If not for road safety advocacy driving regulatory change, Tiger Woods may not have survived this high-speed rollover crash.

VEHICLE SAFETY IMPROVEMENT LESSONS FOR AUSTRALIA

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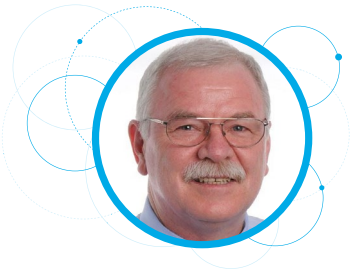

Raphael Grzebieta, PhD

George Rechnitzer, PhD

Road Safety advocates explain that Tiger Woods is alive following his high-speed rollover crash on February 23, 2021, in large part because of regulatory upgrades seen in the USA over the past decade in vehicle roof strength regulations (FMVSS 216) including advanced crashworthiness features of the vehicle he was driving and the installation of crash event data recorder (EDRs) in passenger cars. The crash demonstrated that no one is immune to the effects of irresponsible driving and speeding and highlights the critical safety lessons that can be learnt from the investigation of crashes like Tiger's.

While much has advanced in Australia in road safety, Tiger Woods' high-speed crash has highlighted three critical vehicle safety areas where Australia is lagging:

1. The lack of a rollover roof strength standard or ANCAP Safety Rating for passenger vehicles sold in Australia.
2. Not mandating Event Data Recorder (EDR) devices (Similar in principle to the 'black boxes' fitted to aircraft; proven to be invaluable in crash investigations leading safety improvements in the aviation industry).
3. We do not have a National Crash Investigation entity for vehicles. We have the ATSB for aviation, marine and rail modes of transport – but not for roads [web: www.atsb.gov.au]

From the early 1990s to early 2000s, independent safety experts advocated for more stringent rollover crash worthiness requirements in the USA after observing too many examples of serious injury and death resulting from gross amounts of roof intrusion that violated basic principles of safe occupant packaging and containment espoused decades earlier by De Haven[1]. Many cases involved partial ejection of seat-belted occupants, with a high incidence of horrific injuries resulting when an exposed occupant encountered the road surface during the rollover (Figure 1).

[1]H De Haven, Accident Survival - Airplane and Passenger Car, Society of Automotive Engineers: Detroit, Michigan, SA, 1952.

Road safety advocates including Dr Raphael Grzebieta and Dr George Rechnitzer from Melbourne and Tia Gaffney from California (who now works in Australia for the National Transport Research Organisation, ARRB), along with a small contingent of other independent researchers, began to advocate to the US Government from opposite sides of the globe. In a series of letters to the US Department of Transportation regulatory docket, a small group of experts provided compelling evidence that vehicle roofs were not fit for purpose. They were too weak. They were failing to protect occupants in foreseeable rollover crashes occurring in the real world.

Figure 1: Raphael Grzebieta, PhD, seated in a rolled SUV that met the US roof crush design rule with a narrow margin, demonstrating a typical level of roof crush experienced in a rollover often leading to ejection of seatbelted occupants (vehicles manufactured prior to 2009 after which new regulations were enacted).

Simultaneously, these same road safety advocates were advocating with the US Insurance Institute for Highway Safety (IIHS) who produce public-friendly consumer ratings for vehicles (similar to ANCAP star ratings). The experts urged the IIHS to add a rollover roof strength rating to their suite of star rating criteria.

The safety advocates argued that ensuring the occupant compartment or survival space during a rollover crash is vital. A robust structural performance ensures that seatbelts and airbag systems can function as designed. Further, reducing roof intrusion also allows side glazing (glass) and side air curtains to remain intact, which prevents the opportunity for ejection (Figure 1).

After over a decade of debate and with unrelenting drive from the independent experts, the USA enacted an upgraded version of Federal Motor Vehicle Safety Standard (FMVSS Number 216) – Roof crush resistance released in 2009 (with full applicability starting in 2012).

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The upgraded standard nearly doubled the pass/fail criteria for structural roof strength-to-weight ratio (SWR). Almost concurrently, in 2009 the IIHS implemented a roof strength test, with stringent requirements for achieving a 'GOOD' rating (Figure 2). In parallel, the US Federal Government introduced the FMVSS 226 Ejection Mitigation design rule in 2013 to reduce the partial and complete ejection of vehicle occupants through side windows in crashes, particularly rollover crashes[2].

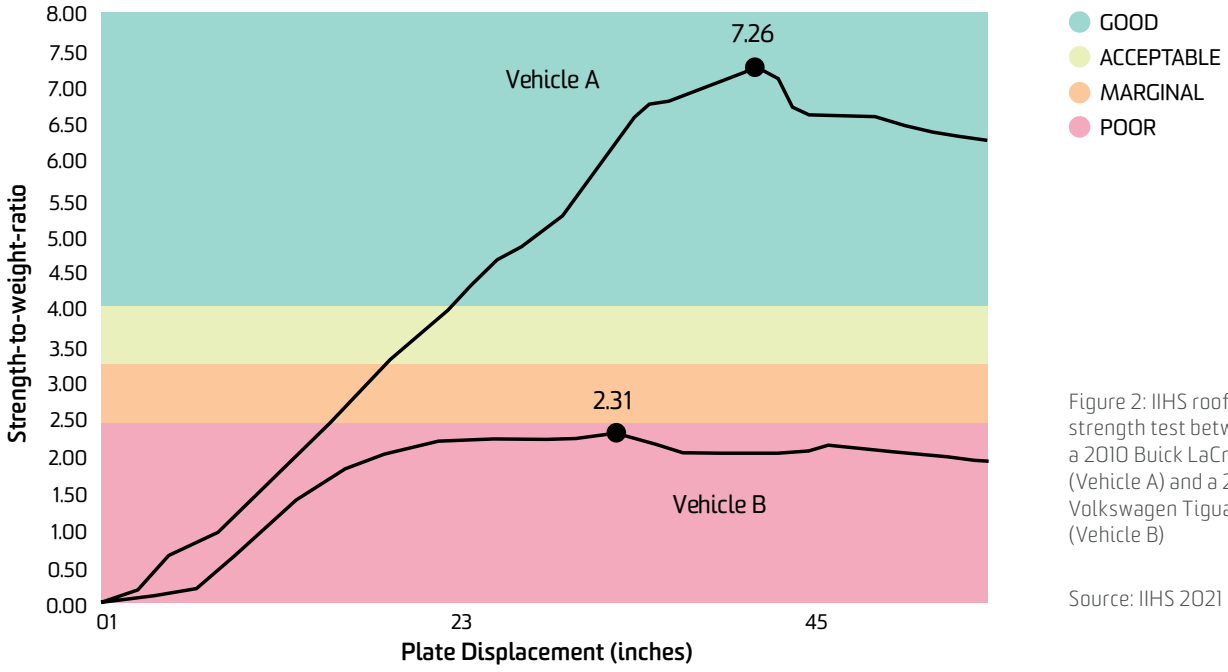

Figure 2: IIHS roof strength test between a 2010 Buick LaCrosse (Vehicle A) and a 2009 Volkswagen Tiguan (Vehicle B)

Source: IIHS 2021

With these increased USA roof strength requirements, manufacturers also produced improved curtain airbag technology, seatbelts with pretensioning devices, side window glazing integrity, effective roof and pillar head impact padding and advanced electronic stability control. Maintenance of the space surrounding the occupant enables the suite of passive technologies to function synergistically.

Volvo proved to be a leader in the rollover safety space, initiating stringent internal requirements for roof strength and occupant protection with the introduction of its Volvo XC90 SUV in the early 2000s. The introduction of the XC90 demonstrated what was possible – a vehicle could be engineered to be safe in a rollover crash with a strong roof and good occupant protection features. (you can watch Volvo's rollover test of the first XC90 design here. The proof is in the pudding. Volvo's XC90 has never been involved in a fatal or serious injury crash since it was introduced in 2003, according to Thatcham Research, the body who executes Euro NCAP testing[3].

[2]https://www.nhtsa.gov/fmvss/ejection-mitigation
[3]https://www.thatcham.org/what-we-do/testing/

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Rollover safety initiatives have resulted in dramatic reductions in very serious injury for lap and shoulder belted front seat occupants.

The risk of very serious injury[4] to lap and shoulder belted ejected occupants has been reduced by an astounding 98.2% (0.346% for 2009 and older vehicles vs 0.006% risk for vehicles 2010 and newer. Viano (2018)[5] documented nearly 6,928 examples of lap/shoulder belted front seat occupants being very seriously injured as a result of ejection in 2009 and older cars, while there have been only 5 examples for cars 2010 and newer.

When a rollover does occur and when the front seat occupants are not ejected, the risk of very serious injury to lap and shoulder belted non-ejected occupants has been reduced by 18.5% (1.183% risk for 2009 and older vehicles vs 0.964% risk for vehicles 2010 and newer).

When we look at Tiger Woods' case, the experts say there is no doubt that the combination of an intact occupant compartment – including a strong roof structure, seatbelts, airbags, padding and side glazing greatly reduced the risk of death. If Mr Woods had rolled in a vehicle manufactured before the new rollover regulations and ratings were applicable, he would have had a significantly higher chance of sustaining a serious head or spinal injury. Many people injured in rollovers in pre-2009 vehicles were not so lucky.

Figure 4: Reductions in very serious (MAIS 4+) injury risk to lap & shoulder belted non-ejected and ejected front seat occupants in rollover crashes from 1995 to 2016 resulting from vehicle rollover safety improvements.

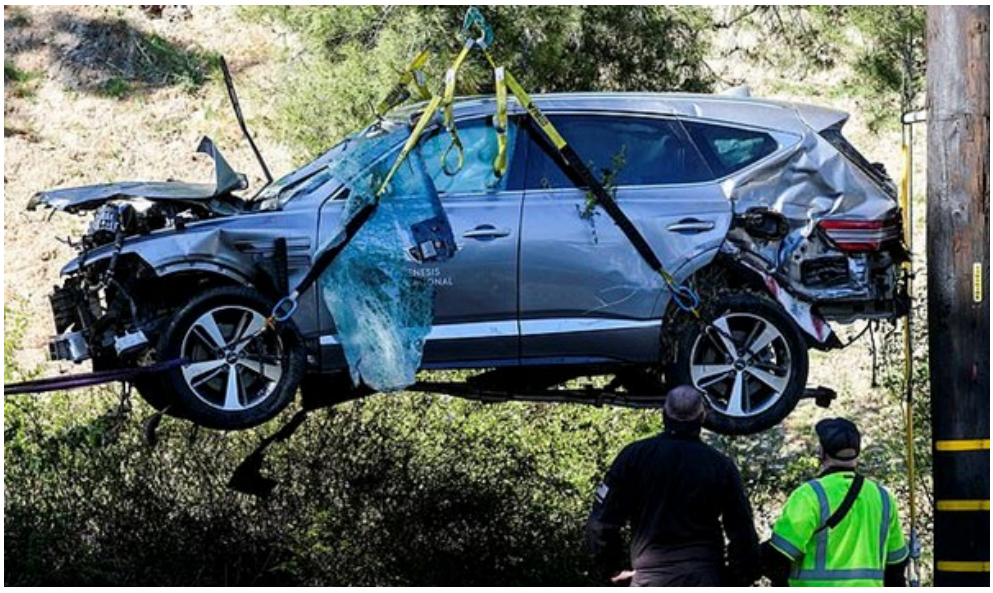

Figure 3: View showing Tiger Woods' rolled Genesis with an intact occupant compartment, intact side glazing and deployed side curtain airbags.

Source: AP Photo/Ringo H.W. Chiu

[4]Maximum Abbreviated Injury Scale MAIS 4+

[5]Viano and Parenteau, Rollover injury in vehicles with high-strength-to weight ratio (SWR) roofs, curtain and side airbags, and other safety improvements, Traffic Injury Prevention, 2018.

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The NHTSA (USA), IIHS (USA), C-IASI (China) and KNCAP (Korea) remain the only bodies who evaluate rollover roof strength around the world. Australia and Europe do not currently have any regulation which mandates vehicle roof strength or ejection prevention. The result? Vehicles which arrive on our shores are de-spec'd – strengthening material and reinforcements are removed by some manufacturers to save in manufacturing costs.

Rollovers may represent a large proportion of fatal crashes in Australia– deaths which might be preventable with better rollover crash worthiness requirements in place.[6] Fréchède et al 2010 analysed 2000–2007 single vehicle rollover fatalities in three Australian states and found that rollovers accounted for 35% of all occupant fatalities.[7]

Without a National Crash investigation entity we simply do not know how many serious and fatal injury crashes involve rollover over the past decade, and whether these crashes might be improved with stronger roofs. This data gap creates a loophole for manufacturers to exploit.

Data is power and we can learn from Mr Woods' crash.

While Woods is reported to have no recollection of the crash and no one saw the events that unfolded, there was one key witness who was able to identify the speed travelled by Woods – his car. Tiger was driving a new Genesis GV80 (Genesis Motors LLC is a Korean subsidiary of Hyundai Motor Group) equipped with a crash Event Data Recorder (EDR) device. In the USA, vehicle EDRs are regulated under National Law[8] with the requirement that light vehicles equipped with EDRs meet certain requirements for data elements, data capture and format, data retrieval, and data crash survivability.

Because the vehicle was equipped with an EDR, the high speeds which led to the crash could be determined immediately. According to the Los Angeles County Sherriff: 'The primary causal factor for this collision was the driver travelling at a speed which was unsafe for the conditions and the inability to negotiate the curvature of the roadway'.[9] The estimated speed at the first area of impact was nearly double the posted speed limit (the speed of the vehicle was estimated by the LA Sherriff to be as high as 87 mph (140 km/h) while the reported speed limit was 45 mph (72 km/h)). In the absence of an EDR module, it could have taken experts months to determine this information using conventional forensic speed calculations.

Currently, no Australian legislation exists mandating that vehicles be fitted with an EDR or that stored data be accessible by Police.[10] The National Highway Traffic Safety Administration (NHTSA), enacted in 2011,[11] that all vehicles sold in the USA that have EDR fitted and are capable of recording data, must have such data available for download to assist collision investigation. The European Union (EU) is set to introduce similar rules in the EU from 2021.

[6]Grzebieta R.H., McIntosh A.S., Bambach M., Young D.P. Dynamic Test Protocol To Assess Rollover Crashworthiness, Proc. 2010 Australasian Road Safety Research, Policing and Education Conference 2010, Canberra, Australia, https://acrs.org.au/article/dynamic-test-protocol-to-assess-rollover-crashworthiness

[7] Fréchède B., McIntosh A.S., Grzebieta R., Bambach M.R. Characteristics of single vehicle rollover fatalities in three Australian states (2000–2007), Accid. Anal. Prev.(2010),doi:10.1016/j.aap.2010.10.028

[8]49 CFR part 563. Part 563 was established on August 28, 2006 (71 FR 50998)

[9]Press release from Los Angeles County Sherriff Alex Villanueva via CNN - https://edition.cnn.com/2021/04/07/us/tiger-woods-update-crash-cause/index.html

[10]Hardiman M., Hardiman J.. Flight C., Proposed Amendments to the Australian Design Rules Pertaining to Mandation of Event Data Recorders in Australian Sold Vehicles, Proc. 2019 Australasian Road Safety Conference, Sept 2019, Adelaide, Australia, https://acrs.org.au/files/papers/arsc/2019/JACRS-D-19-00232-Hardiman.pdf

[11]49 Part 563 of the USA Code of Federal Regulations

A 2014 study published by the Transportation Research Lab in Europe[12] documented the benefits of EDRs in the following key areas:

- In jurisdictions where EDRs are mandated, there have been observable reductions in crashes – this is because people know their actions are being recorded and adjust their behaviour accordingly.
- EDRs enable manufacturers to obtain information on causation (in Tiger Woods case, speed was a significant factor) – this information can be used to influence manufactures in the design of vehicles as well as governmental policy regulating vehicle design.
- Crash reconstruction becomes significantly more accurate – this allows researchers and policy makers to better understand the factors leading to crashes and how proposed countermeasures may work to avoid future crashes. This means that both research and policy can be targeted on the initiatives that will have the greatest societal benefit.
- Better data reduces the costs of legal proceedings and insurance payouts – liability for the crash can be more accurately determined, reducing time and costs and providing swifter justice.

Perhaps the largest benefit of EDRs is in understanding the role of speed in crashes. Current research often relates crash risk to posted speed limit rather than identifying how fast the car is actually going before it crashes (in the case of Tiger Woods, about double the legal limit it would appear). We can also evaluate the human crash response because the crash data provides information about pre-impact braking, acceleration/deceleration and steering responses.

In the USA, there is a system of complete transparency - the USA National Highway Traffic Safety Administration keeps a catalogue of EDR reports and systematic findings on its Special Crash Investigations (SCI) database.[13] The information which can be determined from an open dataset of real crash data is boundless. The University of Adelaide Centre for Automotive Safety Research (CASR) has recently released a series of fatality and serious injury risk curves as a function of crash impact speed.[14] CASR analysed EDR data from 1,274 vehicles the using the open USA EDR database to determine speed-injury risk for frontal, head-on, side and rear crash modes. This information can be used to influence speed-related policy, road and vehicle design, and demonstrates the dramatic benefits of traveling in a newer vehicle.

We should be asking whether Tiger would be alive if he had rolled over in Australia – or whether the lack of a rollover roof strength rating would have resulted in a different and more sinister outcome. We should be asking how long it would take our system – in the absence of EDR regulations - to identify contributing factors like travel speed. We should be asking how we are meant to make decisions which will drive road safety outcomes when our analysis of fatality crashes is lagging by as much as 18 months and injury crashes is lagging by as much as four years. We should be asking why we continue to miss fundamental pieces of the puzzle when there is so much to be learnt from systematic crash investigation.

With 1200 dying and nearly 40,000 seriously injured on Australian roads each year, we need to do better.

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Our experience working with national, state, territory and local governments means we understand your policy development needs and we can help deliver an integrated approach to ensure the network provides a safer and more cost effective environment for all road users.

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[12]https://ec.europa.eu/transport/sites/transport/files/docs/study_edr_2014.pdf
[13]https://www.nhtsa.gov/research-data/special-crash-investigations-sci
[14]Doecke, S., et al., Impact Speed and the risk of serious injury in vehicle crashes, Accident Analysis and Prevention 144, 105629, 2020