OLD CAR CRASH TEST PROGRAM

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ABSTRACT

Older vehicles do not have to meet the same safety standards that modern cars are required to meet. This paper presents some observations about the structural and safety performance of older vehicles in the frontal offset crash test conducted by the Australian New Car Assessment Program (ANCAP), the Insurance Institute for Highway Safety (IIHS) and EuroNCAP for consumer information. Some comparisons of the safety performance between new and old vehicles in offset crash tests are made. The test results were analysed to determine the various factors that contribute making a vehicle crashworthy. The newer vehicles generally scored better than the older vehicles. The results inform consumers about differences in safety features between new and old vehicles.

INTRODUCTION

Objectives

The main objective of this project was to demonstrate differences in occupant protection between new vehicles and older vehicles. This was achieved by crash testing a range of 20 year old vehicles to the ANCAP 64 kmh^{-1} 40% offset crash test procedure and comparing the risk of serious or fatal injury with that from the equivalent modern vehicles tested by ANCAP.

The second objective was to promote these results effectively to the public, encouraging owners to update their vehicles by explaining the importance of vehicle safety. An additional aim was to demonstrate to manufacturers the value of independent crash test programs in being able to make such comparisons.

TEST PROGRAM

To minimise the cost of the program, basic preparation and instrumentation was used. Only a driver dummy was used, instrumented for head, chest and upper leg measurements, with no lower leg transducers as is standard for ANCAP testing. Lower leg injuries are not normally fatal so there was little extra value in measuring them. For this project, the risk of a life-threatening injury from head and chest injuries was the main criterion.

Only the frontal offset crash test was conducted on the old vehicles; again in order to minimise costs. Other research programs have indicated that the data from the offset test are sufficient to make a good comparison of the safety performance between vehicles (Newstead et al,1999).

There was no instrumentation fitted to the vehicle itself, as there was little value in any comparisons to be made. Labeling was kept to a minimum and high-speed camera coverage was limited to the driver-side and overhead with six cameras. Good quality video was necessary to promote the messages from the program.

The vehicles tested were a Holden HZ Kingswood 1977-80 manufacture, a Ford XC Falcon 1976-80, a Mitsubishi GE Sigma 1977-80 and a Toyota KE30 Corolla 1975-78. Vehicles were sourced by NRMA Insurance, were inspected to ensure they were not excessively corroded and had not been subject to severe crash damage. The vehicles were repaired if necessary so they would run in a straight line when towed.

TEST RESULTS

The ANCAP results have been simplified by assigning an overall rating to each vehicle model. This rating takes into consideration the deformation of the vehicles structure and injury measures to the head, neck, chest, and upper and lower legs. The findings in this report are based on a series of crash tests conducted by Crashlab under contract to NRMA Insurance.

OLD CARS

Exact deformation measurements were not taken for the old vehicle crash tests. Judgements were made based on inspection and photographic records. The ability to open the car doors after the crash was not assessed.

Table 1 presents data on the Head Injury Criterion (HIC), chest forces and femur compressive forces. At a HIC of 1000, one in six adults will suffer from a life-threatening brain injury. A chest acceleration of more than 60g indicates poor protection from serious chest injury and a femur force of more than 10.9kN exhibits poor protection from serious upper leg injury.

1977 Holden Kingswood offset crash test at 64 kmh^{-1}

Table 1.
Risk of Injury in Old Cars

Vehicle model	Head Injury Criterion HIC36 (injury criterion 1000)	Maximum Chest Deceleration (injury criterion 60g)	Maximum Femur Compression	
			Left Femur (injury criterion 10kN)	Right Femur (injury criterion 10kN)
Holden Kingswood	1541	69.7	7.5	4.6
Ford Falcon	686	58.0	1.8	1.6
Mitsubishi Sigma	882	58.9	3.4	2.9
Toyota Corolla	1514	54.9	3.0	3.0

The Falcon was the only old vehicle to obtain a reasonable HIC score. The Kingswood and Corolla scored very poorly in this category. These results demonstrate that the drivers of the Kingswood and Corolla would have sustained a high risk of fatal head injuries. Otherwise all of the old vehicle models, except for the Kingswood, scored reasonably well, with low chest and upper leg injury measures.

1977 Holden Kingswood

Overall Evaluation: Poor
The seat belt broke during the Kingswood crash test, contributing to the poor protection from serious head injury for the driver. This could be expected on a number of vehicles of this age in normal use. The passenger compartment held its shape well, but with substantial intrusion into the driver's footwell.

Structure: Marginal
The front part of the driver's floor was pushed substantially rearward and the firewall ruptured. The brake pedal moved up and the accelerator pedal broke off. The dash buckled and moved towards the driver, while the instrument panel was forced downwards. The steering wheel broke away from the steering column. The steering column brackets fractured allowing the steering column to come away from the dash. The roof buckled slightly, though the front pillar on the driver's side appeared to be intact. The width of the driver's doorway did not shortened and the driver door did not buckle. All doors remained closed during the crash.

Restraints: Poor
Seat belt failure meant poor restraint system performance. The seat belt broke across the lap section. The chin, nose, left cheek and the top of the dummy's head hit the steering wheel. The back of the head hit the head restraint of the seat on rebound. The driver's knees and shins were severely impacted on the broken dash and steering column, suggesting serious lower leg injury. The left foot appeared to be caught between the fallen dash and the buckled floor. The driver was wedged between the seat and the steering wheel and dash

1978 Ford Falcon

Overall Evaluation: Good
The offset crash for the Falcon substantially deformed the passenger compartment resulting in significant intrusion into the driver's footwell. This meant poor protection from serious lower leg injury. As the dummy lower legs were not instrumented, the Ford Falcon received good ratings for protection against serious injury.

Structure: Poor
The front part of the driver's floor was substantially forced rearward. The dash buckled and pushed downwards. The steering column brackets sheared off, causing the column to collapse to the seat. The roof buckled very slightly and the front pillar on the driver's side bent away from the windscreen by about 30cm. The width of the driver's doorway shortened by 20cm and the door buckled slightly. All doors remained closed during the crash.

Restraints: Marginal
The driver's head was pushed back into the head restraint and hit the steering wheel across the nose and cheek. The driver's knees were severely impacted by the broken dash and the dummy's legs were wedged between the seat, dash and steering wheel/column. The driver was at risk of serious leg injuries due to its shins being wedged between the fallen dash and the seat. The force of the driver's hands/arms on the steering wheel during the crash pushed it back, leaving the driver's chest exposed to the broken centre of the steering wheel.

1977 Mitsubishi Sigma

Overall Evaluation: **Poor**
The Sigma's passenger compartment held its shape very well and there was only moderate deformation of he driver's footwell. There was marginal protection for the driver's head and the Mitsubishi Sigma received a poor overall evaluation.

Structure: Marginal
The front part of the driver's floor moved slightly rearward. The brake pedal moved up towards the driver. The dash remained reasonably intact, but the instrument panel broke due to the steering column collapsing and caused the plastic casing to come into contact with the driver during the crash. The steering wheel was bent and the steering column dropped onto the dummy's legs. The front pillar on the driver's side remained straight even though the roof buckled considerably. The width of the driver's doorway shortened by around 40cm and this door buckled slightly, causing a strip of metal to protrude into the driver's compartment which could have caused further injury. All doors remained closed during the crash

Restraints: Marginal
The driver's face (chin and forehead) made severe impact with the steering wheel and the back of the driver's head hit the head restraint. The driver's left leg hit the steering column and the gear stick. The back of the driver's seat collapsed, moved forward and then remained in the reclined position after the crash. The large movement of the driver's seat could have caused serious neck injury.

1977 Mitsubishi Sigma offset crash test at 64 kmh^{-1}

1980 Toyota Corolla

Overall Evaluation: Poor
The driver's head received poor protection from serious injury in the offset crash for the Toyota Corolla. Deformation of the passenger compartment and the driver's footwell was quite substantial. Protection from chest and upper leg injuries were good.

Structure: Marginal
The front part of the driver's floor was pushed slightly rearward and the dash was pushed rearwards. The roof buckled substantially and the front right pillar moved rearward and started to shear. The driver's seat back dropped back on impact and then slid forward, remaining in this position after the crash. The width of the driver's doorway shortened by almost 20cm and the door buckled. All doors remained closed during the crash

Restraints: Poor
The driver's head hit the steering across the cheek and nose. The back of the driver's head made impact with the head restraint. The driver's knees were pushed up against the broken, collapsed and jagged dash. There was potential serious lower leg injury as the driver's shins scraped the steering column and hit the gear stick. The driver's chest hit the steering wheel after its head made contact with the steering wheel. The driver was wedged between the seat and the broken dash/steering column.

NEW CARS

New vehicle deformation data for the previous offset crash tests were obtained from ANCAP reports.

1997 Holden Commodore

Overall Evaluation: Acceptable
There was too much deformation of the driver's footwell in the offset test and therefore poor protection from serious lower leg injury. Despite this, the vehicle provided good protection from serious life-threatening injury. The driver's airbag and pretensioner system in the front seat belts contributed to these good results.

Safety features
- A driver's airbag is standard equipment.
- The front seat belt buckles are mounted on the seats.
- Lap/sash seat belts are fitted to all seats, including the centre rear seat.

Structure: Marginal
The front part of the driver's floor was pushed rearwards 20cm and the floor panel tore away from the side of the vehicle, leaving a hole about 40cm long and 8cm wide. The dash was pushed 9cm towards the driver. The width of the driver's doorway shortened by 6cm. All doors remained closed during the crash, although tools were required to open the driver's door.

Restraints: Acceptable
The impact was moderately severe but protection from serious head injury was good due to the driver's head being cushioned by the airbag. The driver's head rolled off the right side of the airbag later in the crash. The driver's knees hit the dash and fuse box.

Table 2.
Ratings - 1997 Commodore vs 1977 Kingswood:

	New Vehicle	**Old Vehicle**
Overall Evaluation	Acceptable	Poor
Structure	Marginal	Marginal
Restraints	Acceptable	Poor
Protection from Serious Injury		
Head	Good	Poor
Chest	Good	Acceptable
Upper legs	Good	Acceptable
Lower Legs	Poor	Not instrumented
Head Restraint design	Marginal	Not measured

1998 Ford Falcon

Overall Evaluation: Acceptable
The Falcon was tested at a vehicle speed of 60km/h. The airbag contributed to the driver being well protected from serious head injury in the offset crash test. Protection from lower leg injury was poor for the driver.

Safety Features
- A driver's airbag is standard equipment.
- The front seat belt buckles are mounted on the seats.
- The front seat belts have webbing grabbers.
- Lap/sash seat belts are fitted to all seats, including the centre rear seat.

Structure: Marginal
The passenger compartment was substantially deformed in the offset crash test. The area at the front of the driver's door was substantially deformed and the door sill buckled severely. Both hinges at the front of the driver's door separated and the width of the driver's doorway shortened by 17cm. The front part of the driver's floor folded over and moved rearwards 29cm, close to the driver's foot. Measurements showed poor protection from serious lower leg injury. The dash moved rearwards by 14cm and the steering column moved upwards by 7cm. The driver's door was easily removed after the crash.

Restraints: Acceptable
The driver's head was cushioned by the airbag and protection from serious head injury was good Initially the driver's head made a stable and central contact with the airbag. Later in the crash the driver's head rebounded and the top of the head came out of the window but did not hit any part of the car.

Table 3.
Ratings - 1998 Falcon vs 1978 Falcon:

	New Vehicle	Old Vehicle
Overall Evaluation	Acceptable	Acceptable
Structure	Marginal	Poor
Restraints	Acceptable	Marginal
Protection from Serious Injury		
Head	Acceptable	Good
Chest	Good	Good
Upper legs	Good	Good
Lower Legs	Poor	Not instrumented
Head Restraint design	Poor	Not measured

1997 Mitsubishi Magna

Overall Evaluation: Marginal
Protection from serious head injury was poor for the driver. There was substantial intrusion into the driver's floor space, which meant poor protection from lower leg injury.

Safety features

- A driver's airbag is only available in a package with ABS brakes and air conditioning.
- The front seat belts have height-adjustable upper anchorages and the seat belt buckles are mounted on the seats.
- A lap/sash seat belt is fitted to the centre rear seat.

Structure: Marginal
The front part of the driver's floor was pushed rearwards a substantial 29cm. The brake pedal was pushed 25cm rearwards and ended up near the seat. The dash was pushed 10cm towards the driver. The roof buckled upwards above the driver's door and the front pillar on the driver's side was bent. The width of the driver's doorway shortened by 8cm. All doors remained closed during the crash. After the crash a crowbar was needed to open the driver's door. The other doors could be easily opened.

Restraints: Marginal
The driver's head hit the steering wheel with a severe impact. The driver's knees hit the steering column and dash.

Table 4.
Ratings - 1997 Magna (no airbag) vs 1977 Sigma

	New Vehicle	Old Vehicle
Overall Evaluation	Marginal	Poor
Structure	Marginal	Marginal
Restraints	Marginal	Marginal
Protection from Serious Injury		
Head	Poor	Acceptable
Chest	Good	Good
Upper legs	Marginal	Good
Lower Legs	Poor	Not instrumented
Head Restraint design	Poor	Not measured

Interior of 1977 Mitsubishi Sigma after offset crash test at 64 kmh^{-1} showing separation of the steering column from its brackets

1995 Toyota Corolla

Overall Evaluation: Marginal
At a test speed of 60km/h, protection from serious head injury was poor for the driver. There was poor protection from lower leg injury due to moderate intrusion into the driver's floor space and substantial movement of the dash and brake pedal. EuroNCAP ratings for a frontal impact test were 'acceptable' for the head/chest assessment and 'marginal' for the leg/foot assessment.

Safety Features
- A driver's airbag is optional.
- The front seat belts have height-adjustable upper anchorages
- Seat belt buckles are mounted on the seats.
- Lap/sash seat belts on all seats except for the rear centre seat.

Structure: Marginal
The front part of the driver's floor was pushed

rearwards an 8cm. The brake pedal was pushed 27cm rearwards and ended up near the seat. The dash was pushed 15cm towards the driver. The roof buckled upwards above the driver's door and the front pillar on the driver's side was bent. The width of the driver's doorway shortened by 8cm. All doors remained closed during the crash. After the crash, the driver's door could be opened after the rear door had been initially opened with moderate effort.

Restraints: Marginal
The driver's brow hit the dash, its nose hit the steering rim and its chin impacted the centre of the steering wheel. The driver's head hit the steering wheel with a severe impact and protection from serious head injury was poor. The steering wheel rotated to the right causing the driver's head to swing to the right during rebound. The driver's head then hit the edge of the head restraint and made light contact with the centre pillar. The driver's knees hit the dash face.

Table 5.
Ratings - 1995 Corolla vs 1980 Corolla

	New Vehicle	**Old Vehicle**
Overall Evaluation	Marginal	Poor
Structure	Marginal	Marginal
Restraints	Marginal	Poor
Protection from Serious Injury		
Head	Poor	Poor
Chest	Good	Acceptable
Upper legs	Acceptable	Good
Lower Legs	Good	Not instrumented
Head Restraint design	Poor	Not measured

VEHICLE COMPARISONS

Risk of life-threatening injury has been calculated from the HIC and chest injury measurements in Table 1. A comparison has been drawn from the risk of life-threatening injury of old and new vehicles by assessing the improvement in newer car safety as tested by ANCAP. Table 6 contrasts this risk between the older vehicles and their equivalent updated models.

Table 6.
Risk of Life-Threatening Injury

Vehicle model	Risk of life-threatening injury to the driver	Improvement
1977 Kingswood	73%	
1997 Commodore	13%	538%
1977 Sigma	29%	
1997 Magna (no airbag)	20%	145%
1980 Corolla	64%	
1995 Corolla	25%	256%
1978 Falcon	23%	
1998 Falcon	13%	177%

For example, the driver of a 1977 Kingswood has a 73% risk of receiving a life-threatening injury compared with 13% in the 1997 Commodore, under identical test conditions. The rating is a measure of the likelihood of a driver being killed or seriously injured once a crash has occurred, not the measure of how likely it is for the vehicle to involved in a crash.

Table 6 emphasises the significant improvement in safety levels manufacturers have achieved over the last two decades. It is evident that modern safety features contribute to better occupant protection. The newer Holden and Toyota vehicles provide the most significant increase in protection from the risk of life-threatening injury. Of the four models tested, the newer Holden and Ford vehicles both have the smallest risk of life-threatening injury to the driver.

Old vehicles are more likely to suffer corrosion, which may result in greater deformation in a crash. This might reduce the impact of the crash on the occupant but also by result in greater intrusion into the passenger space. Corrosion can also make the car structure weaker so it may not be able to cope with crash forces as well. The old cars in these tests were checked to ensure they did not have excessive corrosion and damage. Many of the old cars on the road would not be in such good condition.

Vehicle size is an important characteristic that influences crashworthiness. The larger size of the old Ford Falcon may be a factor in why it rated well in the offset crash test. The poor results for the Kingswood were influenced by the seat belt breaking during the crash test, but the vehicle was tested in the condition in which it was being used on the road.

New vehicles with airbags had better safety scores than cars without them. Airbags are standard in recent model Ford Falcons and Holden Commodores and are optional extras in other modern vehicles. The Mitsubishi Magna and Toyota Corolla were tested with and without a driver's airbag.

For the vehicles tested without an airbag the risk of serious head injury was about double that of the same model with a driver's airbag. The Magna was the best performer of vehicles without an airbag but the risk of serious head injury was four times that of the same vehicle with an airbag (NRMA, 1999). Corollas built since January 1996 have the same body shape but changes to the structure, seat belts and steering wheel should improve safety performance.

A comparison summary of each old vehicle model and its respective new model is provided in Table 7.

Table 7.
Vehicle Comparison Summary

Vehicle Model	Ratings							
	Protection from Serious Injury					Structure	Restraints	Overall
	Head	Chest	Upper legs	Lower legs	Head Restraints			
1977 Kingswood	P	A	A	G	nm	M	P	P
1997 Commodore	G	G	G	P (v)	M	M	A	A
1978 Falcon	G	G	G	G	nm	P	M	A
1998 Falcon	A	G	G	P(v)	P	M	A	A
1977 Sigma	A	G	G	G	nm	M	M	P
1997 Magna	P	G	M	P(v)	P	M	M	M
1980 Corolla	P	G	G	G	nm	M	P	P
1995 Corolla	P	A	A	G(v)	P	M	M	M

Where P = Poor, M = Marginal, A = Acceptable and G = Good ratings, nm=not measured, v=visual inspection. In tests of the old cars the dummy's lower legs were not instrumented.

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