

Vehicle Systems

Crashworthiness

Vehicle safety

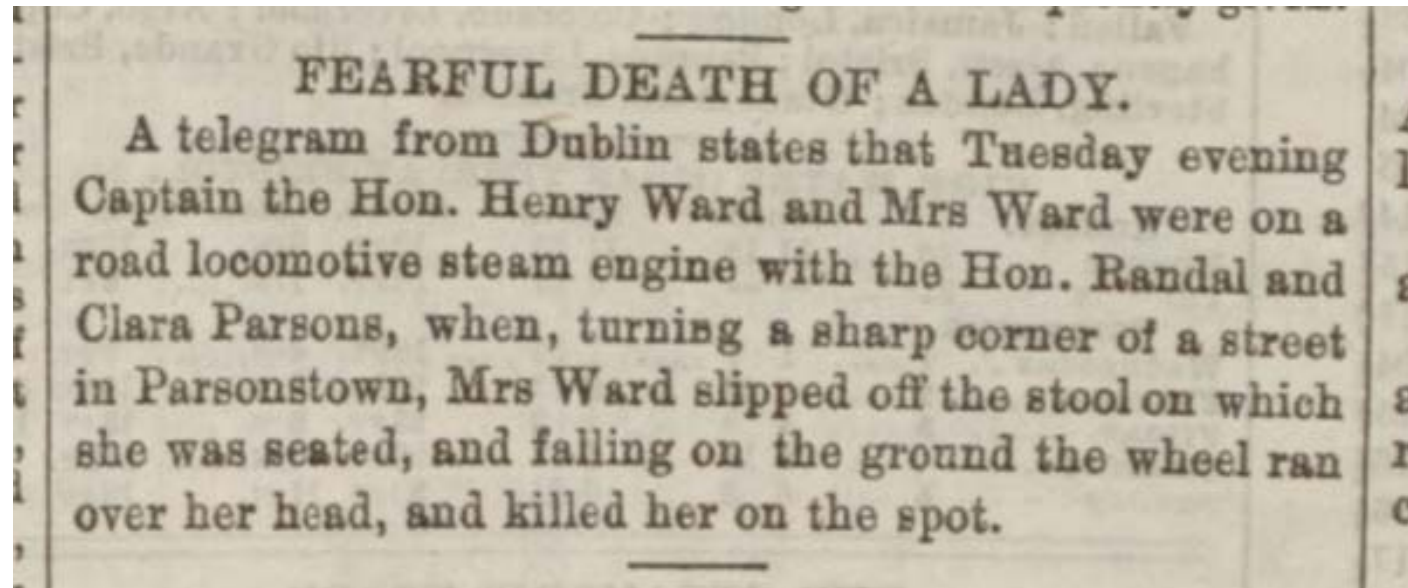
Key aspect of using a vehicle is safety

What is a traffic collision?

What can they result in?



Mary Ward



World's First Automobile Fatality – 31st August 1869

Steam powered vehicle.

Bridget Driscoll



First UK Automobile Fatality – 17th August 1896

Petrol powered vehicle.

THE FATALITY AT THE CRYSTAL PALACE.

KILLED BY A MOTOR CAR.

At the inquest, opened at Penge yesterday, on the body of Bridget Driscoll, who was killed by a motor car at the Crystal Palace on Monday last, May Driscoll, a daughter of the deceased, stated that she and her mother were on the terrace when they saw the cars coming towards them. The last one was steering a zig-zag course. The witness stepped on one side to avoid it, and a moment later it knocked down her mother. She did not hear the driver call out, but she saw her mother hold up her umbrella to warn him to stop. There were no notice boards up cautioning people to look out for the cars. There was plenty of room for the car to have passed without touching her mother.

The witness, in answer to the Coroner, denied that she saw any notice posted up "beware of the horseless carriage."

Another witness, who was called, spoke to the erratic course steered by the car. Another witness declared that the car was going "as fast as a fire-engine—in fact as fast as a good horse can gallop." The driver did his best to pull up, but he sounded no warning.

At this point the inquiry was adjourned. It was announced that the Palace Company had undertaken to defray the cost of the deceased's funeral.

Henry Bliss



FATALLY HURT BY AUTOMOBILE.

Vehicle Carrying the Son of ex-Mayor Edson Ran Over H. H. Bliss, Who Was Alighting from a Trolley Car.

H. H. Bliss, a real estate dealer, with offices at 41 Wall Street, and living at 235 West Seventy-fifth Street, was run over last night at Central Park West and Seventy-fourth Street. He was injured fatally.

Bliss, accompanied by a woman named Lee, was alighting from a south-bound Eighth Avenue trolley car, when he was knocked down and run over by an automobile in charge of Arthur Smith of 151 West Sixty-second Street. He had left the car, and had turned to assist Miss Lee, when the automobile struck him. Bliss was knocked to the pavement, and two wheels of the cab passed over his head and body. His skull and chest were crushed.

Dr. David Orr Edson, son of ex-Mayor Edson, of 38 West Seventy-first Street, was the occupant of the electric cab. As soon as the vehicle was brought to a standstill he sent in a call to Roosevelt Hospital for an ambulance, and until its arrival did all he could to aid the injured man. When he was taken to the hospital Dr. Marny, the house surgeon, said that Bliss was so seriously injured that he could not live.

Smith was arrested and locked up in the West Sixty-eighth Street Station. It is claimed that a large truck occupied the right side of the avenue, making it necessary for Smith to run his vehicle close to the car. Dr. Edson was returning from a sick call in Harlem when the accident happened.

Mr. Bliss boarded at 235 West Seventy-fifth Street. The place where the accident happened is known to the motormen on the trolley line as "Dangerous Stretch," on account of the many accidents which have occurred there during the past Summer.

First American Automobile Fatality –
13th September 1899

Electric powered vehicle.

The New York Times

Published: September 14, 1899

Copyright © The New York Times

Elaine Herzberg



First death caused by an autonomous vehicle – 18th March 2018

The birth of Automotive Safety

Early Period
(1900s – 1935)

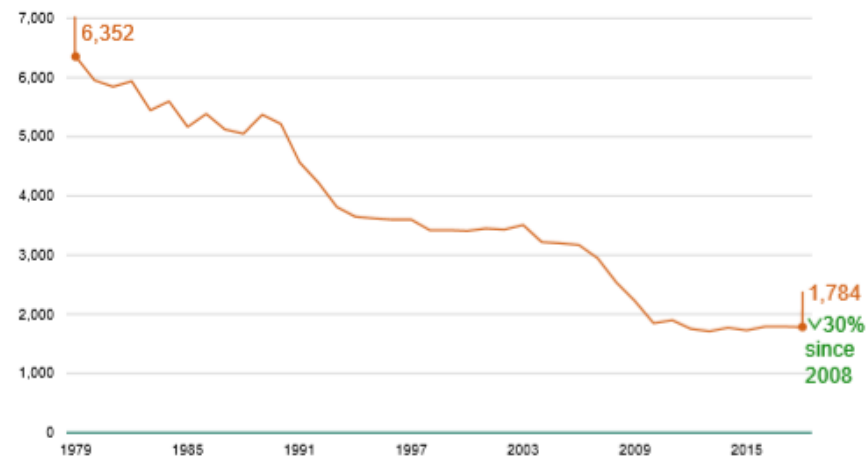


Second Period
(1936 – 1965)



Third Period
(1966
onwards)

Chart 2: Fatalities in reported road accidents: GB, 1979-2018



Department for Transport (2019) Reported Road Causalities in Great Britain: 2018 annual report. DfT, UK Government. London

Early Period (1900's – 1935)

Reduction in tyre blowouts

Self starting engine

Introduction of headlamps

Laminated glass

All steel body structure

Fatality rate

- approximately 17 per 100 millions miles travelled (USA)



Second Period (1936 – 1956)

Crash avoidance devices introduced

- *Indicators*
- *Dual windshield wipers*
- *Improved headlamps*

In 1934, GM conducted first barrier crash test

- *No dummies*
- *No electronic data acquisition*
- *Deformed structure simply observed*

Seatbelts introduced as an option in 1956



Third period (1966 onwards)

9th September 1966

- President Lyndon B Johnson signed the National Traffic and Motor Vehicle Safety Act and the Highway Safety Act

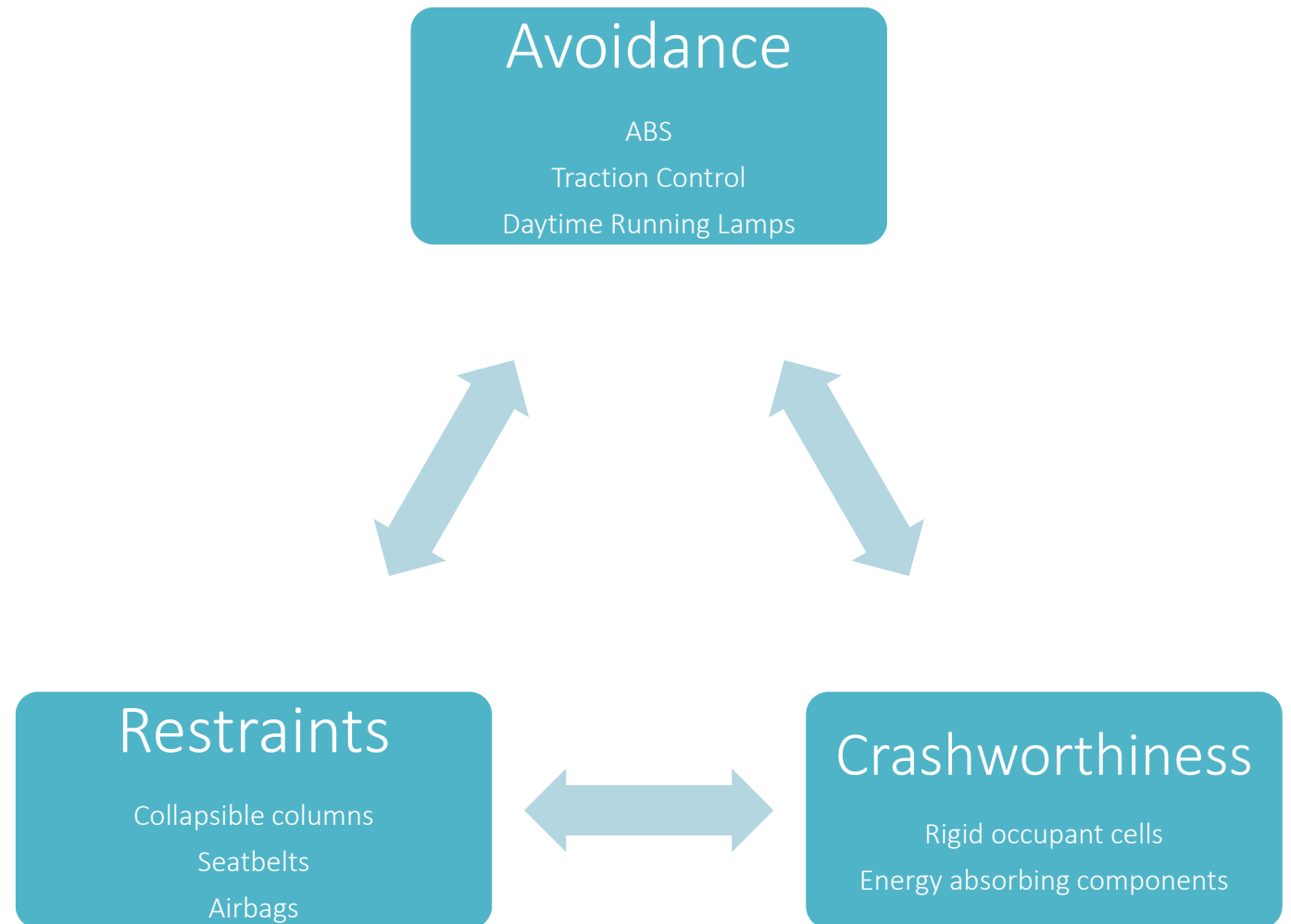
Fatality rate in 1996 was 1.6 per 100 million miles travelled

Fatality rate in 2013 was 0.56 per 100 million miles travelled



Today

Crashworthiness
Crash avoidance
Driver performance
Highway construction
Consumer driven



Goals for Crashworthiness

Early goal was to avoid vehicle deformation

However this has now changed...

- structures have deformable crush zones
- passenger cell remains intact

Crash energy

Crash length

Requirements for Crashworthiness

Absorb
kinetic
energy

Protect
fuel tank

Prevent
Intrusion

Pedestrian
impact

Minimise
acceleration
levels

Doors
staying
shut

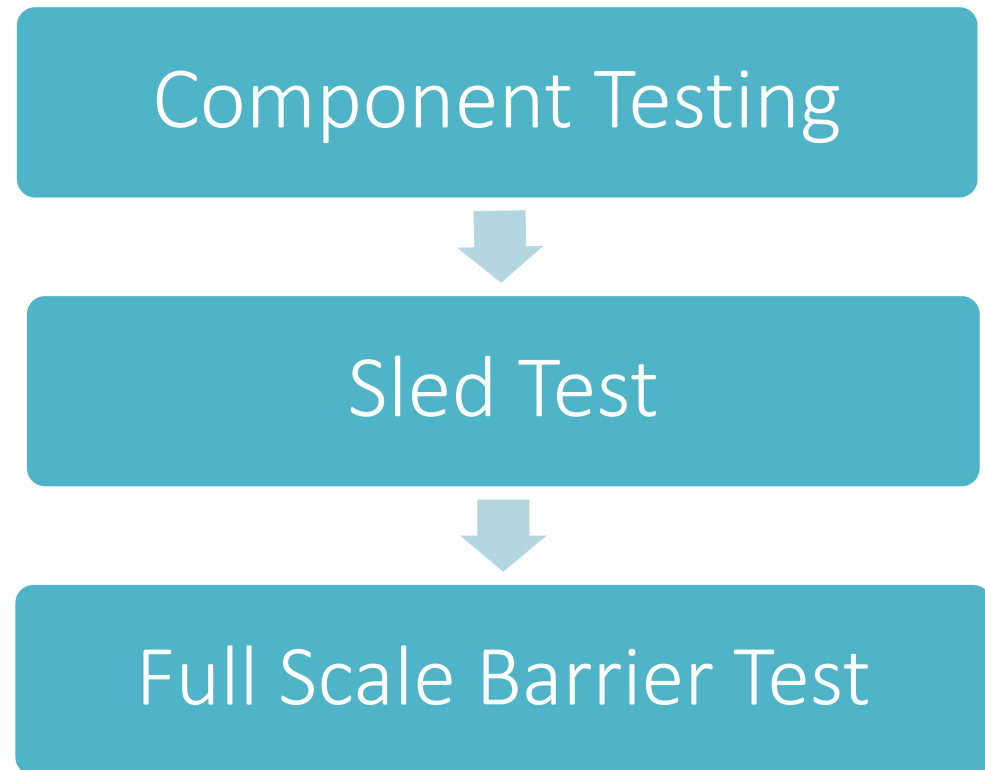
Vehicle
Compatibility



Crashworthiness Tests

Improvements in CAE capabilities
but still need final physical tests for
final crashworthiness and vehicle
certification

Complexity and varies increase
component/vehicle testing needed
- Repeatability decreases



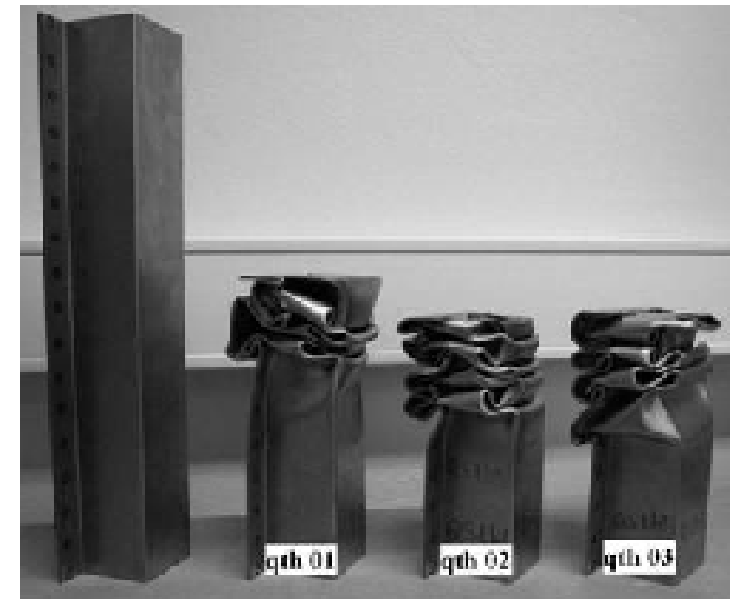
Component Testing

Used to determine;

- dynamic / quasi-static response
- crush mode
- energy absorption capacities

Used to develop;

- Prototype substructures
- Mathematical models



Sled Testing – sub system level

Uses a vehicle buck to test;

- Seats
- IP
- Steering systems
- Seat belts
- Airbags
- Dummies

How does it work?

- accelerated or 'fired' with crash deceleration pulse
- assessed with high speed photography, load cells and accelerometers
- primarily used for restraint systems



Full-scale barrier test – complete vehicle

Guided vehicle propelled into barrier at set;

- Initial velocity
- Angle

Used for;

- Full vehicle development
- Legislative compliance
- New Car Assessment Program (NCAP) tests

Issues;

- Time consuming
- Expensive
- Historically took up to 100 prototypes
 - now reduced due to CAE



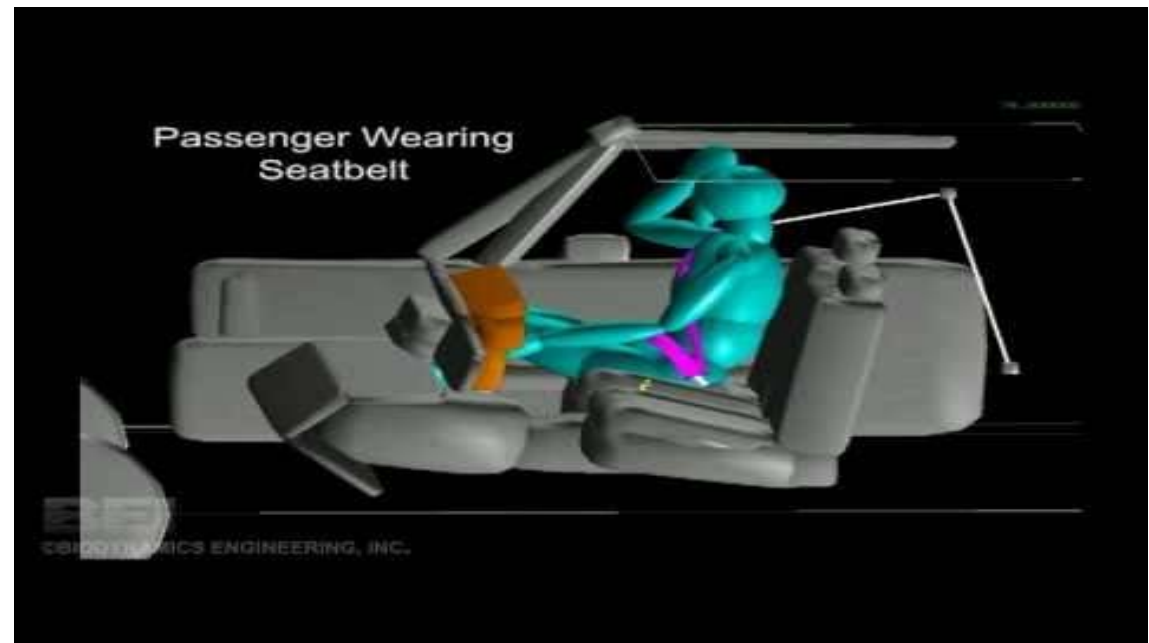
Rigid Body Dynamics

Eg; MADYMO (M^Athematical D^Ynamical M^Odel)

Uses springs, masses and rigid bodies

Component FE modules used to determine spring stiffness

Calculated acceleration pulses applied



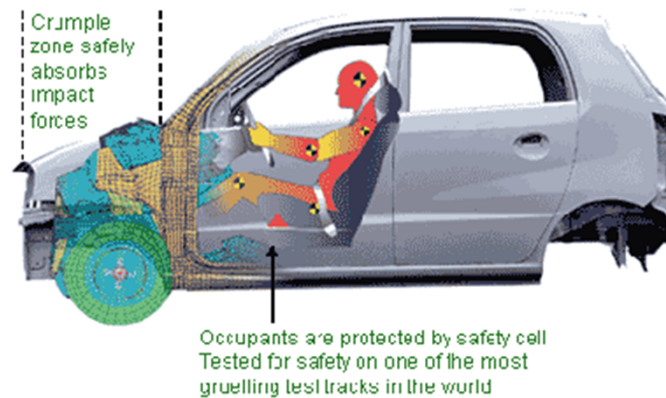
Designing for crash energy management

Three distinct crush zones in frontal impact;

1) Soft front zone

2) Primary zone

3) Secondary zone

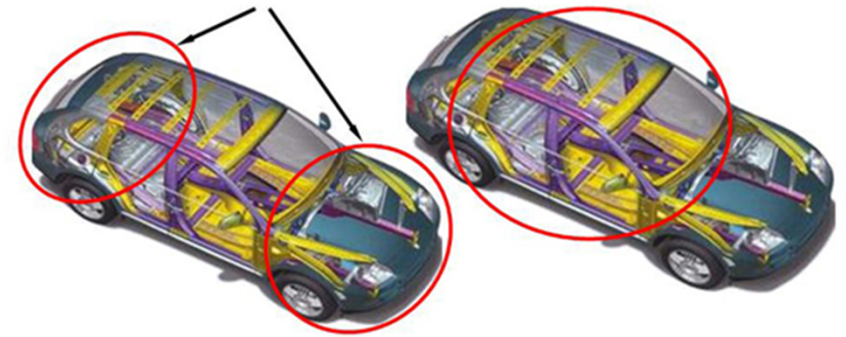


Crumple Zones

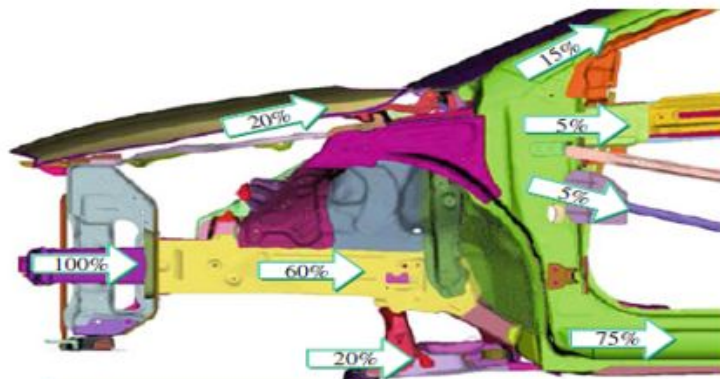
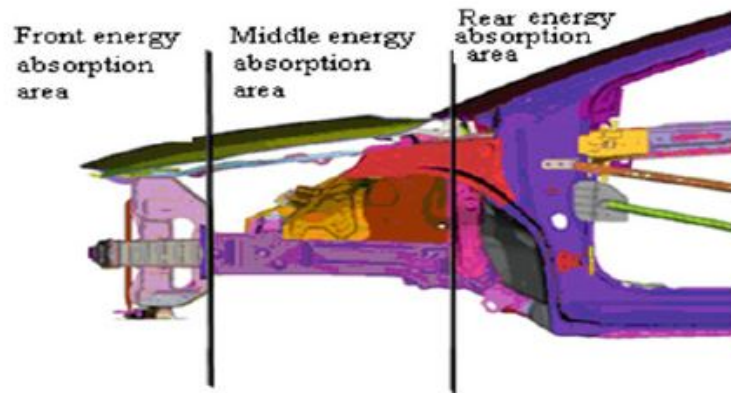
(engine compartment, trunk)
deform to absorb energy and
control magnitude of deceleration

Safety Cage

(passenger compartment)
resists deformation to prevent intrusion

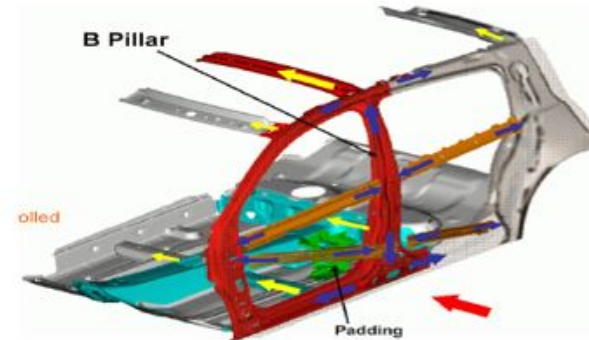


Load impact paths



Frontal Impact Load paths

Primary Load Path in Side Impact



- Structural criteria:**
- Load transfer continuity to doors.
 - Small relative displacements
 - Small absolute displacements up to $t=40\text{ms}$ for enabling air bag inflation

Side Impact Load paths



Rear Impact Load paths

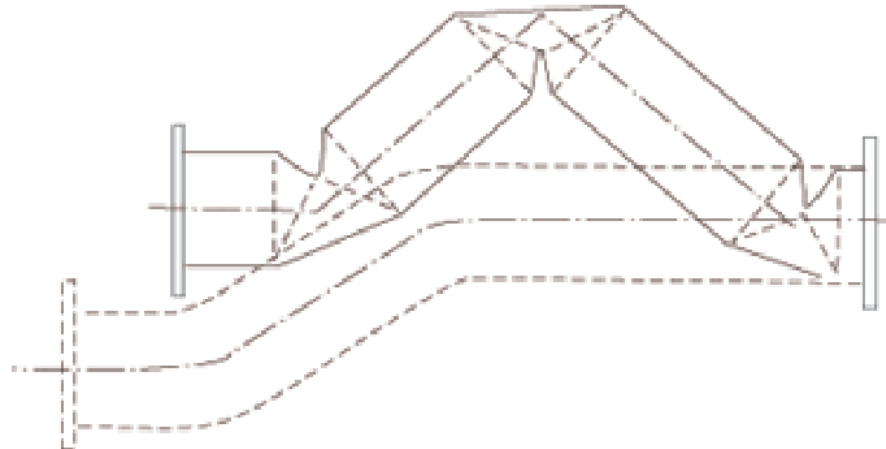
Designing for crash energy management

Energy absorbing structures deform in mixed axial and bending mode

- Axial collapse
- Bending



Torsion is more likely to occur in passenger cell.



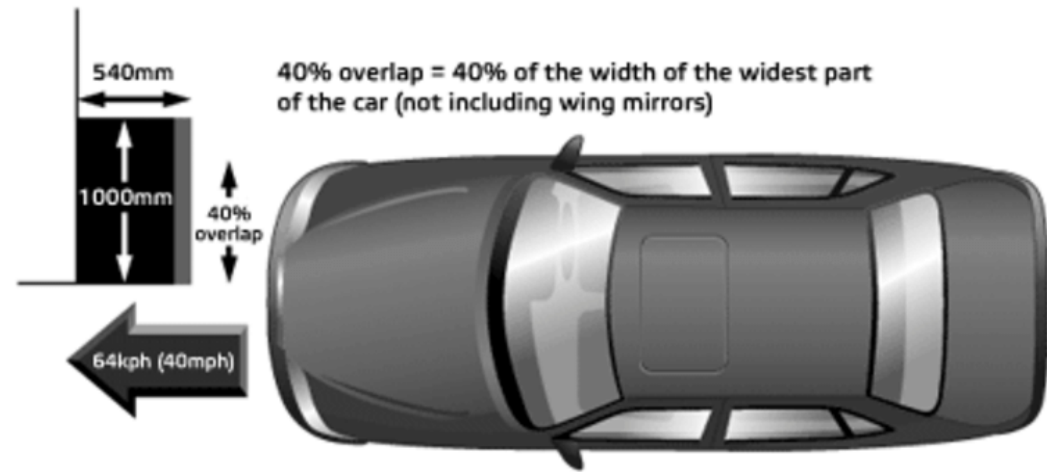
EuroNCAP frontal offset crash

Simulates car having frontal impact with another car or similar mass

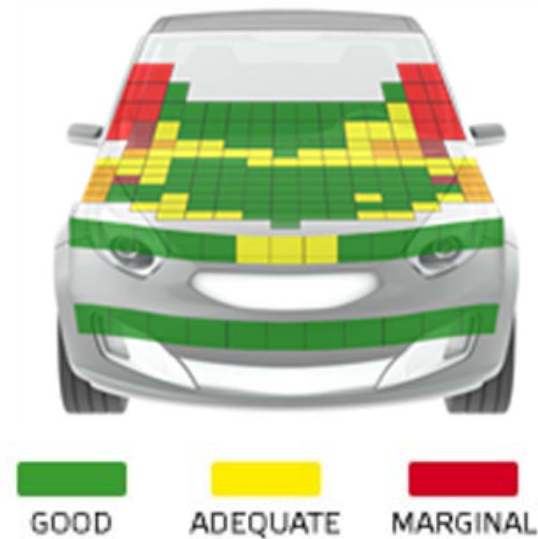
Uses a deformable aluminium honeycomb barrier

Represents most frequent type of crash

Tests the car's ability to survive

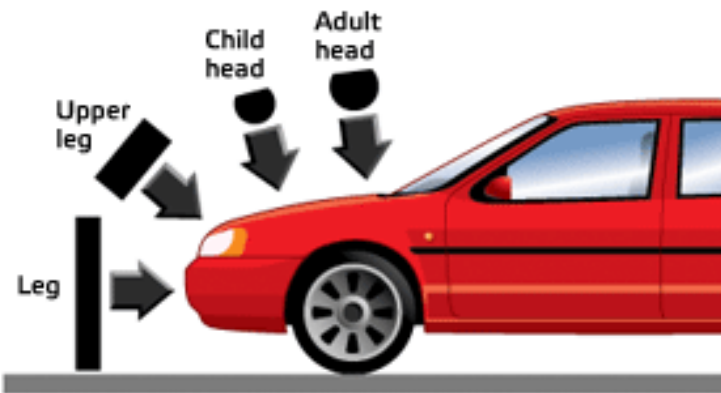


EuroNCAP Pedestrian impact



Impacts occur at 25mph (40kph)

Accelerations measured



How cars have improved?

