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Crash testing for safety
AUSTRALASIAN NEW CAR ASSESSMENT PROGRAM

COMMENTS ON DRAFT PROTOCOL FOR SPEED-LIMITATION DEVICES

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Purpose

To provide comment to Euro NCAP on a draft protocol for speed limitation devices, dated October 2007.

Key Recommendation

a) Include Intelligent Speed Assistance (ISA) in the first issue of the Euro NCAP specification

b) Amend the draft specification as set out in the Appendix, to set functional requirements for ISA systems

c) Set the weights for scoring speed limitation devices according to the potential trauma savings.

Background

Euro NCAP proposes to introduce a "Safety Assist" rating that recognises safety features that are not directly associated with the crashworthiness rating. Safety features under consideration are Electronic Stability Control, Intelligent Seat Belt Reminders and "Speed Limitation Devices".

A draft protocol has been prepared that sets out functional requirements and proposed scoring for speed limitation devices.

This report outlines Australian experience with speed limitation devices and makes recommendations for changing the draft protocol to cover recent technological developments.

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Classification of Speed Limitation Devices

Speed limitation devices assist the driver in not exceeding a specified or selected speed, which is generally the posted speed limit for the section of road being driven along. There are several classifications of speed limitation devices:

- Top-speed limiting - prevents the vehicle for exceeding a set speed. Most modern vehicle engine management systems have a top speed setting but it is usually well in excess of maximum national speed limits and could not be regarded as a safety device.
- Speed alarm set by the driver - alerts the driver if a selected speed is exceeded. Some production vehicles have this feature (eg Holden Commodore).
- Speed limiter set by driver - prevents the vehicles from exceeding the selected speed, except for temporary over-ride situations (eg "kickdown" of throttle pedal). A few production vehicle models have this feature (eg Renault Megane). These are also known as "Adjustable Speed Limitation Function" (ASLF).
- Intelligent speed alarm - system "knows" the speed limit of the current section of road and direction of travel and alerts the driver if that speed is exceeded. Feedback may be an audible alarm, a visual signal, haptic feedabck such as a vibrating throttle pedal or a combination of these. Two commercial products are available with these features in Australia: SpeedAlert works with PDAs and Smart Phones and is portable (between vehicles) and Speed Shield is a unit that is built into the vehicle and interfaces with the vehicle electronics.
- Intelligent speed limiter - the system "knows" the speed limit of the current section of road and direction of travel and prevents the vehicle from being accelerated beyond this speed. These systems normally have provision for temporary over-ride. The Australian Speed Shield product has this function available.

The latter two systems are known as "Intelligent Speed Adaptation" or "Intelligent Speed Assistance" (ISA). The first is known as Passive ISA and the second is known as Active ISA. The speed limit information is available on three levels: static (location based), variable (time and location based) or dynamic (able to be changed in real time through communication with the road infrastructure - eg roadworks). There are increased road safety benefits for each level.

In recent years the feasibility and performance of ISA system have been substantially improved by developments in the Global Positioning Satellite systems (GPS) and the digital mapping of speed limits. Some systems, like Speed Shield augment the GPS positioning with dead-reckoning systems that work in tunnels.

Experience with speed limitation devices

In 1996 Michael Paine researched the topic of speed control devices for the New South Wales Roads and Traffic Authority: http://tinyurl.com/18r (link to PDF). He has been involved in policy and technical development of ISA since that time, which preceded the widespread commercial use of GPS.

Mr Paine has driven vehicles with each type of speed limiter. He has been using a SpeedAlert passive ISA system on Sydney roads since August 2006. In 2007 he co-authored a paper on this topic for the Proceedings of the 20th International Conference on the Enhanced Safety of Vehicles: http://tinyurl.com/18r (link to NHTSA web page PDF).

Key points from that paper are:

a) Speeding is a contributing factor in 10-20% of all crashes and 30-40% of fatal crashes (Australia, New Zealand, Europe and North America).

b) Many road fatalities occur at surprisingly low impact speeds. In the USA in the mid-1990s half of the deaths to seat-belt wearing drivers involved in frontal crashes occurred at a delta-V of 50km/h or less.

c) Crash risk rises dramatically at travel speeds above the speed limit. A study in Adelaide found that the risk of a casualty crash doubled for each 5km/h above the 60km/h urban speed limit.

d) This is consistent with earlier studies that found a 3% reduction in mean traffic speeds produces a 12% reduction in fatal accidents. A 2005 European Transport Safety Council (ESTC) report states that 15% of injury accidents would be saved if mean traffic speeds reduced by 5km/h.

e) Studies of the effects of major speed limit changes (increasing or decreasing the speed limits for a region or major section of road) have had similar results.

f) The same Adelaide study estimated that casualty crashes would reduce by 20% if all vehicles obeyed the speed limits.

g) Properly designed ISA systems can be highly effective in encouraging motorists to obey speed limits and should be encouraged by governments.

h) During a 6 month evaluation the SpeedAlert passive ISA product was found to be highly accurate and reliable under most road conditions. Start-up time and performance in areas of poor GPS reception were issues that needed to be monitored but were acceptable.

i) A variety of speed settings were evaluated in on-road trials. An audible alarm set at 2km/h over the speed limit is optimal for preventing excessive alarms, while enabling the driver to travel at the speed limit. Setting it to 3km/h or more above the speed limit allows continuous driving in excess of the speed limit and so diminishes the road safety benefits.

j) There are myths and misunderstandings about the need for reserve power and excessive speed when overtaking. In nearly all circumstances a decision to use excessive speed to overtake greatly increases the risk of a serious crash and it would have been much safer to brake rather than accelerate. Not only is the time to return to the lane much less with braking but also, if a head-on impact should occur, the speed will be much lower. It has been pointed out that the main effect of a speed limiter is that "the driver of a high-performance vehicle would no longer perform certain manoeuvres which he now regards as safe". However, it is recognised that initial public acceptance of ISA will be improved if there are over-ride capabilities.

It is important to note that ISA in Australia has gone beyond the trial/prototype stage and pilot programs of commercial products are underway.

Since preparing the ESV paper Mr Paine has carried out benefit/cost analyses of numerous in-vehicle technologies. He has developed conservative estimates of the potential savings in serious road crashes *in Australia* through the widespread implementation of various speed limitation devices:

Estimates of crash savings in Australia

Device	% of all serious crashes potentially influenced by use of device (relevant crashes)	% of relevant crashes that are saved by device (effectiveness)	% of all serious crashes saved by device
Top-speed limiting	1% (exceeding 120kmh)	100%	1%
Speed alarm/limiter set by the driver	20%	5% (low due to the task of setting the device)	1%
Passive ISA	20%	25%	5%
Active ISA	20%	50%	10%

It is expected that similar savings would be possible in Europe, based on ETSC documents. This analysis has implications for the proposed scoring of speed limitation devices, as discussed in the next section - Active ISA should score ten times as many points as devices that need to be set by the driver.

In 2006 ETSC wrote: "There is no single vehicle technology remaining to be implemented - neither on the market nor in development - that offers the same safety potential as ISA." Note that this was written after the potential savings from ESC became evident.

The current draft document does not have provision for ISA systems. Systems that require the driver to set the speed have several limitations:

- they assume that the driver knows the speed limit or can decide on a "safe" speed - in both situations the driver can be in serious error.
- the task of setting the speed is tedious and may be distracting.
- in practice these voluntary systems are unlikely to be used on a regular basis

Comments on the draft protocol

Introduction

The introduction states that the protocol is based on the requirements of ECE Regulation 89. This regulation was introduced in 1992, to require top speed limiting of heavy trucks and buses. In 2002 it was amended to provide for speed alarms and limiters voluntarily set by the driver in cars and other classes of vehicle. One intention of the Regulation appears to be to ensure that the driver is able to over-ride the speed limiter under some circumstances. As an aside, it is curious that such specific requirements were applied to speed limiters and yet there do not appear to be any similar provisions for driver-set cruise control, which prevents a vehicle from travelling less than a set speed, unless the driver intervenes.

It is evident that ECE Regulation 89 is based on old technology and does not take into account recent developments. For example, it does not recognise or set requirements for ISA (automated determination of speed limits) and some clauses may hinder worthwhile ISA features, as discussed below.

The draft Euro NCAP protocol acknowledges the existence of ISA but states "The systems currently available have limitations in the map coverage and map quality. When these technical limitations have been resolved, or when systems are available which use other technical approaches, Euro NCAP will incorporate ISA systems into the protocol".

Given the potential crash reductions through the use of ISA, and the rapid progress in the implementation of ISA technology, it is considered that this "wait and see" approach is not justified. It should be possible to set functional and performance requirements for ISA within the current protocol and recommendations for this are contained later in this report. These requirements can be reviewed once more experience is gained with ISA. The scoring system should also recognise the major road safety benefits available from ISA, compared with speed alarms/limiters set by the driver. Without these provisions the introduction of ISA will be severely hampered as manufacturers will look to driver-set speed limitation devices to gain the points for "Safety Assist".

It is recommended that functional and performance requirements for ISA be included in the first issue of the protocol for speed limitation devices and that the scoring system gives recognition to the road safety benefits of ISA.

1. Definitions

It is not clear how the vehicle speed is measured but is presumably through the same system as the vehicle speedometer. Modern speedometers are capable of far greater accuracy than is allowed by regulations and part of the requirements for speed limitation devices should cover vehicle speedometer accuracy. Provision will need to be made for different tyre diameters (tyre wear / under-inflation will result in overestimated speed and is less of a concern).

The definitions should be amended to provide for ISA systems (see suggestions in the appendix). Currently ISA appears to be precluded because the system must allow the driver to set the vehicle speed and ISA systems do this automatically.

2. Requirements for all ASLFs

2.1.1 requires the speed setting (eg speed limit) to be permanently indicated to the driver. This is not essential with ISA systems since the sounding of an alarm (or speed limiting) will indicate the speed limit. However, display of the speed limit is useful as it reduces the time the driver must spend looking for roadside speed limit signs.

2.1.4.1 (and several later clauses) require the warning signal (or limiter) to activate when the vehicle is exceeding the speed setting (limit) by more than 3km/h. In effect, this means a speed of 4km/h or more above the speed limit. This would lose the major road safety benefits from encouraging the minor speeding group to obey the speed limit. Recall that the ETSC estimates 15% of injury accidents would be saved if mean travel speeds reduced by 5km/h and this will not be possible if a major component of the population still travels at 3-4km/h over the speed limit.

Given the accuracy of modern speed measurement techniques, an active speed limiter function should activate as soon as the vehicle speed exceeds the speed limit (ie at 1km/h or more over the limit) and a visual speed warning should also activate in these circumstances. An audible or haptic alarm should activate whenever the speed is 2km/h or more over the limit, as this would allow the driver to travel at the speed limit without excessive alarms (based on extensive experience with the SpeedAlert device in Sydney).

3. Requirements for Active Speed Limitation Devices (speed set by driver)

3.4.2.1 Requires an active speed limiter to limit the speed to within +/-3km/h of the set speed. As discussed above, this eliminates substantial road benefits. Modern systems can be accurate to +/-1km/h. Note that the use of the footnote "2" is confusing here as it looks like the symbol for "squared".

3.5.2.3 Requires that the over-ride force be measured. A force range should be specified, based on the ergonomic capabilities of the driving population.

5. Requirements for additional warning signals

5.1.4.3 sets requirements for audible alarms.

5.1.4.3.2 requires the alarm to sound when the set speed is exceeded by more than 3km/h. As discussed above, this should read "The audio signal commences immediately that the actual speed of the vehicle exceeds V_{adj} by 2km/h or more."

5.1.4.4 covers the use of an audible alarm in conjunction with an active ASLF. The audible alarm can commence up to 5 seconds after the set speed is exceeded by more than 3km/h. Firstly, the speed tolerance should be "2km/h or more" and secondly there should be no delay before the audible alarm activates. The reason is that active speed limiters will not automatically slow the vehicle down and the driver may need to intervene to slow down for critical circumstances such as school zones. This is particularly important for active ISA that "know" school zone operating times* but there is no reason that other active speed limiters should not operate in the same way.

* Several Australian states have time-based speed limits in operation on roads adjacent to schools. A 70km/h road may reduce to 40km/h during school travel times. In 5 seconds a car will travel nearly 100m at 70km/h and be through the school zone.

6. Scoring

There needs to be provision for scoring ISA systems and giving them much more weight than driver-select systems - see appendix.

Suggested requirements for ISA systems

See the appendix to this report. The suggestions are based on extensive experience with ISA systems and review of several specifications and project briefs associated with ISA projects.

Disclaimer

This document represents the views of the author and does not necessarily represent ANCAP policy.

Appendix

ISA - proposed additions to protocol

1. Definitions (additional)

- Intelligent Speed Assistance (ISA) system means a vehicle technology that is able to determine the statutory speed limit of the current section of road and direction of travel and takes action if the vehicle exceeds that speed limit by a specified amount.
- An Active ISA system prevents the vehicle from exceeding the speed limit (beyond a specified amount) through normal operation of the accelerator control. An unusual, positive action by the driver is needed to intentionally exceed the speed limit.
- A Passive ISA system provides a warning to the driver if the speed limit is exceeded by a specified amount.
- V_{limit} is the statutory speed limit as determined by an ISA system.

Where an item is described as "preferred" this means it might be taken into account in a future scoring system.

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6. Requirements for ISA systems

6.1 Requirements for all ISA systems

6.1.1 The ISA system must be capable of locating the vehicle to within a radius of 10m of the true vehicle position (based on a recognised GIS system) for at least 99% of the time that the vehicle is operating on roads with reasonable GPS reception (or other applicable location technology)

6.1.2 In tunnels and other poor reception areas a backup location system is preferred.

6.1.3 At speeds above 20km/h the vehicle speed shall be calculated to within 1km/h of the actual travelling speed (eg 1% accuracy at 100km/h).

6.1.4 The ISA function shall operate whenever the vehicle is travelling at more than 20km/h (it may also operate at lower speeds)

6.1.5 In the event that the system is not functioning correctly the driver is to be notified and the system is to completely disengage.

6.1.6 When the vehicle is travelling along roads at the speed limit the ISA system shall act on a change of speed limit as close as possible to the change location but in no case more than 3 seconds after the change point has been passed.

6.1.7 When there is reasonable GPS reception (or other location technology is available) the time to activate ISA functions shall be no more than 60 seconds after the vehicle is started.

6.1.8 The operation of the ISA functions must be simple, intuitive and cause minimal driver distraction. The system shall be capable of automatic operation whenever the vehicle is started. For important functions audio/voice feedback is preferred to confirm driver selections so that the driver does not need to look at the display after making a selection.

6.2 Requirements for Speed Limit Database

In order to operate correctly, most ISA systems in use or under development need access to a database of speed limits for roads that will normally be used by the vehicle. The following are provisional requirements for such databases, pending the development of appropriate standards for speed limit databases. Other technologies such as roadside transmitters and optical recognition system are not precluded but should provide equivalent system performance.

6.2.1 The ISA system shall have access to an acceptable speed limit database or equivalent data system. This may be stored on the vehicle, accessed by electronic communication or a combination of methods. As a guide to the content of the database, see the Geographic Data File (GDF) recommendations of ERTICO: http://tinyurl.com/2azswt

6.2.2 The speed limit database shall cover at least 80% of the roads in the region in which the ISA system is marketed and be at least 99% accurate for the speed limits on these roads (determined on a per kilometre basis). Partial coverage is acceptable for an on-board database, provided that users can obtain replacement/supplementary data for additional areas to make up the minimum 80% coverage requirement.

6.2.3 Temporal speed limits (eg special speed limits during school commuting times) shall be recorded in the speed limit database.

6.2.4 The speed limit database shall be updateable and the service provider must have a system in place to track speed limit changes and provide updates to users at least every three months.

6.2.5 Other road features/hazards such as tunnels and railway level crossings may be recorded in the database. Roadside speed cameras and similar enforcement devices may also be recorded, where permitted in the country concerned.

6.2.6 ISA systems shall be tested by travelling on a test course that is covered by the ISA speed limit database. It is recommended that the test course includes non-public sections of road so that the vehicle can be driven in excess of a nominal speed limit, set in the ISA speed limit database for this purpose.

6.3. Requirements for alarms/warnings (applies to active and passive ISA)

Alarms may be visual, audible or haptic (physical feedback to driver).

6.3.1 ISA alarms shall activate whenever the vehicle is travelling 2km/h or more beyond V_{limit} . No alarm shall activate when the vehicle is travelling at V_{limit} or less.

6.3.2 Visual ISA alarms may activate at 1km/h beyond V_{limit}. An audible or haptic alarm must not activate at a lower speed than a visual alarm.

6.3.3 There should be no designed delay to the activation of any alarm (that is, it should activate as soon as the designated speed exceedence is detected). However, an audible or haptic alarm may gradually increase in intensity provided that it is audible/detectable in a quiet vehicle from the start and reaches full intensity within 5 seconds.

6.3.4 After the 5 second period the audio warning signal shall be clear to the driver and distinguishable from audio signals used for other purposes. Quieter systems are acceptable if the ISA system causes the audio entertainment system of the vehicle to mute whenever the vehicle is travelling 2km/h or more beyond V_{limit} for more than 5 seconds.

6.3.5 Volume adjustment and muting of audio warning signals is acceptable provided that the system resets to at least half volume when restarted and there is visual indication to the driver that muting is in effect.

6.3.6 The audio alarm may vary (eg more frequent or more intense) if V_{limit} is exceeded by more than 10km/h (or other increments).

6.3.7 Haptic feedback should not cause driver discomfort or distraction. Preferred methods are mild resistance when depressing the accelerator control or vibration of the accelerator control.

6.3.8 A visual ISA signal must be clearly visible to driver, without the need for the head to be moved from the normal driving position. The system should display V_{limit} (preferably in black numerals) and should flash or change colour (preferably to red) whenever the vehicle is travelling 2km/h or more beyond V_{limit} (a change at 1km/h beyond V_{limit} is also acceptable) [this is a good time to set standards for use of colours in ISA displays]

6.3.9 The visual signal may also display the current vehicle speed, as determined by the ISA system and other information relevant to safe driving and operation of the ISA system, provided that the speeding warning of clause 6.3.8 is the most prominent part of the display.

6.4 . Requirements for Passive ISA systems

6.4.1 Passive ISA systems shall use a visual signal (6.3.8) and at least one of the following: audible alarm (6.3.4) or haptic feedback (6.3.7).

6.4.2 Passive ISA systems may allow the driver to change the V_{limit} in the same manner as ASLFs. Where a driver-selected V_{limit} is being used there must be a clear visual indication of this to the driver. For example the display of V_{limit} numerals could be a different colour such as orange. It is preferred that there is a voice announcement of the selected V_{limit}.

6.5 . Requirements for Active ISA systems

Stringent requirements for active ISA are necessary to ensure that motorists are not placed in risky situations, such as not being able to accelerate up to speed to join a motorway. In addition, since it is possible that a vehicle will exceed the speed limit without the driver needing to depress the accelerator pedal (eg speed limit changes or driving down steep hills) then the warning functions of a passive ISA are required so that the driver may intervene to slow the vehicle. Future systems that are able to apply braking might be exempted from this requirement.

6.5.1 Active ISA shall work through modulation of engine power (for example, by intercepting the signal between the accelerator control and the engine management system).

6.5.2 The active ISA system shall prevent an increase in engine power through normal operation of the accelerator control if the vehicle travel speed exceeds V_{limit} by 2km/h or more.

6.5.3 A "kickdown" capability shall be available where the driver may decide to press the accelerator control with extra force or through a large travel in order to over-ride the ISA system and allow the vehicle to exceed V_{limit} .

6.5.4 The "kickdown" function shall deactivate when the vehicle returns to a speed at or below V_{limit} . See also clause 6.5.7.

6.5.5 If an active ISA is capable of applying the brakes or engine braking to reduce vehicle speed then this must be able to be deselected by the driver.

6.5.6 Active ISA systems shall include a visual signal (6.3.8) and at least one of the following: audible alarm (6.3.4) or haptic feedback (6.3.7). See section 6.3 for alarm requirements. Subject to clause 6.5.7, the audible or haptic alarm must operate in "kickdown" mode (6.5.3) but in this case the audible/haptic alarm need not activate until 20 seconds after V_{limit} (+2km/h) is exceeded.

6.5.7 In "kickdown" mode, an audible or haptic alarm need not operate provided that the ISA operation reactivates after two minutes of exceeding V_{limit} and the driver is given clear warning (preferably voice announcement) of the pending activation at least 30 seconds beforehand. Other methods of discouraging prolonged periods of exceeding V_{limit} will be considered.

6.5.8 Active ISA systems may allow the driver to change the V_{limit} in the same manner as ASLFs. Where a driver-selected V_{limit} is being used there must be a clear visual indication of this to the driver. For example the display of V_{limit} numerals could be a different colour such as orange. It is preferred that there is a voice announcement of the selected V_{limit}.

6.5.9 Active ISA shall be capable of working in conjunction with any cruise control fitted to the vehicle or shall disable cruise control, where appropriate. It shall not be possible to over-ride the ISA system through operation of a cruise control function.

6.5.10 Active ISA must allow normal use of the transmission and selection of gears. In particular, when the clutch is depressed the ISA system must allow the engine speed to be controlled to match the gear selection.

6.5.11 Where an active ISA becomes inoperative (eg loss of GPS signal or system malfunction) it shall either disengage completely (restoring all normal control to the driver) or set V_{limit} to the maximum speed permitted in the country or region of operation. Driver setting of V_{limit} is permitted in these circumstances, provided that the over-ride functions of clause 6.5.3 are still available.

6.5.12 The driver shall be given a warning if the ISA system becomes inoperative. A voice announcement is preferred.

6.6 Optional ISA features

These features are not mandatory but may attract bonus points.

6.6.1 Data logging

The ISA system may be capable of recording the time and location of significant events such as incidents of speeding and use of the kickdown function. Logging of ESC events would also be useful.

A method of downloading and analysing the logged data on personal computer shall be provided.

6.6.2 Driver verification and customisation

The ISA system may utilise driver identification technologies to only allow authorised drivers to use the vehicle and/or to set special limits (such as a top speed or curtailed engine power) for some drivers such as novice or unauthorised drivers.

6.6.3 Live updates to speed limit database

In co-operation with road authorities, the ISA system may be capable of receiving live updates to the speed limit database. This could include variable speed limits (as used on some motorways) and temporary situations such as roadworks. Various methods might be used to communicate this information to the ISA system on the vehicle.

7. Scoring

	Passive[1]	Active	Must comply with requirements of Section
System meets general requirements for driver-set speed liimitation devices (ASLFs)	+[0.1]	+[0.8]	2 (& 3 for active ASLF)
System can be set at speed (ASLFs)	+[0.1]	+[0.1]	4
Suitable audio-visual signal (ASLFs)	+[0.3]	+[0.1]	5
ISA system	5	8	6
ISA options a) data logging of speeding events and over-ride events	0.5	0.5	6.6.1
b) driver verification & customisation	0.5	0.5	6.6.2
c) live updates of speed limit database	0.5	0.5	6.6.3

Euro NCAP will accept that speed-limitation devices approved to ECE Regulation 89 can be considered to meet the requirements of sections 2 and 3.

[1] It is not yet established how many points will be awarded to speed-limitation devices. The figures given are fractions which will be multiplied by the appropriate amount when the scoring has been finalised.