Automotive Safety Research Institute
1334 Pendleton Ct.
Charlottesville, VA. 22901
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Docket Management Facility
US Department of Transportation
1200 New Jersey Ave. SE,
West Building, Room W12-140
Washington DC 20590

Submission to: Docket No. NHTSA-2018-0055 Request for Information: New Car Assessment Program

This submission addresses Questions (5), (17) and (18) in the FR Notice and supplements my oral presentation at the public meeting on October 1, 2018.

I am President of the Automotive Safety Research (ASRI), a non-profit organization based in Charlottesville, Virginia. From 1974 to 1989, I was a Senior Executive at NHTSA, where I served primarily as Director of the Office of Passenger Vehicle Research but with stints as acting Associate Administrator for R&D and for Rulemaking. In 1975, I initiated the first NCAP and represented NHTSA to defend and explain the results to the national media. As a consequence of the first NCAP, I observed profound improvements in the safety of vehicles that performed poorly in the tests. There is a current challenge to find ways to continue to provide consumers with accurate information that will enhance vehicle safety. As President of ASRI, I have directed extensive research related to NCAP and reported it in scientific papers and submissions to the docket. The following comments are based on the available research base developed by NHTSA, IIHS, ASRI and others.

The comments to follow address five areas for improvements:

1. Provide consumers an immediate Silver Rating for seniors (in response to Questions (5) and (17))

2. Add a rating for Rear Seat Occupants (in response to Question (17) and (18))

3. Include a Far-side safety rating (in response to Question (17)

4. Enhance Crashworthiness Ratings by the following (in response to Question (17)):
    1. Revise belt positioning procedures
    2. Use of the Thor dummy in frontal NCAP tests
    3. Revise the star rating calculation for each body region to better represent the field data

5. Initiate a Post-crash safety rating system (in response to Questions (5) and (18))

Silver NCAP

The US population over 65 is expected to increase from 40 million in 2010 to 72 million in 2030, an 80% increase [US Census Bureau]. Unless the auto safety needs of this growing population are addressed, they will become an increasing burden on our acute and long-term care facilities, and the families of the injured. A Silver NCAP is needed to improve safety for this growing population.

The older population differs from their younger counterparts in three important ways:

1. Their injury tolerance is lower [Laituri, SAE 2006]
2. Their body region most susceptible to injury and death is the chest (different from younger) [Digges, Dalmotas and Prasad, ESV 2013; Kent, Henary and Matsuoka, AAAM 2005; Hanna and Hershman, NHTSA 2009]
3. Their average crash severity is lower [Digges, Dalmotas and Prasad, ESV 2013]

Our 2013 ESV paper shows that the chest injury rate for 65+ year old is more than 4 times that of persons in the 15 to 43 age range. Even the 44-64 age range has 2 times the chest injury rate. A NHTSA study reported the ratio of chest injuries as the cause of death compared to injuries from other body regions. They found that the ratio was 7 times higher for occupants over 75 and 4 times higher for the 65 to 74 age group [Hanna and Hershman, NHTSA 2009]. The presently used NCAP chest injury risk criteria are for a 35 year-old and it is excessive for a senior who is at a higher risk of chest injury and of death, when a chest injury occurs. [Laituri et al., SAE 2006; Prasad et al., Stapp 2010].

<u>Our Recommendations (from our ESV Papers)</u>

- Use an alternate computation of the current star ratings to make them more relevant to the needs of seniors [Digges, Dalmotas and Prasad, ESV 2013].
- Use chest and neck injury risk curves for older rather than younger occupants [Digges, Dalmotas and Prasad, ESV 2013]
- Move the seat of the 5th passenger dummy to the center position [Digges, Dalmotas, Prasad and Mueller, ESV 2017]
- Control the belt geometry for both dummies [Digges, Dalmotas, Prasad and Mueller, ESV 2017].

In the short term, ASRI recommends an alternate computation of the star ratings derived from the NCAP 35 mph frontal barrier tests to make the ratings more relevant to the needs of older occupants. The recommended change would take the form of using chest injury risk curves for older rather than younger occupants [Digges, Dalmotas and Prasad, ESV 2013]. One option would be to use the Laituri chest injury risk function for a 65 year old [Laituri, et al., SAE 2006]. This supplementary rating scheme could be adopted immediately and would provide a first-generation Silver NCAP Rating.

We also recommend moving the seat of the 5th passenger dummy to the mid fore-aft position and controlling the belt geometry for both dummies. These changes would make the NCAP test more field relevant (See our 2013 ESV Paper). This supplementary rating scheme could be adopted immediately and would provide a first-generation Silver NCAP Rating.

The present NCAP test at 35 mph does not encourage systems that perform equally well at lower severities where older occupants are more frequently injured. It was not uncommon for published crash tests conducted by Transport Canada at 25 or 30 mph to produce higher chest injury risks than the NCAP test of the same vehicle at 35 mph [Digges and Dalmotas, AAAM 2007]. In order to determine the extent to which the higher chest injury risk at 25 to 30 mph is present in newer vehicles, it would be useful for NHTSA conduct and make publically available the results of lower severity crash tests. Collaboration with Transport Canada may be useful, because they may have relevant test data.

A 2013 Stapp Paper found that among seriously injured belted occupants in frontal crashes, over 50% were in crashes less severe than 26 mph [Radwan, Stapp 2013]. Older occupants are overrepresented in these low speed crashes. A 2007 AAAM Paper found that, for front seat occupant occupants over 50 years old, over 70% of the serious injuries occurred at severities less than 26 mph [Augenstein, et al., AAAM 2007].

Based on the predominance of senior chest injuries that occur below 26 mph, and the indication from the available Canadian tests in the NHTSA database that many cars exhibit higher chest injury risks at 25 mph than at 35 mph, we recommend a separate low speed frontal NCAP test. The test should be at a speed in the vicinity of 25 mph and with more stringent injury criteria to address the preponderance of chest injuries among seniors that are caused by the shoulder belt.

A low speed frontal crash test would be beneficial to all ages (but especially to seniors) since it would encourage higher levels of safety at lower speeds where a majority of the serious injuries occur. It should be added to NCAP.

References:

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Augenstein, J, Perdeck, E, Digges, K and Bahouth G, “Age Appropriate Restraints for the Right Front Passenger”, 51th Proceedings of the Association for the Advancement of Automotive Medicine”, October 2007.

Augenstein, J, Perdeck, E, Digges, K, and Bahouth, G, “Opportunities for Protecting the Right Front Passenger in Frontal Crashes”, Paper Number: 09-0410, Proceedings of the 21st ESV Conference, June 2009.

Digges, K and Dalmotas, D, “Benefits of a Low Severity Frontal Crash Test,” 51th Proceedings of the Association for the Advancement of Automotive Medicine, p.299-319, October 2007.

Digges, K, Dalmotas, D, and Prasad, P, “An NCAP Star Rating System For Older Occupants,” ESV Paper Number 13-0064, Proceedings of the 23rd ESV Conference, May 2013.

Digges, K, Dalmotas, D, Prasad, P and Mueller, B, “The Need to Control Belt Routing for Silver NCAP Ratings,” ESV Paper Number 17-0403, Proceedings of the 25th ESV Conference, June 2017.

Hanna, R, and Hershman, L, “Evaluation of Thoracic Injuries among Older Motor Vehicle Occupants,” NHTSA Report, DOT HS 811 101, March 2009.

Kent, R, Henary, B and Matsuoka, F, “On the Fatal Crash Experience of Older Drivers,” 49th Proceedings of the Association for the Advancement of Automotive Medicine, p.371-389, September 2005.

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Prasad, P, Mertz, H, Dalmotas, D, Augenstein, J and Digges, K, "Evaluation of the Field Relevance of Several Injury Risk Functions,” Stapp Car Crash Journal; Vol. 54, 2010.

Projections of the Population by Selected Age Groups and Sex for the United States: 2010 to 2050; National Population Projections; US Census Bureau; 2008 (http://www.census.gov/population/www/projections/summarytables.html)

Radwan, R, Prasad, P and Nix, L, “Opportunities for Injury Reduction in US Frontal Crashes: An Overview by Structural Engagement, Vehicle Class, and Occupant Age,” Stapp, 2009

Rear Seat NCAP

Several recent papers show that the frontal stiffness of recent passenger vehicles has increased, and the rear seat safety has decreased. Historically, belted rear seat occupants have been at a lower fatality risk than their belted front seated counterparts.

Recent papers show (for belted occupants in frontal crashes):

- The rear seat safety has decreased in recent model years [Sahraie SAE 2009]
- Belted occupants 25 years and older are significantly less protected in the rear seat compared to right front seat of 2000+ MY vehicles [Sahraie, AAAM 2010]

- An increase in frontal stiffness is the main cause for the loss in rear seat safety [Samaha, SAE 2010; Sahraie, Accident Analysis, 2014]
- The restraint technology for the rear seating position has not kept up with technology in the front seating positions [Sahraie, Stapp 2009]

Ford has introduced Air Belts in the rear seat to improve the occupant protection. However, no credit is available to rate benefits of new technologies and encourage safety improvements.

We recommend:

- NCAP frontal tests include at least one 5th percentile HIII dummy in the rear seat,
- Apply injury criteria similar to our recommendations for Silver NCAP (in order to provide added safety for children and seniors),
- Ultimately, use the Thor 5% dummy in the rear seat to encourage more innovation, and
- Provide some form of a credit system to reward fitment of advanced restraint technologies such as inflatable seat belts.

A Rear Seat NCAP would encourage more innovation and reverse the decline of safety for rear seat occupants.

References

Sahraie, E., and Digges, K. "Trend of Rear Occupant Protection in Frontal Crashes over Model Years of Vehicles", SAE 2009-01-0377, April 2009.

Samaha, R., Digges, K., Fesich, T., Authaler, M., "Frontal Crash Testing and Vehicle Safety Designs: A Historical Perspective Based on Crash Test Studies", SAE Paper 2010 01-1024, 2010.

Sahraie, E., Digges, K., and Marzougui, D., "Reduced Protection for Belted Occupants in Rear Seats Relative to Front Seats of New Model Year Vehicles", 54th Proceedings of the Association for the Advancement of Automotive Medicine", October 2010.

Sahraie, E., Digges, K., and Marzougui, D., Roddis, K, "High strength steels, stiffness of vehicle front-end structure, and risk of injury to rear seat occupants", Accident Analysis and Prevention, 66 (2014) 43-54

Far-side NCAP

Extensive research and development exist to provide a basis for a far-side NCAP.

An international Far-side research project was completed in 2009 that included participation of Ford, General Motors, Autoliv, NHTSA, Australian MoT and 7 Universities in the US and Australia. [Fildes and Digges, editors, Monash/George Washington Universities Report 2009; Copy included with this submittal]

The research included comparative tests of cadavers with the WorldSID and Thor Dummies [Pintar, et al., Stapp 2007]. Both dummies were found to be suitably biofidelic in representative far-side crashes. The international project also included data analysis of far-side injuries, crash tests, computer models, and benefits analysis [Gabler, et al., SAE 2005; Alonso, et al., SAE 2007 and Bostrom, et al, AAAM 2008]. Computer modeling showed that restraint systems that function well in Far-side crashes could provide benefits in Rollovers as well.

Our 2006 SAE Paper found that 2,166 belted occupants received serious injuries in far-side planar crashes, annually, close to 30% of the MAIS 3+F injuries in all side crashes for belted occupants [Digges and Gabler, SAE 2006]. As discussed below, countermeasures applicable to far-side planar crashes may have benefits in far-side rollovers, i.e. drivers in rollover crashes with clockwise vehicle rotation and right front passengers in rollover crashes with counter clockwise rotation. Half of the MAIS 3+F injuries in all rollovers for belted occupants occur in far-side rolls (3540 MAIS 3+F). As such, the potential target population for countermeasures to reduce far-side casualties is large, when casualties in Far-side rolls are included (a total of 5,706 MAIS 3+F injuries). This target population is almost 80% of the size of seriously injured occupants in near-side without rollovers (7,360 MAIS 3+F injuries).

There is a need to better understand the relationship between occupant kinematics in far-side crashes and rollovers. To this end, it is useful to examine and compare the response of humans, dummies and models in far-side crashes and rollovers. There are currently no publications that report these comparisons. However, there are tests and modeling of idealized rollovers and far-side crashes that can provide insight [Dahdah, 2005; Alonzo, et al., 2005]. Similarity between rollover and far-side kinematics can be illustrated by examining occupant motion in real life rollovers. The kinematics of a living person in a rollover are summarized in Figure 5 of an AAAM Paper [Grzebeita, et al., AAAM 2008]. The kinematics of a HIII dummy in a rollover test are summarized in Figures 10 thru 12 in an ESV Paper [Digges, et al., ESV 2013]. This rollover test is in NHTSA's crash test data files. Modeling of an actual rollover was reported in an AAAM paper [Digges, et al., AAAM 2013]. Figures 3 and 4 of that paper show dummy motion in a rollover that is similar to a far-side crash. Finally, reconstruction of an actual rollover crash with AIS 3+ chest injury caused by contact with the center console has been documented in two ICRASH papers [Tahan, et al., ICRASH 2014 (2 Papers)]. The first paper develops a simulation that reproduces the vehicle damage. The second, examines the dummy motion and the cause of injury. Figure 4 of the thoracic injury simulation (paper 2) shows occupant kinematics similar to those exhibited in a far-side crash. Figures 5 and 6 show an identical chest injury mode to that in some far-side crashes.

We recommended that NHTSA reconstruct typical far-side crashes and rollovers with computer models. Such reconstructions would provide insights into the large opportunity to improve safety that would be afforded by a Far-side NCAP.

It is noted that some General Motors vehicles have Far-side protection provided by a center air bag between the front seat occupants. Far-side NCAP ratings would encourage more competition and innovation that could potentially address a population of injuries at least 80% the magnitude of the near-side injuries.

In 2009 we published recommendations for a far-side NCAP [Digges et al., ESV 2009]. However, our recommendations have been superseded by EuroNCAP. EuroNCAP has developed a Far-side safety assessment protocol that is currently being evaluated. It is scheduled for incorporation in their ratings by 2020 [EuroNCAP Report 2017].

US NCAP should immediately incorporate the principal elements of the EuroNCAP test procedure in a US rating. Minor adjustments in the procedure to incorporate ratings based on injury risk functions that reflect on-the-road risks should be considered.

The Far-side EuroNCAP targets one of the largest injured populations that have not been addressed by regulation or consumer information. The opportunity is larger than any subset of frontal crash modes [Radwan, et al., Stapp, 2013].

References:

Alonso, B, Digges, K, and Morgan, R, "Far-side Vehicle Simulations with MADYMO", SAE 2007-01-0378, April 2007.
Bostrom, O, Gabler, H, Digges, K, Fildes, B and Sunnevang, C, "Opportunities of Far side Impact Countermeasures", 52nd Proceedings of the Association for the Advancement of Automotive Medicine", October 2008.
Dahdah, S, "On Occupant Kinematics during Rollover" Master's Thesis, GW University, May 2005
Digges, K, Eigen, A, Tahan, F and Grzebieta, R, "Factors that Influence Chest Injuries in Rollovers" AAAM, 2005
Digges, K, Gabler, H, "Opportunities for Reducing Casualties in Far-side Crashes," SAE 2006-01-0450, April 2006.
Digges, K, Echemendia, C, Fildes, B and Pintar, F, "A Safety Rating for Far-Side Crashes," Paper Number 09-0217, Proceedings of the 21st ESV Conference, June 2009.
Digges, K, Tahan, F, Grzebieta, R, Bambach, M, Mattos, G and McIntosh, A, "Crash Damage Patterns Associated with Chest Injuries in Far-Side Rollovers," Paper Number 13-0066, Proceedings of the 23rd ESV Conference, May 2013.
Digges K, Eigen A, Tahan F and Grzebieta, R, "Factors that Influence Chest Injuries in Rollovers," Association for the Advancement of Automotive Medicine; Accident Analysis and Prevention, October, 2014
EuroNCAP, "Far Side Occupant Test & Assessment Procedure," European New Car Assessment Program, November 2017.
Fildes, B and Digges, K, (editors) "Occupant Protection in Far-Side Crashes," Research Report by GW University and Monash University, June, 2009.
Gabler, H, Digges, K, Fildes, B and Sparks, L, "Side Impact Injury Risk for Belted Far-side Passenger Vehicle Occupants," SAE 2005-01-0287, April, 2005.
Grzebieta, R, Bambach, M, Mattos, G, McIntosh, A, Simmons, K, Rechnitzer, G and Digges, K, 'Replicating Real World Rollover Crash Injuries," Paper Number 13-0098, Proceedings of the 23rd ESV Conference, May 2013.
Pintar, F, Yoganandan, N, Stemper, B, Bostrom , O, Rouhana , S, Smith, S, Digges, K and Fildes, B, "Far Side Impact Response and Dummy Biofidelity", Proceedings of the 2007 Stapp Car Crash Conference, October, 2007.
Radwan, R, Prasad, P, and Nix, L, "Opportunities for Injury Reduction in US Frontal Crashes: An Overview by Structural Engagement, Vehicle Class, and Occupant Age," Proceedings of the 2009 Stapp Car Crash Conference, October, 2009.
Tahan, F, Digges, K, Kan, C, Grzebieta, R and Bambach, M, "Evaluation of a Real World Damage Reproduction Rollover Crash Case"' ICRASH 2014.
Tahan, F, Digges, K, Kan, C, Grzebieta, R and Bambach, M, "Potential Thoracic Injuries in a Rollover Crash Reproduction" ICRASH 2014.

Crashworthiness Recommendations

ASRI has three Crashworthiness Recommendations:

1- Control the shoulder belt routing in frontal tests,
2- Use the Thor Dummy in all frontal tests, and
3- Use injury criteria and weighting factors that reflect injury priorities on the road.

Shoulder Belt Positioning with the Hybrid III

Chest compression is universally accepted as the preferred metric for assessing chest injury risk. In the case of the Hybrid III family of adult dummies, chest compression is measured by a single chest deflection gauge at the centerline of the dummy's sternum. The way the shoulder belt crosses the chest may make little difference to a living person, but it makes a large difference to the measurement of the chest deflection at a single point on the chest of a dummy. The way the belt crosses the chest is highly dependent on the adjustment of the upper anchorage (D-ring).

The position of the D-ring is not prescribed in current NCAP testing protocols. Instead, the vehicle manufacturer is allowed to specify which adjusted position of the D-ring is to be used in the test. As a result, over 90% of recent frontal NCAP tests were conducted with the D-ring in the uppermost position. When the D-ring is in the uppermost position, the shoulder belt rubs the neck and is well removed from the chest deflection gauge. This high belt routing greatly reduces the magnitude of the chest deflection and the chest injury risk.

In a replicate of an NCAP test, but with the D-ring in the lowermost rather than in the uppermost position, the chest deflection on the passenger side dummy increased from 11.8 mm to 34.5 mm [Digges, Dalmotas, Prasad, and Mueller, ESV 2017]. Given this change in observed deflection, the chest injury risk would change from 0.6% to 15% in the case of a 35 year old male, and from 0.6% to 45% in the case of an elderly female.

The injury risk changes noted above illustrate how fake safety benefits are being realized by simply altering the shoulder belt positioning procedures as permitted in the current Frontal NCAP.

In the short term, this deficiency could be remedied by a requirement that the lowermost anchorage location become the default position. The next highest position(s) could be specified in the event any portion of the belt is off the shoulder.

For the 5th female dummy passenger, we recommend that the position of the seat should be immediately changed from the current foremost position to the mid-position. This change would make the testing environment more field relevant.

In the long term, consideration should be given to the development of a dummy-landmark based belt positioning procedure.

A promising alternative to control belt routing would be the use of rib-eye instrumentation on the 5th dummy. Sled tests to be reported in our proposed 2019 ESV paper indicate that the rib-eye instrumentation can show the degree to which the belt is off-set from the center gage. The rib-eye readings could provide a basis for encouraging proper belt routing.

Controlling shoulder belt routing would close a large loophole in the NCAP test procedure that is producing misleading chest injury risk measurements.

Reference:

Digges, K, Dalmotas, D, Prasad, P, and Mueller, B, "The Need to Control Belt Routing for Silver NCAP Ratings," ESV Paper Number 17-0403, Proceedings of the 25th ESV Conference, June 2017.

Use the Thor Dummy in Frontal NCAP Tests

35 years ago, when I was Director of the Office of Passenger Vehicle Research, I started work on the Thor dummy. One reason I initiated the advanced dummy work was because the Part 572 dummies were not sufficiently sensitive to encourage the best safety systems. The Hybrid II and Hybrid III dummies could differentiate between the presence or absence of air bags, but could not adequately differentiate between the levels of safety provided by various kinds of restraint systems.

In 1975, I had overseen the crash testing of air belts by young Navy volunteers up to frontal crash severities 32.5 mph without injury [Burks and Cromack, NHTSA 1975]. The volunteers were willing to continue the testing to 35 mph, but I was not, because tests of conventional belts produced severe injuries to cadavers at lower crash severities. The maximum crash severity of any volunteer test for a conventional force limited belt was 30 mph. When we tested cadavers in conventional belts at 30 mph, massive (fatal) rib fractures occurred [Walsh, NHTSA 1976].

As a follow-up to the human volunteer air belt tests, we tested two cadavers restrained by air belts at 46.7 mph. One specimen had some rib fractures but they were undisplaced and mostly confined to the external rib surface. The second the specimens had only one rib fracture that was attributed to terminal external cardiac massage. The maximum injury severity ratings were AIS 3 and AIS2, respectively [Walsh, NHTSA 1976].

The contrast between the injuries from conventional belts at 30 mph and air belts at 47 mph suggests that air belts would be beneficial to all ages, but especially to seniors. Tests with Part 572 dummies by NHTSA and others have not shown the benefits of air belts that we saw in human volunteer and cadaver tests. A similar argument could be made when comparing air bags and conventional belts.

The Thor dummy family has improvements in chest biofidelity and instrumentation that are designed to measure the safety differences that were observed in the human tests.

After 35 years of development, it is time to federalize the Thor 50th and 5th dummies and use them to encourage the improvements in restraint systems that are needed to offset the decline in frontal safety caused by the increases vehicle stiffness.

References:

Burkes JM and Cromack JR, "Impact Testing of Allied Chemical "Inflataband" with Dummies and Human Volunteers," Southwest Research Final Report for DoT Contract DOT HS 4 00933, July 15, 1975.

Walsh MJ, "Sled Tests of Three-point Systems Including Air Belt Restraints" Calspan Final Report for DoT Contract DOT HS 5 01017, January 1976.

Apply Weighting of the Risk for each Body Region by the Field Prevalence for that Body Region

We believe that the NCAP test injury risk measurements for each body region should be relevant to injury risks in similar real world crashes. As a minimum, the risks measured for each body should be in the same order as the injury risks in the field. Failure to do this may encourage the safety optimization for a body region where there are few injuries at the expense of one where there are many.

A methodology for developing body region risk curves and weighting factors based on field performance was contained in an earlier ESV paper (Digges, Dalmotas and Prasad, ESV 2013). The methodology develops a correlation between injury risks measured in NCAP crash dummies and injury risks observed in crashes of similar vehicles on-the-road. Dummy risk curves and weight factors can be selected to agree with equivalent populations in the real world crashes.

The referenced 2013 paper suggests that the current criteria requires optimization to reduce injuries to the neck at the expense of the chest, where serious injuries are much more frequent. The use of field relevant injury functions would encourage safety systems that prioritize protection of body regions in the same order as the injuries are occurring in the field.

Reference:

Digges, K, Dalmotas, D and Prasad, P, "An NCAP Star Rating System for Older Occupants," ESV Paper Number 13-0064, Proceedings of the 23rd ESV Conference, May 2013.

Post-Crash NCAP

The Haddon Safety Matrix, proposed by NHTSA's first Administrator, showed 9 opportunities for reducing highway casualties. Dr. Haddon recommended initiatives to reduce casualties in all 9 cells of his matrix. Three of the matrix cells involved vehicle factors. They were: (1) Crashworthiness; (2) Crash Avoidance; and (3) Post Crash Safety.

NCAP currently addresses the first and is considering the second. We recommend adding the third –Post Crash Safety- which is not currently being considered. Haddon identified two vehicle factors in Post-Crash Safety – (1) Ease of Access and/or Egress and (2) Fire risk. Since Haddon, a third factor has emerged – Automatic Crash Notification

We now recommend a Post-Crash NCAP with three components–

(1) The ease of egress from the crashed vehicle,

(2) The post-crash fire safety that includes the prevention of leakage of all flammable fluids and of battery faults, and

(3) The effectiveness of the automatic crash notification system.

Vehicle Egress

We have proposed a door opening test procedure in Appendix A to our 2009 ESV paper on Fireworthiness [Digges and Stephenson, ESV 2009]. We believe a standard door opening test should be applied to all side doors in frontal and rear tests and to rear and opposite side doors in all side tests.

The results from a series of vehicle burn tests conducted by General Motors have been analyzed to determine the effect of vehicle construction materials on passenger survivability in post-crash vehicle fires [Tewarson, 2005 Vol. 1-3]. The vehicles tested were subjected to fires that initiated in the engine compartment or resulted from spilled fuel beneath the vehicle. The authors concluded that once flames penetrated the passenger cabin from either the engine compartment fires or the spilled fuel fires, death of all occupants would occur within about two minutes due to simultaneous effects of heat, burns, and toxic gases [Tewarson, 2005 SAE]. The rapid flame progression that occurs when occupant compartment materials are exposed to a high heat load from external fires makes rapid egress from a crashed vehicle a valuable countermeasure. Entrapment in a burning vehicle is a particularly gruesome form of traffic fatality. Consumers should be very interested in knowing which vehicles are less likely to entrap them after a crash.

<u>A PROPOSED EGRESS RATING PROCEDURE FOR NCAP FOLLOWS:</u>

1. A door opening force test and a latch release force test should be applied to each passenger door after every NCAP test and star ratings awarded based on ease of egress.

2. A minimum acceptable requirement is for least one door per seating row (that has a door) be able to be opened at an acceptable force level after the crash test. This should apply to both hinge and sliding doors. The star rating would be applied to the door in each row that has the lowest opening force.

3. After the crash test, the force required to release the latch and to open each door will be measured. The door opening force can be applied from either the inside or the outside of the door. For

the inside, the force should be applied at the normal shoulder position with the seat far forward. For the outside pull, the force should be applied at the door handle. For sliding doors, the interior force may be applied at the door handle.

4. The star rating can be based on the percentage of the driving population that would be able to apply the force needed to open the door. A research program to determine appropriate thresholds is suggested in the outline to follow.

R & D TEST TO DETERMINE STAR RATING THRESHOLDS FOR DOOR OPENING FORCE:

It is suggested that the star rating thresholds for door-opening force be determined by doing a simple experiment on a few un-crashed cars.

Using an uncrashed vehicle, the door latch should be removed entirely. Then attach a load cell to the door in a way that prevents the door from opening. Have an appropriate number of volunteers push and pull on the door as hard as they can. The subjects should include 5% adult females, 50% males and females, and 95% males of several age groups, including elderly. They should both push from inside the car, and also try to open the door from the outside (as if they are trying to rescue someone). The load cell will hold the door in fixed position. The door does not need to actually open in this force test.

Once the data is in hand, NHTSA can set the force star ratings by deciding what percentile of the population would be able to open the door at a given force level.

References:

Digges, K and Stephenson, R, "Fireworthiness: A Final Report on the Technology Base", Paper Number 09-0211, Proceedings of the 21st ESV Conference, June 2009.

Tewarson, A, Quintiere, J G, and Purser, D J, "Fire Behavior of Materials in Vehicle Crash Fires and Survivability of the Passengers", SAE paper 2005-01-1555, April 2005.

Tewarson, A, Quintiere, J G, and Purser, D J, "Post Collision Motor Vehicle Fires" FM Global Technical Report #0003018009, Volume I, October 2005.

Tewarson, A, Quintiere, J G, and Purser, D J, "Theory and Testing for the Fire Behavior of Materials for the Transportation Industry" FM Global Technical Report #0003018009, Volume II, October 2005.

Tewarson, A, "Thermophysical and Fire Properties of Automobile Plastic Parts and Engine Compartment Fluids" FM Global Technical Report #0003018009, Volume III, October 2005.

Digges, K and Stephenson, R, "Fireworthiness: A Final Report on the Technology Base", Paper Number 09-0211, Proceedings of the 21st ESV Conference, June 2009.

Fire Safety

Extensive research on Fire Safety has been conducted by General Motors and subsequently by the Motor Vehicle Fire Research Institute as part of the CK Pickup Fire Safety Settlement Agreements during the time period 1996 to 2009. This research forms the basis for justifying Fire Safety tests as part of NCAP.

The NCAP rating should encourage the prevention of leakage of all flammable fluids after the crash and the disconnect of all high amperage cables from the batteries.

The technical basis for the Fire Safety NCAP rating is contained in our 2009 ESV Paper.

Reference:

Digges, K, and Stephenson, R, "The Basis for a Fluid Integrity NCAP Rating," Paper Number 09-0215, *Proceedings of the 21st ESV Conference*, June 2009.

Automatic Crash Notification

In July 2018, ASRI submitted to the Docket 18 research papers that that provide a foundation for an NCAP rating of the Automatic Crash Notification System.

With appropriate government guidance, ACN could save lives by notifying 911 operators of crashes with time critical injuries that need urgent response.

<u>Possible levels of star awards are as follows</u>:

1- Robustness of the system - does it transmit in rollovers with the vehicle on its roof and in areas with low cell phone signals?

2- The effectiveness of the system - its ability to rapidly notify emergency responders of crashes with time critical injuries.

It should be noted that some government initiatives are needed to provide the mechanisms for communicating the presence of time critical injuries to the emergency responders.

The references submitted with our July Docket Submission were as follows:

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Conclusions

In summary, ASRI has the following recommendations:

1. Provide consumers an immediate **Silver Rating** for seniors,

    Use injury criteria for seniors in current NCAP tests

    Ultimately add a lower speed crash test

2. Add a rating for **Rear Seat Occupants**

    Add a 5% HII dummy to the rear seat in Frontal NCAP

    Ultimately use Thor Dummy

3. Include a **Far-side Safety Rating**

    Immediately adopt the EuroNCAP Far-side protocol

4. Improve existing **Crashworthiness Ratings**

- **Control the shoulder belt routing in frontal tests**

    Require D-ring in lowest position

    Develop a dummy based belt routing control

    Use rib-eye or IR-TRACC

- **Use the Thor Dummy in all frontal tests**

    Encourage available safety improvements not distinguished by HIII

- **Use injury criteria and weighting factors that reflect injury priorities on the road**

    Encourage systems optimized to mitigate injuries according to frequency of occurrence in similar crashes

5. Include a **Post-crash Safety Rating** that encompasses vehicle safety opportunities identified in the Haddon Matrix

- **Egress**
- **Fire Safety (and Battery Faults)**
- **Automatic Crash Notification**

I am confident that our recommended improvements to NCAP will allow it to continue to advance vehicle safety by providing accurate consumer information.

Sincerely,

K H Digges

Kennerly H. Digges

President, Automotive Safety Research Institute