SEAT BELT REMINDER INCENTIVES IN NCAP PROGRAMS: A SUCCESS STORY

Thierry Mousel
IEE S.A.
Luxembourg
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ABSTRACT

Wearing a seatbelt is considered the most important factor in preventing serious or fatal occupant injuries in a vehicle crash. In order to remind occupants to buckle up, intelligent seat belt reminder (SBR) systems were developed in Sweden in the early 1990s. Since then, many studies have proven that SBR systems are highly effective in raising seat belt wearing rates. About 80% of unbelted drivers will buckle up when reminded to do so [1]. However, in the late 1990s, very few vehicle models offered SBRs.

In order to encourage vehicle manufacturers to install SBR systems, Euro NCAP introduced SBR bonus points into its rating scheme in 2002. In subsequent years, the number of Euro NCAP-tested vehicles that were equipped with SBR systems increased significantly. 2011 was the first year where all of the 51 cars tested were equipped with an SBR system on both front seats. In addition, 50% of the assessed vehicles also had a rear seat SBR system (buckle status monitoring only).

The Australia NCAP rating program adopted a similar approach to Euro NCAP, and implemented the same seat belt reminder protocol into its rating scheme. Other NCAP programs have also introduced their own SBR incentives: China NCAP (2006) and Japan NCAP (2011). ASEAN NCAP, Korea NCAP and Latin NCAP will follow with SBR incentives, starting with the 2013 ratings.

A historical review of the effectiveness of SBR incentives in the NCAP programs that have offered them for a couple of years (Europe, Australia, China) shows a clear trend: the number of vehicles equipped with SBR systems is increasing significantly. In the vehicles tested in 2012 by Australia NCAP, a driver SBR was installed in 98%, a front passenger SBR in 90% and a rear seat SBR in 43%. For China NCAP-assessed vehicles, the SBR installation rates until mid 2012 reached 96% for the driver and 84% for the front passenger seat. For the NCAP regions that have only recently introduced SBR incentives, or those planning on doing so in the near future, a similar trend can be expected.

Although NCAP programs do not test all new vehicle types on the market, an increasing number of SBRs in NCAP-tested vehicles also has an impact on the SBR equipment of all vehicles sold in a specific region. When looking at all new vehicles sold in Europe (EU25) in 2009, only about 15% of the cars did not have any SBR equipment at all. 21.5% only had a driver SBR, 46.5% had an SBR on both front seats and 17% had a rear seat SBR system, in addition to the front seats. The continuously high SBR equipment rates in Euro NCAP-tested vehicle types will obviously have a positive impact on the market penetration of SBR, contributing to the reduction in road traffic fatalities by increasing seat belt wearing rates.

INTRODUCTION

Nils Bohlin is considered the father of the modern three-point seat belt, which was first introduced by Volvo in 1959 as standard equipment. In subsequent years, other vehicle manufacturers also introduced three-point seat belts, either as optional or standard equipment. Bohlin could soon demonstrate the safety benefit of the seat belt in a study based on 28,000 accidents in Sweden [2]. Additional developments such as belt pre-tensioners and belt load limiters have since helped to further improve the safety potential of the seat belt.

Figure 1. Nils Bohlin, father of the modern three-point seat belt (source: Volvo Car Corporation).

The first country to require mandatory fitment of three-point seat belts on the front seats was the

United Kingdom in 1967, followed by Australia and Sweden in 1969, and many other countries in the 1970s. The 1970s also saw the start of mandatory three-point belt fitment on the rear seats.

Mandatory seat belt usage on the front seats was led by Australia (1970, also rear seats), New Zealand (1972) and Sweden (1975). Some countries followed surprisingly late, like the UK in 1983, and also the first US state (NY) only made seat belt wearing mandatory in 1984. Seat belt usage legislation for the rear seat followed for a majority of countries in the 1990s.

Although seat belt wearing is by now mandatory in most countries, many drivers and passengers still do not buckle up. The reasons, motivations or excuses for not using the seat belt are manifold:

- forgetting about it
- only driving a short distance
- am a safe driver
- only drive at low speeds
- uncomfortable
- dangerous
- freedom of choice
- never wear a seatbelt

Road safety statistics, however, show that not wearing the seat belt significantly increases the risk of being killed in an accident, even at impact speeds as low as 30 km/h.

SEAT BELT EFFECTIVENESS

In a crash, the seat belt allows for a controlled deceleration of the occupant and prevents the occupant colliding with rigid vehicle parts or being projected out of the vehicle.

A National Highway Traffic Safety Administration (NHTSA) study [3] has shown that for front seat occupants of passenger cars the three-point seat belt reduces the risk of being fatally injured by 45% and being moderately to critically injured by 50%. For front seat occupants of SUVs, vans and pick-ups the benefit of the three-point belt is even higher, reducing the risk of fatal injuries by 60% and of moderate to critical injuries by 65%.

This safety benefit results in impressive numbers of "lives saved". NHTSA estimates that in the United States, seat belts saved the lives of 12,546 vehicle occupants in 2010. The average seat belt wearing rate was 85%. If the seat belt wearing rate had been at 100%, an additional 3,341 fatally injured occupants would still be alive. [4]

Seat belt wearing also improves the effectiveness of airbags, as the belt controlled upper body forward displacement leads to an ideal interaction with the airbag. The combination of both safety systems offers optimised occupant protection.

SEAT BELT REMINDER SYSTEM

While the level of fines for not wearing the seat belt can have an impact on the belt usage rate, a technical alternative has proven to be highly effective in increasing seat belt wearing rates: the Seat Belt Reminder also called SBR.

Figure 2. Seat belt reminder telltales.

An SBR system monitors the seat belt buckle status and reminds the unbelted occupant via at least a visual, and preferably also an acoustic, warning to buckle up. While driver presence can be assumed, an occupant detection sensor is used on the front passenger seat to confirm the presence of an occupant.

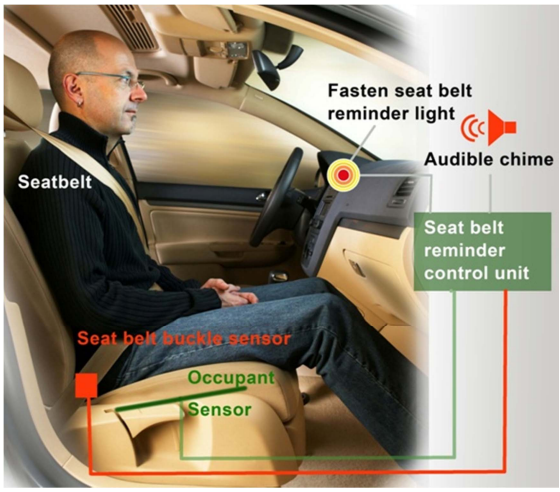

Figure 3. Seat Belt Reminder system for the front passenger seat.

Various occupant detection sensor variants are available. The seat integration can be carried out either on top of the seat foam (A-surface) or at the bottom of it (B-surface), depending on the sensor technology. Sensor design plays a considerable role in avoiding unnecessary sensor activation by objects like handbags or laptops.

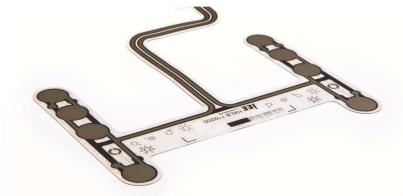

Figure 4. IEE Occupant Detection Sensor

An electronics unit checks the seat belt buckle status of each individual seating position and decides whether a signal needs to be triggered to remind the occupant to buckle up.

As only a minority of people not wearing a seat belt are reluctant non-users (1 - 2%), the potential for increasing the belt usage rates by "reminding" the occupant to buckle-up is very high.

From "mild" to "intelligent" seat belt reminders

In an attempt to increase seat belt wearing rates, the US mandated "seat belt interlocks" in 1973. Such systems prevented the vehicle engine being started when the driver and the front passenger were unbelted. Besides technical problems, the public reaction was extremely negative, so this approach was very short-lived. The interlocks were then replaced by "mild" SBR systems, triggering only a short, four to eight second long, audiovisual alert.

In the early 1990s Swedish research lead to the development of more "intelligent" seat belt reminder systems, which were more effective at reminding vehicle occupants to buckle up.

Intelligent SBR systems, such as defined by Euro NCAP [5], have the following features:

- synchronised audiovisual warning
- warning triggered if the:
    - vehicle is in forward motion exceeding a 25 km/h, or
    - vehicle is in forward motion for more than 60 seconds, or
    - vehicle has driven a distance of more than 500 meters, or
    - engine runs for more than 60 seconds
- warning duration of at least 90 seconds
- warning sound volume increases over time

The warning is not triggered when the vehicle is reversing, e.g. for parking manoeuvres. As seat belt wearing is less important, or can even hinder, during such situations, SBR warnings are dispensable.

Raising seat belt wearing rates

A Swedish study [1] evaluated the effectiveness of "mild" and "intelligent" SBR systems by monitoring driver seat belt usage in the cities of seven European countries. On average, drivers wore the belt in 85.8% of cars without an SBR system, in cars with a "mild" SBR the belted rate increased to 93.2% and in cars with an "intelligent" Euro NCAP type SBR system, 97.5% of the drivers had buckled up. Although the belt wearing levels varied between the different countries, it was observed that everywhere the intelligent SBR systems could reduce the number of unbelted drivers by an impressive 80%!

NCAPS AND SBR

SBR systems have become a rating element in many NCAP programs. This is motivated by the fact that the NCAP ratings are based on belted dummies. As a consequence, a 5-star car can only provide a "5-star protection" if the occupants are belted. Hence the relevance from NCAP's point of view to ensure that occupants are belted when involved in a crash.

The kind of incentives varies between the various NCAP programs. While some award additional bonus points to vehicles equipped with SBR systems, there are others which require SBR equipment as a pre-condition for a top rating. There are also differences in the technical requirements relating to SBR systems.

Euro NCAP

In 2002, Euro NCAP created incentives for seat belt reminder systems, by adding bonus points to the adult occupant protection protocol. One bonus point each was awarded for an SBR functionality for the driver and front passenger seat. Euro NCAP defined requirements regarding the warning signal and its duration, the triggering of the warning and the telltales, leading to the implementation of "intelligent" seat belt reminder systems. Front passenger presence must be confirmed by an occupant detection sensor. For the rear seats, Euro NCAP awarded up to one bonus point for monitoring the status of the rear seat buckles (n/m-point; m: number of rear seats; n: number of monitored buckles) and providing an information to the driver via a display or a text message.

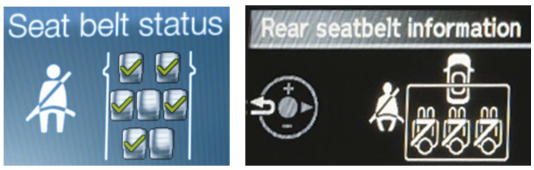

Figure 5. Examples of rear seat belt status information (Ford, Honda).

In the first year, 2002, driver SBRs were fitted to 33% and front passenger SBRs to 21% of the vehicle models tested by Euro NCAP. As shown in Figure 6, the incentives quickly led to an increasing number of vehicle models equipped with SBR systems.

The first cars with rear seat SBR were assessed in 2004, three out of 26 cars (12%) were equipped. Particularly in the early years of the SBR incentives,

these bonus points were very helpful in improving the star rating of many cars. Almost all of the first 5-star cars achieved this safety rating level thanks only to the SBR points.

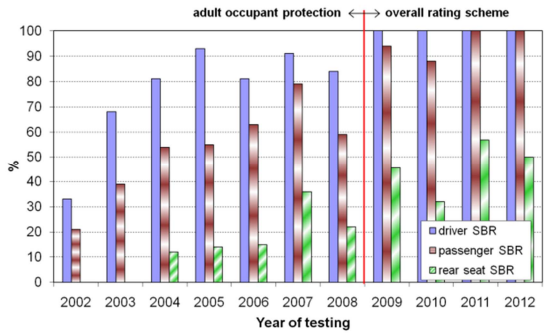

Figure 6. SBR installation rates of Euro NCAP tested vehicle models 2002 - 2012.

With the improving crashworthiness of tested cars, the SBR bonus points became less important and 2008 saw a decrease in the SBR fitment rates for all seating positions.

With the introduction of the overall rating scheme in 2009, Euro NCAP shifted the SBR points to the newly created category of "safety assist" systems (SBR, Electronic Stability Control and Speed Limitation Device).

Figure 7. Euro NCAP overall rating categories.

This reorganisation of the rating increased the relevance of SBR points, and the share of vehicles equipped with SBR increased again. In particular, the front passenger seat and the rear seat equipment with SBRs grew strongly from 2008 to 2009. This rating scheme transition phase is highlighted in Figure 8.

2009 was the first year where all Euro NCAP tested vehicle models were fitted with a driver SBR and another milestone was achieved in 2011 when all tested models were also equipped with a front passenger seat SBR system. And since 2012, Euro NCAP requires SBRs to be installed in 100% of the produced cars of the tested model in order to be eligible for the SBR points.

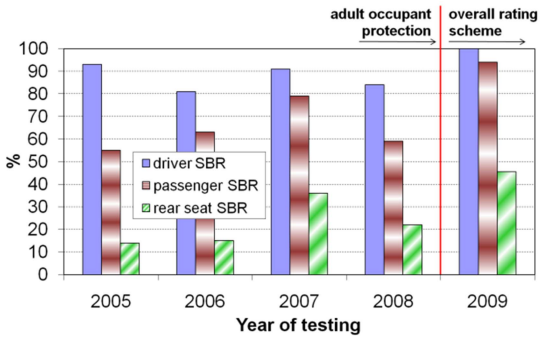

Figure 8. Overall rating scheme impact on SBR fitment.

Further strengthening the importance of SBR, the 2013 protocol only awards two SBR points if both front seats have an SBR system. Single front seat SBR points are no longer available. And, in order to get an SBR point for the rear seat, the buckle status of all rear seating positions must be monitored.

Euro NCAP does not require but recommends the use of occupant detection for the rear seats. However, so far no vehicle has been equipped with such an enhanced rear seat SBR system.

A larger number of Euro NCAP tested cars with SBR systems obviously also has the effect that more and more vehicles on the road are equipped with SBRs. Figure 9 shows the SBR equipment of new vehicles sold in Europe in 2009.

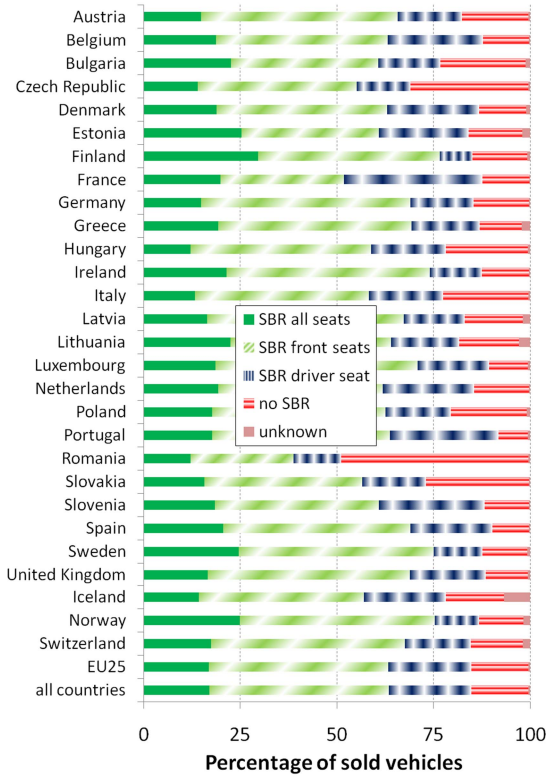

Figure 9. SBR equipment in new vehicles (2009).

There are considerable variations in the market penetration of SBR systems, as well as in the number of seats that are equipped with an SBR in the various countries. This reflects the SBR fitment strategies of the vehicle brands that are the most popular in the corresponding countries. The market obviously lags behind with regards to fitment rates, as Euro NCAP focuses on new vehicle types, while new sales also include many older models. The SBR equipment rate of the new vehicles sold in the EU25 in 2009 corresponds approximately to that of the vehicles tested by Euro NCAP in 2006. So the overall market lags behind Euro NCAP by about three years. Considering the very high SBR fitment on the front seats since the introduction of the overall rating, the fraction of newly sold vehicles in Europe without driver or front passenger SBR should be very small nowadays.

Australasia NCAP (ANCAP)

ANCAP quickly followed Euro NCAP and awarded the first SBR points in 2003, applying the same SBR protocol as Euro NCAP. The incentives started to have a significant effect from 2007 onwards, and the SBR fitment rates are still increasing year to year (Figure 10).

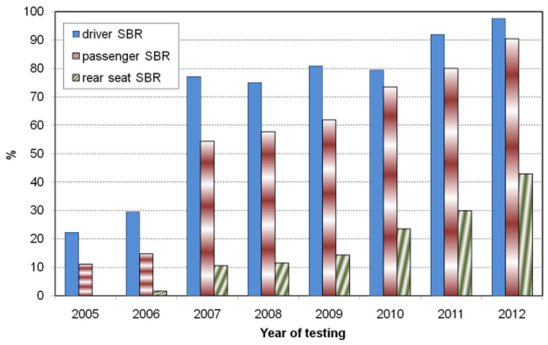

Figure 10. SBR installation rates of ANCAP tested vehicle models 2005 – 2012.

ANCAP is now further promoting the installation of SBR by not only awarding bonus points to the crash test safety rating, but also making SBR equipment a precondition for a certain star rating

- From 2013 on, a car must have an SBR on both front seats in order to qualify for a 5-star rating
- From 2015 on, a car must have an SBR on both front seats in order to qualify for a 4-star rating and a rear seat SBR to qualify for a 5-star rating
- From 2017 on, an SBR system for the driver and the front seat passenger is a pre-condition also for a 1, 2 or 3-star rating, and rear seat SBR becomes a must for a 4-star rating

So the ANCAP message for 2017 is: No SBR, no stars!

China NCAP (C-NCAP)

China NCAP was next, introducing SBR bonus points for the front seats in 2006. Figure 11 shows how the SBR installation rates have evolved since. The SBR protocol recently underwent some changes. While the driver SBR was initially worth a full point, this incentive was reduced to 0.5 points in 2010. A front passenger SBR with occupant detection is worth one point.

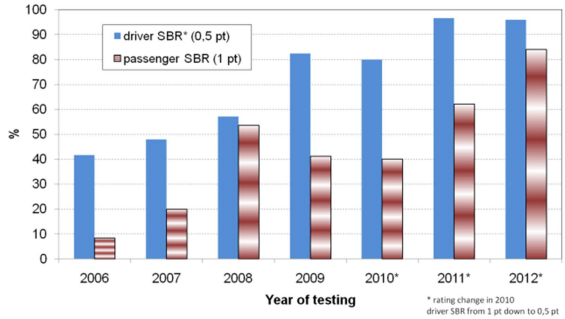

Figure 11. SBR installation rates of C-NCAP tested vehicle models 2006 - 2012.

So, China NCAP was also successful in promoting the installation of SBR systems in vehicles sold in China. The C-NCAP SBR protocol, however, is less stringent than that of Euro NCAP. China NCAP only requires an audible signal for the driver but does not define a minimum warning duration. The type of warning signal for the front passenger is not specified, so a simple telltale is sufficient. Therefore the effectiveness of such an SBR system in raising the seat belt wearing rates is likely to be limited, as a telltale can easily be ignored.

The protocol also allows for the installation of a front passenger SBR system without an occupant detection sensor. However, the incentive for such a system is halved to 0.5 points. This option without occupant detection is not compatible with an audible warning, as it would trigger the acoustic alert for an empty seat. As SBR systems are most effective when combining a visual and an audible warning, it might be worth taking into consideration deleting this option without occupant detection in the future. This would then allow the protocol to define more effective warning signals.

Japan NCAP (J-NCAP)

In 2009, Japan NCAP started to monitor whether vehicles are equipped with seat belt reminder systems or not. As driver SBRs have been mandatory in Japan since 2005, J-NCAP focused its evaluation on the front passenger seat and on the rear seats. However, at that point in time, no SBR

points were allocated. SBR fitment and functionality were only listed as information on the vehicle test datasheet and did not have an impact on the vehicle rating.

Upon introducing an overall rating scheme in 2011, SBR points became part of the evaluation. The overall rating score is based on the sum of three elements: occupant protection (up to 100 points), pedestrian protection (up to 100 points) and seat belt reminder (up to four points for the front passenger seat and up to four points for the rear seats).

The new incentives had a significant impact and in 2012 already 80% of the tested vehicles were equipped with a front passenger SBR system.

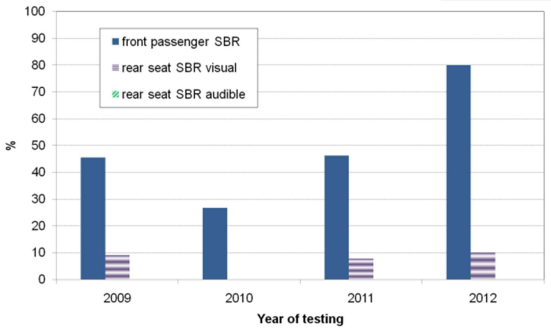

Figure 12. SBR installation rates of J-NCAP tested vehicle models 2009 – 2012.

J-NCAP is the first NCAP program to have created an incentive for occupant detection on the rear seats. Two of the four rear SBR points are only awarded if the rear SBR warning signal includes an audible warning of at least 30 seconds. Such a warning, however, can only be triggered if passenger presence information is available. So far, as no such advanced system has been evaluated, rear SBR functionality is limited to telltale/display-type information.

Latin NCAP

Latin NCAP, launched in 2010, will upgrade its rating with SBR incentives for the front seats in 2013. Latin NCAP has decided to apply the Euro NCAP SBR protocol. The SBR points are allocated in the adult occupant protection category. The incentives are very strong:

- The front passenger and driver SBR function are coupled, so both front seats must be equipped with an SBR system in order to score bonus points

- The weight of the SBR points is very high in the adult occupant protection rating – two out of 18 points (16 points frontal crash test, two points SBR)

- SBR function for the driver and front passenger is a precondition for a 5-star rating

Korea NCAP

Korea NCAP will start to introduce SBR incentives in 2013, together with an overall rating scheme. Upon calculation of the overall score, active safety systems can help to add one bonus point, with SBR contributing here with 0.3 points. Other active safety candidates are Forward Collision Warning (0.4 pts) and Lane Departure Warning (0.3 pts).

ASEAN NCAP

ASEAN NCAP published a first safety rating for cars available in the ASEAN region in early 2013. When setting up the rating protocol, ASEAN NCAP decided to implement SBR incentives from the beginning. An SBR on both front seats is a precondition for a 5-star rating. To assess the SBR functionality, ASEAN NCAP applies the Euro NCAP SBR protocol. In the first rating launch, two of the assessed vehicle models got a 5-star rating for their variants available with seat belt reminders and other safety equipment like frontal airbags and ESC.

IIHS

The Insurance Institute for Highway Safety (IIHS), is a strong supporter of seat belt reminder systems even though they do not include SBR incentives in their "Top Safety Pick" rating. The importance and effectiveness of SBR systems is frequently highlighted in the institute's "Status Report". The January 2013 edition [6] includes a study that surveyed drivers regularly transporting children aged 8 - 15 on the rear seats. A large majority of these drivers (82%) want their vehicle to alert them when the child is not buckled, and more than three quarters want this warning signal to be audible (chime or buzzer). Notifying the driver about children removing their safety belt during the trip is also considered an important feature, as this might otherwise easily remain unnoticed.

CONCLUSIONS

Wherever NCAP programs have implemented incentives for seat belt reminder systems, they had a positive effect on the number of new vehicle models being equipped with SBRs. The same is expected in the regions of the world where NCAP programs have recently started, or are about to start, awarding SBR points.

So NCAP programs can not only have a positive effect on the crashworthiness of cars, they can also help to influence user behaviour by awarding incentives to safety technologies that are able to do so.

The NCAP SBR incentives have an important impact on road safety statistics, as the positive effect of SBR systems on the belt wearing rate has been proven, and as wearing a belt significantly reduces the risk of being fatally or severely injured in a crash. In other words, NCAP incentives can effectively save lives.

However, it is important that the incentives are "rating-relevant" in order to be successful in promoting a technology. As seen in the past, SBR equipment in Euro NCAP tested vehicle models temporarily dropped when SBR points became less important to achieve a 5-star rating.

While current front seat SBR systems have proven to be highly effective, this is not the case for the relatively simple rear seat SBR systems. The time may have come to extend the concept of intelligent SBR to the rear seats and to address the issue of occupant detection in an environment with a higher variability than on the front seats. Incentives like the one from J-NCAP could help to promote such enhanced rear seat SBR systems.

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Back seats also should have belt reminders, parents say

NCAP websites:

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Australasian NCAP: www.ancap.com.au/home

China NCAP: www.c-ncap.org.cn/c-ncap_en/index.htm

Euro NCAP: www.euroncap.com

Global NCAP: www.globalncap.org

IIHS: www.iihs.org

Japan NCAP: www.nasva.go.jp/mamoru/en/

Korea NCAP: www.car.go.kr/jsp/kncap/result.jsp

Latin NCAP: http://latinncap.com/en/