Presentation at the NHTSA Public Meeting on Side Impact Airbags:

A Systems Approach to Help Ensure Safer Side Impact Protection and Inflatable Airbag Restraint Systems

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1. INTRODUCTION: THE EMERGENCE OF SIDE AIRBAGS

It is commendable that the National Highway Traffic Safety Administration (NHTSA) is conducting this important Public Meeting to discuss the potential benefits and risks of inflatable restraint systems (airbags) for side impact protection, and how to test them. It is imperative that side airbags do not cause needless injuries and fatalities to children or anyone else, while still providing optimum performance as an important injury-reduction technology. That lesson has been well-learned from the implementation of frontal airbags in which particular designs caused needless deaths and severe injuries to children passengers, and to short-stature adult drivers.

Rather than focus on side airbags as an isolated element, I believe it is imperative that side airbags be designed and evaluated as an important element within the total side impact protection *system*. Side airbags must interrelate with these other elements, such as seats and seatbelts and side windows and vehicle body structures, so that *collectively* all of these integrated features will enhance occupant protection even more.

Side airbags are a newly-emerging safety technology. Side airbag designs include those that are:

SMALL BOLSTER AIRBAGS built into the outboard side of the front seats, or into the door, that inflate forward, primarily to protect the torso, and also to help reduce head excursion.
LARGE BOLSTER AIRBAGS built into the outboard side of the front seats, or into the door, that extend upward to directly protect both the head and torso.
TUBULAR AIRBAGS that extend diagonally from the A-pillar to the B-pillar, primarily to help protect the head, and used in conjunction with a lower bolster airbag (*BMW*).
SIDE CURTAIN AIRBAGS with multiple chambers that inflate downward from the roof-rail (*Volvo, Mercedes*).

Whatever the particular design of side airbags, it is important to take into account the fact that side-impact protection is dependent upon ***the more complex system*** that includes the following considerations.

2. VEHICLE BODY STRUCTURE: DEFLECTION AND INTRUSION

The vehicle's side body structure should help minimize inward intrusion into the occupant's *"survival space"* and thus lessen interference with the side airbag's performance. For example, some vehicles have subframe members too far inboard from the vehicle body sides, and minimal-strength partially-reinforced rocker sections, and thus there is a structural *"gap"* or softness in the mid-body region, where the passengers are located. That structural *"gap"* can allow excessive inward intrusion into the occupant's *"survival space"* and reduce the effectiveness of side airbags and other protective measures.

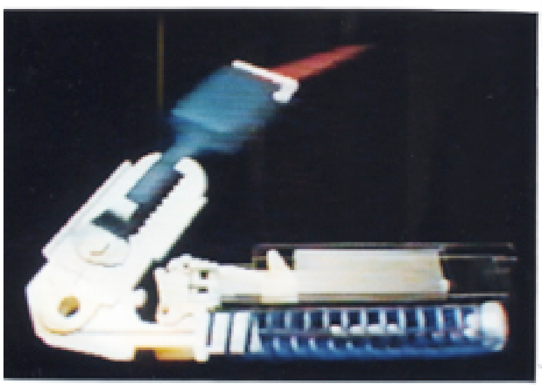
Stronger vehicle body sides and doors serve to encourage *deflection* of an intruding vehicle off of and away from the side of the struck car, rather than the more injurious deeper pocketing and penetration of the intruding vehicle into the struck vehicle. Some vehicles alternatively utilize stronger vehicle body side members, and interconnect the subframe rails outward to reinforced rocker sections, thus strengthening the unitized body into an analogous rendition of having a full-perimeter frame. Box-section lateral stiffeners at the floorpan level and at the roof level can further strengthen the vehicle's side impact resistance.

Vehicle doors have internal stiffeners and door beams to help resist inward intrusion of the door. To help support the door beams and to better transfer loads, most doors use reinforced hinges and latches. Some designs also significantly overlap the top and bottom of the doors over the adjacent sills, to further strengthen the door against being pushed inward. Stronger front seats with lateral stiffeners in the seat base and seat backrest and H-point can also help reduce intrusion in side impacts.

3. SEATBELT DESIGN: SNUG FIT AND PRE-TENSIONERS

Seatbelts may compromise their effectiveness if they have a significant gap between their anchorages and the particular occupant, whose size may be very small or very large, and with the seat adjustment further compromising a snug fit. Many designs have the shoulder anchorages on the mid-body or B-pillar with reduced effectiveness in serving as a lateral restraint. The shoulder belt gap and looseness can allow excessive lateral movement and can slide off the occupant's shoulder. The amount of spool-out of the belt from the retractor before it fully locks the webbing, can also reduce the restraint ability of the shoulder belt.

Seatbelt performance can be enhanced if the lap and torso belts are fully integrated into a stronger seat structure, with pre-tensioners and force-limiters, and with height-adjustability for the shoulder belt's upper anchorage. Therefore, the seatbelt will fit the occupant in a snug, safer manner, and will minimize the potential for sideways and side-angular excursion out of the belt.



4. SEAT DESIGN: WRAP-AROUND CONTOURS AND INTEGRATED BELTS

Seats should have adequate wrap-around contours to help hold the occupant in position during side impacts, and should integrate the seatbelts into the seat structure itself. The wrap-around contour of the backrest, and the upward contour of the outer sides of the seat cushion, can help hold the seated occupant in position in side impacts. Wrap-around seats and integrated seatbelts are a currently re-emerging development, although they were initially shown as feasible concepts back in the 1960's.

5. DOOR STRUCTURES: WITH INJURY MITIGATION FEATURES

Doors can have internal and surface energy-absorbing foam, to help spread and cushion the forces of side impact into larger areas and stronger portions of the passenger's body, and to help control the occupant's lateral movement during the crash.

6. SIDE-WINDOWS: SAFER LAMINATED GLASS-PLASTIC-GLASS

Side windows are typically a single panel of thin tempered glass, but instead can be designed to include an additional middle inner layer of a tough stretchable plastic that is laminated within two outer layers of tempered glass. This is analogous to the front windshield which is also a lamination of glass-plastic-glass. This combination of a glass-plastic-glass lamination or sandwich design would help maintain the side window's integrity in side impacts and during rollovers.

This would allow side airbags to initially inflate in a more outward direction (away from the occupant), and would also help support the side airbag and keep it from being forced outward through the shattered window opening. This initial outward inflation of the side airbag is analogous to the safer frontal airbags that initially inflate upward from the top surface of the instrument panel, and then toward the occupant… rather than the more injurious designs that initially inflate horizontally rearward directly at the head of a seated small child.

Whether it is of a 3-layer *glass-plastic-glass design*, or a 2-layer *glass-plastic* design, such safer side windows can help mitigate head and neck injuries while also serving to reduce partial or complete ejection of the occupant's head and upper body during a side-impact collision. Such safer glass-plastic glazing is duly noted and discussed in *FMVSS 205*, and has been permitted since 1983. Side window glass-plastic glazing is now being brought into some production vehicles, and its widespread usage should be encouraged.

7. "SMART' SENSORS AND TAILORED-INFLATION TECHNOLOGY

The technology is either available or rapidly-emerging to be able to determine the ***weight*** and ***size*** of an occupant on the adjacent seat, their ***proximity*** to the stored airbag, and the ***severity*** of the crash, and then ***tailor*** or vary the inflation rate and pressure of the side-impact airbag accordingly. With the very narrow distance and virtially no significant "crush zone" distance on the vehicle sides, the senors and signal processing must be done in just a few milliseconds of time. With the likelihood that some situations will involve a high-speed impact into the vehicle side, the response time will potentially warrant an extremely high-pressure response from the inflator in order to extend the airbag in time.

Tailored-inflation of the airbag would be desirable to accommodate the many situational variables. For example, if a small child is on the seat, and the side impact is less than 18-20 mph BEV, then the side airbag would inflate in a *"softer"* manner. If a large, heavier adult were on the seat, and the side impact was above 20 mph BEV, then the side airbag would inflate in a *"firmer"* manner. This is analogous to the frontal airbag concept utilized for the passenger airbag to help protect children in the General Motors airbag cars in the 1973-1976 era. This similar ***dual-inflation concept*** will be a re-emerging meritorious feature of the frontal airbag system in the Year 2000 Ford Taurus.

8. THE NEED FOR WARNING LABELS AND SHUT-OFF SWITCHES

In the case of frontal airbags of the 1988-1998 era, it is well known that parents were not properly warned of the hazards of front passenger airbags that could severely injure or kill their children. Nor were parents alerted to the differences in airbag designs, such as why the top-mounted vertically-deploying airbags were safer than front-mounted airbags that deployed horizontally rearward directly at the small child.

In much the same manner for side airbags, parents and others need to be warned about any precautions that must be taken to insure that side airbags… which are of ***varying*** designs… do not cause severe to fatal injuries to infants, children, teenager, or adult passengers of different sizes.

Shut-off switches should be considered so that the vehicle owner could temporarily disable the side airbag for either the driver or passenger, if warranted by a particular situation.

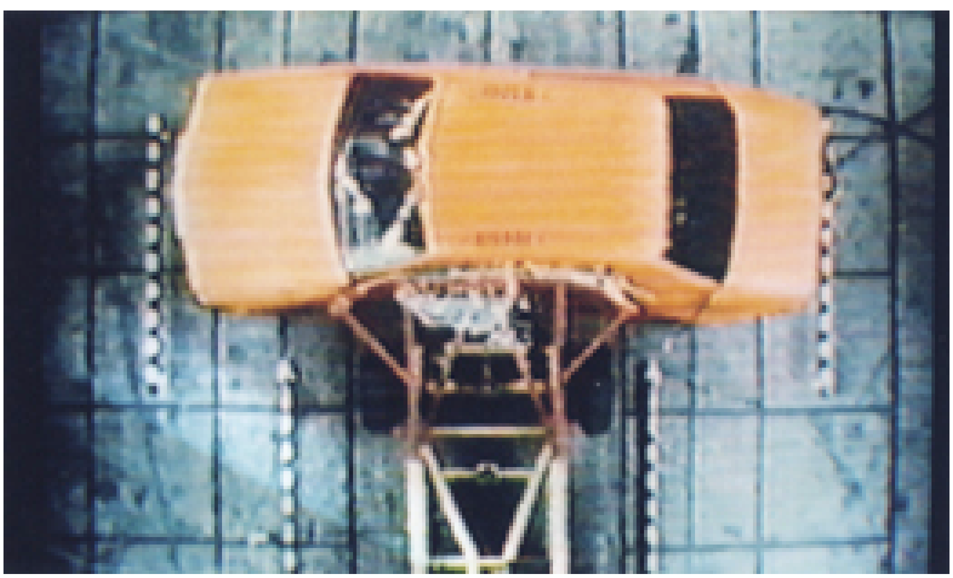
9. RECOMMENDED TEST PROCEDURES TO EVALUATE SIDE AIRBAGS

Any NHTSA-mandated performance test requirements should take into account that the side impact protection afforded by the airbag is *only part of a more complex and interrelated system* that embodies various other elements as well. The test protocol should be of a dynamic or crash test nature. The moving-barrier-into-vehicle-side test, as presently in FMVSS 214, should be expanded to include other side impact tests at higher speeds. Injury criteria should be measured for the head, neck, chest, and pelvic regions, using latest versions of SID and THOR test dummies.

With the continuing tremendous increase in sales of sport utility vehicles (SUVs), and the continuing high sales rate for pickup trucks and vans, it is important for NHTSA to evaluate the side-impact collision effects of these larger, taller, heavier, stiffer vehicles when they impact into the side of passenger cars. This SUV-into-car mismatch has greatly alarmed the public, has caused severe to fatal injuries of the car occupants, and can *overwhelm* the otherwise protective benefits of side airbags. NHTSA must include appropriate SUV-into-car side-impact crash test procedures.

Performance of the side airbag may also be significantly affected by the rate and extent of side intrusion into the door structure and into the occupant's survival space. The crash sensors and signal processing (including algorithm comparisons) and inflator actuation and airbag inflation all need to respond in time. Therefore, the test protocol should also include a range of crash test speeds and angles. The vehicle should also be crash tested by moving it laterally into a fixed pole, so that the contact point or plane is parallel with the driver's head.

The NHTSA-mandated test requirements should include a matrix of crash test dummies that includes infants and small children in child safety seats, and a child on a booster seat, and a 5th-percentile woman, and a 95th-percentile adult male. The side airbag should also be evaluated for any potential adverse effects on pregnant women and their long-term fetuses.(such test dummies are available). With our population including a increasing percentage of overweight and obese persons, there should be consideration for any adverse effects of side airbags upon them.



While FMVSS 214 requires a minimal side impact at 33.5 mph by a deformable moving barrier, with specific injury-related thresholds. Again, that performance requirement is only a *minimal*, and does not itself enable a full evaluation of the *potential benefits* and the *potential detriments* of side airbags and the other variables that can affect the safety of various occupants (children, short elderly adults, very large adults). Nor does it realistically test for the adverse effects of large SUVs and pickup trucks that can often overwhelm the smaller passenger car and its occupants.

10. VEHICLE ROLLOVER TESTS MUST ALSO BE INCLUDED

The side impact issue, with side airbags to help reduce injuries, must also include vehicle *rollover* considerations. This is primarily because, in many rollover incidents, especially those with lateral rollovers such as happens with Sport Utility Vehicles (SUVs) and pickups and minivans, the driver and passengers can impact their head and upper torso into and through the thin tempered-glass side windows, or can strike the adjacent roof pillars and headers, or the road surface. This is analogous to being in a side impact, with the trauma induced by *lateral impact* forces to the occupant's head, or because the occupant's head moved laterally outward of the vehicle periphery and struck the ground. In the rollover, there may also be trauma induced due to the roof buckling and crushing downward in the occupant's head and vertebral column.

This relationship to rollover indents has been well noted by the manufacturers of the head-level tubular airbag (Simula) and the side curtain airbag system, who point out that such airbags stay sufficiently inflated during the rollover sequence so as to help prevent head injuries. It would be important to assess the performance benefits and potential deficits of the various side airbag designs in this regard, and could lead to improved side airbags that substantially reduce trauma in vehicle rollover accidents.

It is imperative for NHTSA and the automakers to include dynamic vehicle rollover tests, with test dummies in all seated positions, to better assess the injury-reduction performance of side airbags. Such dynamic vehicle rollover tests will also, of course, evaluate the performance of ***seatbelt restraints*** to safely hold the occupant in position, ***the roof structures*** as to their propensity to buckle and crush downward and laterally into the survival space, and ***the window glazing*** to stay intact and retained to the vehicle. This rollover test would upgrade or supercede FMVSS 216, which only requires a slow downward push on a frontal section of the roof, with no test dummies, and no measurement of any injury potential.

11. PUBLIC NEED FOR COMPARATIVE PERFORMANCE INFORMATION

The American public should receive information about the performance differences among the various side airbag systems (as well as other crashworthiness performance factors). It is not sufficient to simply note that the particular side airbag system complies with the Federal Motors Vehicle Safety Standard, since such so-called "safety standards" are only *minimal* requirements. Side airbags in vehicle A may just barely meet the FMVSS minimal requirement, say at 33.5 mph. Side airbags in vehicle B may provide protection at the higher level of say 60 mph. In trying to determine the relative safety of various competing vehicles, how will the purchaser obtain information about which side airbags perform at minimal levels versus those that perform at much higher levels?

Side impact protection for all occupants clearly requires a coordinated *systems design* approach. The concerns and suggestions expressed in this paper will hopefully be considered by NHTSA and the automakers and airbag system providers to help ensure well-performing side airbags and *other* side-impact safety measures as well.

Thank you for this opportunity to present my perspectives and suggestions about the subject of side impact protection and the emerging technology of side airbags.

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