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CRASH RESEARCH SECTION

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CALSPAN ON-SITE AIR BAG/CHILD FATALITY INVESTIGATION
CALSPAN CASE NO. CA98-024
VEHICLE: 1997 FORD EXPLORER
LOCATION: VIRGINIA
CRASH DATE: APRIL, 1998

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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 are 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 performance of the involved vehicle(s) or their safety systems.

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BACKGROUND

This on-site investigation focused on the injury mechanisms and cause of death of a 3 year old child front right passenger of a 1997 Ford Explorer that was involved in a single vehicle, run-off-road crash. The Ford Explorer was equipped with frontal air bags for the driver and right front passenger positions. The air bag system deployed as a result of a front left impact sequence with a 22.9 cm (9.0") diameter tree **(Figure 1)**. The child passenger was out of position forward, against the mid mount front right passenger air bag module cover at the time of deployment. Cover flap contact and subsequent bag expansion resulted in a fracture/dislocation of C1/C2 with approximately 5.1 cm (2.0") of separation and complete spinal cord transection **(Figure 2)**. In addition, the child passenger sustained a band-like abrasion pattern that extended across the underside of the chin and anterior neck from ear-to-ear. She was transported by ambulance to a local non-trauma hospital where she expired approximately 12 minutes following arrival.

Figure 1. Frontal view of the Ford Explorer.

Figure 2. Interior contacts of the child passenger.

The crash occurred in a rural area of Virginia in April, 1998. The initial notification was forwarded to the NHTSA Special Crash Investigation COTR on Monday, April 13, as a result of media documentation of the crash. The notification was subsequently forwarded to the Calspan SCI team on the morning of the 13th. The on-site investigation was initiated on Tuesday, April 14. The investigation involved the inspection and documentation of the Ford Explorer and the crash scene, interviews with the investigating police officer, father of the child passenger, funeral home cosmetologist and embalmer, and the acquisition of the child's medical records. There was no autopsy performed on the body.

SUMMARY

Crash Site

The crash occurred on a private roadway of an estate/equestrian center in Virginia **(Figure 3)**. The stone road surface was 4.4 m (14'6") in width and was bordered by grassy shoulders with negative embankments and shallow drainage ditches located outboard of the shoulders. Large diameter trees (hardwoods) were scattered in the lawn area that extended along both sides of the roadway. The private roadway allowed for traffic flow in both the north and southbound directions of travel, however, it was basically designed as a one-lane access road to the facility. In the vicinity of the crash site, the roadway curved slightly to the right and had a negative grade of approximately 2 percent. At the time of the crash, the conditions were daylight, clear, and dry. There was no posted speed limit on the property.

Figure 3. Trajectory of the Ford Explorer.

Pre-Crash

The driver of the Ford Explorer was exiting the facility and was traveling in a southerly direction on the stone roadway. He was descending a long negative grade and crested a shallow hillcrest that was located approximately 107 m (350') north of the impending crash site. The assumed speed limit in the area was 24 km/h (15 mph), therefore the driver was probably traveling within this limit. As he approached the exit to the facility, the driver suffered an apparent stroke. He probably applied a rapid braking force and inadvertently steered the vehicle to the left which displaced the unrestrained child in a forward direction and redirected the vehicle to the left, resulting in an aggressive departure of the left roadside. There was no evidence at the crash scene to support the assumed inadvertent actions of the driver. These actions were, however, assumed to have occurred based on the impact angle of the vehicle and the impact of the child against the windshield prior to air bag deployment.

Crash

The left headlamp area of the Ford Explorer impacted a 22.9 cm (9.0") diameter tree that was located at the base of the negative embankment, 3 m (10.0') outboard of the left edge of the stone roadway **(Figure 4)**. Initial contact involved the front bumper of the vehicle, however, as the bumper crushed, the grille and hood areas engaged against the tree. The resultant direction of force was within the 12 o'clock sector which produced a maximum crush value of 40.6 cm (16.0") located at the front left bumper corner. The total velocity change was computed at 19.8 km/h (12.3 mph) by the WinSMASH program **(Figure 5)**. As a result of the tree impact, the Ford Explorer's frontal air bag system deployed.

Figure 4. Struck tree and its relationship to the private roadway.

Post-Crash

The Ford Explorer came to rest engaged against the struck tree. Due to the slope of the embankment, the left front corner of the vehicle was pitched downward against the tree as the rear of the vehicle straddled the top of the embankment.

Figure 5. Frontal damage to the Ford Explorer.

The first responders to the crash site included a landscaper who was working adjacent to the site and other motorists exiting the facility. They initially approached the vehicle at rest and observed the driver slumped over the deflated air bag. One of these responders opened the rear tailgate to provide support to the driver. As he opened the tailgate, he observed the child's head and feet protruding from under plastic material that was stored in the cargo area of the vehicle. The child was displaced from the front seated position into the rear area of the Explorer by the expanding front right passenger air bag. Emergency personnel responded to the crash scene and found the child pulseless. She was transported by ambulance to a local hospital where she was pronounced deceased 12 minutes following her arrival.

VEHICLE DATA

The involved vehicle was a 1997 Ford Explorer XLT, 4-door, sport utility vehicle. The Explorer was manufactured on 01/97 and was identified by vehicle identification number (VIN)1FMDU34E0VZ (production number deleted). The vehicle was equipped with 4-wheel disc brakes with anti-lock (ABS) and a *Control Trac* 4-wheel drive system. The power train consisted of a 4.0 liter V-6 engine and a 4-speed automatic overdrive transmission with a column mounted transmission selector lever. The Explorer's gross vehicle weight rating (GVWR) was 2,422 kg (5,340 lb). At the time of the inspection, the Explorer's odometer read 25,408 km (15,788 miles). Safety equipment included 3-point lap and shoulder belts in the four outboard seated positions and a Supplemental Restraint System (SRS) that included frontal air bags for the driver and right front passenger positions. The SRS deployed as a result of the Explorer's frontal impact sequence with the struck tree.

In addition to the standard equipment, the Ford Explorer was equipped with 5-spoke alloy wheels with Goodyear Wrangler P235/75R15 mud and snow rated tires, a tempered glass sunroof, keyless entry system, a roof rack, power windows, power door locks, power front bucket seats with a center console, split back/fold-down rear seat back (60/40 wide right).

VEHICLE DAMAGE

Exterior:

The Ford Explorer sustained moderate damage to the front left area from its run-off-road impact sequence with the 22.9 cm (9.0") diameter tree. Maximum crush was cm 40.6 cm (16.0") located at the left front bumper corner **(Figure 6)**. The direct contact damage on the bumper fascia began 55.9 cm (22.0") left

of the vehicle's centerline and extended 24.1 cm (9.5") to the left corner. The damage on the hood face began cm 20.0 cm (7.9") left of center and extended 22.2 cm (8.75") to the right. The narrow impact deformed the full length of the bumper which resulted in a combined direct and induced damage length (Field L) of 138.4 cm (54.5"). The primary damage, however, was focused outboard of the left frame rail. The damage profile at bumper level was as follows: C1 = 40.6 cm (16.0"), C2 = 12.1 cm (4.75"), C3 = 7.4 cm (2.9"), C4 = 3.8 cm (1.5"), C5 = 1.9 cm (0.75), C6 = 0 cm . The Collision Deformation Classification (CDC) was 12-FYEN-2.

Figure 6. Maximum crush at front left bumper corner.

The frontal impact deformed the left front bumper corner rearward into the inboard sidewall area of the left front tire. The tire was aired out, however, there was no visible damage to the sidewall area. The left wheelbase was reduced in length by 1.5 cm (0.6"). Both front fenders were displaced rearward against the leading edge of the front doors. All four doors remained operational, however, the front doors were bound against the fenders.

The windshield was cracked due to right front occupant contact. There was no additional damage to the windshield, side glazing, backlight, or sunroof. Damaged components included the front bumper and rub strip, grille, left headlamp and turn signal assembly, hood, valance, both front fenders, left front tire, and the frontal substructure.

Interior:

The interior of the Ford Explorer sustained minor damage that was associated with air bag deployment and occupant contact. The frontal air bag system deployed as designed from the respective module assemblies. There was no intrusion of the passenger compartment.

The 77 year old driver of the Ford Explorer was not restrained by the manual 3-point lap and shoulder belt system. At impact, he was probably slumped in a forward direction with his face within the deployment path of the front left air bag. His contact with the air bag resulted in facial lacerations which resulted in blood loss onto the deployed air bag and the left door as the vehicle came to rest. A tissue/scuff mark was present of the steering wheel rim at the 10 o'clock sector.

The child passenger was positioned in the right front of the vehicle was not restrained in a child safety seat and/or by the vehicle's manual 3-point lap and shoulder belt system. She contacted and fractured the laminated windshield during her initial trajectory. The star-like contact point was located 34.9 cm (13.75") right of center and 17.1 cm (6.75") above the upper instrument panel. Several strands of blond hair were embedded into the glass at the fracture site. The child was subsequently contacted by the front right air bag module cover flap as the SRS deployed. A large area of tissue was noted to the left side of the mid mount cover flap. Several additional areas of contact (i.e., scuff marks) were noted to the flap. These are further discussed in the Automatic Restraint section of this summary report.

As the air bag membrane expanded, the child was accelerated in a rearward direction between the front bucket seat backs. A 5.7 cm (2.25") scuff mark was noted to the top surface of the center console. Abrasive type marks were noted to both integral head restraints of the front seat back supports. Similar type abrasions were noted to the headliner at the rear edge of the sun roof. The left side mark was located 6.4-11.4 cm (2.5-4.5") left of center and the right side abrasion was located 6.4-12.7 cm (2.5-5.0") right of the vehicle's centerline. Both abrasions extended 5.1 cm (2.0") rearward of the sunroof opening.

MANUAL RESTRAINT SYSTEM

The Explorer was equipped with a continuous loop 3-point lap and shoulder belt system in the front outboard seated positions. A sliding latchplate was mounted on the belt webbing. Both belt systems were fully retracted against the respective B-pillars and were not in use at the time of the crash. The upper anchorages (D-rings) were adjustable and were positioned as follows:

- Left front - mid adjustment point with 8.3 cm (3.25") of vertical adjustment.
- Right front - adjusted 1.9 cm (0.75") below the full up position, 6.4 cm (2.5") above the full down position.

Both belt systems retracted onto dual mode locking retractors that were mounted to the lower B-pillars. The male tabs of the latchplates were abraded from routine usage throughout the life of the vehicle.

AUTOMATIC RESTRAINT SYSTEM

The 1997 Ford Explorer was equipped with a Supplemental Restraint System (SRS) that consisted of frontal air bags for the driver and right front passenger positions. The SRS deployed as a result of the left frontal impact sequence with the tree. The system was configured with a steering wheel mounted driver air bag module and a mid right instrument panel mounted passenger air bag.

The driver air bag deployed from a H-configuration module assembly that was concealed within the four-spoke steering wheel rim. The upper module cover flap was 8.3 cm (3.25") in height and 17.8 cm (7.0") in width across the horizontal tear seam. The lower flap was approximately 4.4 cm (1.75") in height with the same horizontal width of 17.8 cm (7.0"). The cover flaps opened at the designated tear seams and there was no damage or contact evidence to the flaps. The cruise control buttons were positioned vertically between the steering wheel spokes, adjacent to the cover flaps. The right side controls separated from the wheel as a result of the deployment sequence.

The driver air bag was constructed of two different fabric panels that were sewn peripherally with an internal seam. The forward panel (panel adjacent to the steering wheel) consisted of a close weave nylon fabric while the panel exposed to the driver was a coarser weave fabric. The diameter of the bag in its deflated state was 58.4 cm (23.0"). The bag was vented by two 1.3 cm (0.5") diameter vent ports that were located at the 11 and 1 o'clock positions. Internally, the driver side bag was tethered by two internal tether straps that were located at the 12 and 6 o'clock positions. A 17.1 cm (6.75") diameter tether reinforcement was sewn to the center face of the bag.

Although no direct driver contact evidence was visible on the bag, a blood stain was noted to the upper right quadrant of the bag. This stain resulted post-crash as the driver slumped over the deployed bag. Several black vinyl transfers were noted to the forward panel of the bag which resulted from bag expansion against the inside surface of the module assembly.

The front right passenger air bag was concealed within the right instrument panel in a mid mount configuration. The module assembly consisted of a single cover flap design that opened at the lower and side surfaces, while remaining hinged at the top edge. The cover flap was rectangular in shape with a vertical height of 17.1 cm (6.75") and a horizontal width of 37.1 cm (14.6"). The child passenger was out-of-position in a forward direction and was in a close proximity to the cover flap as it opened in an upward direction, contacting the underside of the child's chin. A large tissue transfer was noted to the left side of the cover flap, located 7.6-12.7 cm (3.0-5.0") left of the centerline of the flap and 1.9-8.3 cm (0.75-3.25") above the lower (leading) edge. A pinkish fabric transfer was located on the leading edge of the flap. The transfer began 12.7 cm (5.0") left of the flap's centerline and extended 14.6 cm (5.75") to the right. At a point 2.5 cm (1.0") left of center, the fabric transfer extended 1.9 cm (0.75") onto the face of the flap.

Directly above the pink fabric transfer, a whitish scuff mark extended 0-5.3 cm (0-2.1") left of center and 5.1-12.7 cm (2.0-5.0") above the leading edge of the flap. The whitish transfer probably resulted from contact with the collar area of the child passenger's shirt. On the right side of the mid mount module cover flap, a dark stain was noted, located 11.4-14.2 cm (4.5-5.6") right of the centerline of the flap and 7.0-9.5 cm (2.75-3.75") above the leading edge. The stain was similar to a windshield transfer that possibly resulted from nasal expulsion.

The membrane of the front right air bag deployed as designed with no evidence of defects or damage. The top panel of the bag was 36.8 cm (14.5") in width at the inflator and extended outward approximately 43.2 cm (17.0") to a overall width of 81.3 cm (32.0"). The vertical face of the bag maintained the width of 81.3 cm (32.0") with a height of 58.4 cm (23.0"). The bag was vented by two 4.8 cm (1.9") diameter vent ports located on the side panels at the 3 and 9 o'clock positions. The right (outboard) vent port was centered 21.6 cm (8.5") outboard of the mid panel while the inboard port was positioned 17.8 cm (7.0") rearward of the referenced panel. The bag was not tethered by internal tether straps.

There was no direct contact evidence (i.e., tissue transfers) on the air bag membrane from bag expansion against the facial region of the child passenger. A horizontally oriented area of black vinyl transfers were noted to the upper third area of the bag face. The transfers were located 20.3-26.0 cm (8.0-10.25") below the top horizontal line of the bag face and extended 2.5 cm (1.0") left of center to 19.7 cm (7.75") right of the vertical centerline of the bag. A second area of vertically oriented black vinyl transfers were noted to the left side of the top panel. These abrasions were faint in color and extended approximately 17.8-38.1 cm (7.0-15.0") outboard of the inflator. The transfers extended laterally 22.9-38.1 cm (9.0-15.0") left of center. A heavy line of vinyl transfer was noted to the top panel 17.1-19.1 cm (6.75-7.5") left of center and 1.3-6.4 cm (0.5-2.5") forward of the top seam.

HUMAN DEMOGRAPHICS/OCCUPANT DATA

Driver:	77 year old male
Height:	165.1 cm (65.0")
Weight:	56.7 kg (125 lb)
Seat Track Position:	Mid track position
Manual Restraint Usage:	None, 3-point lap and shoulder belt was available
Usage Source:	Vehicle inspection, first responders to crash scene
Eyeware:	Prescription eyeglasses
Vehicle Familiarity:	Principal driver of vehicle
Route Familiarity:	Long term frequent visitor to area
Mode of Transport From Scene:	Ambulance to a local hospital
Medical Treatment:	Admitted to the local hospital for three days for monitoring and observation

Driver Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanism
Upper lip laceration	Minor (290600.1,8)	Deploying front left air bag
Left scalp laceration	Minor (190600.1,2)	Displaced eyeware from air bag expansion (probable)

Driver Kinematics

The driver of the 1997 Ford Explorer was in a presumed upright driving posture as he was traveling on the private roadway within the equestrian center. He was wearing a tweed hat and prescription eyeglasses in addition to his unspecified clothing. The driver was not wearing the manual 3-point lap and shoulder belt system. The lack of belt usage was confirmed by the first responders to the crash scene and the lack of blood on the webbing. The power seat was found adjusted to a rear track position, 15.9 cm (6.25") forward of the full rear position, or 7.6 cm (3.0") forward of the full forward position. The seat back was set to a near vertical position.

On his approach to the impending crash site, the driver suffered a mild stroke which resulted in a probable black out as he relinquished control of the vehicle. Although not supported by physical evidence, he probably slumped in a forward direction and inadvertently steered the vehicle in a counterclockwise direction which resulted in a departure of the left side of the private roadway.

At impact, the SRS deployed. The driver's facial area was contacted by the membrane of the deploying front left air bag. The air bag contact probably displaced the eyeglasses from the driver's face which resulted in a laceration of the left temporal scalp area. (Family members were unaware of the

status/condition of the eyeglasses at the time of the interview.) The expanding air bag also contacted his upper lip which lacerated (split) the lip resulting in significant blood loss **(Figure 7)**. A large tissue transfer was noted to the steering wheel rim at the 10 o'clock sector. This transfer probably resulted from the driver's left hand as the hand loaded the wheel at impact. Subsequent bag expansion against the left forearm probably displaced his hand from the wheel. There was no reported injury to the hand or forearm areas.

Figure 7. Deployed front left air bag.

The driver came to rest in a semi-conscious state in an upright attitude, slumped against the deployed air bag. Final rest was verified by the blood transfers on the air bag and the left front door glazing and panel. He was removed from the vehicle through the left front door and transported by ambulance to a local hospital where he was admitted for treatment and observation.

Child Passenger Data

Age/Sex:	3 year old female
Vehicle Position:	Right front
Posture:	Probably kneeling on the right front seat cushion
Height:	106.7 cm (42.0")
Weight:	20.4 kg (45.0 lb), estimated
Manual Restraint Usage:	None, child should have been restrained in a child safety seat in the rear seat area of the Ford Explorer.
Usage Source:	Vehicle inspection (occupant contact points), final rest position of child
Mode of Transport From Scene:	Ambulance to a local hospital, no vital signs at scene
Type of Medical Treatment:	CPR, intubated, expired 12 minutes following arrival

Child Passenger Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanism
Source: Hospital records C1/C2 fracture through the odontoid with complete anterior dislocation and spinal cord transection	Maximum (640276.6,6)	Front right air bag module cover flap and expanding air bag membrane

Injury	Injury Severity (AIS 90)	Injury Mechanism
*Chin strap-like narrow abrasion that extended from ear-to-ear onto the right cheek and left earlobe	Minor (290202.1,8, 290202.1,1, 290202.1,2)	Expanding air bag membrane
*Abrasions of the dorsal aspect of the left hand	Minor (790202.1,2)	Rearward trajectory into cargo area of vehicle
*Abrasion of the dorsal aspect of the mid right forearm	Minor (790202.1,1)	Rearward trajectory into cargo area of vehicle

**Source: Funeral embalmer and cosmetologist*

Child Passenger Kinematics

The 3 year old child occupant was positioned on the right front seat of the Ford Explorer. The driver could not recall the exact position of the child, however, the child's father suspected that she was in a kneeling position on the seat cushion to see over the instrument panel and door panel of the vehicle. The right front seat track was adjusted to a rear track position. At the time of vehicle inspection, the seat track was positioned 5.1 cm (2.0") forward of the full rearward position with the seat back set to a near vertical position. The father stated that the child had been raised to ride in a child safety seat, however, he noted that over the last six months, he has not enforced the safety seat issue since the child was very active and large [exceeded 18 kg (40 lb)] for her age.

The child was not wearing the manual 3-point lap and shoulder belt system at the time of the crash. The lack of belt usage was determined from contact points inside the vehicle and the post-deployment trajectory of the child occupant to rest within the Explorer. The belt system was stowed against the right B-pillar with the D-ring adjusted to the upper position. The child was dressed in a white Mermaid T-shirt with a pink design stenciled on the front of the shirt and floral pink pants.

The presumed kneeling position of the child passenger would have placed the child passenger in a forward position on the front seat cushion and raised her center of gravity. In addition, the kneeling position would have made her unstable on the seat of the vehicle. It was unknown if the driver of the vehicle applied a braking force at the on-set of the stroke which would have initiated a forward trajectory to the child. As the vehicle departed the left side of the private roadway and traversed the negative embankment at an estimated velocity of 24 km/h (15 mph), there was no evidence of undercarriage contact which would have displaced the child on a forward trajectory.

The interior contact evidence supported a forward trajectory of the child passenger prior to air bag deployment. This evidence included the windshield impact and the tissue/cloth transfers on the front right air bag module cover flap. The forward trajectory, therefore resulted from a possible braking input by the

driver of the vehicle prior to impact, or the SRS deployed late in the crash sequence due to the narrow impact occurring outboard of the frame rail.

The child passenger initially moved on a forward trajectory and impacted the laminated windshield with her frontal/superior scalp area. The contact fractured the glazing in a star-like pattern located 34.9 cm (13.75") right of the vehicle's centerline and 17.1 cm (6.75") above the top of the instrument panel **(Figure 8)**. This contact was located directly forward of the front right passenger air bag module cover flap. Several strands of fine blond hair, approximately 2.5 cm (1.0") in length, were embedded into the glazing at the fracture site. In addition, two small fragments (possible tissue) were embedded into the glazing at the location of the contact. A long single hair strand was embedded into a glazing crack 49.5 cm (19.5") right of center and 12.1 cm (4.75") above the instrument panel. There was no supporting contact evidence surrounding this hair stand. There was no reported injury from this head contact point.

Figure 8. Child passenger head impact to windshield.

As the child passenger rebounded rearward from the head impact to the windshield, the SRS deployed. At the time of deployment, the child passenger's head was positioned over the top of the mid mount front right air bag module cover flap with her chest within a close proximity to the cover flap. The top hinged cover flap was 37.1 cm (14.6") in width and 17.3 cm (6.8") in height. As the flap opened in an upward direction, the leading edge contacted the chest area of the child passenger which resulted in a pinkish fabric transfer to the leading edge. The transfer began 12.7 cm (5.0") left of the centerline of the flap and extended 1.9 cm (0.75") right of center. The transfer extended 2.5 cm (1.0") upward onto the face of the flap at a point that was located 2.5 cm (1.0") left of the centerline. The clothing was not available for inspection and there was no reported injury to the child's chest from the contact with the leading edge of the flap.

The continued upward rotation of the cover flap resulted in contact of the face of the flap against the underside of the child's chin which rotated the head in an upward and rearward (hyperextension) direction. The contact was evidenced by a large circular tissue transfer that was located 7.6-12.7 cm (3.0-5.0") left of the centerline of the flap and 1.9-8.3 cm (0.75-3.25") above the leading edge **(Figure 9).** Adjacent to the tissue transfer was a whitish scuff that extended 0-5.3 cm (0-2.1") left of center and 5.1-12.7 cm (2.0-5.0") above the leading edge. This scuff mark possibly resulted from the collar area of the child's shirt following the contact with her thoracic area. A third area of possible contact was noted to the upper right quadrant of the cover flap. A dark stain was located 11.4-14.2 cm (4.5-5.6") right of the centerline and 7.0-9.5 cm (2.75-3.75") above the leading edge of the flap. This stain appeared to be a mucous transfer, possibly a nasal expulsion. A similar

Figure 9. Contact evidence on the mid mount cover flap.

transfer was noted on the windshield at the upper right quadrant. The transfer was located 43.2-50.2 cm (17.0-19.75") right of center and 33.0-38.1 cm (13.0-15.0") above the top of the instrument panel.

The cover flap contact hyperextended the head which allowed the air bag membrane to contact the underside of the chin and anterior neck as the bag began to deploy from the module assembly. As a result of the contacts, the child passenger sustained a chin strap-like abrasion pattern that extended across the lower face from ear-to-ear. The cosmetologist at the funeral home noted that the abrasion pattern extended onto the right cheek at the level of the zygomatic arch and onto the right earlobe. The hyperextension resulted in a fracture/dislocation of C1/C2 with a fracture through the odontoid and complete spinal cord transection. Several sources which included the investigating officer and the father of the child, noted that the cervical separation was approximately 5 cm (2") in length.

The continued expansion of the non-tethered front right air bag accelerated the child's rearward motion which was initiated by her rebound from the laminated windshield contact sequence. The child was displaced between the front seat back supports **(Figure 10)**, into the rear cargo area of the vehicle where she came to rest. The rear seat back was folded down onto the seat cushion which allowed the child to continue rearward with her head coming to rest against the tailgate of the Ford Explorer and her feet adjacent to the left C-pillar. At rest the child was covered with plastic sheet which was lying in the cargo area of the truck **(Figure 11)**.

The trajectory of the child was evidenced by contact points on the center console, both integral head restraints, and the headliner at the trailing edge of the sunroof. In addition to the cervical injuries, the child sustained abrasions of the dorsal aspect of the right forearm and of the dorsal left hand. Both injuries possibly resulted form the rebound trajectory into the rear of the vehicle.

Figure 10. Trajectory of child passenger between seat backs.

Figure 11. Final rest position of the child passenger.

Medical Treatment

The child occupant was not initially identified in the vehicle by the first responders to the crash scene. These responders consisted of a landscape laborer who was working opposite of the crash site, and additional motorists who were exiting the equestrian facility. These responders initially attended to the

driver of the vehicle through the left front door. They subsequently opened the rear tailgate of the Explorer to enter the vehicle and attend to the driver within the vehicle. At this point, one of the responders noted the child's feet protruding from under the plastic sheets that were in the rear of the vehicle. As they removed the plastic, they found the child lying on her back in a pulseless state.

The responding medical personnel initiated CPR and immediately transported the child from the scene to the emergency room of a local hospital. The attending physician noted the child was apneic and pulseless on arrival. Aggressive resuscitation was initiated. She was intubated, an IV was administered, however, she remained unresponsive to all attempts and expired 12 minutes following her arrival at the medical facility.

The attending physician ordered a cervical x-ray which identified severe anterior dislocation and listhesis of C1 upon C2, with evidence of fracture through the odontoid. As previously noted, the physician identified a separation of approximately 5 cm (2") of the cervical spine with complete cord transection. The family subsequently declined an autopsy.