Planning and Designing a Safe System

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4TH GLOBAL MINISTERIAL CONFERENCE ON ROAD SAFETY

MARRAKECH - MOROCCO

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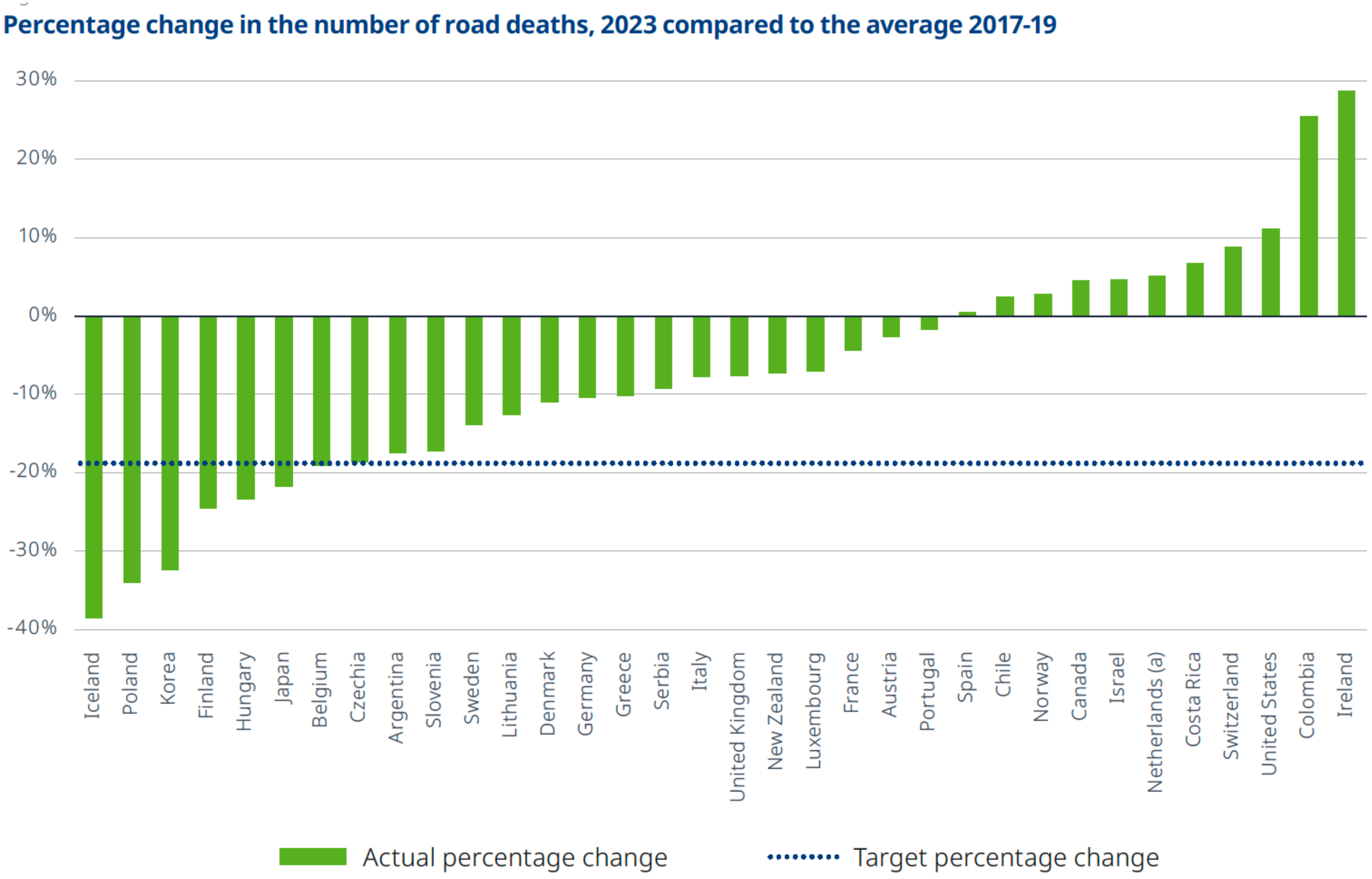
Progress Towards #50by30



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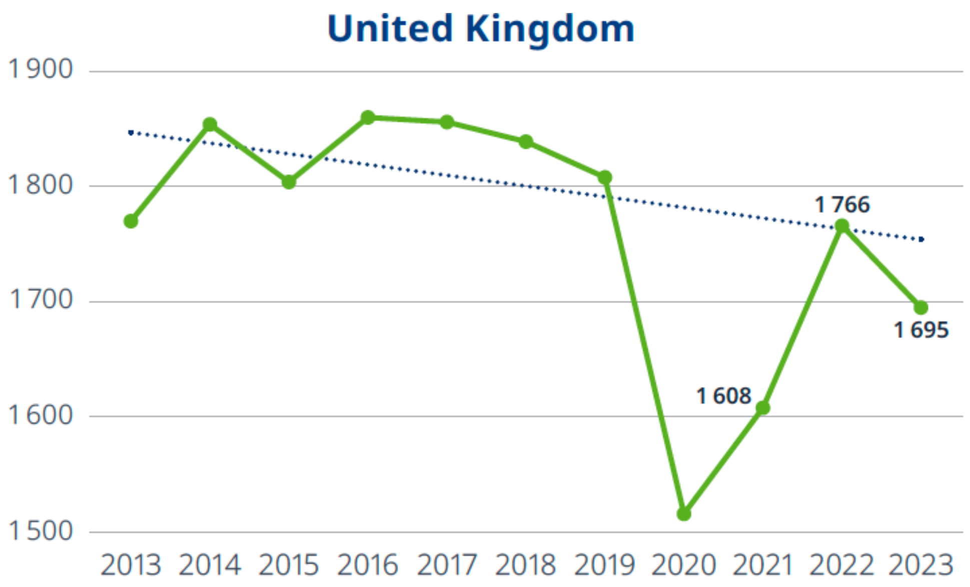
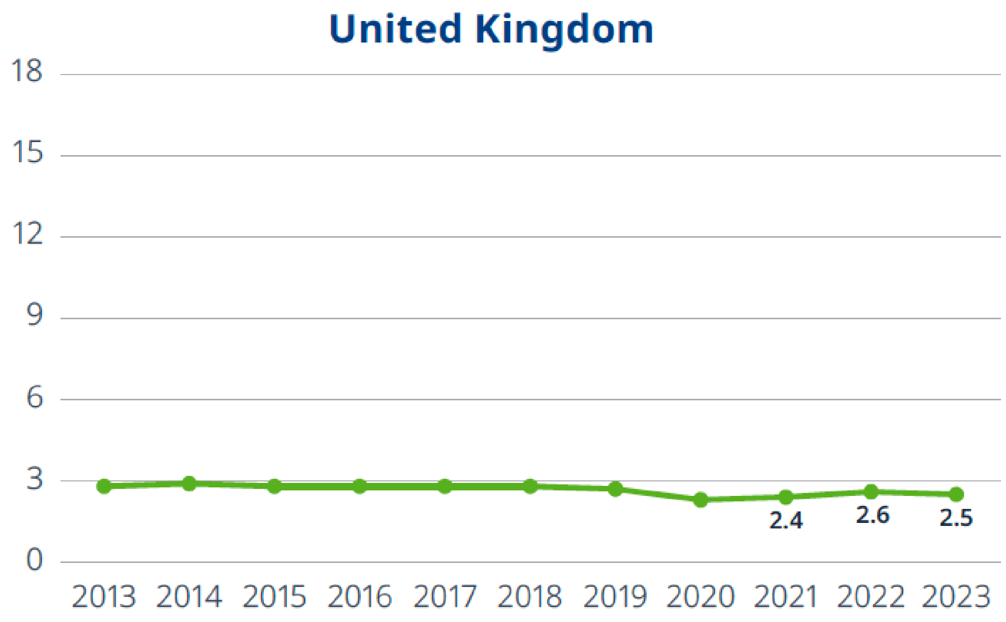
ITF (2024), Road Safety Annual Report 2024, OECD Publishing, Paris.

United Kingdom





ITF (2024), Road Safety Annual Report 2024, OECD Publishing, Paris.

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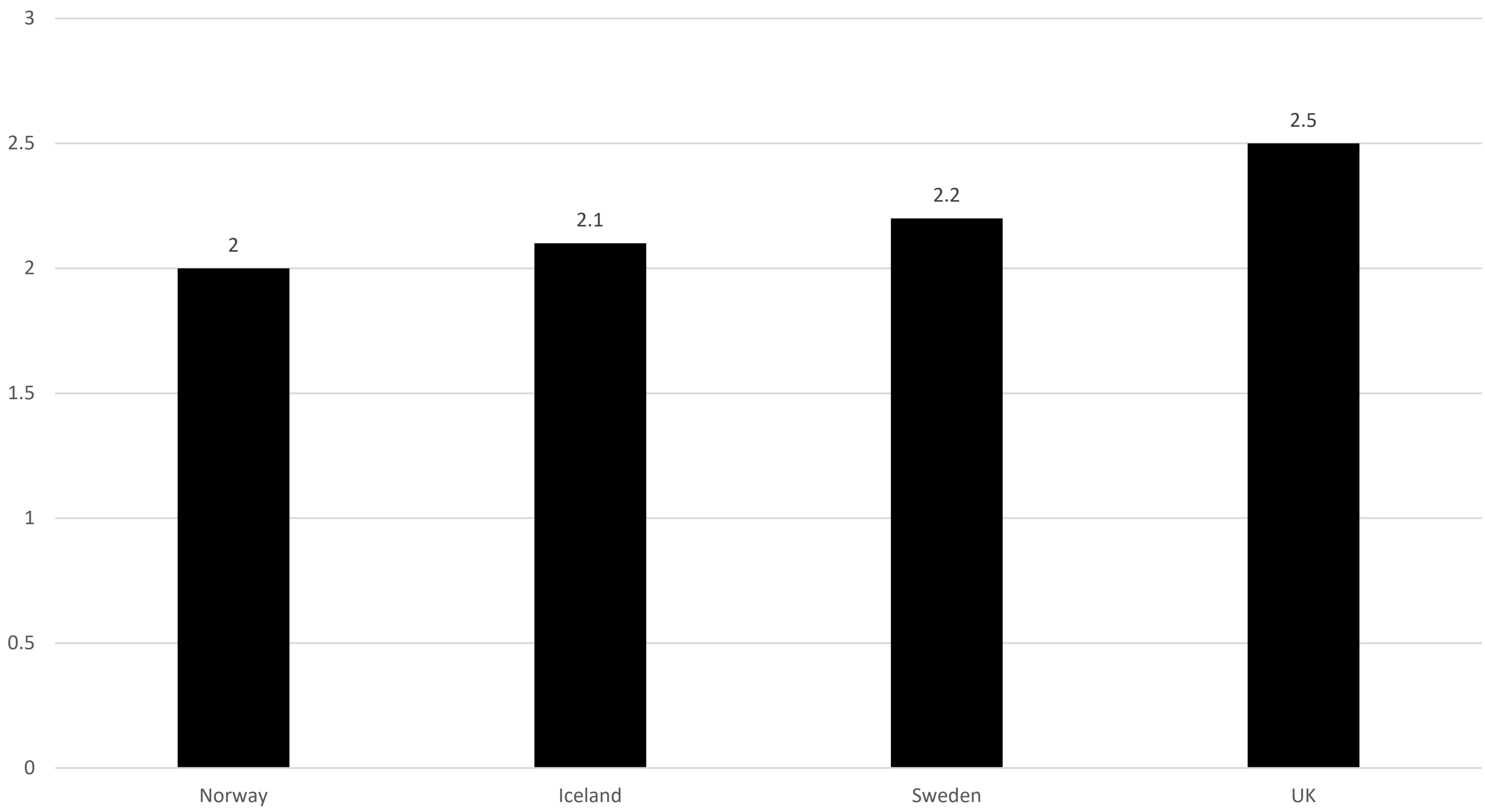
Comparison to best performing countries



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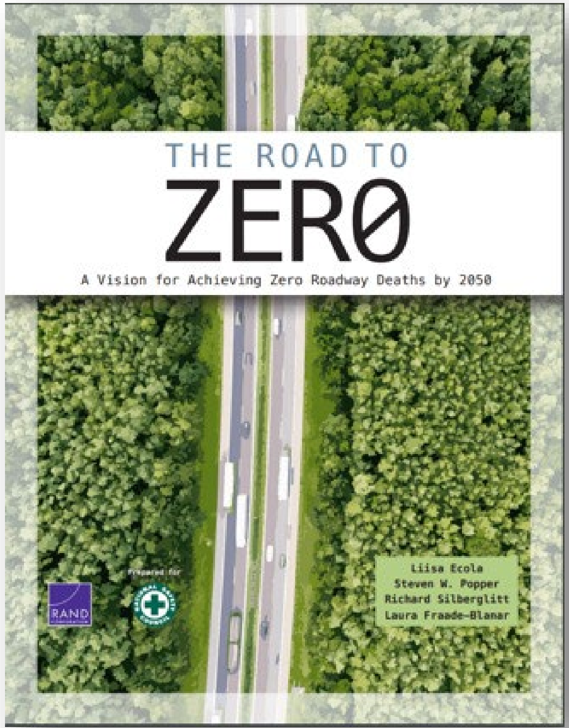
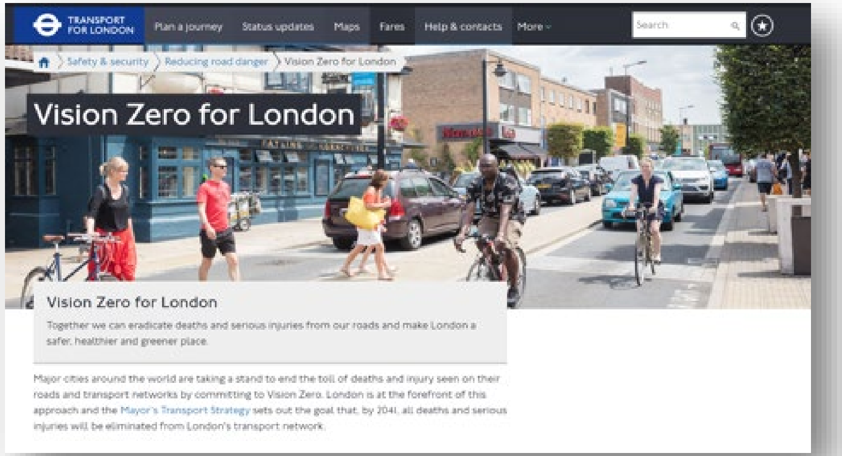
Targeting Zero with a date





Redefining the Safe System

'A system in which people cannot be killed or seriously injured regardless of their behaviour or the behaviour of other road users'

Job, R. F. S., Truong, J., & Sakashita, C. (2022). The Ultimate Safe System: Redefining the Safe System Approach for Road Safety. Sustainability, 14(5), 3491

The Ultimate Safe System

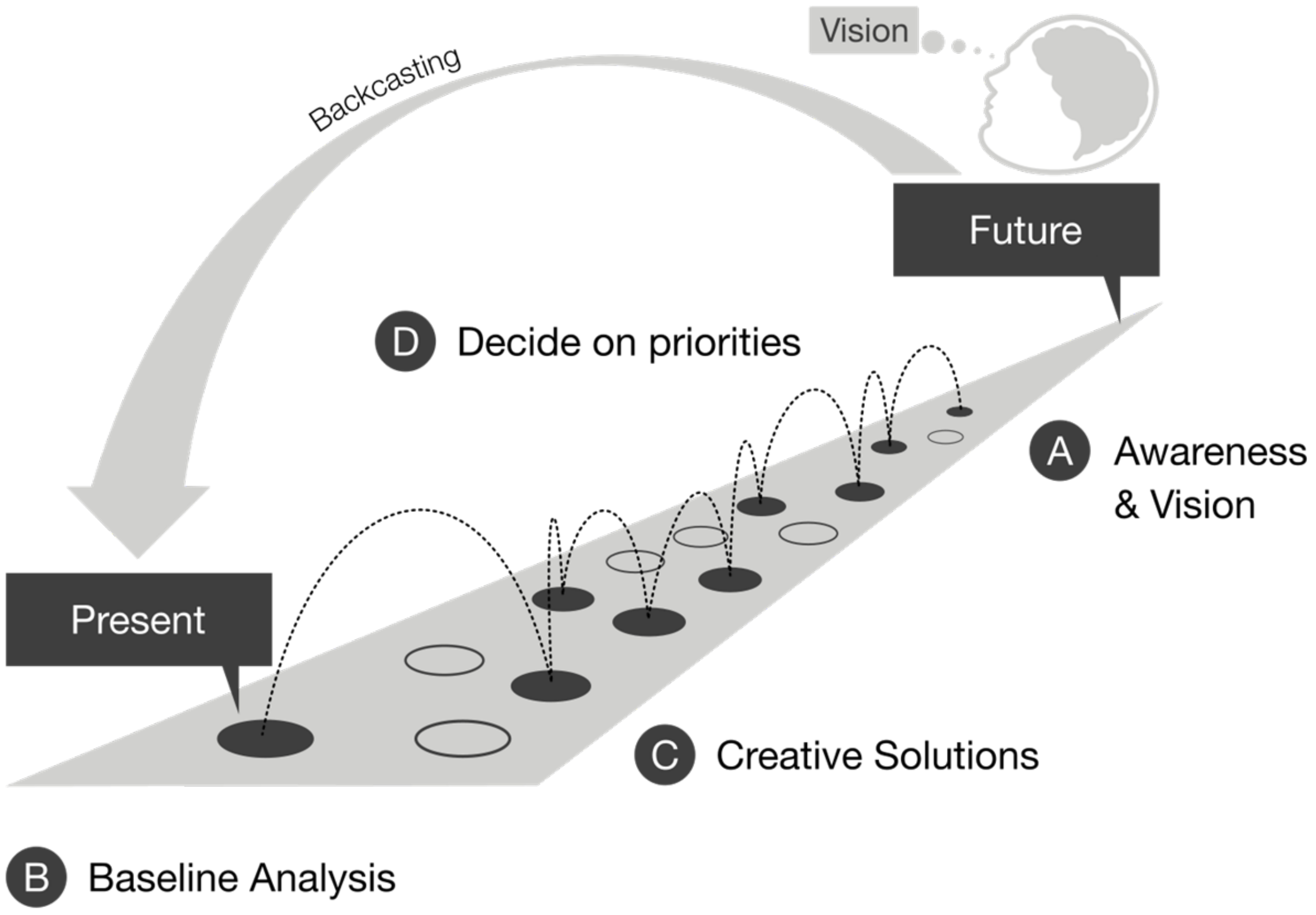
- Road and vehicle features that are maintained, reliable, effective, and can prevent deaths and serious injuries without being reliant on road user behaviour and compliance with laws. Vehicle maintenance can be controlled through systems such as vehicle lockouts without maintenance.

- Setting and achieving compliance with speed limits required to deliver ultimate safety through vehicle engineering (such as speed limiting, intelligent speed assistance) without relying on drivers to choose to comply with limits

Job, R. F. S., Truong, J., & Sakashita, C. (2022). The Ultimate Safe System: Redefining the Safe System Approach for Road Safety. Sustainability, 14(5), 3491

What does a Safe System look like

Vision Zero planning – back-casting



Adapted from The Natural Step, 1991

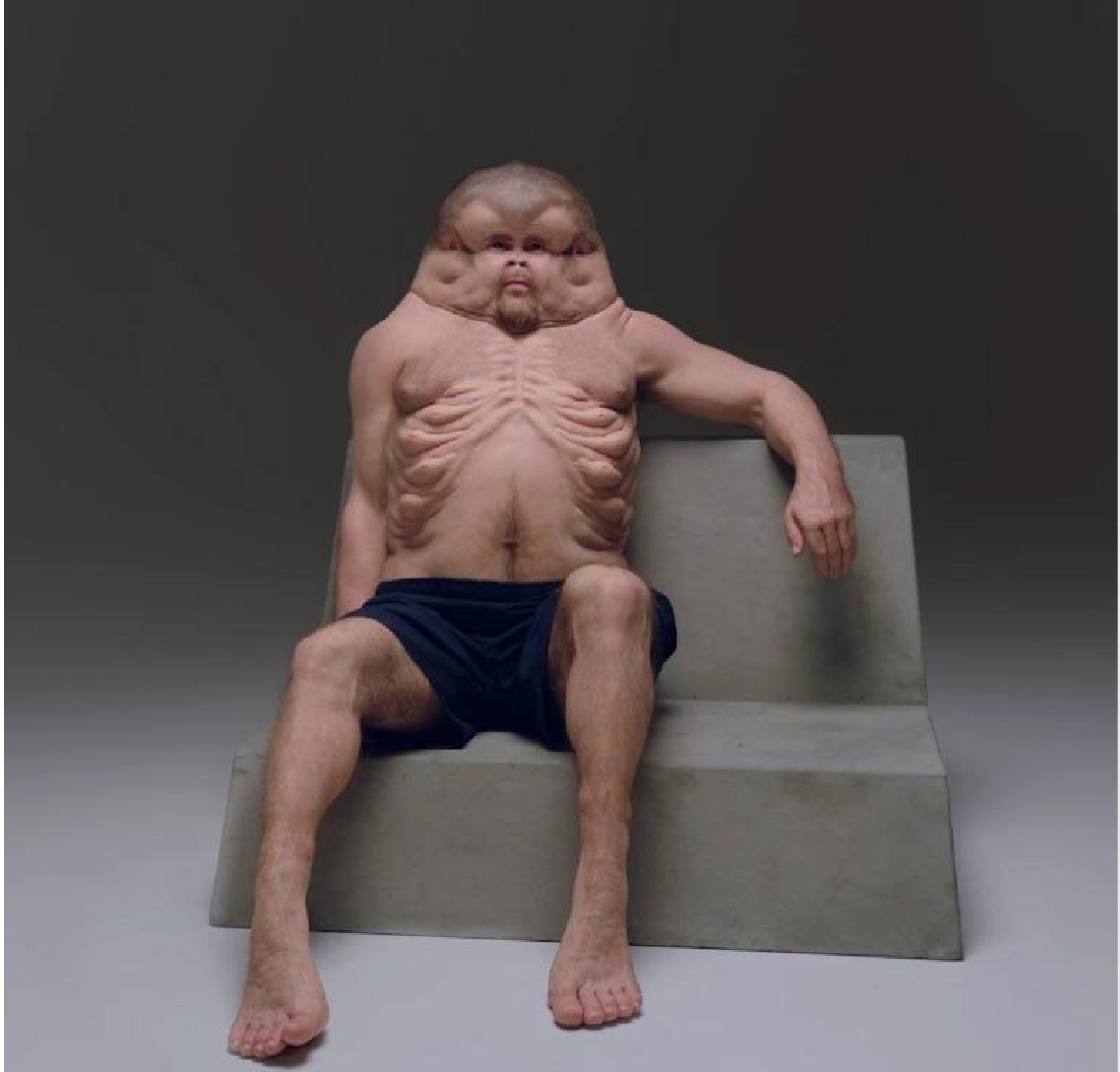
Steps to building a safe transport system

1. Define who and what behaviours the system is designed for
2. Define the level of acceptable health loss for system users
3. Define which system users are the least protected and with the lowest tolerance to injury
4. Design the system to operate within these boundaries
5. Define the types of allowable errors that are within the accepted field of tolerance
6. Use the defined types of allowable errors as the dimensions for the design of the system’s fault tolerance
7. If any individual or behaviour is to be excluded from the system, describe how they will be excluded
8. Define the injury tolerance curves
9. Describe the frequency and level of external forces
10. Control and eliminate external forces so that the tolerance is never lower than the exposure

Source: Swedish Transport Administration, 1996

Meet Graham

The only person designed to survive on our roads

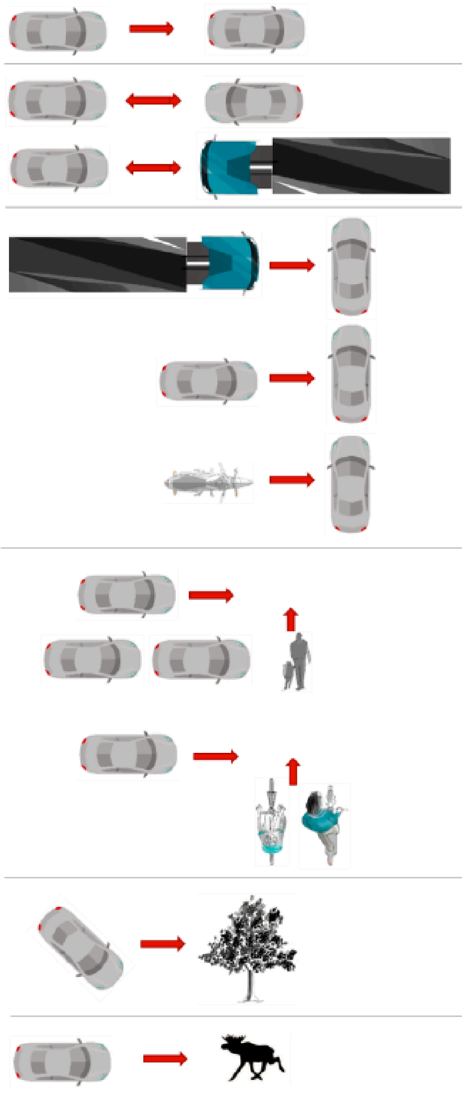


Source: www.tac.vic.gov.au
www.meetgraham.com.au

Utilising human crash tolerance as key design factor

Crash Type		Impact speed
	head on	70 km/h
	side-impact	50 km/h
	side impact with tree	30 km/h
	pedestrian	30 km/h

Source: Transport Accident Commission



Maximum acceptable impact speed (km/h)	Maximum safe travelling speed with optimal sight and road friction (km/h)
dV 15	110
60	80
30	50
40	40
60	60
40	40
0	5-7
20	40
30	60
60	80

Rizzi, M. et al. (2023). Proposed Speed Limits for the 2030 motor vehicle. Proceedings of ESV.

Defining the desired 2050 Safe System – human biomechanical tolerance

Crash Type	10% Risk for Serious Injury		10% Risk for Severe Injury	
	Delta-v km/h	Impact Speed km/h	Delta-v km/h	Impact Speed km/h
Car to Pedestrian crash	No impact allowable	No impact allowable	20	20
Car to powered two-wheeler (PTW)	No impact allowable	No impact allowable	30	30
PTW to wide object	N/A	25	N/A	50
PTW to narrow object	No impact allowable	No impact allowable	No impact allowable	No impact allowable
PTW to ground	N/A	N/A	N/A	75
Car to bicyclists	No impact allowable	No impact allowable	20	20
Side Impact–Car to Car (of equal mass)	20	40	30	60
Side Impact–Heavy Vehicle into Car	20	20	30	30
Head On Impact–Car to Car (of equal mass)	25	25	50	50
Head on Impact–Car to Heavy Vehicle	25	10	50	25
Rear End–car to car	10	20	20	40
Rear End–heavy vehicle into car	10	10	20	20

Table based on risk curves on relatively modern vehicles and belted occupants, rounded to the nearest 5 km/h.

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Backcasting Safe System and mobility needs

Source: New Zealand Transport Agency

Movement & Place

- Pedestrian priority areas = civic hubs, city streets and city places;

- Mixed traffic areas = activity streets;

- Vehicle priority areas = connectors and local streets

■ Trauma Issues by Movement & Place

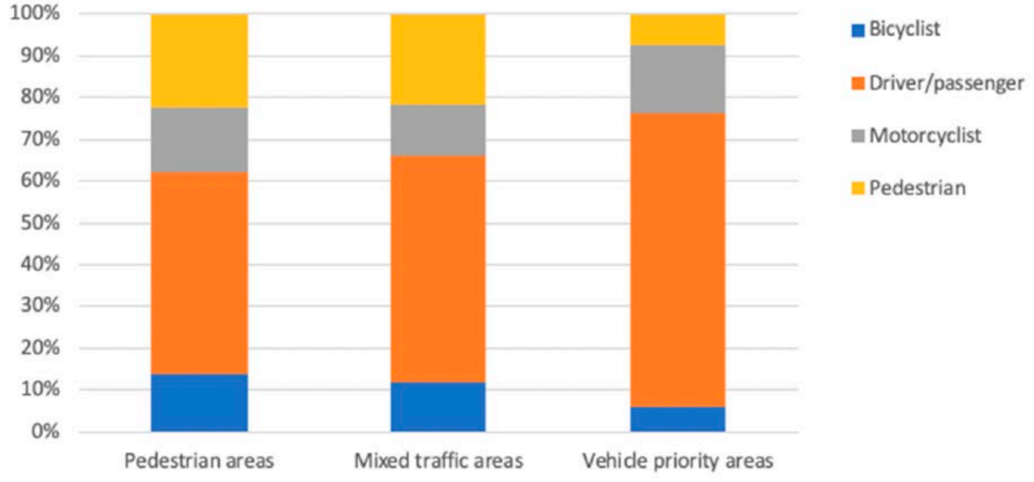


Figure 1. Road user FSI by M&P.

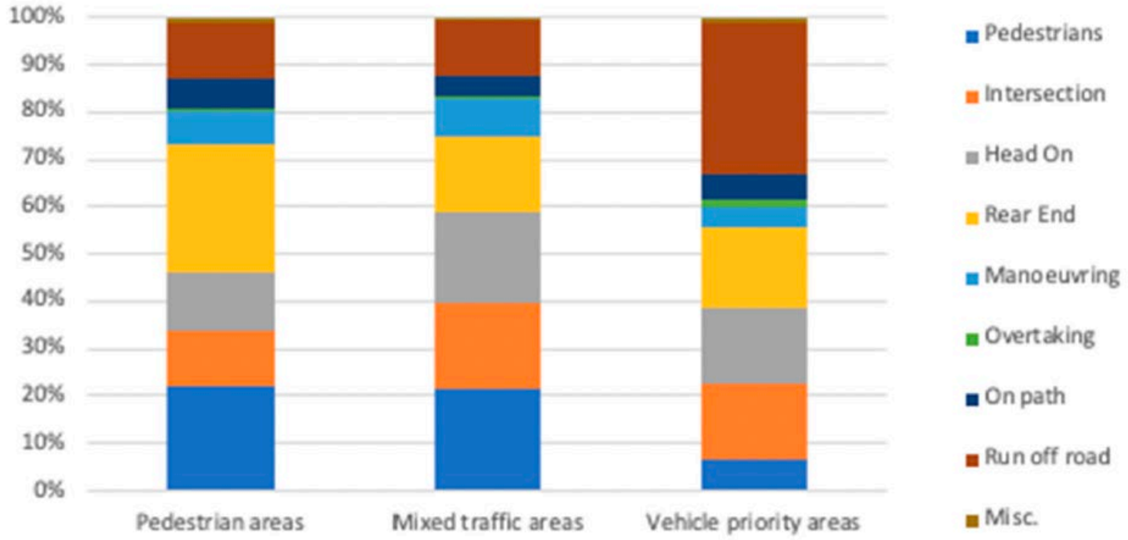


Figure 2. Crash types by M&P.

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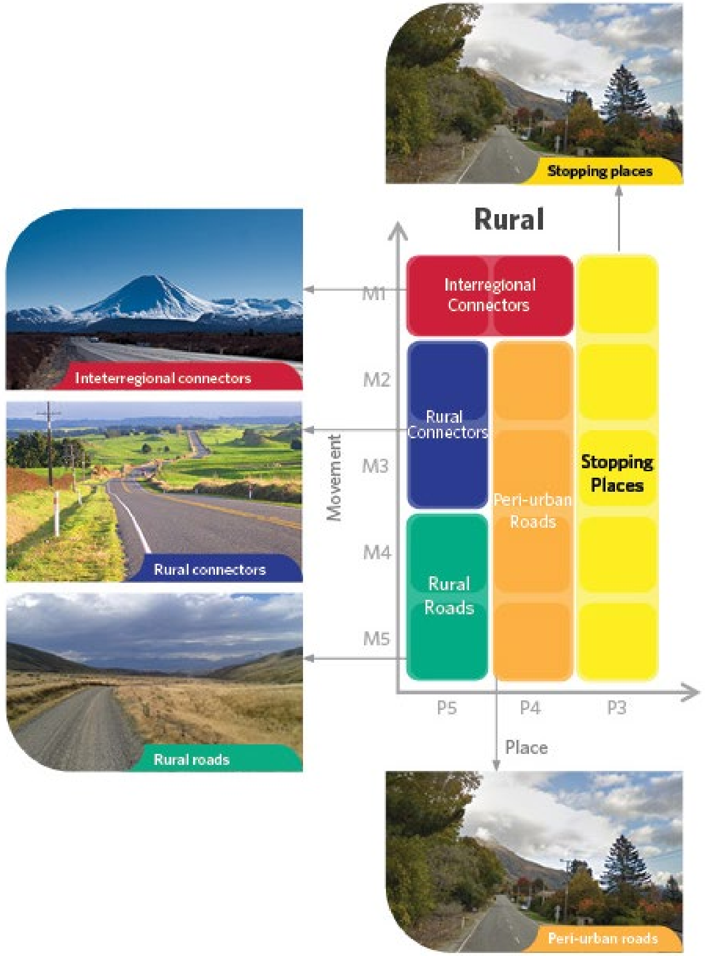
Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

How to build a Safe System – based on mobility needs

Mobility needs



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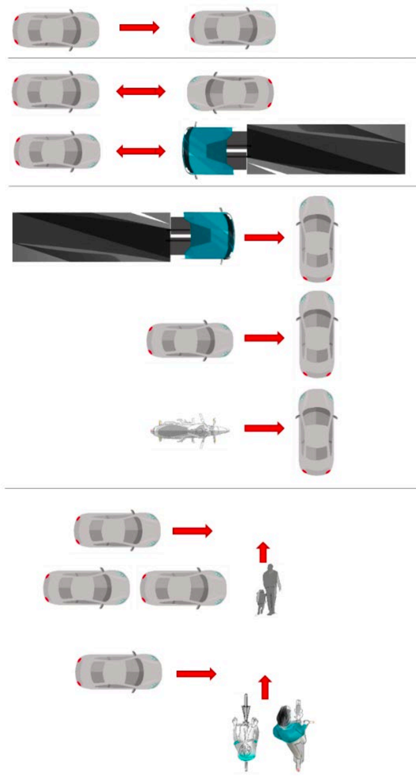
Human biomechanical tolerance

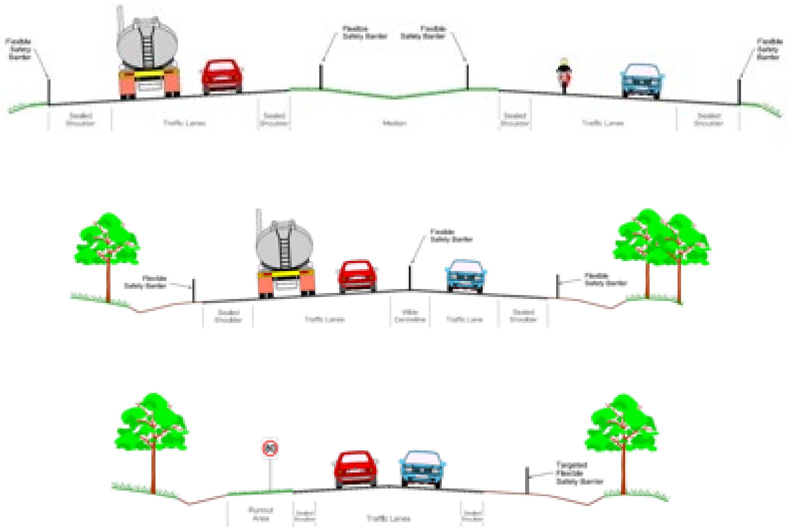


Maximum acceptable impact speed (km/h)	Maximum safe travelling speed with optimal sight and road friction (km/h)
dV 15	110
60	80
30	50
40	40
60	60
40	40
0	5-7
20	40

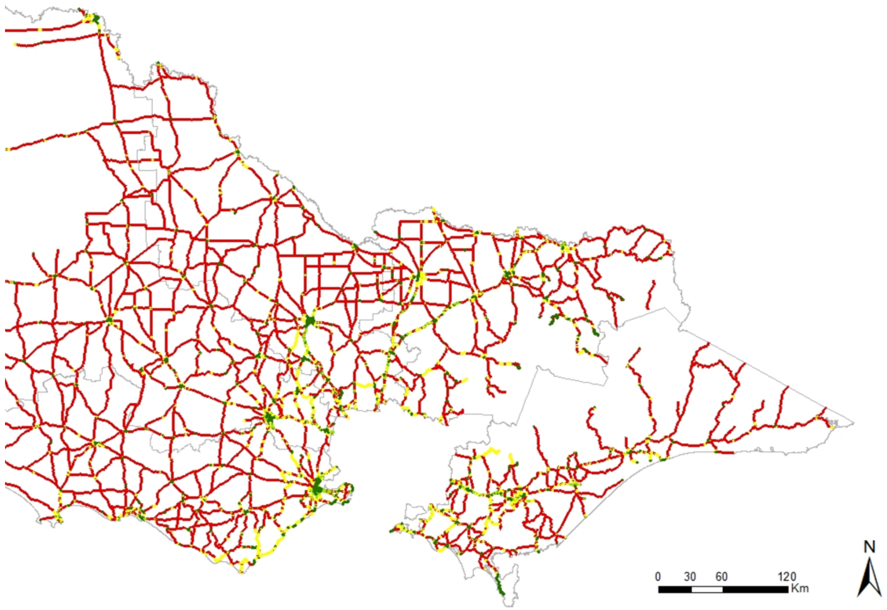
=

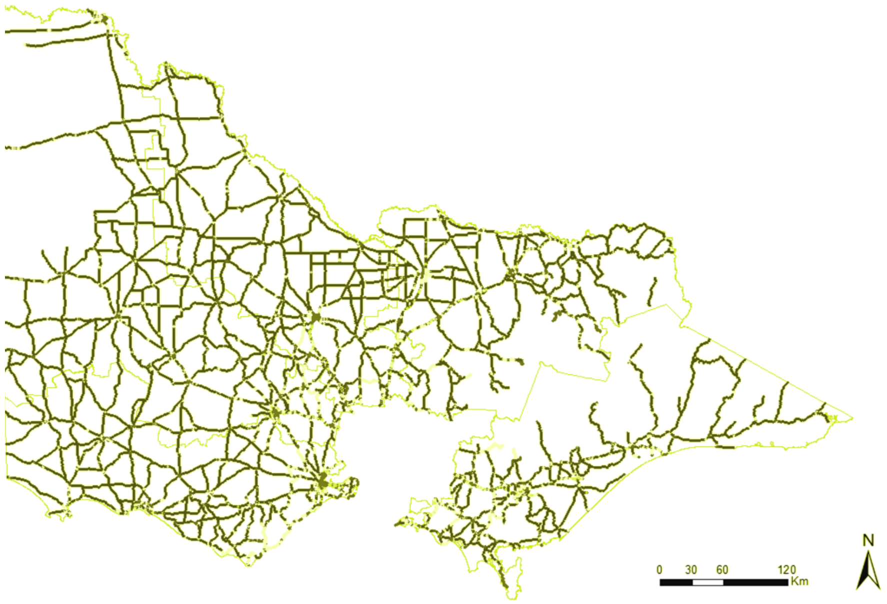
Safe System End States

Example Rural roads



Strandroth, J. et al. (2019). Zero 2050 in Victoria – A planning framework to achieve zero World





Starting point

Ending point

Strandroth, J., Moon, W., & Corben, B. (2019). Zero 2050 in Victoria – A planning framework to achieve zero with a date. World Engineers Convention Australia 2019. 20–22 November 2019, Melbourne, Victoria.

Table 4. Ultimate Safe System in 2050 for Pedestrian Priority Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Vehicle free zone	N/A	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	N/A
Vehicles allowed No motorcycles	AEB pedestrian AEB bicyclist ISA limiting or geofencing for speed control Front, side and rear underrun protection for heavy vehicles	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	10 km/h

Pedestrian Priority Areas

Truong & Strandroth et al. (2022)

Table 4. Ultimate Safe System in 2050 for Pedestrian Priority Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Vehicle free zone	N/A	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	N/A
Vehicles allowed No motorcycles	AEB pedestrian AEB bicyclist ISA limiting or geofencing for speed control Front, side and rear underrun protection for heavy vehicles	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	10 km/h

Pedestrian Priority Areas

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Pedestrian Priority Areas

Table 5. Interim Safe System in 2030 for Pedestrian Priority Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Vehicle free zone	N/A	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	N/A
Vehicles & Motorcycles Allowed	AEB pedestrian AEB bicyclist AEB rear-end (if ISA advisory is in use instead of ISA limiting) ISA limiting/or advisory Alcohol interlocks Driver monitoring Motorcycle ABS Motorcycle Daytime Running Lights	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices Traffic calming (if ISA Advisory is in use instead of ISA Limiting)	30 km/h

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Mixed Traffic Areas

Table 6. Ultimate Safe System in 2050 for Mixed Traffic Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Mix of road users No motorcycles or heavy vehicles	AEB bicyclist AEB pedestrian AEB rear-end AEB intersection AEB head-on ISA limiting or geofencing Seatbelt interlock Front, side and rear underrun protection for heavy vehicles	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices Pedestrian crossings with 10 km/h speed zone Frangible narrow roadside objects/and or removal of hazardous narrow roadside objects 5 m distance from sidewalk to road lane/or pedestrian fencing	40 km/h BUT 10 km/h at pedestrian crossings 20 km/h at intersections

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Table 7. Interim Safe System in 2030 for Mixed Traffic Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Mix of road users Motorcycles and heavy vehicles allowed	AEB bicyclist AEB pedestrian AEB rear-end (if ISA advisory is in use instead of ISA limiting) AEB head-on AEB intersection Seatbelt reminder ISA limiting or advisory Alcohol interlock Driver monitoring Front, side and rear underrun protection for heavy vehicles Motorcycle ABS Motorcycle Daytime Running Lights	Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices Roundabouts at all intersections Pedestrian crossings with 30 km/h speed zone 2 m distance from sidewalk to road lane/or pedestrian fencing Frangible narrow roadside objects/and or removal of hazardous narrow roadside objects Traffic calming to ensure maximum travel speed of 30 km/h at pedestrian crossings (if ISA Advisory is in use instead of ISA Limiting)	40 km/h BUT 30 km/h at pedestrian crosings

Mixed Traffic Areas

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Vehicle Priority Areas

Table 8. Ultimate Safe System in 2030 for Vehicle Priority Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Urban arterial–high movement link between local streets and freeways	AEB bicyclist AEB pedestrian AEB rear-end AEB intersection AEB head-on ISA limiting Lane Keep Assist Emergency Lane Keeping ESC Seatbelt Interlocks Front, side and rear underrun protection for heavy vehicles	Pedestrian grade separation Off road separated bicycle lanes not in pedestrian areas with soft asphalt Grade separation at all intersections if no speed limit reduction Full continuous flexible side barriers Full continuous flexible mid barriers Barrier/fencing to prevent pedestrian access	60 km/h BUT 20 km/h at intersections (if no grade separation)
Unsealed, undivided roads–very low movement, no improvements will be made to road or infrastructure		Close road and reroute to safer route Or One way travel only	30 km/h
Undivided sealed roads–low to high movement		Full continuous flexible side barriers Full continuous flexible mid barriers Pedestrian grade separation Barrier/fencing to prevent pedestrian access near built up areas Grade separation at all intersections if no speed limit reduction Left in Left out with acceleration lanes Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	80 km/h or 100 km/h with good road alignment for good sight lines BUT 80 km/h for heavy vehicles * 20 km/h at intersections (if no grade separation)
Divided multi lane roads with a physical median		Full continuous flexible side barriers Full continuous flexible mid barriers Grade separation at all intersections Barrier/fencing to prevent pedestrian access Off road separated lanes for bicycles and micro-mobility devices	100 km/h BUT 80 km/h for heavy vehicles *

* unless there is a barrier that is tested and can withstand a higher speed.

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Vehicle Priority Areas

Table 9. Interim Safe System in 2050 for Vehicle Priority Areas.

	Vehicles Requirements	Infrastructure Requirements	Maximum Travel Speed Requirements
Urban arterial–high movement link between local streets and freeways	AEB bicyclist AEB pedestrian AEB rear-end AEB intersection (for other access points) AEB head-on ISA limiting/advisory Lane Keep Assist/Emergency Lane Keeping ESC Seatbelt Reminder Alcohol Interlocks Front, side and rear underrun protection for heavy vehicles	Off road separated bicycle lanes not in pedestrian areas with soft asphalt Pedestrian grade separation or pedestrian crossing at roundabouts Traffic calming to ensure traffic speed is 30 km/h or less at pedestrian crossing (if not grade separated) Roundabouts at all intersections and/or raised intersection platforms or grade separation Frangible narrow roadside objects/and or removal of hazardous narrow roadside objects Continuous line markings	60 km/h BUT 30 km/h at pedestrian crossing (if no pedestrian grade separation)
Unsealed, undivided roads–very low movement		No requirements for road or infrastructure	60 km/h *
Undivided sealed roads–low to mid movement		Targeted flexible side barriers at high risk locations **/or frangible narrow roadside objects/and or removal of hazardous narrow roadside objects Continuous line markings plus sufficient shoulder for recovery Pedestrian grade separation Roundabouts at all intersections or grade separation Left in Left out with acceleration lanes Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	80 km/h
Undivided sealed roads–high movement		Full continuous flexible side barriers or Targeted flexible side barriers at high risk locations */Frangible narrow roadside objects/and or removal of hazardous narrow roadside objects Full continuous flexible mid barriers Pedestrian grade separation Roundabouts at all intersections or grade separation Left in Left out with acceleration lanes Off road separated lanes not in pedestrian areas for bicycles and micro-mobility devices	100 km/h 80 km/h for heavy vehicles ***
Divided multi lane roads with a physical median		Full continuous flexible side barriers Full continuous flexible mid barriers Grade separation at all intersections Barrier/fencing to prevent pedestrian access Off road separated lanes for bicycles and micro-mobility devices	100 km/h 80 km/h for heavy vehicles ***
Separated Motorcycle Only Routes ** Motorcycles prohibited from other routes**	Motorcycle ABS Motorcycle Daytime running lights	Motorcycle rub rails on identified prioritised motorcycle only routes with a high number of motorcycle riders	75 km/h

Truong, J., Strandroth, J., Logan, D. B., Job, R. F. S., & Newstead, S. (2022). Utilising Human Crash Tolerance to Design an Interim and Ultimate Safe System for Road Safety. *Sustainability*, *14*(6).

Modelling the System

Swedish Model

- Developed by Strandroth, Sternlund, Tingvall, Johansson, Rizzi & Kullgren, 2012

- Designed to:
  - Facilitate the prioritizing of countermeasures by considering future crash characteristics
  - Reduce a population of crashes by applying known effective vehicle & infrastructure countermeasures

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- Designed to:
  - Facilitate the prioritizing of countermeasures by considering future crash characteristics
  - Reduce a population of crashes by applying known effective vehicle & infrastructure countermeasures

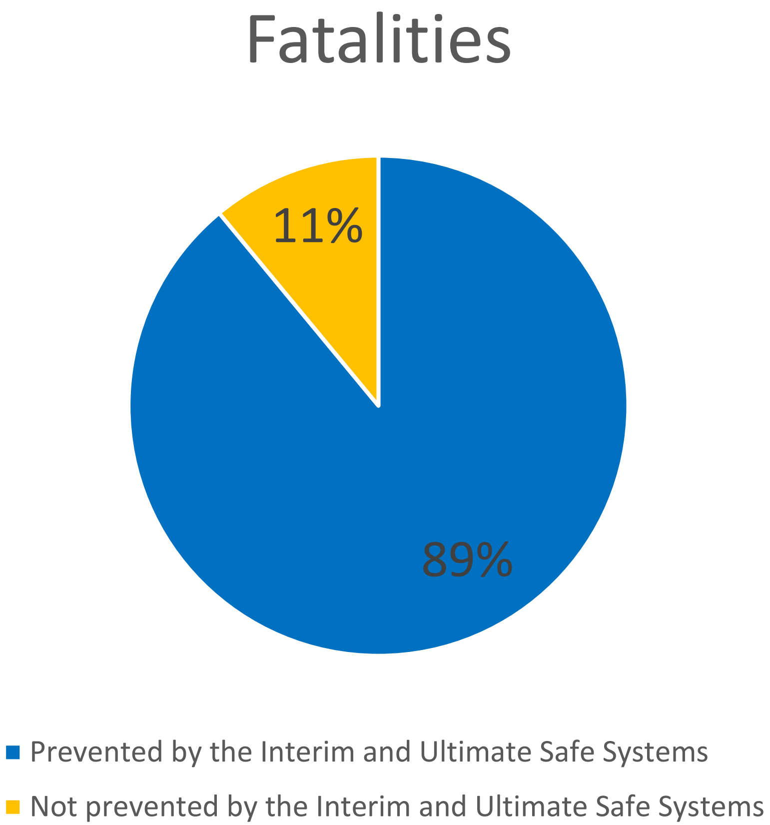
Data Sources

- Transport Accident Commission (TAC) data
- Victoria Police data

The total number of cases analysed in this study included:

- 266 fatalities
- 1155 MAIS 3+
- 51 MAIS 2

Model the Ultimate and Interim Safe Systems



29 residual fatalities:

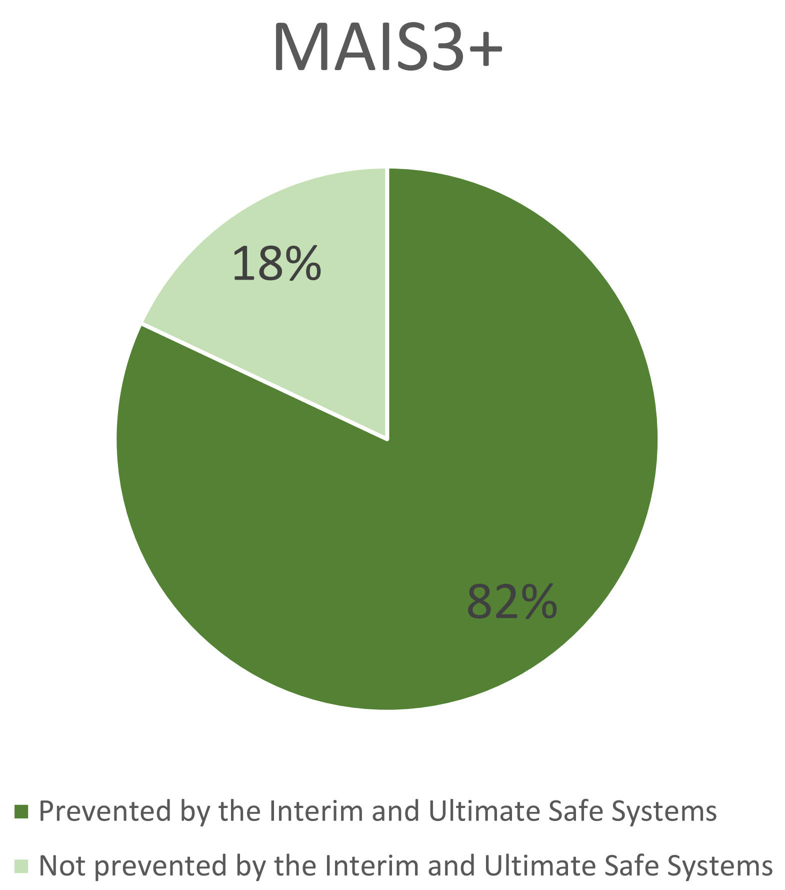
- 13 Car occupants
- 10 pedestrians
- 5 Motorcyclists
- 1 bicyclists

*266 cases

Residual Fatalities

- Passengers falling out of ute trays and jumping on bonnets of cars
- Drivers being pinned/trapped by vehicles after exiting vehicle
- Intrusion
- Elderly fall from mobility scooters
- Pedestrians on skateboards on high speed roads
- Access to freeway – exiting vehicle on freeways to pick up an item
- Tow hook flicking into oncoming car
- Horse rider falling from height
- Motorcyclists
- Poor lighting
- Outside of tolerance - hitting head on road surface, crushed by vehicle, intrusion
- Fall from bicycle – no collision
- Pedestrian on mobility scooter crashing into a bench on a footpath

Model the Ultimate and Interim Safe Systems

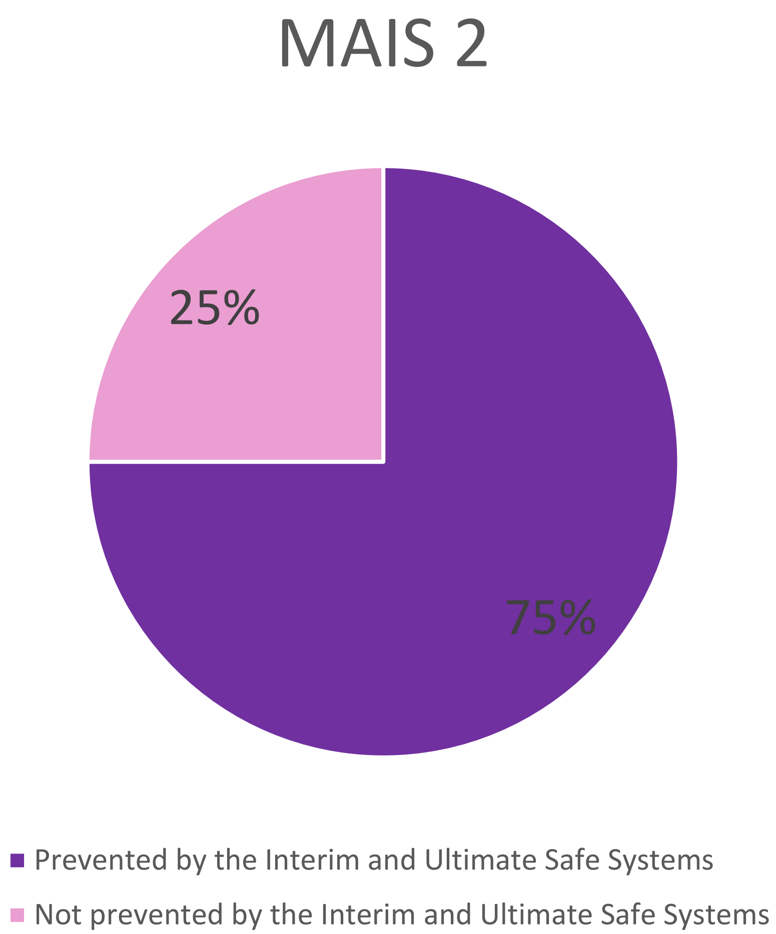


211 residual severe injuries:

- 114 Motorcyclists
- 78 Car occupants
- 19 Pedestrians

*1155 cases

Model the Ultimate and Interim Safe Systems



13 residual serious injuries:

- 9 (69%) Motorcyclists
- 2 (15%) Car occupants
- 2 (15%) Pedestrians

*51 cases

Residual Severe and Serious Injuries

MAIS 3+

- Jumping on car bonnets
- Being below injury tolerance levels already
- Technologies operating outside of boundary conditions
- Occurring in car parks where no treatments apply
- Fall on bus
- Motorcyclists

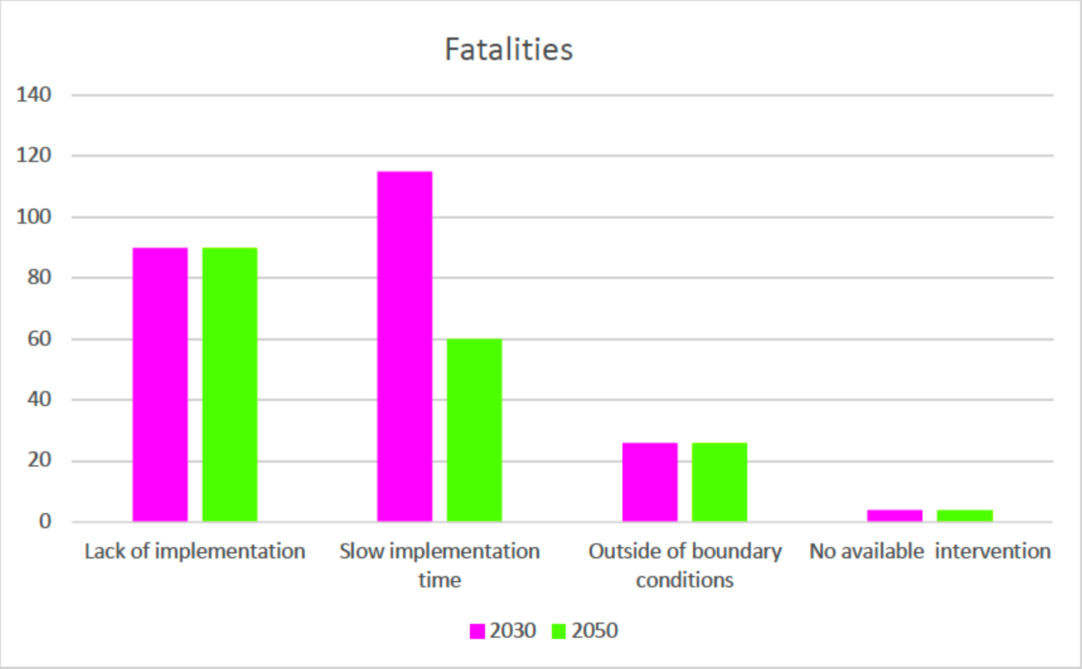
MAIS 2

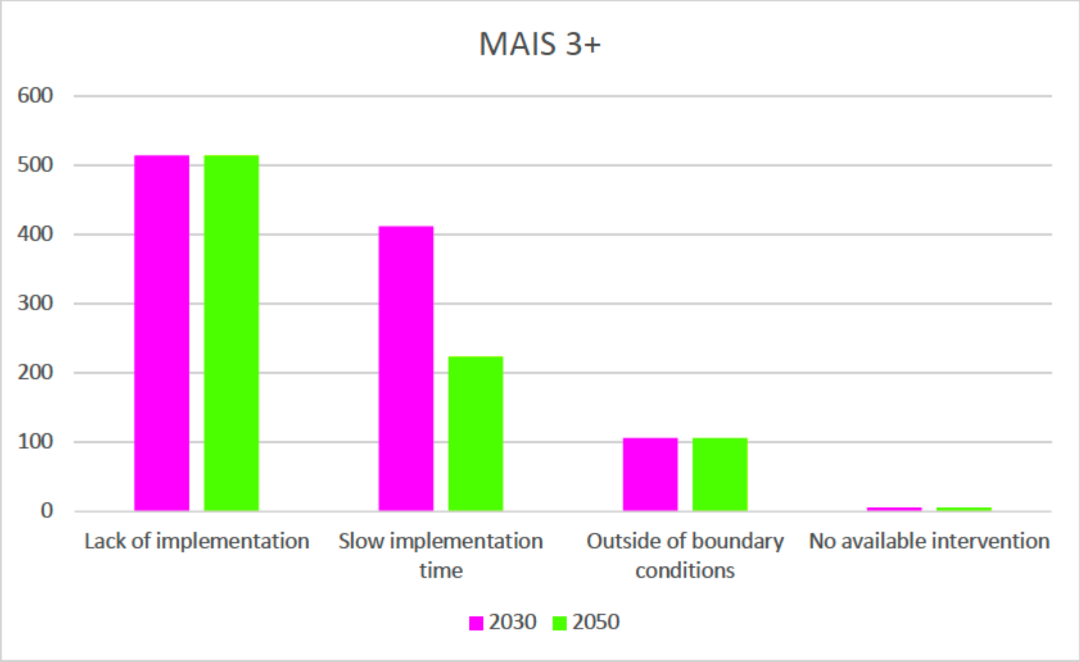
- Pedestrian walking into the side of a car
- Motorcyclists
- Crush injuries and thus outside of injury tolerance

75-89% of fatalities and serious injuries can be prevented by currently available measures

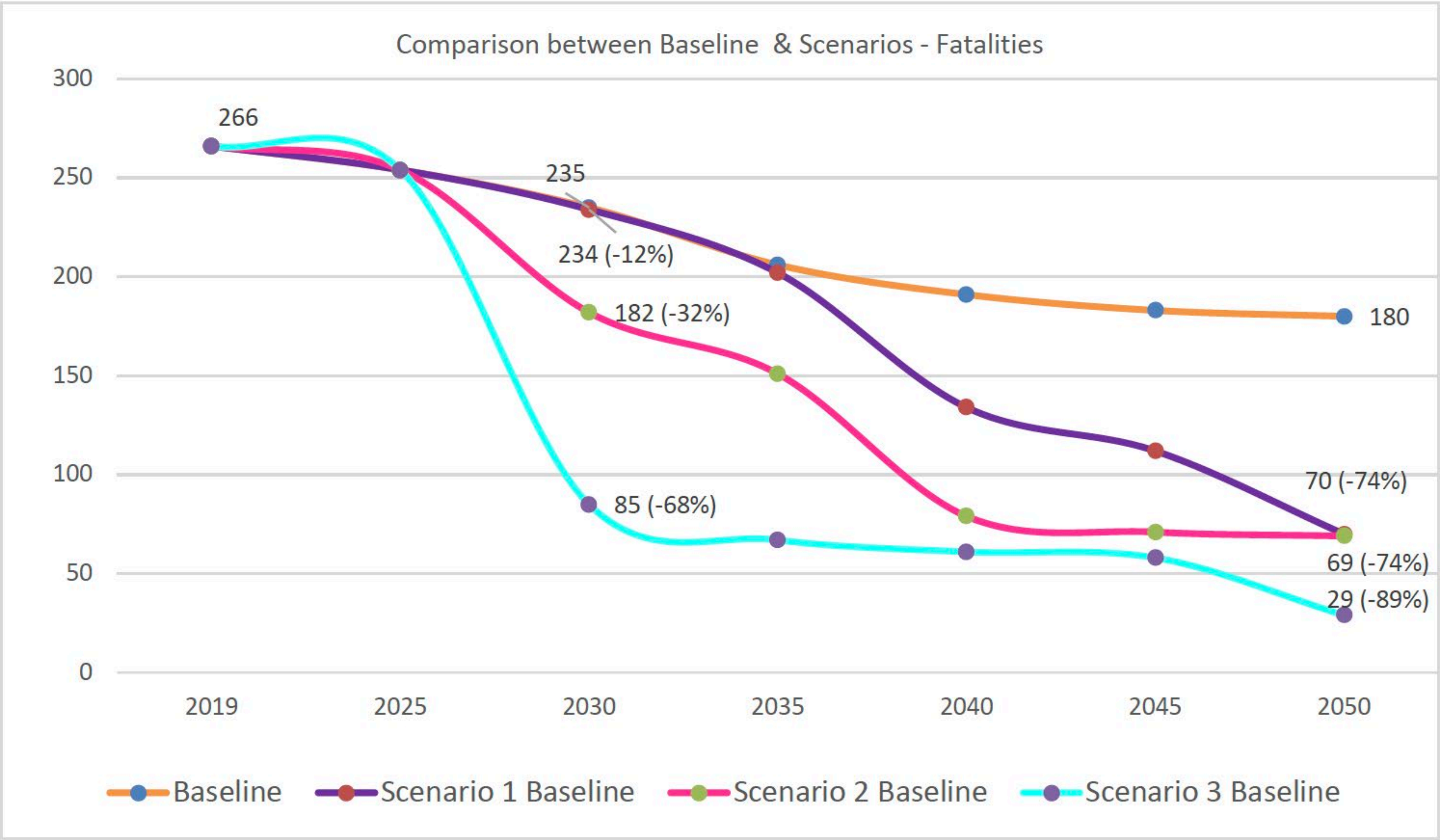
Reasons for residuals

- Slow implementation
- Lack of implementation





▪ Scenario Development



Summary

- Data is critical at every stage of the target and strategy planning and evaluation process
- Case by case analysis a novel model for strategy planning
- Priorities from now to 2030 is accelerated implementation of known solutions