REAL-WORLD EXPERIENCE WITH ADVANCED AIR BAGS

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ABSTRACT

The National Center for Statistics and Analysis's (NCSA) Special Crash Investigations (SCI) program provides the National Highway Traffic Safety Administration with an anecdotal data set that allows the agency to analyze in-depth clinical evaluations of real-world crashes that involve new and emerging technologies. One of SCI's responsibilities is to investigate alleged fatalities that are related to the deployment of air bags in minor to moderate severity crashes. The first part of this paper will compare the number of occupants fatally injured by deploying air bags for either a given model year or a 12-month release period to the number of air-bag-equipped vehicles in the corresponding fleet. In this paper sled-certified air bags with advanced features are defined as air bag systems with one or more advanced occupant protection features such as: multi-stage air bag inflators, seat belt sensors, weight sensors, seat position sensors, or automatic suppression systems. The number of fatalities for occupants injured by sled-certified air bags with advanced features will be compared to those injured by air bags without advanced features. Based on our most recent observations the number of fatalities associated with sled-certified air bags with advanced features is lower than that for air bags without advanced features [1]. An overview of the only published air-bag-related fatality attributed to a sled-certified air bag with advanced features will be provided.

NCSA's National Automotive Sampling System Crashworthiness Data System (NASS CDS) collects data on representative crashes through 27 field research teams who investigate about 4,500 crashes a year. The second part of this paper will analyze SCI and NASS CDS advanced-air-bag data through the end of 2005. A variety of advanced-air-bag-related topics for front-seat occupants will be discussed. Crash severity, occupant seat weight sensors and dual-stage air bag deployments will also be discussed.

BACKGROUND

The SCI program typically classifies frontal air bags into four vehicle categories:

- Predominately pre-1998 model year vehicles certified to unbelted barrier test requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208 by barrier testing, or "barrier-certified" vehicles.

- Vehicles (1998 model years and above) certified to the unbelted sled test frontal impact requirements of FMVSS No. 208, or "sled-certified" vehicles.

- Vehicles certified to unbelted sled test requirements of FMVSS No. 208 that have air bag systems incorporating "advanced occupant protection features" (as defined in the abstract), but not certified to the advanced air bag requirements of FMVSS No. 208. In this paper these vehicles are referred to as sled-certified vehicles with "advanced features."

- Vehicles (2003 model years and above) certified to meet the advanced-air-bag requirements of FMVSS No. 208. Hereinafter these vehicles will be referred to as certified, advanced, 208-compliant (CAC) vehicles.

The distinction between the last two types of vehicles is significant, because only the CAC vehicles have been certified to meet the advanced-air-bag requirements of FMVSS No. 208, which are described in the next paragraph. Sled-certified vehicles equipped with air bags with advanced features and CAC vehicles were identified from information that vehicle manufacturers supplied to NHTSA.

The earlier barrier-certified air bag systems are used in vehicles that were certified to a fixed rigid-barrier

crash test. In March of 1997, NHTSA issued a rulemaking that made it easier for automobile manufacturers to quickly reduce the inflation power of their air bags, certified to new sled test requirements of FMVSS No. 208. These sled-certified air bags are often referred to as redesigned air bags. Sled-certified air bag systems have been certified using an unbelted sled test option instead of the 30 mph rigid barrier crash test with an unbelted Hybrid III 50th percentile male anthropomorphic test dummy [2]. In May 2000, NHTSA amended FMVSS No. 208 to require the use of advanced-air-bag technology to provide improved frontal occupant protection to all occupants. These CAC air bags were phased in, beginning with vehicles manufactured for sale in the United States on or after September 1, 2003. The rule, with a few minor exceptions, states that light passenger vehicles manufactured for sale in the United States on or after September 1, 2006, are required to have advanced air bags that are certified to S14 [3] of FMVSS No. 208. This amended standard requires vehicles to be certified to meet the following requirements:

- Rigid barrier belted test (at a speed up to and including 30 mph), using a 50th percentile adult male anthropomorphic test dummy.

- Rigid barrier unbelted test (at a speed between 20 and 25 mph), using a 50th percentile adult male anthropomorphic test dummy.

- Rigid barrier belted test (at a speed up to and including 30 mph), using a 5th percentile adult female anthropomorphic test dummy.

- Rigid barrier unbelted test (at a speed between 20 and 25 mph), using a 5th percentile adult female anthropomorphic test dummy.

- Offset frontal deformable barrier belted test (at a speed up to and including 25 mph), using a 5th percentile adult female anthropomorphic test dummy.

- Protection for infants in rear-facing and convertible child restraints and car beds, using a 12-month-old anthropomorphic test dummy either by an automatic suppression feature or a low-risk deployment feature.

- Protection for children, using a 3-year-old anthropomorphic test dummy by an automatic suppression feature, a dynamic automatic suppression system that suppresses the air bag when an occupant is out of position, or a low-risk deployment feature.

    - It is important to note that a manufacturer must petition the agency to accept and put into a final rule a specific test procedure for a dynamic automatic suppression system. There is a requirement that low-risk deployment tests be performed. No manufacturer has successfully petitioned the agency for a dynamic automatic suppression test procedure and thus there are no vehicles certified to this option.

- Protection for children, using a 6-year-old anthropomorphic test dummy either by an automatic suppression feature, a dynamic automatic suppression system that suppresses the air bag when an occupant is out of position, or a low-risk deployment feature.

- Protection for adult female drivers, using an out-of-position 5th percentile adult female anthropomorphic test dummy at the driver position either by a dynamic automatic suppression system that suppresses the air bag when the driver is out of position or a low-risk deployment feature.

AIR-BAG-RELATED FATALITIES AND SERIOUS INJURIES

In October 1996, NHTSA began publishing summary tables for each confirmed air-bag-related fatality and seriously injured occupant. Since January 2001, SCI has published on its Web site quarterly reports of crashes in which a deploying air bag or a deploying module cover flap was determined to have caused a fatality or life-threatening injury to a vehicle's occupant in a minor- to moderate-severity crash.

Beginning in January 2007, the SCI report of air-bag-related fatalities and serious injuries will be published biannually. An air bag causes fatal and life-threatening injuries when an occupant is either in the deployment path or moves into the deployment path of the air bag and is hit by the deploying air bag or cover flap. The deployment energy is then transferred to the occupant. For the remainder of this paper these

cases will be referred to as "air-bag-related" fatalities and life-threatening injuries.

SCI classifies air-bag-related cases as either "confirmed" or "unconfirmed." Confirmed cases are those where the air bag has been confirmed by NHTSA as being the injury mechanism. Unconfirmed cases are crashes under active investigation where an air bag is either alleged to be, or suspected of being, the injury mechanism. Each SCI report consists of:

- A summary of the status of SCI investigations during the reporting period.
- A count of occupants who have sustained fatal or serious injuries in air-bag-deployment-related crashes.
- Tables and charts that show the amount of air-bag- related fatalities, that are normalized by the number of air-bag-equipped vehicles in a given fleet.

Each normalized table and chart consists of confirmed and unconfirmed cases. Summary tables are also published that list all confirmed air-bag-related fatalities and life-threatening injuries. Air-bag- related crashes are grouped into three categories:

- Children under the age of 13.
- Adult drivers.
- Adult passengers.

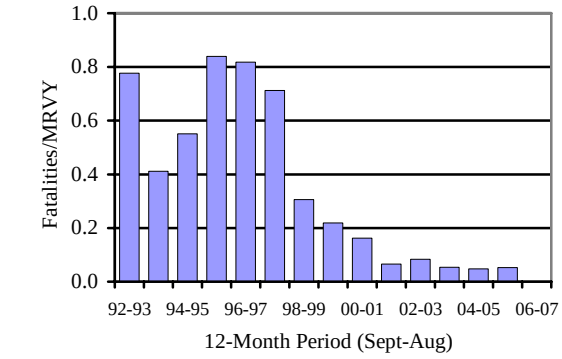
Cases involving children are further divided into two subgroups: infants seated in rear-facing safety seats (RFCSS) and children not seated in RFCSS.

Child Air-Bag-Related Fatalities

Infants in Rear-Facing Safety Seats - As of October 1, 2006, there were 26 confirmed cases of infants seated in RFCSS who sustained fatal injuries in air-bag-related cases. These fatalities occurred between the 1995 and 2004 crash years. Four of these fatalities involved an infant in a RFCSS that was held on the lap of a passenger. There were three unconfirmed cases that involved infants in RFCSS.

Children Not in Rear-Facing Child Safety Seats - There were 148 confirmed cases of children not in RFCSS who were fatally injured in air-bag-related crashes. These fatalities occurred between the 1993 and 2006 crash years. Of these crashes, 141 involved children who were fatally injured by a passenger air bag. Eight of these children who sustained passenger air-bag-related injuries were seated in forward-facing child safety seats. Of the 133 children who were fatally injured by a passenger air bag and who were not in a child safety seat, 127 were either unrestrained or improperly restrained. Eleven unconfirmed cases are under active investigation, where a child was not seated in a RFCSS and was suspected of sustaining a passenger air-bag-related fatal injury.

Figure 1 presents the number of children who sustained air-bag-related fatalities from a passenger air bag, normalized by the number of passenger air-bag-equipped vehicles in the fleet (in millions) over a 12-month release period.



Source: NHTSA, NCSA (SCI Quarterly Report)

Figure 1. Children fatally injured by a passenger air bag, normalized by MRVY; confirmed and unconfirmed as of October 1, 2006.

R.L. Polk data on new registrations was used to estimate the number of passenger air-bag-equipped vehicles in each fleet. R.L. Polk is a company that provides automotive and marketing data. SCI calculates the fatalities per million registered vehicle years (F/MRVY) for specific vehicle model years and 12-month release periods. The F/MRVY for specific vehicle model years is calculated by dividing the count of occupants fatally injured by deploying air bags for a given vehicle model year, by the product of the number of new vehicles registered that are air-bag-equipped for the given year and the number of years the vehicles of that year have been on the road. Vehicles are estimated to be on the road for one-half a year during their first production year. The F/MRVY for a given 12-month release period is calculated by dividing the count of occupants fatally injured by deploying air bags for the given 12-month period by the sum of the total number of registered

vehicles with air bags of the previous model years and one half the registered vehicles of the vehicle model year that corresponds to the production period of the crash. Each 12-month production period was aligned with the vehicle production year, September 1 through August 31.

The rate of child F/MRVY dropped significantly between the 1997-1998 production year and the 1998-1999 production year, from 0.712 F/MRVY to 0.305 F/MRVY, respectively. Fatality rates have continued to remain lower than those for the 1997-1998 vehicle production year. The most recent full year rate, the 2005-2006 vehicle production year, was 0.052 F/MRVY. A detailed explanation of how the denominator, MRVY, is calculated can be found on the Explanation page of the SCI report, which is published with the SCI summary tables on the Internet site shown at the end of this paper.

Figure 2 presents the number of children who sustained air-bag-related fatalities from passenger air bags normalized by the number of passenger air-bag-equipped vehicles in a fleet for a given vehicle model year.

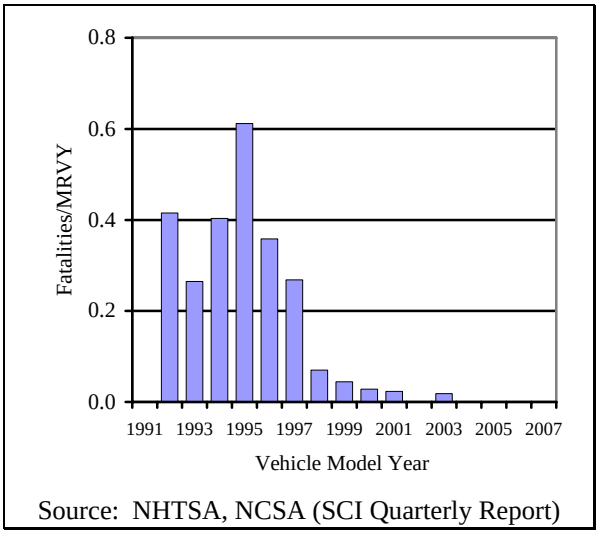


Figure 2. Children fatally injured by passenger air bags by vehicle model year, normalized by MRVY; confirmed & unconfirmed as of October 1, 2006.

The rate of F/MRVY peaked at, 0.612, for 1995 model year vehicles. There was a significant drop in the fatality rate between the 1997 and 1998 model year vehicles. The rates continued to decrease for vehicles after the 1998 model year. No air-bag-related fatalities have been found for the 2002, 2004, 2005, and 2006 model year vehicles.

The rates shown in Figures 1 and 2 show air-bag-related fatalities for children in vehicles equipped with barrier-certified air bags, sled-certified air bags, and sled-certified air bags with advanced features. None of the air-bag-related fatalities sustained by children were caused by CAC air bags. There was one confirmed air-bag-related fatality in which an infant in a RFCSS sustained a fatal injury from a sled-certified 2003 model-year vehicle equipped with dual-stage air bags. This case is currently under review.

Adult Air-Bag-Related Fatalities

Adult Drivers - There were 88 confirmed adult-driver air-bag-related fatalities. These fatalities occurred between the 1990 and 2005 crash years. Twenty-seven fatally injured adult drivers were wearing seat belts. Some type of misuse of the driver's seat belt was found in three of these cases. In each case, the driver didn't use the lap and shoulder belt together. Fifty-four of the fatally injured adult drivers were not restrained by seat belts. The belt use of four adult drivers was unknown. Six cases where adult drivers were suspected of sustaining air-bag-related fatalities are under active investigation.

Figure 3 displays the number of adult drivers who were fatally injured by driver air bags normalized by the number of driver air-bag-equipped vehicles in the fleet over a 12-month release period.

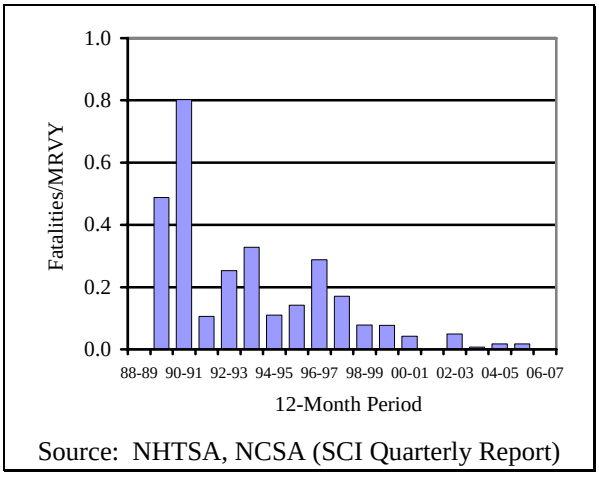
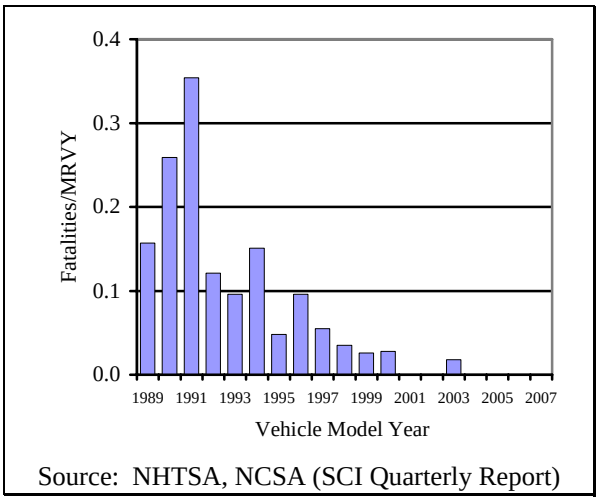


Figure 3. Adults fatally injured by driver air bags, normalized by MRVY; confirmed and unconfirmed as of October 1, 2006.

In the 1990-1991 vehicle production year, the rate of F/MRVY reached its highest point at 0.802. After that production year, none of the fatality rates have been over 0.328 F/MRVY, the fatality rate for the 1993-1994 vehicle production year. The rate for the

most recent full 2005-2006 vehicle production year was 0.018 F/MRVY. Figure 4 shows that the rate of adult drivers who sustained air-bag-related fatalities, normalized by the number of driver air-bag-equipped vehicles in a fleet for a given vehicle model year, has declined since the 1996 model year.



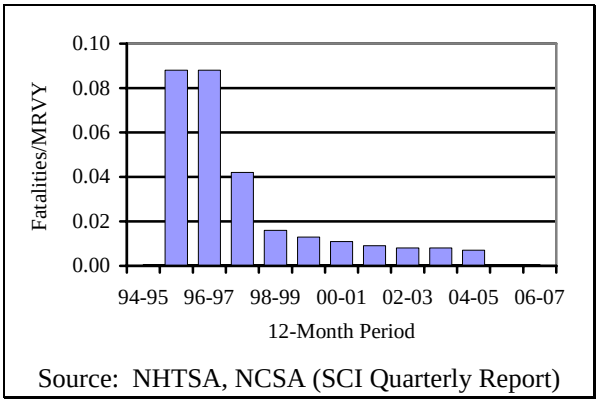
Source: NHTSA, NCSA (SCI Quarterly Report)

Figure 4. Adults fatally injured by driver air bags by vehicle model year, normalized by MRVY; confirmed & unconfirmed as of October 1, 2006.

There were no adult-driver air-bag-related fatalities found for the 2001, 2002, 2004, 2005, and 2006 model years. SCI is investigating two unconfirmed driver air-bag-related fatalities that involve 2000 and 2003 model year sled-certified vehicles that were equipped with dual-stage driver air bags. It is important to note that there were no air-bag-related fatalities of adult drivers that were attributed to CAC air bags.

Adult Passengers - Thirteen adult passengers sustained air-bag-related fatal injuries. These fatalities occurred between the 1996 and 2004 crash years. One of these passengers misused the seat belt by positioning the shoulder belt under the arm. Five adult passengers were restrained by their seat belts. The remaining 7 were not restrained by their seat belts.

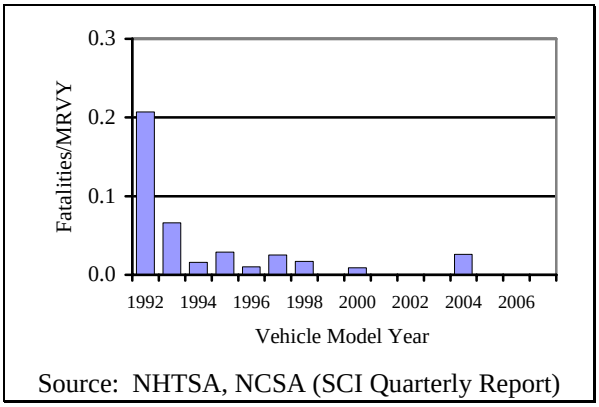
In Figure 5, the number of adult passengers who were fatally injured by passenger air bags normalized by the number of passenger air-bag-equipped vehicles in the fleet over a 12-month release period, shows a decrease in F/MRVY from 0.088 to 0.042, between the 1996-1997 vehicle production year and the 1997-1998 vehicle production year. There were no passenger air-bag-related fatalities in the last full vehicle production year.



Source: NHTSA, NCSA (SCI Quarterly Report)

Figure 5. Adults fatally injured by passenger air bags, normalized by MRVY; confirmed and unconfirmed as of October 1, 2006.

Figure 6 shows that after model year 1998, there have been six model years with no adult passenger air-bag-related fatalities. There were only two adult passenger air-bag-related fatalities after the 1998 model year. These fatalities occurred in 2000 and 2004 model year vehicles equipped with sled-certified air bags.



Source: NHTSA, NCSA (SCI Quarterly Report)

Figure 6. Adults fatally injured by passenger air bags by vehicle model year, normalized by MRVY; confirmed & unconfirmed as of October 1, 2006.

The one crash in the 2004 model year vehicle was the only published dual-stage air-bag-related fatality. This case is summarized in the paragraph below. None of the air-bag-related fatalities of adult passengers were attributed to CAC air bags. There was one unconfirmed air-bag-related adult passenger fatality involving a 2006 model year barrier-certified vehicle that is under active investigation by SCI.

The only confirmed adult passenger sled-certified dual-stage air-bag-related fatality involved a 56-year-old female passenger [66 inches, 190 pounds], who was restrained by her three-point lap and shoulder

seat belt system, which included a buckle pretensioner. She sustained critical head and chest injuries in the crash. The case vehicle's 17-year-old male driver sustained moderate and minor injuries. The case vehicle was equipped with dual-stage frontal air bags; a front right seat weight sensor; and seat belt sensors. The crash was a multiple event crash. The case vehicle's total delta V was 19 mph for the first impact and 6 mph for the second impact. The passenger's multiple air-bag-related injuries included a subdural hematoma/hemorrhage (AIS-5), a diffuse axonal injury (AIS-5), an atlanto-occipital dislocation (AIS-2), a brain hemorrhage (AIS-5), and rib fractures (AIS-5).

Fatality Comparisons

An ideal comparison of the fatality rates of sled-certified air bags with advanced features and air bags without advanced features would involve dividing the number of occupants fatally injured by a specific type of deploying air bag (e.g. sled-certified with advanced features) by the number of vehicles equipped with the specific type of air bag in a given fleet. Although the information that was supplied by manufacturers was used by SCI investigators to determine whether a sled-certified air bag with advanced features was present in a case vehicle, the supplied information was not detailed enough to estimate the number of vehicles in a given fleet that were equipped with sled-certified air bags with advanced features. Since a breakdown of the number of sled-certified vehicles with advanced features in a fleet is not obtainable, the number of air-bag-related fatalities attributed to sled-certified air bags with advanced features and air-bag-related fatalities from vehicles without advanced features will be compared in the next paragraph.

The data provided by vehicle manufacturers shows that sled-certified vehicles were equipped with air bags with advanced features such as dual-stage air bags as early as the 1999 model year. With the exception of 2003 model year vehicles, the number of adult-driver air-bag-related fatalities for sled-certified vehicles equipped with air bags with advanced features, for all other model year vehicles was either less than or equal to that of vehicles equipped with air bags without advanced features. Similarly, excluding 2004 model year vehicles for adult passengers and 2003 model year vehicles for children, the number of child and adult passenger air-bag-related fatalities attributed to air bags in sled-certified vehicles equipped with air bags with advanced features was lower than or equal to those of vehicles equipped with air bags without advanced features.

CASE SELECTION

The second part of this paper evaluates CAC vehicle data for NASS CDS and SCI cases. Since NHTSA's Electronic Data System (EDS) does not have a variable that specifically states whether a vehicle is equipped with CAC air bags, the CAC vehicle data presented in this paper were found by querying EDS for vehicles that were on the list of CAC vehicles that were provided by vehicle manufacturers. Analysis for this study is limited to CAC vehicle models that were certified for a full production year.

The data from 561 cases, which included either single-event or multiple-event crashes, were analyzed for this paper. Twenty of these cases were published in SCI, and 541 of these were NASS CDS cases. This data was used to provide background information about the type of impact of the CAC vehicles in the study, and is not intended to represent CAC vehicle crashes nationwide. Of the 561 cases, there were 389 cases in which a CAC vehicle had a direction of force between 10 and 2 o'clock, deemed a "near-frontal impact" for an event in a crash. The 10-to-2-o'clock direction of force is within the range a frontal air bag will deploy, regardless of the plane of impact. Eighteen (5%) of these cases that had at least one near-frontal impact were SCI cases, and 371 were NASS CDS cases. Cases with a near-frontal impact were then segregated into cases with a single event. There were a total of 193 of these single-event cases. Five of these cases were investigated by SCI, and 188 were investigated by NASS CDS.

Event data recorder (EDR) data are evaluated in the last section of this paper. NCSA uses the generic term "EDR" to refer to recording devices that are found in certain air bag control modules. SCI and NASS field investigators are equipped with commercially available tools to download data from EDRs of two vehicle manufacturers. EDRs are the only source of data regarding the decision logic of a CAC vehicle's safety system. This data includes the status of automatic suppression systems, the deployment level of frontal air bags, and the change in forward velocity experienced by an air bag's sensing system.

CONFIGURATION

Figure 7 shows the impact plane for the event with the highest crash severity, of the 519 CAC vehicles in which the impact plane is known.

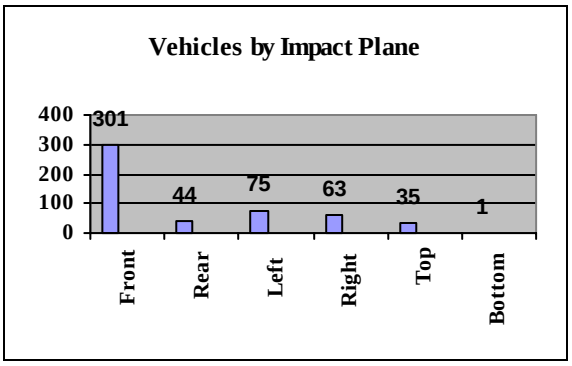


Figure 7. Impact configuration by impact plane in CAC cases published by SCI and NASS CDS.

Frontal impacts represented the highest number of known impacts, 301 (58%). Frontal impacts were followed by: left-side impacts, 75 (14%); right-side impacts, 63 (12%); rear impacts, 44 (8%); top impacts, 35 (7%); and an undercarriage (bottom) impact. The impact plane of an additional 48 vehicles was unknown. The analyses in each of the following sections, except the EDR section, are limited to vehicles that were involved in near-frontal-plane impacts in an event in the crash.

CRASH SEVERITY

The deployments of frontal air bags are based on a number of crash factors including deceleration, time, and the change in forward velocity experienced by the air bag sensing system mounted in the vehicle. Delta V as determined by WinSMASH is used in this analysis to indicate crash severity. WinSMASH is a crash reconstruction algorithm that is used in NHTSA's data collection programs. Figure 8 shows the highest longitudinal delta Vs for CAC vehicles, where the crash event with the highest crash severity was a frontal impact.

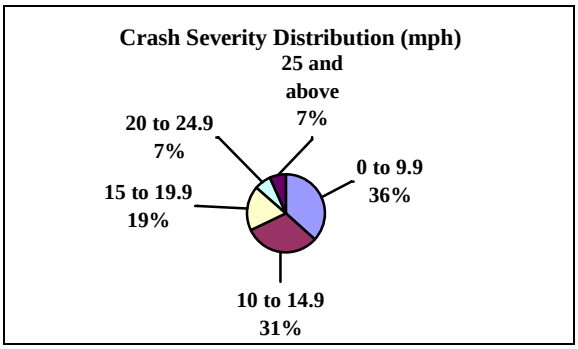


Figure 8. Maximum longitudinal crash severity of frontal impacts as measured by delta V in CAC vehicles in cases published by SCI and NASS CDS.

Since minor- to moderate-severity crashes range from 0 to 25 mph, the highest longitudinal delta Vs that were experienced by vehicles were first grouped in increments of: 0 to 9.9 mph; 10 to 14.9 mph: 15 to 19.9 mph; 20 to 24.9 mph; and 25 mph and above. There were 183 maximum longitudinal delta Vs that were known, and 84 that were unknown. Of the CAC vehicles with a known delta V, 171 (93%) had longitudinal delta Vs below 25 mph. The five groups: 0 to 9.9 mph; 10 to 14.9 mph; 15 to 19.9 mph; 20 to 24.9 mph; and 25 mph and above; made up 36 percent, 31 percent, 19 percent, 7 percent and 7 percent of the maximum longitudinal delta Vs experienced by CAC vehicles in frontal impacts, respectively. Figure 9 shows the maximum longitudinal delta V distribution for CAC vehicles in left- and right-side impacts.

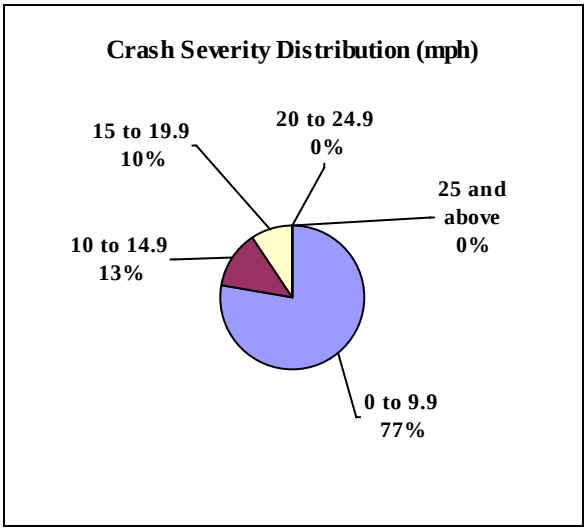


Figure 9. Longitudinal crash severity of side impacts as measured by delta V in CAC vehicles in cases published by SCI and NASS CDS.

All of the known impacts were below 20 mph. Forty-nine (77%) of the known impacts were between 0 and 9.9 mph. Impacts in the 10 to 14.9 mph range, were 13 percent of known impacts, while 10 percent of the known impacts were in the 15 to 19.9 mph range. The delta V for the 33 of the left- and right-side impacts were unknown.

CASE OCCUPANTS

Figure 10 presents the demographics of front-seat occupants in CAC vehicles that had a near-frontal-plane impact.

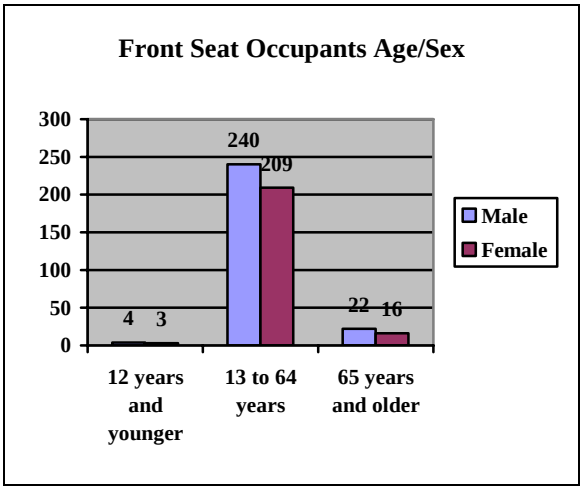


Figure 10. Front-seat occupant demographics in cases published by SCI and NASS CDS.

Front-seat occupants were divided into three age ranges: 12 years old and younger; 13 to 64 years old; and 65 and older. Occupants were then divided by sex. Cases in which the age or sex of an occupant was unknown were excluded from this analysis. There were only seven children 12 and younger seated in front seating positions in CAC vehicles. Four of the children were males, and three were females. The majority of the front-seat occupants, 91 percent, were in the 13 to 64-year-old age range. Front-seat occupants 65 and older were only 8 percent of the occupants. Two hundred sixty-six (54%) of the occupants were male, and 228 (46%) were female.

Figure 11 shows the front-row seating positions of drivers and front-right passengers in near-frontal impacts.

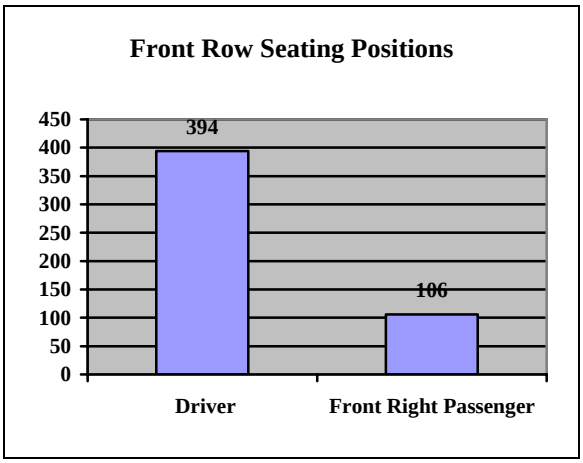


Figure 11. Front-row seating positions of vehicle occupants in CAC cases published by SCI and NASS CDS.

Drivers comprised 394 (79%) of the occupants known to be seated in the front row, and front-right passengers accounted for 106 (21%) of the occupants known to be seated in the front row.

OCCUPANT BELT USAGE

The seat belt usage for drivers and front-seat passengers whose vehicle had a near-frontal-plane impact is shown in Figure 12.

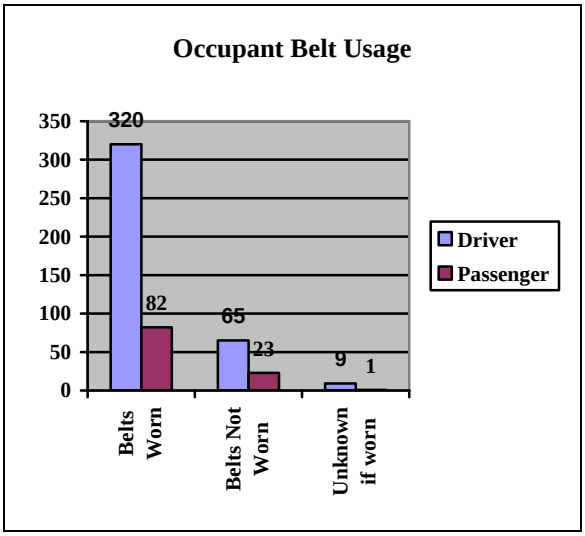


Figure 12. Seat belt usage of front-seat occupants in CAC cases published by SCI and NASS CDS.

Eighty-two percent of the occupants whose restraint use was known were restrained by seat belts. Restraint use among drivers was 83 percent, which was higher than that of front passengers, which was 79 percent.

OCCUPANT INJURY LEVEL

There were 459 occupants in CAC vehicles who were seated in either the front-right passenger or driver seating position of vehicles that had near-frontal impacts that were either not injured or sustained a known injury. These occupants were divided into two groups, according to the maximum abbreviated injury scale (MAIS) injury that they sustained. The first group is composed of occupants who were not injured and occupants whose most severe injury was a minor or moderate injury. These injuries ranged from MAIS 0 (no injury) to MAIS 2 (moderate). The second group consists of occupants whose injuries are usually considered life-threatening. This group ranges from MAIS 3 (serious) to MAIS 6 (maximum). Figure 13 shows the injury severity and belt use of frontal occupants.

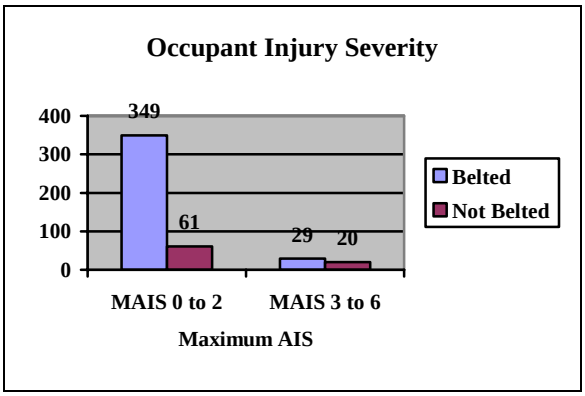


Figure 13. Most severe injury sustained by front seat occupants in CAC cases published by SCI and NASS CDS.

The first group, MAIS 0 to 2, represents 89 percent of the occupants. Eighty-five percent of the occupants in the MAIS 0 to 2 range were restrained by seat belts. Only 59 percent of the 49 occupants who sustained MAIS 3 to 6 injuries were restrained. None of the MAIS 3 to 6 injuries were air-bag-related.

AIR BAG DEPLOYMENTS

Figure 14 shows whether there was an air bag deployment in either the driver or front-right passenger seating position in a near-frontal impact when the occupant's seating position was known.

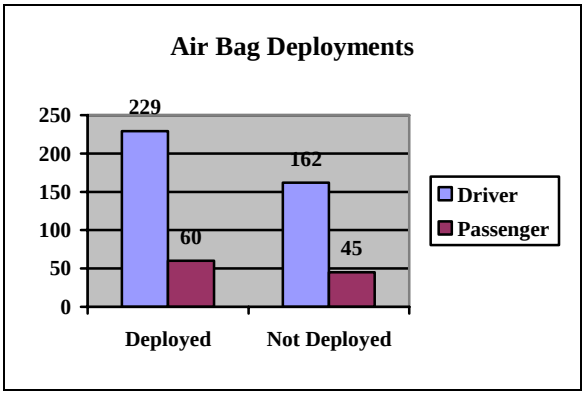


Figure 14. Air bag deployments by seating position in CAC cases for published SCI and NASS CDS cases.

There were 289 (58%) air bag deployments and 207 (42%) non-deployments. The percentage of deployments when the deployment status was known was similar for drivers and passengers, 59 percent, and 57 percent, respectively. There were 229 deployments into the driver seating position and 60 deployments into the front-right passenger seating position. With the exception of one deployment, all the deployments occurred during the crash. At this time the exact details of the one exception are unknown.

NHTSA's advanced air bag rule specifies that vehicle manufacturers meet performance standards, as specified on page 2 of this report, that relate to automatic suppression or a benign deployment of air bags. One way that vehicle manufacturers can meet the automatic suppression options in FMVSS No. 208 is to use seat weight sensors. The only automatic suppression option currently available to manufactures requires that vehicles be equipped with at least one telltale that emits yellow light, with the words "PASSENGER AIR BAG OFF" when the passenger air bag is deactivated. Telltales can be illuminated on the rearview mirror or instrument panel. Some vehicles have a sensing system that automatically deactivates the passenger air bag based on whether the weight in the passenger seat is consistent with a child or child seat. Sensors in the passenger's seat belt are often used to ensure that the belt's tension doesn't cause an inaccurate weight measurement. An EDR download is needed to determine the status of an automatic suppression system. In the future, NHTSA will pursue data on the status of automatic suppression systems when they become available.

OCCUPANT WEIGHT

Figure 15 divides occupants into weight ranges and indicates the number of air-bag deployments into an occupant's seating position, when both the occupant's weight and deployment status are known.

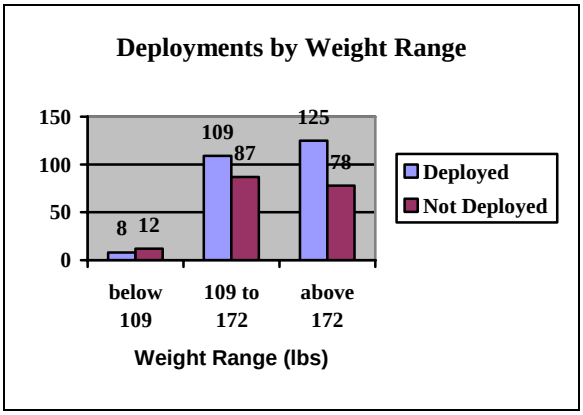


Figure 15. Air-bag deployments by weight range in CAC cases for published SCI and NASS CDS cases.

Since the advanced-air-bag section of FMVSS No. 208 includes tests that use the 5th percentile adult female anthropomorphic test dummy (108 pounds)

and the 50th percentile adult male anthropomorphic test dummy (171.3 pounds), the weights of occupants involved in crashes with near-frontal impacts were divided into increments of: "below 109 lbs," "109 to 172 lbs," and "above 172 lbs." Unlike the other two weight ranges, the "below 109 lbs" range had more non-deployments (12) than deployments (8). The weight range "above 172 lbs" was the largest of the three groups, with 125 deployments and 78 non-deployments. The "109 to 172 lbs" weight range had 109 deployments and 87 non-deployments.

EVENT DATA RECORDERS

There were 307 CAC vehicles that were equipped with EDRs in this study. NASS CDS cases that include CAC vehicles involved in crashes in the crash year 2002 (i.e., early 2003 model year vehicles) were excluded from the analysis in this section. Figure 16 indicates the number of EDRs that were downloaded by SCI and NASS field investigators.

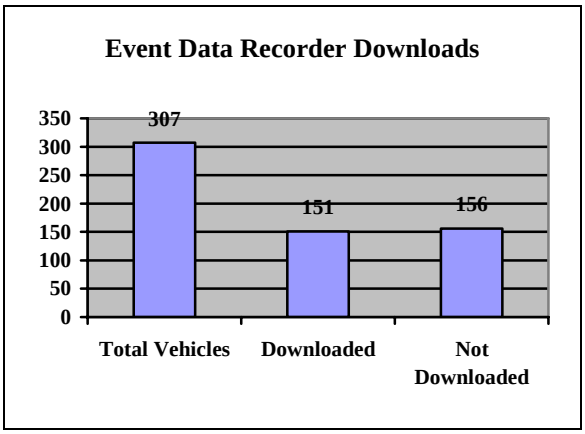


Figure 16. EDRs downloaded in CAC cases published by SCI and NASS.

One hundred fifty-one of 307 EDRs were successfully downloaded. The most common reason cited by the field investigator for not being able to download a CAC vehicle's EDR was that the vehicle was not supported by software. This reason, which was selected 79 times, describes instances when field investigators were not equipped to read the EDRs of a specific vehicle make or model. The next most common reason cited, accounting for 45 of the selections, was that field investigators were not given permission to download the EDRs. Damage preventing the field investigators from accessing the EDRs accounted for 26 selections.

The EDR downloads included crashes with multiple events. Of the 151 downloads, there were 175 EDR recordings where air bags either deployed or didn't deploy. Figure 17 shows that there were 68 (39%) deployments and 107 (61%) non-deployments.

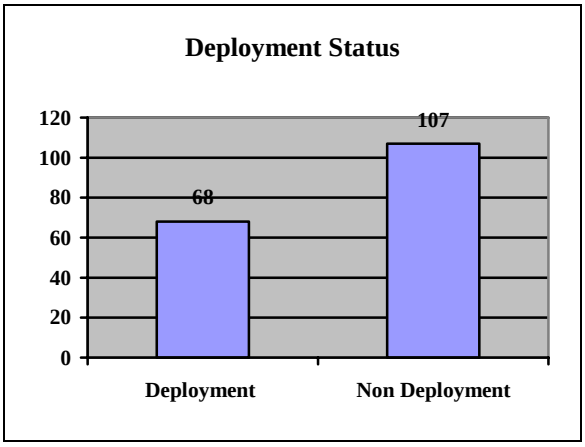


Figure 17. Air bag deployment status of downloaded EDR recordings in CAC cases published by SCI and NASS.

The average and median maximum longitudinal delta V experienced by the air bags' sensing systems for the deployments were, 14.8 mph and 12.6 mph, respectively. The standard deviation of the maximum longitudinal delta V, for deployments was 8.6 mph. Non-deployments had an average and median maximum longitudinal delta V of 3.5 mph and 1.9 mph, respectively. The standard deviation of the maximum longitudinal delta V for non-deployments was 5.1 mph.

Figure 18 shows the number of EDR-recorded air bag deployments where the deployment stage is known.

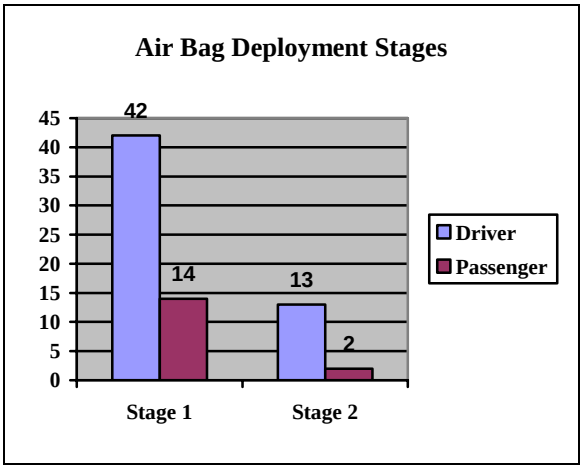


Figure 18. Air-bag deployment stages for frontal seating positions in CAC cases published by SCI and NASS.

There were a total of 56 "Stage 1" deployments and 15 "Stage 2" deployments. In each case, at least

three-quarters of the deployments were in the driver's seating position.

CONCLUSIONS

The Analysis of SCI and NASS CDS air bag data show the following:

- The data evaluated from SCI shows an overall decrease in the number of air-bag-related fatalities for the model and production years that were not associated with barrier-certified air bags: post-1997 model years and post-1997-1998 production years.

- SCI has not investigated any cases where there was a fatality or life-threatening injury attributed to the deployment of air bags in vehicles that were certified to the advanced-air-bag section of FMVSS No. 208. SCI will continue to monitor the real-world crash performance of CAC vehicles.

- The data shows, as detailed in Figure 8, that 93 percent of the maximum longitudinal crash severities of this study's CAC vehicles involved frontal impacts were below 25 mph.

- Figure 12 shows that 83 percent of the drivers and 79 percent of the front passengers were restrained by seat belts. This percentage is consistent with the 81 percent nationwide seat belt use rate measured by NHTSA's National Occupant Protection Use Survey in 2006 [4].

- As indicated in Figure 13, NASS and SCI show that almost 90 percent of the known injury severities to front-seat occupants in front of air bags certified to the advanced standard were in the MAIS 0 to 2 range. The belt usage rate for the occupants who sustained the more serious injuries, MAIS 3 to 6, was significantly lower than that for occupants who sustained MAIS 0 to 2 injuries.

- EDR data will continue to play an essential role in the analysis of CAC vehicle safety systems. Downloaded EDR data provides field researchers with the only available information about the decision logic of key safety system features, such as, the stage the air bag was commanded to deploy.

SCI DATA AVAILABILITY

SCI summary tables are now published biannually on NHTSA's Internet site at the following Internet address:

http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/sci.html

The SCI online data access page is located at:

http://www-nass.nhtsa.dot.gov/BIN/logon.exe/airmislogon

ACKNOWLEDGEMENT

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[2] Kindelberger, John, et al., *Air Bag Crash Investigations*, 18th Enhanced Safety of Vehicles Conference 2003; Washington, DC: National Highway Traffic Safety Administration. Downloaded from the Web on February 2007 at www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv18/cd/files/18ESV-000299.pdf

[3] Title 49 Code of Federal Regulations (CFR) Part 571 Section 208, Occupant Crash Protection, S14, Advanced air bag requirements for passenger cars and for trucks, buses, and multipurpose passenger vehicles with a GVWR of 3,855 kg (8,500 pounds) or less and an unloaded vehicle weight of 2,495 kg (5,500 pounds) or less, except for walk-in van-type trucks or vehicles designed to be sold exclusively to the U.S. Postal Service. Downloaded from the Web on February 2007 at http://a257.g.akamaitech.net/7/257/2422/13nov20061500/edocket.access.gpo.gov/cfr_2006/octqtr/pdf/49cfr571.208.pdf

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