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Consumer Information; New Car Assessment Program; Notice

DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

[Docket No. NHTSA–2006–26555]

Consumer Information; New Car Assessment Program

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Final decision notice.

SUMMARY: On January 25, 2007, NHTSA published a notice announcing a public hearing and requesting comments on an agency report titled, ''The New Car Assessment Program (NCAP) Suggested Approaches for Future Program Enhancements.'' This notice summarizes the comments received and provides the agency's decision on how it will improve the NCAP ratings program.

For model year (MY) 2010, the agency will make changes to its existing front and side crash rating programs. For the frontal crash test program, NHTSA will maintain the 35 mph (56 kmph) full frontal barrier test protocol but will update the test dummies and associated injury criteria used to assess and assign a vehicle's frontal impact star rating. For side impact, NHTSA will maintain the current moving deformable barrier test at 38.5 mph (63 kmph) but will update that test to include new side impact test dummies and new injury criteria that are used to assign a vehicle's side impact star rating. Additionally, vehicles will also be assessed using a new pole test and a small female crash test dummy.

For rollover, the agency will continue to rate vehicles for rollover propensity, but will wait to update its rollover risk model to allow for more real-world crash data of vehicles equipped with electronic stability control.

Also for MY 2010, the agency will implement a new ratings program that will rate vehicles on the presence of select advanced technologies and establish a new overall Vehicle Safety Score that will combine the star ratings from the front, side, and rollover programs.

Finally, for the agency's vehicle labeling program, we are announcing that the side score, rather than being based only on the moving deformable barrier test, will be based on the combination of the moving deformable barrier test and the pole test. Additionally, the agency will initiate rulemaking to include the new overall crashworthiness rating on the Monroney label.

DATES: These changes to the New Car Assessment Program are effective for the 2010 model year.

FOR FURTHER INFORMATION CONTACT: For technical issues concerning the enhancements to NCAP, contact Mr. Nathaniel Beuse or Mr. John Hinch. Telephone: (202) 366–9700. Facsimile: (202) 493–2739. For legal issues, contact Dorothy Nakama, NHTSA Office of Chief Counsel, Telephone (202) 366–2992. Facsimile: (202) 366–3820. You may send mail to these officials at: The National Highway Traffic Safety Administration, Attention: NVS–010, 1200 New Jersey Avenue, SE., Washington, DC 20590.

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I. Introduction

The National Highway Traffic Safety Administration (NHTSA) is responsible for reducing deaths, injuries, and economic losses resulting from motor vehicle crashes. One way in which NHTSA accomplishes this mission is by providing consumer information to the public. NHTSA established the New Car Assessment Program (NCAP) in 1978 in response to Title II of the Motor Vehicle Information and Cost Savings Act of 1972. Through NCAP, NHTSA currently conducts tests and provides frontal and side crash, and rollover ratings and communicates the results using a five-star rating system. With this information, consumers can make better-informed decisions about their purchases. In turn, manufacturers respond to the ratings by voluntarily improving the safety of their vehicles beyond the minimum Federal safety standards.

For MY 1979, when the agency began rating vehicles for frontal impact safety, fewer than 30 percent of vehicles tested would have received the top ratings of 4 or 5 stars for the driver seating position.[1] By comparison, for MY 2007, 98 percent of vehicles received 4 and 5 stars in the frontal NCAP rating for that same seating position. Equally impressive is that while it took almost 30 years to reach this level for frontal NCAP performance, the more recent NCAP programs, like side and rollover NCAP, have started reaching this level of safety performance at a pace that can be measured in years rather than decades. The agency believes that consumers continue to consider safety in their purchasing decisions and are demanding ever-increasing levels of safety.

Similarly, recent advances in crash avoidance technology offer a new opportunity for NCAP to further enhance its ability to inform consumers about new systems and encourage them to purchase systems that NHTSA has found to be effective in improving safety.

On January 25, 2007 NHTSA published a notice outlining proposed enhancements to the NCAP activities. In this notice, we requested comments on any additional actions that the agency could undertake so that the program could continue to provide consumers with relevant safety information.[2] These enhancements included new test dummies and injury criteria for frontal NCAP, the addition of a new side pole test, new test dummies, and new injury

[1] NHTSA began using stars in model year 1994. See 69 FR 61072, Docket No. NHTSA–2004–18765.

[2] 72 FR 3473, Docket No. NHTSA–2006–26555.

criteria for side NCAP, an overall summary rating, and a new program to promote advanced crash avoidance technologies. Additionally, the notice announced a March 7, 2007 public hearing to allow interested parties the opportunity to address the suggested approaches for enhancing the program.

Seventy-six (76) individual comments were received in response to the notice and the public hearing.[3] Commenters offered mixed responses to the various proposals for enhancing NCAP; however, most commenters commended the agency's initiative to reexamine the program and supported the proposed approaches. This notice summarizes comments to the January 2007 notice, the March 2007 public hearing, and provides the agency's decision on how it will proceed with changes to NCAP.

I. Summary of Request for Comments

In its notice, the agency presented proposals to improve not only the program's current front, side and rollover activities, but also approaches to improve its information with regards to rear impact, and certain crash avoidance (or active safety) technologies such as Electronic Stability Control (ESC). NHTSA also outlined alternatives to enhance the presentation and dissemination of safety information to consumers, and solicited feedback for additional considerations that would allow NCAP to remain effective and relevant in improving vehicle safety.

A. Frontal NCAP

NHTSA proposed three approaches to enhance the frontal NCAP. The first approach was to maintain the current 35 mph (56 kmph) test protocol with a 50th percentile male Hybrid III dummy, but to account for injuries to the knee/thigh/hip (KTH) complex. This would be accomplished by including a new injury criterion into the formula used to calculate the frontal NCAP rating for the driver and front passenger seating positions. Second, while keeping the test protocol the same, the agency considered determining whether injury measures obtained below the knee using the Denton or Thor-Lx dummy legs are predictive of real-world injuries. Last, the agency considered evaluating vehicles based on a lower test speed.

B. Side NCAP

To enhance its side impact safety ratings, the agency presented two approaches for consideration. NHTSA proposed continuing to rate vehicles using the moving deformable barrier test protocol but would also encourage manufacturers to provide better head and pelvis protection by including the side impact pole test and the new test dummies recently finalized in Federal Motor Vehicle Safety Standard (FMVSS) No. 214 ''Side Impact Protection'' prior to the performance requirements being fully phased-in.[4] Furthermore, the agency proposed research that would focus on the assessment of the injury mechanisms in a fully equipped side impact air bag fleet. The purpose of the research would be to evaluate how serious injuries occur in the new fleet and to develop test procedures to reflect these impact conditions. The outcome of this research could lead to a new barrier test protocol (which could include increased test speed and different barrier characteristics).

C. Rollover NCAP

To enhance its rollover program, the agency indicated that it would continue tracking the rollover rate and the single vehicle crash rate of vehicles equipped with ESC to create a new rollover risk model.

D. Rear Impact

Currently, NHTSA does not provide consumer information on rear impacts. However, NHTSA is aware of recent research suggesting that consumers are concerned about rear crashes. As such, the agency proposed two approaches. First, NHTSA proposed that it could provide consumers with basic information on rear crashes such as safe driving behavior, proper adjustment of head restraints, real-world safety data by vehicle classes, and links to the Insurance Institute of Highway Safety (IIHS) rear impact test results. Second, as a longer term approach, the agency proposed that a dynamic test, which addresses those injuries not covered by the agency's current standards, could be investigated and incorporated into the ratings program.

E. Crash Avoidance Technologies

Technologies such as ESC, forward collision warning (FCW), lane departure warning (LDW) and crash mitigation systems have been developed and are being offered in the current vehicle fleet. Some of these technologies have shown effectiveness in reducing the number of relevant crashes in Department of Transportation (DOT)-sponsored field operational tests.[5] Research by the agency and others has shown that consumers are generally unaware of these technologies or their potential safety benefits. As a result, the agency believed that NCAP should be used to better highlight those beneficial technologies to consumers and sought to establish a new ratings program that evaluated vehicles on the presence of proven crash avoidance technologies. Based on technical maturity, fleet availability, and available effectiveness data, NHTSA identified three technologies that fit these criteria. These technologies are ESC, LDW, and FCW.

NHTSA proposed two possible approaches and illustrated a possible implementation of the program with an A, B, C letter grade system. First, the agency proposed that each of the technologies would have equal weight. For example, if a vehicle had only one technology, it would receive a C; whereas, another vehicle that had all three technologies would receive an A. Approach two would attempt to quantify a technology's real-world benefits by taking into account the target population and anticipated effectiveness of the technology to decide whether a particular type of technology would be given more weighting than another and thus prompt a higher score. For example, in this scheme, if ESC was found to be more effective than lane departure, a vehicle equipped only with ESC could receive a B versus a vehicle equipped only with lane departure warning which would receive a C rating.

It was further stated that this second approach could be expanded into a more comprehensive performance-based crash avoidance rating. As the technologies evolved and as the agency gathered more information related to various versions of these technologies and their associated safety effectiveness, NHTSA proposed that a safety score (i.e., star rating) on individual technologies could then be developed (e.g., different version of ESC might yield different performance results and thus a different star rating).

F. Presentation and Dissemination of NCAP Information

Combined Crashworthiness Rating

Several NHTSA-sponsored research reports and consumer surveys, as well as a Government Accountability Office and a National Academy of Sciences review of NCAP, have all pointed to the public's desire for a summary safety rating. Similarly, other consumer information programs around the world

[3] This count does not include duplicative or multiple comments from the same source.

[4] 73 FR 32473, Docket No. NHTSA–2008–0104. On June 9, 2008 the agency responded to petitions for reconsideration of the final rule, changing the effective date of the pole test. Now, with certain exceptions, all vehicles have to meet the upgraded pole test by September 1, 2014.

[5] See 72 FR 3475, Docket No. NHTSA–2006–26555.

such as the IIHS, Japan NCAP, and EuroNCAP use summary ratings that combine their respective crashworthiness tests. The agency proposed two summary crashworthiness rating concepts. In both concepts, the existing rollover rating was not included in the calculation of the overall summary rating, and star rating boundaries would have to be developed for both individual crash tests and the overall summary rating.

The first approach computed the overall crashworthiness rating by first averaging the driver and right front passenger dummy injury results from the frontal crash mode into a single star rating. The same would be done for the seating positions in the side crash mode to compute the overall side crash rating. To compute the overall crashworthiness rating, the overall frontal and the overall side impact performance would be combined by using weighting factors obtained from real-world data (i.e. the National Automotive Sampling System (NASS)). Each individual total (overall front and overall side) would be weighted by that crash mode's contribution to the total injuries occurring in the real-world.

The second approach computed the overall crashworthiness rating by normalizing the seating positions for each individual crash mode (front and side) using the Injury Assessment Reference Values (IARVs) established for that dummy, body region, and crash mode. Using the NASS data, these normalized values would then be multiplied by the occurrence of that injury in the real-world. Body injury regions that are coded by NASS but are not measured by the dummy and/or not selected by NHTSA for inclusion in the rating would be equally distributed among the remaining body regions.

Presentation of Safety Information

As the consumer's use of the Internet for vehicle safety information has grown, so has the need to consolidate and better present NCAP vehicle safety information to consumers on *http://www.safercar.gov.* The four approaches proposed by the agency were: (1) Developing other topical areas under the Equipment and Safety section of the Web site; (2) redesigning the Web site to improve organization; (3) improving search capabilities on the Web site; and, (4) combining agency recall and ratings database information.

G. Manufacturer Self-Certification

In addition to NHTSA's proposed suggestions in the notice the agency also sought comment at the public hearing on whether or not manufacturers should be allowed to conduct and publish their own NCAP ratings via a self-certification process. We indicated that such an approach would be one way to improve not only the timeliness of NCAP ratings but also to increase the number of vehicles rated by the agency.

III. Summary of Comments

This section provides a brief summary of the seventy-six (76) comments submitted to the docket by vehicle manufacturers, safety advocates, public health groups and the general public in response to the notice and the public hearing.[6] It should be noted that comments unique to the public hearing are stated as such.

A. Frontal NCAP

Comments regarding NHTSA's frontal program are grouped into four categories: Impact Protocol, Test Dummies (in the Front Seating Position), Injury Criteria and Test Speed.

1. Impact Protocol

The Alliance of Automobile Manufacturers (Alliance), Automotive Occupant Restraints Council (AORC), Toyota Motor North America, Inc. (Toyota), BMW of North America (BMW), Fuji Heavy Industries USA, Inc. (Subaru) and Volkswagen of America, Inc. (VW) supported the retention of the current frontal crash test protocol at 35 mph (56 kmph). Consumers Union and Public Citizen suggested adding an offset frontal crash test rating, which Public Citizen believed would be far more useful in assessing the structural integrity of different vehicle models. Likewise, Toyota also encouraged NHTSA to investigate ways to include information on offset collision conditions in its NCAP program. Toyota explained that their investigation of National Automotive Sampling System Crashworthiness Data System (NASS–CDS) data showed that an overwhelming majority of frontal crashes occur in either the full overlap or offset condition. They believed that vehicle performance assessed in the offset condition should yield relevant improvements in safety technology and provide considerable benefit.

IIHS and Subaru recommended the addition of a frontal pole test to address significant injuries resulting from impacts with narrow objects. IIHS asserted that offset tests more closely simulate impacts with narrow objects than do full-width tests, and that a narrow-object NCAP test could have an important impact on real-world vehicle crashworthiness, and would give consumers a wide range of results to inform their purchasing decisions. Subaru suggested that NHTSA should study and possibly propose a frontal pole test for inclusion into NCAP if the frequency of frontal crashes with narrow objects is high. However, General Motors North America (GM) asserted that a pole test is unlikely to result in significant change or further improvement in structural stability and resultant injury reduction. They stated that research in this area may yield only limited or incremental gains in injury mitigation, and that the public interest is likely to be better served by channeling resources into areas that could produce greater societal benefit.

2. Test Dummies (in the Front Seating Position)

With regard to test dummies, the Alliance stated that test dummies in frontal NCAP should be the same as those in FMVSS No. 208. Additionally, GM, AORC, Consumers Union and the Alliance supported the use of the 5th percentile female Hybrid III dummy in the right front passenger position. GM provided NASS data which suggested that small females were over-represented (with regard to serious injuries) in the right front passenger seating position. GM also suggested that in the future, the 5th percentile female dummy should be used in both seating positions to optimize safety. AORC asserted that the substitution of the 5th female for the 50th percentile male would demonstrate a broader population range of protection since some data has been shown which suggests that the weighted frequency of serious and fatal injuries to women is greater than to men in the right front passenger seating position.

Furthermore, Consumers Union asserted that the agency should investigate using the 5th percentile female and 95th percentile male dummies to evaluate NCAP tests for all sizes of vehicle occupants. Subaru supported the continued use of 50th percentile adult male dummies in both front seating positions indicating that this was more representative of real-world occupants. Subaru also asserted that additional tests with other dummies, such as the 5th percentile adult female, should be done only if well supported by real-world data.

3. Injury Criteria

Most vehicle manufacturers agreed that NHTSA should develop and incorporate a KTH injury criterion into

[6] These submissions are available at *http://www.regulations.gov* in Docket No. NHTSA–2006–26555.

the NCAP frontal rating. They noted that a KTH assessment would drive vehicle countermeasures that could mitigate lower leg injuries and also yield important information relevant to vehicle design. Likewise, adding KTH and/or lower leg injury criteria to the NCAP rating protocol could expand the usefulness of the NCAP system by addressing the societal cost of Abbreviated Injury Scale (AIS) 2+ injuries. The Alliance, Autoliv, Consumers Union and IIHS also supported NHTSA's efforts to incorporate a KTH injury criterion into the frontal program. However, IIHS urged the agency to concentrate its research tests on serious injuries and fatalities in frontal impacts to encourage more protective vehicle design. Additionally, Autoliv stated that although a reduction in KTH injuries would have a significant impact on societal cost, they believed that it would have little effect in reducing fatalities.

Nissan North America (Nissan) stated that the agency should consider a KTH assessment only after further study is conducted. Instead, Nissan urged NHTSA to harmonize knee and thigh injury values with those required in Japanese and European regulations. Likewise, the Association of International Automobile Manufacturers (AIAM) did not believe that the agency should move expeditiously to include a KTH criterion in the current frontal NCAP program since the agency had identified crashes of lower test speed as the primary concern regarding leg injuries. They recommended that NHTSA present the analysis and results of their KTH research for public comment prior to including a KTH criterion in the frontal program.

For lower leg assessments, several commenters suggested that additional research was needed to determine whether injury measures obtained below the knee were predictive of real-world injury. GM noted that adding a femur load injury criterion to frontal NCAP would drive many of the same vehicle countermeasures that would mitigate lower leg injuries.

With regards to what anthropomorphic test device (ATD) could be used for these new criteria (KTH and lower leg), Honda specifically stated that a KTH assessment would be possible using the Denton dummy leg. For injuries to the lower leg (below the knee), Honda, Subaru, Nissan, and Volvo Cars of North America, LLC (Volvo), suggested that the agency adopt the Thor-Lx legs in the future. The Alliance did not support the introduction of either the Denton or Thor-Lx legs unless they were included in FMVSS No. 208. Furthermore, VW believed that these test devices must be validated, and the applicable injury criteria and rating must be verified for correlation with real-world safety.

Some commenters suggested that all injury criteria incorporated in FMVSS No. 208 (beyond head injury criteria and chest acceleration criteria) should also be included in frontal NCAP. Specifically, Honda, Ford, GM, the Alliance, and Autoliv supported the inclusion of a chest deflection criterion into the frontal NCAP rating based on NASS–CDS data indicating a substantial number of injuries to ribs and internal organs resulting in AIS 3+ or higher severity injuries. However, Honda stated that the current chest deflection calibration procedure may not be appropriate to assure that chest deflection measurements are accurate enough to provide useful data. GM and the Alliance recommended including a chest compression criterion into frontal NCAP. The Alliance urged NHTSA to conduct research on neck (tension) injury criteria before including it into frontal NCAP. However, GM suggested that the agency add neck injury criteria to frontal NCAP since these criteria are already measured by the Hybrid III dummies and included in FMVSS No. 208.

4. Test Speed

With regards to adopting a lower test speed, the Alliance, GM and Volvo agreed with NHTSA's analysis and supported the agency's proposal to conduct more research on lower test speeds. However, VW questioned whether lower speed crashes represented a greater risk of occupant injury than the current NCAP test procedure. Therefore, VW as well as the Alliance believed that an additional test in frontal NCAP would add significant expense and strain on available resources without any commensurate advantages or benefit.

Subaru asserted that they did not support adding low speed bumper tests to frontal NCAP since those tests would overlap with existing IIHS tests.

Two individual commenters, Mr. Dainius Dalmotas and Dr. Harold Mertz stated that a full vehicle crash test designed to promote enhanced chest protection in low-to-moderate speed frontal crashes would be most promising since the vast majority of serious and fatal injuries among belted drivers occur at collision speeds of 25 mph (40 kmph) or less. They also asserted that incentives to promote improved safety in low-to-moderate speed frontal impacts were lacking and could be addressed through NCAP.

At the public hearing, Consumers Federation of America (CFA) and the Center for Auto Safety (CAS) suggested that NHTSA increase test speeds and challenge manufacturers to post the highest speed at which their vehicles are tested, in order to differentiate amongst the performance of vehicles. However, the Alliance, Consumers Union, AIAM and Subaru opposed a higher speed test for frontal NCAP. The Alliance stated that field data did not show the need for higher test speeds. AIAM and Consumers Union did not believe that increasing crash test speeds would benefit the overall safety of occupants; but rather, it could cause vehicles to become stiffer. Subaru asserted that a higher speed test is not representative of the vast majority of fatal crashes, does not enhance NCAP's consumer information goals, and risks increasing vehicle aggressiveness.

B. Side NCAP

Comments regarding NHTSA's side program are divided into the following categories: Oblique Pole Test (Test Dummies and Implementation Time), Moving Barrier Protocol (Test Speed, Test Dummies, and Injury Criteria), and Side NCAP Research.

1. Oblique Pole Test (Test Dummies and Implementation Time)

GM, Subaru, Toyota, the Alliance, and Autoliv agreed with the agency's proposal to incorporate an oblique pole test into NCAP. However, with regards to adopting the oblique pole test prior to the completion of the FMVSS No. 214 pole test phase-in, BMW, Ford, Toyota, and the Alliance, asserted that such action would be premature, and these commenters suggested that NHTSA adopt the test after the oblique pole test had been fully phased-in. Furthermore, Subaru suggested that 3 years be allowed after the agency announced a new test before rating vehicles under the new test protocol.

Toyota explained that they understood NHTSA's intention to use an early introduction of the pole test to drive the installation of advanced head protection systems (like curtain airbags), but they believed that significant benefits in head protection were already being realized from the introduction of curtain air bags, which was driven by industry's commitment to the industry voluntary compatibility requirements.[7]

[7] IIHS and the Alliance created a voluntary agreement wherein automotive manufacturers agreed to improve occupant protection in front and side crashes involving cars and light trucks. For front-to-side impacts, most automakers agreed to design their vehicles to meet the head injury

Continued

Therefore, Toyota recommended additional investigation into whether there are merits of an early introduction of an oblique pole test into NCAP. Honda recommended adding to the existing side impact test by introducing a second side impact test that is similar to the current IIHS moving deformable barrier (MDB) test.[8] Honda suggested that this would extend the coverage of NHTSA's side impact testing, be more representative of real-world crashes, and help to provide a more realistic assessment of a vehicle's crashworthiness in these types of two-vehicle collisions.

If the agency went forward with an oblique pole test, Subaru recommended a side impact assessment based on two tests (the oblique pole test and IIHS's MDB test) with head injury criteria and the SID–IIs dummy, as long as the results could be combined into a single rating. BMW and the Alliance suggested that the 5th percentile female SID–IIs dummy be used for the driver position in the oblique pole test. BMW asserted that the smaller SID–IIs dummy is most appropriate for determining the geometric coverage area required for a curtain airbag. The Alliance believed that it is appropriate to test only with the 5th percentile female dummy in the front seating position because this is a very severe test condition, and it would serve to meet the intent of NCAP while minimizing additional test burdens on NHTSA and the automotive industry.

Honda, Nissan and VW did not support the inclusion of an oblique pole test into side NCAP. Honda believed that introducing an oblique pole test would be a temporary measure until the test was fully phased-in as a requirement for FMVSS No. 214. To comply with the requirements of FMVSS No. 214, the head protection benefits of the oblique pole test would already have been realized in every vehicle, so there would be little practical benefit to consumers as a result of temporarily including such a test in NCAP. VW and Nissan, similar to Toyota, stated that automobile manufacturers were already committed to front-to-side impact protection, and that the addition of a side impact pole test would provide no added incentive for the manufacturers to implement additional side impact protection. Nissan also believed that incorporating the pole test into NCAP is unnecessary to encourage head protection in new vehicles.

IIHS stated that the current NCAP barrier test did not fully address the mix of vehicles on the road and that the agency needed to improve the existing side impact barrier. IIHS suggested giving greater priority to adopting or modifying the IIHS side impact barrier rather than incorporating a new oblique pole test. However, GM asserted that the pole test is structurally more challenging than the IIHS MDB test, and that the IIHS MDB test and the pole test will not necessarily drive installation of the same air bag solutions.

2. Moving Barrier Protocol (Test Speed, Test Dummies, and Injury Criteria)

NHTSA proposed a new side NCAP barrier test protocol that would include new dummies and additional injury criteria. The Alliance supported the maintenance of the current barrier test but they suggested a revised, lower test speed of 33.5 mph (54 kmph).

With regards to the incorporation of new dummies into the side MDB test, the Alliance, Subaru, Honda, Nissan, Volvo, and AIAM proposed the incorporation of WorldSID into NCAP. Specifically, Volvo and the Alliance suggested that the WorldSID dummy should be introduced in FMVSS No. 214 and NCAP simultaneously. Honda stated that the WorldSID dummy provides excellent biofidelity, and does not present problems with rib guide shape that the ES–2re dummy appears to have based on their evaluation. AORC believed that the current test dummy does not adequately address head injuries, and they encouraged NHTSA to use either EuroSID–2 and/or the SID–IIs side impact dummy.

Volvo recommended that the dummies and injury criteria for the NCAP side barrier test procedures be the same as they are for FMVSS No. 214. Volvo supported the addition of head injury criteria in the NCAP evaluation for the side barrier; however, they would prefer that the NCAP criteria limits are set more stringent in order to encourage manufacturers to exceed the performance standards outlined in the legal requirement. BMW recommended that NHTSA use the ES–2re dummy for the driver position in the MDB test because the SID–IIs dummy is already included in the MDB test conducted by IIHS, and the biofidelity of the SID–IIs dummy in these types of impacts is well understood. GM also suggested the ES–2re dummy for the driver position since the most frequent occupant, and most frequently injured occupant type at the driver position is an adult male.

Autoliv asserted that the ES–2re dummy should be used for the front seating position in both the oblique pole and MDB tests, as this dummy represents the largest percentage of front seat occupants. They also recommended the SID–IIs dummy for the rear seating position to provide information on protection for older children and small adults seated in the rear. GM also recommended the SID–IIs dummy for the rear seating position because more frail persons tend to sit in the rear, the SID–IIs dummy is tuned for frail occupants, and placement in the rear will import safety improvements across the range of occupants.

3. Side NCAP Research

As a longer term approach, the agency suggested research into the moving barrier test protocol to address injuries and fatalities that might occur in vehicles equipped with curtain and side impact air bags. The agency indicated this research could lead to a new barrier, an increased barrier test speed, and a reevaluation of the impact configuration.

The Alliance, AIAM, Honda and Subaru agreed that NHTSA should analyze real-world side impact crashes for vehicles with side curtain airbags. However, the Alliance recommended that the agency and automotive industry should develop more experience with the new pole test and test dummies before considering any increase in test speeds. In addition, the Alliance asserted that future research should evaluate whether it would be beneficial for NCAP to harmonize with the existing IIHS barrier.

Toyota supported additional research efforts to gain a better understanding of the potential for and the necessity of changes to the test device and configuration for vehicles equipped with side airbags. Furthermore, Toyota stated that questions remain relating to barrier characteristics, injury criteria and appropriate ATDs that should be researched from relevant field data.[9]

Autoliv recommended that NHTSA research increasing the test speed and develop a single test that would assess both the head and thorax injury protection systems installed in newer vehicles. Autoliv also suggested that the adoption of the WorldSID dummy would be suitable if incorporated into Part 572 and FMVSS No. 214.

performance requirements of NHTSA's FMVSS No. 201 side-pole test or the IIHS moving deformable barrier test. By September 1, 2007, at least half of all new passenger vehicles would meet one of the two requirements, and by September 1, 2009 model year, all new passenger vehicles would meet the head injury requirements of the Institute's moving deformable barrier test.

[8] This test would represent an SUV to subject vehicle crash (IIHS Side Impact Crash Evaluation test procedure—SICE).

[9] In particular, Toyota recommended continued investigation into previously identified concerns with the performance of the SID–IIs upper arm, which they believed was not biofidelic and affected the thoracic rib response.

Additionally, Delphi opposed releasing a new regulation under FMVSS No. 214 and then promoting a different set of barrier protocols, dummy types and injury metrics for side NCAP evaluation since that decision could cause misdirection for original equipment manufacturers and suppliers.

C. Rollover NCAP

Comments regarding NHTSA's rollover program are grouped into the following categories: Rollover Risk Model and Dynamic Rollover Structural Test.

1. Rollover Risk Model

Most commenters supported the development of a new rollover risk model. Several commenters agreed that real-world crash data was necessary to develop an effective rollover risk model. Specifically, the Alliance, AIAM, the National Automobile Dealers Association (NADA), and VW each commented that NHTSA should collect new crash data for rollover NCAP. In particular, the Alliance and Ford recommended that the agency collect crash data on both ESC and non-ESC equipped vehicles to develop a new rollover risk model that better describes rollover risk for all vehicles, but also accurately reflects the differences between ESC and non-ESC vehicles. Toyota believed that the update to rollover NCAP should reflect real-world benefits of ESC on rollover risk, and that the rollover rating should be combined (with advanced technologies) into an overall crash avoidance rating. AIAM suggested that NHTSA consider adjusting a vehicle's rollover risk rating to reflect the safety benefits of ESC or adopt some other means of communicating those benefits to consumers.

Recognizing that since such a data collection and analysis cannot be completed in the near term, Ford, the Alliance and Volvo suggested that in the near term, an additional rollover NCAP star should be awarded to those vehicles equipped with an ESC system to recognize the benefits of ESC. Specifically, the Alliance recommended that NHTSA provide additional information in the form of a footnote on the agency's Web site and in the Safer Car brochure that explains the benefits of ESC and why these benefits warrant an additional star.

2. Dynamic Rollover Structural Test

Some commenters encouraged NHTSA to develop a test for structural integrity to enhance rollover NCAP. Specifically, Consumers Union, Public Citizen and ARCCA Incorporated (ARCCA) urged the agency to consider a dynamic test to assess body structure, seat belt design (including pretension), side curtain airbags, roof strength, door locks and retention, and the retention of window glazing. In particular, Public Citizen believed that a rollover NCAP rating should be based on a vehicle's ability to resist rollover and to protect occupants in a rollover crash. They suggested a rating that included ejection as a consideration since this would provide valuable information about a vehicle's ability to prevent death or serious injury in a rollover crash. Additionally, the rating should measure rollover propensity, as well as crashworthiness measures of performance in a rollover crash.

The Center for Injury Research (CIR) recommended that an NCAP rollover test be dynamic and somewhat more severe than a dynamic compliance standard. According to CIR, a dynamic test for use as both a safety compliance standard and as an NCAP test can and should be developed simultaneously with action on the roof crush standard. Moreover, CFA and CAS recommended adding a rollover test with comparative roof crush tests, while IIHS suggested that NHTSA should conduct additional research on roof crush. Bidez and Associates stated that a meaningful rollover crashworthiness test must include roof deformation, seat belt performance, door opening, and window breakage. They emphasized that protection should be assessed for front and rear passengers, adults and children, and that the Jordan Rollover System (JRS) holds great promise. Conversely, the Alliance, Ford and Nissan opposed the use of JRS in NCAP. The Alliance commented, and Ford and Nissan stated at the public meeting that there has been no JRS tests conducted with an instrumented dummy and therefore, the JRS test results cannot be related scientifically to the real-world risk of injury in a rollover crash.

D. Rear Impact

Comments regarding NHTSA's rear impact NCAP activity are divided into the following categories: Basic Information, Links to the IIHS, and Dynamic Test.

1. Basic Information

Commenters presented similar views on how NHTSA should provide consumers with basic information concerning rear impact crashes in an NCAP publication. GM, Toyota, Subaru and VW supported the inclusion of information on the proper adjustment and utilization of head restraint systems. Additionally, GM supported consumer education that included material such as safety tips and safe driving practices.

2. Links to the IIHS

The IIHS endorsed the agency's proposal and offered their head restraint evaluation information for posting on the agency's Web site. Toyota believes that the IIHS results are only one way to assess rear impact performance, and thus the agency should be cautious and thorough when determining what rear impact evaluation should be part of a future NCAP evaluation. They also stated that ample consideration should be given to passive and active head restraint concepts in order to maintain benefits from all design types.

The Alliance felt that NHTSA's proposal did not seem consistent with the principle of the Federal government independently generating all NCAP data. Rather, they advocated that the agency should investigate further the injury mechanism of whiplash and then choose which responses to evaluate based on biomechanics. Similarly, GM discouraged NHTSA from implementing this option. According to GM, links to the IIHS Web site might imply that NHTSA has given full endorsement of IIHS methodology and interpretations, and some consumers may even conclude that IIHS is a government agency.

3. Dynamic Test

The Alliance believed that NHTSA should first evaluate potential effectiveness and safety benefits prior to incorporating a rear crash rating into NCAP. Consumers Union stated that rear impact whiplash injuries are debilitating to those involved and cause a large cost to society. Consumers Union recommended that NHTSA look at IIHS's work on rear impact testing to determine whether developing NCAP ratings for rear impact results would be cost effective. Public Citizen suggested that the agency develop a rear-impact crash NCAP rating, especially at speeds of 35 to 40 mph (56 to 64 kmph) to improve rear-impact occupant protection and seat back strength. Furthermore, ARCCA stated that rear impact testing for fuel integrity should be utilized, and that this type of testing would enable the agency to assess occupant kinematics and interactions in rear impacts.

Nissan recommended that NHTSA harmonize with the global technical regulation (GTR) dynamic test

procedure.[10] GM stated that the development of a dynamic test by NHTSA should be considered only after recent revisions to FMVSS No. 202 are assessed. According to GM, if the regulatory changes are shown to be effective in mitigating injury, a rear impact NCAP could be better directed toward areas not fully addressed by the current regulation. Similarly, while Subaru did not support new requirements for FMVSS No. 202a in the short term, they asserted that NHTSA needs to educate consumers on the proper use and adjustment of head restraints. However, Subaru believed that in the long term, NHTSA should focus on the study of whiplash-type injury mechanisms and applicable countermeasures.

E. Crash Avoidance Technologies

Comments regarding NCAP information on crash avoidance technologies are grouped into three categories: Program Implementation, Selected Technologies, and Rating System.

1. Program Implementation

Most commenters encouraged NHTSA to implement a new component into NCAP to rate vehicles on the presence of crash avoidance technologies. They agreed that such a program would help educate consumers about these technologies and encourage manufacturers to include them in more vehicles. According to Ford, the first step would be to identify promising technologies with measurable real-world safety benefits. Next, those items must be assessed using developed performance based metrics, and finally, the assessments should be used to develop crash avoidance NCAP ratings that balance rating flexibility with stability.

GM emphasized an overarching principle that crash avoidance NCAP should be biased toward including features that have a high likelihood of improving safety. GM suggested further that the agency consider a wording revision, perhaps to 'Collision Avoidance and Post-Crash Safety (CAPS)' NCAP so that a technology such as Automatic Collision Notification could be considered and included.

Honda encouraged NHTSA to consider a program that would define the various crash avoidance technologies. They stated that these definitions should be based on the effect each function of a particular system has from the driver's point of view, and include a clear explanation of the actions the system can take to enhance safety. Honda, along with Delphi, suggested the development of assessment-weighting coefficients derived from a system's expected benefits and the frequency of the crash type (using appropriate U.S. databases) that the system is supposed to address.

BMW suggested a program that would accomplish the agency's goals without over-promising consumers on expected performance and avoid crediting systems prematurely. They suggested a program that would differentiate technologies with real-world effectiveness from those whose effectiveness numbers were generated by some other means. They also suggested that NHTSA and manufacturers collaborate on ways to educate consumers on emerging technologies with promising capabilities and proven benefits.

Mercedes-Benz (Mercedes) recommended that NHTSA work with the automotive industry before developing crash avoidance ratings. To develop future ratings they, along with Continental Automotive Systems, supported the idea of creating an advisory panel that represents the viewpoints of all manufacturers competing in the U.S. market.

Nissan agreed with the agency's desire to implement this new program. They also stated that the agency should identify immediately its priority technologies through a press release, on the NCAP Web site, through the ''Buying a Safer Car'' brochure, and on each vehicle's NCAP summary Web page.

IIHS and NADA were not convinced of the need for NCAP crash avoidance ratings at this time. IIHS suggested that NHTSA should not rate vehicle crash avoidance technologies, since the agency cannot currently identify which systems are most effective.

2. Selected Technologies

Nissan and Delphi agreed with the three technologies selected by the agency. However, GM and Toyota believed that there were additional crash avoidance technologies that should be promoted because they would provide safety value to consumers. For brevity, we chose not to list them all in this document, but they included such things as daytime running lights, backover prevention technology, and advanced collision notification. GM further believed that there were data for some of these crash avoidance technologies and methods by which potential benefits could be assessed, and they could be included in the initial implementation of a crash avoidance NCAP. GM felt that limiting crash avoidance technologies to the three identified by the agency would unnecessarily limit the potential safety benefits to consumers.

3. Rating System

a. Cumulative Rating (NHTSA's Approach 1)

There was little support for NHTSA's proposed Approach 1. In the short term, only Nissan supported a simple cumulative rating whereby each priority technology would be weighted the same. Both the Alliance and GM were opposed to this approach. GM believed that a cumulative rating would not discriminate among the three technologies, and they would prefer that NHTSA weight appropriately safety-enhancing features based on their relative benefits. The Alliance stated that the effectiveness of the selected technologies was not equal, and providing equal weighting would significantly mislead the consumer as to their relative safety benefits.

Rather than a star rating or the use of a cumulative rating, BMW suggested a ''thumbs up'' rating system to assist consumers in quickly and intuitively distinguishing among technologies on the basis of maturity. BMW believed that this approach would deliver to consumers two levels of information: which technologies have the potential for success and which technologies have a history of success. Furthermore, BMW felt that this approach would reduce the need for NHTSA to research, analyze and document the actual benefits of a technology. Mercedes believed that NCAP should issue publications that would rank the merits of emerging technologies in a manner similar to that used in the IIHS status reports, and that NHTSA should communicate with the industry so that public safety messages could be coordinated with industry advertisements.

b. Effectiveness Rating (NHTSA's Approach 2)

Nissan, in the long term, along with Toyota, Volvo, Public Citizen, AORC, the Alliance, AIAM and GM favored the agency's proposed Approach 2 of establishing an effectiveness rating for crash avoidance technologies. Toyota, however, believed that it would be ideal to develop information related to each new technology's safety potential and to establish a ''Graduated Comprehensive Crash Avoidance Rating System'' concept. They also recommended

[10] See *http://www.unece.org/trans/doc/2007/wp29/WP29-143-23r1e.doc*. This is an agreement to begin work on Phase 2 of this GTR, which will analyze a revised dynamic test procedure incorporating the BioRID–II dummy.

further study to expand the list of technologies beyond ESC, lane departure warning and forward collision warning to include systems such as rear pre-collision preparation/warning, emergency stop signal, blind zone alert, vehicle-to-vehicle and vehicle-to-infrastructure communications.

F. Presentation of NCAP Information

Comments regarding the presentation and dissemination of NCAP focused mainly on a combined crashworthiness rating. A few commenters offered suggestions on the dissemination of NCAP information. NADA suggested that NHTSA develop, maintain and make available a database of non-agency sources of credible vehicle safety information. The CAS and CFA suggested that the agency implement additional and more sophisticated systems that deliver safety information at the point of sale. They believed this information should be beyond the agency's new NCAP labeling program (no examples were given).

Combined Crashworthiness Rating

Most responders to the NCAP notice expressed support for an overall crashworthiness rating that combined the results from all the crash modes (front and side) tested. However, IIHS cautioned that an all-encompassing single rating may allow some poor performance qualities to be hidden under the umbrella rating. Therefore, they urged NHTSA to provide consumers with all of the scores in each crash mode to allow them to choose which vehicle to purchase. Additionally, Delphi, Public Citizen and Bidez and Associates noted that while a single overall crashworthiness rating would simplify information for consumers, it could also confuse consumers if not based on sound science.

Toyota believed there is merit to combining ratings for crashworthiness evaluations to provide the consumer with a comprehensive summary of the crash performance of the vehicle in front and side impacts. They recommended weighting the injuries and assessment in each impact condition by the distribution of serious injuries (AIS3+) and fatalities. After determining the weighting factors for each injury, each impact configuration should receive similar ''Field Relevance Weighting'' based on frequency, severe injury risk, and occupancy. Because of the small number of fatalities in NASS, Toyota suggested exploring FARS augmented with the Multiple Cause of Death (MCOD) database.

Honda supported a combined crashworthiness rating that covers a wide variety of real-world collisions. Honda recommended compatibility testing that assesses performance in crashes between two vehicles with different geometries and/or weights. Further, they recommended weighting coefficients for each region of the crash test dummy, representing specific types of injuries, based on real-world crash and injury data.

The Alliance generally supported the concept of a combined crashworthiness rating. They believed that it is possible to combine the different body regions into a single star rating for both frontal and side. However, they noted that the frontal NCAP ratings are vehicle-weight dependent while the side NCAP ratings are generally weight independent. Thus, the Alliance asserted that a combined crashworthiness rating would be comparable only within vehicle weight class. Moreover, AIAM urged NHTSA to ensure that a single rating is meaningful in terms of real-world performance to drive safety improvements in all crash modes. They recommended that changes to the star system be considered only if based on appropriate research involving consumer surveys or focus groups, and not on intuitive judgments about what data presentation is most effective.

Public Citizen supported a single rating if it were weighted with respect to saving lives and preventing injuries. They also suggested that NHTSA use a letter grade rating system instead of ''stars.'' Volkswagen believed that the agency should consider a single crash rating only until a crash avoidance NCAP rating grows in substance and scope. Delphi expressed that a combined crashworthiness rating would obscure safety benefits; rather, they supported a Euro NCAP style point system and recommended that key performance-based assessments be presented as the primary information and that feature-based indicators be presented as of secondary importance.

G. Manufacturer Self-Certification (of NCAP Results)

With regards to manufacturers providing their own NCAP test results, GM and Toyota supported the implementation of a type-approval program wherein NHTSA would oversee NCAP testing conducted by the manufacturer. GM felt that NHTSA's attendance (or the presence of a NHTSA representative) would allow appropriate scrutiny of the testing and ensure consumer confidence in such a program. Additionally, they strongly discouraged implementation of any program that could compromise NHTSA-sanctioned vehicle ratings because of results obtained through spot-checking (presumably conducted by NHTSA). Bidez and Associates, Consumers Union and Public Citizen urged NHTSA to consider a manufacturer self-certifying process in which the industry would test and rate its own vehicles and undergo spot checking of their test results by NHTSA. According to these commenters, the benefit of such a program would be to disseminate NCAP test information on newly-introduced vehicles more rapidly than under the current system.

H. Other Suggestions

In addition to the approaches that NHTSA had proposed to further enhance its NCAP crashworthiness and crash avoidance activities, commenters submitted other recommendations to the agency. These comments on other possible approaches to improving NCAP are grouped into the following categories: Child Restraints and Rear Seat Testing, Lighting, and Pedestrians.

1. Child Restraints

Public Citizen suggested that NHTSA incorporate a dynamic child restraint system (CRS) test into NCAP in all crash modes (including frontal, rollover, side and rear crashes). They recommended that a six-year old Hybrid III dummy be restrained in a backless booster and a 5th percentile female Hybrid III dummy be placed in a 3-point belt in both rear-outboard seating positions. ARCCA recommended adding instrumented child dummies to the outboard-designated seating positions in the rear to investigate issues associated with accommodations and crash performance of rear-seated occupants resulting from cargo.

Bidez & Associates asserted that the agency should build upon and leverage the experience of EuroNCAP in child protection to force design innovation in rear seat safety for six to twelve-year olds.[11] They believed there was a need to enhance frontal impact protection of nine to twelve-year old children who are properly belted in the rear seat. Their research for restrained nine to twelve-year old children suggested that rear seat occupants had a risk of serious injury 78 percent higher than that of front seat occupants. They estimated that the overall injury rate for all restrained nine to twelve-year olds in all crash types was 38 percent higher in the rear seat than in the front seat. As such,

[11] The commenter did not provide specific detail as to what design innovations have occurred as a result of the EuroNCAP activity.

Bidez & Associates recommended that NHTSA immediately warn consumers, retract its message to parents about placing children in the rear, and force the automobile industry to upgrade the safety of the rear occupant area of the existing and future vehicle fleet.

Subaru, GM and the Alliance opposed implementation of a CRS test into NCAP. GM asserted that there can be no meaningful dynamic NCAP test for CRS until there is a meaningful way to tie a CRS NCAP performance rating to real-world performance. They believed that it is inappropriate to invent a test and claim correlation to real-world safety performance improvements without sound data to back this claim. These commenters felt that using child safety seats in NCAP vehicle tests would confound the test results and would not lead to a meaningful vehicle or CRS rating. Additionally, the Alliance asserted that the real-world safety benefits of child restraints demonstrate the children are already very well-protected in the rear seat. As such, they believed that adding child dummies in child restraints to the rear seating position for front or side NCAP testing would not maximize advancements in child protection.

Volvo suggested that if the agency wanted to develop a child restraint test, then the test should be performed on a sled, and they asserted that there should be improvements in FMVSS No. 213. According to Volvo, the restrictions for design and testing of the restraints, as set up in this standard, basically prohibit innovative concepts with improved performance for reducing misuse and improper installation and for improving safety performance in a crash. To improve child safety, Consumers Union recommended that NHTSA pursue research toward an NCAP rating on (rear) vehicle visibility since they believed that data from Kids and Cars and others suggest that children are most at risk from poor visibility and blind zones around the vehicle.

2. Rear Seat Testing

Adding rear seat dummies into the frontal NCAP program was encouraged by some commenters. In particular, AORC and Bidez and Associates suggested the addition of the 5th percentile female or the 10-year old dummy. However, AORC asserted that an analysis of field data would be needed to determine the most appropriate dummy and seating position, and that dummy development may be required in this area to better measure abdominal injuries that may be present among belted occupants in the rear seat.

Individual commenter Mr. Todd Saczalski recommended rear seat testing with adult and child dummies and child restraints to assess the difficulty exiting the vehicle and to examine injuries due to seat back failure. The Children's Hospital of Philadelphia (CHOP) stated that the agency should place an older belt-restrained dummy, such as the six or ten-year old Hybrid III child dummy, in the rear seat of the NCAP frontal test to better understand rear restraint systems for child occupants. Additionally, they encouraged the use of a belt-positioning booster seat with the six-year old Hybrid III dummy.

Subaru did not support adding dummies to the rear seating position. Subaru stated that it might not be possible, with the current front seat positioning procedure, to properly position a 50th percentile male Hybrid III dummy in the rear seat of some vehicles; the result could be inconsistent performance evaluations across all vehicles.

3. Lighting

Some public commenters expressed concerns about lighting and glare related to daytime running lights (DRLs). However, the glare comments were focused on the agency's rulemaking activity and not its consumer information activity. Therefore, daytime running lights are not discussed in this notice. GM stated that numerous field effectiveness studies conducted throughout the world show that DRLs could prevent some crashes. Citing an analysis of field data suggesting that under daytime conditions, daytime running lights can prevent 5 percent of opposite direction crashes and 12 percent of pedestrian and pedalcyclist crashes, GM encouraged NHTSA to expand the installation of DRLs and include this technology in its crash avoidance rating so that manufacturers will be encouraged to install them and provide additional collision avoidance benefit.

4. Pedestrians

Consumers Union recommended that NHTSA study the work of auto safety researchers in other countries to determine whether a pedestrian-friendly NCAP rating would be effective in the United States. Consumers Union noted that Honda has taken a leadership role in designing a dummy for testing pedestrian safety and designing its vehicles with pedestrian safety in mind. They urged NHTSA to consider using the Honda pedestrian dummy and to pursue other opportunities to improve pedestrian safety. Public Citizen encouraged NHTSA to issue a pedestrian NCAP test and an accompanying safety standard. They also challenged NHTSA to follow the lead of the rest of the world by taking a far more aggressive stand against the dangers vehicles pose to pedestrians and to raise the bar for pedestrian safety in its discussions for a Global Technical Regulation (GTR) on pedestrian safety.

IV. Discussion and Agency Decision

A. Frontal NCAP

In the comments to the notice and the public hearing concerning enhancements to frontal NCAP, most manufacturers and vehicle safety advocates supported the retention of the current frontal crash test protocol at 35 mph (56 kmph). Additionally, several comments suggested that NCAP injury criteria and metrics be consistent with FMVSS No. 208. Most responders favored using the KTH injury metric (after additional research) but also encouraged the inclusion of other injury criteria such as neck and chest deflection. Some commenters suggested that the agency immediately evaluate lower leg injuries with the Thor-Lx dummy, while others recommended that NHTSA harmonize with Japan and Euro NCAP on lower leg assessments. The agency's analysis and decisions on frontal NCAP are grouped by categories: Test Dummies, Injury Criteria and their associated Risk Curves, and Lower Speed Testing.

Test Dummies

Comments pertaining to the adoption of additional test dummies included wide support for the 5th percentile female Hybrid III dummy, including its placement in the right front seating position. Others recommended that the agency include a 95th percentile male Hybrid III dummy in frontal NCAP. It was also suggested that dummies be placed in the rear seat for the purpose of rating vehicles.

In response to these comments, NHTSA has decided to include the 5th percentile female Hybrid III dummy in the right front passenger seating position. GM provided the most compelling evidence, and the agency reexamined its own data and reached the same conclusion.[12] That is, the real-

[12] The agency's analysis found, based on NASS–CDS estimates from 1997–2006, that the risk of AIS 2+ injury for smaller belted occupants in the right front passenger seating position is 33% greater than that of a mid-sized adult belted occupant in the same seating position in full frontal crashes (0–40 delta velocities, non-rollover cases, age ranges from 13 years old or older, height for small adult: Less

world data suggest that the smaller females were at greater risk and more likely to be seated in the right front position in frontal crashes. The agency believes that this dummy's incorporation into the NCAP frontal program is reflective of real-world crash conditions.

NHTSA has chosen, however, not to include the 95th percentile male Hybrid III dummy in frontal NCAP at this time. The 95th percentile male Hybrid III dummy has not been evaluated for robustness, reproducibility, and repeatability in laboratory impact conditions and it has only undergone very limited sled and vehicle testing. As such, we believe additional research and testing with this dummy is necessary before it can be included into frontal NCAP.

With regards to placing adult dummies in the rear seating positions of frontal NCAP tests, NHTSA believes that more analysis is needed before a rating program that includes rear seat occupants can be established. The agency has conducted some limited testing with both the 50th and 5th percentile Hybrid III adult dummies in the rear seat under a full frontal impact condition. However, these preliminary results did not correlate to findings in the real-world and additional research is necessary to better understand the results.[13] Similarly, none of the commenters that suggested an NCAP rating program for the rear seat provided the necessary data to establish how such a program would lead to meaningful improvements in safety.

The agency has decided not to incorporate the use of the lower legs from the Thor dummy to evaluate lower leg injuries into the program at this time. The agency is awaiting the completion of research currently in progress by an SAE task group. Additionally, this tool has not undergone the necessary robustness, reproducibility, and repeatability testing that the agency believes is necessary for incorporation into an NCAP ratings program.

Injury Criteria and Risk Curves

With regards to frontal NCAP injury criteria, the agency agrees with the commenters and has decided to include all of the FMVSS No. 208 body regions into the frontal NCAP rating system. As suggested by many commenters, the agency believes that their inclusion will not only add to the robustness of vehicle evaluations, but it will make the criteria used to assign NCAP frontal ratings consistent with those used in FMVSS No. 208 and in other frontal-crash vehicle assessment programs. It will also allow the agency to incorporate all safety concerns related to injury criteria readings into the calculation of the frontal rating thus eliminating the need to use the safety concern symbol.[14] However, unlike the current NCAP program which uses chest acceleration to assess thoracic injury risk, the new frontal program will focus instead on peak chest deflection instead. We believe that the inclusion of chest deflection into frontal NCAP will encourage development of restraint systems that will further reduce the risk of thoracic injuries.[15] This is especially true given a manufacturer's compliance margin with the chest acceleration limit of 60 G's and the fact that the FMVSS No. 208 belted test is now conducted at the same speed as the frontal NCAP test. Accordingly, frontal NCAP will include the following body regions and injury criteria: Head (HIC_{15}), neck (Nij, tension, and compression), chest (deflection), and femur (axial force). The risk curves that will be used for these criteria are described below.

As indicated in our proposal, NHTSA is also adopting AIS 3+ and AIS 2+ injury risk curves to assess the risk of injury to front seat occupants.[16] This approach is different from the current NCAP rating system which uses AIS 4+ (severe) injury risk curves. The new risk curves will focus vehicle performance on more frequently occurring injuries than severe (AIS 4+) or critical (AIS 5+) injuries.

With the exception of chest deflection, the AIS 3+ injury risk curves that will be used by the agency in NCAP are the same as those used for FMVSS No. 208. The AIS 3+ chest deflection injury risk curve that the agency will use in NCAP was developed in 2003 by Laituri et al.[17] The agency chose this risk curve for deflection because, as noted by the agency during the FMVSS No. 208 advanced air bag rulemaking, the chest deflection risk curve published by the agency was not used to establish the performance limits currently in FMVSS No. 208.

The agency will be using an AIS 2+ risk curve for the femur because most femur fractures are either of the AIS 2 or AIS 3 injury severity. Additionally, the AIS 2+ femur risk curve was primarily developed from multi-fragmentary patellar fractures, which, like other articular surface injuries, are associated with a high level of disability. As such, using an AIS 2+ injury risk curve will help ensure that debilitating multi-fragmentary patellar fractures are addressed.[18]

NHTSA has decided not to incorporate an advanced KTH risk curve into frontal NCAP at this time. In consideration of the comments received and because this risk curve is undergoing additional evaluation, the agency felt it would be premature to include it in NCAP. However, we do believe that the inclusion of a femur injury criterion, as indicated above, will lead to improved bolster design. Similarly, when coupled with the other injury criteria for chest deflection and neck, will lead to overall improved restraint system designs. NHTSA has also decided not to harmonize its NCAP femur injury values with those of EuroNCAP and Japan NCAP. The agency evaluated the rating schemes of these international programs along with that from the IIHS. These programs use a sliding scale to rate vehicles as opposed to injury risk curves. As such, as will be explained later in this document, because we have chosen to maintain our current methodology for combining injury risk we cannot substitute sliding scales for risk curves.[19]

The injury risk curves used in the NCAP frontal crash test program for the 50th percentile male Hybrid III and 5th percentile female Hybrid III dummies

than 65 inches, and height for mid-sized adult: 65–73 inches).

[13] Kuppa, S., Saunders, J., Fessahaie, O., *Rear Seat Occupant Protection in Frontal Crashes,* Paper No. 05–0212, Nineteenth ESV Conference, Washington DC (2005).

[14] A safety concern symbol is a test occurrence that is not reflected in a vehicle's star rating but that NHTSA feels is of significant importance that the event should be communicated to consumers.

[15] The agency evaluated new MY 2005–2007 tested vehicles and found that for acceleration, the standard deviation for risk of injury was approximately ±3% compared to chest deflection which was approximately ±4%.

[16] Details of these injury risk curves are provided in Appendix C, Injury Risk Curves for the NCAP Combined Crashworthiness Rating System.

[17] Laituri, T., Prasad, P., Sullivan, K., Frankstein, M., Thomas, R. (2005), *Derivation and Evaluation of a Provisional, Age Dependent AIS 3+ Thoracic Risk Curve for Belted Adults in Frontal Impacts,* SAE Paper No. 2005–01–0297.

[18] See Ore, L., Tanner, B., States, J. (1993), *Accident Investigation and Impairment Study of Lower Extremity Injury,* SAE Paper No. 930096, SAE International Congress and Exposition, Detroit, MI, and MacKenzie, E. (1986), *The Public Health Impact of Lower Extremity Trauma,* SAE Paper No. 861932, Symposium on Biomechanics and Medical Aspects of Lower Limb Injuries, San Diego.

[19] The sliding scales in these programs relate injury measures to point values without equating them to probability of injury. However, risk curves equate the injury measures to expected risks of injury.

are shown below. How these injury risk curves will be combined to generate a vehicle's frontal NCAP star rating will be discussed later in Section IV–F.

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Injury Risk Curves for Frontal NCAP

(HIII 50M dummy):

Injury Criteria	Risk Curve
Head (HIC_{15})	$P_{head}(AIS3+) = \Phi\left(\frac{\ln(HIC15) - 7.45231}{0.73998}\right)$ $where\ \Phi = \text{cumulative normal distribution}$
Chest (deflection in mm)	$P_{chest_defl}(AIS3+) = \frac{1}{1+e^{10.5456-1.568*(ChestDefl)^{0.4612}}}$
Femur (force in kN)	$P(AIS\ 2+) = \frac{1}{1+e^{5.795-0.5196\,Femur_Force}}$
Neck (Nij and tension/compression in kN)	$P_{neck_Nij}(AIS3+) = \frac{1}{1+e^{3.2269-1.9688Nij}}$ $P_{neck_Tens}(AIS3+) = \frac{1}{1+e^{10.9745-2.375Neck_Tension}}$ $P_{neck_Comp}(AIS3+) = \frac{1}{1+e^{10.9745-2.375Neck_Compression}}$ $P_{neck} = \max imum(P_{neck_Nij}, P_{neck_Tens}, P_{neck_Comp})$

(HIII 5F dummy):

Injury Criteria	Risk Curve
Head (HIC_{15})	$P_{head}(AIS3+) = \Phi\left(\frac{\ln(HIC15) - 7.45231}{0.73998}\right)$ where Φ = cumulative normal distribution
Chest (deflection in mm)	$P_{chest_defl}(AIS3+) = \frac{1}{1+e^{10.5456-1.7212*(ChestDefl)^{0.4612}}}$
Femur (force in kN)	$P(AIS2+) = \frac{1}{1+e^{5.7949-0.7619Femur_Force}}$
Neck (Nij and tension/compression in kN)	$P_{neck_Nij}(AIS3+) = \frac{1}{1+e^{3.2269-1.9688Nij}}$ $P_{neck_Tens}(AIS3+) = \frac{1}{1+e^{10.958-3.770Neck_Tension}}$ $P_{neck_Comp}(AIS3+) = \frac{1}{1+e^{10.958-3.770Neck_Compression}}$ $P_{neck} = \max imum(P_{neck_Nij}, P_{neck_Tens}, P_{neck_Comp})$

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Lower Test Speed

A lower test speed for frontal NCAP was supported by some commenters but an almost equal number opposed such an NCAP test. In light of the real-world studies conducted by the agency and some of the commenters, NHTSA has decided that additional research is necessary to fully address the proposal for a lower test speed. At this time, the agency has insufficient data with respect to test speed, injury mechanisms, dummy biofidelity, and risk curves to proceed.

B. Side NCAP

Most commenters supported the agency's proposal to incorporate an oblique pole test into the program, with several suggesting that this test should be adopted after the completion of the FMVSS No. 214 phase-in. Additionally, several responses encouraged the adoption of new test dummies for side NCAP including WorldSID, SID–IIs and ES–2re dummies. Commenters also suggested that side impact test procedures and injury criteria be consistent with FMVSS No. 214. Finally, IIHS encouraged NHTSA to adopt or modify their current moving deformable barrier (MDB). The agency's analysis and decisions on side NCAP are grouped into the following categories: MDB Design, MDB Test Speed, Oblique Pole Test, Test Dummies in the MDB and Oblique Pole Tests, and Injury Criteria and their associated Risk Curves.

MDB Design

The agency has decided against any modifications to the existing moving deformable barrier. Instead, we will evaluate the IIHS MDB (including the crabbed vs. perpendicular configuration) as part of a more comprehensive approach that is currently underway. This research will help the agency decide what properties a new MDB should have. As noted in the FMVSS No. 214 Final Rule,[20] initiatives to improve vehicle compatibility between passenger cars and light truck vehicles in side crashes are likely to change the characteristics of striking vehicles in the future.[21] As such, we believe these new characteristics should be included in any upgraded MDB.

MDB Test Speed

There was little support for an increased test speed for side NCAP, while some urged the agency to maintain or lower the current speed. As indicated in our request for comments, the real-world data indicates that the current test speed is largely representative of real-world crashes in which serious and fatal injuries occur; yet, increasing the test speed by 5 mph (8 kmph) would capture approximately 5,000 more serious and fatal injuries. No commenters disagreed with this data. However, NHTSA has not conducted any testing at this increased test speed with the ES–2re or SID–IIs dummies, and we want to better understand what countermeasures would be developed if the test speed in side NCAP were increased to 43.5 mph (71 kmph) or higher. As such, NHTSA has decided to maintain the current test speed and we will evaluate the test speed as part of our more comprehensive research work that is already underway.

Oblique Pole Test

Most commenters supported incorporating an oblique pole test into NCAP. However, some opposed this proposal, stating that a pole test would not add an incentive for manufacturers to provide additional head side impact protection beyond the IIHS side impact test. The agency does not agree with these commenters. As we stated in the FMVSS No. 214 Final Rule, we believe that the pole test in conjunction with our current MDB will drive better head, chest and pelvis protection than conducting the IIHS side impact test alone. Recent pole tests conducted on vehicles that were found to have ''Good'' or ''Acceptable'' performance in the IIHS barrier test had dummy head and pelvis injury readings, for some vehicles, that were significantly higher than the IIHS test indicated.[22] These test results indicate that the use of the oblique pole test in NCAP will demand more robust countermeasure designs leading to higher levels of safety performance.

Because the pole test can evaluate only one seating position at a time, most commenters were in support of running one pole test. Several stated that conducting multiple side impact pole tests with different sizes of dummies would introduce significant test burden. We have decided to add the oblique pole test procedure specified in the FMVSS No. 214 Final Rule for all vehicles tested by NCAP. Therefore, rather than conducting a pole test for each outboard seating position in the vehicle, we will conduct only one test to evaluate the front seat outboard performance of vehicles. NHTSA believes that a single pole test with one dummy will provide consumers with information on side pole performance without introducing significant test burden to both NHTSA and manufacturers.

Test Dummies in the MDB and Oblique Pole Tests

Outside of those commenters who suggested use of the World SID, most commenters supported the incorporation of the new, recently federalized side impact crash test dummies into side NCAP. Some specifically proposed that the agency use the 50th percentile male ES–2re dummy for the driver seating position and the 5th percentile female SID–IIs dummy for the rear seating position in the MDB test. For an oblique pole test, most encouraged the use of the SID–IIs dummy in the driver seating position.

Several commenters recommended that the agency incorporate the WorldSID dummy into Part 572 and side NCAP. For both test configurations (pole and MDB), the agency has decided not to incorporate this dummy into NCAP at this time. Although the agency has been conducting testing and evaluation to determine the suitability of incorporating the WorldSID into Part 572 and side impact crash tests, further work remains to be completed before its use in NCAP can occur.

Test dummy selection for the MDB and the pole test are discussed below.

a. MDB Test

NHTSA has decided to incorporate the new 50th percentile male ES–2re dummy into the driver seating position and the 5th percentile female SID–IIs dummy in the rear seating position for the MDB test as adopted in the FMVSS No. 214 Final Rule. The agency selected the 50th percentile male ES–2re dummy in the driver position because its weight and height is more representative of the average driving population than is the SID–IIs dummy. The 5th percentile SID–IIs dummy was selected for the rear seating position because it is closer in height to the average outboard rear seat occupant than the 50th percentile ES–2re dummy, and its placement in the rear seat will lead to a more demanding test.[23]

b. Oblique Pole Test

NHTSA has decided to conduct only one oblique pole impact test with the 5th percentile female SID–IIs dummy in the driver position. As stated in our recent FMVSS No. 214 Final Rule, small stature drivers (height up to 5 feet 4 inches) comprise approximately 28 percent of seriously or fatally injured drivers in narrow object side impacts. In addition, real-world crash data suggests that small stature occupants have a higher proportion of head, abdominal, and pelvic injuries and a lesser proportion of chest injuries than median stature occupants.

So while we selected the 50th percentile dummy for the front seating position in the MDB test (because it represents the average driver), for the pole test we are selecting the 5th percentile dummy as the driver because in collisions with narrow objects, the 5th percentile has the higher risk of injury. Additionally, since we are conducting the MDB test with the 50th percentile dummy in the driver seating position and the 5th percentile dummy in the driver seating position for the pole test, manufacturers will have to encompass a broader range of seating positions with their vehicle and restraint system designs.

Injury Criteria and Risk Curves

As with frontal NCAP, several commenters stated that the injury metrics used in NCAP should be consistent with the safety standard that serves as their basis. In the case of side NCAP, the safety standard is FMVSS No. 214. Several commenters stated that

[20] 72 FR 51908, Docket No. NHTSA–2007–29134.

[21] 69 FR at 27992, Docket No. NHTSA–2004–17694.

[22] See Appendix A, NCAP and IIHS Pole Test Results.

[23] In the testing which supported the FMVSS No. 214 upgrade, both the 5th and the 50th percentile dummies passed the MDB test but the rear was more stringent and difficult for the 5th percentile dummy.

the adoption of the 50th percentile male ES–2re and 5th percentile female SID–IIs dummies and their associated injury criteria from FMVSS No. 214 would facilitate a more comprehensive assessment of side impact injury. NHTSA agrees with these commenters and has decided to incorporate head (HIC_{36}), chest (deflection), abdomen (force), and pelvic (force) injury criteria as well as applicable risk curves to rate vehicles for the ES–2re and, consistent with the safety standard, HIC_{36} and pelvic (force) for the SID–IIs dummy.[24] NHTSA believes that these criteria and their inclusion in side NCAP will lead to a more robust rating. Similarly, it will also allow the inclusion of head- and pelvic-related injury criteria in the calculation of the side rating without the need for the safety concern symbol. Similarly, the injury risk curves that the agency will use in side NCAP are the same as those used for the recent upgrade to FMVSS No. 214.[25]

The table below presents the applicable injury criteria and associated injury risk curves for each dummy that will be used in the side NCAP vehicle rating. How these injury risk curves will be combined to generate a vehicle's side NCAP star rating will be discussed later in Section IV–F.

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[24] We note that for the SID IIs, we are not incorporating spine acceleration at this time. Even though this measure is included in the new FMVSS No. 214, we do not have a risk curve that has been validated at this time to include in our rating scheme for rating vehicles for side impact protection.

[25] Details of these injury risk curves are provided in Appendix C, Injury Risk Curves for the NCAP Combined Crashworthiness Rating System.

Injury Risk Curves for Side NCAP

(ES-2re 50M dummy):

Injury Criteria	Risk Curve
Head (HIC_{36})	$P_{head}(AIS3+) = \Phi\left(\frac{\ln(HIC36) - 7.45231}{0.73998}\right)$ *where* Φ = cumulative normal distribution
Chest (rib deflection in mm)	$P_{chest}(AIS3+) = \frac{1}{1+e^{5.3895-0.0919*\max.\,rib\,deflection}}$
Abdomen (total abdominal force in N)	$P_{abdomen}(AIS3+) = \frac{1}{1+e^{6.04044-0.002133*F}}$ *where F =total abdominal force (N) in ES-2re*
Pelvis (Force)	$P_{pelvis}(AIS3+) = \frac{1}{1+e^{7.5969-0.0011*F}}$ *where F is the pubic force in the* ES-2re *in Newtons*

(SID-IIs 5F dummy):

Injury Criteria	Risk Curve
Head (HIC_{36})	$P_{head}(AIS3+) = \Phi\left(\frac{\ln(HIC36) - 7.45231}{0.73998}\right)$ where Φ = cumulative normal distribution
Pelvis (acetabular + iliac force in N)	$p_{pelvis}(AIS2+) = \frac{1}{1+e^{6.3055-0.00094*F}}$ where F is the sum of acetabular and iliac force in the SID – IIs dummy in Newtons

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Lead Time

While most commenters supported the inclusion of the pole test in NCAP, an almost equal number suggested that the test not be incorporated until after FMVSS No. 214 is fully phased-in. NHTSA does not agree with these commenters. NHTSA believes that some manufacturers have begun to design vehicles to meet the pole test and we want consumers to be aware of those vehicles. Additionally, we believe that conducting the pole test for MY 2010 will provide an incentive for others to begin and/or accelerate their processes for improvement as well. Finally, rating vehicles on both their performance in the pole test and the MDB test, which will now incorporate HIC and other criteria, will help foster an environment for vehicle manufacturers to design better side impact designs for the head, chest and pelvis, and allow consumers to make more informed choices based on these new tests.

C. Rollover NCAP

Several commenters suggested that the agency add an additional star to the Rollover NCAP rating for vehicles equipped with ESC. They suggested the extra star be supplemented by a footnote saying, ''equipped with electronic stability control.'' In addition, one commenter suggested that a star be subtracted from vehicles not equipped with ESC. Commenters also recommended that NHTSA incorporate a new, dynamic structural test into rollover NCAP. The agency's analysis

and decisions regarding NHTSA's rollover program are grouped into two categories: Rollover Risk and Injury Risk Models and Dynamic Rollover and Structural Test.

Rollover Risk and Injury Risk Models

With regards to the agency's proposal to develop a new rollover risk model, the agency agrees with commenters' concerns about the effects of ESC on the rollover risk model. However, we do not agree that is appropriate to add or subtract a star in the rollover rating to account for ESC. The current rollover rating is the result of a detailed analysis of a vehicle's potential risk of rollover if a crash is initiated. Given that the star bands are set at 10 percent, adding a star to the rollover risk rating could suggest to consumers that ESC would reduce a particular vehicle's risk of rollover by up to 10 percent in a given crash. This could result in unsupported and inaccurate vehicle ratings.

The current rollover risk model was fit using crash data collected several years ago (at a time when ESC was available in relatively few vehicles). We are monitoring the fit of the model to newer data and, in particular, to data for ESC-equipped vehicles. We have identified 7,000 single-vehicle crashes with NCAP-tested vehicles equipped with ESC in our State Data System (SDS). At this time, the current model appears consistent with the newer data, possibly (at least in part) because of the sampling variability associated with the relatively small ESC subset. A larger sample may produce different results, and we will recalibrate the estimates if we determine conclusively (that is, beyond the effects of statistical variability) that the current estimates do not describe the newer data. In the meantime, we will continue to use the risk estimated from the vehicle's Static Stability Factor (SSF) and its propensity to tip up in the dynamic rollover ''fishhook'' test as described in 68 FR 59250 (October 14, 2003). These are provided below:

$$\textit{Vehicles not tipping in dynamic test: Rollover risk} = \frac{1}{1+e^{2.8891+1.1686\times Ln\,(SSF-0.9)}}$$

$$\textit{Vehicles tipping in dynamic test: Rollover risk} = \frac{1}{1+e^{2.6968+1.1686\times Ln\,(SSF-0.9)}}$$

Where SSF=static stability factor

This model describes the absolute risk of rollover given a single-vehicle crash.

As will be discussed later, we will include ESC in the new NCAP Crash Avoidance Rating. We feel this will be much more effective in highlighting the importance of ESC and other potentially life-saving technologies.

Dynamic Rollover and Structural Test

In their public hearing testimony, Ford suggested that NCAP dynamic rollover protocol be aligned with compliance protocol for ESC to minimize the risk of unintended consequences from the program. The agency does not agree with this suggestion. These tests have significantly different performance requirements and are intended to measure different dynamic vehicle responses. In the future, it may be possible to address the likelihood of aligning the new ESC compliance test with the NCAP dynamic rollover ''fish-hook'' test, but additional research is needed before these two tests can be combined. Neither test measures the responses from the other test; therefore, neither test could be used as a substitute for the other.

Some commenters suggested a structural rollover test; in particular, NHTSA received comments regarding the Jordan Rollover System (JRS) test device.[26] Some commenters believe that the JRS test can be conducted with dummies to demonstrate whether vehicle roof performance meets objective injury and ejection criteria for belted and unbelted occupants. As part of our roof crush upgrade, the agency has received numerous comments regarding the JRS device.[27] The JRS and other dynamic rollover procedures are being addressed as a part of the roof crush rulemaking currently underway. Therefore, a decision on its appropriateness for incorporation into NCAP would be premature at this time.

D. Rear Impact

With regards to rear impact NCAP, some commenters urged the agency to include a rear impact crash test rating and/or the IIHS test results in NCAP. Others indicated that linkage to IIHS could appear to be an agency endorsement of the IIHS testing and that it would be premature to incorporate a new rear impact dynamic test into NCAP since the effect of the new FMVSS No. 202a requirements is unknown at this time.[28] Rather, they suggested that NHTSA educate consumers on the proper use and adjustment of head restraints.

NHTSA does not agree that a dynamic test would be premature at this time since such an option exists in our FMVSS No. 202a. However, we do agree with the commenters that providing the IIHS results on our Web site could lead to consumers believing that the agency has approved, in particular, their dynamic test procedure. In addition, we note that the test dummy used by IIHS has not been approved for regulatory use, and some of the injury criteria used for this assessment have not been correlated with real-world injury.

We also see very little benefit to consumers in publishing IIHS's static head restraint ratings of Good, Acceptable, Marginal, etc. on *http://www.safercar.gov*. The agency's upgraded head restraint regulation (FMVSS No. 202a) will begin an 80% phase-in for front seats in MY 2010. Any manufacturer certifying their head restraint to the static option of FMVSS No. 202a, according to IIHS's current scheme, would be placed in the Good or Acceptable category. Most of those not achieving a Good rating will be adjustable head restraints that IIHS downgrades by one category simply because they are adjustable. Thus, there would be very little meaningful difference in the rating.

For those manufacturers certifying their head restraints to the dynamic option in FMVSS No. 202a, the static IIHS rating would not provide a meaningful metric of performance. The agency also contemplated publishing the actual numerical values of static height and backset that the IIHS measures but have decided against this course. We believe that consumers would find this information confusing

[26] The JRS device rotates a vehicle body structure on a rotating apparatus (''spit'') while the road surface moves along the track and contacts the roof structure.

[27] See Docket No. NHTSA–2005–22143.

[28] By MY 2012, 100% of front and rear seats will have to meet the upgraded FMVSS No. 202a.

and difficult to interpret. As such, rather than providing the IIHS data on our Web site, we have decided to update *http://www.safercar.gov* to include information related to proper head restraint adjustment.

E. Crash Avoidance Technologies

Most commenters supported the agency's proposal to implement a crash avoidance ratings program. However, there were two commenters who did not believe that a crash avoidance rating program was needed at this time. Two commenters suggested that NHTSA work with the automotive industry to create an advisory panel to develop a crash avoidance rating system. Additionally, most responses did not favor a cumulative rating system; instead, several commenters emphasized the importance of selecting advanced technologies and developing a rating system based on real-world effectiveness. Furthermore, several commenters recommended that the agency consider other advanced technologies beyond ESC, FCW and LDW.

NHTSA agrees that a rating system that incorporates a crash avoidance system's estimated benefit is ideal. We also believe that we should establish this new program quickly for two reasons. First, we want to draw a greater distinction for consumers regarding vehicles that are being equipped with ESC during the phase-in period. Second, in addition to ESC, there are other new safety technologies which exist today that can assist a driver in preventing severe and frequently occurring crashes. We believe that through NCAP, we can provide an incentive to encourage accelerated deployment of these new, advanced technologies. The agency's analysis and decisions on new crash avoidance ratings program are grouped into the following categories: Selected Technologies and Rating System.

Selected Technologies

Those commenters who supported establishment of a program that would promote crash avoidance technologies agreed with the agency's selection of ESC, FCW and LDW as beneficial technologies. Others believed that the agency should expand its list to encompass crash avoidance, crashworthiness and post-crash technologies so as not to limit the potential safety information that could be provided to consumers. NHTSA believes that ESC, FCW and LDW are the only technologies that meet the agency's criteria and are mature enough for inclusion in a crash avoidance rating program. That is, all three have available benefits data and performance test procedures to be included in a rating program.

We believe that both FCW and LDW will address major crash problems seen on U.S. roadways. FCW is designed to address primarily rear-end crashes, which account for approximately 30 percent of all crashes, while LDW is designed to address crashes due to unintended lane drift. Crash types that may result from lane drift include road departure and opposite direction crashes. The NCAP report showed that rear-end road departure, and opposite direction crashes represent a significant amount of the total maximum AIS 3+ injuries.[29] Results from large scale field tests for FCW and LDW provided effectiveness and benefit information for each technology and suggest that FCW and LDW have the potential to significantly reduce the number of crashes that occur in the U.S.[30]

Additionally, NHTSA used data from these field operational tests (FOTs), as well as additional agency research, to finalize performance tests establishing minimum performance criteria for FCW and LDW so that vehicles can be rated on their presence.[31] For ESC, because it had been in the field for some time, we used real-world data to establish effectiveness and then used the test procedure which accompanied the Final Rule (FMVSS No. 126) to develop a performance test and minimum performance criteria.[32] The table below presents NHTSA's effectiveness estimate values for ESC, FCW, and LDW.[33] A range was used for LDW to reflect potential system availability variation due to lane marking quality.

EFFECTIVENESS ESTIMATES FOR ESC, FCW, AND LDW

System	Effectiveness (percent)
ESC	59
FCW	15
LDW	6–11

NHTSA believes that the FOT results for FCW and LDW are applicable for estimating real-world safety benefits since these technologies were evaluated in the same real-world driving environment in which they would be deployed. In general, in an FOT, the major variables impacting a technology's safety benefits, including differences in individual driving styles and behavior, system performance, and driver acceptance, are taken into account. Likewise, critical safety incidents (i.e. near-crash incidents that occur during the FOT) data are recorded and evaluated to determine if the technology provided a safety benefit in terms of critical incident reduction. Assuming a proportional relationship between near-crash events and actual crashes, critical incident data are further evaluated using statistical methods to estimate crash reduction benefits. In the field tests for FCW and LDW systems, NHTSA provided technical management and the Volpe National Transportation Systems Center performed an independent evaluation to estimate safety benefits which included rigorous statistical analysis.

NHTSA believes that ESC, FCW and LDW are the only crash avoidance technologies that meet the agency's criteria for inclusion in a crash avoidance rating program at this time. That is, all three address a major crash problem, safety benefit projections have been assessed, and performance tests and procedures are available to ensure an acceptable performance level. The agency acknowledges that many other technologies were identified by commenters such as collision mitigation braking systems, lane keeping assist systems, and side object detection technologies. However, at this time the agency does not have enough data to estimate the safety benefits of these systems, and therefore will not promote these other technologies at this time.

Through our current research activities and/or information obtained from the automotive industry and the public, the agency anticipates that it will gain information on the benefits and performance capabilities of other advanced safety technologies. If the agency anticipates making changes to the rating system or the technologies that the agency has chosen to promote

[29] See *http://www.safercar.gov/newcarassessmentenhancements-2007.pdf* at page 18, Table 6.

[30] LDW effectiveness estimated from data included in NHTSA Report No. DOT HS 810 854, *Evaluation of a Road Departure Crash Warning System,* December 2007. FCW effectiveness estimated from data included in NHTSA Report No. DOT HS 810 569, *Evaluation of an Automotive Rear-End Collision Avoidance System,* March 2006.

[31] See Docket No. NHTSA–2007–27662 for ESC, LDW, and FCW test procedures.

[32] See NHTSA Report No. DOT HS 810 794, *The Statistical Analysis of the Effectiveness of Electronic Stability Control (ESC) Systems-Final Report,* July 2007. See also 72 FR 17236, Docket No. NHTSA–2007–27662.

[33] See Appendix B, Effectiveness Estimates for ESC, FCW and LDW for a summary explanation of how overall effectiveness estimate values were generated.

as that information is gathered, the agency will seek public input on the appropriateness of such changes. At this time, we anticipate using similar criteria (addresses a major crash problem, assessed safety benefits, and established performance tests and procedures) to determine technologies for future program inclusion.

Rating System

Generally, there was little support for a crash avoidance rating system based on a cumulative concept (e.g., the more technology you have; the higher the rating). Instead, several commenters preferred that the agency develop a rating system based on a computation of benefits to be expected from the crash avoidance technologies of a rated vehicle. Regardless of approach, these commenters all suggested that the agency use a star rating system to inform consumers about the presence of advanced technologies. BMW and Mercedes suggested a simpler approach whereby technologies would essentially be listed without regards to their effectiveness and without summing them into an overall rating crash avoidance rating. BMW offered an approach where all technologies would all be treated equally but where those technologies that had been proven beneficial by real world studies would somehow (in their scheme solid green and hollow thumbs were used) be denoted differently. Similarly, Mercedes suggested a simple ranking system for technologies.

To gauge consumer understanding and acceptance of these various systems, NHTSA tested the cumulative approach, the effectiveness approach, and the list approach with groups of consumers.[34] NHTSA conducted four focus group sessions in the DC area with participants who had to qualify as either a primary or shared decision maker with respect to automobile purchases for their household and intended to purchase a new or used automobile in the next two years. Participants in both groups were also screened to ensure they had some level of concern about the safety of automobiles and the groups represented a mix of age, education, and income. The agency tested letters, stars, words, check marks, and color schemes (for standard and optional availability) depending on which one of the three approaches was being tested. The agency also tested a subset of these treatments in an on-line forum.

With regards to what type of rating system should be used, participants overwhelmingly preferred a rating system that was a simple list approach. Additionally, focus group participants unanimously agreed that the use of colors is not visually appealing to fully comprehend what they are viewing. In the treatments tested by the agency, single check marks as opposed to multiple check marks to indicate a technologies importance were preferred by most participants. Additionally, to display and communicate the information, consumers stated that a single check mark or the use of text (indicating standard or optional) is the most understandable way to illustrate the presence of crash prevention technologies, though neither marking was overwhelmingly preferred.

Participants overwhelmingly objected to the multiple checks, star markings and A–D grading scale, saying they were very difficult to understand, despite having an associated key. Several participants also stated that if there were a technology or several technologies that were more important than the others, than that should be specifically communicated or noted on the layout and inferred, not the use of stars, individual letter grades, or multiple check marks.

The agency believes that the preference for the use of check marks or text over the use of an effectiveness approach may be rooted in the fact that participants (and to the extent that they are reflective in general of new car buyers) may not fully grasp the importance of these features. For example, participants generally stated that they think of these features as ''nice to haves'' rather than ''must haves'' because they are not yet aware of how the features can reduce fatalities. As such, the agency intends to continue monitor the public's understanding of this new rating program and if necessary change the way in which ratings are communicated to the public. For now, based on these focus group results, the agency will use text to communicate the standard or optional presence of ESC, LDW, and FCW on vehicles.

F. Presentation and Dissemination of Safety Information

Some commenters encouraged the agency to disseminate additional and more sophisticated consumer information but no specific examples were given. Most commenters discussed and supported the agency's proposal for a combined crashworthiness rating. The agency's analysis and decisions on the presentation and dissemination of safety information are divided into the following categories: Presentation of Safety Information and Combined Crashworthiness Rating.

Presentation of Safety Information

Some commenters supported consumer education materials such as safety tips and safe driving practices. Others suggested that NHTSA develop, maintain and make available a database of non-agency sources of credible vehicle safety information. Finally, some commenters suggested that the agency provide additional information at the point of sale (beyond that required by the new labeling program). NHTSA agrees with many of these suggestions. NHTSA continuously investigates ways to improve marketing the NCAP vehicle ratings program. We will place the results of our enhanced marketing studies in Docket No. NHTSA–02004–19104, as they are completed.

Combined Crashworthiness Rating

Most commenters supported an overall crashworthiness rating that combined the results from all test conditions. Honda and Toyota provided some details but GM and Ford provided very specific information on how this new rating could be calculated. Some commenters cautioned that an overall rating would overly simplify information for consumers, and that it could mislead consumers if poor performance were hidden under an umbrella rating. Given the general support for an overall rating and the public's desire for simpler information, NHTSA is implementing a new overall crashworthiness rating that combines the results of the front, side and rollover programs.

NHTSA will provide a summary crashworthiness rating for each vehicle (which we will call the Vehicle Safety Score) plus individual scores for each occupant in each crash condition for that vehicle (as a set of relative risk measures). This is in accordance with comments from Delphi, Public Citizen, Bidez and Associates, and the IIHS who expressed concern over individual test results being masked and that individual scores in each crash mode should continue to be provided to the consumer. Scores for vehicles will be provided to the consumer via a star rating system where the new bands for 1 to 5 stars were determined by the mean and dispersion of the risk of injury in each crash test condition (front and side) and the risk of rollover.

Although NHTSA's previous proposal did not suggest including the rollover risk rating in the crashworthiness rating, the agency has now decided to do so.

[34] The full study report is available *http://www.regulations.gov* in Docket No. NHTSA–02004–19104.

The agency's decision to include the rollover rating in the combined rating is consistent with the 1996 Transportation Research Board recommendation,[35] and we believe that its inclusion provides a more complete summary rating. Below, we describe how the frontal and side scores are developed and how these scores are combined with the rollover score to create an overall score.

Consistent with what has already been presented, NHTSA has selected the following test conditions, test dummies and injury criteria to develop its combined rating:

- One frontal impact crash test (full frontal rigid barrier crash test at 35 mph (56 kmph)) with a 50th percentile male Hybrid III dummy in the driver position and a 5th percentile female Hybrid III dummy in the front passenger seating position.
- One side impact crash test (38.5 mph (62 kmph) with NHTSA's moving deformable barrier (MDB) crabbed at 27 degrees into the side of vehicle) with an ES–2re dummy in the front seating position and a SID-IIs dummy in the rear seating position on the struck side of the vehicle.
- An oblique pole impact test (20 mph (32 kmph)) at 75 degrees into a 25 cm diameter pole including the SID-IIs dummy in the front seating position.
- Dynamic maneuvering (fish-hook) rollover test and static stability factor (SSF).
- All applicable injury criteria.
- Use of injury risk curves.

a. Combining Injury Risk From Different Body Regions

The agency has chosen to maintain its current method for combining injury metrics for any seating position in its test. That is, the risk of injury to each body region are assumed to be independent events and can be statistically combined to determine the joint probability of injury to the occupant using the following equation: $p(A \text{ or } B) = p(A)+p(B) - p(A)*p(B)$ where A and B are the independent events. Using injury risk curves for different body regions, this method results in an overall risk of injury for the occupant. For the two adult Hybrid III dummies there are four independent events to combine, which are injury risk to the head, neck, chest, and femur/knee. For the ES–2re dummy, there are also four independent events, which are injury risk to the head, chest, abdomen, and pelvis, while for the SID–IIs dummy, there are only 2 independent events which are injury risk to the head and pelvis.

In GM's proposal, the normalized injury measures for different body regions are combined by weighting each by the proportion of injuries associated with each injury measure. The result of this method does not represent either an absolute injury risk or a relative injury risk (as in NHTSA's method). Therefore, the risk levels of different vehicles are not quantifiable. In addition, Ford stated that GM's proposal assumes a linear relationship between the dummy response and injury risk, when generally the relationship is non-linear. Therefore, Ford expressed that GM's proposal could result in an inaccurate estimation of the relative vehicle safety performance. NHTSA agrees with this assessment and has chosen to use the joint probability of injury formula, as it does now, to combine injury risks to different body regions for an occupant. However, the agency notes that computation of the joint probability requires there to be quality data available for all of the injury risks being combined. Similarly, to compute the overall summary rating, data must also be available from all of the tests to prevent a model from not being rated. As such, the agency has included redundant sensor measurement capability in the test dummies (where possible), grouped tests (front, side, and rollover) together, and worked with our test labs to ensure that they are using the most up to date calibration procedures. In this way, we hope to alleviate the potential loss of data and subsequently, vehicles with incomplete ratings.

b. Risk of Injury by Seating Position and Test Condition

For each vehicle, the risk of injury is estimated from six test results, which are: (1) Driver in frontal crash, (2) passenger in frontal crash, (3) driver in side MDB crash, (4) rear seat passenger in side MDB crash, (5) driver in oblique pole impact, and (6) rollover potential in single-vehicle crashes using rollover test results. Ford suggested that the agency combine results using a simple average, but GM suggested a weighted approach to combine results.

To combine the risk of injury by occupant seating position, GM suggested weighting based on occupant demographics and the relative frequency of exposure by seating position. Ford commented that this approach would undervalue NCAP test results for passengers since the proportion of drivers is far greater than that of passengers. Ford asserted that this method of obtaining the overall injury risk might confuse consumers who seek a broader assessment of safety performance than one limited to the driver. Ford proposed using the straight average of the risks of injury for the driver and the passenger to obtain the overall injury risk. NHTSA agrees with Ford's suggested approach.

However, rather than use the percentages calculated from the probability of injury results (as is currently done), NHTSA will be computing the relative risk for each seating position and each test condition. This relative risk measure provides an estimate of an occupant's risk of injury compared to a baseline injury risk. The score for each occupant in each test condition is computed by dividing the overall risk of injury in each test condition by a baseline risk of injury. As will be explained below, the baseline risk of injury in each test condition is an approximation of the fleet average injury risk for that test condition. The baseline risk of injury is set once and reused for subsequent model years. This allows cross-year comparisons with future fleets.[36] This operation results in six summary scores for each vehicle representing the relative risk of injury for the driver and passenger in the frontal crash test and side MDB test, the driver in the oblique pole test, and the relative risk for all occupants in rollovers with respect to a baseline injury risk. As such, the scores indicate how a particular vehicle compares to a baseline risk and these are the scores (star ratings) that will be presented to consumers on the Web site and in agency publications.

To compute a vehicle's overall risk of injury in frontal crash tests, NHTSA has decided to use the simple average of the probability of injury to the driver and front passenger. The risk of injury to the driver in side crashes is calculated as the weighted average of the combined probability of injury of the driver in the MDB test (weighted by 80 percent) and that of the driver in the oblique pole test (weighted by 20 percent). The weights reflect the proportion of belted driver fatalities in real-world crashes represented by the MDB and pole tests in MY 1999 and newer vehicles (FMVSS No. 214 Final Rule, Docket No. NHTSA–2007–29134). The overall risk of injury in side crashes is then computed as the average of the risk of injury to the driver in side impacts (weighted average from MDB and pole test results) and the probability of injury to the rear seat

[35] See Transportation Research Board, *Shopping For Safety: Providing Consumer Automotive Safety Information*. TRB Special Report 248 (1996).

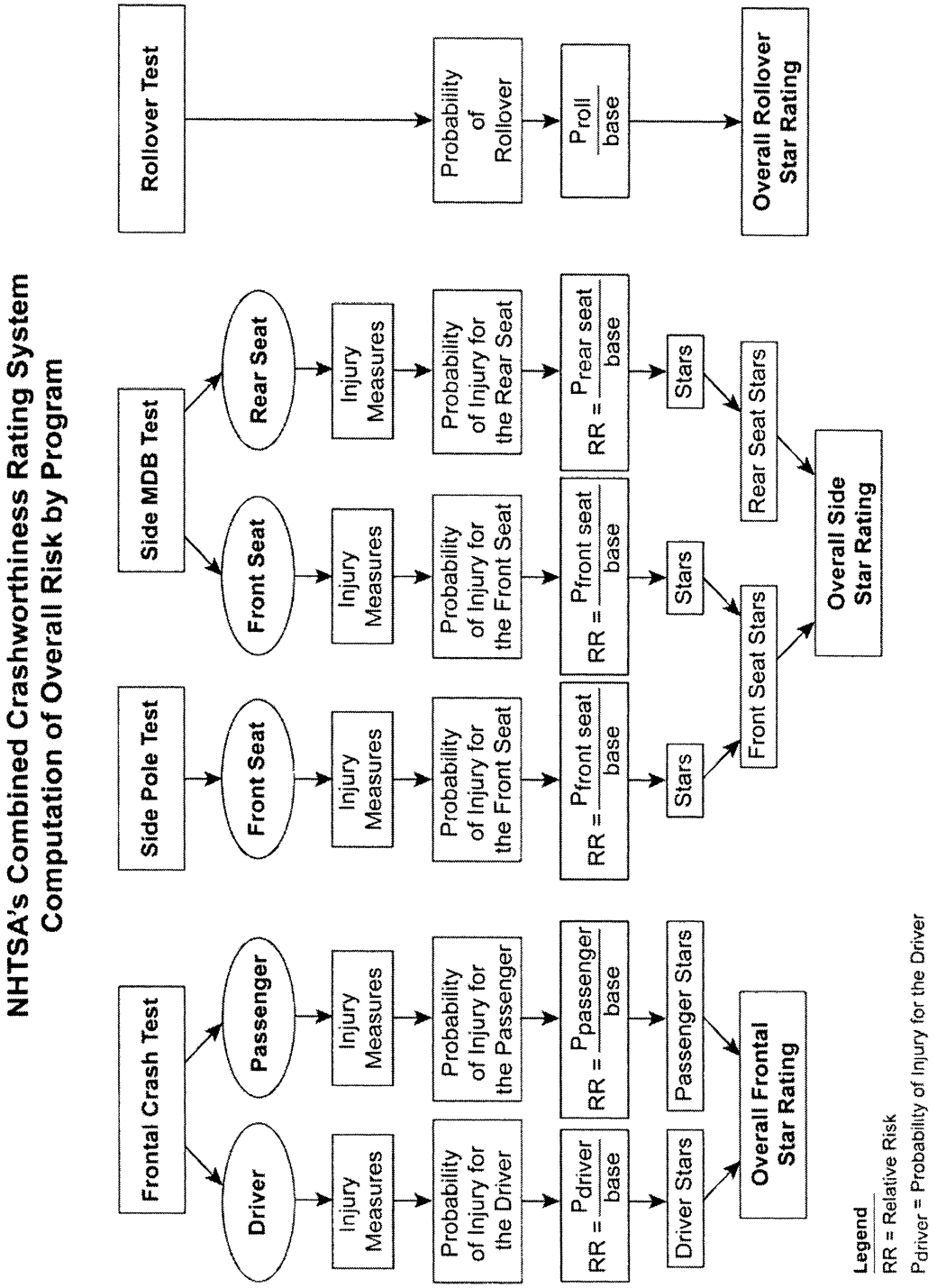
[36] In the future, the baseline could be adjusted to reflect vehicle designs. However, the agency would seek public input on the issue before such an adjustment would occur.

passenger in the MDB test. For rollover, in order to combine the risk from the rollover test with the risk of injuries obtained from the crash test, the agency has assumed that a belted occupant in a single-vehicle crash p(roll) has the same *relative* risk of injury as the risk of rollover given a single vehicle crash.

As suggested in Ford's proposal, NHTSA is adopting this method of averaging the risk of injury between the driver and the passenger to obtain an overall injury risk for each crash mode to ensure equal weighting for all seating positions. This is unlike GM's approach of applying significantly higher weight to the driver than the passenger based on occupancy rates in each seating position. NHTSA believes that GM's proposal would not encourage manufacturers to offer advanced safety systems to all seating positions, thereby resulting in reduced protection to some. This is especially significant in the side MDB crash test where the SID–IIs dummy in the rear seat generally demonstrates a higher risk of injury than the driver. Under GM's approach, the rear seating position would have far less value than the driver seating position because the rear seat has a relatively low occupancy rate. However, when combining the pole test results with the MDB results for the front seat, we do believe that weighting by crash test condition is appropriate. In this way, the results from the pole tests are proportional to their occurrence and do not mask a vehicles performance in the MDB test, possibly providing an inaccurate portrayal of the vehicle.

The figure below graphically illustrates the method of combining the different risks.

BILLING CODE 4910–13–P



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c. Combined Crashworthiness Rating

The agency's combined crashworthiness rating, the Vehicle Safety Score (VSS), is computed as the weighted average of the three summary scores for front, side, and rollover. The weight factors applied (5/12 for frontal crashes, 4/12 for side crashes, and 3/12 rollovers) reflect the proportion of injuries for belted occupants (in vehicles of model year 1999 and later) in each crash mode.[37] This approach is similar to GM's proposal of combining the crash test results using a weighted average.

Since the NCAP frontal crash test involves a vehicle with a fixed rigid barrier, it represents a crash between two vehicles of the same weight. Therefore, the safety rating from the NCAP frontal crash test and the combined crashworthiness rating (which includes the frontal crash test results) depends on vehicle mass, and cannot be compared across vehicle weight classes. In contrast, on an individual basis, the side crash (pole and MDB) test results and the rollover results can be compared across vehicle classes.

[37] These model years were chosen to reflect newer vehicle designs and to obtain a statistically robust trend from the NASS/CDS data.

d. Determination of Baseline Risk and Star Bands

NHTSA will continue to use the star rating system to provide an individual crashworthiness rating for each seating position, each crash mode, and their combination. However under the new system, stars will be interpreted differently. Bands for 1 to 5 stars were determined by the mean and dispersion of the risk of injury in all three test conditions (front, side, and rollover).

In the NCAP frontal tests, the average risk of injury to the driver in all 2008 model year vehicles is 15 percent ± 5 percent. Based on our NCAP injury data for the 50th percentile male seated in the right front passenger seat, we expect that a 5th percentile seated in that same seating position would have a similar distribution. Therefore, the agency selected a baseline injury risk of 15 percent to compute the frontal relative risk scores. A relationship between relative risk of injury and the number of stars assigned was developed using the existing NCAP frontal crash test data for the 50th percentile male Hybrid III dummy in the driver seating position.

To determine the star bands for frontal NCAP, NHTSA selected a baseline risk of 15 percent (representing the average risk of injury to the driver in MY 2008 vehicles in the NCAP frontal crash test) to serve as the break point for the 4 star and 3 star rating. Other criteria used to determine the star bands were (1) vehicles performing exceptionally well (At 0–15 percentile of vehicles tested) are assigned a five star rating, and (2) Vehicles performing very poorly (greater than 4 standard deviations from mean) would be assigned a one star. Attempts were also made to maintain equidistant star band boundaries. Based on these criteria and the distribution of the relative risk of injury scores of MY 2008 vehicles, the relationship between the Relative Risk Score (RRS) and the number of stars was established, and is presented below. The RRS is computed by (1) rounding the injury risk to the nearest tenth of a percent in accordance with the rounding-off method of ASTM Standard Practice E 29 for Using Significant Digits in Test Data to Determine Conformance with Specifications, (2) dividing the injury risk by 0.15 (15.0 percent baseline injury risk), (3) and finally rounding the result to the nearest one hundredth in accordance to ASTM Standard E 29.

As with frontal NCAP, this same methodology was applied to the scores in the side MDB and oblique pole tests as well as the combined crashworthiness Vehicle Safety Score. The agency found, for a limited number of newer vehicles tested to both the MDB and Pole test, that when the MDB test results were combined with the pole test, the average risk was 15%. As such, for side NCAP, the combined crashworthiness rating also represents the relative risk of injury with respect to an injury risk of 15 percent.

RELATIONSHIP BETWEEN THE RELATIVE RISK AND THE STAR BANDS FOR FRONT AND SIDE CRASH TESTS USING 15 PERCENT RISK OF INJURY AS THE FLEET AVERAGE

	5 stars	4 stars	3 stars	2 stars	1 star
RRS Values	RRS < 0.67	0.67 ≤ RRS < 1.00	1.00 ≤ RRS < 1.33	1.33 ≤ RRS < 2.67.	RRS ≥ 2.67.
Probability	P < 0.100	0.100 ≤ P < 0.150	0.150 ≤ P < 0.200	0.200 ≤ P < 0.400	P ≥ 0.400.

Similarly for rollover, we selected a baseline risk of 15 percent for the risk of rollover, which produces the relative risk measures shown below.[38]

CURRENT NCAP STAR RATING IN ROLLOVER AND ITS RELATIONSHIP WITH THE RELATIVE RISK IN ROLLOVER USING 15 PERCENT RISK OF INJURY AS THE BASELINE

Number of stars	Risk of rollover	Relative risk score in rollover
1 star	P ≥0.40	RRS ≥2.67.
2 stars	0.30 ≤P <0.40	2.00 ≤RRS <2.67.
3 stars	0.20 ≤P <0.30	1.33 ≤RRS <2.00.
4 stars	0.10 ≤P <0.20	0.67 ≤RRS <1.33.
5 stars	P <0.10	P <0.67.

G. Manufacturer Self-Certification

Several commenters suggested that NHTSA consider a self-certification process in which NHTSA would oversee the testing conducted by the manufacturer. However, it seems possible that manufacturers could run several tests and report only the best results; or because manufacturers would know exactly what vehicle was being tested, the vehicle's star ratings might not be indicative of a random sample (as currently done by the agency). Additionally, because NHTSA does not currently have the resources to conduct oversight over a manufacturer's test facility, dummy certification and test setup, a manufacturer's facilities might take more liberty than agency contract laboratories in their testing procedures.

These issues do not affect a manufacturer's self-certification of compliance with the Federal motor vehicle safety standards. A manufacturer had a legal duty to report any non-compliance promptly to NHTSA. They must also recall and remedy without charge to the purchaser any vehicle that fails to comply with an applicable safety standard. The manufacturer also is subject to additional penalties if it cannot demonstrate that it had no reason to know, despite exercising reasonable care, that the vehicle did not comply with the standard. These are all express provisions of Title 49, Chapter 301 of the United States Code. There are no

[38] See Appendix D, Probability of Injury, Vehicle Safety Score, and the Star Rating System.

parallel provisions for the New Car Assessment Program.

In addition, one of the primary reasons for allowing manufacturer self-certification in NCAP was to allow information about new vehicles to be provided more quickly. In this case, NHTSA has had an optional NCAP test program in place for nearly 20 years. This allows manufacturers to request a test of new or redesigned vehicles and get the NCAP information out quickly to the public. Given these considerations, NHTSA is not adopting the suggestions to permit manufacturer self-certification of NCAP results.

H. Other Recommendations

Several commenters, in their responses to the notice and at the public hearing, presented other recommendations for the agency's consideration. NHTSA has decided not to adopt any of these recommendations at this time for the reasons outlined below.

Compatibility Assessment

Some commenters recommended front-to-front compatibility assessments, while others suggested vehicle aggressivity evaluations for frontal NCAP. These commenters did not provide (and NHTSA is not aware of) any data that would support an NCAP compatibility evaluation at this time. The agency has a research program in this area and should a valid compatibility metric emerge from that research, the agency will consider it at that time.

Child Restraints

Some commenters suggested that the agency test and rate child restraints either in the vehicle and/or on a sled test. NHTSA has examined this in the past and at that time concluded that: (1) A dynamic rating for a child restraint system (CRS) was not feasible; (2) the agency wanted to focus on ease of use ratings; and (3) limited in-vehicle testing with a six-year old dummy did not correlate with real-world data.[39] However, the agency has continued to investigate CRS and child dummy performance in the current NCAP test environment, and their correlation to injury risks for children in real-world crashes. The agency will take actions at such time as the test results and analyses can be used to support such a rating program.

[39] See 70 FR 29815, Docket No. NHTSA–2004–18682.

Increased Test Speed

Two commenters and most automobile manufacturers stated that increased test speeds in frontal NCAP would promote stiffer vehicle designs and more aggressive restraints. NHTSA agrees that without an appropriate measure of vehicle stiffness, a higher speed test could lead to more aggressive vehicle designs. Therefore, NHTSA has decided not to adopt a 40 mph (64 kmph) frontal NCAP test because of concerns about vehicle compatibility, the lack of test data, and no clear understanding of potential countermeasures that could be used by manufacturers to achieve the top rating. In addition, the agency notes that the current frontal NCAP test speed represents 99 percent of all crashes, and increasing the test speed would not address a large portion of real-world crashes.

Lighting

Some commenters recommended that NHTSA incorporate a lighting/visibility program into NCAP to address vehicle blind spots and glare. The commenters did not provide (and NHTSA does not believe that there is) sufficient data to justify incorporating a lighting or visibility measure into NCAP at this time. The agency is conducting research in both of these areas to better assess the safety problem and explore what approaches and/or countermeasures should be considered. Therefore, NHTSA has decided not to incorporate an NCAP rating for lighting or visibility at this time.

Frontal Offset Test

Some commenters encouraged the incorporation of a frontal offset test into frontal NCAP. However, others did not support an offset test stating that such a test did not provide sufficient benefit to consumers or that it was already being done by others (e.g., IIHS). NHTSA has been studying the offset test procedure, but we continue to believe that further research and analysis is needed to ensure that improved occupant protection is provided by such a test without potential unintended consequences such as increased vehicle stiffness and aggressivity.

Pedestrians

Some commenters encouraged NHTSA to pursue opportunities to improve pedestrian safety through NCAP. The agency has no pedestrian standard at this time. While NHTSA is actively engaged in the development of a Global Technical Regulation on pedestrian safety, we feel it would be premature to develop a rating program before the details, test protocol and potential benefits of this activity have been resolved. Therefore, we are not incorporating pedestrian rating into NCAP at this time.

Frontal Pole Test

A frontal pole test was suggested by two commenters and specifically opposed by one. While the real-world data presented by the IIHS seems to imply that a number of fatalities and injuries are occurring in narrow object frontal impacts, at this time NHTSA is unclear as to what countermeasures might be developed. Similarly, a significant amount of research would need to be conducted to establish a new frontal impact pole test for NCAP. Accordingly, the agency is not adopting this proposal at this time.

I. Monroney Label

On August 10, 2005, the President signed into law the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA–LU). Section 10307 of the Act requires new passenger automobiles to have NCAP safety ratings displayed on the price sticker, known as the Monroney label. As required by SAFETEA–LU, on September 12, 2006 (71 FR 53572), NHTSA published a final rule implementing this statutory requirement, including prescribing the form, required information, and layout of the label. The rule, set forth at 49 CFR part 575.301, applied to covered vehicles manufactured on or after September 1, 2007.

Regulation 575.301 specifies the required information for the NCAP front, side and rollover tests. For the frontal crash, there are two separate ratings, one for the driver and one for the right front passenger. Similarly, two separate ratings are established for the side crash, one for the front seat and one for the rear seat. One rating is provided for rollover.

Under our regulation, front, side and rollover NCAP ratings must be placed on new vehicles manufactured 30 or more days after the manufacturer receives notification from NHTSA of the ratings. As explained earlier in this notice, in addition to any overall rating, the agency will still make available on *http://www.safercar.gov* the individual seating position results for each crash condition (front, side pole, and side MDB) and for side NCAP, the front seat and rear seat score developed from the combination of the pole and MDB test results. However, the agency is using this notice to inform manufacturers and other interested persons of our intent to use the new combined side impact score

developed from the pole and MDB tests for the Monroney label. In addition, we will initiate rulemaking to change the format and/or the layout of the Monroney label to incorporate the new overall combined crashworthiness rating. We believe that the combined rating and the new side impact score will provide consumers with the information they need to make comparative judgments on new vehicles.

When we issue the notice of proposed rulemaking, we will address relevant issues including changing the layout and format of the label to incorporate this new, additional information and to address other labeling issues such as the lead time necessary for the manufacturers to update their labeling operations.

V. Conclusion

NHTSA will implement these decisions regarding enhancements to NCAP beginning with MY 2010 vehicles. For that model year, the agency will make changes to its existing front and side testing activities requiring all vehicles to be rated using these new protocols. With regards to the frontal crash test program, NHTSA will maintain the 35 mph (56 kmph) full frontal barrier test protocol but will incorporate the following body injury criteria: Head (HIC_{15}), neck (Nij, tension, and compression), chest (deflection), and femur (axial force). The agency will also add the 5th percentile female Hybrid III dummy in the right front seating position. For side impact, NHTSA will maintain the current moving deformable barrier test at 38.5 mph (63 kmph) but will update that test to include head (HIC_{36}), chest (deflection), abdomen (force), and pelvic (force) injury criteria for the ES–2re and, consistent with the safety standard, HIC_{36} and pelvic (force) for the SID–IIs dummy. For the MDB test, the 50th percentile male ES–2re dummy will be used for the driver position and the 5th percentile SID–IIs dummy for the rear seated passenger position. Additionally, vehicles will also be assessed using a new oblique pole test and a 5th percentile female dummy in the driver position, using HIC_{36} and pelvic (force). For rollover, the agency will continue to rate vehicles for rollover propensity, but will wait to update its rollover risk model to allow for more real-world crash data of vehicles equipped with electronic stability control.

For MY 2010, the agency will also implement a new crash avoidance program that will rate vehicles on the presence of select advanced technologies and a new overall Vehicle Safety Score that will combine the star ratings from the front, side, and rollover programs.

Appendix A

NCAP and IIHS Pole Test Results

NHTSA

Vehicle	Vehicle class	SAB type	Driver test dummy	HIC36	Lower spine accel (Gs)	Combined acetabulum & iliac force (N)
			IARV Limits	1000	82	5525
2007 Honda Pilot	SUV	Curtain + Torso	SIDIIs	3464	68	6649
2007 Nissan Quest	Van	Curtain	SIDIIs	5694	79	5786
2007 Ford Escape	SUV	Curtain + Torso	SIDIIs	407	65	6515
2006 VW Passat	Medium PC	Curtain + Torso	SIDIIs	323	40	3778
2006 Subaru Impreza	Medium PC	Combo	SIDIIs	184	58	4377
2007 Toyota Avalon	Heavy PC	Curtain + Torso	SIDIIs	642	62	6672

Vehicle	Vehicle class	SAB type	Driver test dummy	HIC15	Combined acetab-ulum & iliac force (N)	Overall rating	Head/ neck	Torso	Pelvis/leg	Head protec-tion	Structure/ safety cage
2007 Honda Pilot	SUV	Curtain + Torso	SID–IIs	167	4700	G	G	G	G	G	A
2007 Nissan Quest.	Van	Curtain + Torso	SID–IIs	207	2900	G	G	G	G	G	A
2007 Ford Escape	SUV	Curtain + Torso	SID–IIs	216	5600	G	G	G	A	G	A
2006 VW Passat	Medium PC	Curtain + Torso	SID–IIs	168	3300	G	G	G	G	G	G
2006 Subaru Impreza.	Medium PC	Combo	SID–IIs	325	5100	G	G	G	G	G	A
2007 Toyota Avalon.	Heavy PC	Curtain + Torso	SID–IIs	350	4100	G	G	A	G	G	A

Appendix B

Effectiveness Estimates for ESC, FCW and LDW

Electronic Stability Control (ESC)

This effectiveness estimate comes from the report: *Statistical Analysis of the Effectiveness of Electronic Stability Control (ESC) Systems—Final Report.* Report No. DOT HS 810 794, July 2007.

From the Executive Summary, page vii, for Road Departure—Police Reported Crashes:

- The effectiveness of ESC for passenger cars = 45% (weighting for the difference in crash reporting among the States).
- The effectiveness of ESC for Light Trucks and Vans (LTV's) = 72% (weighting for the difference in crash reporting among the States).
- Assuming an equal weighting between passenger cars and LTVs, the average effectiveness = 59% for Road Departure Crashes.

59% was assumed to be a best overall effectiveness estimate for road departure crashes.

Forward Collision Warning (FCW)

Based on field operational test (FOT) data from the *Automotive Rear-End Collision Avoidance FOT (ACAS FOT)* collected from 66 participants who each drove an FCW-equipped vehicle for 3 weeks, it was estimated that the FCW system has the potential to reduce about 15% of all rear-end crashes. The FCW system integrated rear-end crash warning function with adaptive cruise control function. This system becomes operational when vehicle speed exceeds 25 mph and disengages when the speed falls below 20 mph. The participants accumulated 98,000 miles of driving data. The FCW system operated in the background during the first week of the FOT, providing information about baseline driving. The final 2 weeks of the FOT generated information

about driver performance with the FCW system while it operated in the foreground.

FCW system effectiveness was estimated separately in each of nine driving conditions based on FOT data, which combined three driving states (lead vehicle stopped, lead vehicle decelerating, and slower constant-speed lead vehicle) and three travel speed bins (<25, between 25 and 35, and ≥35 mph). Total system effectiveness was derived by integrating individual system effectiveness estimates in the nine driving conditions using corresponding rear-end crash data from the GES (see Equation (6) in Section 4.2.2.3 on page 4–70). Based on available FOT data, the FCW has shown crash prevention potential in lead vehicle stopped at speeds over 25 mph, slower constant-speed lead vehicle at speeds below 25 and over 35 mph, and lead vehicle decelerating at speeds over 35 mph (see Table 4–32 on page 4–73). Using corresponding crash data by travel speed only (not taking into account crash data by attempted avoidance maneuver), total system effectiveness was estimated at 9±5% of all rear-end crashes (see Figure 4–42 on page 4–74). However, GES crash data on travel speed are unreliable since the travel speed variable is coded as ''unknown'' in over 70% of the rear-end crash cases. As an alternative to travel speed, it is recommended that the posted limit data be used to break down the rear-end crash data. Thus by using corresponding crash data by posted speed limit, total system effectiveness was estimated at 15±11% of all rear-end crashes assuming that crash-involved vehicles were traveling at the posted speed limits reported in the crash database (see Figure 4–42 on page 4–74). This safety benefit also assumes 100% system deployment in the vehicle fleet.

15% was assumed to be a best overall effectiveness estimate for rear-end crash prevention.

Reference

Najm, W.G., Stearns, M.D., Howarth, H., Koopmann, J., and Hitz, J., ''*Evaluation of an Automotive Rear-End Collision Avoidance System*''. U.S. Department of Transportation, National Highway Traffic Safety Administration, DOT HS 810 569, March 2006.

Lane Departure Warning (LDW)

The overall average crash reduction estimate range (6% to 11%) for Lane Departure Warning was obtained from data collected during a Road Departure Collision Warning (RDCW) System Field operational test (FOT). The system merged and arbitrated warnings between a lane departure warning system (referred to as a lateral drift warning function in the study) and Curve speed warning (CSW) function. LDW monitored the vehicle's lane position, lateral speed and available maneuvering room. The CSW monitored the vehicle's speed and upcoming road curvature.

The RDCW Evaluation Final Report [1] discusses numerous safety-related benefits that resulted during the treatment period, when the RDCW alerts were enabled. Most safety benefits were accrued by the LDW portion of the RDCW system. These benefits include increased turn signal use, improved lane keeping, and fewer crossings of a solid lane marker at speeds above 55 mph. However, only one of these benefits—fewer crossing of a solid lane marker—was used to forecast a reduction in road-departure crashes. Solid lane markers serve as the road boundary. During the treatment period and at speeds above 55 mph, drivers crossed solid lane markers 44 percent less often than they did in the baseline period, when RDCW alerts were not enabled. This reduction, weighted by the national departure crash counts at this speed range, resulted in a forecasted reduction in road-departure crashes.

Road-departure crash statistics presented in Section 4.1 of the RDCW Evaluation Report.[1]

TABLE 4–1.—ROAD-DEPARTURE PRECRASH SCENARIOS (THOUSANDS) GES 2003

[Critical event]

	Vehicle movement	Departed road edge	Lost control	Other	Row totals
Count		261	208		469
Row Percent	Going Straight	55.7	44.3		
Percent		25.4	20.3		45.7
Count		116	172		288
Row Percent	Negotiating a Curve	40.3	59.7		
Percent		11.3	16.7		28.0
Count		65	55		120
Row Percent	Initiating a Maneuver	54.2	45.8		
Percent		6.3	5.4		11.7
Count				150	150
Percent	Other				14.6
Count		442	435	150	1,027
Percent	All Groups	43.0	42.4	14.6	

From section 4.4.1, this results in an estimated 9,372 to 74,844 fewer road-departure crashes each year. The average of this range equals 42,108. This range is based on full LDW availability.

Effectiveness = collisions avoided/collision population

Collision population originates from two departure road edge cells in Table 4–1, and equals 377,000 crashes. With full availability, the effectiveness equals:

$$\frac{42108}{377000} \approx 11\% \qquad (1)$$

With the 56% availability observed in the FOT, the estimated effectiveness estimated is (.56)(.11) = 6%.

Since system availability may vary depending on the quality of lane markings, a range of 6 to 11% was assumed to be the best overall effectiveness estimate for crashes caused by lane drift.

Reference

[1] Wilson, B.H., Stearns, M.D., Koopman, J., Yang, D., ''*Evaluation of a Road Departure Crash Warning System*''. U.S. Department of Transportation, National Highway Traffic Safety Administration, DOT HS 810 854, December 2007.

Appendix C

Injury Risk Curves for the NCAP Combined Crashworthiness Rating System

This Appendix presents the injury risk curves for various body regions applicable to the Hybrid III 50th percentile male (HIII 50M) and the Hybrid III 5th percentile female (HIII 5F) dummies in frontal crash tests and the ES–2re and the SID–IIs side impact dummies in lateral crash tests.

Injury Risk Curves for Frontal NCAP Head

The head injury criterion (HIC_{15}) as a metric for assessing head injury risk is well established and in use in FMVSS No. 208 (Eppinger et al., 1999).

$$P(AIS3+) = \Phi\left(\frac{\ln\ (HIC15) - 7.45231}{0.73998}\right) \qquad (1)$$

Where Φ = *cumulative normal distribution*

The AIS 3+ head injury risk curve from the FMVSS No. 208 Advanced Airbag Final Economic Assessment was extended from the Hertz (1993) AIS 2+ head injury risk curve using real-world data to determine the relative incidence of different severity brain injuries. Since NHTSA will assess the risk of serious or more severe head injuries, this equation has been selected for use in NCAP (Equation 1). Due to the uncertainty in the scaling methods, NHTSA took the conservative approach in estimating head injury assessment reference values for the HIII 5F dummy. As such, this equation will also be used to assess the risk of AIS 3+ head injury for the HIII 5F dummies.

Neck

The risk of AIS 3+ neck injury is assessed using Nij (Equation 2) as described in Eppinger *et al.* (1999, 2000) and currently used in FMVSS No. 208. The equation below presents the Nij formulation and Table 1 presents the intercept values (from FMVSS No. 208) of F_{int} and M_{int} used in Nij.

$$N_{ij} = \frac{F_z}{F_{\text{int}}} + \frac{M_y}{M_{\text{int}}} \qquad (2)$$

Where F_z *is the axial force and* M_y *is the flexion/extension moment measured in the upper neck load cell.*

TABLE 1.—NIJ INTERCEPT VALUES AND TENSION/COMPRESSION LIMITS FOR IN-POSITION 50TH PERCENTILE ADULT MALE AND 5TH PERCENTILE FEMALE DUMMIES

Dummy	Nij intercepts					
	Tension	Compression	Tension	Compression	Flexion	Extension
HIII 50M	4170 N	4000 N	6806 N	6160 N	310 Nm	135 Nm.
HIII 5F	2620 N	2520 N	4287 N	3880 N	155 Nm	67 Nm.

In general, neck injuries occur due to combination loading to in-position occupants. As such, the Nij injury risk curve is applicable and the agency has selected the risk curve used in the establishment of the Advanced Air Bag rule for FMVSS No. 208 from Eppinger. The neck tension injury risk curve was developed using the same paired pig and dummy test data used for the development of Nij. NHTSA assumed that the tensile neck tolerance is approximately equal to the compressive neck tolerance. Therefore, the injury risk curve for neck tension can also be applied to obtain neck injury risk due to neck compression. Equations 3–5 present the risk of AIS 3+ neck injury as a function of Nij, neck tension, and neck compression for the HIII 50M and HIII 5F dummies.

$$\text{HIII 50M and HIII 5F: } P(AIS3+) = \frac{1}{1+e^{3.227-1.969*N_{ij}}} \qquad (3)$$

$$\text{HIII 50M: } P(AIS3+) = \frac{1}{1+e^{10.9745-2.375*Tension_or_Compression}} \qquad (4)$$

$$\text{HIII 5F: } P(AIS3+) = \frac{1}{1+e^{10.958-3.770*Tension_or_Compression}} \qquad (5)$$

Where tension_or_compression is in kV.

The risk of AIS 3+ neck injury in the NCAP frontal crash test is the greater of the injury risk for Nij, neck tension, and neck compression. In general, the risk of injury obtained from Nij is higher than that for neck tension or compression in frontal NCAP tests.

Chest

Eppinger et al. (1999) developed injury risk curves for chest deflection. However, the derived injury risk curve was independent of occupant age and was not adequately adjusted to reflect real-world chest injury risk. As such, we have chosen to use a more recent, peer reviewed thoracic injury risk curve using chest deflection. Laituri *et al.* (2003, 2005) developed AIS 3+ thoracic injury risk curves by analyzing published cadaveric sled test data and then developing a transfer function between dummy chest deflection measurements and cadaveric chest deflection under similar impact conditions. The resulting thoracic injury risk curve is based on dummy measured chest deflection and occupant age and was evaluated against real world injury risk in frontal crashes. In order to apply this AIS 3+ thoracic injury risk curve in NCAP, it was normalized to the average age of the driving population which is approximately 35 years. The injury risk curve based on this evaluation for assessing risk of AIS 3+ chest injury is presented in Equation 6 for the Hybrid III 50th percentile male dummy. The injury risk curve as a function of chest deflection (Equation 7) for the HIII 5th percentile female dummy (HIII 5F) is obtained by scaling the risk curves for the HIII 50M using the scale factor for chest deflection (=0.817) which is the ratio of the chest depth of a 5th percentile female to that of a 50th percentile male (Eppinger (1999) and Mertz (2003)).

$$50th\ percentile\ \ P(AIS3+) = \frac{1}{1+e^{12.597-0.05861*35-1.568*(ChestDefl)^{0.4612}}} \qquad (6)$$

$$5th\ percentile\ P(AIS3+) = \frac{1}{1+e^{12.597-0.05861*35-1.568*(ChestDefl/0.817)^{0.4612}}} \qquad (7)$$

Knee-Thigh-Hip

The injury risk curve that the agency will use for the Knee-Thigh-Hip (KTH) is the same as that reported by Eppinger et al. (1999) in support of FMVSS No. 208 (Equation 8). The injury risk curves represent femur and knee injury risk since most of the injuries in the datasets that were used to develop these injury risk curves were to the distal femur and knee and only four of the 126 tests used to develop these risks curves produced a hip fracture. In addition, the knee injuries in this dataset were primarily multifragmentary patellar fractures, which, like other articular surface injuries, are associated with a high level of long-term disability.

The femur injury risk curve as a function of femur axial force for the HIII 5th percentile female dummy (HIII 5F) was developed by scaling the risk curves for the HIII 50M using a scale factor of 0.68 (Equation 9). This scale factor was proposed by Eppinger (1999) and later by Mertz (2003) and is based on the ratio of the thigh circumference of a 5th percentile female to that of a 50th percentile male.

$$50th\ percentile\ \ P(AIS\ 2+) = \frac{1}{1+e^{5.7949-0.5196\ Femur_Force}} \qquad (8)$$

$$5th\ percentile\ P(AIS\ 2+) = \frac{1}{1+e^{5.7949-0.7619\ Femur_Force}} \qquad (9)$$

Joint Probability of Injury

The joint probability of injury to an occupant is obtained by combining the risk of injury to each body region assuming the injury to different body regions are independent events. Therefore the probability of serious injury, P_{joint}, is given by:

$$P_{joint} = 1-(1-P_{head})\times(1-P_{neck})\times(1-P_{chest})\times(1-P_{femur})$$

Injury Risk Curves for Side NCAP

The injury risk curves for the side impact dummies, ES–2re and SID–IIs (Kuppa, 2006), were developed from biomechanical tests involving human cadaveric subjects and detailed in NHTSA docket (NHTSA–2007–29134).

Head

The Head Injury Criterion (HIC), used for assessing injury risk in frontal impacts is based on repeated drop tests of embalmed human cadavers onto rigid and padded surfaces where the impact area was the forehead (Lissner et al. 1960, Hodgson et al. 1972). Though forehead impacts are representative of a frontal impact scenario, the ECE R95 directive and Euro NCAP continue to apply HIC for head injury assessment in lateral impact scenarios, implicitly assuming that the head/brain injury tolerance is independent of loading direction and impact location. Similarly, NHTSA applied HIC36 to assess head/brain injuries in lateral crashes in the upgrade to FMVSS No. 214 so as to harmonize with the existing FMVSS No. 201 optional pole impact test.

Therefore, the FMVSS No. 208 AIS 3+ injury risk function presented above for the HIII 50M and HIII 5F dummies will be used in the NCAP side impact tests with the ES–2re and SID–IIs dummies. However, in order to be consistent with FMVSS No. 214, HIC36 will be used rather than HIC15 (Equation 10).

$$\mathrm{P(AIS3+)} = \Phi\left(\frac{\ln\ (HIC36)-7.45231}{0.73998}\right) \qquad (10)$$

Where Φ = *cumulative normal distribution*

Chest

The risk of AIS 3+ and AIS 4+ thoracic injury for a 45 year old (average age of the driving population involved in side impacts) 50th percentile adult male occupant as a function of maximum rib deflection of the ES–2re side impact dummy was developed by Kuppa (2006) by considering the injury severity to be a polychotomous variable (AIS<3, AIS=3, AIS>3). However, this AIS 3+ injury risk curve has a finite risk of injury even at zero mm of rib deflection. The same cadaver and dummy test data reported by Kuppa (2006) were reanalyzed considering the injury severity to be dichotomous (AIS<3 and AIS≥3 or AIS<4 and AIS≥4) to develop new AIS 3+ and AIS 4+ injury risk curves. Since the injury risk curves have not been adjusted to represent the average risk of injury in real world side crashes, NHTSA will use the AIS 4+ injury risk curve as the corresponding AIS 3+ injury risk in NCAP. The risk of AIS 3+ thoracic injury for a 45 year old (average age of the driving population involved in side impacts) 50th percentile adult male occupant as a function of maximum rib deflection of the ES–2re for use in NCAP is presented in Equation 11.

$$p(AIS3+) = \frac{1}{1+e^{(5.3895-0.0919\ *\ \max.\ rib.\ defl.)}} \qquad (11)$$

FMVSS 214 final rule does not utilize rib deflection measures of the SID IIs dummy and so they are not considered in NCAP at this time. Additionally, because the agency does not have a valid risk curve at this time for spine acceleration, it is also not included.

Abdomen

The AIS 3+ abdominal injury risk curve using the total force in the ES–2re abdomen reported by Kuppa (2006) is utilized in NCAP and is presented in Equation 12.

$$p(AIS3+) = \frac{1}{1+e^{6.04044-0.002133*F}} \qquad (12)$$

Where F is the total force in the ES–2re abdomen in Newtons.

Since FMVSS No. 214 does not utilize the abdominal rib deflection measures of the SID-IIs dummy for injury assessment, no abdominal injury risk assessment will be applied to the NCAP side MDB test and the oblique pole test using the SID IIs dummy.

Pelvis

NHTSA will utilize the AIS 3+ pelvic injury risk curve (Equation 13) reported by Kuppa (2006) for injury assessment with the ES–2re driver in the side MDB NCAP test.

$$p(\text{AIS3+}) = \frac{1}{1+e^{7.5969-0.0011*F}} \qquad (13)$$

Where F is the pubic force in the ES–2re dummy in Newtons

Kuppa (2006) developed the risk curve for AIS 2+ pelvic fracture as a function of the sum of iliac wing and acetabular force in the SID-IIs by scaling the normalized 50th percentile male data to that of a 5th percentile female, accounting for older subject age, adjusting for lower bone tolerance among female occupants, and transforming the applied force on the cadaver to the sum of acetabular and iliac force measured in the SID–IIs dummy. This pelvic injury risk function for the SID–IIs is presented in Equation 14.

$$p(\text{AIS2+}) = \frac{1}{1+e^{6.3055-0.00094*F}} \qquad (14)$$

Where F is the sum of the acetabular and iliac force in the SID–IIs dummy in Newtons

In developing the pelvis injury criteria for the SID-IIs, an occupant age of 56 years was considered to correspond to the average age of AIS 3+ injured occupants (of height less than 5 ft 4 inches) involved in side crashes. Research has indicated that pelvic injuries to older occupants are associated with increased mortality (O'Brien et al. 2002; Henry et al. 2002). During a 5-year period, O' Brien et al. and Henry et al. examined patients who sustained a pelvic fracture and found that patients 55 years and older were more likely to sustain a lateral compression fracture pattern and had a higher frequency of mortality due to the injury than younger patients (<55 years old). Due to the higher mortality rate associated with the elderly, an AIS 2+ injury risk curve is used in NCAP for the SID–IIs representing a 56 year old small female rather than the AIS 3+ injury risk specified for the ES–2re dummy

Joint Probability of Injury

The joint risk of injury to an occupant is obtained by combining the risk of injury to the head, chest, abdomen and pelvis assuming the injury to different body regions are independent events (as was done for frontal impact). Note that for the SID–IIs, the risk of chest and abdomen injury is omitted and only the risk of injury to the head and pelvis are combined.

$$P_{joint} = 1-(1-P_{head})\times(1-P_{chest})\times(1-P_{abdomen})\times(1-P_{pelvis})$$

Injury Risk In Rollover Crashes

The Static Stability Factor (SSF) of a vehicle is defined as one-half the track width, *t*, divided by *h*, the height of the center of gravity above the road (SSF = t/(2 × h)). Since 2004, the NCAP vehicle rollover rating has been calculated as a function of the vehicle's static stability factor and its propensity to tip up in the dynamic rollover ''fishhook'' test (68 FR 59250). The risk of rollover in single-vehicle crashes as a function of the static stability factor and the results of the dynamic rollover test was estimated from the State Data System and is presented below in Equations 15 and 16.

$$\textit{Vehicles not tipping in dynamic test : Rollover risk} = \frac{1}{1+e^{2.8891+1.1686\times Ln\,(SSF-0.9)}} \qquad (15)$$

$$\textit{Vehicles tipping in dynamic test : Rollover risk} = \frac{1}{1+e^{2.6968+1.1686\times Ln\,(SSF-0.9)}} \qquad (16)$$

Where SSF=static stability factor

This model describes the absolute risk of rollover given a single-vehicle crash. We can also describe the risk of rollover relative to an ''average'' vehicle. For example, we could use a ''typical'' SSF (which is about 1.35 for the current fleet) for vehicles that did not tip up in the dynamic test (which reflects the future in the sense that when all vehicles are equipped with ESC there will be essentially no tip-ups in the dynamic test). The risk of rollover for a subject vehicle compared to the risk of rollover for this baseline case describes how much more or less likely the subject vehicle is to roll over compared to the baseline. Thus, for example, a relative risk of rollover of 0.80 means that the subject vehicle is 20 percent less likely to roll over than the baseline; a relative risk of 1.25 means that the subject vehicle is 25 percent more likely to roll over than the baseline. For certain purposes (specifically, in producing the Vehicle Safety Score as described elsewhere in this Notice), we treat this as equivalent to the relative risk that a belted occupant is injured in a rollover crash given a single-vehicle crash. This is not strictly true, but our review of the SDS data for belted drivers indicates that it is approximately true. Therefore, the relative risks of injury to a belted driver in a rollover crash conditional on being involved in a single-vehicle crash are approximately proportional to the risks of rollover outlined above.

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Appendix D

Relative Risk of Injury, Vehicle Safety Score, and the Star Rating System

Introduction

The risk of injury to each occupant in NHTSA's Crashworthiness Rating System is the joint probability of injury to each body region considered for that occupant. The overall risk of injury in frontal crashes is the average of the injury risk to the driver and passenger in the frontal crash test. The risk of injury to the driver in side crashes is the weighted average of the risk to the driver in the MDB test (weight=0.8) and the pole test (weight=0.2). The overall risk of injury in side crashes is the average of the injury risk to the driver in side crashes (MDB and Pole) and the injury risk to the rear seat passenger in the MDB test.

The crashworthiness rating system provides relative risk of injury for each occupant in each crash test condition (driver and front outboard passenger in the frontal crash test, driver and near side rear seat passenger in the side MDB test, driver in the oblique pole impact test, and rollover test) and a Combined Crashworthiness Rating Vehicle Safety Score. The relative risk of injury in each test condition for a vehicle is computed by dividing the overall risk of injury in each crash mode by an average baseline risk (for example, the average risk of serious injury in the fleet or that of a group of select vehicles in the fleet for a certain model year). The Combined Crashworthiness Rating Vehicle Safety Score (VSS) is obtained as a weighted average of the individual Relative Risk Score (RRS) in each test condition.

The RRS for each test condition and the VSS represent the risk of injury to occupants of the vehicle relative to a baseline risk of injury. For example, a VSS of 1.15 for a vehicle implies that the occupants in that vehicle are 15 percent more likely to sustain serious injury than a vehicle representing the baseline risk.

Frontal Crash Test Rating

The historical frontal NCAP crash test data for the driver from the model years 1995 through 2008 were examined using the injury risk curves presented in Appendix C.

The average risk of injury to the head, neck, chest, and femur of the driver, computed using the injury risk curves from Appendix C, for each vehicle of model years 2004 to 2008 is presented in Figure 1.

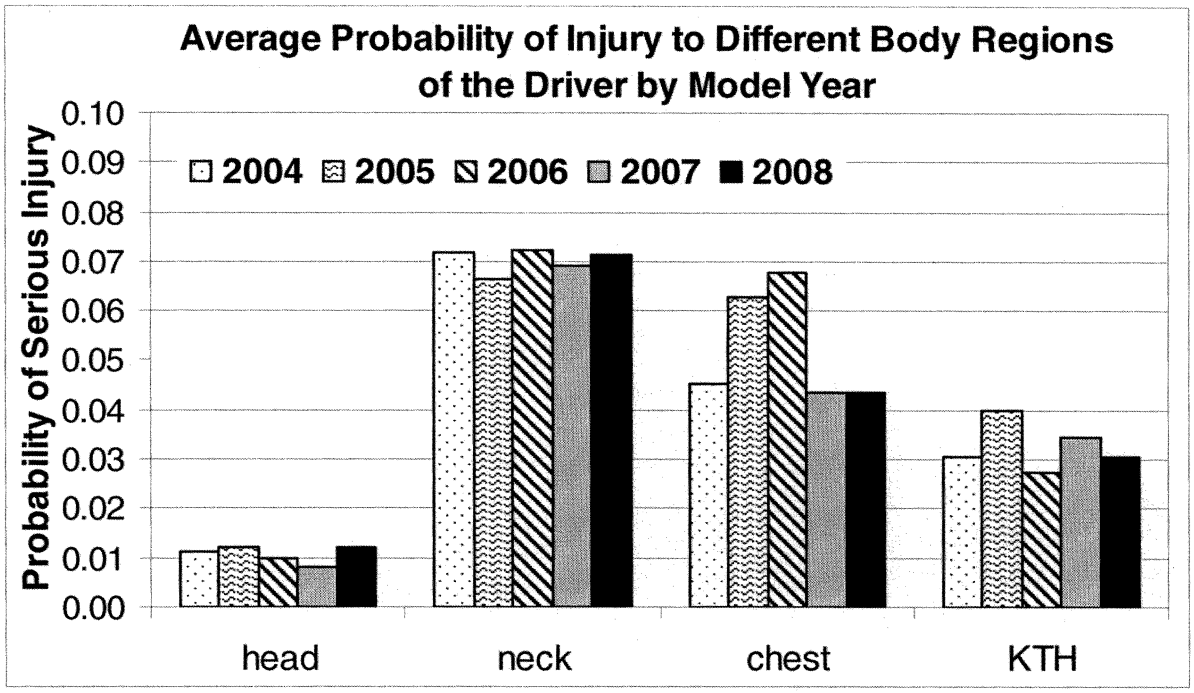

Figure 1. Average risk of serious injury to different body regions by vehicle model year.

When compared to data from 1995, these data indicate that the average risk of injury to the driver by model year has been reduced since 1995 and is less than 0.2 after MY 2002 (Table 2). If the average performance of all the vehicles tested in NCAP each year is used to represent the fleet of new cars, then for MY 2008, the average risk of serious injury in the fleet is approximately 0.15. Therefore, the baseline injury risk of 0.15 was used to compute the relative risk of injury in frontal crashes for each vehicle (Table 3).

TABLE 1.—PROBABILITY OF INJURY STATISTICS FOR DRIVERS IN NCAP FRONTAL CRASH TESTS BY MODEL YEAR

MY	Average prob	Prob Std. deviation	Minimum P	P 25% quartile	P Median	P 75% quartile	Maximum P
1995	0.30	0.12	0.10	0.21	0.27	0.35	0.62
1996	0.32	0.18	0.13	0.18	0.28	0.40	0.86
1997	0.26	0.14	0.12	0.17	0.22	0.28	0.69
1998	0.26	0.11	0.11	0.20	0.24	0.30	0.63
1999	0.29	0.18	0.09	0.17	0.23	0.36	0.71
2000	0.25	0.15	0.11	0.15	0.22	0.28	0.64
2001	0.23	0.12	0.09	0.17	0.19	0.26	0.63
2002	0.20	0.09	0.09	0.14	0.17	0.22	0.61
2003	0.18	0.09	0.08	0.12	0.15	0.18	0.45
2004	0.15	0.07	0.08	0.11	0.14	0.18	0.46
2005	0.17	0.11	0.09	0.11	0.14	0.19	0.57
2006	0.17	0.06	0.08	0.13	0.15	0.22	0.31
2007	0.15	0.05	0.09	0.12	0.14	0.17	0.38
2008	0.15	0.04	0.09	0.12	0.14	0.18	0.24
Average MY 1995–2008			0.10	0.15	0.19	0.25	0.56
Average MY 2004–2008			0.08	0.12	0.14	0.19	0.39

Table 2: Relative Risk Score statistics for drivers in NCAP frontal crash tests by model year

MY	average RRS	RRS Std. deviation	Minimum RRS	RRS 25% quartile	RRS Median	RRS 75% quartile	Maximum RRS
1995	1.98	0.78	0.70	1.40	1.82	2.34	4.14
1996	2.16	1.20	0.87	1.23	1.83	2.70	5.73
1997	1.74	0.91	0.82	1.13	1.49	1.89	4.59
1998	1.77	0.74	0.73	1.31	1.57	1.98	4.19
1999	1.96	1.23	0.59	1.12	1.52	2.42	4.76
2000	1.67	1.00	0.75	1.03	1.44	1.84	4.27
2001	1.51	0.78	0.59	1.10	1.25	1.72	4.23
2002	1.31	0.61	0.62	0.95	1.16	1.46	4.09
2003	1.19	0.60	0.55	0.82	1.00	1.22	2.99
2004	1.00	0.44	0.54	0.75	0.91	1.21	3.08
2005	1.16	0.72	0.57	0.74	0.93	1.24	3.82
2006	1.13	0.38	0.55	0.86	0.99	1.44	2.05
2007	0.98	0.34	0.59	0.78	0.91	1.10	2.52
2008	0.99	0.28	0.58	0.79	0.93	1.19	1.63
Average MY1995-2008			0.65	1.00	1.27	1.70	3.72
Average MY2004-2008			0.57	0.78	0.93	1.24	2.62

The average, minimum, maximum, and the quartiles presented in Table 3 provide an estimate of the dispersion of Relative Risk Score (RRS) in different model years. Since most of the current vehicles receive four or five stars in the NCAP frontal crash tests, NHTSA prescribed the baseline risk of 15 percent (representing the average risk of injury to the driver in MY 2007 and MY 2008 vehicles in the NCAP frontal crash test) to be at the border of the 4 star and 3 star rating. Other criteria used to determine the star bands were (1) vehicles performing exceptionally well (at 0–15 percentile of vehicles tested) are assigned a five star rating, and (2) vehicles performing very poorly (greater than 4 standard deviations from mean) would be assigned a one star. Attempts were also made to maintain equidistant star band boundaries. Based on these criteria and the distribution of relative risk of injury scores presented in Table 3, the relationship between RRS and the number of stars was established as presented in Table 4. The RRS is computed by (1) rounding the injury risk to the nearest tenth of a percent in accordance with the rounding-off method of ASTM Standard Practice E 29 for Using Significant Digits in Test Data to Determine Conformance with Specifications, (2) dividing the injury risk by 0.15 (15.0 percent baseline injury risk), (3) and finally rounding the result to the nearest one hundredth in accordance to ASTM Standard E 29. It should be noted that a vehicle which passes compliance (with a 20 percent compliance margin) would have an injury risk of 52.1 percent corresponding to a RRS value of 3.47.

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Table 3. Relationship between Relative Risk Score (RRS) and the star rating
(using 15 percent baseline injury risk)

	5 stars	4 stars	3 stars	2 stars	1 star
RRS Values	RRS <0.67	0.67 ≤ RRS <1.00	1.00 ≤ RRS < 1.33	1.33 ≤ RRS < 2.67	RRS ≥ 2.67
Probability	P < 0.100	0.100 ≤ P < 0.150	0.150 ≤ P < 0.200	0.200 ≤ P < 0.400	P ≥ 0.400

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Side Crash Test Rating

Because the agency did not have test data using the ES 2re or SID IIs dummies at the NCAP test speed for the MDB test, the agency computed the average risk of serious injury derived from relevant MDB tests and oblique pole impact tests done in support of the FMVSS 214 side impact protection upgrade. The MDB test is conducted with the ES–2re dummy in the front driver seat and the SID–IIs in the rear passenger seat. The pole impact test is conduced with the SID–IIs in the driver's seat.

The injury risk curves for side impact reported in Appendix C are applied to side MDB tests and oblique pole tests. These tests were part of NHTSA's fleet evaluation for the FMVSS 214 side impact upgrade and details and thorough analysis of these tests are available in the NHTSA docket number NHTSA–2007–25441.

There were six vehicles which were tested in the FMVSS 214 test conditions (MDB impact at 53 km/h rather than the NCAP 62 km/h) as well as the oblique pole impact with the SID–IIs dummies. The dummy injury measures in the paired crash tests of these vehicles with the ES–2re and SID–IIs dummies were used to determine risk of injury in side crashes and a Relative Risk Score (RRS) for side crashes. Table 4 presents the statistics for the risk of injury (average, standard deviation, minimum, maximum, median, and 25 and 75 percentile injury risk values) for each dummy in the MDB and oblique pole tests using the injury risk curves from Appendix C.

The overall risk of injury to the driver for each vehicle is the weighted average of the driver injury risk in the MDB test (multiplied by 0.8) and that in the oblique pole test (multiplied by 0.2). The risk of injuries in side crashes for a vehicle is the simple average of the injury risk of the rear seat passenger in the MDB test and the overall driver injury risk. Table 4 also presents the statistics for the overall risk of injury to the driver and the risk of injury in side crashes.

TABLE 4.—PROBABILITY OF INJURY (P) STATISTICS FOR DIFFERENT OCCUPANTS IN THE SIDE MDB AND THE OBLIQUE POLE CRASH TESTS

Crash type	Average P	Std. Dev. P	Min P	25% quartile P	Median P	75% quartile P	Max P
MDB Driver	0.09	0.04	0.04	0.06	0.09	0.12	0.13
MDB Pass	0.13	0.21	0.03	0.03	0.04	0.07	0.55
Pole Driver	0.64	0.39	0.13	0.32	0.79	0.93	0.98
Overall Driver	0.20	0.11	0.06	0.12	0.23	0.28	0.30
Side Impact	0.16	0.16	0.05	0.07	0.14	0.18	0.43

• The overall risk of injury to the driver is computed as the weighted average of the risk of driver injury in the MDB test (multiplied by 0.8) and the risk of driver injury in the pole test (multiplied by 0.2).
• The risk of injury in side impact is the average of the overall driver risk and the risk of rear passenger in the MDB test.

The average risk of injury from the six MDB tests for the driver and the rear passenger is 0.09 and 0.13, respectively. The average risk of injury to the driver in the six oblique pole tests is 0.64 and the average overall risk of injury to the driver (combining the MDB and pole test results) is 0.20. For these six vehicles, the average risk of injury in side crashes is 0.16.

In order to promote improvement in side impact safety in all the vehicles, the baseline risk of injury to compute Relative Risk Scores (RRS) in side crashes is taken to be 15 percent. As in frontal crash tests, the RRS in side MDB and pole crash tests is computed by 1) rounding the injury risk to the nearest tenth of a percent in accordance with the rounding-off method of ASTM Standard Practice E 29 for Using Significant Digits in Test Data to Determine Conformance with Specifications, 2) dividing the injury risk by 0.15 (15.0 percent baseline injury risk), 3) and finally rounding the result to the nearest one hundredth in accordance to ASTM Standard E 29. Table 5 presents the RRS statistics corresponding to the injury risk presented in Table 4 using a baseline injury risk of 15 percent.

TABLE 5.—RELATIVE RISK SCORE (RRS) STATISTICS FOR DIFFERENT OCCUPANTS IN THE SIDE MDB AND THE OBLIQUE POLE CRASH TESTS

Crash type	Average RRS	Std. Dev. RRS	Min RRS	25% quartile RRS	Median RRS	75% quartile RRS	Max RRS
MDB Driver	0.60	0.25	0.28	0.42	0.59	0.80	0.87
MDB Pass	0.86	1.39	0.20	0.21	0.28	0.45	3.69
Pole Driver	4.27	2.57	0.89	2.15	5.24	6.23	6.54
Overall Driver	1.33	0.71	0.40	0.77	1.52	1.89	2.00
Side Impact	1.09	1.05	0.30	0.49	0.90	1.17	2.84

• The Relative Risk Score for MDB tests, pole tests, and side impacts is obtained by dividing the risk of injury in each side crash mode listed in Table 4 by 0.15 which represents the baseline risk of injury in side impacts.

Vehicles for which all the dummy injury measures (for the ES–2re and SID–IIs) in the MDB and pole tests just meet the compliance limits, the risk of injury is 0.70 for the ES–2re and 0.42 for the SID IIs dummies resulting in an overall risk of injury in side crashes of 0.532, a RRS of 3.54.

Rollover Rating

Since the proposed rollover rating is the same as that currently used in NCAP, the current relationship between the risk of rollover and star rating used in NCAP is applied here and is shown in Table 11. If 15 percent risk (corresponding to a 4 star rating) is used as the baseline risk (as that in front and side crash test rating), then the relationship between the vehicle safety score in rollover is as shown in Table 11.

TABLE 11.—STAR RATING, RISK OF ROLLOVER, AND THE RELATIVE RISK SCORE IN ROLLOVER

[Using a baseline risk of 15 percent]

Number of stars	Risk of rollover	Relative risk score in rollover
1 star	P ≥ 40 percent	RRS ≥ 2.67
2 stars	30 ≤ P < 40 percent	2.0 ≤ RRS < 2.67
3 stars	20 ≤ P < 30 percent	1.33 ≤ RRS < 2.0
4 stars	10 ≤ P < 20 percent	0.67 ≤ RRS < 1.33
5 stars	P < 10 percent	RRS < 0.67

Combined Crashworthiness Rating Vehicle Safety Score

The weighted average of the Relative Risk Scores (RRS) in front, side, and rollover crashes is the combined crashworthiness rating Vehicle Safety Score (VSS). The weight applied to each crash mode represents the proportion of injury associated with that crash mode. Since the baseline injury risk used to compute RRS in each crash mode is 15 percent, the combined crashworthiness rating also represents the relative risk of injury with respect to a baseline of 15 percent. The Vehicle Safety Score for the Combined Crashworthiness Rating is computed below:

$$\text{Combined Rating} = (5/12) \times \text{RRS(front)} + (4/12) \times \text{RRS(side)} + (3/12) \times \text{RRS(roll)}$$

The final VSS value is obtained by rounding the result from the above equation to the nearest one hundredth in accordance to ASTM Standard E 29. The star bands used for rating frontal and side impacts are applied to the combined crashworthiness rating using VSS and is presented in Table 12.

TABLE 12.—RELATIONSHIP BETWEEN VEHICLE SAFETY SCORE AND THE STAR RATING

	5 stars	4 stars	3 stars	2 stars	1 star
VSS Values	VSS <0.67	0.67 ≤ VSS <1.00	1.00 ≤ VSS < 1.33	1.33 ≤ VSS < 2.67	VSS ≥ 2.67
Probability	P < 0.100	0.100 ≤ P < 0.150	0.150 ≤ P < 0.200	0.200 ≤ P < 0.400	P ≥ 0.400

Authority: 49 U.S.C. §§ 32302, 30111, 30115, 30117, 30166, and 30168, and Pub. L. 106–414, 114 Stat. 1800; delegation of authority at 49 CFR 1.50.

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