DETERMINATION OF FRONTAL OFFSET TEST CONDITIONS BASED ON CRASH DATA

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ABSTRACT

This paper reports on the test procedure development phase of the agency's Improved Frontal Protection research program. It is anticipated that even after all cars and light trucks have air bags for drivers and front seat passengers there will remain over 8,000 fatalities a year and over 100,000 moderate to severe injuries. This research program will address these injuries/fatalities through development of crash tests with impact conditions not currently addressed by FMVSS No. 208, development of additional or more appropriate instrumentation and injury criteria on the test surrogate, and evaluation of other sizes of test surrogates.

An analysis of crash data is presented using the National Automotive Sampling System (NASS) and the Fatality Analysis Reporting System (FARS) for fatality counts. The population is drivers in frontal collisions with air bag restraints. Using NASS, frontal impact modes are grouped into general "test" conditions which will best represent the real world impact environment. These general test conditions include full barrier, left and right offset, and other impact modes. Using these general groupings of impact conditions, the analysis further assesses degree of overlap and impact direction to determine more specifically which crash conditions result in highest injury/fatality to drivers with air bags. Injury/fatality risk is also assessed by driver size and body region, with a more detailed analysis of leg injuries. Finally, a preliminary benefits analysis is presented for a future frontal, left, offset test procedure.

A test procedure has been developed, and is reported on in a separate paper [1]. Collinear and oblique, offset, frontal crash testing, at different widths of overlap, has been conducted with several current model, "target" cars into a standard "bullet" car at closing speeds of about 110 kph. Dummy injury measurements and structural responses provide a basis for determining which impact conditions produce the most severe environment for occupants with air bags. It appears that the oblique impact with over 50 percent overlap produces the most severe responses on the "target" car. Development of this impact configuration into a potential frontal test procedure has been completed using a moving deformable barrier (MDB).

INTRODUCTION

In the United States, air bags with lap and shoulder belts are specifically required by legislation (i.e., the National Highway Traffic Safety Administration Authorization Act of 1991) for both front outboard seating positions in all passenger cars manufactured after September 1, 1997. They are also required in all light trucks, multipurpose passenger vehicles (e.g., vans, utility and sport vehicles), and buses with a gross vehicle weight rating of 3,846 kilograms (8,500 pounds) or less and an unloaded vehicle weight of 2,489 kilograms (5,500 pounds) or less manufactured after September 1, 1998. NHTSA's "Third Report to Congress - Effectiveness of Occupant Restraint Systems and Their Use", dated December 1996, estimates that drivers protected by air bags experience a reduced fatality risk of 11 percent overall and 31 percent in pure frontal accidents.

The detailed performance requirements for these systems are contained in Federal Motor Vehicle Safety Standard (FMVSS) No. 208, Occupant Crash Protection. The standard has long specified a barrier test requirement using both belted and unbelted dummies. Beginning in March, 1997, Standard 208 has been temporarily modified to allow for a 48 kmph sled test requirement for unbelted dummies which made it easier for manufacturers to quickly introduce less aggressive, depowered air bags. This temporary option expires in September, 2001 and thereafter the full barrier test is again required. The main dynamic performance requirements in FMVSS No. 208, either sled or barrier test, involves successful testing with a 50th percentile adult dummy at all speeds up to 48 kilometers per hour (30 miles per hour) at all angles between perpendicular and 30 degrees to either side of perpendicular. The tests can be run both with the dummy being unbelted and with the belts on. "Successful" crash testing requires that the dummy Head Injury Criterion (HIC) be 1,000 or less, the dummy chest deceleration be 60 G's or less, and the dummy femur loads be at or below 10,000 Newtons. The chest deflection on the Hybrid III dummy must be less than 75 millimeters.

The agency is currently in the process of proposing further requirements for reducing air bag aggressiveness which will lead to advanced air bags. Based on assessment of technologies which will come available in the next few years future air bag systems may include variable level deployments, or suppression, based on crash severity, and/or restraint use, pre-crash occupant position and/or size. As previously noted the full barrier test will again be required in September, 2001 to possibly "recapture" injuries/fatality savings in high severity crashes which may have been lost with depowered air bags. Part of the analysis in this paper is to look at crashes which may be represented by the 30 mph fixed barrier test of FMVSS No. 208 in terms of frequency of involvement, and injuries.

Even after full implementation of driver and passenger air bags as required by FMVSS No. 208, it has been estimated that frontal impacts will still account for over 8,000 fatalities and 120,000 moderate-to-critical injuries (i.e., injuries of AIS $\geq$ 2). The fatality estimate is based on 1995 FARS figures adjusted to a baseline non-air bag fleet and applying an air bag effectiveness estimate of 11 percent (from the Agency's "Third Report to Congress - Effectiveness of Occupant Protection Systems and Their Use.") to predict fatalities for an all air bag fleet. The number of fatalities in non-rollover frontal impacts is based on the proportion estimated by the NASS analysis and the computations are shown as part of Table 9. The estimates of annual numbers of moderate-to-critical injuries are from the Agency's "Final Regulatory Evaluation - Actions to Reduce the Adverse Effects of Air Bags - FMVSS No. 208 - Depowering." The objective of this research program is to address these fatalities and injuries and provide a basis for the possible future improvements in frontal protection. This may include upgrade of FMVSS No. 208 injury criteria and test devices, and the development of supplementary test procedures for the evaluation of occupant injury in crashes of higher severity and in different impact modes than those addressed by the current FMVSS No. 208 [2-5].

The agency has been directed by Congress to develop a frontal, offset compliance test to complement the current FMVSS No. 208 full frontal test. The agency is evaluating a 40 percent overlap, 60 Kmph full-fixed-deformable barrier test which has been adopted in Europe, but at a test speed of 56 kmph. This will determine whether benefits can be realized in the U.S. from adopting this test procedure in the near future. The plan for making this assessment was presented in a report to Congress in April, 1997. The results of the FY 1997 testing is presented in a proposed paper for the 16th ESV Conference [6]. The oblique/offset test being developed by NHTSA 's Research and Development office would be considered a longer term project.

Defining the problem includes assessing crash data and identifying general laboratory test conditions that can be used to replicate the safety performance of air bag vehicles in use. Then, evaluating the performance of a variety of production vehicles under those preliminary crash conditions, comparing their performance, and conducting potential benefits assessments to guide the agency for the "final" selection of a test procedure(s).

Some general conclusions from the analysis are:

- For drivers in frontal collisions with air bags, the offset crash configurations with highest frequency and risk of serious to fatal injuries is a left offset, vehicle-to-vehicle impact with substantial overlap .
- Drivers with air bags have a higher risk of leg injury in left offset crashes than in other frontal crashes and, thus, reducing leg injuries should be a prime objective in development of a offset test procedure. Leg injury should address tibia, knee and ankle measures, not addressed currently in the standard.
- For left offset impacts, improvements to reduce injury should address leg/instrument panel and floor interaction and all regions with left side surfaces.
- The size grouping representing 50th percentile males results in the highest crash exposure and number of injuries/fatalities for left offset impacts. However, both smaller and larger drivers have a higher risk of AIS$\geq$2 injuries and larger drivers have higher risk of AIS$\geq$3 injuries and fatalities even though their crash exposure is much lower than that for the 50th percentile grouping.

- Based on various assumptions, a requirement for a left offset test procedure could save as many as 5,100 AIS≥3 injuries and over 20,000 AIS≥2 injuries each year. Leg injuries alone could be reduced annually by about 11,000 for AIS≥2 and about 2,000 for AIS≥3. Although not estimated, it appears that substantial fatalities could be reduced. The European (EU) offset test procedure could potentially address many of the leg injuries, while other recent or future vehicle improvements, such as FMVSS No. 201 head protection or future advanced air bags will eliminate many of the other injuries and fatalities.

The analysis is based on relatively limited cases of drivers with air bags in NASS and findings may change with additional data.

CRASH ENVIRONMENT

The agency's National Automotive Sampling System (NASS) files for the years 1988-96 were used to project the occupant injuries that will occur in an all air bag fleet. In the 1988-1996 NASS there are about 2700 vehicles with driver air bags in frontal crashes. The analysis will identify test conditions to simulate crashes with highest risk and frequency of injury/fatality. These test conditions can be used to analyze the safety performance of baseline vehicles and to assess potential countermeasures. The NASS is a statistical sample of the United States accidents investigated in detail. About 4,500 crashes per year are currently being investigated. The NASS files for these years differ from those of previous years in that only the more serious accidents qualified for inclusion into the files. Crashes involving air bag-equipped vehicles have been increasing along with the increasing installations. Between 1988 and 1996, the NASS teams investigated 44,368 crashes, representing an estimated 21 million crashes and 12 million injured vehicle occupants nationwide. In these crashes, 2,891 driver and 378 right, front passenger air bag deployments were investigated, representing an estimated 1,012,263 driver and 124,506 right, front passenger air bag deployments that occurred during that time frame.

When comparing drivers with air bags to those without air bags serious injury risk is slightly lower with air bags and belts and belts "as used", i.e, no discrimination for whether belts were or were not used (Figure 1, and Table 1.) However, for fatalities air bags have lower rates for all restraint conditions and

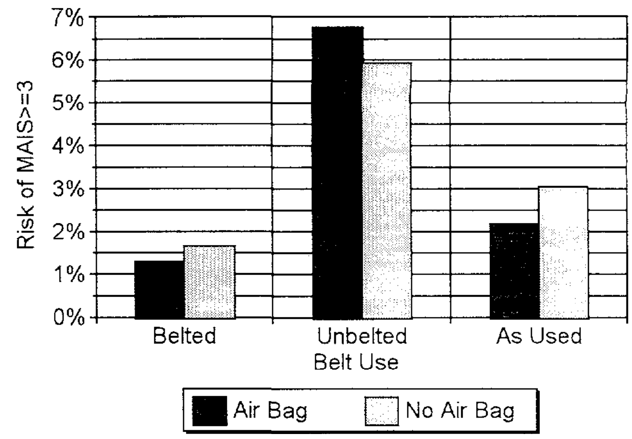

Figure 1. Serious Injury Risk by Restraint, Drivers in Frontals

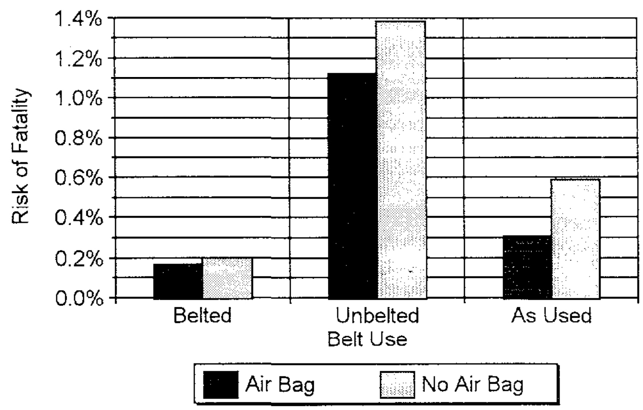

Figure 2. Fatality Risk by Restraint, Drivers in Frontals

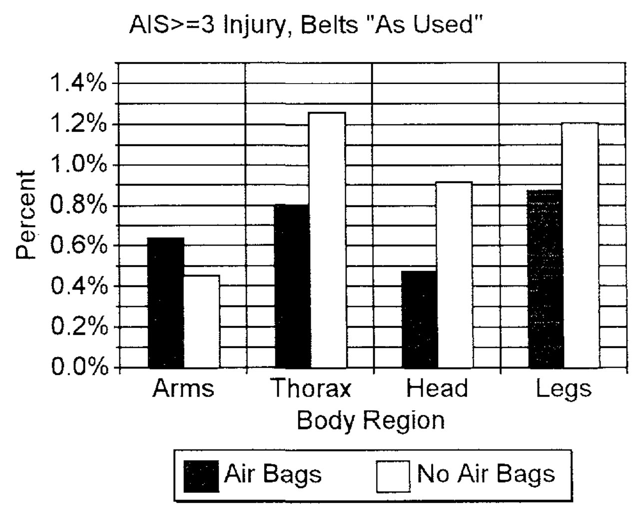

Figure 3. Serious-to-Fatal Injury Risk by Body Region, Belts "As Used"

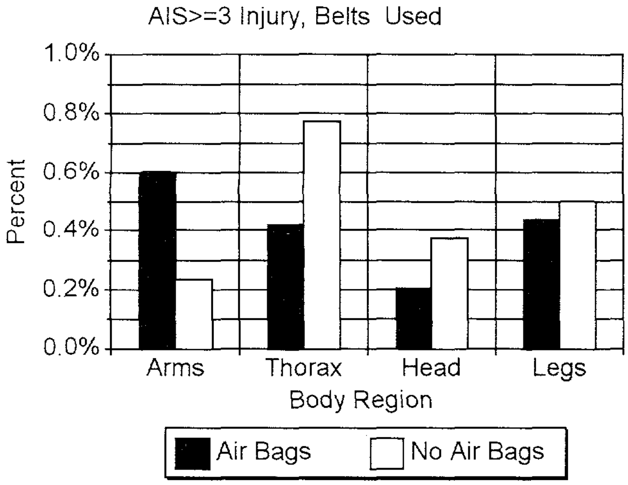

Figure 4. Serious-to-Fatal Injury Risk by Body Region, Belts Used

substantially lower for belts "as used" (Figure 2.)

Figures 3 to 5 and Table 2 show risk of serious injury by body region in frontal crashes for drivers of air bag equipped vehicles in air bag and non-air bag cars with and without belts. For serious-to-fatal injury and belts "as used" head, thorax and leg injuries are substantially lower with air bags. (Figure 3.) Arm injuries are somewhat higher with air bags. Since the majority of drivers in frontal impacts are belted (about 84 percent with air bags and 68 percent without) the injury risks by body region are similar when belts are used (Figure 4) as when "as used". For unbelted drivers there is no apparent reduction in serious to fatal chest or head injuries with air bags (Figure 5.)

Traditionally, fatality reduction has been the emphasis of the agency's research program. More recently, however, attention has been focused toward injury reduction, particularly for those injuries which lead to life long disabilities. This added focus includes the role of lower extremity and pelvic injuries in frontal crashes.

Selection of Test Conditions Based on Crash Impact Modes

An additional test procedure for increased frontal protection should simulate those impact modes in the "real-world" crash environment which result in highest frequency and risk of injury/fatality. Since FMVSS No. 208 sets performance requirements for full frontal impacts, the initial analysis focused on "offset", frontal

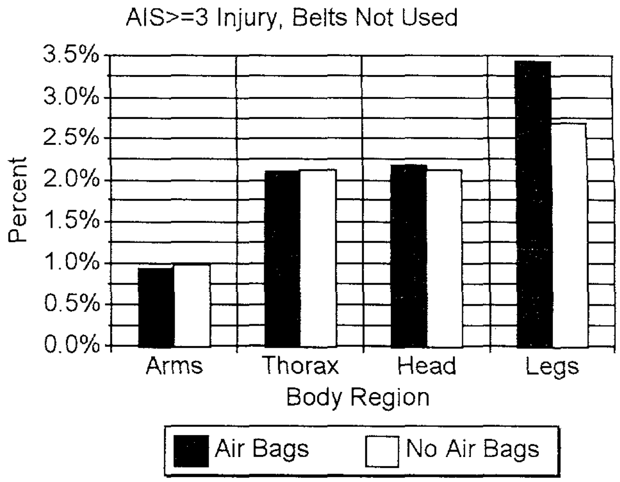

Figure 5. Serious-to-Fatal Injury Risk by Body Region, Belts Not Used

impacts as candidate accident modes for simulation. The accident analysis has been coupled with offset crash testing to determine which impact configurations produce the highest likelihood and frequency for injury/fatality.

Drivers of all vehicles in 1988-1996 NASS were grouped by their general area of damage (GAD) and principal direction of force (DOF1) into a frontal impact population. Drivers were considered to be in frontal impacts if their vehicle sustained DOF1 between 11 and 1 o'clock or DOF1 was 10 or 2 and GAD1 was front or side with damage forward of the A-pillar. The frontal impact population is then separated into specific crash modes to identify potential impact configurations with high frequency and risk of injury to be simulated by crash test procedures. The frontal population was separated by direction of force (DOF) into collinear or oblique (left or right), by damage distribution into offset (left or right) or distributed, and by object contacted into another vehicle or fixed object. Counts in the paper are weighted unless noted. DOF is used to delineate collinear (12 o'clock), left (10 & 11 o'clock) and right (1 & 2 o'clock) oblique impacts. For frontal damage (GAD1=F), overlap is defined by the crash "D" variable when known and after 1989; otherwise, the primary specific horizontal location (SHL1) is used, and is separated into distributed ("D"=0 or SHL1=D), left ("D"<0 or SHL1=Y or L) and right ("D">0 or SHL1=Z or R) offset impacts. For those impacts with left or right damage (GAD1) the location must include the front corner of the vehicle (SHL1=F) and is entered as left or right 1/3 of the vehicle's front (equivalent to SHL1=L or R for GAD1=F.)

Grouping Into Most Appropriate Test Procedure

The exposure population for frontal impacts, i.e, number of collisions, is based on 1988 to 1996 NASS to estimate the exposure for an all air bag fleet. Drivers in frontal collisions are grouped by impact conditions (DOF, damage distribution and crash partner) into the most appropriate test situation to simulate the type of collision.

For specifying impact conditions for a future frontal, offset test both crash pulse and intrusion are of comparable importance in occupant injury outcome. However, the agency is also currently addressing issues of what are the appropriate conditions for a full frontal test procedure in FMVSS No. 208, i.e, the full barrier, the current sled test or some other simulation test. For these types of tests, intrusion is of secondary importance and crash pulse alone is the important crash factor in the occupants injury outcome. To show a comparison of intrusion in full barrier type impacts and offset impacts, crash situations with intrusions of 6 inches or more into the vehicle compartment are assumed to compromise the compartment integrity and lead to serious or fatal injuries. As shown in Figure 6 the incidence of 6 inches or more intrusion is much greater in the offset impact modes than in the full barrier type modes, especially for crash severities less than 30 mph.

Figure 7 shows the test situations, the impact conditions for that test and the percentage of all frontal impacts represented. The first group of impact modes are those in which the test must account for both crash pulse and intrusion. The current frontal test is a full frontal impact into a fixed rigid barrier with impact angles on the car from -30 to +30 degrees. As shown in the figure, all collinear, distributed damage impacts and oblique, distributed damage, fixed object impacts with distributed damage are assumed to be best simulated by this test condition. The left offset configuration, either collinear or oblique direction of impact is assumed that all left offset impacts, either collinear or oblique, are best represented by this test condition. Also, it is assumed that the left oblique, vehicle-to-vehicle impact, with distributed damage is better simulated by the left offset test than by the barrier test. Not only may less than full overlaps often produce distributed damage, but the interaction of the vehicle and the propensity for higher intrusion is well simulated by this test even though there may be near distributed damage.

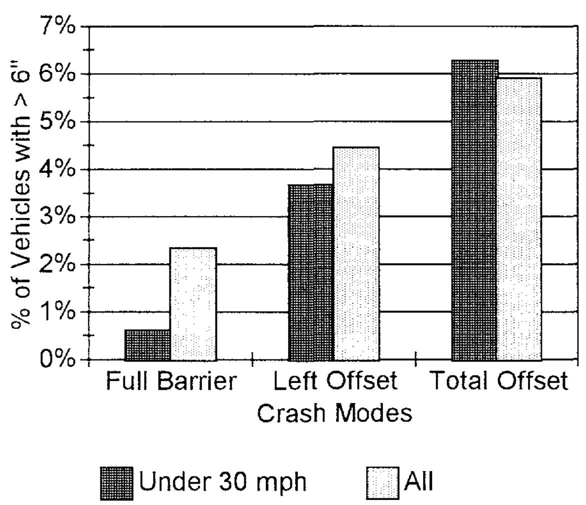

Figure 6 - Percent of Vehicles with 6 inches or more Intrusion by Crash Mode

A right offset configuration would include right side impacts in the same way as left side impacts are included in the left offset test. About 9 percent of cars have offset, frontal damage which is opposite to the clock direction, i.e., left and right oblique impacts with right and left offset damage, respectively. Note that this would be the impact configuration for the "bullet" vehicle in a left or right oblique impact to the "target" vehicle, as shown in Figure 6. Based on the assumed groupings of vehicle impact conditions from above, the left offset test would represent about 34 percent of cars with air bags in "frontal" crashes, with right offset making up about 35 percent and full barrier about 22 percent.

If only crash pulse is considered, the full frontal fixed barrier accounts for the majority of impact modes in frontal crashes. Collinear, car-to-car crash tests at partial overlaps of 50, 60 and 70 percent, and a 30 degree oblique car-to-car impact with 50 percent overlap on a Chevrolet Corsica using a Honda Accord as the striking vehicle have been conducted. The car-to-car tests were conducted with both cars moving at about 56 kmph. Also, the agency has conducted an NCAP test using the Corsica, i.e., a 56 kmph, full frontal, rigid barrier test. The longitudinal compartment deceleration crash pulses are shown in Figure 8. The collinear 60 and 70 percent overlap crash tests appear to be well simulated by the full barrier impact along with the oblique impact at 50 percent overlap. However, for the collinear impact at 50 percent overlap the crash pulse appears to deviate somewhat from the full barrier pulse. Based on these comparisons, the collinear impacts with overlaps ranging from somewhere between 50 and 60 percent (say 55

TEST CONFIGURATIONS TO SIMULATE CRASH MODES

Test	Configuration	Crash Modes (Intrusion/Pulse)	% of Frontals	Crash Modes (Pulse Only)	% of Frontals
Frontal Barrier FMVSS No. 208 + - 30 Degrees	1	All; Fixed Object; Fixed Object	**21.7 %**	All > 55% Overlap; All > 33% Overlap	**74 %**
Left Offset (0 to30 Degrees)	2; 1	All; All; Vehicle	**33.8 %**	All <55% Overlap; All <33% Overlap	**~13%**
Right Offset (0 to30 Degrees)	2; 1	All; All; Vehicle	**35.3 %**	All <55% Overlap; All <33% Overlap	**~13 %**
L. Obl./R. Off. R. Obl./L. Off. (+-30 Degrees)	2; 1; 2; 1	All; All	**8.8 %**		

Figure 7. Possible Frontal Test Conditions and Impact Modes Addressed (1988-1996 NASS)

percent) to full overlap were classified as "full barrier-like" crashes. Since exact overlap dimensions are not available in all NASS cases, SHL1 also must be used. SHL1 is used to define a crash as "full barrier-like" for values of ⅔ and greater overlap.

Oblique, car-to-car impact tests have been conducted only at nominally 50 percent overlap impact conditions. As shown in Figure 8 the 50 percent overlap, oblique crash test actually produces as severe compartment deceleration crash pulse as the NCAP full barrier test, at similar impact speeds for the Corsica. Thus, in the absence of additional tests with varying proportions of overlap, it is assumed that oblique impacts can be represented by the full barrier test at overlaps of ⅓ and greater. The category of frontal impacts which qualify as "full barrier" (FB) like crash pulses, based on this analysis, include:

- Collinear with 55 percent and greater overlap or SHL1 ≥ ⅔ when exact overlap dimension is not available
- Oblique (DOF1 12 o'clock) with SHL1 ≥ ⅓

The 1988 through 1996 NASS-CDS files are queried for impact conditions shown above. Drivers in crashes with "barrier-like" impact conditions on the vehicle are compared to drivers of vehicles in all frontal crashes to determine what proportion of all frontal impacts are

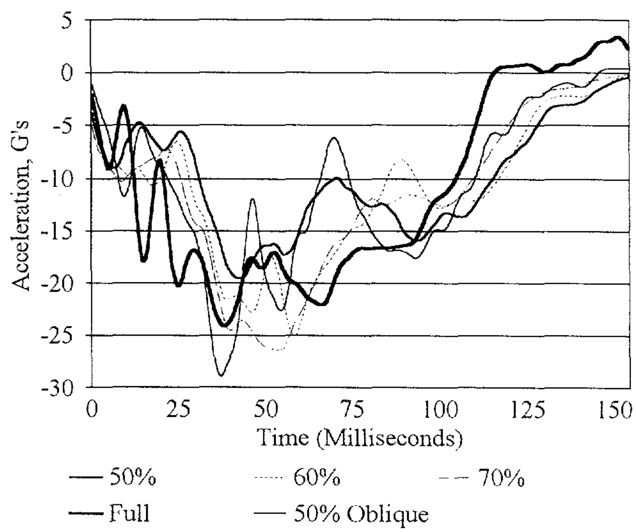

Figure 8. Crash Pulses by Overlap, Chevrolet Corsica, hit by Honda Accord and NCAP, at 56 Kmph

represented by "barrier-like" impact conditions. This comparison is made for:

- All drivers
- Drivers of vehicles with air bags, and MAIS≥3 injuries

The 1988 through 1996 NASS-CDS files are queried for impact conditions which produce crash pulses which may be fairly well represented by the full barrier crash pulse, as discussed above (referred to subsequently as "barrier-like.") Drivers in crashes with "barrier-like" impact conditions on the vehicle are compared to drivers of vehicles in all frontal crashes.

For drivers in vehicles with air bags the proportion of driver in vehicles with "barrier-like" crashes as a percent of all frontal crashes is:

- 74 percent for all drivers
- 83 percent for drivers with MAIS≥3 injuries
- 73 percent for driver fatalities

The remainder of the paper will consider those crash configuration groupings which account for both crash pulse and intrusion as factors in occupant injury.

Injury Risk by Test Configuration

Comparing injury risk shows that for moderate and more severe injuries (MAIS≥2) the injury risk is somewhat higher for vehicles in crashes fitting "left offset" than those described by "full barrier" (7.6 percent and 6.8 percent, respectively.) For serious and higher injuries (MAIS≥3), the "full barrier" groupings has the highest injury rate (3.8 percent.) Left offset and right offset groups both have much lower serious injury rates of about 2.1 percent and 1.3 percent, respectively (Figure 9. And Table 3) Figure 10 shows fatality risk for the various impact modes grouped into appropriate test condition. These fatality rates are based on limited observations: 10 for full barrier, 38 for left offset, and 10 for right offset. The left offset grouping has much higher fatality risk (0.43 percent) than full barrier (0.25 percent) and almost four times that experienced by drivers with air bags in right offset modes (0.11 percent.)

An estimate of the annual injuries/fatalities which might be expected with an all air bag fleet is computed in Table 3 and shown in Figures 11 and 12. The estimates are based on the injury/fatality risks, shown previously,

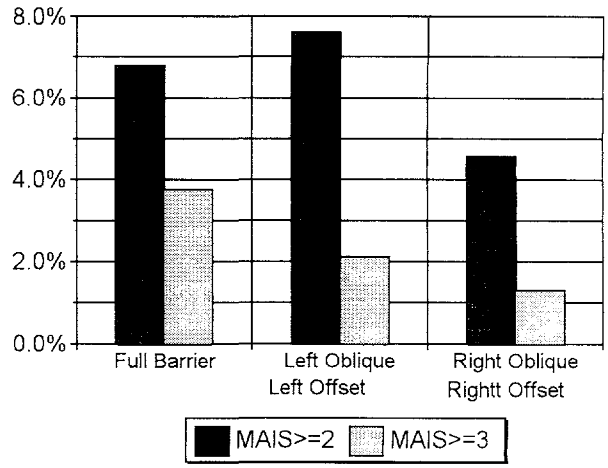

Figure 9. Injury Risk by Test Condition

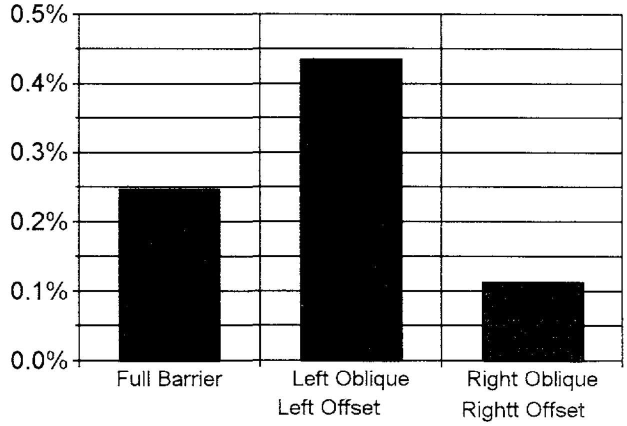

Figure 10. Fatality Risk by Test Condition

applied to the expected number of drivers with air bags in tow-away crashes in an average year (1988 through 1996 NASS divided by nine.) Based on these estimates the left offset impact modes would result in the highest number of drivers with MAIS≥2 and fatal injuries (about 47,000 and 4,200, respectively.) Although full barrier type impacts would account for the highest number of MAIS≥3 injuries (14,942) the left offset modes are only slightly less (13,042.)

Within the test groupings for left offset and right offset the effect of overlap on injury rate was assessed. As a rough approximation of overlap percent, an average car width of 66 inches is assumed for "L" in the offset formula: Overlap = 1-(2*D/L), where "D" is the distance from the vehicles center-line to the damage mid-point.

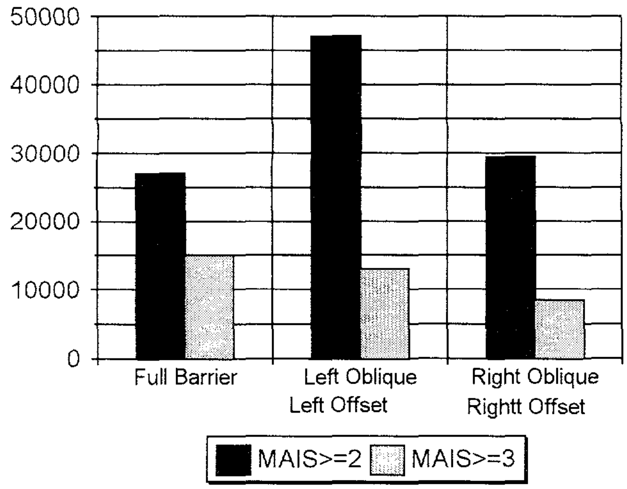

Figure 11. Estimated Annual Injuries by Test Condition

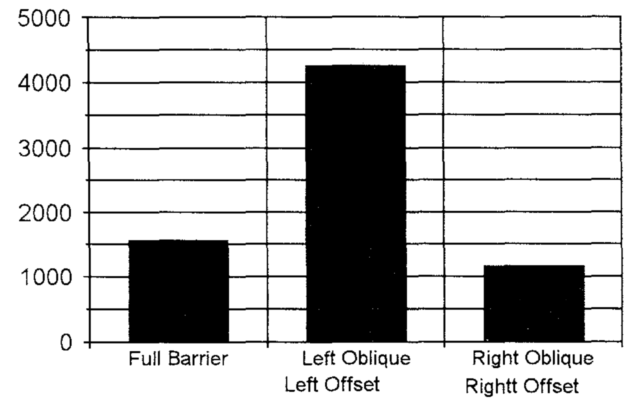

Figure 12. Estimated Annual Fatalities by Test Condition

Overlap is then separated into 1/3 or less of the car width, over 1/3 to 2/3 of the width and over 2/3 of the width. As discussed above, left and right damaged vehicles with damage to the front corner were grouped into the 1/3 overlap category. By using these damage width groupings, the SHL1 parameter, which is separated into damage width increments of one-third of the vehicle width, may be used when "D" is not known. The relatively low injury risk for configurations grouped under a left offset test appears to be due to low occurrence of MAIS≥3 injuries in narrow overlap impacts. For left offset impacts the rate of MAIS≥3 injuries is about 1.5% for 1/3 or less overlap (Figure 13 and Table 4.) Overlaps in the 1/3 to 2/3 range, also, result in fairly low injury rates for these configurations. At overlaps over 2/3, left offset impacts produce higher MAIS≥3 injury rates, increasing to about 3.6 percent for over 2/3 overlap while right offset impacts at larger

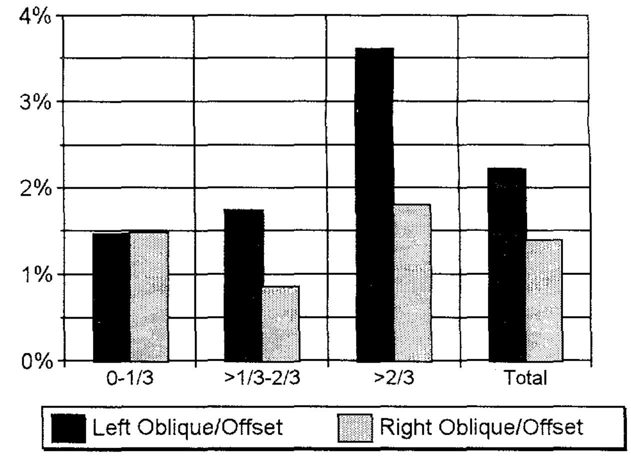

Figure 13. Serious-to-Fatal Injury Risk by Overlap

overlaps produce lower injury rates (1.8 percent for right offset.) The left offset impact at over 2/3 overlap produces the highest MAIS≥3 injury rate of all offset impact modes considered (3.8 percent.)

Recommendation

Based on analysis of the NASS crash data files of drivers in frontal collisions with air bag restraints, the offset crash test which represents actual crash configurations with the highest frequency and risk of serious to fatal injuries is a left offset, vehicle-to-vehicle impact with substantial overlap (⅔ or greater.) The specific recommendations for impact angle and overlap percentage will be variables addressed in the crash test development phase of the program. The remainder of the paper assumes that this type of test condition will be selected as the offset procedure for the future and the analysis focuses on these crash modes.

Body Region Injury Assessment

Injury measures, criteria and instrumentation and the test surrogate itself should be selected based on the location and type of injuries experienced by the driver in frontal, left offset crashes.

Injuries to specific body region are tallied by AIS level counting only the single, most severe injury to each individual body region which make up the general body region group (head, chest, arms and legs.) The risk of injury to a body region is the sum of injuries at the specific AIS level divided by all drivers in the crash mode. As shown in Figures 14 and 15 and Table 5, legs

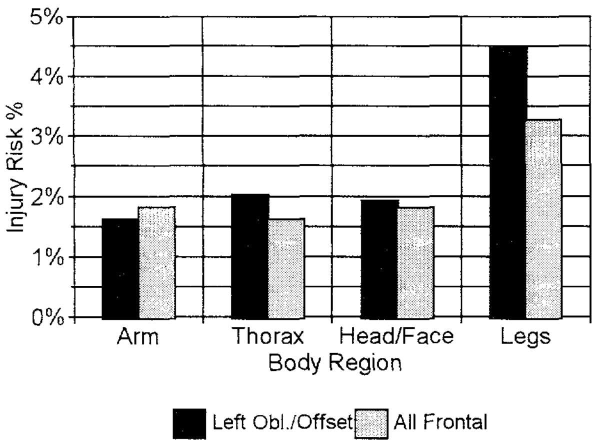

Figure 14. AIS≥2 Body Region Injury Risk, Left Offset and All Frontal Impacts

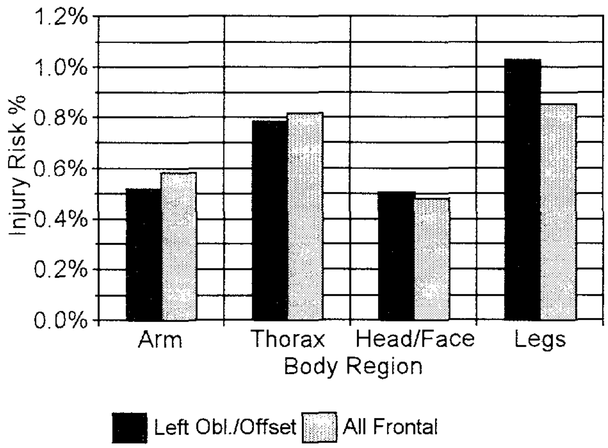

Figure 15. AIS≥3 Body Region Injury Risk, Left Offset and All Frontal Impacts

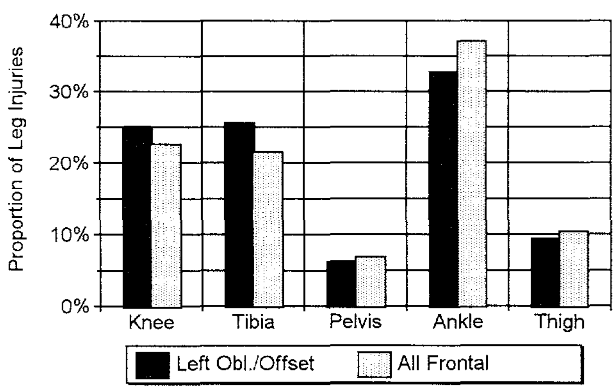

Figure 16. Proportion of AIS≥2 Leg Injuries

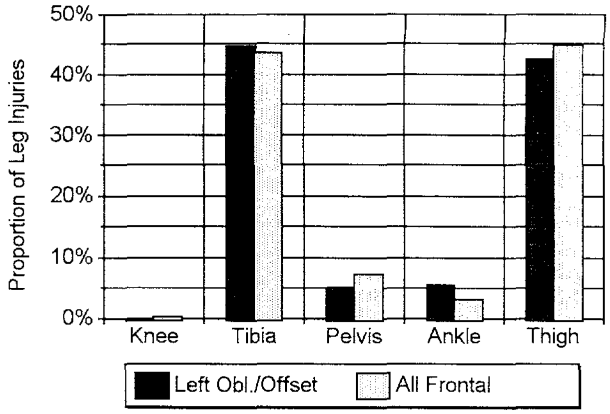

Figure 17. Proportion of AIS≥3 Leg Injuries

have a higher risk of AIS≥2 and AIS≥3 injury in left offset impacts than all frontals with other body regions having similar rates in both crash modes. Thus, reducing leg injuries should be a prime objective in addressing left offset crashes.

For drivers with air bags, AIS≥2 leg injuries are separated into specific injury location in Figure 16 and Table 6. For these injuries, the ankle is most frequently injured followed by the knee and tibia, regardless of whether the impact is left offset or all frontals. Together these regions make up almost 90 percent of all AIS≥2 leg injuries in left offset crashes. The tibia and femur dominate the severe leg injuries, with about 45 percent of leg injuries to the tibia and almost 43 percent to the femur, again, regardless of impact mode (Figure 17.) About ⅔ of moderate and serious leg injuries are fractures. Thus, a test surrogate should have appropriate hardware and be instrumented to assess AIS≥2 ankle and knee injuries and AIS≥3 tibia and femur injuries with the type of lesions listed.

Injury Assessment by Size

The current frontal impact protection standard (FMVSS No. 208) assesses vehicle performance with a single size, 50th percentile, male dummy. An assessment of the crash environment by driver size was conducted to indicate whether there is a need to incorporate additional size dummies in future frontal test procedures. Drivers were grouped into three categories based on height of test dummies representing the 5th percentile female, 50th percentile male and 95th percentile male. The heights for each category are:

- 5th % group - less than 164 cm

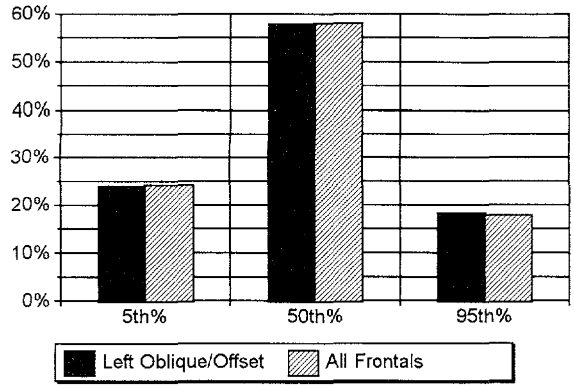

Figure 18. Crash Exposed Drivers by Size

- 50th % group - 164 to 180 cm
- 95th % group - over 180 cm

The distribution of drivers with air bags grouped by height is shown in Figure 18 and Table 7 for left offset impacts and for all frontal impacts. The 50th % grouping represents about 58 percent of all involved drivers in left offset and all frontal impacts, the 5th % about 24 percent and the 95th about 18 percent.

Figures 19 and 20 show MAIS≥3 injury and fatality risk, respectively, by the three size groupings. Previous analyses have shown that smaller drivers, generally females, tend to have lower severity crashes and thus may have lower injury risk as a result. Because of the limited observations, as shown in Table 8, for assessing injury/fatality risk, no attempt is made to consider severity (deltaV.)

The fatality risk is based on limited numbers with "raw" counts shown above each bar in Figure 20. The 5th percentile generally shows a lower injury/fatality rate for the left offset crash modes; however, this group experiences a higher MAIS≥2 injury rate than the 50th percentile group. The 95th percentile shows highest risk for MAIS≥2 and MAIS≥3 injuries and fatalities. The higher injury risk for the 95th % grouping is due, at least in part, to the higher risk of leg and head injury (Table 8.) For all frontal impacts the 5th percentile exhibits similar injury risk as the other size groupings; however for fatalities the risk is much lower, but is based on limited observations.

The number of injuries and fatalities which might be expected annually for each size group with an all air bag fleet is estimated below for left offset impact modes. The estimates are based on current year Fatality Analysis

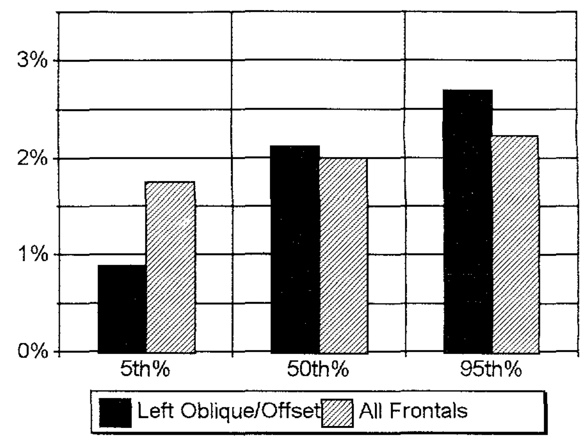

Figure 19. MAIS≥3 Injury Risk by Size

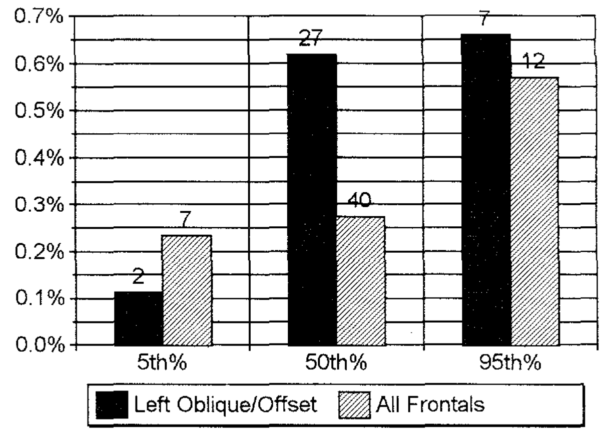

Figure 20. Fatality Risk by Size

Reporting System (FARS, 1995) for fatalities and the NHTSA Final Regulatory Evaluation (FRE) on Air Bag Depowering for MAIS≥2 injuries.

Table 9 presents the work sheet for computing the estimates. The annual exposure by size group is from 1988-1996 NASS for an average year which is multiplied by the injury risk (Table 8) to give an estimate of annual injuries/fatalities. Since the total driver fatalities based on NASS appears low, the estimates are adjusted by the computed number of driver fatalities in non-rollover, frontal crashes with an all air bag fleet based on 1995 FARS as shown in the table. The fatalities for left offset crash modes are adjusted to be consistent with the proportion of all frontal impact fatalities for these modes, computed earlier. Likewise, the number of injuries are adjusted based on the NHTSA Final Regulatory Evaluation (FRE) on Air Bag Depowering for MAIS≥2 injuries, which predicted 120,000 annually. The same adjustment factor for MAIS≥2 injuries is also applied to MAIS≥3 injuries. As shown, based on the assumed size groups, i.e., based on the division of sizes by the mid-point of the difference in height between successive dummy sizes, the 50th percentile group is the most populous and thus experiences the most injuries/fatalities. However, the 95th percentile group, although the least populous, experiences substantially more fatalities and MAIS≥3 injuries than the 5th percentile group and has the highest injury and fatality risks.

Based on the assumptions made and the limited data on severe and fatal injuries, the 95th percentile group experiences a substantial number of injuries/fatalities and should be considered as an additional test surrogate to be used in a proposed left offset test procedure. The 5th percentile group, although experiencing less injuries, still has substantial numbers of moderate and severe to fatal injuries in this impact mode. A different definition of 5th, 50th and 95th percentile groupings, perhaps based on statistical groupings or more narrow height ranges for the 50th group would possibly lead to a different conclusion.

Benefits Assessment for an Improved Test Procedure

A preliminary method for estimating injury and fatality reductions for a left offset test procedure is proposed. This method assumes that for under 48 kph (the current FMVSS No. 208 test speed) the injury/fatality rates for drivers with air bags in left offset crash modes will be reduced to levels similar to those for drivers in full barrier modes. In other words, drivers with air bags in the proposed impact modes to be addressed by a left offset test would experience the same injury risk as drivers with air bags in impact modes addressed by the current requirement.

As shown in Figure 21 and Table 10 for speeds of 48 kph and less the MAIS≥2 injury and fatality rates are higher for the left offset crash modes (8.6 and 0.2 percent) compared to full barrier modes (5.2 and 0.0 percent.) No fatalities occurred at 48 kph and less in full barrier type impacts. For MAIS≥3 injuries the full barrier risk is actually higher than for the left offset for impacts at 48 kph and less (2.3 and 2.2 percent, respectively.)

As shown in the previous sections, arm injuries in the full barrier impact modes occur at a much higher rate than in impacts without air bags or even left offset impacts with air bags. Arm fractures and other less severe laceration and contusion type injuries occur quite frequently from aggressively deploying air bags. Another NHTSA research program is vigorously addressing problems associated with aggressive

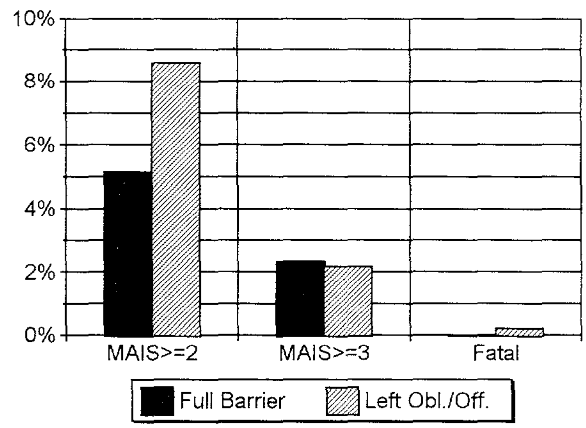

Figure 21. Driver Injury/Fatality Risk for All Injury, ≤ 48 KPH

Estimated Annual Driver Injury/Fatalities in Left Offset Impacts With Air Bags

		DRIVER SIZE GROUP		
INJURY LEVEL	**Total**	**5th Percent**	**50th Percent**	**95th Percent**
MAIS≥2	45,924	11,796	19,819	14,309
MAIS≥3	11,520	1,261	7,307	2,953
Fatalities	4,243	224	3,004	1,015

deployment of air bags on out-of-position occupants and arm injuries. This research program supported by this crash analysis is focused on improved frontal protection and not on resolving problems with aggressive air bag deployment. Since arm injuries are not the main concern of an alternative frontal test the analysis was repeated to compare injury risk when arm injuries are removed (Figure 22, Table 10.) Relative to the injury risk in full barrier type impacts this method shows a much higher risk for left offset impacts (1.66 percent for MAIS≥3 and 7.86 percent for MAIS≥2) than for full barrier (0.69 percent for MAIS≥3 and 3.15 percent for MAIS≥2.)

The percent decrease in injury risk for the left offset impacts compared to the full barrier impacts is shown in the following table. Since the estimate of fatality risk in impacts of 48 kph and less are based on few numbers and a total reduction in fatalities is unreasonable no

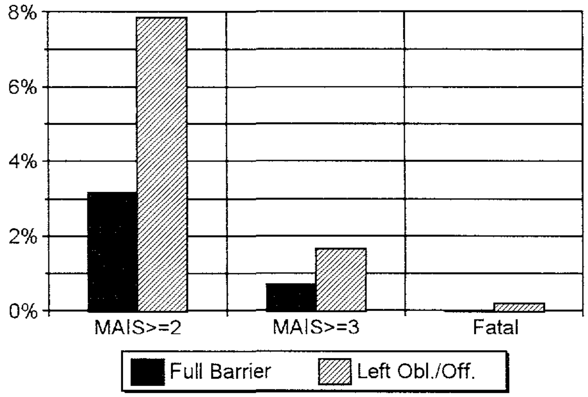

Figure 22. Injury/Fatality Risk Without Arm Injuries, ≤48 KPH

numerical estimate is made for fatality reduction, except to say there appears to be potential for substantial reductions. Also, for drivers with air bags subjected to a left offset test procedure, an increase in MAIS≥3 injuries in impacts is not expected and, thus, no change is predicted. The number of driver injuries and fatalities expected in left offset impacts with an all air bag fleet is shown in Table 10 and repeated below. The reduction in injuries/fatalities is then the percent change applied to these expected injuries and fatalities.

An analysis was also conducted to estimate the number of leg injuries which might be eliminated by a left offset test. Again, it is assumed that the benefit of adopting a left offset test procedure is an injury rate reduction for drivers with air bags below 48 kph to the injury rate experienced in full barrier type crashes. Table 11 shows the risk of receiving a leg injury of AIS≥2 and of AIS≥3 level for left offset and full barrier type impact modes. Drivers with air bags in full barrier type impacts below 48 kph have a lower risk of leg injury than those in left offset impacts by the percentages shown in the Table 11 worksheet. It is assumed that the number of injuries in NASS are below the annual nationwide count by the same factor as that used previously to estimate occupants. This factor is then applied to the NASS injury counts and the proportion of leg injuries computed to yield an estimate of leg injuries expected nationwide in one year. This annual estimate is then multiplied by the reduction in injury rate to give a rough approximation of number of leg injuries, AIS≥2 and AIS≥3, which might be eliminated with a left offset test procedure, as shown below. Based on this computation, over 11,400 AIS≥2 and over 2,200 AIS≥3 leg injuries could be saved.

Injury/Fatality Risk Difference: Left Offset Compared to Full Barrier, Under 48 KPH

	Percent Change		**Number in Left Offset**		**Reductions for Offset Test Procedure**	
	All MAIS	**Arms Excluded**	**All MAIS**	**Arms Excluded**	**All MAIS**	**Arms Excluded**
MAIS≥2	**- 40.0%**	**-59.9%**	40568	34611	**16,227**	**20,732**
MAIS≥3	*0%* (+7.3%)	**-58.7%**	10889	8689	**0**	**5,100**
Fatality	*Not Computed**		2664	2664	*Not Computed**	

	AIS≥2	**AIS≥3**
Annual Leg Injuries	**24,169**	**4,834**
Reduction for Left Offset Test (Table 11)		
Percent	**47.2%**	**45.8%**
Annual Leg Injuries	**11,416**	**2,215**

*** There were 13 fatalities (unweighted) to drivers in left offset impacts under 48 kmph with no fatalities in full barrier type impacts.**

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TABLE 1 - Injury Risk by Restraint Condition, Drivers in Frontal Impacts, 1988-1996 NASS

RESTRAINT		MAIS 2-6	MAIS 3-6	MAIS Fatal	Total
All Air Bag (Belted+Unbelted)	**#**	78845	24979	3488	1142704
	Row%	6.90%	2.19%	0.31%	
	Raw#	614	294	64	2555
Non-Air Bag (Belted+Unbelted)	**#**	934506	287563	55423	9428597
	Row%	9.91%	3.05%	0.59%	
	Raw#	6732	3031	1078	23730
Air Bag and Belts	**#**	52082	12355	1610	953887
	Row%	5.46%	1.30%	0.17%	
	Raw#	347	149	29	1884
Belts	**#**	397403	101323	12230	6107706
	Row%	6.51%	1.66%	0.20%	
	Raw#	2391	897	224	12568
Air Bags and No Belts	**#**	24095	10612	1756	156198
	Row%	15.43%	6.79%	1.12%	
	Raw#	246	132	32	598
No Restraint	**#**	480798	166496	38787	2806459
	Row%	17.13%	5.93%	1.38%	
	Raw#	3919	1892	752	9728

TABLE 2 - Injuries by Body Region for Drivers With and Without Air Bags

Serious and Greater Injuries by Body Region (Most Severe AIS>=3)		Arms	Thorax	Head	Legs	Occupants Known AIS
Air Bag Belts "As Used"	Raw	66	110	64	142	2555
	#	7369	9314	5472	10058	1161513
	Risk%	0.63%	0.80%	0.47%	0.87%	
Non Air Bag Belts "As Used"	Raw	385	1433	1034	1236	23730
	#	43300	120297	87340	115450	9566033
	Risk%	0.45%	1.26%	0.91%	1.21%	
Air Bag Belts	Raw	51	42	23	71	1884
	#	5840	4070	1979	4236	970219
	Risk%	0.60%	0.42%	0.20%	0.44%	
Non Air Bag Belts	Raw	137	406	265	338	12568
	#	14647	48205	23219	31261	6220408
	Risk%	0.24%	0.77%	0.37%	0.50%	
Air Bag No Belts	Raw	13	57	40	64	598
	#	1474	3327	3438	5423	158090
	Risk%	0.93%	2.10%	2.17%	3.43%	
No Restraint	Raw	226	888	701	791	9728
	#	27812	59930	59948	75979	2825620
	Risk%	0.98%	2.12%	2.12%	2.69%	
Moderate and Greater Injuries by Body Region (Most Severe AIS>=2)						
Air Bag Belts "As Used"	Raw	172	183	199	321	2555
	#	21781	18701	20077	38286	1161513
	Risk%	1.88%	1.61%	1.73%	3.30%	
Non Air Bag Belts "As Used"	Raw	1246	2578	3612	2699	23730
	#	177592	296200	448255	309813	9566033
	Risk%	1.86%	3.10%	4.69%	3.24%	
Air Bag Belts	Raw	117	89	84	188	1884
	#	16371	9033	11603	27537	970219
	Risk%	1.69%	0.93%	1.20%	2.84%	
Non Air Bag Belts	Raw	459	976	1046	939	12568
	#	77453	148062	138056	125161	6220408
	Risk%	1.25%	2.38%	2.22%	2.01%	
Air Bag No Belts	Raw	49	81	111	120	598
	#	4875	7685	8199	10168	158090
	Risk%	3.08%	4.86%	5.19%	6.43%	
No Restraint	Raw	721	1395	2385	1557	9728
	#	90587	124360	283675	161361	2825621
	Risk%	3.21%	4.40%	10.04%	5.71%	

TABLE 3 - Injury/Fatality Rates by Test Condition

		Full Barrier	Left Obl./ Left Off.	Right Obl./ Right Off.	L&R Obl./ R&L Off.	Other	TOTAL
MAIS>=2	#	15100	32841	20449	10445	10	78845
	Raw#	127	270	169	47	1	614
	Row%	19.2%	41.7%	25.9%	13.2%	0.01%	
	Risk	6.79%	7.61%	4.58%	10.25%	0.33%	6.54%
	Annual#	18175	31710	19882	11095	16	80879
Adjusted Injuries to FRE		26967	47048	29499	16462	24	120000
MAIS>=3	#	8367	9104	5870	1628	10	24979
	Raw#	71	130	75	17	1	294
	Row%	33.5%	36.4%	23.5%	6.5%	0.04%	
	Risk	3.76%	2.11%	1.31%	1.60%	0.33%	2.07%
	Annual#	10071	8791	5707	1729	16	26315
Adjusted Injuries to FRE		14942	13042	8468	2566	24	39043
Fatality	#	548	1875	506	548	10	3487
	Raw#	10	38	10	5	1	64
	Row%	15.7%	53.8%	14.5%	15.7%	0.29%	
	Risk	0.25%	0.43%	0.11%	0.54%	0.33%	0.29%
	Annual#	660	1810	492	582	16	3561
Adjusted to FARS Annual		1546	4243	1153	1364	39	8345
Drivers with Air Bags	#	222419	431302	446804	101858	2993	1205376
	Raw#	457	1067	895	265	5	2689
Exposed Annual Drivers	#	267716	416450	434416	108198	4921	1231701
	Row%	21.7%	33.8%	35.3%	8.8%	0.40%	

TABLE 4 - Injury Risk by Overlap Proportion for Left and Right Offset Impacts

		Left Offset			
		0-1/3	>1/3-2/3	>2/3	Total
MAIS>=2	#	8017	6553	18273	32843
	Raw#	68	76	126	270
	Row%	24.4%	20.0%	55.6%	
	Risk	5.01%	5.34%	14.23%	7.99%
	Annual#	11484	9387	26176	47048
MAIS>=3	#	2335	2136	4634	9105
	Raw#	37	39	54	130
	Row%	25.6%	23.5%	50.9%	
	Risk	1.46%	1.74%	3.61%	2.21%
	Annual#	3345	3060	6638	13042
Total	#	160134	122614	128445	411193
	Raw#	315	279	418	1012
	Row%	38.9%	29.8%	31.2%	
		Right Offset			
MAIS>=2	#	5353	6650	8445	20448
	Raw#	48	42	79	169
	Row%	26.2%	32.5%	41.3%	
	Risk	3.66%	4.96%	5.91%	4.83%
	Annual#	7722	9594	12183	29499
MAIS>=3	#	2152	1137	2580	5869
	Raw#	20	15	40	75
	Row%	36.7%	19.4%	44.0%	
	Risk	1.47%	0.85%	1.80%	1.39%
	Annual#	3105	1641	3723	8468
Total	#	146108	133960	142960	423028
	Raw#	282	214	352	848
	Row%	34.5%	31.7%	33.8%	

TABLE 5 - Injury by Body Region for Left Offset and All Frontal

Body Region		Left Offset AIS>=3	Left Offset AIS>=2	TOTAL AIS>=3	TOTAL AIS>=2
Arm	#	2126	6669	6656	20929
	Raw#	32	75	66	173
	Risk%	0.5%	1.6%	0.6%	1.8%
Thorax	#	3220	8343	9329	18555
	Raw#	51	84	111	184
	Risk%	0.8%	2.0%	0.8%	1.6%
Head/Face	#	2077	7939	5472	20740
	Raw#	27	84	64	201
	Risk%	0.5%	1.9%	0.5%	1.8%
Legs	#	4227	18423	9761	37269
	Raw#	69	155	142	321
	Risk%	1.0%	4.5%	0.9%	3.3%
Total Injuries	#	11650	41374	31218	97493
	Raw#	179	398	383	879
Total Drivers	#	411192	411192	1142603	1142603
	Raw#	1012	1012	2554	2554

TABLE 6 - Leg Injuries for Left Offset and All Frontal

Left Offset		Knee	Tibia	Pelvis	Ankle	Thigh	Whole	Total	Drivers
AIS>=3	Raw#	1	27	6	2	42	2	80	1012
	#	0	2153	247	268	2051	105	4824	411192
	Row%	0.0%	44.6%	5.1%	5.6%	42.5%	2.2%		
AIS>=2	Raw#	34	46	25	76	44	7	232	1012
	#	7073	7189	1745	9220	2638	316	28181	411192
	Row%	25.1%	25.5%	6.2%	32.7%	9.4%	1.1%		
All Frontals									
		Knee	Tibia	Pelvis	Ankle	Thigh	Whole	Total	Drivers
AIS>=3	Raw#	2	53	18	5	80	2	160	2554
	#	26	4579	765	323	4706	105	10504	1142603
	Row%	0.2%	43.6%	7.3%	3.1%	44.8%	1.0%		
AIS>=2	Raw#	66	90	54	157	82	9	458	2554
	#	11650	11106	3536	19034	5293	745	51364	1142603
	Row%	22.7%	21.6%	6.9%	37.1%	10.3%	1.5%		

TABLE 7 - Driver Exposure by Size Groups

Test Condition		Driver Size 5th%	50th%	95th%	Total
Left Obl/Off	Raw#	194	512	169	875
	#	86118	208241	66045	360404
	Row%	23.9%	57.8%	18.3%	
All Frontals	Raw#	502	1231	426	2159
	#	238928	571491	176787	987206
	Row%	24.2%	57.9%	17.9%	

TABLE 8 - Driver Injury by Size Group

Test Condition	MAIS		Driver Size 5th%	50th%	95th%	Total
Left Obl/Off	2-6	Raw#	48	135	47	230
		#	7111	11948	8626	27685
		Row%	25.7%	43.2%	31.2%	
		Risk%	8.26%	5.74%	13.06%	7.68%
	3-6	Raw#	21	65	21	107
		#	760	4405	1780	6945
		Row%	10.9%	63.4%	25.6%	
		Risk%	0.88%	2.12%	2.70%	1.93%
	Fatal	Raw#	2	27	7	36
		#	96	1287	435	1818
		Row%	5.3%	70.8%	23.9%	
		Risk%	0.11%	0.62%	0.66%	0.50%
All Frontals	2-6	Raw#	116	290	96	502
		#	16821	37941	12236	66998
		Row%	25.1%	56.6%	18.3%	
		Risk%	7.04%	6.64%	6.92%	6.79%
	3-6	Raw#	49	145	48	242
		#	4176	11416	3948	19540
		Row%	21.4%	58.4%	20.2%	
		Risk%	1.75%	2.00%	2.23%	1.98%
	Fatal	Raw#	7	40	12	59
		#	557	1567	1008	3132
		Row%	17.8%	50.0%	32.2%	
		Risk%	0.23%	0.27%	0.57%	0.32%

TABLE 9 - Worksheet for Estimating Annual Injuries/Fatalities

ANNUAL EXPOSURE						
		Total	5th%	50th%	95th%	
Left Offset		416450	99510	240624	76316	88-95 NASS
All Frontal		1231701	298102	713029	220571	/8 Years

ANNUAL INJURIES/FATALITIES

Left Offset				
MAIS>=2	31990	8217	13806	9967
MAIS>=3	8025	878	5090	2057
Fatalities	2101	111	1487	503

All Frontal				
MAIS>=2	83591	20987	47338	15266
MAIS>=3	24379	5210	14243	4926
Fatalities	3908	695	1955	1258

FARS 1995 Fatalities	8345
FRE on DePowering MAIS>=2 Injuries	120000
Adjustment Factors	
All Frontal Fatals	2.14
MAIS>-2	1.44
MAIS>-3	1.44
Left Obl./Off. Fatals*	2.02

* Adjusted to agree with Table 3 estimate of fatalities in left offset crashes

1995 Driver Fatalities in Light Vehicles	
1995 FARS driver fatalities	31786
- Non-rollover	23995
- Rollover	7791
Total non-air bag fatalities	31952
- Non-rollover	24120
- Rollover	7832
Total air bag effectiveness	11%
- Non-rollover	14.6%
- Rollover	0
Total fatalities with air bags	28437
- Non-rollover	20606
- Rollover	7832
% Non-rollover fatalities in frontals	54%
1995 fatalities in frontals	11127
Frontal air bag effectiveness	25%
Frontal fatalities with air bags	**8345**

ANNUAL INJURIES/FATALITIES (Adjusted)

Left Offset	Total	5th%	50th%	95th%
MAIS>=2	45924	11796	19819	14309
MAIS>=3	11520	1261	7307	2953
Fatalities	4243	224	3004	1015

All Frontal				
MAIS>=2	120000	30128	67956	21916
MAIS>=3	34998	7480	20447	7071
Fatalities	8345	1484	4175	2686

TABLE 10 - Comparison of Injury/Fatality Risk, Left Offset vs. Full Barrier

TEST			MAIS Without Arm Injury: DeltaV <=30	DeltaV >30	DeltaV Unk.	Known Total	Total	MAIS All Body Regions: DeltaV <=30	DeltaV >30	DeltaV Unk.	Known Total	Total
Full Barrier	Fatal	Raw#	0	6	4	6	10	0	6	4	6	10
		#	0	410	138	410	548	0	410	138	410	548
		Risk%	**0.00%**	**20.60%**	**0.17%**	**0.33%**	**0.26%**	**0.00%**	**20.60%**	**0.17%**	**0.33%**	**0.26%**
	MAIS>=3	Raw#	15	23	24	38	62	20	24	27	44	71
		#	838	969	4264	1807	6071	2840	1052	4475	3892	8367
		Risk%	**0.69%**	**48.69%**	**5.13%**	**1.46%**	**2.93%**	**2.32%**	**52.86%**	**5.38%**	**3.14%**	**4.04%**
	MAIS>=2	Raw#	37	31	42	68	110	46	33	48	79	127
		#	3852	1455	6250	5307	11557	6290	1979	6831	8269	15100
		Risk%	**3.15%**	**73.12%**	**7.51%**	**4.27%**	**5.57%**	**5.15%**	**99.45%**	**8.21%**	**6.66%**	**7.28%**
	Total	Raw#	223	34	180	257	437	223	34	180	257	437
		#	122152	1990	83186	124142	207328	122152	1990	83186	124142	207328
		Row%	98.40%	1.60%	40.12%	59.88%		98.40%	1.60%	40.12%	59.88%	
Left Offset	Fatal	Raw#	13	8	17	21	38	13	8	17	21	38
		#	447	265	1164	712	1876	447	265	1164	712	1876
		Annual#	2664	1579			4243	2664	1579			4243
		Risk%	**0.20%**	**7.93%**	**0.65%**	**0.31%**	**0.46%**	**0.20%**	**7.93%**	**0.65%**	**0.31%**	**0.46%**
	MAIS>=3	Raw#	55	18	38	73	111	66	20	44	86	130
		#	3779	902	2831	4681	7512	4930	975	3198	5905	9103
		Annual#	8689	2074			10763	10889	2153			13042
		Risk%	**1.66%**	**27.01%**	**1.57%**	**2.03%**	**1.83%**	**2.17%**	**29.19%**	**1.77%**	**2.56%**	**2.21%**
	MAIS>=2	Raw#	134	31	69	165	234	154	32	84	186	270
		#	17878	3091	7368	20969	28337	19526	3119	10196	22645	32841
		Annual#	34611	5984			40596	40568	6480			47048
		Risk%	**7.86%**	**92.54%**	**4.09%**	**9.08%**	**6.89%**	**8.58%**	**93.38%**	**5.66%**	**9.81%**	**7.99%**
	Total	Raw#	611	37	364	648	1012	611	37	364	648	1012
		#	227573	3340	180280	230913	411193	227573	3340	180280	230913	411193
		Row%	98.55%	1.45%	43.84%	56.16%		98.55%	1.45%	43.84%	56.16%	

TABLE 11 - Leg Injuries in Full Barrier and Left Offset Crashes

TEST	MAIS Level		DeltaV			Known Total	Total
			<=30	>30	Unk.		
Full Barrier	MAIS>=3	Raw#	10	15	14	25	39
		#	577	758	1082	1335	2417
		Risk%	**0.47%**	**38.09%**	**1.30%**	**1.08%**	**1.17%**
	MAIS>=2	Raw#	30	24	23	54	77
		#	3427	1138	3214	4565	7779
		Risk%	**2.81%**	**57.19%**	**3.86%**	**3.68%**	**3.75%**
	Total	Raw#	223	34	180	257	437
		#	122152	1990	83186	124142	207328
		Row%	98.40%	1.60%	40.12%	59.88%	
Left Offset	MAIS>=3	Raw#	36	11	22	47	69
		#	1984	478	1765	2462	4227
		Row%	79.82%	20.18%	31.43%	68.57%	
		Annual#	**4834**	**1222**			**6056**
		Risk%	**0.87%**	**14.31%**	**0.98%**	**1.07%**	**1.03%**
	MAIS>=2	Raw#	89	21	45	110	155
		#	12100	2590	3733	14690	18423
		Row%	91.57%	8.43%	28.99%	71.01%	
		Annual#	**24169**	**2224**			**26393**
		Risk%	**5.32%**	**77.54%**	**2.07%**	**6.36%**	**4.48%**
	Total	Raw#	611	37	364	648	1012
		#	227573	3340	180280	230913	411193
		Row%	98.55%	1.45%	43.84%	56.16%	
Percent of drivers with AIS>=2 leg injury of all drivers with MAIS>=2 injury						**56.1%**	
Percent of drivers with AIS>=3 leg injury of all drivers with MAIS>=3 injury						**46.4%**	
Annual drivers with AIS>=2 leg injuries = 56.1%*(all drivers with MAIS>=2)						**26393**	
Annual drivers with AIS>=3 leg injuries = 46.4%*(all drivers with MAIS>=3)						**6056**	

Driver Leg Injuries in Left Offset Impacts

	MAIS or AIS>=2		MAIS or AIS>=3	
	<=30	>30	<=30	>30
Annual Leg Injuries	24169	2224	4834	1222
Reduction Over Full Barrier (Table 10)				
Percent	47.2%		45.8%	
Annual Leg Injuries	**11416**		**2215**	