

AIR BAG CRASH INVESTIGATIONS

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ABSTRACT

The performance of occupant protection systems, especially air bags, is of high interest to the National Highway Traffic Safety Administration (NHTSA). Since 1972, the NHTSA has operated a Special Crash Investigations (SCI) program which provides the agency with the flexibility to acquire detailed engineering information quickly on high visibility traffic crashes of special interest. The SCI collects in-depth crash data on new and rapidly changing technologies in real world crashes. The NHTSA established the National Automotive Sampling System (NASS) in 1979 to provide a nationally representative sample of motor vehicle crashes, injuries, and deaths on our nations highways. A component of the NASS, the Crashworthiness Data System (CDS), collects statistical crash data on crashes involving passenger cars, light trucks and vans to help government scientists and engineers analyze motor vehicle crashes and resulting injuries. The NHTSA uses the data collected in these programs to evaluate rulemaking actions. The data are also used by the automotive industry and other organizations to evaluate the performance of motor vehicle occupant protection systems such as air bags.

This paper presents information from NHTSA's SCI and NASS CDS programs concerning crash investigations on air bag equipped vehicles. The paper's focus is providing information on data collection and findings in the NHTSA sponsored air bag crash investigations. Topics include: air bag related severe injuries and fatalities for belted and unbelted children, adults, adult females 157 centimeters (62 inches) or less in height, and pregnant women.

BACKGROUND

The NHTSA performs research and develops safety programs and standards in an effort to reduce the toll of deaths, injuries, and property damage from traffic crashes. Field investigations on crashes with an air bag deployment conducted in the NASS and the SCI programs under the auspices of the National Center for Statistics and Analysis (NCSA) play a vital role by providing data relative to real

world events. The basic objective of NCSA's crash investigation and analysis of air bag deployments include the documentation of crash circumstances, the identification of injury mechanisms, the evaluation of safety countermeasure effectiveness, and the early detection of design and functional problems relative to air bags and vehicle occupants.

The NASS was established to collect a nationally representative statistical sample of motor vehicle safety data for the NHTSA. The NASS CDS is comprised of 24 data collection sites, called Primary Sampling Units (PSUs). The NASS data are collected by highly trained data collectors. The data collection follows a systematic format, including interviews, and scene and vehicle inspections.

The SCI program was established to collect detailed in-depth data on specific crashes of interest to the NHTSA. SCI cases are an anecdotal data set used to examine and evaluate the latest safety systems in real world crashes. The SCI data are used by NHTSA, automobile manufacturers, research engineers and scientists to explore ways to reduce the risks associated with motor vehicle crashes. In the SCI program, professional crash investigators perform an extensive examination of the vehicles and scene during which they secure and analyze the evidence necessary to reconstruct the pre-crash, at-crash and post-crash events.

The investigators follow up their on-site investigations by interviewing crash victims and other involved parties and by reviewing medical records to determine the nature, cause, and severity of the injuries. Each investigation provides extensive information about pertinent pre-crash, crash, and post-crash events involving the occupants, vehicles, rescue procedures, and environmental factors that may have contributed to the event's occurrence and/or resulting severity. Included in each report are analyses and determinations of occupant kinematics and vehicle dynamics.

The SCI program investigated all crashes reported to NHTSA for the early air bag vehicles. However, due to the rapid growth in the number of air bag equipped vehicles

present in the marketplace in 1990 and thereafter, the SCI program shifted from investigating all air bag vehicle crashes to investigating special interest cases. These cases involve such issues as air bag related serious and fatal injuries, interaction between air bags and child safety seats, air bag non-deployment crashes, inadvertent air bag deployments, front right passenger air bag performance, side air bag performance, depowered air bag systems and air bag success stories. These SCI air bag cases have been utilized by the agency and the automotive safety community to acquire knowledge in real world performance of new and emerging air bag systems and have been instrumental in influencing subsequent second and third generation improvements to these new air bag technologies.

AIR BAG VARIABLE ENHANCEMENTS

The air bag related data variables coded in the NASS CDS and SCI have been modified extensively to collect more detailed information on occupant protection systems. Prior to 1991 both air bags and automatic belts were intermingled as passive restraint variables. In 1991, to collect more detailed information, the passive restraint variables were divided into subsets of automatic belts and air bags. Fourteen air bag related variables were added in the 1995 data collection year, including: air bag type, location, failures, previous deployments, replacement, service/maintenance, deployment status, specific deployment event, specific deployment speed change, damage, tethering, venting and all injuries related to the air bag deployment. In addition, the cover flap geometry, location and its relationship to injuries are also documented.

Additional air bag information became available in January 1997, with the introduction of the electronic data collection system (EDCS). The expanded data collection provides the ability to collect detailed information on the number of air bags per seating position. In addition, each specific air bag deployment is linked with detailed information on the crash event including: the event sequence number, Collision Deformation Classification (CDC), and crash severity indicator. These enhancements allow researchers to study multiple side and front air bag system deployments by sequence and severity.

A new variable was added to identify the class of air bag. The variable will identify whether the air bag system is pre-1998, depowered, or whether the vehicle is equipped with an advanced air bag system.

ELECTRONIC DATA COLLECTION SYSTEM (EDCS)

The EDCS is a paperless data collection system introduced into the NASS CDS and SCI for data collection year 1997. The investigators use pen-based computers in NASS, notebook computers in SCI, and digital cameras to collect field data in an electronic format. The field data are collected electronically on the pen based and notebook computers and then transferred via a wide area network for quality assurance to either the NASS CDS Zone Centers or from the SCI teams to NHTSA.

The SCI data will contain a complete automated variable set compatible with the NASS CDS. This will allow for clinical and statistical analysis on specific areas in air bag research.

The completed cases are stored in an electronic format and will be available in multiple formats including a hard copy print out, CD ROM, or by access through the Internet.

CONFIRMED AIR BAG FATALITIES

NHTSA has made an exhaustive effort through the SCI program to locate, document and confirm air bag deployment related life threatening and fatal injuries.

In October 1996, NHTSA began publishing summary tables for each confirmed air bag related fatality and seriously injured person on the first and fifteenth of each month. Beginning in December 1997, the tables are published during the first week of the month. These summary tables contain basic information about air bag deployment related serious injuries and fatalities sustained in minor, low and moderate severity crashes by:

- (1) infants in rear facing child safety seats (RFCSS);
- (2) children not in RFCSS;
- (3) adult drivers; and
- (4) adult passengers.

Serious injury has been defined as a level sufficient to be a threat to life. The injuries that are considered a threat to life have a significant effect on mortality rather than just a high Abbreviated Injury Scale (AIS). For example, a broken neck, while a significant threat to life is only an AIS-2.

Minor crashes include speed changes of 16 KMPH (10 MPH) or less, low is a range greater than 16 KMPH (10 MPH) to 29 KMPH (18 MPH), moderate speed changes are in the range greater than 29 KMPH (18 MPH) but less than or equal to 39 KMPH (24 MPH).

NHTSA has defined children as occupants 12 years of age and under. NHTSA recommends that no children be placed in a seating position equipped with a front deploying air bag. Children should always be properly restrained in a rear facing child safety seat (RFCSS) that is correctly secured in the vehicle until they reach at least one year of age and weight at least 9 kilograms (20 lbs). Children over one year of age and weighing more than 9 kilograms (20 lbs) but less than 18 kilograms (40 lbs) should ride in a forward facing child safety seat (FFCSS). Children that have outgrown their forward facing child seats or harnesses should ride in booster seats until adult safety belts fit them properly. A proper fit is when the lap belt stays low and flat across the hips without riding up over the stomach and the shoulder belt does not cross the face or front of the neck.

In an effort to create as close to a census as possible, the Fatality Analysis Reporting System (FARS) was queried for possible cases. All crashes that met a pre-determined criteria were then evaluated to determine if there was any potential to suspect the air bag may have been a contributing factor. A number of additional driver and child cases were identified and investigated. In addition, NHTSA asked the motor vehicle manufacturers to identify any and all cases they believed involved a potential air bag related fatality. These cases were reviewed and evaluated. In all but two cases, these were either under investigation or had been investigated by the SCI program. The SCI continues to monitor the FARS, NASS, law enforcement community and media for potential cases.

The SCI has confirmed, as of March 1, 1998, 94 air bag related fatalities as noted in Figure 1. Fifty four of the 94 air bag related fatalities were children. Forty-one were children not in a rear facing child safety seat (RFCSS), 13 were infants in rear facing child safety seats. There have been 36 adult driver and 4 adult front right passenger fatalities.

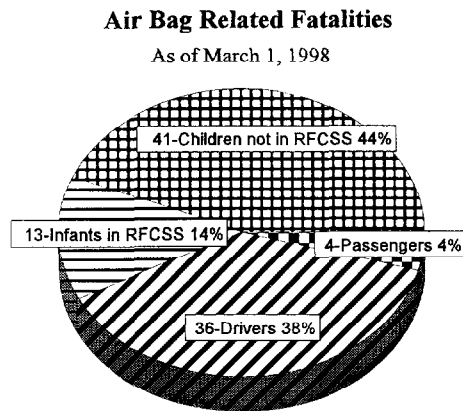


Figure 1. Percentage of Air Bag Related Fatalities.

CHILDREN CONFIRMED AS AIR BAG RELATED FATALITIES

There have been 10 cases with a child fatality in which the RFCSS was correctly secured to the vehicle with the child correctly secured in the child safety seat (see Figure 2). However, the RFCSS was secured in a seated position in which a front right passenger air bag deployed. In all 10 of these cases the air bag was the injury mechanism.

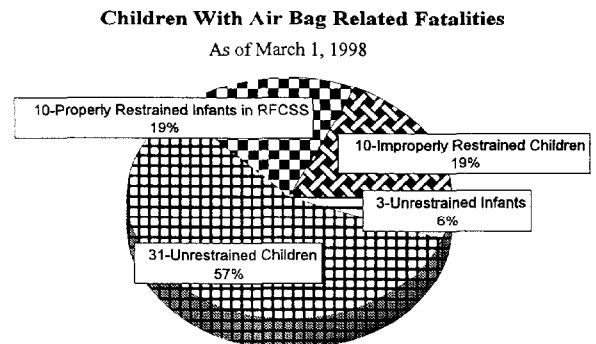


Figure 2. Children with Air Bag Related Fatalities.

Thirty four of the children were not restrained, while ten were improperly restrained. Of the 34 unrestrained (see Figure 3), seven children were being held in the lap of the right front occupant. Three of the seven children were infants in rear facing child safety seats being held on the lap of the right front passenger. Twenty seven children were not wearing the available lap and shoulder belts.

Unrestrained Children With Air Bag Related Fatalities

As of March 1, 1998

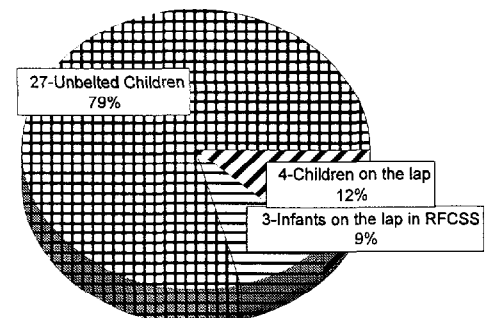


Figure 3. Unrestrained Children with Air Bag Related Fatalities.

Ten children were improperly restrained. Four children were wearing only the lap portion of the lap and shoulder belt. One child was belted with the lap and shoulder belt, but was leaning forward in the path of the deploying air bag. Three children were belted, however, the proper restraint for their physical dimensions is a child safety seat. Two children were restrained in forward facing child safety seats improperly secured to the vehicle.

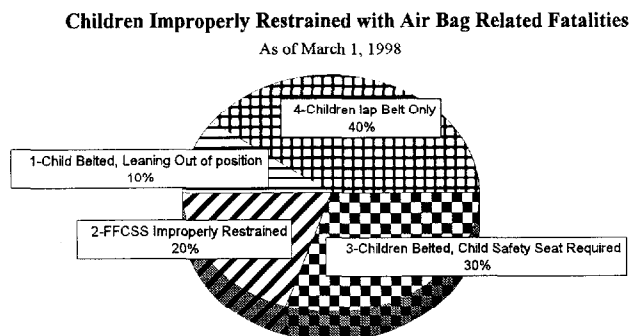


Figure 4. Children Improperly Restrained with Air Bag Related Fatalities.

NASS CDS AIR BAG INVESTIGATIONS

The NASS CDS has collected data on 3,058 crashes with air bag deployments from 1988 to 1996. Currently the NASS has 24 CDS teams with 60 field data collectors investigating an expected yield of 5,000 cases per year. As noted in Figure 5, the number of air bag deployment cases has increased year to year.

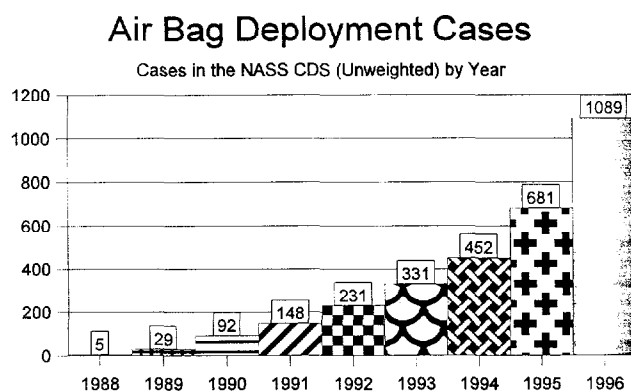


Figure 5. The number of air bag deployment cases represented by unweighted counts in NASS CDS.

The 3,058 NASS CDS cases, when weighted, represent 1,135,457 crashes with air bag deployments (Figure

Weighted Counts of Air Bag Deployments

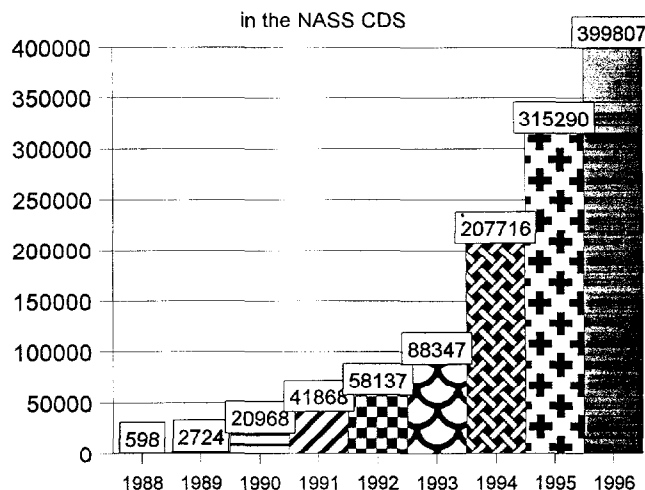


Figure 6. The number of air bag deployment cases represented by weighted counts in NASS CDS.

6).

In the unweighted (1988 to 1996) NASS CDS there are 34 children, 12 years old or less, seated in the front right occupant position where the air bag deployed with minor (AIS-1) or no injury. When the weighting factor is applied, these 34 children represent 11,783 occupants.

In the NASS CDS data collection year 1996, there were a number of cases of special interest involving children and air bag related injuries. Two children were seriously injured by a deploying air bag, while in a third case a child received minor injuries from a side air bag.

The first 1996 case involved a head-on crash which resulted in critical head injuries to a 3 year old front right child passenger of a 1995 Ford Escort. The Ford Escort was equipped with automatic shoulder restraints with manual lap belts and dual driver and passenger side air bags which deployed during the crash. The front right passenger of the Escort was a 3 year old male with a height of 107 cm (42") and weight of 15 kg (32 lbs.), seated in a forward position and restrained by the manual lap belt system. The motorized shoulder belt webbing was positioned behind the back of the forward facing child passenger. A booster seat was positioned in the rear seat area of the Escort, however, the child restraint was not in use at the time of the crash. The child responded to the frontal impact force by initiating a forward trajectory into the path of the deploying passenger

side air bag. Based on the severity of his injuries, the child passenger was probably out of position in a forward direction with his head exposed to the inflating passenger side air bag. His involvement with the deploying passenger side air bag resulted in multiple soft tissue injuries of the scalp which included a right frontal/parietal contusion, a right scalp abrasion over the right ear, a left temporal laceration, and a contusion of the right earlobe. Internal air bag induced head injuries included cerebral edema (AIS-3), subarachnoid hemorrhage, and a diffuse axonal shear injury, with extreme loss of consciousness and non-responsiveness to pain. These injuries suggest an acceleration of the head from exposure to the inflating air bag. The child occupant came to rest on the right seat cushion of the Escort with his upper body and head slumped over the center console area of the vehicle. The child was transported to a pediatric hospital where he was admitted for a period of 28 days for evaluation and treatment of his injuries. He was discharged as an out-patient to a rehabilitation facility for occupational and physical therapy for motor function deficits.

The second 1996 NASS CDS case involved the front of a 1995 Plymouth Voyager minivan that impacted the left side of a 1990 Eagle Talon. The front right occupant was a six year old male, 132 centimeters (52 inches) tall and weighing 25 kilograms (55 pounds). This passenger was not wearing the available lap and shoulder belt. The unrestrained child responded forward during the pre-crash braking and contacted the front right passenger instrument panel and air bag cover flap. At impact the front passenger air bag deployed. The leading edge of the air bag cover flap and air bag contacted the occupant from the neck to the upper lip. The air bag contact produced severe abrasions from the neck to the upper lip. The inflating air bag contact also resulted in a subluxation of vertebrae C-2 over C-3 with spinal cord injury and a resulting quadriplegia. The child passenger was thrown in an upward motion and contacted the roof and rotated landing face down in the front right seat with his head against the front right door. The passenger was hospitalized until February, 1997 when he was transferred to a rehabilitation institute.

The third 1996 case involved a 3-year-old male, 91 centimeters (36 inches) tall and weighing 14.5 kilograms (32 pounds), not using the available lap and shoulder belts who was sitting in the front right passenger seat of a 1997 BMW 528i. The BMW was equipped with driver and passenger side frontal air bags and supplemental side door air bags. Both front air bags and the right door air bag deployed as a result of the crash. At initial impact the front right occupant moved forward and to the right contacting the passenger side frontal air bag with no subsequent injury. The vehicle then rotated clockwise and side slapped the other vehicle. The

side slap consequently deployed the right side door air bag. The child was contacted by the deploying air bag cover which is hinged at the bottom. The child sustained minor lacerations/contusions/avulsions to the right facial area from the deploying right side door air bag cover.

The NASS CDS recorded its first two child fatalities in 1997. The first crash involved a 2 year old male who was fatality injured when the front of his vehicle struck the rear of another vehicle in a low speed impact. The child was seated on the lap of the front right seat passenger. Both occupants were unrestrained. As the deploying air bag inflated it expanded under his chin and jaw. The contact resulted in an abrasion across the chin and jaw that was approximately 1.75" wide. The contact to the top of the inflating air bag forced the head of the occupant upwards and the boy sustained a fracture/dislocation of the C1 and C2 vertebrae with a complete cord transection at the C1 level.

The second case was a three vehicle front to back chain reaction crash. A 3-month-old male was seated in a rear facing child seat (RFCSS) which was in the lap of the front right 17 year old female occupant. The child was not strapped to the child seat, nor was the child seat strapped to the vehicle in any way. The child seat was being held sideways so that the child would have been facing the driver.

The front of the case vehicle struck the rear of another vehicle. The case vehicle sustained a delta V of 26 km/h (16 MPH). At impact both air bags deployed. There were a total of 4 unbelted occupants injured in the case vehicle. The driver sustained contusions to the chest and the hand. The front right occupant sustained an abrasion to the left cornea. The rear seat middle occupant sustained a facial abrasion. The infant in the front right position sustained numerous skull fractures bilaterally with associated subdural and subarachnoid hemorrhage and cerebral edema.

Upon vehicle braking, the front right occupant moved forward and leaned her upper torso over the infant seat in a protective maneuver. This pre-impact occupant movement placed the front right occupant and the infant seat in a closer proximity to the instrument panel. The infant seat pitched laterally and moved forward due to this pre-impact occupant movement.

At impact, the front right seated occupants moved forward. The front right seat back was also being heavily loaded by a rear seated occupant. The infant seat impacted the instrument panel (right side) and the glove box door as evidenced by a straight edged vertical white mark left residually. This impact occurred simultaneously with the air bag deployment. Although the air bag made significant

contact with the infant seat, there was some underriding effect with the infant seat-air bag interaction. The lack of frontal lobe injuries suggest that the child's head sustained forces from either side. The combination of air bag forces in conjunction with the instrument panel loading account for the numerous injuries sustained to the right side and parietal regions of the child's head. The left side (head) injuries are likely due to the front right seated occupant loading the infant seat with her torso.

The only NASS CDS driver fatality listed in SCI monthly counts occurred in data collection year 1996. The crash involved a 1995 Ford Escort that had multiple impact events with another vehicle, a stop sign, and a small diameter tree.

The driver of the Escort was a 79 year old male with a reported height of 175.3 cm (69.0") and weight of 81.6 kg (180 lbs.). He was restrained by the automatic 2-point shoulder belt webbing and the manual lap belt. The seat track was adjusted to a forward third track position. The initial right side impact sequence moved him laterally to the right and forward. The belt systems restrained the driver from contact with interior components and prevented him from contact injury. The minor secondary side slap configuration did not displace the driver to the right. He would have initiated a rebound trajectory to the left and was probably in an upright position as the front right corner area of the vehicle impacted the stop sign. Although the impact with the stop sign was minor, it displaced the driver forward. The inertia activated belts relaxed during the post-impact travel and locked at impact with the sign. The movement of the driver within the vehicle could have resulted in spool-out of the shoulder belt webbing which allowed him to move forward within close proximity to the steering wheel. As the vehicle impacted the small diameter tree, the driver air bag deployed.

The deploying driver's side air bag contacted the chest of the driver as he moved forward in response to the frontal impact with the tree. He subsequently loaded the belt webbing, however, his loading of the shoulder belt webbing was minimal due to the air bag expansion against his chest. As a result of the driver's involvement with the deploying air bag, he sustained multiple bilateral rib fractures with contusions over the hila of both lungs, a fractured sternum at the second intercostal space, a 1 cm laceration of the myocardium over the anterior surface, and a perforation (laceration) of the pericardium with 250 ml of blood. In addition to the internal injuries attributed to the air bag, the driver sustained numerous soft tissue injuries that were associated with air bag deployment. These soft tissue injuries included ecchymosis of the dorsum of the right wrist from

probable contact with the instrument panel as the air bag expanded against his forearm, a 6 cm diameter contusion of the forehead from air bag contact, an abrasion of the left upper arm, an abrasion of the inferior nose, and two partial thickness linear abrasions of the right chin. The driver also sustained superficial lacerations of the left upper arm which were attributed to flying right side glass. There was no other mechanism visible within the interior of the vehicle to support the superficial lacerations.

His loading force against the shoulder belt webbing resulted in oblique linear abrasions that extended across the chest from the left shoulder to the right upper chest. The autopsy report noted that the abrasion pattern was indicative of shoulder belt usage. The hospital medical report noted a contusion to the left upper chest area that probably overlapped the abraded area. The driver's abdominal loading of the manual lap belt webbing resulted in a contusion over the lower portion of the falciform ligament of the liver and a 3 cm laceration of the medial portion of the anterior right lobe of the liver, inferiorly, up to 2 cm in depth which is surrounded by a crush exhibiting injury, 400 ml of blood in the peritoneal cavity, and hemorrhage in the omentum and mesentery. The driver was removed from the vehicle by paramedics and transported by ambulance to a local hospital where he died in the emergency room following arrival.

SPECIAL CRASH INVESTIGATIONS

The SCI program has performed 1,659 in-depth crash investigations on air bag equipped vehicles since its inception in 1972.

The SCI program has been tasked with tracking and reporting NHTSA's list of confirmed air bag related life threatening and fatal injury counts. The SCI program has been significantly expanded in order to perform an investigation of all air bag related life threatening or fatal injuries. As a result, there are a significant number of active investigations. Cases are not listed as confirmed until the crash severity, injury and injury mechanism have all been confirmed. In the majority of the cases the time from case assignment to confirmation is lengthy due to the procurement of the official medical reports.

CHILDREN IN AIR BAG DEPLOYMENTS

Table 1 is a listing of the case counts by year of children (occupants 12 years old and under) confirmed as fatally injured by a deploying air bag. While it appears that the number of confirmed cases is on a downward trend, this in fact may not be the case. As previously noted, there are

a number of cases under active investigation.

Table 1
Children Confirmed as an Air Bag
Related Fatal Injury by Year
As of March 1, 1998

YEAR	Children in RFCSS	Children NOT in RFCSS	TOTAL
1993	0	1	1
1994	0	5	5
1995	3	5	8
1996	6	17	23
1997	3	13	16
1998	1	0	1
TOTAL	13	41	54

In October 1993, the SCI confirmed the first known air bag deployment related child fatality of the 1990's. The crash involved a 1993 Volvo 850 GLT, four-door sedan that was involved in a minor front-to-rear impact sequence. As a result of the crash, the Volvo sustained an estimated velocity change of 12 KPH (7 mph) which was sufficient to deploy the front driver and passenger air bags.

The front right occupant of the vehicle was the driver's six year old daughter. She had a reported height of 112 cm (44") and weight of 23 kg (51 lbs.). The investigation determined that she was not restrained by the available lap and shoulder belts.

Based on the location and severity of the child passenger's injuries and the associated contact points within the vehicle, it was presumed that the child was in a normal seated position and rotated slightly to her right, exposing her front left side to the instrument panel. Immediately prior to impact, the driver applied a rapid braking force in an attempt to avoid the impending crash. Due to the brake induced deceleration, the child passenger moved forward from the seat and against the right instrument panel and passenger side air bag module assembly. As the child contacted the involved components, the frontal area of the case vehicle impacted the rear of the stopped other vehicle which resulted in deployment of the driver and passenger air bags.

As the passenger side air bag deployed, the left lower

edge of the module cover flap contacted her arm as the flap began to open in an upward direction. The initial contact resulted in a 3 x 1 cm hematoma over the anterior arm fold at the left elbow and crepitation of the elbow. The deploying passenger side air bag subsequently expanded across the child's chest as she was positioned against the module assembly. The left lower edge of the flap contacted the inferior aspect of the child's chin. The flap continued up into the left anterior aspect of her chin and into the lips and left side of the mouth area. As a result, she sustained a 10 x 5 cm abrasion to the anterior and inferior aspects of the chin, a 4 x 1 cm hemorrhagic area to the upper and lower lips, and a 3 x 1.5 cm abrasion at the left lateral aspect of the mouth.

The upward rotation of the module cover flap and contact with the inferior aspect of the occupant's chin, in combination with deployment of the passenger side air bag, accelerated the child in both a vertical and rearward direction. As the child was thrust upward and rearward, the superior aspect of the child's head impacted the right side of the rear view mirror and compressed the mirror into the overhead map light area. The impact fractured the mirror glass and separated the mirror from its windshield header mount. The subsequent contact from the mirror into the map light area resulted in multiple black plastic transfers to the lenses and switches of the lights. As a result of the contact, the child sustained a 5 cm diameter hematoma over the superior sagittal suture line of the scalp, a 0.7 cm hematoma of the front right scalp, fine, diffuse, acute subarachnoid hemorrhage, acute contusions of the superior aspect of the left and right temporal lobes of the brain anteriorly, uncus and cerebellar tonsillar herniation, acute contusion of the inferior aspect of the pons on the right, and pronounced brain swellings. At the hospital, the child was stabilized before being transported by helicopter to a children's hospital. She was maintained on life support until she died, approximately 41 hours after the crash.

The extension injury pattern noted in this case has been seen in the majority of the unrestrained children not in a RFCSS cases performed in the SCI. During pre-impact braking the child slides forward into the path of the deploying passenger side air bag. As the air bag deploys it wraps under the chin against the neck lifting the child's head. The result is usually a severe anterior neck abrasion pattern. The internal injuries to the children have included severe brain, brain stem, spinal column and skeletal neck injuries. The most severe air bag induced injuries have been complete decapitations.

In a more recent confirmed case, the front right 11 year old male passenger received a blunt force trauma from the deploying air bag. The front of the case vehicle impacted

the back of a stopped vehicle, causing the case vehicle's driver and front right air bags to deploy. Immediately prior to the crash, the front right passenger was bending forward in the process of retrieving a tissue out of the drawer underneath the front right seat. The crash severity to the case vehicle (Figure 8) was low.

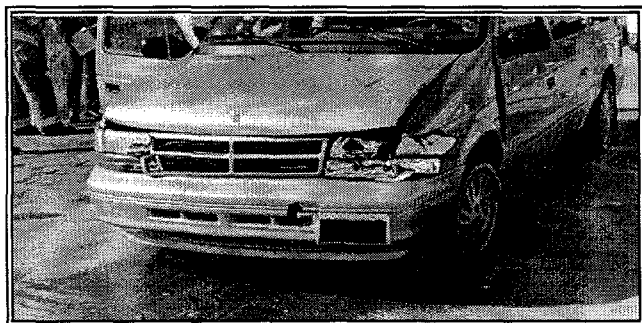


Figure 8 . Front of case vehicle's damage.

The front right passenger [152 centimeters and 32 kilograms (60 inches, 70 pounds)] was restrained by the three-point lap and shoulder belt. An inspection of the front right air bag revealed skin evidence on the bottom portion of the air bag. An inspection of the front right air bag module's cover flap revealed no evidence of contact. The front right passenger's use of his available seatbelt played no injury prevention role in the crash because of his close proximity to the front right air bag just prior to the crash.

The case vehicle's primary impact with the other vehicle thrust the front right passenger forward and slightly upward into the deploying air bag. The front right passenger's forward excursion put his head into the path of the deploying air bag. As the air bag deployed, the front passenger was raising up looking forward (i.e., sunglass lens has air bag material imprinted on it). The front right passenger sustained a non-anatomic brain injury, herniation of his brain stem (bilateral tonsillar and uncal), massive right subdural hematoma, massive cerebral edema, a subarachnoid hemorrhage, a contusion to the right lung with a small apical pneumothorax, an abrasion across the forehead, and a contusion to the upper chest. All these severe head injuries have been attributed to being struck by the deploying front right passenger air bag.

ADULTS CONFIRMED AS AIR BAG RELATED FATALITIES.

Since 1990, 40 adults (36 drivers and 4 passengers) have been confirmed as fatally injured by a deploying air bag (Table 2).

Table 2
Adults Confirmed as Fatally Injured by the Air Bag
By Crash Year
As of March 1, 1998

YEAR	ADULT DRIVERS	ADULT PASSENGERS	TOTALS
1990	1	0	1
1991	4	0	4
1992	3	0	3
1993	4	0	4
1994	7	0	7
1995	4	0	4
1996	6	1	7
1997	7	3	10
1998	0	0	0
TOTAL	36	4	40

Thirty-five percent of the adult drivers and passengers in confirmed air bag related fatalities are 65 years of age or older. Only 5% are under the age of 25 years old.

Table 3
Adult Drivers and Passengers Confirmed as
Air Bag Related Fatalities by Age of
Occupant
As of March 1, 1998

Age in Years	Count	Percent
Under 25	2	5 %
26 to 39	8	20 %
40 to 55	8	20 %
56 to 64	8	20 %
Over 65	14	35 %

Fifty five percent of the drivers and passengers confirmed as an air bag related fatality were not belted.

Table 4
Adult Drivers and Passengers Confirmed as Air Bag
Related Fatalities by Belt Usage
As of March 1, 1998

Belt Usage	Count	Percent
No Belts	22	55%
Yes, Lap & Shoulder	10	24%
Yes, Shoulder only	1	3%
Yes, Shoulder, Lap use	1	3%
Yes, Slumped forward	2	5%
Mis-used	1	3%
Unknown if used	3	7%

Thirteen of the thirty-six adult drivers are females 157 centimeters (62 inches) or less in height. The SCI has not confirmed any drivers (62 inches) or less centimeters in height in vehicles with a model year 1995 or newer. There may have been design changes and or the dissemination of information on sitting 10" from the air bag, that appear to have resulted in a decline in the number of female driver 157 centimeters (62 inches) or less in height, involvements. Both of the confirmed front right female 157 centimeters (62 inches) or less in height involve a passenger over 65 years of age that were not restrained by the available lap and shoulder belts.

Table 5
Females 157 Centimeters (62 inches) or Less in Height
Fatally Injured by a Deploying Air Bag
By Vehicle Model Year
As of March 1, 1998

YEAR	Drivers	Front Right Passengers	TOTALS
1989	1	0	1
1990	3	0	3
1991	4	0	4
1992	2	1	3
1993	0	0	0
1994	3	0	3
1995	0	1	0
1996	0	0	0
1997	0	0	0
1998	0	0	0
TOTAL	13	2	15

Of the 15 females 157 centimeters (62 inches) or less in height only 2 were using the available lap and shoulder belt correctly. Ten were noted as not restrained by the belts. In two cases it was not possible to determine belt usage. The remaining case is noted as belt mis-used.

Table 6
Females 157 Centimeters (62 inches) or Less in
Height Fatally Injured by a Deploying Air Bag
By Age
As of March 1, 1998

Age	Count	Percent
Under 25	2	13%
25 to 64	5	33%
Over 65	8	53%

The majority of the females 157 centimeters (62 inches) or less in height fatally injured by a deploying air bag were over 65 years of age. Of these 8 women, only one occupant was confirmed as wearing a lap and shoulder belt correctly.

PREGNANT DRIVERS AND AIR BAG DEPLOYMENTS

In October of 1994, a crash was investigated involving a women, in her thirty-fifth week of pregnancy, who was seriously injured as a result of a driver air bag deployment. The driver was a 29 year old female, 157 centimeters (62 inches) tall and having a weight of 74.8 kilograms (165 lbs). She was not wearing the available three point lap and shoulder restraint. The case vehicle was a 1992 Ford Taurus station wagon. The case vehicle was struck head-on by a pickup truck. At impact the driver's side air bag deployed in the case vehicle. The low impact speed resulted in a near threshold deployment. Due to the pre-impact braking and an extended time period between the point of contact and deployment, the driver's position had moved forward into the path of the deploying air bag. The cover flap and air bag struck the driver on the right side of her abdominal area which resulted in an abruption of the placenta.

The NASS CDS adjusted the occupant demographics on females in 1995 to include data on pregnancy. For 1995 through June of 1996, NASS reports 16 cases of pregnant women in seating positions involved in crashes in which the air bag deployed. None of these women experienced placenta abruption or uterine injuries.

These data do not suggest a conclusion that air bag deployment leads to an increased risk of injury and fatality to the mother or the unborn child. Of the 16 pregnant women, 13 were drivers and 3 were right front passengers. Nine used manual lap and shoulder belts, three used automatic belts and four were unbelted. These NASS CDS cases suggest that air bags are providing crash protection to pregnant females as well as to their unborn children.

"SAVED BY THE AIR BAG"

As of March 1998, the NHTSA estimates 2,536 drivers and 384 front right passengers lives have been saved by air bag deployments. The SCI has researched at least 46 crashes, where an occupant is reported to have been saved the air bag.



Figure 8. High speed frontal crash in which the driver was saved by the air bag.

One of the "saved-by-the-bag" crashes occurred when a law enforcement officer, driving his police cruiser, was impacted head-on by a pick up truck driving the wrong way on the expressway. The police car's Impact speed was about 60 miles per hour. The police vehicle pushed the pick up truck backwards more than 10 feet from the point of impact.

The law enforcement officer was wearing his lap and shoulder belt and was protected by the air bag. Although this vehicle sustained a speed change around 49 miles an hour, the driver received no life threatening injuries. His injuries included contusions and a right knee (patella) fracture .



Figure 9. The interior of the high speed frontal crash in which the driver was saved by the air bag.

SIDE AIR BAGS

The SCI has investigated 12 cases involving side air bag deployments. Ten of the twelve cases are side bag deployments related to a side impact. In all ten of these cases the air bag provided occupant protection.

The SCI has performed two investigations on 1998 vehicles equipped with an inflatable head protection system deployment. In both of these cases, the additional head protection reduced the potential for injury.

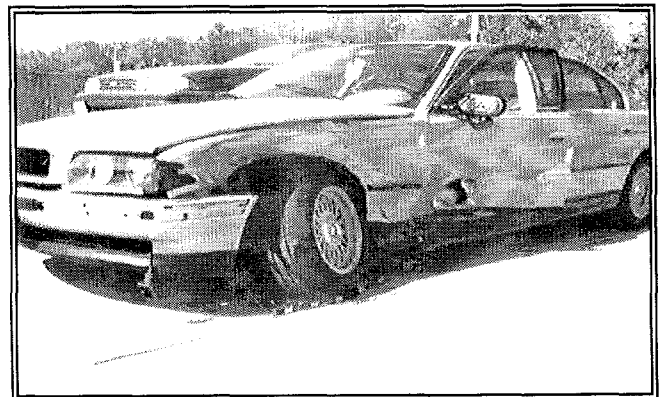


Figure 10 Exterior damage on a 1998 vehicle equipped an inflatable head protection system.

Two side air bag cases were performed as potential defects. The first of these was an inadvertent deployment in a vehicle equipped with a seat mounted air bag. A 15 year old male seated in the front right position placed his street hockey stick (plastic blade) with the blade forward of the

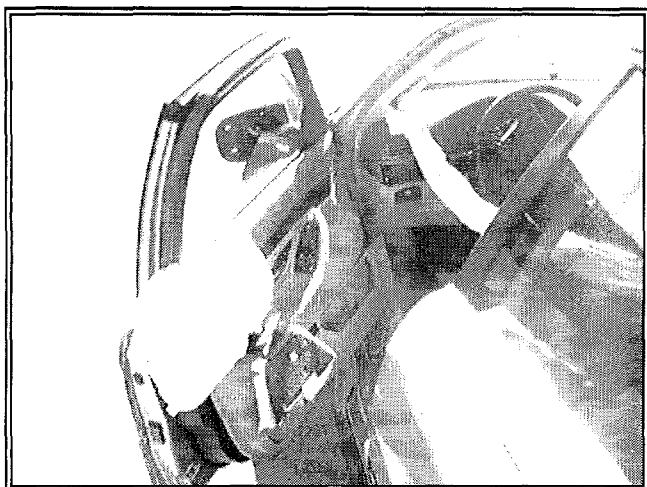


Figure 11. 1998 vehicle with deployment of the door mounted side air bag and the inflatable head protection system.

front seat with the handle extended along the right sill area and into the right rear area. The door was closed with sufficient force to drive the firing pin into percussion cap, deploying the seat mounted air bag. The handle was compressed into the seat at the location of the mechanical sensor located on the outboard aspect of the lower seat frame. The 15 year occupant sustained a severe contusion (AIS-1) on his right forearm.

The second case involved a 1998 vehicle struck in the driver's door. Our investigation determined the speed change to be slightly under the threshold for deployment. The manufacturer completed a diagnostic test on the system with no faults reported. The driver reported no injury.

DEPOWERED AIR BAGS

As of April 1998, the SCI has initiated 56 cases involving 1998 vehicles with a depowered air bag deployment. The SCI has screened over 325 police crash reports involving 1998 vehicles. From October 1997 to January 1998 the SCI was selecting any case with a depowered air bag deployment. In an effort to focus the depowered investigations toward cases of interest the agency established the following criteria for cases selected after January 1998:

- A child seated in a position where a depowered air bag has deployed.
- The crash was severe ($\Delta V > 24$ MPH).
- When a vehicle has driver and passenger in seat

positions protected by a depowered air bag.

- When an injured driver or passenger are in a seat position protected by a depowered air bag and transported to a medical facility for treatment

In FY1998, the SCI anticipates initiating field investigations on approximately 100 crashes in this category.

CONCLUSIONS

In the majority of frontal crashes air bags are highly effective in reducing fatal injuries. As of March 1, 1998, NHTSA has estimated 2,920 lives saved by air bags.

NHTSA recommends that no children be placed in a seating position equipped with front deploying air bag. There have been 54 children confirmed as fatally injured by the deploying air bag. However, in the unweighted (1988 to 1996) NASS CDS there are 34 children, 12 years old or less, seated in the front right occupant position where the air bag deployed with minor (AIS-1) or no injury. When the weighting factor is applied these 34 children represent 11,783 occupants.

Most occupants fatally injured by deploying air bags are not restrained by the lap and shoulder belt, using it improperly or are out-of-position at the time of deployment.

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AIR BAG CRASH INVESTIGATION DATA AVAILABILITY

The NHTSA has a number of methods in which the air bag crash data is distributed. The 1979 through 1996 NASS CDS electronic files can be obtained by contacting the following:

Marjorie Saccoccio, DTS-44
DOT/Volpe National Transportation Systems Center
Kendall Square
Cambridge, MA 02142
USA

Summary tables are available to the public after the third business days of each month. Copies of the summary tables can be obtained by calling one of the following telephone numbers and requesting "Air Bag Fatality Reports

for Special Crash Investigations" or by visiting the SCI on the National Highway Traffic Safety Administration's (NHTSA) Internet web site.

Toll Free 800-934-8517
Local Number 202-366-4198
SCI on NHTSA's Internet Web Site
<http://www.nhtsa.dot.gov/people/ncsa/sci.html>

Copies of completed hard copy NASS and SCI reports listed as available on the summary tables can be obtained from the hard copy storage facility at the address below. The reports contains slides and/or photographs and accordingly there is a cost associated with reproduction of the crash report.

Lyndra Marshall
Zimmerman Associates, Inc.
1815 North Fort Myer Drive
Suite 100
Arlington, VA 22209
USA

Completed SCI reports can be reviewed at the hard copy storage facility. There is a nominal cost for case retrieval and handling.

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