

## **Classifying Safe System Fatalities**

### **An examination of Victorian road fatalities in relation to components of the safe system**

Page-Smith, J.<sup>1</sup>, Nieuwesteeg, M.<sup>2</sup> & Healy, D.<sup>3</sup>  
<sup>1& 2</sup>Transport Accident Commission  
<sup>3</sup>Road Safety Consultant

#### **Abstract:**

The safe system, if properly and fully applied, should see the near elimination of deaths and permanently disabling injuries from road crashes. As Victoria's road safety agencies increasingly adopt and apply safe system principles, it becomes important to be able to measure and report on progress of safe system implementation and coverage. Application of the safe system principles requires action in three areas: road users, particularly in relation to access to the road network and adherence to road rules; vehicles, in relation to crashworthiness and crash avoidance; and roads and roadsides with associated speed limits. It is important to measure the effectiveness of the application of the safe system principles within these three areas.

The TAC created a framework for classifying fatality crashes according to the presence or absence of each of the three elements of the safe system. Subsequently, the TAC appraised 578 fatality crashes that occurred during 2009 and 2010 and evaluated them within this classification framework. Information including vehicle safety ratings and road user compliance with certain road rules such as restraint wearing was recorded. An assessment was made of the environment and infrastructure involved in the crash, for example, the presence of run-off-road protection and posted speed limits.

This paper describes the classification framework and the application of the framework to police reported fatalities. It then presents some key metrics arising from analysis of the compiled data and highlights challenges to the realisation of the safe system.

**Keywords:** Safe System, Road Fatalities, Measurement

## **Introduction**

The safe system approach to road safety has been an integral focus of road safety strategy for a number of years. Understanding of the benefits of the application of the principles of the safe system approach, particularly in terms of the reductions in road deaths that would be derived from its implementation, is limited. The safe system approach has its basis in physics and the subsequent effects of force and acceleration/deceleration on moving bodies and particularly what is known about human tolerances to these forces (Healy & Corben, 2009).

The TAC sought to create a framework for classifying fatality crashes according to the presence or absence of each of the three elements of the safe system by developing a tool to measure the efficacy of the safe system in reducing fatalities.

In early 2009, the authors started to develop a methodology to investigate the effect of safe system measures on the road toll. This data collection and analysis has been applied to all fatalities counted in Victoria's road toll from January 2009 onwards. This study concentrates on fatalities counted in Victoria's road toll in 2009 and 2010. It is anticipated that this work will continue into the future in order to monitor changes in trauma outcomes linked to safe system treatments.

For the purpose of this project, the authors have considered three elements of a safe system: road users; vehicles and roads and roadsides (including speed limits). By collecting information and analysing data about these aspects of crashes that occur both within and outside of the safe system, this project should contribute toward understanding the ongoing benefits – in terms of lives saved - of the safe system approach as it becomes more prevalent across Victoria.

## **Methodology**

In order to determine whether a crash fell within or outside of the parameters of safe system principles, an assessment tool with which to categorise each fatality was developed. The assessment tool was designed to enable each road toll fatality to be assessed against a set of objective criteria to determine whether each of the three elements was compliant with a safe system. Where an element was not compliant, a brief, coded, explanation of the omission was recorded. Where all three elements were in fact compliant, a short comment outlining other factors that did not fall within the scope of safe system principles was then recorded.

The assessment tool needed to be an instrument that was practical, easy to understand and apply and able to be utilised in the current business environment. For the tool to be suited to long term integration within the existing processes for recording fatalities in the fatal diary database, it had to be simple to use and require minimal time and effort. The fatal diary is a database collected and maintained by the Road Safety research team at the TAC. It is compiled from information provided by the police, in the form of incident fact sheets, received in the wake of a fatal collision.

The incident fact sheets currently provided to the TAC by Victoria Police formed the basis for initial decisions made about the presence of safe system elements in road fatality crashes. Subsequently, information recorded on the Traffic Incident System – the Victoria Police database for recording data about road collisions - or reported in the National Coroners

Information System were utilised if further detail was required. BAC data was utilised when available, and images on Google Maps were used to examine some roads and roadsides to get a better understanding of the configuration of some roads.

It was determined that by considering each of the situational factors present in a collision individually, this information could be used to classify fatalities based on the elements of a safe system that are present. This would serve to augment the data currently held in the TAC's fatal diary database. By collecting and analysing further details about road fatalities in terms of the presence or otherwise of the elements of a safe system, it should be possible to see the benefits of implementing the safe system principles throughout Victoria on an ongoing basis.

Each fatality in each crash was assessed in isolation to determine which elements (if any) of safe system were present. This was considered to be the best approach given the constraints of the data available, and crash circumstances would normally indicate the presence or absence of a safe system element. Once each element was assessed, an evaluation was made as to whether the elements of the safe system were present in their entirety. Therefore, each fatality was determined to either occur within a safe system or not.

#### *User*

An assessment was made as to whether human behaviour contributed to a fatal collision: all key road users involved in the collision were considered. This included the deceased person and all drivers involved in the collision, but would only include passengers if the passenger was deceased.

A road user was assessed as being compliant with safe system principles if they were obeying all applicable road rules at the time of the collision. Failure to comply with all road rules may not necessarily render a road user as not safe system compliant. Only when it can be determined that the infringement was deliberate (eg overtaking on double lines, travelling at excessive speed, driving with a blood alcohol concentration over the legal limit) would the road user be classed as not compliant with safe system. In other words, unintentional infringements (for example, failure to give way, failure to see traffic signals) were considered to be mistakes and are expected within the safe system.

Pedestrians were always assessed as being compliant with safe system principles. Cyclists and motorcyclists were also generally considered to be safe system compliant unless they were deliberately breaking a road rule (for example, helmet usage, blood alcohol limits, or where there is no doubt the user was travelling at excessive speed).

Therefore, a person who was abiding by the applicable road rules, or was not intentionally breaking the law was assessed as a safe system compliant road user. Only deliberate and overt rule-breaking would take a person outside of the safe system.

#### *Vehicles*

Crashworthiness was only considered for the vehicle of the deceased occupant. For a vehicle to be considered crashworthy, it should offer a certain level of protection for its occupants. This assessment was not made for pedestrians, cyclists and motorcyclists.

The model assesses a vehicle as providing a suitable level of protection for its occupants, it should have a minimum four star crash rating using the occupant safety rating from Used Car Safety Ratings (USCR) or using the European New Car Assessment Program (EuroNCAP) or The Australasian New Car Assessment Program (ANCAP) crash ratings (TAC, 2011). Cars in this study were assessed using the 2010 Used Car Safety Ratings for occupant protection. Crashworthiness is not related to the roadworthiness of the vehicle.

The crashworthiness of a vehicle was not considered relevant for motorcyclist, pedestrian or cyclist fatalities. Trams, trains, buses and trucks were also excluded because there are no readily available measures of crashworthiness for these vehicles. There were also a small number of vehicles involved in fatal collisions where data relating to crashworthiness was not available – these vehicles were classed as “unknown” for the purpose of this exercise. When the crashworthiness of a vehicle was unknown, the vehicle was assessed as being compliant.

### *Roads and Roadsides*

In order to determine whether a road is to be classified as a complying with safe system guidelines, consideration of crash type, speed limit and road infrastructure was made. The condition of the road (e.g. road surface, or state of repair) was not considered.

Initially, a determination was made as to whether the speed limit was appropriate for the road and road use. This was guided by the crash type and the ability of the human body to withstanding certain forces associated with road crashes. Thresholds have been estimated for the scenarios present in most road crashes, representing the maximum speed for which survival of impacts is likely (Wegman and Aarts, 2006).

- *Vulnerable road user (pedestrian, cyclist) struck by vehicle – 30km/h*
- *Single vehicle colliding side-on into tree or pole – 30km/h*
- *Side-on impact of two cars – 50km/h*
- *Head-on impact of two cars – 70km/h*

While the safe system would demand 30km/h speed settings in locations frequented by pedestrians (Wegman & Aarts, 2006), the approach used in the assessment of speed setting acknowledges the default speed limit of 50km/h in Victoria. Where pedestrian fatalities have occurred in 50km/h zones, the road and roadside have been assessed as being compliant with safe system principles.

An exception was made for pedestrians who were killed on roads with a speed limit greater than or equal to 90km/h. Because these roads are designed solely for vehicular travel; if a pedestrian was killed on one of these roads, it was quite likely they are there for a vehicular related purpose (for example, leaving a broken down car). In these situations, the road and roadside was judged as being compliant.

A crash involving the death of a vehicle occupant (driver or passenger of a car, truck, bus or tram) was assessed in relation to the speed limit, road infrastructure and crash type.

Where a single vehicle collision involved an object (such as a tree or a pole); the road was classified as safe system compliant if run-off road protection (including barriers or clearances) was present or the speed limit was at or below 50km/h. If a vehicle ran off the road and

collided with an object, regardless of whether the object was hit from head on or from the side, then the assessment would be made that run-off road protection was not sufficient.

The quality of roadside protection was not assessed in this project – barriers can be limited in their effectiveness; the presence of barriers was usually sufficient for a road to be classed as compliant with safe system principles regardless of the barrier performance. For example if a vehicle hit a barrier or went through a barrier, the road and roadside would be classified as compliant; however, if a vehicle went through a gap in a barrier, or went around a barrier, then the road and roadside was assessed as if the barrier was not present. The efficacy of roadside clearances was judged by the outcome of a crash. If nothing was hit, then the roadside clearance was assessed as safe system compliant. Where a head-on collision occurred, the road was classified as safe system compliant where there were centre-road barriers or clearances present or where the speed limit was below 70km/h.

Crashes involving intersections with a speed limit greater than 50km/h were generally not considered to be safe system compliant intersections. However, as safe system principles are concerned with travel speed, if a speed moderating road treatment (eg roundabouts, raised platforms or plateaus) was present at an intersection, in this study the intersection was considered safe system compliant. Roundabouts are considered to be compliant with safe system principles regardless of the speed limits of the intersecting roads entering the roundabout as the roundabout serves to reduce speeds to less than 50km/h as well as improving the angle of impact in the event of a collision.

The following flow chart depicts the decision making process in the assessment of fatalities with regard to whether the road and road side complied with safe system principles. This was based on whether or not the person killed was a vehicle occupant, the type of collision (for example, single vehicle or multiple vehicle, at an intersection or mid-block), and the speed limit at the place of the collision. This simplified the process of determining whether the road environment was compliant with safe system principles. An annotation was then made in the fatal diary to indicate whether any element was missing.

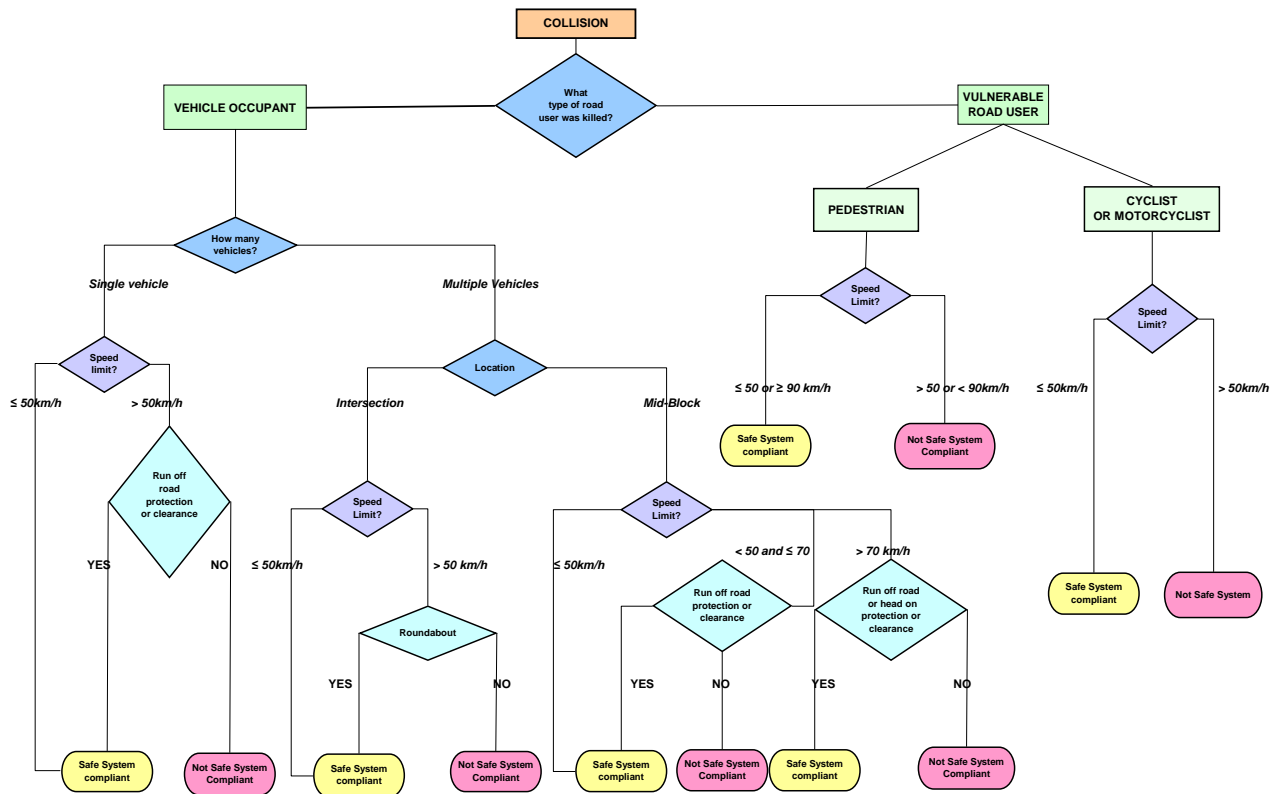


Figure 1: Decision making tool for determining whether a road is within safe system parameters

**Assessment**

Finally, an assessment was made as to whether safe system principles are present. The assessment was made solely on the circumstances of the particular crash, so where a fatality collision has occurred on a road with appropriate roadside infrastructure for the speed limit applicable to the road; the road user was abiding by all applicable road rules, and for a vehicle occupant, was inside a crashworthy car, the fatality would be considered to occur within a safe system.

Table 1: Description of the data entry parameters used within the fatal diary

Description of field	Data entry parameters
Occupant car meets crashworthiness standards?	Yes/No/NA/UK
Is the road system compliant with safe system principles?	Yes/No
Were all key road users (deceased and other drivers) involved in crash complying with applicable road rules?	Yes/No
Were all elements of a safe system present?	Yes/No
Comments on nature of crash, particularly regarding the elements of Safe System that were not present; or if all elements were present, the factors outside of the scope of Safe System that contributed to the fatality	Relevant codes from a code list; free text (see appendix)

**Results:**

In 2009 and 2010, 578 people were killed in Victoria. Using the assessment tool, it was possible to determine that 8% of fatalities occurred within the bounds of safe system principles. In 2009, 8% were killed within a safe system, and in 2010, 9% were killed.

Table 2: Proportion of fatalities where safe system principles are present

	2009			2010			Total		
	%	Safe system deaths	Total deaths	%	Safe system deaths	Total deaths	%	Safe system deaths	Total deaths
Vehicle	34%	67	196	29%	55	192	31%	122	388
Road	19%	54	290	20%	57	288	19%	111	578
User	56%	163	290	61%	177	288	59%	340	578
Occupant	47%	92	196	58%	111	192	52%	203	388
Non-occupant	76%	71	94	69%	66	96	72%	137	190
Vehicle * Road	8%	15	196	8%	16	192	8%	31	388
Vehicle * Occupant	21%	41	196	17%	33	192	19%	74	388
Road * Occupant	10%	29	290	14%	40	288	12%	69	578
Road * Non-occupant	18%	17	94	16%	15	96	17%	32	190
Vehicle * Road * User	8%	22	290	9%	27	288	8%	49	578
Vehicle * Road * Occupant	3%	5	196	6%	12	192	4%	17	388

\*Occupant - driver and passenger

\*Non-occupant - pedestrians, cyclists and motorcyclists (inc pillions)

The majority of users (56%) complied with safe system principles; with three quarters (76%) of non-occupant users compliant. However, 29% of pedestrians killed in 2009 and 2010 died inside safe system parameters as they are defined in this study.

- More than 60% of those pedestrians were killed on 50km/h roads
- Of the pedestrians killed on 50km/h roads, 40% were elderly (over 75) or very young (under 4)
- One in five were killed while working on their cars on the road
- Three pedestrians were killed while at the scene of another collision

Of the vehicle occupants who died within safe system:

- 60% were involved in same lane and/or same direction collisions with another vehicle
- 12% involved trucks going through barriers

Close to a third (31%) of vehicles were classified as crashworthy. Of the vehicles that were not safe system compliant, more than half also involved a non-compliant user. 54% of vehicle occupants killed on safe system compliant roads were in vehicles that were classified as not crashworthy, whereas 72% of vehicle occupants killed on non-compliant roads were in vehicles classified as not crashworthy.

38% of people killed on safe system compliant roads were non-compliant users; and 58% of safe system compliant users were killed on roads classified as non safe system compliant.

It was possible for people killed in a single crash to be classified differently. This was the case for a crash involving the deaths of two belted and two unbelted passengers travelling in a safe system compliant vehicle on a safe system compliant road.

The authors were not able to determine whether a person intended to break a road rule, or whether the rule-breaking was accidental, particularly in regard to a situation where a person was travelling in excess of the posted speed limit – it is not possible to tell if they were speeding because they made a decision to speed, or because they were unaware of the prevailing speed limit on the road they were travelling on.

Determining where some roads and roadsides fit in relation to safe system principles was complicated particularly in regard to deciding whether some road situations should be classified as an intersection or not: for example, where a driveway entered a road i; or provision for a u-turn on a road with a speed limit greater than 50km/h.

## **Discussion**

The main strength of the assessment tool is its simplicity. The comments recorded by the TAC during the assessment process can be evaluated to see what factors contributed to the crash – be it the actions of the road user, the presence or otherwise of roadside treatments, or the crashworthiness or otherwise of the vehicle containing the deceased person. The coded comments entered into the fatal diary allowed more detailed analysis of fatalities and the relationship between fatal crashes and various elements of safe system.

While the assessment tool does enable us to make a decision about the circumstances of most collisions that lead to a fatality, there are still a number of crashes that are not able to be classified because they don't seem to fit within the guidelines for a safe system. Whether this is because of a lack of more detailed information about any or all of the three elements of safe system that may or may not have been present; or because there will always be fatality crashes that will not be able to be prevented is unknown.

The following are some examples of circumstances that may lead to such outcomes:

- A collision between vehicles with an extreme mass differential (e.g. car v truck);
- A person's physical ability to withstand forces present during a collision is compromised by frailty or illness;
- A broken down car in a high speed zone or a road user alighting from a broken down vehicle in a high speed zone;
- Freak environmental events (flash flood, fire, wind gusts);
- Vehicle failure including loss of a wheel, or brake failure;
- Vehicle catching fire;
- Inadequately restrained objects inside or outside of vehicles.

All have the potential to impact negatively in a crash, even at low speed, and may not be able to be accommodated using safe system principles. Regardless of the thresholds a human body is capable of withstanding, there is still a small chance a person will die even when a collision occurs at low speed – an elderly person or a young child may have a lower tolerance to the forces present in a collision, or there may be some unknown factor relating to the health of that person that will impact on their ability to withstand the impact in a crash.

Pedestrians that are lying or sitting on the road surface or walking on the road itself may not be behaving in a 'safe' fashion, but they are not necessarily breaking the law. There may also be extenuating circumstances for their being on the road. It is not against the law to be an



intoxicated pedestrian; so a pedestrian affected by alcohol was assessed as a safe system compliant road user.

The authors were limited by the amount of data readily available. For example, it was not possible to physically investigate each crash site to determine the presence of roadside barriers or other roadside treatments. While the images on Google Maps provided some information about roadside infrastructure, the images are often two or more years out of date; therefore were only suitable to be used as a guide.

Specific details about vehicles involved in fatal collisions were limited to make, model and year, leading to some assumptions being made as to the crashworthiness of a particular vehicle. In addition, only the vehicle of a deceased occupant was considered for crashworthiness. It is also difficult to determine whether a more crashworthy vehicle could have prevented a fatality - in the vast majority of cases where an un-crashworthy car is involved; other factor(s) have generally contributed to the collision result.

A further limitation of the assessment tool was the decision to consider each element in isolation. This means the interaction between elements was not considered, particularly in relation to the consideration of human behaviour. In the case of a person who chooses to travel at an excessive speed, loses control of their vehicle and collides with a tree; the roadside would be classified as non-compliant with safe system principles because an object was hit; however, had the person been travelling at the speed limit, it is possible the collision may not have occurred.

One of the challenges faced by the implementation of the safe system principles was highlighted by the assessment of the fatalities that occurred within the parameters of the safe system principles. This was related to the setting of an appropriate speed limit for pedestrian areas. A large proportion (60%) of pedestrians died on 50km/h roads; which suggests that a lower speed limit for roads that are heavily populated by pedestrian traffic may be appropriate.

## **Conclusions:**

The prime objective of creating an assessment tool with which to determine whether a fatality collision occurred within or outside of the provisions of safe system was met in that this approach does cater for the majority of fatality crashes that occur. The assessment tool is simple to use and to understand, with most of the decision making reduced to a simple 'Yes' or 'No' response to determine whether a fatality has occurred within safe system principles.

In no way does this tool attribute responsibility for a fatality to any individual, vehicle or infrastructure; as a failure of one safe system element in the collision may confound the protection offered by other elements that were present. This tool will be used to derive measures of the effectiveness of safe system into the future, and will contribute to the suite of performance measures and indicators used by road safety agencies in Victoria.

**Reference List:**

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**Appendix:**  
**Code list utilised in fatal diary coding**

	<b>Crash worthy Car</b>	<b>Compliant Road</b>	<b>Compliant User</b>	<b>Safe System</b>	<b>Comment</b>
1	Yes	Yes	Yes	Yes	Comment as to how system failed or collision was outside of system
2	Yes	Yes	No	No	Comment as to User action
3	Yes	No	Yes	No	Comment as to missing road features
4	Yes	No	No	No	Comment as to Road and User
5	No	Yes	Yes	No	Comment as to other factors
6	No	Yes	No	No	Comment as to User
7	No	No	Yes	No	Comment as to Road
8	No	No	No	No	Comment as to Road and User
9	N/A	Yes	Yes	Yes	Comment as to system fail
10	N/A	Yes	No	No	Comment as to user action
11	N/A	No	Yes	No	Comment as to Road
12	N/A	No	No	No	Comment as to Road and User

*COMMENTS* are used to describe the factors that lead to the collision.

- Roads – if the road is not safe system compliant:
  - ROR – no run off road protection present
  - HOP – no head on protection present
  - PED – a pedestrian on a road with a speed limit greater than 50km and less than 90km/h
  - CYC – cyclist on a road greater than 50 km/h
  - MOTO - motorcyclist on a road greater than 50 km/h
  - INT – intersection greater than 50km/h
  
- User – if the users actions are not safe system compliant
  - UNLIC – Unlicensed driver
  - UNREG – Unregistered vehicle
  - ALC – Alcohol affected driver or rider
  - DRUG – Drug affected driver or rider
  - SPEED – Excess speed (not inappropriate speed)
  - SB – Not wearing restraint (includes child restraint)
  - HEL – Not wearing approved helmet (Motorcyclist and cyclist)
  - MOB – Use of mobile phone while driving
  - RULE – Deliberate breaking of road rules (eg crossing double white lines to overtake)