TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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CALSPAN ON-SITE REAR FACING CHILD SAFETY SEAT/AIR BAG DEPLOYMENT FATALITY INVESTIGATION

CALSPAN CASE NO. CA98-34

VEHICLE - 1997 FORD F150 PICK-UP

LOCATION - OHIO

CRASH DATE - MAY, 1998

Contract No. DTNH22-94-07058

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness of the involved vehicle(s) or their safety systems.

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17. *Abstract*

This investigation focused on the fatal injury mechanisms of a 2 month old infant, restrained in a rear facing child safety seat (RFCSS). The child seat was positioned in the right front of a 1997 Ford F150, 3-door pickup, that was involved in an intersection crash with a 1997 Ford Ranger. The Ford F150 was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. The Ford F150 was also equipped with a cut-off switch to disable the front passenger air bag. The cut-off switch was not utilized at the time of the crash. The 1997 Ford Ranger was equipped with a SRS that consisted of a driver air bag, which also deployed as a result of the crash.

The infant was restrained in the rear facing child safety seat by the seat's integral harness. The RFCSS was restrained by the vehicle's lap and shoulder belt in the right front seated position of the Ford F150. The vehicle's restraint was properly routed through the safety seat according to the labeled instructions. A locking clip was not used. The vehicle's seat track was adjusted 5 cm (2 in) forward of the most rearward position. The size and position of the RFCSS placed it in the deployment path of the front passenger air bag.

The force of the impact caused the deployment of the vehicle's SRS and the front passenger air bag expanded against the back of the RFCSS early in its deployment sequence. The continued expansion of the air bag fractured the upper left aspect of the seat back. The head of the infant passenger was adjacent to the site of the fracture and suffered massive head trauma. He died 4 days post-crash of the injuries.

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CALSPAN ON-SITE AIR BAG FATALITY INVESTIGATION

VEHICLE: 1997 FORD F150 PICKUP
LOCATION: OHIO
CRASH DATE: MAY, 1998

BACKGROUND

This investigation focused on the fatal injury mechanisms of a 2 month old infant, restrained in a rear facing child safety seat (RFCSS). The child seat was positioned in the right front of a 1997 Ford F150, 3-door pickup, that was involved in an intersection crash with a 1997 Ford Ranger. The Ford F150 was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. The Ford F150 was also equipped with a cut-off switch to disable the front passenger air bag. The cut-off switch was not utilized at the time of the crash. The 1997 Ford Ranger was equipped with a SRS that consisted of a driver air bag, which also deployed as a result of the crash.

The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash on May 27, 1998 and assigned an investigation to the Special Crash Investigations Team at Calspan on the same day. The investigating police department impounded the subject vehicle pending the SCI investigation that began on May 28.

SUMMARY

This two-vehicle crash occurred in the afternoon hours of May, 1998. At the time of the crash, it was daylight and the weather was not a factor. The crash occurred at the urban intersection of a north/south five lane local roadway and an east/west two lane roadway. The north/south roadway was configured for two travel lanes in each direction, with a center left turn lane. The east/west roadway was configured for a single travel lane in each direction, with a center left turn lane. The intersection was controlled by standard (red/amber/green) traffic signals. The speed limit in the area of the crash was 40 km/h (25 mph). **Figure 1** is an overall southeasterly view of the intersection. **Figure 2** is a northbound view of the area of impact.

Figure 1: Overall southeasterly view of the intersection.

Figure 2: Northbound view of the area of impact.

The 1997 Ford F150 was northbound in the curb lane on the approach to the intersection, driven by a 29 year old male. The driver's 26 day old son was restrained in an Evenflo "On My Way" rear facing child seat, positioned in the right front of the F150. The 1997 Ford Ranger was westbound in the curb lane on the approach to the intersection and intended to continue west, straight across the intersection. The traffic light was red for traffic in the north/south direction. The crash occurred when the Ford F150 entered the intersection against the red traffic signal and struck the Ford Ranger.

The driver of the Ford F150 reacted to the Ford Ranger by steering counterclockwise and braking. The area of impact (**Figure 2**) was identified by a 4 m (13 ft) skid mark directed northwestward. The skid mark began at the point of impact. The skid mark was attributed the right front tire of the F150 and defined its post-impact trajectory. Two 1.5 m (5 ft) long gouge marks directed northeastward were also identified at the scene. The gouge marks were attributed to contact from the left front suspension of the Ford Ranger during its post-impact travel.

The right frontal area of the Ford F150 struck the front left side of the Ford Ranger in a 12/9 o'clock impact configuration. The 12 to 1 o'clock direction of the impact force deployed the SRS in the Ford F150. Both the driver and front passenger air bags deployed. The SRS of the F150 had a switch to disable the front passenger air bag, however, the police investigation indicated the switch was in the ON position at the time of the crash. The force of the impact also caused the deployment of the driver air bag in the Ford Ranger.

The Ford F150 sustained 114.3 cm (45.0 in) of direct contact damage to the center and right portions of the front plane (**Figures 3 and 4**). The direct contact began 24.1 cm (9.5 in) left of center and continued to the front right bumper corner. The measured crush profile at the elevation of the front bumper, across the 114.3 cm (45.0 in) field L, was as follows: C1=10.2 cm (4.0 in), C2=19.8 cm (7.8 in), C3=10.2 cm (4.0 in), C4=5.1 cm (2.0 in), C5=3.8 cm (1.5 in), C6=7.6 cm (3.0 in). The right front fender was buckled restricting the operation of the right door. There was no measurable change in the wheelbase dimensions. The Ford sustained disabling damage and was towed to the police impound post-crash. However, the vehicle was still operational, as it was started and driven out of the garage bay at the SCI inspection. The Collision Deformation Classification (CDC) of the vehicle was 12-FZEW-01. The barrier equivalent delta V calculated by the WINSMASH model was 16.1 km/h (10.0 mph)

Figure 3: Front view of the Ford F150.

Figure 4: Right lateral view across the front plane.

The Ford Ranger sustained 127.5 cm (49.5 in) of direct contact damage to the forward portion of the left side plane (**Figure 5**). The direct contact damage began 221 cm (87 in) forward of the left rear axle and continued to the left front bumper corner. The impact was approximately centered on the left front suspension and displaced the tire and rim from the axle. The measured crush profile at the trim elevation was as follows: C1=0, C2=12.7 cm (5.0 in), C3=22.9 cm (9.0 in), C4=20.9 cm (8.2 in), C5=17.5 cm (6.9 in), C6=5.1 cm (2.0 in). The Ranger's entire front structure was displaced laterally (slightly) to the right restricting the operation of the right door. The CDC of the Ranger was 09-LFEW-03.

Figure 5: Left side view of the Ford Ranger.

The force of the initial impact caused the Ranger to rotate clockwise approximately 100 degrees and the vehicles impacted again in a minor sideslap. The left rear corner of the Ranger contacted the right side of the F150 immediately aft of the extended cab. The CDC's of this secondary impact were 03-RZEN-01 and 09-LBEN-02 for the Ford F150 and Ford Ranger, respectively.

After the sideslap, the Ford F150 continued northward and came to rest in the in-board northbound lane approximately 40 m (130 ft) from the point of impact. The Ford Ranger came to rest in the northeast quadrant of the intersection facing northeast, approximately 11 m (35 ft) from the point of impact. The initial impact displaced the left front tire and rim from the Ranger.

The 29 year old unrestrained male driver of the Ford F150 had a police estimated height/weight of 183 cm (72 in) and 82 kg (180 lb). He was not injured in the crash. The 2 month old male infant had a reported height/weight of 63 cm (25 in) and 13 lb (6 kg). He was restrained in the rear facing child safety seat by the seat's integral harness. The RFCSS was restrained by the vehicle's lap and shoulder belt in the right front seated position of the Ford F150. The vehicle's restraint was properly routed through the safety seat according to the labeled instructions. A locking clip was not used. The vehicle's seat track was adjusted 5 cm (2 in) forward of the most rearward position. The size and position of the RFCSS placed it in the deployment path of the front passenger air bag.

Upon impact, the RFCSS initiated a forward trajectory and loaded the 3-point vehicle restraint. The force of the impact caused the deployment of the vehicle's SRS and the front passenger air bag expanded against the back of the RFCSS early in its deployment sequence. The continued expansion of the air bag fractured the upper left aspect of the seat back. The head of the infant passenger was adjacent to the site of the fracture and suffered massive head trauma.

After the crash, the driver exited the vehicle and removed the infant from the safety seat. Upon the arrival of the EMS, he was standing outside the vehicle cradling the child. The infant was transported to the emergency room of a local hospital and was then life-flighted to a level 1 trauma center due to the severity of his injuries. The infant succumbed to the injuries 4 days after the crash. An autopsy was performed.

AIR BAG VEHICLE

The 1997 Ford F150 pickup was identified by the manufacturer's vehicle identification number (VIN): 1FTDX18W9VN (Production sequence deleted). The date of manufacture was July, 1997. The vehicle was configured with an extended cab and third door. It was also equipped with 4-wheel drive. The power train consisted of a 4.6 liter, V8 engine linked to a 4-speed automatic transmission. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags. The SRS also included a cut-off switch that could disable the front passenger air bag. The cut-off switch was mounted in the center aspect of the mid-instrument panel. The vehicle was also equipped with an anti-lock braking system. The odometer read 19,170 km (11,912 miles) at the time of the inspection.

The vehicle's front seating positions were cloth covered, 40/60 split bench seats with separate reclining back rests. The driver's seat was adjusted to the full rear track position. The anti-submarine angle of the seat cushion was 10 degrees and the seat back was reclined 25 degrees.

Upon inspection, the right front seat was found in the full rear track position. The track position of the seat appeared to have been altered from its at crash position. The police indicated the driver was known to have retrieved some personal possessions from the vehicle and in the process may have altered the seat track position. Utilizing photographs taken during the police on-scene investigation, the position of the seat was reconstructed. This process indicated the right front seat was located 5 cm (2 in) forward of the full rear position at the time of the crash. The total travel of the seat track was measured at 15.2 cm (6.0 in). The seat back was reclined 20 degrees at the time of the inspection.

INTERIOR DAMAGE

The interior damage of the Ford F150 was limited to the occupant contacts as a result of the crash and damages associated to the deployment of the air bag system. There was no damage within the occupant compartment associated to the exterior forces of the crash.

The sole contact identified in the driver interior was a scuff to the knee bolster. The contact scuff was located 11.4 cm (4.5 in) right of the steering column centerline and was attributed to an interaction with the driver's right lower leg. The scuffed region measured 6.4 cm x 12.7 cm (2.5 in x 5.0 in), width by height.

A fracture of the right aspect of the windshield was located 16.5 cm (6.5 in) left of the A pillar and 28 cm (11 in) below the header (**Figure 6**). Surrounding the fracture site was an area of air bag fabric transfers that measured approximately 48 cm x 38 cm (19 in x 15 in), width by height. The windshield fracture resulted from the altered deployment path of the front passenger air bag due to the placement of the rear facing child seat in the front right of the vehicle.

Figure 6: View of the windshield fracture and air bag fabric transfers.

INTERIOR DAMAGE (CONT'D)

Figure 7 is a view of 4 specific contacts to the right side interior of the F150. The right hand grip attached to the A-pillar was scuffed and abraded along its outer surface. The right door pull was scuffed on its lower center aspect. A 30 cm x 18 cm (12 in x 7 in) width by height area of vinyl transfers was identified on the right window glazing and the center aspect of the upper window frame was impacted. All these contacts were linked to an interaction with the fractured carrier handle of the child seat. The carrier handle was fractured by the deployment of the air bag.

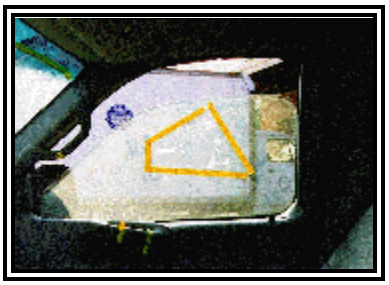

Figure 7: View of the right side interior contacts.

MANUAL RESTRAINT SYSTEM

The Ford F150 was equipped with 3-point lap and shoulder belt systems in the front outboard seated positions. The front center rear position was equipped with a lap belt. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. An inertia activated locking retractor was located in the base of the left B-pillar. The inertia activated locking retractor for the right front restraint was floor mounted near the outboard aft aspect of the right front seat. The upper anchorage (D-ring) for the left front restraint was adjustable. The left front D-ring had 4 adjustment positions over a range of 9.1 cm (3.6 in) and was located 1 notch - 2.3 cm (0.9 in)- above the lowest position. The right front D-ring was attached to a D-ring extender fastened to the right roof rail. Both front restraints were found in the stowed position at inspection. The respective retractors were not locked. No conclusive evidence of restraint usage was found during the examination of the front left restraint webbing and hardware surfaces. The lack of evidence and the driver's forward kinematic pattern indicate he was unrestrained in the crash. Photographs of the child seat taken at the time of the police on-scene investigation indicate the rear facing child seat was restrained. The right front restraint was properly routed through the carrier, however a locking clip was not utilized. A warning label regarding the dangers associated with the placement of the RFCSS in the right front of the vehicle was visible on the lower aspect of the right front restraint webbing.

SUPPLEMENTAL RESTRAINT SYSTEM

The Ford F150 was equipped with a Supplemental Restraint System that consisted of driver and front passenger air bags that deployed as a result of the crash. The SRS utilized a cut-off switch that could disable deployment of the front passenger air bag. The switch was in the ON position at the time of the crash documented by the on-scene police photographs (**Figure 8**). The front passenger air bag is active with the switch in this position and the indicator light is dark. During the course of the SCI inspection, the ignition key was used to place the cut-off switch in the OFF position (**Figure 9**). In this position the front passenger air bag is disabled and the indicator is illuminated. Visual inspection of the illuminated light indicated the switch functioned properly.

Figure 8: View of the air bag cut-off switch in the ON position.

Figure 9: View of the air bag cut-off switch in the OFF position.

The driver air bag module was located in the typical manner in the center hub of the tilt steering wheel. The steering wheel was adjusted to the full down position. There was no steering wheel rim deformation or movement of the steering column's shear capsules. The H-configuration air bag module flaps opened as designed at the designated tear points during the deployment sequence. The height of the upper flap measured 16.5 cm (6.5 in). The width of the upper flap measured 19.3 cm (7.6 in) at the center seam and tapered to 14.0 cm (5.5 in) at the hinge. The date 6/11/97 was stamped on the interior surface of the upper flap. The width of the lower flap measured 19.3 cm (7.6 in) and tapered to 14.0 cm (5.5 in) over its height of 6.4 cm (2.5 in).

The driver air bag measured 61 cm (24 in) in its deflated state. The air bag was tethered by four internal straps sewn to the face of the bag. The air bag was unvented. The following manufacturer's designation was printed on the face of the air bag:

120781R

The back side of the driver's air bag was scuffed in all four quadrants indicative of an impeded deployment due to the forward position of the unrestrained driver. The shape of the scuff marks matched to the configuration of the flaps. A 3.8 cm (1.5 in) diameter burn hole was noted in the 12 o'clock sector on the back side of the bag, **Figure 10**. This hole was caused due to post-crash contact between the hot inflator and the deflating air bag membrane.

Figure 10: View of a hole in the driver air bag 12 o'clock sector.

The front passenger air bag was configured in a mid-mount module on the right side of the instrument panel. The air bag module cover consisted of a single top hinged flap that measured 39.4 cm x 16.5 cm (15.5 in x 6.5 in), width by height. The front passenger air bag (**Figure 11**) was L shaped. The extension of the air bag membrane toward the center of the vehicle would provide protection for a center occupant. The

SUPPLEMENTAL RESTRAINT SYSTEM (CONT'D)

overall dimensions of the face of the deflated bag were 81 cm x 61 cm (32 in x 24 in), width by height. The air bag extended rearward approximately 46 cm (18 in), measured from the lower edge of the cover flap.

Figure 11: View of the front passenger air bag.

Contact evidence of the face of the air bag consisted of a large blue fabric transfer (**Figure 12**). The transfer was attributed to contact with the restraint harness that extended from the back of the child seat. The blue transfer measured approximately 5 cm (2 in) in width and 38 cm (15 in) in length on the face of the air bag. The transfer extended 23 cm (9 in) further onto the outboard surface of the bag and tapered to 10 cm (4 in) in width. On the bottom surface of the bag were 3 holes in the bag fabric (**Figure 13**). The holes measured 8.9 cm x 3.8 cm (3.5 in x 1.5 in), 8.9 cm x 1.3 cm (3.5 in x 0.5 in) and 1.3 cm (0.5 in) in diameter, inboard to outboard respectively. There was also a 8.9 cm x 3.8 cm (3.5 in x 1.5 in) hole on the lower aspect of the outboard side panel. The air bag fabric was holed when it became snagged on the fractured carrier handle and back of the child seat, in the deployment sequence.

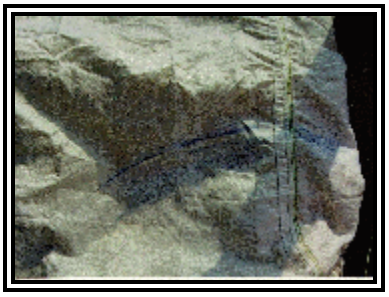

Figure 12: View of blue fabric transfers on the face of the PAB.

Figure 13: View of holes in the bottom surface of the PAB.

REAR FACING CHILD SAFETY SEAT

The Evenflo "On My Way" rear facing infant car seat was identified by a model number of 4921A5P1 (production sequence deleted) and is depicted in **Figure 14**. The seat was manufactured on September 29, 1997. The seat was configured as a rear facing restraint to carry infants from 2.3 - 9.1 kg (5.0 - 20.0 lb) and consisted of the infant carrier and a removable base unit. In this manner, the base unit could remain restrained within the vehicle and the carrier detached for ease of ingress/egress. A U-shaped movable handle was attached to the sides of the carrier. The handle was to be lowered (rotated rearward with respect to the restraint) when used in a vehicle. The handle was lowered at the time of the crash.

The deployment of the front passenger air bag fractured the U-shaped carrier handle (**Figure 14**). The left section of the fractured handle was then displaced into the right side interior evidenced by the aforementioned interior contacts. Gray vinyl transfers on the mid and lower aspects of the carrier handle related to these contacts. A 16.5 cm x 21.6 cm (6.5 in x 8.5 in) area of the upper left aspect

REAR FACING CHILD SAFETY SEAT (CONT'D)

of the car seat's seat back was also fractured in the deployment (**Figure 15**). The location of the seat back fractured corresponded to the location of the child's head injury.

Figure 14: View of the Evenflo rear facing child seat.

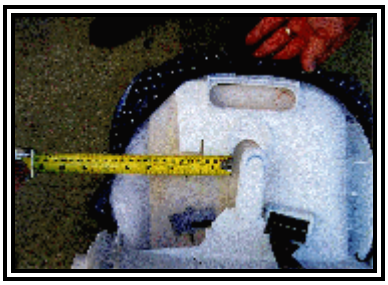

Figure 15: View of the fractured back of the child seat.

During the course of the SCI inspection, the approximate position of the restraint within the vehicle at the time of the crash was reconstructed. The position of the vehicle's seat and the rear facing restraint was determined through the use of the on-scene police photographs. The horizontal distance between the back of the car seat and the lower edge of the front passenger air bag module measured 30 cm (12 in). **Figure 16** is a view of the car seat with the front passenger air bag extended rearward.

Figure 16: View of the reconstructed at-crash position of the child seat.

INFANT PASSENGER INJURIES

Injury	Severity (AIS 90)	Injury Mechanism
20 ml subdural hemorrhage (clotted blood)	Severe (140652.4,9)	RFCSS/deploying passenger air bag
Diffuse subarachnoid hemorrhage superolateral aspect of the left hemispheres and mid posterior aspect of the cerebellum	Serious (140684.3,2) Serious (140466.3,6)	RFCSS/deploying passenger air bag RFCSS/deploying passenger air bag
Diffuse cerebral edema with flattening of the convolutions	Serious (140668.3,9)	RFCSS/deploying passenger air bag

INFANT PASSENGER INJURIES (CONT'D)

Injury	Severity (AIS 90)	Injury Mechanism
Cerebral cortical contusions (small)	Serious (140606.3,9)	RFCSS/deploying passenger air bag
Cerebellar cortical contusions (small)	Serious (140403.3,6)	RFCSS/deploying passenger air bag
Right lung contusion - posterior aspect of the right upper lobe	Serious (441406.3,1)	RFCSS/deploying passenger air bag
Linear antero-posterior fracture left parietal bone extending to the sagittal suture across the coronal suture	Moderate (150402.2,2)	RFCSS/deploying passenger air bag
Multiple scalp contusions: - 8.9 cm (3.5 in) left temporal region - 1.3 cm (0.5 in) left fronto-parietal region - 1.3 cm (0.5 in) occipital region (mid-line)	Minor (190402.1,0)	RFCSS/deploying passenger air bag
5.7 cm (2.3 in) contusion of the right forehead	Minor (290402.1,7)	Inertial contact w/ vehicle seat back
Multiple forehead abrasions 1.6 to 9.5 mm (0.06 to 0.38 in) in size over a 8.9 x 5.1 cm (3.5 x 2.0 in) area	Minor (290202.1,7)	Inertial contact w/ vehicle seat back
Multiple punctate scalp abrasions: - right temporal (x 2) - left temporal (x 5) - parietal (x 3) - occipital (x 1)	Minor (190202.1,0)	RFCSS/deploying passenger air bag

NOTE: These injuries come from a review of the autopsy record.

INFANT KINEMATICS AND INJURY

The 2 month old male infant had a reported height/weight of 63 cm (25 in) and 6 kg (13 lb.) He was lying in the rear facing child safety seat, which was positioned in the right front seated position of the Ford F150. The size and position of the RFCSS placed it in close proximity to the mid-mount front passenger air bag module and in the deployment path of the air bag. The right front seat was positioned 5 cm (2 in) forward of full rear. The police photographs revealed two towels were used under the base of the RFCSS to level the restraint on the vehicle's seat. The vehicle's manual 3-point restraint was properly routed through the base of the RFCSS per the labeled instructions, however, the locking clip supplied with the RFCSS was not in use. The infant was positioned in the RFCSS properly restrained by the RFCSS's restraint harness. A padded head support was also in use and would have supported the infant's head in an upright position.

Upon impact, the RFCSS initiated a forward trajectory and loaded the vehicle's 3-point restraint. The force of the impact deployed the vehicle's SRS. The front passenger air bag deployed and expanded against the carrier handle and back of the RFCSS. The air bag's expansion forced the RFCSS upward and rearward (with respect to the vehicle) and fractured the carrier handle and upper left aspect of the child seat's shell. The continued expansion of the air bag caused the seat to rotate rearward about the vehicle's 3-point restraint. The RFCSS rotated rearward and probably contacted the vehicle's right front seat back. The RFCSS then rebounded back into the seat where it was found.

At impact and deployment of the air bag, the infant's head was positioned adjacent to the location of the RFCSS's fractured shell. The fractured shell and expanding air bag impacted the left posterior aspect of the infant's skull. This impact coupled with the rapid acceleration of the infant's head resulted in skull fracture and massive brain injuries. As the RFCSS rotated rearward, the infant was then displaced rearward with respect to the vehicle and contacted the vehicle's right front seat back. The abrasions and contusions to the forehead and scalp were a result of this kinematic pattern. The child then rebounded back into the RFCSS were he was found.