POP-UP HOOD PEDESTRIAN PROTECTION

Eva Ames
Peter Martin
National Highway Traffic Safety Administration
United States of America
Paper Number 15-0111

ABSTRACT

Objective: One means of protecting pedestrians is through vehicle safety systems that are built into a vehicle's front-end to protect pedestrians should a vehicle impact occur. These pedestrian protection systems include hood structures aimed at reducing pedestrian head injuries. Pop-up hoods function by increasing the head penetration space beneath the hood by quickly lifting upon vehicle contact with a pedestrian. This paper explores the prevalence of vehicles with pop-up hoods to show that their market penetration and performance benefits merit consideration in standardized pedestrian protection test protocols.
Methods: Euro NCAP test scores and the Parkers United Kingdom (UK) vehicle database were used to better understand the fleet performance and market penetration of vehicles with pop-up hoods. An analysis of Euro NCAP pedestrian test results and overall vehicle test scores was performed to compare the performance of vehicles equipped with pop-up hoods to those without, and the Parkers UK vehicle database was used to estimate historical vehicle prices and demonstrate that pop-up hoods are available on both high- and low-cost vehicles.
Results: There are many different types of systems that operate pop-up hoods, and their architectures vary widely from one vehicle to the next; however, they typically create an increase in the distance from the hood to rigid components in the engine bay, thus reducing the probability and/or severity of a head injury of a struck pedestrian. Compared to vehicles with non-deploying hoods, vehicles with pop-up hoods rated by Euro NCAP had better pedestrian protection scores on average. In the European Union (EU), pop-up hood systems, which have become more prevalent over time, were found on vehicles outside the oft-assumed market of only low-volume luxury models.
Discussion and Limitations: Pedestrian Protection is mandatory on all vehicles sold in the EU Conformity of pop-up hoods is based largely on headform impact tests conducted on a fully popped-up hood. During the Type Approval process, the determination of system reliability and consistency also must be demonstrated by the vehicle manufacturer, but the means and requirements to do so are not defined within the regulation itself. Because the operation of pop-up systems varies widely and they are generally unique to specific vehicle models, the demonstration of system functionality is agreed upon between the manufacturer and the Type Approval Authority. Euro NCAP operates in a similar manner.
Conclusions: Pop-up hoods generally perform better than non-deploying hoods in headform impact tests. As their development matures and vehicle styling progresses towards low, sleek, aerodynamic hood profiles, demand as well as variation in these systems may grow. To date there is not a published, fully prescriptive test protocol that tests the full functionality of such systems, including reliability and deployment thresholds, to objectively ensure that they function properly during an actual collision with a pedestrian.

INTRODUCTION

Fatal injuries to pedestrians from motor vehicles often result from the pedestrian's head striking either the vehicle or the ground. There are two primary means of protecting pedestrians through vehicle safety systems: one involves the use of crash avoidance safety systems, such as those for braking and lighting, to help the driver see the pedestrian and avoid a collision, and the other involves structural designs and mechanisms built into the vehicle front-end that reduce the injury potential to pedestrians should a crash occur. This paper will discuss pop-up hood systems, which increase the distance to rigid components in the engine bay, potentially reducing the head injury risk of a struck pedestrian [14], by quickly lifting the rear edge of the hood a few inches when triggered.

A sleek vehicle profile, and therefore a low hood profile, is often desirable by vehicle manufacturers for both styling purposes and aerodynamic performance. These low hood profiles are contrary to what is desired for good pedestrian head protection because they leave less space between the hood and underlying hard surface components, a clearance necessary for energy absorption during impact through free deformation of the hood. Though many manufacturers are able to provide the desired clearance through other means such as structural changes and component layout adjustments, some use pop-up hoods as an alternate strategy [5].

Pop-up hoods are particularly beneficial because they provide head penetration clearance near the hinges and at the rear edge of the hood along the cowl, where the windshield, hood, and firewall all intersect. It is in this area where pedestrian heads often strike. But it is also the area where non-deploying hoods are typically stiffest – even those

designed to conform to pedestrian safety standards. The beneficial qualities of pop-up hoods have been demonstrated in numerous studies [8][12][14].

Also, the addition of a pop-up hood to an existing vehicle designed for a market without pedestrian protection requirements may allow a vehicle manufacturer to sell vehicles in additional marketplaces while avoiding major structural and styling changes.

The basic premise behind pop-up hood deployment is that the vehicle is outfitted with a control unit which triggers hood deployment when the vehicle senses a pedestrian collision and is traveling within a predetermined threshold for which the control unit knows hood deployment will be effective. The control unit receives input from a contact sensor and/or pre-crash sensing technologies. Contact sensors in the bumper, in the form of accelerometers, pressure tubes, or resistive/capacitive sensors, detect that the vehicle has struck a pedestrian's leg (rather than a tree, pole, or other inanimate roadside object) through classification of the impact pulse. Some new vehicles are outfitted with pre-crash sensing technologies such as radar and LIDAR, which are able to influence the control unit's hood deployment algorithm through identification of a pedestrian prior to vehicle-pedestrian impact.

Deployment (lifting) technologies vary from springs and motors to pyrotechnic actuators using rapidly expanding gas to provide the necessary lift, similar to the devices used in air bag deployment. The lifting actuators are located at the rear corners of the hood at the hinge locations, and they lift the hood up as it pivots at the latch in the front [12]. The spring and motor method is considered to be desirable because the hood could be fully reset post-impact or after a false trigger, whereas the pyrotechnic method would require the replacement of certain components. Conversely the pyrotechnic method is desirable because of its ability to deploy the hood faster than the other option, and most research has focused in this area. Also, pyrotechnic components are generally smaller and weigh less. Minimizing the repair costs of a vehicle equipped with pop-up hood deployment also requires a hood that could be reused, which would depend upon a hood rigid enough to resist deformation from the impact of a head or torso. This may conflict with the ability of a hood to absorb energy when not deployed [11]. A newer pop-up hood system, first seen in mass production on the Volvo V40, is the pedestrian air bag [8]. Triggered with the same sensing methods as used for traditional pop-up hood actuation systems, an inflator fills the pedestrian air bag which then lifts the hood. This air bag is located at the base of the windshield, and it not only lifts the hood for additional clearance but also provides air bag coverage to the vehicle's A-pillars and lower windscreen, which are relatively very hard surfaces.

METHODS

The United States does not currently have pedestrian protection requirements applicable to vehicles, so vehicles in markets with pedestrian protection requirements were studied to examine trends regarding pop-up hood systems. Pedestrian safety systems such as pop-up hoods are not new to Europe. Euro NCAP, a non-regulatory consumer ratings group in Europe, supported by various European governments and motoring organizations, has been testing pedestrian protection for more than a decade. Additionally, many European countries are subject to pedestrian protection regulations.

In this paper, 498 Euro NCAP test reports from 2000-2014 were entered into a database. Next, the Parkers database of United Kingdom (UK) vehicle prices was consulted to assign new vehicle prices to each vehicle in the database. The Parkers information was consulted because it includes a wealth of historical vehicle pricing information, and the UK market was deemed large and varied enough to be an appropriate sample.

From these 498 database entries, 63 were excluded from the following calculations regarding test scores and price, leaving 435 unique vehicle entries with full Euro NCAP test scores and Parkers vehicle pricing information. Of the excluded entries, 33 were repeated entries, 1 was a Euro NCAP test report (the 2008 Mercedes Viano) that did not include pedestrian protection scores, and 29 were vehicles that lacked historical price information through Parkers.co.uk or were not offered for sale in the UK. The 33 Euro NCAP vehicle retests came from both the 2009 Euro NCAP test protocol change regarding rescoring and retesting and also from design changes stemming from poor initial Euro NCAP scores. In all of these cases, the most recent test report was kept. These repeat test vehicles had identical pedestrian scores except for the Mazda 6 retest in 2005, VW Passat retest in 2010, and Jaguar XF in 2011. The Passat and XF tests were redone specifically for pedestrian protection. The complete list of these

vehicles, as well as 12 additional European vehicles with pop-up hoods but not tested by Euro NCAP which were identified through various media outlets, is included in Appendix A.

Euro NCAP assigns an overall vehicle score on a five star scale, similar to the star assignment system used by NHTSA's own NCAP program. The number of overall stars is determined by the scores a vehicle receives in four main areas: Adult Occupant, Child Occupant, Pedestrian, and Safety Assist. For the year 2015, a vehicle must achieve 65 percent of the total possible points in the pedestrian test to qualify for a five star rating, and the pedestrian score comprises 20 percent of the overall score [1]. The pedestrian scores are compiled from three tests: headform, upper legform, and legform. The headform test is potentially 24 of the 36 total possible pedestrian points, and it tests for both child and adult impacts [3].

A vehicle equipped with a pop-up hood is tested with the pop-up hood only if the sales volume of vehicles with this feature is high enough according to the Euro NCAP sales volume specifications for that model year and if the vehicle manufacturer can work with the Euro NCAP Secretariat prior to testing to prove system functionality and reliability. Otherwise, it is tested without having its hood activated. In the Euro NCAP headform test, point values are assigned based on the HIC value from free motion headforms fired at the hood, targeting a grid of impact locations for both children and adults. This physical testing validates a simulation model provided by the vehicle manufacturer prior to the test [4].

RESULTS

Listed in Appendix B, there are 24 vehicles sold with pop-up hoods that Euro NCAP has tested, and they span the whole gamut of vehicle sizes and prices, going from the Fiat Freemont and Hyundai Santa Fe to the Mercedes M-Class, BMW 5-series and Jaguar XF. This is not to say that vehicles must have an pop-up hood to achieve a good head impact test score or that a pop-up hood guarantees a good head impact score – the 2012 Subaru Forester (without an pop-up hood) scored 20.3 of 24 potential points for head impact, and the 2011 Dodge Caravan (with an pop-up hood) scored only 11 points for head impact. Additionally, not all luxury vehicles have pop-up hoods – the Maserati Ghibli uses passive pedestrian protection without a pop-up hood. Inclusion of pop-up hoods in new vehicles has become more common over time.

As seen **Error! Reference source not found.** in Figure 1, the percentage of vehicles with pop-up hoods in the Euro NCAP test inventory has increased over time. Euro NCAP cannot test every vehicle so their inventory is not a census, but each year's vehicle selection is made in order to provide the broadest range of consumer information possible by collecting information about the most popular and interesting vehicle models [5]. Assuming the sample selection to be consistent over time, it can be posited that though pop-up hoods remain a small part of the vehicle fleet, they already have a high enough market penetration to have a tangible effect on overall pedestrian safety in the EU. However, we have no data on hood activations and pedestrian injury outcomes in real-world pedestrian crashes in the EU.

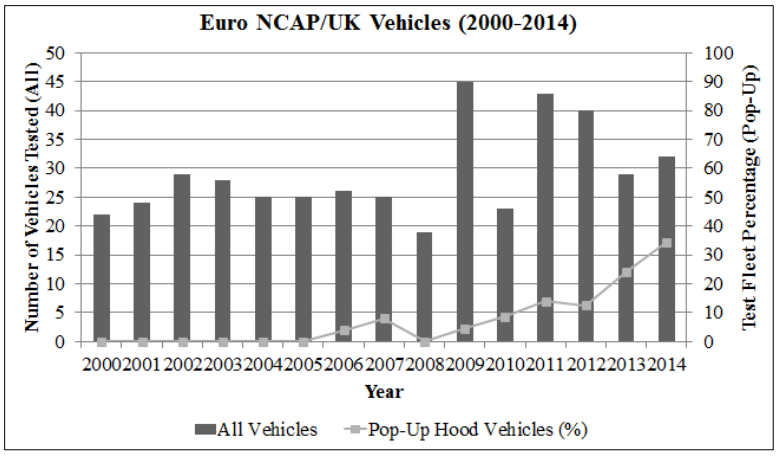

Figure 1. Pop-up Hood Market Penetration for 2000-2014 Euro NCAP/UK Vehicles Tested

Figure 2, below, shows the pedestrian protection scores for all vehicles. Those vehicles without pop-up hoods have increased their scores over time. Figure 3, below, shows that this trend is consistent with that for looking only at the scores from the headform test. Though the sample size is relatively small for vehicles with pop-up hoods, score gaps in both figures indicate that they yield higher scores than those without pop-up hoods.

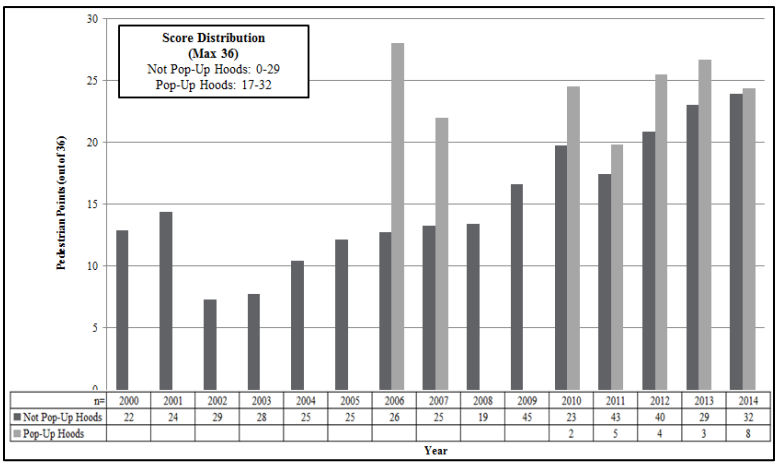

Figure 2. 2000-2014 Euro NCAP/UK Vehicle Overall Pedestrian Scores over Time

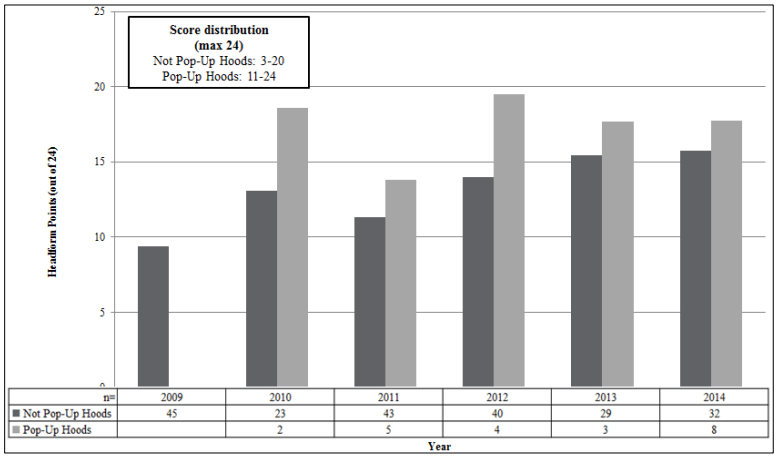

Figure 3. 2000-2014 Euro NCAP/UK Vehicle Average Pedestrian Headform Scores

To date, the 2012 Volvo V40 is the only vehicle in the Euro NCAP database to achieve a perfect 24 point score for the head impact testing. (The V40 is not sold in the U.S.) Note that prior to 2009, publically reported Euro NCAP pedestrian protection scores were given as overall scores and not broken into separate head, upper leg, and leg scores as they are currently. This result was achieved with a pedestrian air bag that deploys when the vehicle is moving at speeds between 20 and 50 km/h to not only lift the hood, but to also cushion the windshield wiper, windscreen, and A-pillar areas in case of a strike from a pedestrian head [6]. The 2010 BMW 5-series, equipped with a pop-up hood, also scored highly in both child and adult head impact tests, receiving 22 of 24 possible points. The 2006 Citroen C6 is also noteworthy because it is one of the earliest vehicles featuring a pop-up hood. Until 2009, Euro NCAP translated the overall pedestrian point score into a separate rating out of 4 stars. The 2006 Citroen C6 was the first vehicle to achieve that top 4 star pedestrian rating with a score of 28 of 36 points. This pre-2009 Euro NCAP pedestrian score was a single score with all of the three factors combined into a single score.

The effectiveness of the pop-up hood technology alone is seen with the 2013 Skoda Octavia and the 2010-2012 Jaguar XF. The 2013 Skoda Octavia's test results were updated in June 2013 because Skoda made the decision to remove the pop-up hood, which had previously been standard equipment on vehicles sold throughout the EU. The Euro NCAP test report states that the full pedestrian protection score, not specific to only head impact, was 30 points

with the pop-up hood technology or 24 without, out of a potential 36 points. Without the pop-up hood, the head impact score was only 16.5 out of a potential 24 points. Conversely the Jaguar XF was tested in 2010 without pop-up hood technology, where it scored 16 points out of a potential 24 for head impact testing. The 2010 XF was outfitted with pop-up hood technology, but was tested without it because the sensors in the bumper did not meet Euro NCAP standards. The XF was tested again in 2012 with the pop-up hood technology activated, which improved that score to 22 out of 24 points.

The historical pricing information from the Parkers database was used to characterize original, new vehicle sales prices for the vehicles in the database. The Parkers database provided a range of prices for the various option levels, and the median of this range was calculated for each vehicle and used to create Figure 4, below. Median new vehicle sales prices for vehicles with pop-up hoods are higher than those for vehicles without a pop-up hood, but as seen in Figure 4, not all vehicles with pop-up hoods are at the absolute top end of the price spectrum.

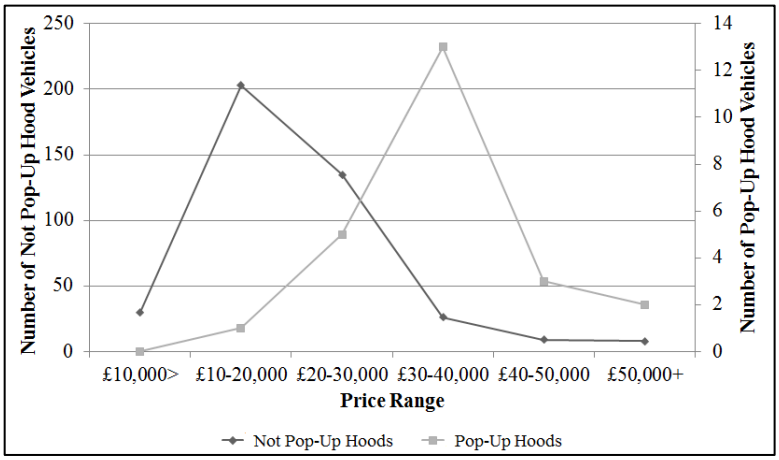

Figure 4. 2000-2014 Euro NCAP/UK Vehicle Median Price Distribution

The analysis of the vehicles in the database showed that while pop-up hoods can help to get a high pedestrian headform score in the Euro NCAP test, it was not essential to doing so. below, in Figure 5, it can be seen that the 2012 Subaru Forester, without a pop-up hood, scored 20.3 out of 24 headform points, while the comparably priced 2011 Dodge Caravan, with an pop-up hood, only scored 11 out of 24 headform points.

Figure 5. Pedestrian Protection Vehicle Comparison With and Without Pop-Up Hood

Market Penetration

We identified 40 vehicle models with pop-up hoods that have been marketed in Europe, as shown in Table 1 below. Only two of them are no longer produced: the Citroen C6 (ceased production in 2012) and the Acura RL (also ceased in 2012 but reintroduced in 2015). Of the current European models with pop-up hoods, most are versions of similar models sold in the U.S. without a deployment actuator.

One such vehicle is the Dodge Caravan, sold in the Europe as the Lancia Voyager. The Caravan is an example of a vehicle not originally designed for a market with pedestrian protection requirements (only 4,140 sales units in the EU vs. 272,191 in the U.S. for 2014). In light of these sales figures and its marginal headform score of 11.0 (lowest of all vehicles with pop-up hoods and below average for all), it would appear that the pop-up hood provided the manufacturer with a more economic option to allow an existing vehicle design entry into the European market. Otherwise, a costly redesign of the whole front end including hood under-components may have been required to achieve comparable pedestrian headform scores.

As seen in Table 1, about 8% of new cars sold in Europe have pop-up hoods and the U.S. market share of the North American versions is about the same. The market share of vehicles with pop-up hoods could increase further as the systems mature. Aside from the benefits to pedestrians discussed in the Introduction, a pop-up hood offers other advantages. From a vehicle styling viewpoint, a pop-up hood provides a means to achieve a desired appearance of a sleek vehicle with a low hood profile, which may provide better aerodynamic performance.

Table 1. European Passenger Cars with Pop-Up Hoods

Make	Model	United States version		European version		Euro NCAP head score /36	European name
		Sales 2014	Median Price	Sales 2014	Median Price		
Acura	RL	Discont.	$49,490	Discont.	£37,713	n/a	Honda Legend
Aston Martin	DB9	1,224	$191,200	285	£140,527	not tested	
Aston Martin	Vanquish		$279,995	325	£198,640	not tested	
Audi	A3	22,250	$29,060	199,537	£29,158	18	
BMW	2-Series	7,345	$33,000	26,215	£26,993	14.9	
BMW	6-Series	8,647	$53,253	7,902	£67,050	not tested	
BMW	5-Series	52,704	$50,950	98,519	£44,080	22	
Cadillac	ATS	29,890	$40,445	365	n/a[1]	not tested	
Cadillac	CTS	31,115	$63,215		n/a[1]	not tested	
Citroen	C6	not sold in U.S.		Discont.	£33,578	n/a[2]	
Chrysler	300	53,382	$33,745	487	£38,000	15.3	Lancia Thema
Dodge	Journey	93,572	$27,945	17,417	£20,970	12	Fiat Freemont
Dodge	Caravan	272,192	$34,710	4,140	£32,265	11	Lancia Voyager
Hyundai	Genesis	29,992	$42,125	247	n/a[3]	16.7[3]	
Hyundai	Santa Fe	107,906	$27,075	13,332	£30,363	18.6	
Infiniti	Q50	36,899	$41,200	2,426	£69,253	19.1	
Jaguar	F-type	4,112	$80,500	4,654	£69,253	not tested	
Jaguar	XF	5,880	$65,150	20,328	£40,670	16.2	
Jaguar	XK	1,452	$77,835	1,882	£81,965	not tested	
Kia	Sorento	102,520	$28,275	9,325	£31,900	18.3	
Land Rover	Discovery Sport	n/a	$41,320	n/a	£39,195	19.2	
Lexus	IS	51.358	$50,979	9,552	£33,643	16.9	
Mazda	MX-5/Miata	4,745	$26,485	5,787	£21,095	not tested	
Mercedes	A-Class	not sold in U.S.		121,321	£26,058	18	
Mercedes	CLA-Class	27.365	$38,675	38,423	£30,155	17	
Mercedes	GLA-class	6,884	$39,800	44,930	£30,218	18.4	

Make	Model	United States version		European version		Euro NCAP head score /36	European name
		Sales 2014	Median Price	Sales 2014	Median Price		
Mercedes	C-Class	75,065	$49,275	136,431	£32,580	21	
Mercedes	C-Class Coupe		$46,095		£33,725	14.6	
Mercedes	E-Class	66,400	$66,900	99,441	£37,563	15.2	
Mercedes	S-Class	25,276	$114,070	17,694	£74,900	not tested	
Mercedes	SL	5,030	$101,565	2,638	£78,190	not tested	
Mercedes	SLK	4,737	$51,150	11,107	£38,705	not tested	
Mercedes	M-Class	46,726	$71,990	23,710	£48,035	17.4	
Mini	Cooper	33,467	$22,900	94,909	£19,053	18.1	
Nissan	GT-R	1,436	$77,965	275	£81,610	not tested	
Peugeot	RCZ	not sold in U.S.		5,772	£27,050	not tested	
Porsche	Panamera	5,740	$111,200	5,647	£97,603	not tested	
Tesla	Model S	36,400	$81,650	8,841	£75,535	13.9	
Audi	TT	1,158	$40,795	9,786	£32,320	17.7	
Volvo	V40	not sold in U.S.		80,948	£25,388	24	
Total vehicles w/ pop-up hoods		1,174,225		1,043,650			
Total all light vehicles		16,531,070		12,939,046			

[1] Cadillac ATS and CTS not sold in U.K. Estimated price for the CTS in EU: 56,200 € (£40,800). No estimate for the ATS.
[2] Citroen C6: Separate headform score not reported.
[3] Hyundai Genesis not sold in U.K. Estimated price in EU: 65,000 € (£47,200). Headform score of 16.7 reported by Australia NCAP.

Standardized Test Protocols

Test protocols for pop-up hoods and associated requirements are discussed below. In addition to Euro NCAP's five star consumer ratings, which are consumer information ratings and not regulations, some countries also subscribe to various United Nations agreements and are therefore subject to United Nations regulations. United Nations Global Technical Regulation No. 9 (GTR No. 9), *Pedestrian Safety*, which applies to WP29 1998 Agreement signatory countries, includes a test protocol for evaluating the pedestrian friendliness of light duty vehicles. GTR No. 9 provides general guidance as to how testing of vehicles with pop-up hoods could be done.

GTR No. 9. GTR No. 9 [15] addresses pedestrian safety, targeting the energy absorption abilities of the bumper and hood areas in 40 km/h vehicle-to-pedestrian crashes. GTR No. 9 is broken into two main parts: Section A, the Statement of Technical Rationale and Justification, and Section B, the Text of the Regulation. The regulatory requirements are prescribed in Section B, where it is stated: "[a]ll devices designed to protect vulnerable road users when impacted by the vehicle shall be correctly activated before and/or be pop-up during the relevant test. It shall be the responsibility of the manufacturer to show that any devices will act as intended in a pedestrian impact." However, there are no specifics on how this demonstration is carried out. Pop-up hoods were still conceptual during the 1990s when the work of the ISO, IHRA, the EEVC, and NHTSA formed the building blocks of the GTR.

Section A, however, does provide informal guidance on pop-up hoods. It states that pop-up hoods "must not create a higher risk of injuries for the pedestrians." In conjunction with this point, working paper INF GR/PS/141, Certification Standard for Type Approval Testing of Active Deployable Systems of the Bonnet/Windscreen Area, is offered as a guideline for the certification of deployable devices by Contracting Parties looking to implement test procedures in their home countries, with previous working papers giving additional insight [1][16].

Another working paper provides a decision tree analysis for a Type Approval system of compliance in which the vehicle manufacturer and a type approval authority agree on the timing between a headform launch and a hood activation [17]. The guidelines serve mostly to specify terminology for defining the timing of a launch as provided by the manufacturer. They do not specify the timing itself, nor do they provide requirements for the triggering threshold or any requirements for hood activation.

Euro NCAP. Though not a regulatory body, Euro NCAP has had a pedestrian testing protocol in place for more than a decade, which covers headform, legform, and upper legform impact tests. The first vehicle tested with a pop-up hood in the Euro NCAP database of test results was the 2006 Citroen C6, followed by the 2007 Honda Legend and several others.

Since Version 5.2 (implemented in 2009), Section 2 in the Euro NCAP pedestrian testing protocol has been dedicated to the "assessment of vehicles with active bonnets," laying out detailed information for how Euro NCAP will assess not only the deployment but also the triggering and sensing capabilities of these pop-up systems. As the pop-up systems have matured, the Euro NCAP testing protocol has undergone periodic refinement to provide more objective assessment procedures.

Notwithstanding higher Euro NCAP scores, uncertainty remains over the true effectiveness of pop-up hoods. Absent a real-world analysis of pedestrian collisions, it is unknown whether higher headform scores for pop-up hoods have translated into reduced injury risk for pedestrians. Much of the uncertainty surrounds questions on how well pop-up hoods function in the real-world. The discussion below highlights these uncertainties and explains how they are treated under the current Euro NCAP protocol (Version 8.0, implemented in 2014).

DISCUSSION

Questions Regarding Real-World Effectiveness

The effectiveness of pop-up hoods has been questioned since the early stages of pedestrian safety standards development. The original uncertainties are perhaps best summarized in a 2006 feasibility report by Lawrence and Hardy [11]. The authors expressed low confidence for pop-up systems due to their complexity and the amount of tuning needed for them to work properly. The device must trigger and then physically push the bonnet upwards, before the pedestrian's head strikes, and the lifting mechanism must be strong enough for not only the initial lift but also to support the weight of the pedestrian's head and torso. The lift timing must be precise, and the sensors must be calibrated as to prevent false triggering. They must be able to differentiate between pedestrians about to be or having just been struck versus non-pedestrians, and a triggering threshold for a minimum vehicle collision speed must be established. The introduction of vehicles with active suspensions only serves to complicate the matter further.

In Euro NCAP, the functionality of the pop-up hood system is demonstrated through computer simulations carried out by the vehicle manufacturer. This exercise must adhere to a set of guidelines laid out in Section 2 of the Euro NCAP protocol and the integrity of the analysis must be approved by the Euro NCAP Secretariat. The protocol is not prescriptive of the system. Instead, Euro NCAP allows manufacturers to set their own sensing and triggering criteria and then performs a limited number of verification tests based on these provided criteria. System reliability and consistency is largely left to the discretion of the vehicle manufacturer. Some of the more prominent functionality concerns are discussed below.

Pedestrian sensing. All vehicles with pop-up hoods have some sort of pedestrian sensing mechanism to trigger the deployment of the hood. In Euro NCAP, this functionality is demonstrated by the manufacturer through computer simulations of knee-to-bumper interactions using full body models of pedestrians of various sizes. The simulations are run using models of various pedestrian sizes, but only for stances in which the pedestrian is walking perpendicular to the line of vehicle travel.

Hence, there is no physical test method for assuring that the sensors detect pedestrians in various gaits and stances and in a range of collision speeds, vehicle maneuvers (turning or braking) and environmental conditions (temperature, icy vs. dry). To verify sensing and deployment through a physical test, a special pedestrian manikin may be needed. Such a manikin would likely differ in form and function from the legform impactor used by Euro NCAP (and known as the Flex-PLI) to assess pedestrian leg injury risk.

There are also concerns that pedestrians will be left unprotected in a collision that is not initiated by leg-to-bumper contact so that the hood does not deploy. And since the sensors are located on the bumper, a criterion may be needed to assure that they do not become easily damaged. Also, it is also entirely possible that future systems would

use visual detection and not require actual contact, which would require even another manikin with considerations for environmental operating conditions (dirt, rain and snow, lighting).

Timing. In Euro NCAP, computer simulations are carried out by the manufacturer to demonstrate that the hood is fully deployed before landed upon by a pedestrian. However, it may be necessary to account for various pedestrian gaits and stances since they can influence the time lapse between the initial bumper-to-pedestrian contact and the subsequent head-to-hood impact. In Euro NCAP, there are no physical tests associated with this demonstration due in part to the absence of a standardized pedestrian test dummy.

Deployment threshold. In Euro NCAP, the manufacturer specifies the hood deployment thresholds (both at a speed below 40 km/h and at a speed of 50 km/h or higher), which are then verified through physical testing. Triggering thresholds generally differ from one vehicle to the next. The vehicle speed at which activation occurs may depend upon the protectiveness of the hood in its undeployed state, which is dependent on under-hood clearances and the size of the hood. Thus, a blanket requirement for a single threshold for all vehicles might not achieve all the potential benefits it could otherwise achieve if, for example, it did not deploy at a low enough speed. . However, a protocol may be needed to verify the thresholds are met under a variety of collision scenarios.

Head impacts below the deployment threshold. If a low-speed collision occurs below the hood activation threshold, a pedestrian may be placed in undue risk if the undeployed hood is overly stiff. In Euro NCAP, manufacturers are required to show that HIC values in actual headform impact tests on an undeployed hood are not exceedingly high (HIC values must be less than 1350) when the tests are run at the deployment threshold speed.

Width of bumper sensitivity. Relative to the width of the hood, the front-end vehicle width over which trigger sensors apply should be sufficiently wide. However, the legform test area specified by Euro NCAP (used in conjunction with the Flex-PLI to assess lower leg injuries) only extends to the edges of the bumper support structure. In the case of a vehicle with beveled front corners, the test area can be quite narrow (less than half the full width of some vehicles). Therefore, added assurance may be needed to verify that the hood deploys for any bumper-to-leg impact that could precede a head-to-hood impact.

Lifting device. The actuators used to raise the hood pose one of the greater risks to failure of the entire pop-up hood system. Test procedures may be needed to assure that the lifting linkages are strong enough for not only the initial lift but also to support the weight of the pedestrian's torso so that the hood does not collapse prior to or upon head-to-hood impact. In Euro NCAP, such assurances are provided by the manufacturer through computer simulations of vehicle-to-pedestrian collisions. For pyrotechnic devices, further requirements may be needed to assure that their performance does not degrade over time due to the harsh environmental conditions under a hood.

False deployments. Bumper sensors are tuned in some manner to differentiate between a human leg and an object of a similar shape. A test method for a pedestrian detection sensor may be needed to show that the trigger sensor is able to differentiate between a pedestrian and a common roadside object, such as a garbage can. False deployments are not explicitly covered by the Euro NCAP protocol. However, there could be visibility risks for occupants of a vehicle in motion whose pop-up hood deploys from a false-positive trigger event. Furthermore, deployed hoods have cost implications which require additional consideration. Not only is a pop-up hood system added cost to the vehicle at purchase, but it is also potentially an area for costly repairs. Will the driver be able to drive the vehicle with deployed hood to a repair shop, or will a tow truck be required? These are factors which need to be balanced when assessing false deployments. [11]

Overall objectivity. Standardized test methods with objective assessment criteria may be needed in order to fully assess the overall effectiveness of pop-up hood systems on real-world pedestrian safety. They may also be needed to assure conformity to given level of pedestrian safety by a third party. A performance requirement for a device that is reliant on a manufacturer to prescribe how it should be tested and assessed may lessen the ability of an independent evaluator to provide such assurances.

CONCLUSIONS

The range of vehicles in the Euro NCAP database shows that the early concerns about prohibitive cost and reliability of pop-up hoods did not appear to come to fruition. Our observations revealed the following:

• Since 2010, vehicles with pop-up hoods generally produced better Euro NCAP headform scores on average: 17.2 (out of a possible 24) for cars with pop-up hoods vs. 13.8 for cars with non-deploying hoods.

• From year-to-year, the Euro NCAP headform scores of cars with traditional, non-deploying hoods have been trending upwards. Nonetheless, in the latest year of our assessment (2014), the scores of cars with pop-up hoods were still higher.

• In 2014, there were 38 European new car models with pop-up hoods. The models tended to be in a higher price range (such as several Jaguar and Mercedes Benz models), but there are exceptions (examples: Hyundai Santa Fe, Mini Cooper).

• Cars with pop-up hoods comprise about 8% of all new light vehicles in Europe. These same vehicles comprise about 7% of new light vehicles sold in the U.S.

• Only one vehicle so far, the 2013 Skoda Octavia, has introduced pop-up hood technology as standard and later removed it.

• Pop-up hood technology is generally more costly than other passive strategies for protection pedestrians, but this examination of pop-up hood trends showed that sometimes a pop-up hood can lead to lower HIC values while enabling the vehicle to attain a better Euro NCAP score and still achieving a desired vehicle style.

• The Dodge Caravan exemplifies a situation where a pop-up hood provided an expedient means to achieve an acceptable pedestrian rating in a vehicle not originally designed for a market with pedestrian protection requirements. By fitting the sensing and lifting components to an existing design (rather than engaging in a lengthy and costly redesign of the vehicle front-end using a non-deploying hood), the vehicle was brought to the European market promptly.

• Notwithstanding the guidelines laid out in Section 2 of the Euro NCAP protocol, there is no standardized means to independently test and assess entire pop-up hood systems because of their unique and vehicle-specific operations. The basic technologies vary widely, and pop-up hoods activate within different speed ranges depending on the vehicle. These conditions make it difficult to develop a standardized test and criteria that is objective, uniform, and repeatable during testing across a fleet of vehicles with differing pop-up deployment designs.

Given the number of these systems in production today, it is clear that engineering has been able to overcome the initial technical challenges in a safe and reliable manner regardless of the remaining testing standardization challenges. Pop-up hoods are now yet another technical advance in the field of automotive engineering. The trends in the preceding analysis show that pop-up hoods are worthy of consideration for the development of new standardized test methods and assessment criteria.

ACKNOWLEDGMENTS
The authors would like to thank Euro NCAP for their support in the collection of vehicle test reports.

REFERENCES

[1] CLEPA European Association of Automotive Suppliers (2004). *INF GR/PA/67 Pedestrian Protection Test method – Active hood/bonnet systems.* [Working Paper]

[2] Euro NCAP (July 2012). *European New Car Assessment Programme (Euro NCAP) Assessment Protocol – Overall Rating, Version 6.0.* [Test Protocol].

[3] Euro NCAP (June 2014). *European New Car Assessment Programme (Euro NCAP) Assessment Protocol – Pedestrian Protection, Version 8.0.* [Test Protocol].

[4] Euro NCAP (June 2014). *European New Car Assessment Programme (Euro NCAP) Pedestrian Testing Protocol, Version 8.0.* [Test Protocol].

[5] Euro NCAP (2015). *The Car Selection Explained | Euro NCAP – For Safer Cars Crash Test Safety Rating.* [Web]. Retrieved January 8, 2015 from http://euroncap.com/ourtests/selectionexplained.aspx.

[6] European Motor News. (2013, May 30). *THE ALL-NEW VOLVO V40 – PEDESTRIAN AIRBAG TECHNOLOGY* [Video File]. Retrieved from http://www.youtube.com/watch?v=NCjVS_-6hYs

[7] Evrard, Borg (2011). *Innovative Bonnet Active Actuator (B2A) For Pedestrian Protection*, Proceedings of the 22nd International Technical Conference on the Enhanced Safety of Vehicles, paper 11-0113, Washington, D.C.

[8] Fredriksson, R., Boström, O., Chang, L.Y., Yang, K., (2006). *Influence of pop-up hood systems on brain injuries for vulnerable road users*. In: 2006 International IRCOBI Conference on the Biomechanics of Impact, Madrid, Spain.

[9] Key, Edwin (2012). "Volvo S40 Comes with Pedestrian Airbag." *Ubergizmo*.

[10] Honeywill, Tristan. (2013, June 27). Skoda withdraws pedestrian-friendly pop-up hood on Octavia [Online Article]. *Car Safety Rules*. Retrieved August 28, 2013 from http://www.carsafetyrules.com/skoda-withdraws-pedestrian-protecting-hood-on-octavia/0627/.

[11] Lawrence, G J L, Hardy, B J, et al. (2006). *A study on the feasibility of measures relating to the protection of pedestrians and other vulnerable road users* [Project Report]. Berkshire, England, United Kingdom: Transportation Research Laboratory Limited (TRL), EC Contract No. UPR/VE/045/06 ENTR/05/17.01.

[12] Nagatomi K, Hanayama K, Ishizaki T, Sasaki A, Matsuda K (2005), *Development and full-scale dummy tests of a pop-up hood system for pedestrian protection,* Proceedings of the 19th International Technical Conference on the Enhanced Safety of Vehicles (ESV) - Washington D.C. June 6-9, 2005.

[13] *Road Safety Information: Pop Up Bonnet* [Pamphlet]. September 2005, Birmingham, England, United Kingdom: The Royal Society for the Prevention of Accidents (RoSPA).

[14] Takahashi, H, Miyazaki, H, et al. (2013). *Development of Pop-Up Hood System for Pedestrian Protection*, Proceedings of the 23rd International Technical Conference on the Enhanced Safety of Vehicles, paper 13-0126, Seoul, Korea.

[15] United Nations (18 November 2004). *Global technical regulation No. 9: Pedestrian Safety* [Addendum to GTR]. Geneva, Switzerland.

[16] United Nations (6 December 2003). *INF GR/PS/104 Minimum Standard for Type Approval Testing of Active Deployable Systems of the Bonnet/Windscreen Area.* [Working Paper]

[17] United Nations (6 December 2003). *INF GR/PS/141 Certification Standard for Type Approval Testing of Active Deployable Systems of the Bonnet Area.* [Working Paper]

APPENDIX A

Table 2, below, includes the processed list of vehicles described above in the Methods section. At the end of the list of vehicles used in the above calculations, 12 additional vehicles which were sold in Europe with pop-up hoods but not tested by Euro NCAP are listed. These 12 additional vehicles were identified through other media outlets.

Table 2. Vehicle Database

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2000	Citroen	Saxo	3 door hatch	no	n/a	2	10	n/a	n/a	n/a
2000	Daewoo	Matiz	5 door hatch	no	n/a	2	15	n/a	n/a	n/a
2000	Daihatsu	Sirion	3 door hatch	no	n/a	3	19	n/a	n/a	n/a
2000	Fiat	Seicento	3 door hatch	no	n/a	2	13	n/a	n/a	n/a
2000	Ford	Fiesta	3 door hatch	no	n/a	1	8	n/a	n/a	n/a
2000	Ford	Ka	3 door hatch	no	n/a	1	9	n/a	n/a	n/a
2000	Honda	Accord	4 door saloon	no	n/a	2	16	n/a	n/a	n/a
2000	Honda	Logo	3 door hatch	no	n/a	2	14	n/a	n/a	n/a
2000	Lancia	Ypsilon	3 door hatch	no	n/a	2	12	n/a	n/a	n/a
2000	Nissan	Micra	3 door hatch	no	n/a	2	16	n/a	n/a	n/a
2000	Opel/Vauxhall	Corsa	3 door hatch	no	n/a	2	14	n/a	n/a	n/a
2000	Peugeot	206	3 door hatch	no	n/a	2	11	n/a	n/a	n/a
2000	Renault	Clio	3 door hatch	no	n/a	2	13	n/a	n/a	n/a
2000	Saab	9-3	5 door hatch	no	n/a	1	4	n/a	n/a	n/a
2000	Seat	Ibiza	3 door hatch	no	n/a	2	17	n/a	n/a	n/a
2000	Skoda	Fabia	5 door hatch	no	n/a	2	12	n/a	n/a	n/a
2000	Smart	City Coupe	2 door saloon	no	n/a	2	14	n/a	n/a	n/a
2000	Toyota	Yaris	3 door hatch	no	n/a	2	13	n/a	n/a	n/a
2000	Volvo	S80	4 door saloon	no	n/a	2	14	n/a	n/a	n/a
2000	VW	Beetle	2 door saloon	no	n/a	2	14	n/a	n/a	n/a
2000	VW	Lupo	3 door hatch	no	n/a	2	13	n/a	n/a	n/a
2000	VW	Polo	3 door hatch	no	n/a	2	13	n/a	n/a	n/a
2001	Alfa Romeo	147	3 door hatch	no	n/a	2	17	n/a	n/a	n/a
2001	Audi	A4	4 door saloon	no	n/a	1	7	n/a	n/a	n/a
2001	BMW	3 Series	4 door saloon	no	n/a	1	8	n/a	n/a	n/a
2001	Citroen	C5	5 door hatch	no	n/a	2	16	n/a	n/a	n/a
2001	Citroen	Picasso	5 door MPV	no	n/a	2	12	n/a	n/a	n/a
2001	Fiat	Multipla	5 door MPV	no	n/a	2	13	n/a	n/a	n/a
2001	Honda	Civic	5 door hatch	no	n/a	3	26	n/a	n/a	n/a
2001	Hyundai	Elantra	4 door saloon	no	n/a	2	16	n/a	n/a	n/a
2001	Mazda	Premacy	5 door MPV	no	n/a	3	19	n/a	n/a	n/a
2001	Mercedes	C-Class	4 door saloon	no	n/a	2	12	n/a	n/a	n/a
2001	Mitsubishi	Carisma	5 door hatch	no	n/a	2	16	n/a	n/a	n/a
2001	Mitsubishi	Space Star	5 door MPV	no	n/a	2	14	n/a	n/a	n/a
2001	Nissan	Almera	5 door hatch	no	n/a	2	16	n/a	n/a	n/a
2001	Nissan	Almera Tino	5 door MPV	no	n/a	2	16	n/a	n/a	n/a
2001	Opel/Vauxhall	Vectra	5 door hatch	no	n/a	2	14	n/a	n/a	n/a
2001	Opel/Vauxhall	Zafira	5 door MPV	no	n/a	2	13	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2001	Peugeot	307	5 door hatch	no	n/a	2	14	n/a	n/a	n/a
2001	Peugeot	406	4 door saloon	no	n/a	2	14	n/a	n/a	n/a
2001	Renault	Scenic	5 door MPV	no	n/a	2	10	n/a	n/a	n/a
2001	Rover	25	3 door hatch	no	n/a	2	18	n/a	n/a	n/a
2001	Rover	75	4 door saloon	no	n/a	2	13	n/a	n/a	n/a
2001	Skoda	Octavia	5 door hatch	no	n/a	2	14	n/a	n/a	n/a
2001	Volvo	S60	4 door saloon	no	n/a	2	14	n/a	n/a	n/a
2001	VW	Passat	4 door saloon	no	n/a	2	13	n/a	n/a	n/a
2002	Audi	A2	5 door hatch	no	n/a	1	5	n/a	n/a	n/a
2002	Chrysler	PT Cruiser	5 door MPV	no	n/a	1	3	n/a	n/a	n/a
2002	Citroen	C3	5 door hatch	no	n/a	2	11	n/a	n/a	n/a
2002	Ford	Fiesta	3 door hatch	no	n/a	2	14	n/a	n/a	n/a
2002	Ford	Mondeo	5 door hatch	no	n/a	2	13	n/a	n/a	n/a
2002	Honda	CR-V	5 door	no	n/a	3	19	n/a	n/a	n/a
2002	Hyundai	Santa Fe	off-roader	no	n/a	1	4	n/a	n/a	n/a
2002	Jaguar	X-Type	4 door saloon	no	n/a	1	2	n/a	n/a	n/a
2002	Land Rover	Freelander	off-roader	no	n/a	1	7	n/a	n/a	n/a
2002	Land Rover	Range Rover	Large Off-Road 4x4	no	n/a	1	2	n/a	n/a	n/a
2002	Mazda	MX-5	2-seater roadster	no	n/a	1	7	n/a	n/a	n/a
2002	Mercedes	E-Class	4 door saloon	no	n/a	1	4	n/a	n/a	n/a
2002	Mercedes	M-Class	off-roader	no	n/a	1	4	n/a	n/a	n/a
2002	Mercedes	SLK	2-seater roadster	no	n/a	1	8	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2002	Mercedes	Vaneo	5 door MPV	no	n/a	2	10	n/a	n/a	n/a
2002	MINI	One	3 door hatch	no	n/a	1	8	n/a	n/a	n/a
2002	Nissan	Primera	5 door hatch	no	n/a	1	9	n/a	n/a	n/a
2002	Nissan	X Trail	5 door	no	n/a	2	10	n/a	n/a	n/a
2002	Opel/Vauxhall	Corsa	3 door hatch	no	n/a	1	9	n/a	n/a	n/a
2002	Opel/Vauxhall	Frontera	5 door	no	n/a	1	2	n/a	n/a	n/a
2002	Opel/Vauxhall	Vectra	4 door saloon	no	n/a	1	5	n/a	n/a	n/a
2002	Peugeot	607	4 door saloon	no	n/a	1	3	n/a	n/a	n/a
2002	Proton	Impian	4 door saloon	no	n/a	1	4	n/a	n/a	n/a
2002	Renault	Megane	5 door hatch	no	n/a	2	11	n/a	n/a	n/a
2002	Saab	9-3	4 door saloon	no	n/a	1	7	n/a	n/a	n/a
2002	Seat	Ibiza	5 door hatch	no	n/a	2	14	n/a	n/a	n/a
2002	Suzuki	Grand Vitara	off-roader	no	n/a	0	0	n/a	n/a	n/a
2002	Toyota	Corolla	5 door hatch	no	n/a	2	11	n/a	n/a	n/a
2002	VW	Polo	5 door hatch	no	n/a	1	6	n/a	n/a	n/a
2003	Audi	A3	Small Family	no	n/a	1	8	n/a	n/a	n/a
2003	Audi	TT	2-seater roadster	no	n/a	0	0	n/a	n/a	n/a
2003	BMW	X5	5 door	no	n/a	1	2	n/a	n/a	n/a
2003	Citroen	C2	Super mini	no	n/a	2	12	n/a	n/a	n/a
2003	Citroen	C3 Pluriel	Super mini	no	n/a	2	13	n/a	n/a	n/a
2003	Ford	Focus C-MAX	Small MPV	no	n/a	2	14	n/a	n/a	n/a
2003	Ford	Fusion	Small MPV	no	n/a	2	11	n/a	n/a	n/a
2003	Honda	Accord	4 door saloon	no	n/a	2	16	n/a	n/a	n/a
2003	Hyundai	Trajet	MPV	no	n/a	1	9	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2003	Jeep	Cherokee	Small Off-Road 4x4	no	n/a	1	3	n/a	n/a	n/a
2003	Kia	Carnival/Sedona	MPV	no	n/a	1	4	n/a	n/a	n/a
2003	Kia	Sorento	Large Off-Road 4x4	no	n/a	1	3	n/a	n/a	n/a
2003	Mitsubishi	Pajero Pinin	off-roader	no	n/a	1	1	n/a	n/a	n/a
2003	Nissan	Micra	Super mini	no	n/a	2	12	n/a	n/a	n/a
2003	Opel/Vauxhall	Meriva	Small MPV	no	n/a	1	3	n/a	n/a	n/a
2003	Opel/Vauxhall	Signum	5 door hatch	no	n/a	1	1	n/a	n/a	n/a
2003	Peugeot	807	MPV	no	n/a	1	6	n/a	n/a	n/a
2003	Peugeot	307CC	Cabriolet	no	n/a	2	10	n/a	n/a	n/a
2003	Renault	Espace	MPV	no	n/a	2	10	n/a	n/a	n/a
2003	Renault	Kangoo	Small MPV	no	n/a	1	2	n/a	n/a	n/a
2003	Renault	Laguna	5 door hatch	no	n/a	2	12	n/a	n/a	n/a
2003	Renault	Scenic	Small MPV	no	n/a	2	11	n/a	n/a	n/a
2003	Saab	9-5	4 door saloon	no	n/a	2	12	n/a	n/a	n/a
2003	Skoda	Superb	4 door saloon	no	n/a	0	0	n/a	n/a	n/a
2003	Toyota	Avensis	4 door saloon	no	n/a	1	8	n/a	n/a	n/a
2003	Toyota	Previa	MPV	no	n/a	1	5	n/a	n/a	n/a
2003	Volvo	XC90	Large Off-Road 4x4	no	n/a	2	10	n/a	n/a	n/a
2003	VW	Touran	Small MPV	no	n/a	3	19	n/a	n/a	n/a
2004	Audi	A6	4 door saloon	no	n/a	1	3	n/a	n/a	n/a
2004	BMW	1 Series	5 door hatch	no	n/a	1	2	n/a	n/a	n/a
2004	BMW	5 Series	Executive	no	n/a	1	2	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2004	BMW	Z4	2-seater roadster	no	n/a	2	13	n/a	n/a	n/a
2004	Citroen	C4	Small Family	no	n/a	3	22	n/a	n/a	n/a
2004	Citroen	C5	Large Family	no	n/a	1	8	n/a	n/a	n/a
2004	Fiat	Doblo	Small MPV	no	n/a	1	1	n/a	n/a	n/a
2004	Fiat	Panda	Super mini	no	n/a	1	6	n/a	n/a	n/a
2004	Ford	Focus	5 door hatch	no	n/a	2	15	n/a	n/a	n/a
2004	Honda	Jazz	Super mini	no	n/a	3	19	n/a	n/a	n/a
2004	Hyundai	Getz	Super mini	no	n/a	1	5	n/a	n/a	n/a
2004	Kia	Picanto	Super mini	no	n/a	1	6	n/a	n/a	n/a
2004	Mazda	2	Super mini	no	n/a	2	10	n/a	n/a	n/a
2004	Opel/Vauxhall	Astra	5 door hatch	no	n/a	1	3	n/a	n/a	n/a
2004	Opel/Vauxhall	Tigra	2-seater roadster	no	n/a	2	10	n/a	n/a	n/a
2004	Peugeot	407	4 door saloon	no	n/a	2	15	n/a	n/a	n/a
2004	Renault	Megane CC	Cabriolet	no	n/a	2	11	n/a	n/a	n/a
2004	Renault	Modus	Super mini	no	n/a	1	6	n/a	n/a	n/a
2004	Saab	9-3 Convertible	Convertible	no	n/a	1	7	n/a	n/a	n/a
2004	Seat	Altea	Small MPV	no	n/a	3	22	n/a	n/a	n/a
2004	Skoda	Octavia	Family Saloon	no	n/a	2	17	n/a	n/a	n/a
2004	Toyota	Prius	4 door	no	n/a	2	13	n/a	n/a	n/a
2004	Volvo	S40	Family Saloon	no	n/a	2	18	n/a	n/a	n/a
2004	VW	Golf	5 door hatch	no	n/a	3	19	n/a	n/a	n/a
2004	VW	Touareg	Large Off-Road 4x4	no	n/a	1	7	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2005	BMW	3 Series	Large Family	no	n/a	1	4	n/a	n/a	n/a
2005	Chevrolet	Matiz	5 door hatch	no	n/a	2	13	n/a	n/a	n/a
2005	Citroen	C1	Super mini	no	n/a	2	14	n/a	n/a	n/a
2005	Daihatsu	Sirion	5 door hatch	no	n/a	2	15	n/a	n/a	n/a
2005	Fiat	Croma	Large Family	no	n/a	1	6	n/a	n/a	n/a
2005	Fiat	Grande Punto	3 door hatch	no	n/a	3	19	n/a	n/a	n/a
2005	Fiat	Stilo	Small Family	no	n/a	1	8	n/a	n/a	n/a
2005	Honda	FR-V	Small MPV	no	n/a	3	20	n/a	n/a	n/a
2005	Jeep	Grand Cherokee	Large Off-Road 4x4	no	n/a	0	0	n/a	n/a	n/a
2005	Kia	Rio	5 door hatch	no	n/a	2	13	n/a	n/a	n/a
2005	Lexus	GS	Executive	no	n/a	2	18	n/a	n/a	n/a
2005	Mazda	5	Small MPV	no	n/a	2	12	n/a	n/a	n/a
2005	Mazda	6	5 door hatch	no	n/a	1	5	n/a	n/a	n/a
2005	Mercedes	A-Class	Small Family	no	n/a	2	17	n/a	n/a	n/a
2005	Mitsubishi	Colt	5 door hatch	no	n/a	1	7	n/a	n/a	n/a
2005	Opel/Vauxhall	Zafira	Small MPV	no	n/a	2	16	n/a	n/a	n/a
2005	Peugeot	1007	3 door hatch	no	n/a	2	10	n/a	n/a	n/a
2005	Peugeot	407 Coupe		no	n/a	2	15	n/a	n/a	n/a
2005	Renault	Clio	Super mini	no	n/a	1	9	n/a	n/a	n/a
2005	Renault	Vel Satis	4 door saloon	no	n/a	1	2	n/a	n/a	n/a
2005	Seat	Leon	5 door hatch	no	n/a	3	24	n/a	n/a	n/a
2005	Smart	forfour	Super mini	no	n/a	1	7	n/a	n/a	n/a
2005	Suzuki	Swift	Super mini	no	n/a	3	20	n/a	n/a	n/a
2005	Toyota	Yaris	5 door hatch	no	n/a	2	18	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2005	VW	Fox	3 door hatch	no	n/a	2	12	n/a	n/a	n/a
2006	Alfa Romeo	159	4 door saloon	no	n/a	1	9	n/a	n/a	n/a
2006	Audi	Q7	5 door SUV	no	n/a	2	15	n/a	n/a	n/a
2006	Chevrolet	Aveo	4 door saloon	no	n/a	3	19	n/a	n/a	n/a
2006	Chevrolet	Kalos	5 door hatch	no	n/a	2	11	n/a	n/a	n/a
2006	Citroen	C6	4 door saloon	yes	n/a	4	28	n/a	n/a	n/a
2006	Fiat	Idea	5 door MPV	no	n/a	1	8	n/a	n/a	n/a
2006	Ford	Galaxy	5 door MPV	no	n/a	2	15	n/a	n/a	n/a
2006	Ford	S-MAX	5 door MPV	no	n/a	2	13	n/a	n/a	n/a
2006	Hyundai	Santa Fe	off-roader	no	n/a	0	0	n/a	n/a	n/a
2006	Hyundai	Sonata	5 door sedan	no	n/a	2	12	n/a	n/a	n/a
2006	Hyundai	Tucson	5 door	no	n/a	1	4	n/a	n/a	n/a
2006	Kia	Carnival /Sedona	5 door MPV	no	n/a	1	3	n/a	n/a	n/a
2006	Kia	Cerato	5 door hatch	no	n/a	1	8	n/a	n/a	n/a
2006	Kia	Magentis	4 door saloon	no	n/a	1	3	n/a	n/a	n/a
2006	Land Rover	Discovery	Large Off-Road 4x4	no	n/a	1	8	n/a	n/a	n/a
2006	Lexus	IS	5 door saloon	no	n/a	2	15	n/a	n/a	n/a
2006	Mazda	3	5 door hatch	no	n/a	2	15	n/a	n/a	n/a
2006	Mercedes	B-Class	5 door MPV	no	n/a	2	12	n/a	n/a	n/a
2006	Nissan	Note	5 door hatch	no	n/a	2	15	n/a	n/a	n/a
2006	Nissan	Pathfinder	5 door	no	n/a	2	18	n/a	n/a	n/a
2006	Opel/Vauxhall	Corsa	3 door hatch	no	n/a	3	19	n/a	n/a	n/a
2006	Peugeot	207	5 door hatch	no	n/a	3	19	n/a	n/a	n/a
2006	Skoda	Roomster	5 door MPV	no	n/a	2	14	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2006	Suzuki	SX4	5 door hatch	no	n/a	3	22	n/a	n/a	n/a
2006	Toyota	Auris	5 door hatch	no	n/a	3	21	n/a	n/a	n/a
2006	Toyota	RAV4	5 door SUV	no	n/a	3	21	n/a	n/a	n/a
2007	Chrysler	Voyager	5 door MPV	no	n/a	0	0	n/a	n/a	n/a
2007	Daihatsu	Materia	5 door hatch	no	n/a	2	16	n/a	n/a	n/a
2007	Dodge	Caliber	5 door hatch	no	n/a	1	5	n/a	n/a	n/a
2007	Fiat	500	3 door hatch	no	n/a	2	14	n/a	n/a	n/a
2007	Fiat	Bravo	5 door hatch	no	n/a	2	16	n/a	n/a	n/a
2007	Ford	Mondeo	5 door hatch	no	n/a	2	18	n/a	n/a	n/a
2007	Honda	Civic Hybrid	4 door sedan	no	n/a	3	21	n/a	n/a	n/a
2007	Honda	CR-V	5 door SUV	no	n/a	2	13	n/a	n/a	n/a
2007	Honda	Legend	4 door saloon	yes	n/a	3	n/a	n/a	n/a	n/a
2007	Kia	Carens	5 door MPV	no	n/a	1	9	n/a	n/a	n/a
2007	Kia	Cee'd	5 door hatch	no	n/a	2	11	n/a	n/a	n/a
2007	Land Rover	Freelander	5 door SUV	no	n/a	1	7	n/a	n/a	n/a
2007	Mazda	2	5 door hatch	no	n/a	2	18	n/a	n/a	n/a
2007	MINI	Cooper	3 door hatch	no	n/a	2	14	n/a	n/a	n/a
2007	Mitsubishi	Outlander	5 door SUV	no	n/a	2	17	n/a	n/a	n/a
2007	Nissan	Qashqai	5 door	no	n/a	2	18	n/a	n/a	n/a
2007	Nissan	X Trail	5 door SUV	no	n/a	2	12	n/a	n/a	n/a
2007	Peugeot	207CC	2-seater roadster	no	n/a	2	16	n/a	n/a	n/a
2007	Renault	Laguna	5 door hatch	no	n/a	2	10	n/a	n/a	n/a
2007	Renault	Twingo	3 door hatch	no	n/a	2	11	n/a	n/a	n/a
2007	Skoda	Fabia	5 door hatch	no	n/a	2	17	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2007	Smart	fortwo	2 door	no	n/a	2	10	n/a	n/a	n/a
2007	Suzuki	Grand Vitara	5 door SUV	no	n/a	3	19	n/a	n/a	n/a
2007	VW	Caddy	5 door MPV	no	n/a	2	13	n/a	n/a	n/a
2007	VW	Eos	2 door cabriolet	no	n/a	2	13	n/a	n/a	n/a
2008	Alfa Romeo	MiTo	3 door hatch	no	n/a	2	18	n/a	n/a	n/a
2008	BMW	X3	5 door SUV	no	n/a	1	5	n/a	n/a	n/a
2008	Citroen	Berlingo	5 door MPV	no	n/a	2	10	n/a	n/a	n/a
2008	Daihatsu	Terios	5 door SUV	no	n/a	3	19	n/a	n/a	n/a
2008	Ford	Fiesta	5 door hatch	no	n/a	3	20	n/a	n/a	n/a
2008	Ford	Ka	3 door hatch	no	n/a	2	11	n/a	n/a	n/a
2008	Ford	Kuga	5 door SUV	no	n/a	3	20	n/a	n/a	n/a
2008	Hyundai	i10	5 door hatch	no	n/a	3	21	n/a	n/a	n/a
2008	Hyundai	i30	5 door hatch	no	n/a	2	14	n/a	n/a	n/a
2008	Lancia	Delta	4 door saloon	no	n/a	2	15	n/a	n/a	n/a
2008	Mercedes	M-Class	Large Off-Road 4x4	no	n/a	1	6	n/a	n/a	n/a
2008	Mitsubishi	L200	4 door pickup	no	n/a	1	2	n/a	n/a	n/a
2008	Nissan	Navara	4 door pickup	no	n/a	2	14	n/a	n/a	n/a
2008	Renault	Kangoo	5 door MPV	no	n/a	2	14	n/a	n/a	n/a
2008	Renault	Koleos	Small Off-Road 4x4	no	n/a	2	14	n/a	n/a	n/a
2008	Renault	Megane	5 door hatch	no	n/a	2	11	n/a	n/a	n/a
2008	Seat	Ibiza	5 door hatch	no	n/a	3	19	n/a	n/a	n/a
2008	Suzuki	Splash	5 door hatch	no	n/a	3	19	n/a	n/a	n/a
2008	VW	T5	MPV	no	n/a	1	3	n/a	n/a	n/a

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2009	Audi	A4	Large Family	no	5	n/a	14	7.9	0.0	6.0
2009	Audi	Q5	Small Off-Road 4x4	no	5	n/a	12	5.5	0.0	6.0
2009	Chevrolet	Cruze	Small Family	no	5	n/a	12	6.2	0.0	6.0
2009	Chevrolet	Spark	Super mini	no	4	n/a	16	9.6	0.0	6.0
2009	Citroen	C3	Super mini	no	4	n/a	12	5.8	0.0	6.0
2009	Citroen	C3 Picasso	Small MPV	no	4	n/a	16	5.6	4.0	6.0
2009	Citroen	C4 Picasso	Small MPV	no	5	n/a	16	8.0	2.4	6.0
2009	Citroen	C5	Large Family	no	5	n/a	11	5.4	0.0	6.0
2009	Citroen	DS3	Super mini	no	5	n/a	13	6.3	0.3	5.9
2009	Honda	Accord	Large Family	no	5	n/a	19	13.3	0.0	6.0
2009	Honda	Civic	Small Family	no	5	n/a	24	12.2	6.0	6.0
2009	Honda	Insight Hybrid	Small Family	no	5	n/a	27	15.4	6.0	6.0
2009	Honda	Jazz	Super mini	no	5	n/a	22	10.4	5.2	6.0
2009	Hyundai	i20	Super mini	no	5	n/a	23	12.0	5.2	5.8
2009	Infiniti	FX	Large Off-Road 4x4	no	5	n/a	16	10.2	1.6	4.2
2009	Kia	Sorento	Large Off-Road 4x4	no	5	n/a	16	10.2	0.0	5.7
2009	Kia	Soul	Small MPV	no	5	n/a	14	8.0	0.0	5.9
2009	Mazda	3	Small Family	no	5	n/a	18	10.2	2.0	6.0
2009	Mazda	6	Large Family	no	5	n/a	18	10.1	1.5	6.0
2009	Mercedes	C-Class	Large Family	no	5	n/a	11	3.7	1.5	5.6
2009	Mitsubishi	Lancer	Small Family	no	5	n/a	12	7.5	0.0	4.7
2009	Opel/Vauxhall	Astra	Small Family	no	5	n/a	16	10.4	0.0	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2009	Opel/Vauxhall	Insignia	Large Family	no	5	n/a	14	8.3	0.0	6.0
2009	Peugeot	308	Small Family	no	5	n/a	19	7.7	5.3	6.0
2009	Peugeot	3008	Small Family	no	5	n/a	11	3.0	2.1	6.0
2009	Peugeot	5008	Small MPV	no	5	n/a	13	7.4	0.0	6.0
2009	Peugeot	308CC	Small Family	no	5	n/a	12	4.9	0.8	6.0
2009	Renault	Grand Scenic	Small MPV	no	5	n/a	15	6.8	2.3	6.0
2009	Saab	9-5	4 door saloon	no	5	n/a	16	9.9	0.0	6.0
2009	Skoda	Superb	5 door saloon	no	5	n/a	18	12.0	0.0	6.0
2009	Skoda	Yeti	5 door SUV	no	5	n/a	17	10.7	0.0	6.0
2009	Subaru	Impreza	5 door hatch	no	4	n/a	26	16.2	3.6	6.0
2009	Subaru	Legacy	5 door	no	5	n/a	21	15.1	0.0	5.8
2009	Suzuki	Alto	Super mini	no	3	n/a	13	9.5	0.0	3.3
2009	Toyota	Avensis	Large Family	no	5	n/a	19	12.6	0.5	6.0
2009	Toyota	iQ	Super mini	no	5	n/a	19	11.8	1.7	6.0
2009	Toyota	Prius	Large Family	no	5	n/a	24	14.9	4.3	5.2
2009	Toyota	Urban Cruiser	Small MPV	no	3	n/a	19	13.1	0.0	5.9
2009	Volvo	C30	Small Family	no	5	n/a	9	5.2	0.0	4.0
2009	Volvo	V70	Large Family	no	5	n/a	16	9.6	0.0	6.0
2009	Volvo	XC60	Small Off-Road 4x4	no	5	n/a	17	11.3	0.0	6.0
2009	VW	Golf	Small Family	no	5	n/a	22	12.0	3.9	6.0
2009	VW	Polo	Super mini	no	5	n/a	15	8.5	2.4	4.0
2009	VW	Scirocco	Small Family	no	5	n/a	19	7.1	6.0	6.0
2009	VW	Tiguan	Small Off-Road 4x4	no	5	n/a	17	11.2	0.0	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2010	Alfa Romeo	Giulietta	Small Family	no	5	n/a	23	13.5	3.1	6.0
2010	Audi	A1	Super mini	no	5	n/a	18	11.6	0.2	6.0
2010	BMW	5 Series	Executive	yes	5	n/a	28	22.0	0.0	6.0
2010	Citroen	C4	Small Family	no	5	n/a	15	7.9	4.5	6.0
2010	Citroen	Nemo	Small MPV	no	3	n/a	20	9.0	4.8	6.0
2010	Ford	C-MAX	Small MPV	no	5	n/a	18	13.0	0.9	4.0
2010	Ford	Grand C-MAX	Small MPV	no	5	n/a	18	13.0	0.9	4.0
2010	Honda	CR-Z	Super mini	no	5	n/a	25	15.5	6.0	4.0
2010	Hyundai	ix35	Small Off-Road 4x4	no	5	n/a	20	14.0	0.0	5.6
2010	Kia	Sportage	Small Off-Road 4x4	no	5	n/a	18	11.6	1.2	4.9
2010	Kia	Venga	Small Off-Road 4x4	no	5	n/a	23	12.8	4.2	6.0
2010	Mazda	CX-7	Small Off-Road 4x4	no	4	n/a	16	6.5	3.1	6.0
2010	Mercedes	E-Class	Executive	yes	5	n/a	21	15.2	0.0	6.0
2010	MINI	Countryman	Small MPV	no	5	n/a	23	15.3	1.5	6.0
2010	Nissan	Cube	Small MPV	no	4	n/a	20	14.0	0.3	6.0
2010	Nissan	Micra	Super mini	no	4	n/a	21	13.4	1.6	6.0
2010	Opel/Vauxhall	Meriva	Small MPV	no	5	n/a	20	15.0	0.9	4.0
2010	Seat	Alhambra	Large MPV	no	5	n/a	16	12.4	0.0	4.0
2010	Seat	Exeo	4 door saloon	no	4	n/a	18	12.2	0.0	5.9
2010	Suzuki	Swift	5 door hatch	no	5	n/a	22	18.4	0.0	4.0
2010	Toyota	Verso	Small MPV	no	5	n/a	25	18.8	0.0	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2010	VW	Passat	Large Family	no	5	n/a	19	14.0	0.0	5.3
2010	VW	Sharan	Large MPV	no	5	n/a	16	12.4	0.0	4.0
2011	Audi	A6	Executive	no	5	n/a	15	8.7	0.0	6.0
2011	Audi	Q3	Small Off-Road 4x4	no	5	n/a	19	12.8	0.0	6.0
2011	BMW	X3	Small Off-Road 4x4	no	5	n/a	19	13.1	0.0	6.0
2011	Chevrolet	Aveo	Super mini	no	5	n/a	19	13.7	0.2	5.3
2011	Chevrolet	Captiva	Small Off-Road 4x4	no	5	n/a	17	14.0	0.0	3.3
2011	Chevrolet	Orlando	Small MPV	no	5	n/a	18	13.1	0.0	4.5
2011	Chevrolet	Volt	Small Family	no	5	n/a	15	8.9	0.0	6.0
2011	Citroen	C-Zero	Super mini	no	4	n/a	17	11.2	0.0	6.0
2011	Citroen	DS4	Small Family	no	5	n/a	15	7.5	2.0	6.0
2011	Citroen	DS5	Large Family	no	5	n/a	15	6.3	2.2	6.0
2011	Dacia	Duster	Small Off-Road 4x4	no	3	n/a	10	10.0	0.0	0.0
2011	Fiat	Freemont	Large MPV	yes	5	n/a	18	12.0	0.0	6.0
2011	Fiat	Panda	Super mini	no	4	n/a	18	10.7	0.8	6.0
2011	Hyundai	i40	Large Family	no	5	n/a	16	8.1	1.5	6.0
2011	Hyundai	ix20	Small MPV	no	5	n/a	23	12.8	4.2	6.0
2011	Hyundai	Veloster	Small Family	no	5	n/a	18	7.3	4.4	6.0
2011	Jaguar	XF	Executive	yes	4	n/a	22	16.2	0.0	6.0
2011	Jeep	Grand Cherokee	Large Off-Road 4x4	no	4	n/a	16	10.1	0.0	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2011	Kia	Picanto	Super mini	no	4	n/a	17	9.2	1.5	6.0
2011	Kia	Rio	Super mini	no	5	n/a	17	11.3	0.0	5.4
2011	Lancia	Thema	Executive	yes	5	n/a	21	15.3	0.0	6.0
2011	Lancia	Voyager	Large MPV	yes	4	n/a	17	11.0	0.0	6.0
2011	Land Rover	Range Rover Evoque	Small Off-Road 4x4	no	5	n/a	15	8.8	0.0	6.0
2011	Lexus	CT200h	Small Family	no	5	n/a	20	13.5	0.2	6.0
2011	Mercedes	B-Class	Small MPV	no	5	n/a	20	14.1	0.0	6.0
2011	Mercedes	C-Class Coupe	Small Family	yes	5	n/a	21	14.6	0.0	6.0
2011	Mitsubishi	ASX	Small Family	no	5	n/a	22	17.6	0.0	4.0
2011	Mitsubishi	i-MiEV	Super mini	no	4	n/a	17	11.2	0.0	6.0
2011	Nissan	Juke	Super mini	no	5	n/a	15	9.5	0.8	4.4
2011	Opel/Vauxhall	Ampera	Small Family	no	5	n/a	15	8.9	0.0	6.0
2011	Opel/Vauxhall	Astra GTC	Small Family	no	5	n/a	18	12.0	0.0	6.0
2011	Opel/Vauxhall	Zafira Tourer	Small MPV	no	5	n/a	19	14.0	0.0	4.9
2011	Peugeot	508	Large Family	no	5	n/a	15	9.1	1.5	4.0
2011	Peugeot	iOn	Super mini	no	4	n/a	17	11.2	0.0	6.0
2011	Renault	Fluence ZE	Small Family	no	4	n/a	13	7.2	0.1	6.0
2011	Seat	Ibiza	Super mini	no	5	n/a	21	15.3	0.0	6.0
2011	Seat	Mii	Super mini	no	5	n/a	17	11.7	0.0	4.9
2011	Skoda	Citigo	3 door hatch	no	5	n/a	17	11.7	0.0	4.9
2011	Toyota	Yaris	Super mini	no	5	n/a	21	15.3	0.1	6.0
2011	VW	Beetle	Small Family	no	5	n/a	19	15.0	0.0	4.0
2011	VW	Golf Cabriolet	Small Family	no	5	n/a	19	11.3	3.9	3.8

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2011	VW	Jetta	Small Family	no	5	n/a	20	11.7	2.5	6.0
2011	VW	up!	Super mini	no	5	n/a	17	11.7	0.0	4.9
2012	Audi	A3	Small Family	no	5	n/a	27	19.6	1.0	6.0
2012	BMW	1 Series	Small Family	no	5	n/a	23	16.6	0.0	6.0
2012	BMW	3 Series	Large Family	no	5	n/a	28	15.9	6.0	6.0
2012	BMW	X1	Small Off-Road 4x4	no	5	n/a	23	16.9	0.0	6.0
2012	Citroen	C1	Super mini	no	3	n/a	19	13.2	0.0	6.0
2012	Citroen	Jumpy	Van-based people carrier	no	3	n/a	8	7.8	n/a	0.0
2012	Fiat	500L	Small MPV	no	5	n/a	23	15.0	2.5	6.0
2012	Fiat	Scudo	Van-based people carrier	no	3	n/a	8	7.8	0.0	0.0
2012	Ford	B-MAX	Small MPV	no	5	n/a	24	15.0	3.0	6.0
2012	Ford	Fiesta	Super mini	no	5	n/a	23	12.2	5.1	6.0
2012	Ford	Focus	Small Family	no	5	n/a	26	16.0	6.0	4.0
2012	Ford	Kuga	Small Off-Road 4x4	no	5	n/a	25	15.4	3.7	6.0
2012	Honda	Civic	Small Family	no	5	n/a	25	12.9	6.0	6.0
2012	Hyundai	H-1	Van-based people carrier	no	3	n/a	10	4.2	n/a	6.0
2012	Hyundai	i30	Small Family	no	5	n/a	24	14.3	4.0	6.0
2012	Hyundai	Santa Fe	Large Off-Road 4x4	yes	5	n/a	25	18.6	0.9	6.0
2012	Isuzu	D-Max	4 door pickup	no	4	n/a	18	12.4	0.0	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2012	Jeep	Compass	Small Off-Road 4x4	no	2	n/a	8	8.4	0.0	0.0
2012	Kia	Cee'd	Small Family	no	5	n/a	22	12.6	3.6	5.8
2012	Land Rover	Range Rover	Large Off-Road 4x4	no	5	n/a	23	16.6	0.0	6.0
2012	Mazda	CX-5	Small Off-Road 4x4	no	5	n/a	23	17.0	0.2	6.0
2012	Mercedes	A-Class	Small Family	yes	5	n/a	24	18.0	0.0	6.0
2012	Mercedes	M-Class	Large Off-Road 4x4	yes	5	n/a	21	17.4	0.0	4.0
2012	Mitsubishi	Outlander	Small Off-Road 4x4	no	5	n/a	23	16.9	0.0	6.0
2012	Nissan	Leaf	Small Family	no	5	n/a	23	15.2	3.0	5.1
2012	Opel/Vauxhall	Mokka	Small Family	no	5	n/a	24	18.0	0.0	6.0
2012	Peugeot	107	Super mini	no	3	n/a	19	13.2	0.0	6.0
2012	Peugeot	208	Super mini	no	5	n/a	22	12.5	3.5	6.0
2012	Peugeot	Expert	Van-based people carrier	no	3	n/a	8	7.8	n/a	0.0
2012	Renault	Clio	Super mini	no	5	n/a	24	11.8	5.9	6.0
2012	Renault	Trafic	Passenger Van	no	2	n/a	8	8.5	n/a	0.0
2012	Seat	Leon	5 door hatch	no	5	n/a	25	16.9	2.2	6.0
2012	Seat	Toledo	5 door hatch	no	5	n/a	25	16.6	2.1	6.0
2012	Skoda	Rapid	5 door hatch	no	5	n/a	25	16.6	2.1	6.0
2012	Subaru	Forester	5 door SUV	no	5	n/a	26	20.3	0.0	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2012	Subaru	XV	5 door hatch	no	5	n/a	23	16.9	0.0	6.0
2012	Toyota	Aygo	Super mini	no	3	n/a	19	13.2	0.0	6.0
2012	Volvo	V40	Small Family	yes	5	n/a	32	24.0	2.0	5.8
2012	Volvo	V60	Large Family	no	5	n/a	23	14.7	2.8	5.7
2012	VW	Golf	Small Family	no	5	n/a	24	14.8	2.8	6.0
2013	BMW	i3	Small Family	no	4	n/a	21	14.8	0.0	6.0
2013	Chevrolet	Trax	Small Family	no	5	n/a	23	17.1	0.0	6.0
2013	Citroen	C4 Picasso	Small MPV	no	5	n/a	25	15.3	3.3	6.0
2013	Dacia	Sandero	Super mini	no	4	n/a	21	14.8	0.0	6.0
2013	Ford	EcoSport	Small Family	no	4	n/a	21	14.7	0.4	6.0
2013	Ford	Tourneo Connect	Small MPV	no	5	n/a	22	16.2	0.3	6.0
2013	Honda	CR-V	Small Off-Road 4x4	no	5	n/a	25	15.8	2.9	6.0
2013	Infiniti	Q50	Executive	yes	5	n/a	24	19.1	0.0	5.1
2013	Jeep	Cherokee	Small Off-Road 4x4	no	5	n/a	24	16.9	1.6	6.0
2013	Kia	Carens	Small MPV	no	5	n/a	23	15.4	1.7	6.0
2013	Lexus	IS 300h	Large Family	yes	5	n/a	29	16.9	6.0	6.0
2013	Maserati	Ghibli	Executive	no	5	n/a	27	14.8	6.0	6.0
2013	Mazda	3	Small Family	no	5	n/a	24	17.1	0.5	6.0
2013	Mazda	6	Large Family	no	5	n/a	24	17.8	0.0	6.0
2013	Mercedes	CITAN Kombi	Small MPV	no	4	n/a	20	14.0	0.5	5.9
2013	Mercedes	CLA-Class	Small Family	yes	5	n/a	27	17.0	4.0	6.0
2013	Mitsubishi	Space Star/Mirage	Super mini	no	4	n/a	26	16.5	3.8	6.0

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2013	Nissan	Evalia	Small MPV	no	3	n/a	24	14.4	5.0	4.8
2013	Nissan	Note	Super mini	no	4	n/a	21	15.0	0.0	6.0
2013	Opel/Vauxhall	Adam	Super mini	no	4	n/a	24	13.6	4.0	6.0
2013	Peugeot	308	Small Family	no	5	n/a	23	12.2	5.2	6.0
2013	Peugeot	2008	Super mini	no	5	n/a	26	16.0	4.2	6.0
2013	Renault	CAPTUR	Super mini	no	5	n/a	22	13.4	2.7	6.0
2013	Renault	ZOE	Super mini	no	5	n/a	24	14.2	3.9	6.0
2013	Skoda	Octavia	5 door hatch	no*	5	n/a	24	16.5	1.6	6.0
2013	Suzuki	SX4	Small Family	no	5	n/a	26	20.2	0.0	6.0
2013	Toyota	Auris	Small Family	no	5	n/a	25	16.8	2.0	6.0
2013	Toyota	RAV4	Small Off-Road 4x4	no	5	n/a	24	18.0	0.0	6.0
2013	VW	T5	Business and family van	no	4	n/a	10	9.8	0.0	0.0
2014	Audi	A3 Saloon	Small Family	yes	5	n/a	24	18.0	0.1	6.0
2014	BMW	2 Series Active Tourer	Small Family	yes	5	n/a	22	14.9	2.0	4.9
2014	Citroen	Berlingo	Small MPV	no	3	n/a	23	13.3	3.5	6.0
2014	Citroen	C4 Cactus	Small Family	no	4	n/a	29	17.1	6.0	6.0
2014	Dacia	Logan MCV	Small MPV	no	3	n/a	20	14.8	0.0	5.2
2014	Ford	Mondeo	Large Family	no	5	n/a	24	17.9	0.0	6.0
2014	Ford	Tourneo Courier	Super mini	no	4	n/a	27	16.3	4.6	6.0
2014	Hyundai	i10	Super mini	no	4	n/a	26	16.0	3.7	6.0
2014	Kia	Sorento	Large Off-Road 4x4	yes	5	n/a	24	18.3	0.0	5.9

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2014	Kia	Soul	Small MPV	no	4	n/a	21	15.3	0.0	6.0
2014	Kia	Soul EV	Small MPV	no	4	n/a	21	15.3	0.0	6.0
2014	Land Rover	Discovery Sport	Small Off-Road 4x4	yes	5	n/a	25	19.2	0.0	5.9
2014	Lexus	NX	Small Off-Road 4x4	no	5	n/a	25	18.8	0.1	6.0
2014	Mercedes	C-Class	Large Family	yes	5	n/a	28	21.0	0.8	5.9
2014	Mercedes	GLA-class	Small Off-Road 4x4	yes	5	n/a	24	18.4	0.0	6.0
2014	MG Motor	MG 3	Super mini	no	3	n/a	21	16.4	0.0	5.1
2014	Mini	Cooper (F56)	Super mini	yes	4	n/a	24	18.1	0.0	6.0
2014	Nissan	Pulsar	Small Family	no	5	n/a	27	15.8	5.5	6.0
2014	Nissan	Qashqai	Small Family	no	5	n/a	25	15.8	3.1	6.0
2014	Nissan	X Trail	Small Off-Road 4x4	no	5	n/a	27	15.4	5.8	6.0
2014	Opel/Vauxhall	Corsa	Super mini	no	4	n/a	26	14.3	5.3	6.0
2014	Porsche	Macan	Small Off-Road 4x4	no	5	n/a	22	15.6	0.0	6.0
2014	Renault	Megane Hatch	Small Family	no	4	n/a	22	14.2	1.6	6.0
2014	Renault	Twingo	Super mini	no	4	n/a	25	15.3	3.2	6.0
2014	Skoda	Fabia	Super mini	no	5	n/a	25	14.6	4.4	6.0
2014	Smart	forfour	Super mini	no	4	n/a	24	15.2	2.4	6.0
2014	Smart	fortwo	Super mini	no	4	n/a	20	13.3	1.2	6.0
2014	Subaru	Outback	Large Family	no	5	n/a	25	18.9	0.4	6.0
2014	Tesla	Model S	Executive	yes	5	n/a	24	13.9	4.1	5.8

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2014	Toyota	Aygo	Super mini	no	4	n/a	23	16.3	0.2	6.0
2014	VW	Golf Sportsvan	Small MPV	no	5	n/a	22	16.4	0.0	6.0
2014	VW	Passat	Large Family	no	5	n/a	24	15.3	2.6	6.0
2007	Jaguar	XK		yes						
2009	Nissan	GT-R		yes						
2009	Porsche	Panamera		yes						
2011	Peugeot	RCZ		yes						
2012	BMW	6-Series Coupe		yes						

Vehicle Information					Euro NCAP Scores					
					Overall	Pedestrian Scores				
Yr	Make	Model	Ctgry	Pop Up ?	Stars (/5)	Stars (/4)	Pts (/36)	Head (/24)	Pelvis (/6)	Leg (/6)
2013	Cadillac	ATS		yes						
2013	Cadillac	CTS		yes						
2013	Fiat	Punto		yes						
2013	Mazda	MX-5 Roadster (Miata)		yes						
2014	Aston Martin	DB9		yes						
2014	Aston Martin	Vanquish		yes						
2014	Jaguar	F-type		yes						

*The Skoda Octavia was originally to be sold with a pop-up hood as standard equipment and was tested by Euro NCAP as such. Later, Skoda announced the pop-up hood would no longer be included as standard, so Euro NCAP retested the vehicle without the pop-up hood. The scores on the report for this vehicle are for the test without the pop-up hood deployment [10].

APPENDIX B

Table 3. Vehicles With Pop-up Hoods and Euro NCAP Scores

Year	Make	Model
2006	Citroen	C6
2007	Honda	Legend
2010	BMW	5-series
2010	Mercedes	E-class
2011	Fiat	Freemont
2011	Lancia	Thema
2011	Lancia	Voyager
2011	Mercedes	C-Class Coupe
2012	Hyundai	Santa Fe
2012	Jaguar	XF
2012	Mercedes	M-Class
2012	Volvo	V40
2013	Infiniti	Q50
2013	Lexus	IS 300h
2013	Mercedes	A-Class
2013	Mercedes	CLA-Class
2014	Audi	A3 Saloon
2014	BMW	2 Series Active Tourer
2014	Kia	Sorento
2014	Land Rover	Discovery Sport
2014	Mercedes	C-Class
2014	Mercedes	GLA-Class
2014	Mini	Cooper (F56)
2014	Tesla	Model S