

'Sierra Sam' – The Antediluvian Crash Test Dummy

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Approximately 1.2 million people are killed on the world's roads every year. Much of this appalling loss of life can be attributed to motor vehicles and their errant drivers. Since 1949 when the first crash test dummy - 'Sierra Sam' - was 'invented', motor vehicles have become safer to drive as car manufacturers include more safety features in their vehicles. With the advent of Euro NCAP in 1997, and in conjunction with car manufacturers, safety features have improved significantly for occupants both inside and for those outside the vehicle. Features such as seatbelts, airbags and other safety developments are estimated to have saved nearly 329,000 lives in the US, whilst it is estimated that more than 15,000 lives have been saved on UK roads since safety tests were first launched. With the advent of autonomous cars, it remains to be seen whether road safety will improve further and the number KSIs that occur annually as a result of vehicle collisions will be reduced dramatically. This article focuses on the role of crash test dummies in preventing KSI's in vehicle collisions.

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4/2/2018



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“Merriam-Webster ¹ defines a crash test dummy simply as: “A life-size model of a person used on tests to see what happens to people when a car gets into an accident”. However, Humanities, ² a global leader in crash test dummy innovation, more specifically defines a crash dummy as: “A calibrated test instrument used to measure human injury potential in collisions. It stimulates human response to impacts, accelerations, deflections, forces and moments generated during a collision.” ³

Introduction

ON August 31, 1869, at the age of 42, Mary Ward - writer, artist, draughtsman and amateur scientist - of Parsonstown, (present-day Birr) Co. Offaly, Ireland - became the first recorded Irish fatality of a vehicle crash when she was thrown off an experimental powered steam vehicle, built by her cousins, and killed. ⁴ (Karl Benz did not invent the gas-powered vehicle until 1886) Twenty years later, on 13 September 1889, Henry Bliss entered the history books as North America’s first motor vehicle fatality when hit while stepping off a New York City trolley. This sensational news was reported worldwide and since then; in excess of 20 million people worldwide have been killed and seriously injured by the invention of the ‘*internal combustion engine*’. However, since circa 1949 with the creation of “Sierra Sam” and more recently since 1997, Euro NCAP in conjunction with car manufacturers has endeavoured to improve vehicle safety for occupants inside and also for those outside the vehicle. The European New Car Assessment Programme (Euro NCAP) is a European car safety performance assessment programme based in Brussels and founded in 1997 by the Transport Research Laboratory (TRL) for the Department for Transport (DfT). It is backed by several European Governments as well as the European Union (EU). ⁵ Euro NCAP is a not for profit organisation funded by its own members and European Governments. While manufacturers do not have to have their cars tested by Euro NCAP, around 90% of new models are. This means Euro NCAP’s verdicts have a huge influence in swaying safety-minded car buyer’s decisions.

¹ <https://merriam-webster.com>

² Humanetics (ATD) is a global leader in the design, development and manufacturing of anti-crash test devices (ATD’s). Their HQ is in Farmington Hill, Michigan. int.search.myway.com

³ *A Brief History of the Original Automotive Crash Dummy; Meet Sierra Sam.* <https://www.keepingussafe.org>

⁴ Mary Ward 1827-1869. Famous Offaly People. Offaly Historical and Archaeological Society. Archived from the original on 27 September 2007. Retrieved 25 April 2006.

⁵ Pernille Larsen (2011-05-25) “Fia region1) Euro NCAPs standard set for upcoming electric and range-extender cars. Fiabrussels.com Retrieved 2011-11-02

Crash test dummies provide invaluable data on how human bodies react in crashes and have contributed greatly to improved vehicle design. While they have saved millions of lives, like cadaver and animals, they have reached a point where they are almost like us – humans.

The Birth of Sierra Sam

Before the first crash test dummy was invented, crash-testing relied on cadavers, sandbags and the occasional human volunteer. In 1949, Colonel J. P. Stapp, an American Air Force surgeon studying the “physiology of rapid deceleration” wanted to test his rocket sled on something resembling a human. In one of his experiments, he propelled himself to over 630mph (1010 km/h) on a rocket sled and stopped in less than a second. He commissioned a dummy on plaster casts of an actual pilot. A Californian firm called Sierra Engineering Co. responded with ‘Sierra Sam’ – a six-foot-tall steel-and-rubber dummy with instruments in its thorax and head. Thus, ‘Sierra Sam’ was born. The 95th percentile adult male crash test dummy was developed under a contract with the US Air Force, to be used for evaluation of aircraft ejection seats on rocket test sleds.

Before General Motors developed Hybrid 1 in 1968, dummy manufacturers had no consistent methods to produce their devices. The basic weight and size of the body parts were based on anthropological studies, but the dummies were inconsistent from unit to unit. The science of anthropomorphic dummies was in its infancy, and their production quality varied. GM used this mode internally, but shared its design and cutting-edge technology with competitors including Government regulators. This was done through special committee meetings at the Society of Automotive Engineers (SAE). Hybrid 1 was more durable and produced more repeated results than its predecessors. ⁶ The sharing of this tool was made in the name of improved safety testing and reduced highway injuries and fatalities worldwide. The Hybrid II crash test dummy, originally designed by Alderson Research Laboratories was modified by GM and the National Highway Transport Safety Association (NHTSA) using Alderson and Sierra Engineering parts. In 1973, the dummy was mandated by the NHTSA for use in testing automotive restraint systems to meet Federal Motor Vehicle Safety Standard No. 208 (FMVSS208). The size and weight of Hybrid II represented the ‘average’ US male. ⁷

⁶ Mary Bellis March 06 2017. *The History of Crash Test Dummies* <https://www.thoughtco.com>

⁷ Humanetics Innovate Solutions www.humanetics.atd.com

Since Hybrid II first appeared in 1976, seatbelts, airbags and other safety features are estimated to have saved nearly 330,000 lives in the US and also it is estimated more than 15,000 lives have been saved in the UK since safety tests were launched. Hybrid I and Hybrid II were very crude and their use was limited to development and testing of seatbelts. Today, Alderson's average-male dummy has a family: dummy women, children and infants.^{8 9} In 1997, General Motors Hybrid III crash test dummies became the industry standard for testing to comply with Government frontal impact regulations for airbag safety. GM developed this test device over twenty years ago to provide a biofidelic¹⁰ measurement tool for crash test dummies that behave very similarly to human beings. The 1997 version of Hybrid III is the GM invention that included some vehicle manufacturers. It marks another milestone in the car maker's trailblazing journey for safety.¹¹ Hybrid III is the state-of-the-art for testing advanced restraint systems; GM has been using it for years in the development of front-impact airbags. It provides a broad spectrum of reliable data that can be related to the effects of crashes on human injury. Hybrid III features a posture representative of the way drivers and passengers sit in vehicles.

'Sierra Sam's' Successors

Soon it became apparent that such a dummy could have a big impact on the auto industry. With the development of the Interstate Highways System¹² in 1956, Americans began driving longer distances in bigger and more powerful cars. Then in 1965, Ralph Nadir published "Unsafe at Any Speed" and the following year Congress passed the National Traffic and Motor Vehicle Safety Act. The same year, engineer Samuel Alderson, who studied physics under J. Robert Oppenheimer, built another dummy also designed for the car industry. He called it V.I.P.50. Samuel W. Alderson, a physicist and engineer who was a pioneer in developing the long-suffering curiously beautiful human surrogates known as automotive crash test dummies died on 11 February 2005 at his home in Los Angeles.

⁸ Mail Online Sat. 17 March 2018 www.dailymail.co.uk

⁹ SID – Side-impact dummy; BioRID – A dummy designed to assess the effects of a rear impact; CRABI – A child dummy used to evaluate the effectiveness of child restraint devices including seat-belts and airbags and THOR – An advanced 50th percentile dummy – is more humanlike and the successor to Hybrid III

¹⁰ This is a jargon used by those in the automotive industry. It is the result of combining two words "bio", signifying life or living organism and "fidelity" meaning faithfulness. Biofidelity is used to describe something that is "faithful to life" or put into simple terms, something that responds in a life-like way. When we say a dummy is biofidelic we mean that it has a human-like response. www.epoch7.org

¹¹ *History of crash test dummies – Sierra Sam and the family of crash test dummies.* <https://www.thoughtco.com>

¹² On June 29th 1956, President Dwight D. Eisenhower signed the Federal-Aid Highways Act of 1956. The Bill created a 41,000 National System of Interstate and Defence Highways. At 3,020 miles, I-90 is the longest Interstate Highway. It connects Seattle, Washington, Boston and Massachusetts.

The dummy that is the current industry standard for frontal crash testing in the US, is a linear descendant of one Alderson began manufacturing for the aerospace industry in the early 1950s. It is used today by car manufacturers and Government agencies to test safety features like seat-belts. Seat-belts, airbags and other safety features are estimated to have saved nearly 329,000 lives since 1960, according to a study released in January 2005 by the National Highway Traffic Safety Administration (NHTSA).¹³ In 1968, Alderson produced a further test dummy, in a series called the V.I.P.50 and built it specifically for automotive testing. With the dimensions of an average adult man, the dummy had a steel rib cage, articulated joints, flexible neck and lumbar spine. The cavities held instruments for collecting data.¹⁴ Hybrid 111, released in 1977 remains the industry standard model.

THOR – New Kid on the Block

THOR stands for Test device for Human Occupant Restraint. THOR incorporates enhanced biofidelic features and significantly expanded instrumentation compared to the standard Hybrid III. THOR has been in development since the 1990's, and is reported to replace Hybrid III – currently the crash test dummy of choice for the National Highway Traffic Safety Administration (NHTSA). The biofidelity (a fancy word for lifelike) of THOR is amazing. THOR's head and neck are designed with muscular resistance so they swivel like an actual human's head and not like a rag doll. THOR also features clavicles and an entire set of ribs with sensors to give researchers a better understanding of how crashes affect the human thorax. And as development continues THOR will react (and look) more and more humanlike. But THOR isn't just a pretty face filled with over 134 channels of data (78 more than Hybrid III). He can also decipher everything from the tension in the Achilles tendon during a crash to the force of a blow to the head in a front-end collision. And in addition to loads of sensors that measure the force of impact, THOR sports accelerometers, which record post-crash acceleration on particular parts of the body. While THOR hasn't quite made his way into the standard rotation of NHTSA's dummy list, his development has certainly paved the way for even more detailed crash test results. THOR represents the future of more lifelike crash testing and increased automotive safety.¹⁵ Euro NCAP is considering the usage of THOR for future frontal crash impacts as part of their continuous efforts to improve road safety. At a cost of \$400,000, THOR is not yet an official global standard crash test dummy.¹⁶

¹³ S. Alderson, Crash-Test Dummy Inventor, dies at 90. www.nytimes.com. (18 February 2005)

¹⁴ S. Alderson, Crash-Test Dummy Inventor, dies at 90. www.nytimes.com. (18 February 2005)

¹⁵ THOR The God of Crash Test Dummies blog.enurance.com

¹⁶ THOR The God of Crash Test Dummies blog.enurance.com

History of CTD's

The first crash test dummies may have been the best, most responsive, most life-like dummies in history, because they were actual people ... human volunteers, such as medical professionals and engineers. Believe it or not, prior to the 1950's, cadavers also served as crash test dummies. The news was that this allowed injuries to be observed on real bodies. The bad news was that cadavers did not come in standard shapes and in test crashes they didn't behave like bodies of living, breathing human beings. In addition to cadavers, pigs were also commonly used as early crash dummies. Pigs could sit upright in a car and they have a similar internal structure to humans. For these two reasons, pigs were often used in testing steering wheel impact.

On 27 September 1991, the New York Times published an article entitled: ***“19,000 Animals Killed in Automotive Crash Tests”***. In that article, the Times reported: ¹⁷

“About 19,000 dogs, rabbits, pigs, ferrets, rats and mice have been killed during the last decade in automotive safety tests performed by General Motors. A company spokesman explained that the tests helped to reduce injuries to drivers and passengers and were performed on animals that had been anesthetized. The tests were condemned by a leading animal rights organisation, People for the Ethical Treatment of Animals, which called for a boycott of General Motors products.”

Animal testing is no longer practiced by any of the major automobile manufactures; General Motors discontinued their live testing in 1993 and other car makers followed suit shortly afterwards.

What are CTD's Made Of?

Crash test dummies are full-scale replicas of human beings, weighted and articulated to simulate behaviour of a human body in a motor-vehicle collision. It is instrumented to record as much data as possible on variables such as speed of impact, crushing force, bending, folding, and torque of the body and deceleration rates during a collision. In modern times they remain responsible in the development of new makes and models of all types of vehicles, from family sedans to fighter aircraft. A crash test dummy is an anthropomorphic ¹⁸ testing device (ATD).

¹⁷ New York Times, (by Associated Press) *19,000 Animals Killed in Automobile Tests* <https://www.nytimes.com>

¹⁸ Ascribing human form or attributes to a being or thing not human, especially to a deity. www.dictionary.com

This is a fancy way of saying that a crash test dummy is a mannequin that closely imitates the size, shape, mass, stiffness and energy absorption of an actual human being. He/she is then placed in the awkward position of testing vehicles for crash resilience. Today, the skeleton of a crash test dummy is constructed of aluminium and steel. Each skeleton has six ribs made of steel and synthetic plastic to mirror a human chest. Vinyl “skin” is stretched over the skeleton. The dummy is then outfitted with advanced electronic tools that measure a range of effects on the human body from acceleration, electronic force, torque and deflection. Realistic joints as well as a neck, spine and pelvis made of rubber or foam encased in metal constructions give the dummy a life-like posture and flexibility, both of which play a large part in collision injuries.¹⁹

Star Ratings

Crash testing is widely welcomed by legislation and motoring organisations because basic Governmental regulations would only require a legal car to score the equivalent of a one-star rating out of five to be acceptable for use on the road. Euro NCAP publish safety reports on new cars and awards ‘Star Ratings’ based on the performance of the vehicles in a variety of crash tests; including front, side and pole impacts and impacts with pedestrians. The top overall rating is 5 Stars. From January 1 2009, they adopted the rear-impact (whiplash) test as part of its new crash-test regime. The new rating system also focused more of the overall score on pedestrian protection; Euro NCAP were concerned the car manufacturers were too fixed on occupant safety rather than safety of those outside the vehicle. Results of the first two cars to be tested under the new scheme were released in February 2009.²⁰

Rover v Honda

In November 1996, the Swedish National Road Administration (SNRA), the *Federation Internationale de L’Automobile (FIA)* and International Testing were the first organisations to join in the UK (DfT) with the newly formed Euro NCAP. The British and Swedish Governments decided to work together on crash testing to drive safety forward by setting up the first car crash aimed at informing customers. In the first ever Euro NCAP test, seven popular ‘super minis’ were chosen - the Ford Fiesta and Volkswagen Polo each achieved three out of the then maximum of four based on protection levels offered to adult occupants. The top-selling Rover 100 achieved only one star while the Fiat Punto, Nissan Micra, Vauxhall Corsa and the Renault Clio achieved only two.

¹⁹ A typical crash test dummy can cost well over \$600,000 (shipping extra)

²⁰ *Euro NCAP 2008: Making Safety Your Top Priority*. 15 January 2009. <https://www.euroncap.com>

When pedestrian protection was assessed, no vehicle secured more than two points, suggesting that manufacturers were not designing front ends with vulnerable road users in mind.²¹ Rather than replicating the standard crash test, they decided to do the most fatal type of head-on crash of that time in which 75% of people would die.

The Demise of the Metro

Thatcham Research, the UK's accredited crash testing centre, crashed a Rover Metro and a Honda Jazz to demonstrate how much car safety improved over the past 20 odd years. None of the cars did well in the tests. In fact, neither scored more than three out of the possible five stars and the Rover 100 scored just one star. The front of the British hatchback interior caved in - first the steering column cover, and then the ignition switch smashed into the drivers legs. Even though the car had a driver's airbag, the crash test dummy's head missed it and hit the car's front pillar, causing even worse injuries. The 1997 Rover Metro was reduced to a mangled wreck after it hit a barrier at 40mph. Any occupants would be facing life-changing injuries or even death after the head-on crash even though the car was fitted with an airbag. However, anyone who crashed in its modern day equivalent, the Honda Jazz, would walk away with minor bruising. Footage of the crashes shows the Metro's safety cell was "severely compromised" while the driver's compartment of the Jazz remained intact. The results were published on 4 February 1997, and soon afterwards the Rover 100 was withdrawn from sale because so many people were put off by the test results. Many 1990's cars had shortcomings in two key areas; they weren't structurally strong enough, so the occupants would be crushed during an impact, so the load on people's bodies would be more than they could withstand. However, there was a huge amount of pushback from the manufacturers about the tests. They said the testing was unfair and that it would be impossible for any car to get four stars, let alone five, recalls Matthew Avery, who has been involved with Euro NCAP since its inception.²²

People v Dummies

If you've ever been lucky enough to walk away from a car crash without any serious injury, then you may want to thank Hybrid III. This pinkish-brown humanoid, with distinctive yellow and black patches on its temples, is the most common crash test dummy used to prove that most new vehicles can meet safety standards. But this long standing guardian of health and safety may soon be forced to retire, and its thanks, in part to our eating habits.

²¹ Fleet News 02/02/2017 Thatcham Research Celebrates 20 Years of Euro NCAP Testing. www.fleetnews.co.uk

²² What is Euro NCAP and how does it work? <https://www.whatcar.com>

When Hybrid III was introduced in 1976 it was designed to represent the “average” American male: 1.8 metres (5 feet 9 ins. tall) and weighing 77 kilos (170 lbs). Since then, the average American male has gained more than 11 kilos (25 lbs) and is 2.5cm (1 inch) shorter. “*There is now a distinct mismatch between people and dummies,*” says Scott Gayzick, a scientist at the Wake Forest Centre for Injury Biomechanics in Virginia.

“Playing Frankenstein”

The virtual humans – Global Human Body Models Consortium (GMBHC) scientists are creating sophisticated affairs. Unlike ‘Sierra Sam’s’ humble beginnings - to develop the models, they start by taking computed tomography (CT) scans of people both in lying and seating positions to build up a 3D representation of a human skeleton. Then they add magnetic resonance imaging (MRI) scans of people in a seated position using an upright MRI machine, to add the muscles, internal organs and the brain. So far, the GHBMC has completed a model of a 50th percentile male, and despite its complexity it is only about 1Mb in size – small enough to fit into an old – fashioned floppy disc. The group is now working towards constructing a more sophisticated model than can easily be scaled up or down and adjusted to simulated people of different sizes, builds and ages. A typical car crash – or even one using a crash test dummy – takes just one tenth of a second or about half the time it takes to blink, according to Dr Stitzel. But a virtual simulation can take up to 10 hours, running on a powerful 64-bit processor computer system.²³ That’s because rather than taking sensor readings at a few discrete points, they can show millions of points of information and create detailed models of exactly what is happening to different parts of the body.²⁴

Thatcham GB

Based in Berkshire, Thatcham Research is the only accredited crash testing centre in Great Britain. It has been a member of Euro NCAP since 2004. It has a key role, both in crash testing and evaluating the protection offered by the vehicle in the event of a crash (secondary safety) and in the development of testing protocols for new technology designed to prevent the crash happening in the first place.²⁵ For Euro NCAP assessments, Thatcham conducts three specific crash tests on each car model it handles – a 40% offset frontal crash at 64km/h; a 50km/h side crash into a moving barrier, and a 30km/h crash into a static pole.

²³ Crash Car Tests Not for Dummies. www.bbc.com

²⁴ Joel Stitzel, one of the leaders of the GHBMC team working at Wake Forest Centre for Biomechanics, Virginia.

²⁵ Thatcham Research – making an impact <https://www.thatcham.org>

It is estimated more than 15,000 lives have been saved on UK roads since the car safety tests were launched.²⁶ According to Andrew Miller, President of Euro NCAP and Chief Technical Officer at Thatcham Research:

“Vehicle safety has undergone significant progress during recent years and the years to come will involve great changes to take account of the newest and essential technology on offer. I look forward to supporting Euro NCAP’s initiatives and role in Europe to supply consumers with precise safety information and safer vehicles”.²⁷

20 Years of Success

Today, Euro NCAP celebrates over 20 years of crash testing that has reduced UK car occupant deaths and injuries by 63pc. However, Euro NCAP wants to cut the number of deaths and injuries on our roads further by getting car manufacturers to make autonomous emergency braking (AEB) as standard equipment on all new cars. It states that by doing so would prevent 2,700 deaths and serious injuries in the UK every year. Euro NCAP has arguably done more to improve the safety of modern European cars than anyone else. Crash test dummies remain indispensable in the development of all types of vehicles, from cars to aircraft and “Sierra Sam’s” successor(s) – Hybrid III will ably assist

Conclusion

Over the last decade Euro NCAP has become synonymous with crash testing and safety ratings. In the same period, the total road death toll in the European Community has been reduced by roughly a quarter, despite a significant growth in road traffic volumes. One important factor is that cars in Europe have become much safer, partly due to the vehicle industry’s response to initiatives such as Euro NCAP. Euro NCAP provides motoring consumers with a realistic and objective assessment of the safety performance of the most popular cars sold in Europe. Most consumers will have no personal experience on which to judge the crash safety of their car. Are they happy with the level of safety offered? Can they specify the level they want? Can they assess whether this objective has been met? Clearly without objective and transparent safety information, these questions would be impossible to answer. This underlines the importance of public safety ratings and justifies why Euro NCAP continues to develop its comparative safety tests.

²⁶ Mail Online Sat. 17 March 2018 www.dailymail.co.uk

²⁷ Thatcham Research – Making an Impact <https://www.thatcham.org>

Moreover, it explains why Euro NCAP's online and written publications continue to grow in popularity, not only with consumers but also more and more with public and private fleet managers to help them ensure that the safety of their fleet provides acceptable levels of protection to their employees. Euro NCAP has now families of test crash dummies that simulate human beings in crash tests. Today, Hybrid III is the standard dummy used in test crashes. However, we must not forget the development of the first 95th percentile adult male test crash dummy commissioned by American Air Force surgeon Colonel John Paul Stapp and created by the Sierra Engineering Co. in 1949. To some, he may be *vieux jeu*, inchoate and obsequious and didn't suffer from amaxaphobia and could never compare with THOR – the smarter New Kid on the Block - but he was the pioneer of crash test dummies that did so much for people and vehicle safety – the trailblazing six-foot tall, steel and rubber crash test dummy was simply called - “Sierra Sam”.

