	83	92	102	113	123
80	88	99	–	103	114	126	141	152
90	107	119	132	126	139	151	173	185
100	–	141	155	–	165	179	207	221
110	–	165	180	–	193	209	244	260
120	–	190	207	–	224	241	285	301
130	–	217	235	–	257	275	328	346

Road Design for Heavy Vehicles

Sight distance

Truck SSD

Deceleration based on braking on dry, sealed roads

Includes 0.5 s delay for operation of air brakes

Table 5.6: Truck stopping sight distances

Operating speed (km/h)	Single unit trucks, semi-trailers and B-doubles Based on $d = 0.29^{(1)}$		
	$R_T = 1.5$ s[2]	$R_T = 2.0$ s	$R_T = 2.5$ s
40	38	44	49
50	55	62	69
60	74	82	91
70	96	105	115
80	120	131	142
90	147	160	172
100	–	191	205
110	–	225	241

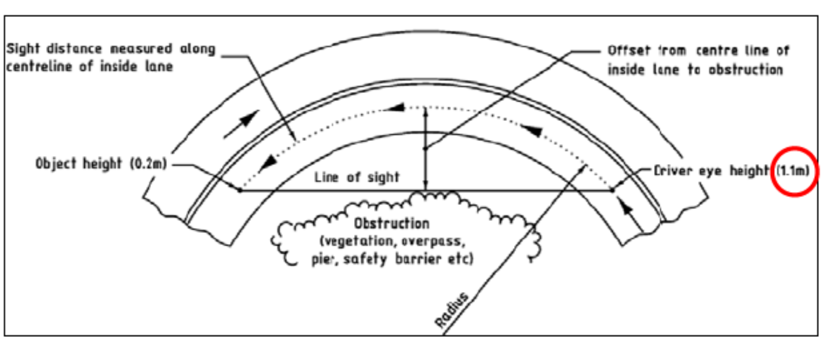
ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles

Sight distance

SSD



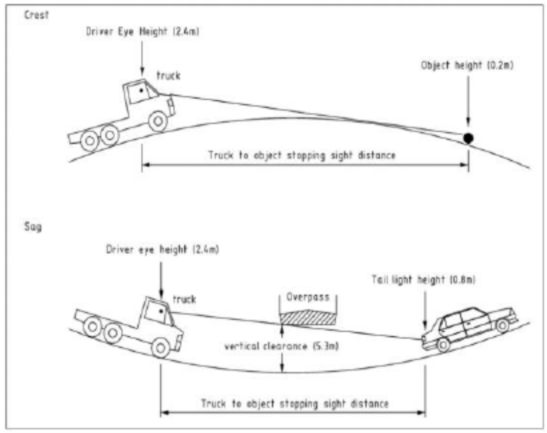
AGRD Part 3

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Sight distance

SSD



AGRD Part 3

Rollover prevention

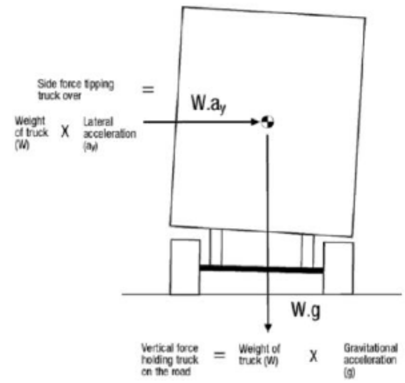
- Hundreds of truck rollovers occur each year in Australia
- Truck rollovers are especially common for trucks carrying timber, livestock and liquids
- Horizontal curve standards are based on friction, however heavy vehicles tend to roll over before skidding, due to their higher centre of gravity than cars

Rollover prevention

Rollover generally occurs due to excessive lateral forces when cornering.

The contributing factors are:

- Speed
- Turning radius
- Centre of gravity
- Load transfer
- Vehicle features



DESIGN ELEMENTS

Cross section

- Lane width

Table 4.3: Urban arterial road widths

Element	Lane width (m)	Comments
General traffic lane	3.5	General traffic lane widths to be used for all roads
	3.0–3.4	For use on low speed roads with low truck volumes
Service road lane	3.4–5.5	Range of lane widths on service roads (refer to Section 4.11)
Wide kerbside lane	4.2	Locations where there are high truck volumes (additional width provided for trucks)
	4.2–4.5	Locations where motorists and cyclists use the same lane (refer Section 4.8.11 and Commentary 6)
HOV lane	3.5–4.5	Bus lane (refer Section 4.9.2)
	3.3	Tram/light rail vehicle lane (refer Section 4.9.3)
Minimum width between kerb and channel (to provide for passing of broken down vehicles)	5.0[1]–6.5[2]	Width of a single lane suitable for use in a left turn slip lane, or two lane, two way divided road with a raised median
	2 × 4.0 (8.0)	Width of two lanes that provide for two lines of traffic to (slowly) pass a broken down vehicle.

Road Design for Heavy Vehicles

Cross section

- Lane widening at curves (per lane)

Radius (m)	Single unit truck/ bus (12.5 m)	Long rigid bus (14.5 m)	Articulated bus (19 m)	Prime move and semi-trailer (19 m)	Prime move and semi-trailer (25 m)	B-double (25 m)	B-double (26 m)	A-double (Type I) (36.2 m)	B-triple (35.4 m)	A-triple (53.4 m)
30								Use Turning Templates		
40	1.00									
50	0.80		1.00							
60	0.70	1.00	0.80							
70	0.60	0.90	0.70	1.00						
80	0.50	0.80	0.60	0.90		1.10				
90	0.50	0.70	0.50	0.80		1.00	1.10			
100	0.40	0.60	0.50	0.70		0.90	1.00			
120	0.30	0.50	0.40	0.60	1.00	0.70	0.80	1.00	1.10	
140	0.30	0.40	0.30	0.50	0.90	0.60	0.70	0.90	0.90	
160	0.30	0.40	0.30	0.40	0.80	0.60	0.60	0.80	0.80	1.10
180	0.20	0.30	0.30	0.40	0.70	0.50	0.50	0.70	0.70	1.00
200	0.20	0.30	0.20	0.30	0.60	0.40	0.50	0.60	0.70	0.90
250	0.20	0.20	0.20	0.30	0.50	0.40	0.40	0.50	0.50	0.70
300	0.10	0.20	0.20	0.20	0.40	0.30	0.30	0.40	0.40	0.60
350	0.10	0.20	0.10	0.20	0.30	0.30	0.30	0.40	0.40	0.50
400	0.10	0.20	0.10	0.20	0.30	0.20	0.20	0.30	0.30	0.40
450	–	0.10	0.10	0.20	0.30	0.20	0.20	0.30	0.30	0.40
500	–	0.10	–	0.10	0.20	0.20	0.20	0.20	0.30	0.40
600	–	0.10	–	0.10	0.20	0.10	0.20	0.20	0.20	0.30
700	–	–	–	–	0.20	0.10	0.10	0.20	0.20	0.30
800	–	–	–	–	0.20	0.10	0.10	0.20	0.20	0.20
900	–	–	–	–	0.10	–	0.10	0.10	0.10	0.20
1000	–	–	–	–	0.10	–	–	0.10	0.10	0.20
1200	–	–	–	–	0.10	–	–	0.10	0.10	0.10
1400	–	–	–	–	–	–	–	–	–	0.10
1600	–	–	–	–	–	–	–	–	–	0.10

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Cross section

- Seal width
- Shoulders

Cross section

- Crown lines

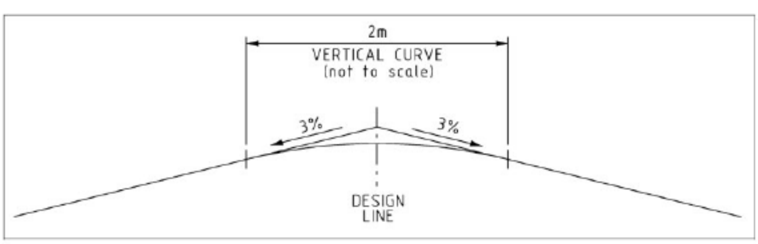


Figure 4.3: 2 m rounding across crown line

Road Design for Heavy Vehicles

Cross section

- Batters

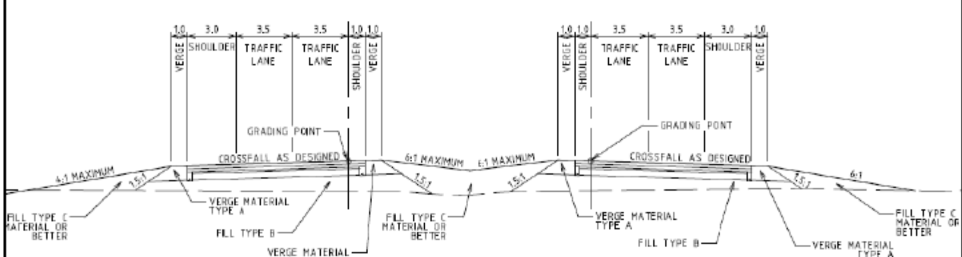
Fill batters may be hazardous due to the combination of height and slope and surface condition, as well as what may be on the slope or at the base of the embankment.

Slope	Cars	Trucks
Traversable and: • Recoverable • Non-recoverable	 4:1 or flatter 4:1 to 3:1	 10:1 or flatter 10:1 to 6:1
Non-traversable and non-recoverable	steeper than 3:1	steeper than 6:1

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles

Cross section



ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles

Horizontal geometry – minimum curve radii

Table 7.5: Recommended side friction factors for cars and trucks

Operating speed (km/h)	f			
	Cars		Trucks	
	Des max	Abs max	Des max	Abs max
40	0.30	0.35	0.21	–
50	0.30	0.35	0.21	0.25
60	0.24	0.33	0.17	0.24
70	0.19	0.31	0.14	0.23
80	0.16	0.26	0.13	0.20
90	0.13	0.20	0.12	0.15
100	0.12	0.16	0.12	0.12
110	0.12	0.12	0.12	0.12
120	0.11	0.11	0.11	0.11
130	0.11	0.11	0.11	–

Table 7.6: Minimum radii of horizontal curves based on superelevation and side friction at maximum values (cars)

Operating speed km/h	Urban roads	
	e_{max} = 5%	
	f_{max} = Des min	f_{max} = Abs min
40	36	31
50	56	49
60	98	75
70	161	107
80	240	163
90	354	255
100	–	–

(or **319m** for trucks)

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles

Horizontal geometry

Key considerations:

- Successive curves should be joined by a short length of straight
- **Compound** and **broken back** curves may cause instability for trucks due to the change in friction demand
- **Reverse** curves may not allow for truck tracking

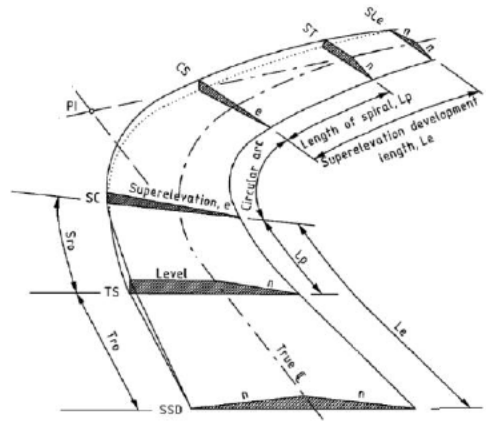
ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Superelevation

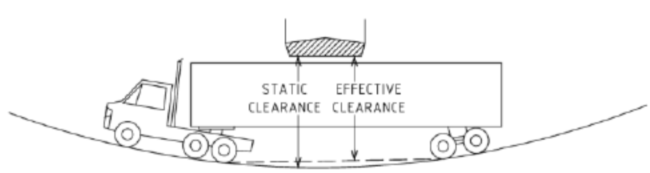
Key considerations:

- Super development
- Crossfall
- Adverse crossfall
- Effects of downgrades



Vertical geometry

- Generally controlled by stopping sight distance
- Crest curves
- Sag curves
- Vertical clearances



Grades

Table 8.2: **Effect of grade on vehicle type**

Grade %	Reduction in vehicle speed as compared to flat grade %				Road type suitability
	Uphill		Downhill		
	Light vehicle	Heavy vehicle	Light vehicle	Heavy vehicle	
0–3	Minimal	Minimal	Minimal	Minimal	For use on all roads
3–6	Minimal	Some reduction on high speed roads	Minimal	Minimal	For use on low-moderate speed roads (incl. high traffic volume roads)
6–9	Largely unaffected	Significantly slower	Minimal	Minimal for straight alignment. Substantial for winding alignment	For use on roads in mountainous terrain. Usually need to provide auxiliary lanes if high traffic volumes
9–12	Slower	Much slower	Slower	Significantly slower for straight alignment. Much slower for winding alignment	Need to provide auxiliary lanes for moderate – high traffic volumes. Need to consider run-away vehicle facilities if proportion of commercial vehicles is high
12–15	10–15 km/h Slower	15% max. Negotiable	10–15 km/h Slower	Extremely slow	Satisfactory on low volume roads (very few or no commercial vehicles)
15–33	Very slow	Not negotiable	Very slow	Not negotiable	Only to be used in extreme cases and be of short lengths (no commercial vehicles)

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Grades

Table 8.3: **General maximum grades (%)**

Operating speed (km/h)	Terrain		
	Flat	Rolling	Mountainous
60	6–8	7–9	9–10
80	4–6	5–7	7–9
100	3–5	4–6	6–8
120	3–5	4–6	–
130	3–5	4–6	–

Table 8.4: **Desirable maximum lengths of grades**

Grade %	Length (m)
2–3	1800
3–4	900
4–5	600
5–6	450
> 6	300

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Grades

- Length limits on steeper grades
- Beware steep downhill grades
- Avoid steep grades at intersections
- Use grades to advantage
    - Overtaking lanes
    - Climbing lanes
    - Acceleration lanes
    - Deceleration lanes

43

Road Design for Heavy Vehicles

Grades

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS

44

References:

- Austroads Guides to Road Design
- State Road Authority Supplements
- Austroads Design Vehicles and Turning Path Templates

Research:

- Austroads Research Reports and Technical Reports
- ARRB Research Reports

INTERSECTION DESIGN

Swept paths

Truck tracking characteristics are a primary consideration for intersection geometry

- Ensure intersections can accommodate the swept paths of larger vehicles
- Ensure the choice of design vehicle(s) is correct

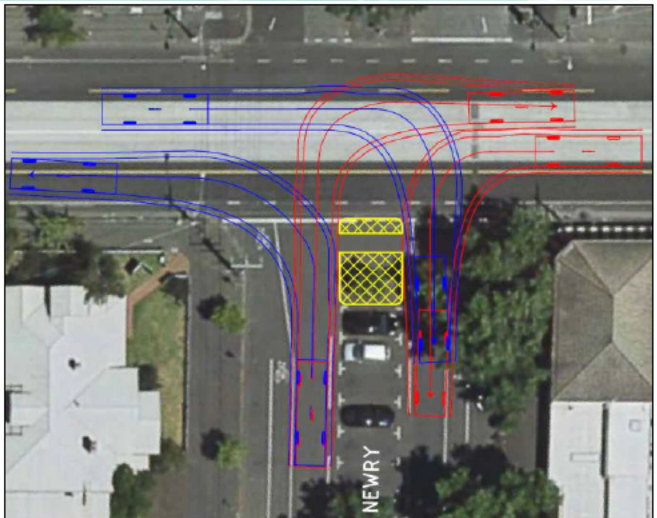
Road Design for Heavy Vehicles

Swept paths

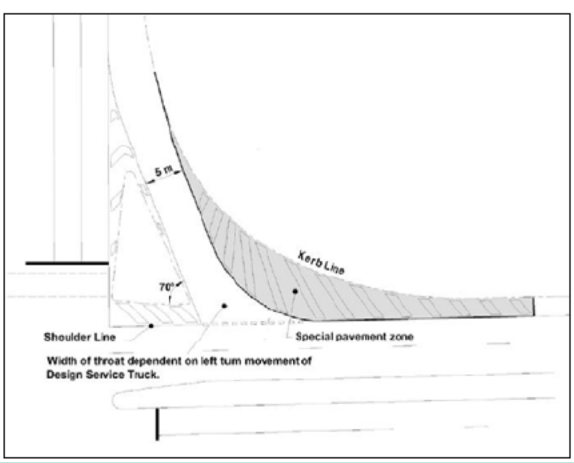
Potential issues may include:

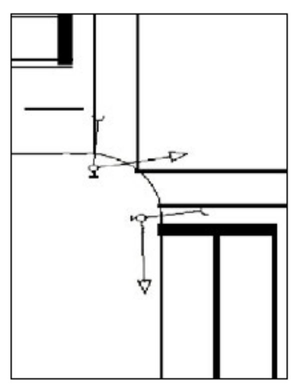
- Encroachment into adjacent lanes
- Encroachment into pedestrian areas
- Vehicle conflicts within intersections
- Impacts with roadside furniture

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS



Left turn treatments

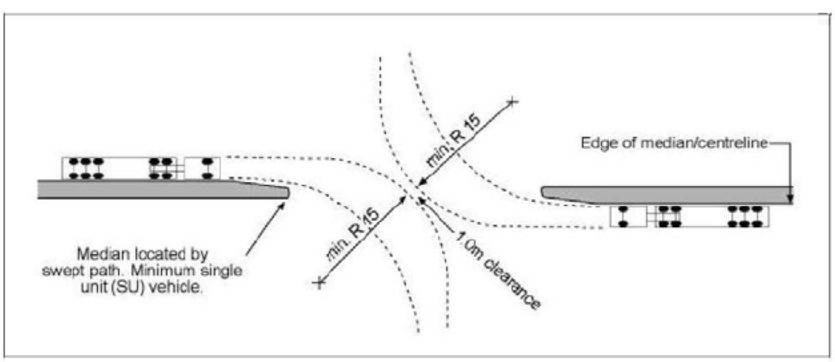




51

Road Design for Heavy Vehicles

Right turn treatments

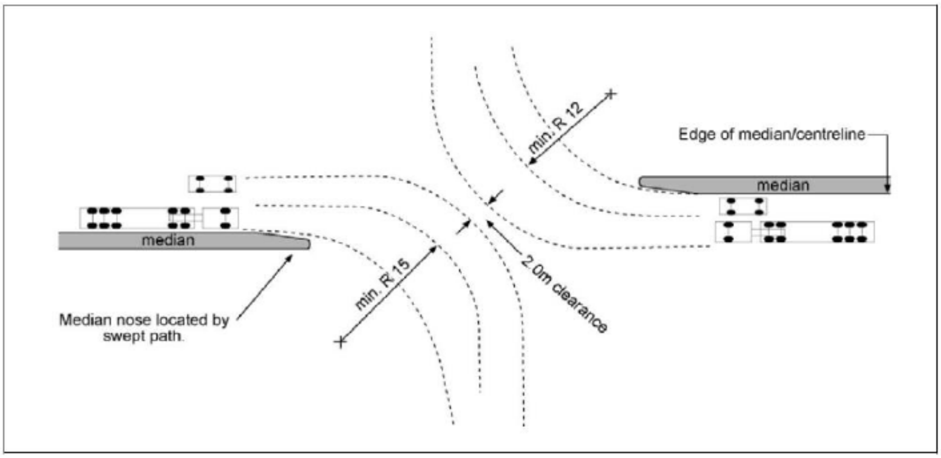


ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

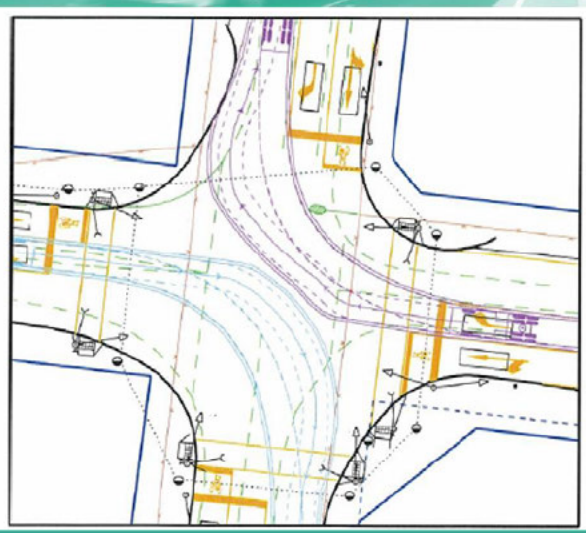
SAFE SYSTEM SOLUTIONS

52

Road Design for Heavy Vehicles



Road Design for Heavy Vehicles



55

56

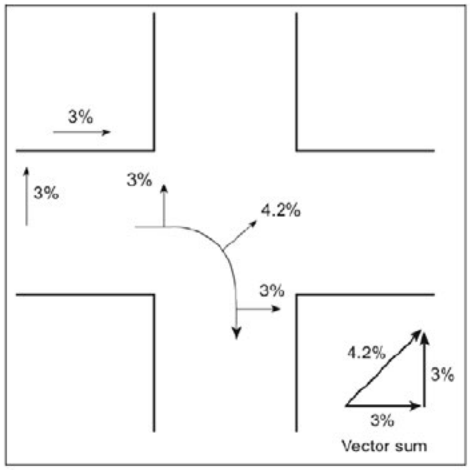


Figure 2.7: Illustration of adverse crossfall for a right-turn movement

Road Design for Heavy Vehicles

Radius (m)	Critical speeds for high trucks within intersections (km/h)														
	Positive superelevation (m/m)							0	Negative superelevation (i.e. adverse)						
	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.07
10	17	17	17	16	16	15	15	14	13	12	11	10	9	7	4
11	19	18	18	17	17	16	16	15	14	13	12	11	10	8	5
12	20	19	19	18	18	17	16	16	15	14	13	12	10	8	5
13	21	20	20	19	19	18	17	17	15	15	14	12	11	9	6
14	22	21	20	20	19	19	18	18	17	16	14	13	12	10	7
15	22	22	21	21	20	20	19	18	17	16	15	14	12	10	7
16	23	23	22	22	21	21	20	19	18	17	16	14	13	11	8
17	24	24	23	23	22	21	21	20	19	18	17	15	13	11	8
18	25	25	24	24	23	22	22	21	20	19	17	16	14	12	9
19	26	26	25	24	24	23	22	22	21	19	18	16	15	13	10
20	27	26	26	25	25	24	23	22	21	20	19	17	15	13	10
21	28	27	27	26	25	25	24	23	22	21	19	18	16	14	11
22	29	28	28	27	26	25	25	24	23	21	20	18	17	14	11
23	30	29	28	28	27	26	25	25	23	22	21	19	17	15	12
24	30	30	29	28	28	27	26	25	24	23	21	20	18	16	13
25	31	30	30	29	29	28	27	26	25	24	22	20	18	16	13
26	31	31	30	30	29	29	28	27	26	24	23	21	19	17	14
27	32	32	31	30	30	29	29	28	26	25	23	22	20	17	14
28	33	32	32	31	30	30	29	28	27	26	24	22	20	18	15
29	33	33	32	32	31	30	30	29	28	26	25	23	21	19	16
30	34	33	33	32	32	31	30	30	28	27	25	24	22	19	16

Sight distance

- Approach Sight Distance (ASD)
- Safe Intersection Sight Distance (SISD)
- Minimum Gap Sight Distance (MGSD)

59

Sight distance

ASD

Table 3.1: Approach sight distance (ASD) and corresponding minimum crest vertical curve size for sealed roads (S < L)

Design speed (km/h)	Based on approach sight distance for a car[1] $h_1 = 1.1$, $h_2 = 0$, $d = 0.36$[2]					
	$R_T = 1.5$ sec[3]		$R_T = 2.0$ sec		$R_T = 2.5$ sec	
	ASD (m)	K	ASD (m)	K	ASD (m)	K
40	34	5.3	40	7.2	–	–
50	48	10.5	55	13.8	–	–
60	64	18.8	73	24.0	–	–
70	83	31.1	92	38.9	–	–
80	103	48.5	114	59.5	–	–
90	126	72.3	139	87.3	151	104
100	151	104	165	124	179	146
110	–	–	193	171	209	198
120	–	–	224	229	241	264
130	–	–	257	301	275	344
Truck stopping capability provided by the minimum crest curve size[4]	$h_1 = 2.4$ m, $h_2 = 0$ m, $d = 0.22$					

Table 5.6: Truck stopping sight distances

Operating speed (km/h)	Single unit trucks, semi-trailers and B-doubles Based on $d = 0.29$[1]		
	$R_T = 1.5$ s[2]	$R_T = 2.0$ s	$R_T = 2.5$ s
40	38	44	49
50	55	62	69
60	74	82	91
70	96	105	115
80	120	131	142
90	147	160	172
100	–	191	205
110	–	228	241

60

Deceleration lanes

Table 5.2: Deceleration distances required for cars on a level grade

Design speed of approach road (km/h)	Length of deceleration D – including diverge taper T (m)										Diverge length L_d[3] for lane widths (m)	
	Stop condition[1] (m)		Design speed of exit curve (km/h)[2]									
	0	0	20	30	40	50	60	70	80	90	3.5 m[4]	3.0 m[4]
	Comfortable 2.5 m/s²	Maximum 3.5 m/s²	Comfortable average rate of deceleration 2.5 m/s²									
50	40	30	30	25	15						33	27
60	55	40	50	40	30	15					40	33
70	75	55	70	60	50	40	20				47	40
80	100	70	95	85	75	60	45	25			54	44
90	125	90	120	110	100	85	70	50	25		60	50
100	155	110	150	140	130	115	100	80	55	30	67	57
110	185	135	180	175	160	150	130	110	90	60	74	62

Table 5.6: Truck stopping sight distances

Operating speed (km/h)	Single unit trucks, semi-trailers and B-doubles Based on d = 0.29[1]		
	R_T = 1.5 s[2]	R_T = 2.0 s	R_T = 2.5 s
40	38	44	49
50	55	62	69
60	74	82	91
70	96	105	115
80	120	131	142
90	147	160	172
100	–	191	205
110	–	225	241

- Turning lanes are generally designed for the deceleration of cars and require heavy vehicles to reduce speed significantly within the through lane
- Consider increasing turn lane lengths at movements that cater for high numbers of heavy vehicles

Acceleration lanes

Table 5.6: Acceleration lane lengths (m) for semi-trailers to accelerate from rest to a specified speed on a level or downgrade

Downgrade (%)	Truck speed (km/h)				
	100	90	80	70	60
0	2,400	1,500	910	550	320
1	1,400	940	640	410	250
2	970	700	500	330	210
3	760	560	400	280	180

Table 5.7: Acceleration lane lengths (m) for semi-trailers to accelerate from rest to a speed on an upgrade

Upgrade (%)	Truck speed (km/h)						
	100	90	80	70	60	50	40
1	-	-	2,000	890	480	230	100
2	-	-	-	-	890	320	130


Road Design for Heavy Vehicles
ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS

63

64

65

66

SAFETY ISSUES & TREATMENTS

Road Design for Heavy Vehicles

Fatigue

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS


Road Design for Heavy Vehicles
ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS

69


ON SHOULDER

70

Safety barriers

Test levels

Level	MASH - Designed Containment
TL5	1,100 kg & 2,270 kg at 100 km/h 36,000 kg at 80 km/h
TL4	1,100 kg & 2,270 kg at 100km/h 10,000 kg at 90 km/h
TL3	1,100 kg & 2,270 kg at 100km/h
TL2	1,100 kg & 2,270 kg at 70km/h
TL1	1,100 kg & 2,270 kg at 50km/h

5

71

Safety barriers

Accepted products

- Rigid concrete barriers (TL 5 & 6)
- Wire Rope Safety Barrier (TL 3 & TL4)
- Thriebeam (TL 4)
- Flexible W-beam systems (TL3 & TL4)
- Guard Fence
- Temporary barriers (TL 1 & 2)

Refer Austroads Technical Conditions of Use

72

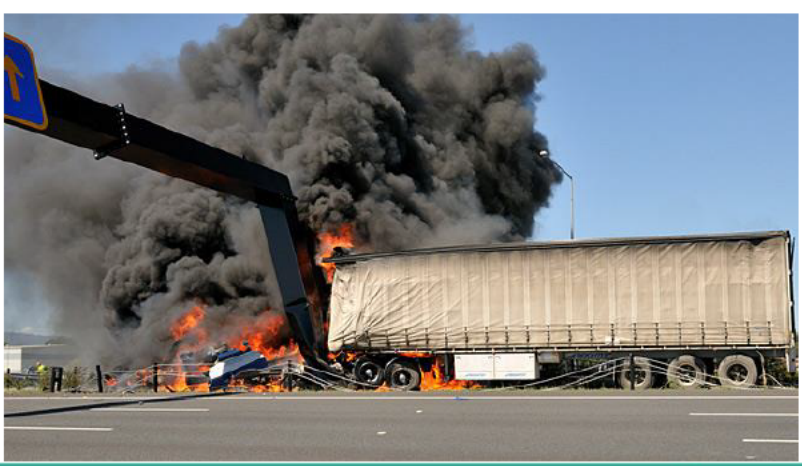
Road Design for Heavy Vehicles

Successful Containment?

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles

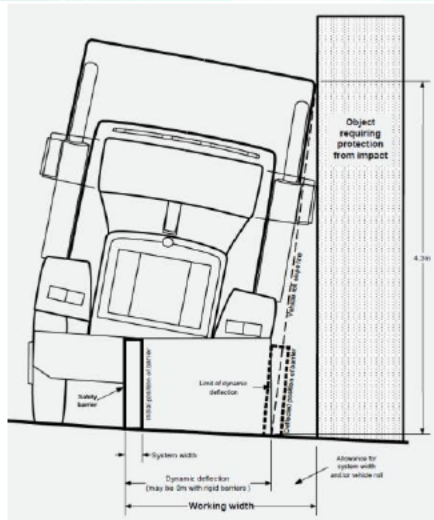
Unsuccessful Containment



SAFE SYSTEM SOLUTIONS

Safety barriers

- Dynamic Deflection
- Working width

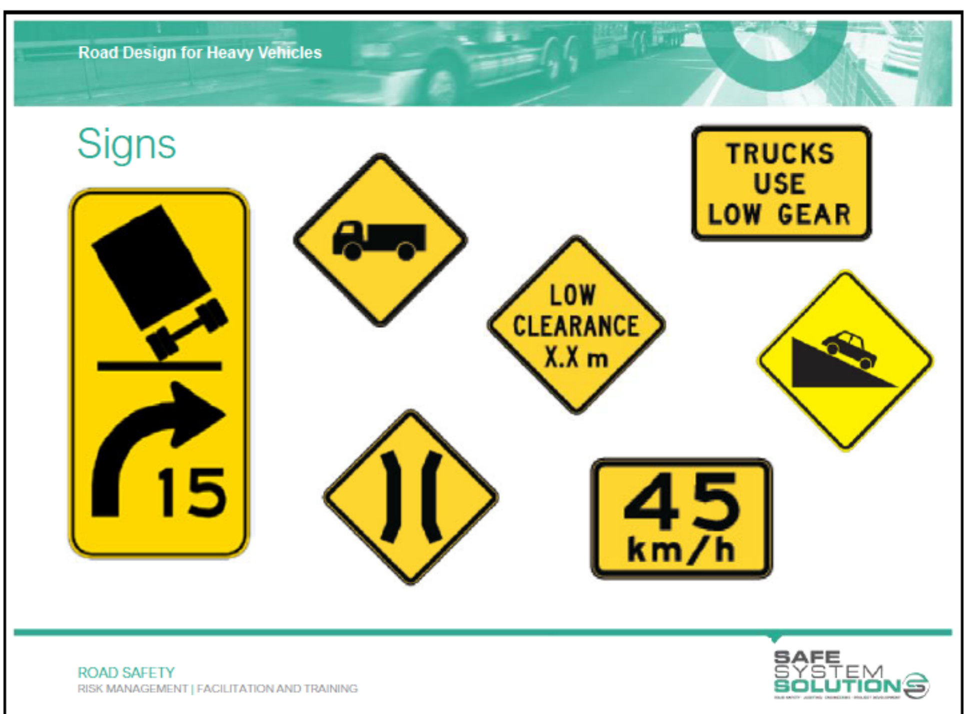


75

76


STOP

77


Road Design for Heavy Vehicles
Signs
TRUCKS USE LOW GEAR
LOW CLEARANCE X.X m
15
45 km/h
ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING
SAFE SYSTEM SOLUTIONS

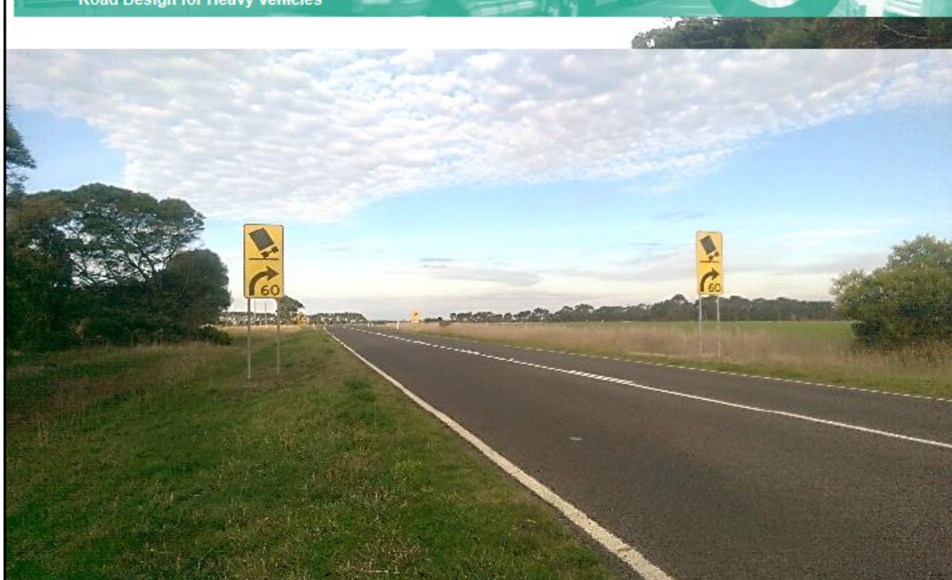
78

Road Design for Heavy Vehicles

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles



ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

Road Design for Heavy Vehicles

ROAD SAFETY
RISK MANAGEMENT | FACILITATION AND TRAINING

SAFE SYSTEM SOLUTIONS

81

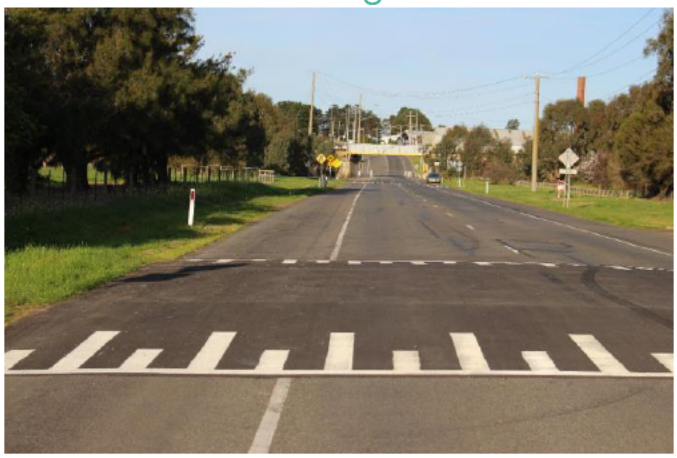
82

83

Local Area Traffic Management

84

Local Area Traffic Management



Local Area Traffic Management

Safe System Solutions Pty Ltd

[redacted]

[redacted]

[redacted]

SAFE SYSTEM SOLUTIONS

ROAD SAFETY · AUDITING · ENGINEERING · PROJECT DEVELOPMENT

TRAINING FEEDBACK

Thank you for participating in our training!

We love feedback and want to hear from you so we can keep improving our training. Please fill this quick survey using the QR code below and let us know your thoughts (your answers will be anonymous).

Thank you.