

## Crash testing for safety - possible enhancements to ANCAP test and rating methods

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### Abstract

The Australasian New Car Assessment Program (ANCAP) started in 1992, based on a crash test program introduced by the US government in the 1970s. In 1993 ANCAP became the first organisation to introduce the frontal offset crash test. Subsequently various “NCAPs” have started in Europe, Japan and Korea, as well as at the Insurance Institute for Highway Safety in the USA. In 1999 ANCAP (then Australian NCAP) aligned its test and assessment protocols with Euro NCAP and has been republishing applicable European results each year.

During 2008 Euro NCAP plans to implement major changes to its program. This paper outlines the Euro NCAP changes and discusses their applicability to Australia and New Zealand. Test and assessment methods by other NCAP organisations are also reviewed. Possible future enhancements to ANCAP are described.

### Introduction

This paper reviews possible changes to the various New Car Assessment Programs around the world. It has been prepared for discussion purposes and should not be regarded as a policy statement.

New Car Assessment Programs (NCAP), which are comparative crash testing programs providing consumers with relative information for new cars, operate in North America, Europe, Australasia, Japan and Korea. The first NCAP started in the USA in 1979, partly out of frustration with the slow process of regulating safer vehicles. NCAP was seen as a way of driving improvements to vehicle safety through consumer demand - by pointing out that some vehicles offered far better protection from serious injury for occupants than those which just passed regulation requirements. The USA started out with a regulation full-frontal crash test but with the impact speed raised from 48km/h to 56km/h (resulting impact energy increased by about 36%). Australian NCAP (ANCAP) introduced the same crash test in 1992 and one year later was the first NCAP to introduce the frontal offset crash developed by the European Experimental Vehicles Committee (EEVC). Figure 1 shows the frontal offset crash test configuration.

The first offset crash tests were conducted at 60km/h but this was increased to 64km/h in 1995, when the US Insurance Institute for Highway Safety (IIHS) began frontal offset crash tests at 40mph (64km/h). These crash tests proved to be very demanding of vehicle structure at that time (Figure 4 - 1995).

### Rating protocols

Initially ANCAP rated crash tests according to the risk of life-threatening injury using similar methods to the US NCAP - injury risk based on dummy head injury criterion (HIC) and chest deceleration. However, cases were encountered where vehicle structure and/or restraint systems did not perform well but, by chance, the dummy injury measurements were relatively low. To cater for this ANCAP introduced structural and restraint system (seat belts and airbags) assessments in 1996. The assessment and scoring

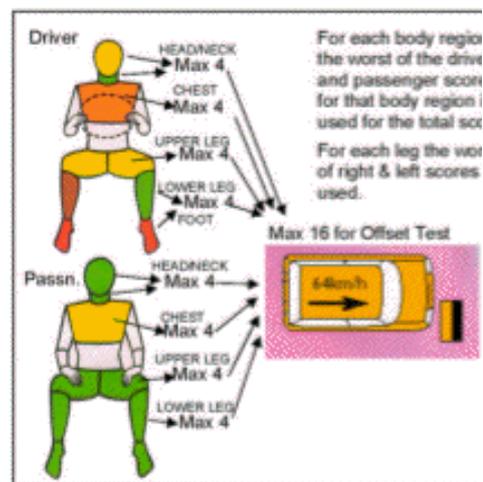


Figure 1. Offset crash test

methods were similar to those used by IIHS and encouraged manufacturers to improve systems that were not normally controlled by regulation.

Around this time various groups in Europe were crash testing new cars and, with encouragement from the USA and Australia, a new organisation, Euro NCAP was formed. Euro NCAP decided to carry out the same frontal offset test as ANCAP and IIHS but also introduced mobile barrier side impact test (Figure 2) based on a new UN ECE Regulation. It is understood that, because the regulation was new, the Euro NCAP test was performed at the same speed as the regulation. Considerable debate ensued over the appropriate height of the mobile impact barrier to accommodate the relative differences in sill height. Structure and restraint performance in the offset test were assessed as "modifiers" which reduced the score obtained from dummy injury measurements. Euro NCAP combined the frontal offset and side impact scores (each out of a maximum of 16) to obtain an overall score. A star rating out of 5 stars was awarded, based on this overall score.

In 1999 ANCAP decided to harmonise with Euro NCAP as many new Australian imports were sourced from Europe, and added the same side impact test to its program. A Memorandum of Understanding on the exchange of results was agreed.

It soon became evident that the side impact test was not particularly demanding and most vehicles scored well in this test. It was also observed that this effect was, in some cases, disguising poor frontal offset test results. ANCAP raised these concerns with Euro NCAP and suggested that a minimum score should be required for each type of crash test in order to earn a certain star rating, in addition to the overall score criteria. This became known as "point balance" in the Euro NCAP protocols effective from 2003.

Euro NCAP introduced the 29km/h pole test in 2000 (Figure 3). This test was optional and although some offset tests, particularly for "pre-release" production vehicles were funded in Europe by the manufacturer, the pole test was required to be always funded by the manufacturer to engage their support. The main incentive is to earn a further two points and a possible increase in star rating. The pole test is only available to vehicles with head-protecting side airbags, such as inflatable side curtains, and a good head score in the side impact test (Coxon 2005). A year later the Renault Laguna earned the first five star rating. ANCAP made the pole test available at this time but the first vehicle to undergo a pole test was the Subaru Forester in 2003 - this was also the first ANCAP five star rating. ANCAP did consider increasing the points for a good pole test result, to encourage manufacturers to fit head-protecting airbags, but ultimately decided to remain aligned with Euro NCAP.

ANCAP introduced pedestrian protection ratings in 2000, based on Euro NCAP protocols. A series of sub-system tests determines the likelihood of serious injury to a pedestrian in a 40km/h impact. A separate four star rating system was applied.

In 2003 Euro NCAP and ANCAP introduced bonus points for advanced seat belt reminders that, in effect, activate an alarm if the seat belt is not buckled and the vehicle is moving at more than 25km/h. This was done because, while there were generally high seat belt wearing rates in the community, there was a very high incidence of non-belt wearers in fatal crash statistics. These bonus points have enabled many more vehicles to reach a five star rating. For example, out of 70 models awarded five stars by Euro NCAP or ANCAP only 23 would have retained five stars without advanced seat belt reminders. In 2003, partly due to concern about the effects of the seat belt reminder bonus points, ANCAP added a requirement that a vehicle must earn at least one point in the pole test in order to be eligible for 5 stars (prior to this a vehicle

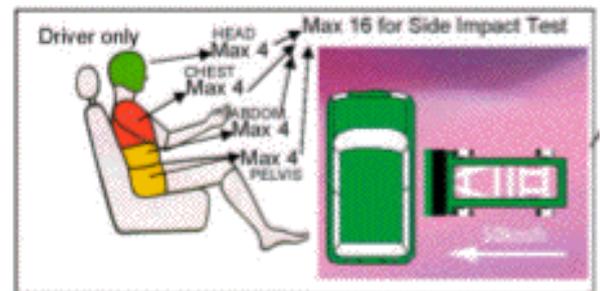


Figure 2. Side impact crash test

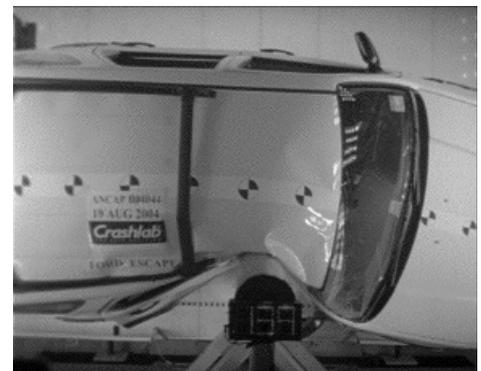


Figure 3. Pole crash test

could reach the required 32.5 points for 5 stars without a pole test). This was the first prerequisite for a five-star rating and set a precedent for ways to encourage other safety features.

### *The Australasian context*

Australia and New Zealand are relatively small vehicle markets, with total sales of about 1 million vehicles per year. New Zealand joined ANCAP through their Land Transport Authority and the NZAA early this decade. There are only a handful of vehicles that are designed and manufactured in Australia and these account for about 14% of new vehicle sales. Small, low-cost, imported models with minimal safety features still tend to be popular in Australia. As a result, the overall passive safety for new car sales is not as strong as most European and USA markets. It is estimated that about 14% of all Australian new car sales have an ANCAP rating of 3 stars or less. About 27% are 5 star ratings, which is a great improvement in recent years but still lags behind the European market.

A major concern in Australia and New Zealand is the commercial vehicle market - utilities/pickups and vans. These make up about 20% of all new vehicle sales. Several models do not have a driver airbag. About 2/3rds of commercial vehicle sales are 3 stars or less.

New Zealand tends to be similar to the Australian market except that the base models tend to have better safety specifications than Australia.

ANCAP republishes crash test results that have been published by Euro NCAP - just over half of the 261 ratings published by ANCAP since late 1999 have been based on Euro NCAP crash test assessments. With some popular models, however, it has been necessary for ANCAP to conduct an additional side impact test because the model tested by Euro NCAP had head-protecting side airbags (usually inflatable side curtains) and the Australian base model did not have these as standard.

Electronic Stability Control (ESC) is showing great promise as a crash avoidance feature (Sully 2007, Thomas 2006). The Australian motor industry has been generally supportive of ESC and fitting rates of this active safety feature are increasing but still lag some European countries and the USA. To encourage the process, ANCAP decided that, from January 2008, it would require ESC to be available as a prerequisite for a 5 star occupant protection rating. So far IIHS is the only other NCAP organisation that has made ESC a requirement for a top safety rating.

### **Trends with crashworthiness**

Over the fifteen years since the first frontal offset crash tests were conducted ANCAP has seen a dramatic improvement in the crashworthiness of vehicles. This is most evident through improved structural performance, as illustrated in Figure 4. Frontal offset crash tests by ANCAP, IIHS, Euro NCAP and Japan NCAP are likely to have had the most influence on this trend (Paine 2001).

Similarly the risk of serious injury, as measured by dummy sensors, has also improved substantially. In the USA and Europe, where frontal airbags were widely fitted from the start, the most noticeable improvement has been the risk of serious lower leg injuries - due mainly to reduced footwell and pedal intrusion. In Australia, the tests have helped to increase the uptake of frontal airbags - the prevailing government regulations could be passed without airbags (Paine 2002).



Figure 4. Improvement in structural performance

Similarly, the attraction of a five star occupant protection rating has led to strong uptake of head-protecting side airbags in Europe. This has started to happen in Australasia, with an increasing number of models having them as standard equipment (Coxon 2005).

### **Program reviews**

An informal association known as "World NCAP" has biannual meetings and there is regular email exchange between members. This association effectively began with the international Enhanced Safety of Vehicles (ESV) conference in Melbourne in 1996.

Despite regular calls from the automotive industry for "harmonisation" of NCAP tests and ratings systems, it has been realised amongst NCAP organisations that there are benefits in having variations between regions. Firstly there are differences in crash statistics between the regions so the types of tests and weights given to them may vary to suit the particular region. Secondly, on a technical level, the differences are seen to complement each other and the respective regulations. For example, this situation reduces the incentive to tune vehicle designs for a small number of specific crash test types and give less attention other types of crashes.

ANCAP regularly reviews its program. Key issues taken into consideration includes but are not limited to:

- Designing a test program that covers vehicles of interest and takes into account the opportunity to republish Euro NCAP results
- Generating consumer demand for safer small vehicles
- Generating consumer demand for safer commercial vehicles
- Monitoring the uptake of ESC and head-protecting side airbags and determining whether additional strategies are needed to encourage these safety features
- Monitoring other promising safety features as possible additions to the 5 star prerequisites.

The appendix contains a summary of possible changes to other NCAPs, based on documents and discussions in mid 2008.

### ***Differences between Euro NCAP and ANCAP***

As indicated above, there are several differences between ANCAP and Euro NCAP protocols. In brief, these differences are:

- a) For ANCAP 5 stars, at least one point must be scored in a pole test
- b) For ANCAP 5 stars the tested model must have ESC available either as standard or an option. If optional, the vehicle without ESC is rated 4 stars.
- c) Vehicles with high seating positions (i.e. those exempt from ECE Regulation 95/ Australian Design Rule 72), of which many are sold each year in Australasia, are not subjected to a side impact test. Instead a default score of 16 points is awarded.
- d) The "points balance" system is applied by ANCAP so, for example, a vehicle that scores less than 12.5 points in the offset test is not eligible for 5 stars. Where a star rating is limited in this way (or through lack of ESC or a pole test), the overall score is truncated to the maximum available of the star rating. For example, a vehicle reduced from 5 stars to 4 stars would receive a truncated overall score of 32.49 points (32.5 is needed for 5 stars).
- e) The assessment of knee modifiers is slightly different to that used by Euro NCAP. In particular, areas of uncertainty are generally decided in favour of the manufacturer but any concerns are relayed to the manufacturer with the intention of improving future designs.
- f) Where Euro NCAP tested a model with a driver knee airbag and this is not available in Australia then 2 points are deducted from the upper leg score, unless there is evidence to show that this is inappropriate.

- g) Steering wheel and pedal intrusion are measured relative to the final position of the driver seat. This is similar to procedures used by IIHS. This issue first came to attention when ANCAP tested a series of utility vehicles that deformed substantially in the load-space region.
- h) ANCAP includes child dummies in child restraints for the offset and side impact tests, but does not currently assess child occupant protection. The Euro NCAP protocols were found to be inappropriate for the Australian situation. There is a separate consumer rating program for child restraints in Australia (Brown 2007).

### Future directions

Euro NCAP has announced major changes to its rating system commencing in 2009 (Euro NCAP 2008).

The key elements of the new Euro NCAP system are shown in the appendix. In brief:

- the adult occupant protection rating will be based on the three crash tests plus a new head restraint (whiplash protection) rating,
- child occupant protection assessment is unchanged
- pedestrian protection rating is unchanged
- A new "safety assist" category is introduced that gives points for advanced seat belt reminders (moved from adult occupant protection), ESC and a new feature "speed limitation devices".
- These four categories are reported as a percentage of the maximum available for the category.
- Weighting is applied to the four category scores to derive an overall score and a star rating is assigned from this overall score. There will no longer be a star rating for each category. The "points balance" system will also apply to the star rating to ensure that good scores in some categories do not disguise a poor score in one category.

ANCAP will most likely be reviewing its position in the light of these changes, and discussions with other world "NCAP" organisations (see appendix for a summary of possible changes in the USA, Japan and Korea). In principle, there are no major obstacles to ANCAP adopting these changes locally. However, there are also practical reasons for ANCAP to continue with the current system for a few more years and it is expected that ANCAP will be able to continue to use test data from Euro NCAP for the purpose of publishing local ratings, using current protocols. A difficulty will be that a 5 star ANCAP rating will no longer be the same as a 5 star Euro NCAP rating and so care will be needed in the presentation and marketing of results. However, this situation has already been encountered since ANCAP started to require ESC for a 5 star rating from January 2008. Some cars rated 5 stars by Euro NCAP have been downgraded by ANCAP due to a lack of ESC on the base model.

One area of concern with the revised Euro NCAP scheme is what the authors see as the missed opportunity to encourage intelligent speed assistance (ISA) through the Safety Assist category. The proposed protocol for "speed limitation devices" only recognises speed alarms and speed limiters that are manually set by the driver and is based on a 1992 ECE regulation. ISA uses GPS positioning and other modern technologies to determine local speed limits and automatically take action, such as alerting the driver to speeding. These have been shown to be far more effective than manually set devices. Pilot/demonstration projects for ISA are taking place in Australia, Canada and Europe and initial results are very promising for safety and fuel economy benefits (Paine 2007). There is an opportunity for NCAPs to encourage the introduction of this technology (ETSC 2005 & 2006).

In addition to considering the Euro NCAP changes, ANCAP will most likely need to review several rating-related issues in the near term. These include but may not be limited to:

- 1) Reviewing the relative weighting applied to each type of crash test, taking into account associated serious injury rates
- 2) Reviewing ways to assess active and passive safety in a rollover crash. Rollover crashes account for approximately 25% of light vehicle occupant fatalities in Australia.

- 3) Looking at the introduction of a child occupant protection rating that takes into account crash test performance, compatibility between the child restraint and vehicle, seat belt geometry and top tether anchorage geometry.
- 4) Looking at small adult or large child occupant protection in rear seats, including seat and seat belt geometry and crash test performance.
- 5) Reviewing ways to assess rear crash (whiplash) protection. One of ANCAP's stakeholders - NRMA Insurance - already tests and rates whiplash protection according to the RCAR procedures. The new Euro NCAP whiplash assessment involves more tests than the RCAR one.

### **Conclusion**

Through its contacts with other NCAP organisations, road safety researchers and regulators, ANCAP monitors and contributes to the improvement of world NCAP procedures and policy. During 2008 there have been substantial changes to NCAPs in Europe and the USA. In addition, there have been developments in the fields of crash avoidance and occupant protection that deserve consideration by NCAPs. These changes and developments will be considered by ANCAP as part of its regular review process.

### **Disclaimer**

This paper represents the views of the authors and does not necessarily reflect the views or policy of ANCAP or any other organisation.

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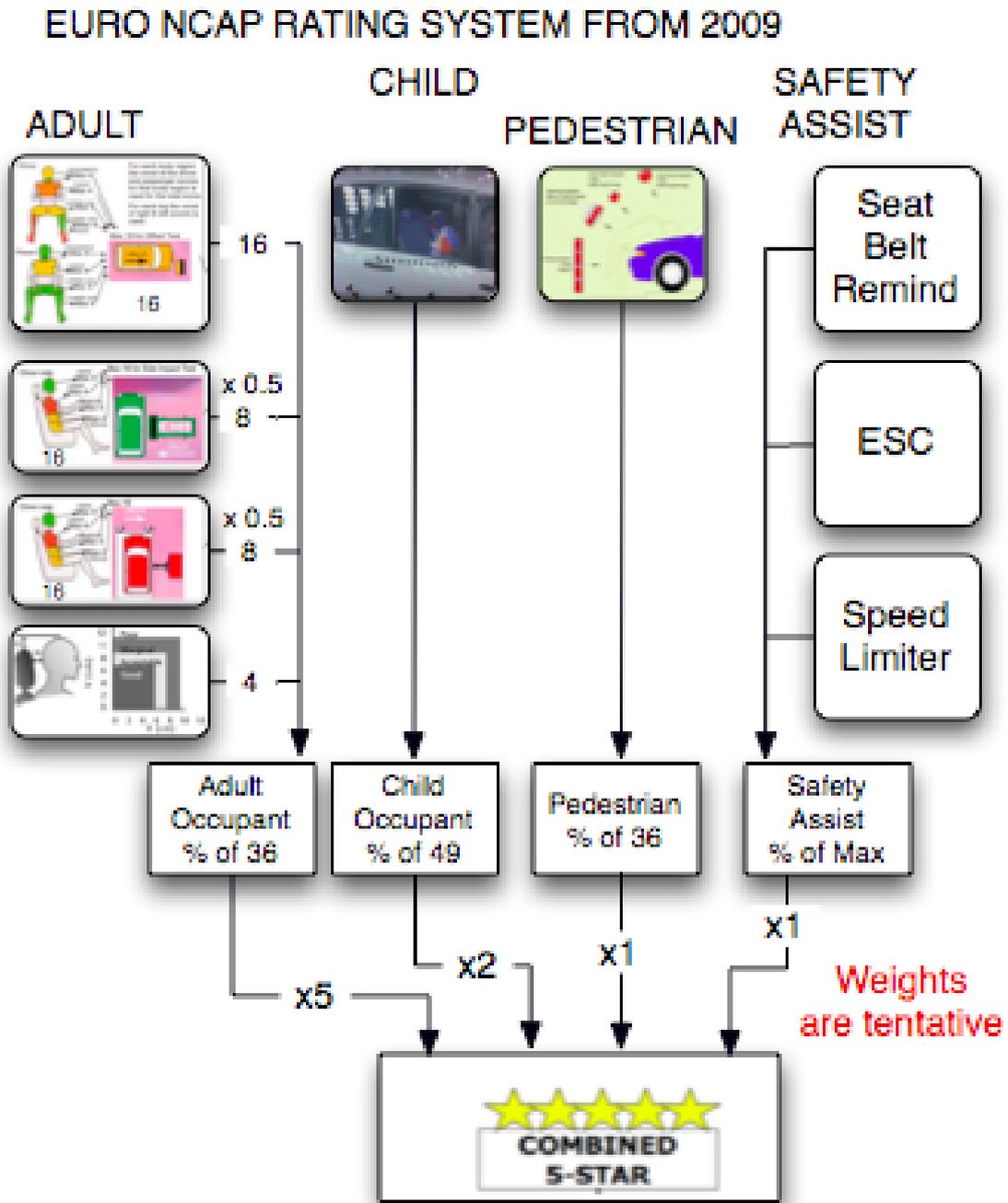
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Summary of changes to Euro NCAP



### Summary of changes to US NCAP

In July 2008 NHTSA released a document that describes a review of US NCAP and the changes that are proposed for introduction in 2010. The following summarises the changes that are relevant to ANCAP.

#### *Crash tests*

- The 56km/h full frontal and 63km/h side impact (oblique mobile barrier) crash tests are retained.
- The 50<sup>th</sup>ile male front passenger dummy is replaced with a 5<sup>th</sup>ile female.
- Injury risk criteria (scores) are being refined for some tests and dummies. Star breakpoints are also being revised. These better match real-world injury outcomes and will make it more difficult to obtain a 5 star rating.
- Neck, chest deflection and femur injury assessments are being added to the frontal test (chest deceleration is dropped).
- An ES-2re (Euro SID) dummy will be the driver in the MDB side impact test and a SID-II 5<sup>th</sup>ile female dummy will be placed in the rear seat for this test. Head, rib deflection and pelvis injury is assessed for the ES-2 dummy and head and pelvis injury are assessed for the SID-II dummy.
- An oblique side impact pole test (32km/h at 75°) is being introduced and will use a SID-II 5<sup>th</sup> female dummy as the driver (head and pelvis injury assessed). This is severe crash test that will challenge side impact protection systems.
- The MDB oblique side impact and pole test results will be combined into a side impact protection rating
- An overall occupant protection rating will be developed, based on the three crash tests plus the rollover rating (see below) and occupant seating position risk factors.

#### *Other ratings*

- The rollover propensity rating will be retained, based on static stability factor and a dynamic ("fishhook") test.
- NHTSA will look at accounting for Electronic Stability Control (ESC) in the rollover propensity rating process.
- A crash avoidance (safety feature) rating will be introduced, based initially on three technologies: ESC, forward collision warning (FCW) and lane departure warning (LDW).
- The Monroney label (where cars for sale are required to display NCAP and other information) is being reviewed to provide more useful information for consumers

#### *Proposals rejected by NHTSA*

The following items were suggested during the comment period but have been *rejected by NHTSA* for the current review. In almost all cases NHTSA considered that further research was needed into test methods and/or real-world outcomes. NHTSA has associated research programs for some of these issues and will consider adding them to NCAP at a later date.

- Frontal offset crash test - concern that it may increase aggressivity.
- Lower speed full frontal crash test (40km/h) - main concern is thorax injury to older occupants. Note that the resulting car body decelerations appear to be similar to those in a 64km/h offset test. Therefore the offset test might already address the concerns about aggressive restraint systems but this does not appear to have been explored by NHTSA.
- Higher speed full frontal crash test (64km/h) - risk of increased aggressivity for minimal occupant safety benefits.

- Occupant protection in rollover crashes (eg Jordan Rollover System) - ongoing research into roof crush and rollover injuries.
- Compatibility/aggressivity - ongoing research.
- Child occupant safety - ongoing research into child restraint systems.
- Adult occupant in rear seat during frontal crash test - ongoing research.
- Rear impact (whiplash) rating - republication of IIHS ratings may be seen as endorsing the test method, when NHTSA is conducting separate research into a dynamic test.
- Frontal pole test.
- Lighting and conspicuity rating - ongoing research.
- Pedestrian protection ongoing research. The new Global Technical Regulation is acknowledged.
- Numerous other crash avoidance technologies will not be assessed in the initial crash avoidance rating because they do not meet the agency's criteria: "address a major crash problem, safety benefit projections have been assessed, and performance tests and procedures are available to ensure an acceptable performance level.
- Manufacturer self-certification for NCAP ratings - insufficient resources available to manage such a program. Existing arrangements provide for expediting NCAP tests.

**Summary of changes to Korean NCAP**

Korean NCAP started with a 56km/h full frontal and 55km/h side impact crash tests. Recently the program was expanded with dynamic brake tests (similar to Japan NCAP), rollover propensity (NHTSA fishhook dynamic test) and pedestrian head protection.

Korean NCAP is introducing additional types of tests and has innovative scoring methods. A possible implementation program is:

- 2008 - Pedestrian protection (leg assessments being introduced) = Whiplash rating
- 2009 - 64km/h frontal offset crash test
- 2010 - 29km/h pole test

**Summary of changes to Japan NCAP**

Japan NCAP conducts 55km/h full frontal, 64km/h frontal offset and 55km/h side impact crash tests. JNCAP also conducts dynamic brake performance tests and recently introduced pedestrian head protection tests. Driver and front passenger occupant protection is rated out of 6 stars.

A possible implementation program for additional ratings is:

- 2008 - protection of rear seat occupants and ways to encourage head protection in side impacts.
- 2009 - Whiplash rating and pedestrian leg protection
- 2010 - Crash avoidance technologies