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CALSPAN ON-SITE AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. CA98-19

VEHICLE #1 - 1996 ACURA TL 2.5
VEHICLE #2 - 1979 FORD ECONOLINE E-150 CARGO VAN

LOCATION - STATE OF FLORIDA

CRASH DATE - MARCH, 1998

Contract No. DTNH22-94-D-07058

Prepared for:

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National Highway Traffic Safety Administration
Washington, D.C. 20590

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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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On-site investigation of a dual air bag deployment crash that resulted in critical injuries to the right front occupant.

16. *Abstract*

An on-site investigation was conducted into a two vehicle crash involving the frontal plane of an air bag equipped 1996 Acura TL 2.5 four door sedan (Vehicle #1), and the frontal plane of a 1979 Ford Econoline 150 cargo van (Vehicle #2). The crash occurred in the month of March, 1998 during the morning hours in the State of Florida. The ambient condition at the time of the crash was sunny with no adverse weather conditions. Vehicle #1 was traveling east on a two lane, undivided, negative 1 degree, left curve, dry, asphalt roadway when the driver of Vehicle #2 who was traveling southbound on an intersecting roadway made a wide right turn and entered Vehicle #1's travel lane. Vehicle #2 struck Vehicle #1 in a head-on impact configuration at a SMASH computed impact speed of 27 km/h (17 mph). This impact resulted in the deployment sequence of Vehicle #1's dual front air bag system.

The seven year old female right front occupant in Vehicle #1 who weighed 19 kg (42 lbs.) was restrained by the lap portion of the three point lap and shoulder belt. The girl's upper torso moved forward during pre-impact braking and was in close proximity to the passenger side air bag module cover at the time of deployment. The expanding air bag contacted the child's face, neck, and chest which resulted in multiple soft tissue lesions (AIS-1), complete cord injury at C1/C2 (AIS-6), closed head injury (AIS-4), subarachnoid hemorrhage (AIS-3), intraventricular hemorrhage (AIS-4), and left pulmonary contusion with pneumothorax (AIS-3). The air bag lifted her upward and rearward. She came to rest in the right front seat slumped forward. She was transported via helicopter from the scene to a trauma hospital. She remained at that hospital five days before being transferred to another trauma facility for further treatment and rehabilitation.

Driver #1, a 34 year old female, who was using the lap and shoulder belt was not injured. Driver #1 was transporting her 7 year old daughter to the neighborhood school at the time of the crash. Driver #1's four year old daughter seated in the left rear seat was restrained in a child safety seat. She was not injured.

Driver #2, a 16 year old male, indicated to police that his vehicle did not respond to braking efforts prior to the crash. Inspection of the brake system indicated that the vehicle had defective brakes. During the right turn, he told police that he attempted to steer straight in order to avoid rolling over. He indicated that he was not aware of Vehicle #1 until just prior to the impact. The driver complained of a wrist injury.

17. *Key Words* Passenger side air bag deployment Delta V 24 km\h (15 mph) Seven year old female right front seat occupant AIS-6 (Maximum) Defective brakes, Vehicle #2		18. *Distribution Statement* General Public	
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CALSPAN AIR BAG DEPLOYMENT INVESTIGATION

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VEHICLE #2 - 1979 FORD ECONOLINE E-150 CARGO VAN

STATE OF FLORIDA

MARCH, 1998

BACKGROUND

The Field Operations Branch (FOB), Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) was notified by SCI Team #3 of a two vehicle crash where a child in the right front seat reportedly suffered injuries from a deploying front right air bag. The Calspan Team was directed by the FOB to conduct an on-site investigation which began the same day of notification.

SUMMARY

This crash which involved a 1996 Acura TL 2.5 (Vehicle #1) equipped with dual front air bags and a 1979 Ford Econoline E-150 cargo van (Vehicle #2) occurred during the mid morning hours in the month of March, 1998. The 16 year old male driver of Vehicle #2 was reportedly en route to a construction site when his vehicle struck the front of Vehicle #1 in a head-on impact configuration.

Figure 1- Approach of Vehicle #2, 30 m prior POI

Figure 2- Approach of Vehicle #2, 15 m prior POI

Prior to the crash, Vehicle #2 was traveling southbound on a two lane, undivided, level, dry asphalt, local roadway which curved to the left prior to a 3-leg intersection **(refer to Figure 1)**. The posted speed limit was 48 km/h (30 mph). As Driver #2 entered the intersection, he abruptly initiated a right turning maneuver which resulted in a wide turn and positioned his vehicle in the opposing (eastbound) travel lane on the intersecting roadway **(refer to Figure 2)**. Driver #2 indicated that the brakes were not working and the steering felt loose. Driver #2 indicated to police that he was concerned that his vehicle would rollover and attempted to steer in a straight direction just prior to the crash.

Driver #1 had departed her residence and was transporting her seven year old daughter to a nearby neighborhood school. The child was wearing a book bag back pack which was empty at the time of the vehicle inspection. She was also carrying a lunch bag. Her seat was adjusted in a forward position on the seat track. The driver's 4 year old daughter was seated in a child safety seat located in the left rear seat.

Figure 3- Approach of Vehicle #1 prior to the POI

As Driver #1 proceeded eastbound **(refer to Figure #3)**, she observed the approach of Vehicle #2 in her travel lane and applied the brakes in an attempted avoidance maneuver. The crash occurred approximately 21 m (70') south of the intersection.

The head-on collision between these vehicles resulted in Collision Deformation Classification (CDC) codes of 12-FDEW-2 for Vehicle #1 and 12-FDEW-1 for Vehicle #2. The damage algorithm of the SMASH speed reconstruction program indicated Vehicle #1 sustained a delta V of 24 km/h (15 mph) which was sufficient to actuate the Supplemental Restraint System (SRS) while Vehicle #2 sustained a delta V of 19 km/h (12 mph). The trajectory algorithm of SMASH computed the impact speed at 17 km/h (10 mph) for Vehicle #1 and 27 km/h (17 mph) for Vehicle #2. Vehicle #1 was pushed rearward 1.8 m (5.9')to its final rest position (FRP) in the northbound travel lane. Vehicle #2 came to its FRP locked by damage to the front of Vehicle #1.

The seven year old 19 kg (42 lbs.) female right front occupant in Vehicle #1 was restrained by the lap portion of the three point manual lap and shoulder belt. The girl's upper torso moved forward during pre-impact braking and was in close proximity to the passenger side air bag module cover at the time of deployment. The expanding air bag contacted the child's face, neck, and chest which resulted in multiple soft tissue lesions (AIS-1), complete cord injury at C1/C2 (AIS-6), closed head injury (AIS-4), subarachnoid hemorrhage (AIS-3), intraventricular hemorrhage (AIS-4), and left pulmonary contusion with pneumothorax (AIS-3). The air bag lifted her upward and propelled her rearward where she contacted the seat back support. She rebounded forward where she came to rest slumped forward in the right front seat.

A witness to the crash arrived at Vehicle #1 as the driver was removing her daughter from the vehicle. The witness determined that the child was not breathing and according to the police report proceeded to perform CPR. The witness was joined shortly after by a police officer and a nurse who happened to be in area. They also concluded that she had experienced cardiac and respiratory arrest and continued with CPR until the arrival of the local rescue squad.

The local rescue squad responded and requested a life flight helicopter which arrived 27 minutes after the police reported time of the crash. It remained at the scene for 6 minutes before departing for the local trauma hospital. It arrived 7 minutes later with the child who was unconscious upon arrival at the emergency room.

An ICP monitor was placed after arrival in the emergency room. She remained at this hospital five days before being transferred via life flight to another trauma facility for further treatment and rehabilitation. Ancillary to this treatment was the sudden demise of her treating neurosurgeon.

Driver #1 was wearing her restraint belt and was not injured in the crash. The left rear occupant (4 year old child) in Vehicle #1 reportedly was not injured in the crash. Driver #2 exited his vehicle and approached Vehicle #1. According to the police report, he observed that the seven year old right front passenger was using the restraint belt. The driver of Vehicle #2 sustained a minor injury to his wrist.

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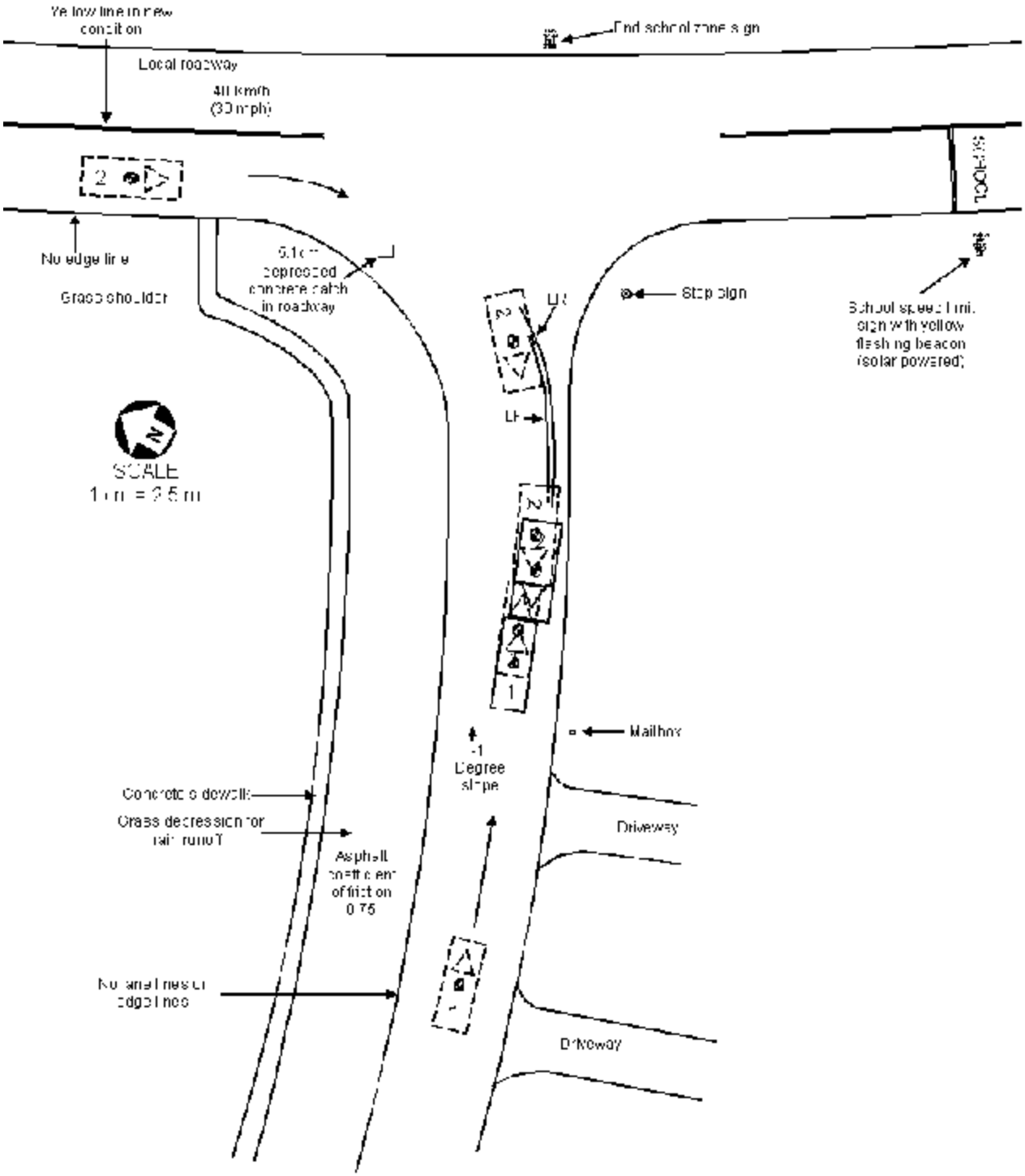
Scene Schematic



VEHICLE DATA

***Exterior - 1996 Acura TL 2.5 (Vehicle #1)*:**

The 1996 Acura TL 2.5 was equipped with a dual front Supplemental Restraint System (SRS) which deployed as the result of the impact with Vehicle #2. The vehicle was equipped with a four wheel disc ABS braking system. Exterior damage to the vehicle involved the front bumper, the grille, the hood, both front fenders, and radiator **(refer to Figure 5)**. The maximum crush of 29.2 cm (11.5") was located 54.6 cm (21.5") right of the left bumper corner. A square type deformation pattern located 27.9 cm (11.0") left of the Acura's centerline was attributed to contact with Vehicle #2's right frame rail end. The frontal crush profile is listed in the following table:

Figure 5- Left front corner view of the 1996 Acura TL 2.5

Frontal Crush Profile	$C_1 = 0$	$C_2 = 8.6$ cm (3.4")	$C_3 = 20.7$ (8.2")
	$C_4 = 10.9$ cm (4.3")	$C_5 = 2.3$ cm (0.9")	$C_6 = 4.8$ cm (1.9")

CDC: 12-FDEW-2

Interior - 1996 Acura TL 2.5 (Vehicle #1):

Interior vehicle damage to the 1996 Acura TL 2.5 was attributed to occupant contacts and the deployment of the Supplemental Restraint System (SRS). The driver side rigid plastic knee bolster exhibited a light color transfer and was cracked adjacent to the right side of the steering column. These artifacts were located 29.2 cm (11.5") left of the vehicle centerline and were attributed to contact by the driver's right knee during the crash. Another light color transfer mark noted on the driver side knee bolster was attributed to contact by the driver's left knee. It was located left of the steering column or 61.0 cm (24.0") left of the vehicle centerline.

The lower surface of the windshield wiper control arm exhibited a scuff mark which was attributed to contact by the driver's right hand. There was a transfer mark on the windshield directly in front of the steering wheel which was the result of contact by the front left air bag during the deployment cycle. There was no visible driver contact evidence on the air bag module cover or air bag. The right shear capsule had a measured displacement value of 3.2 mm (0.125") with no displacement noted at the left shear capsule.

Figure 6- Lateral view of the right front seat in the 1996 Acura

The driver seat was adjusted in a forward position at the time of the crash. This was consistent with the driver's reported height of 160.0 cm (63.0"). It was positioned 5.1 cm (2.0") rearward from full forward over a seat track adjustment range of 18.7 cm (7.4"). The adjustable seat back support was reclined 28

degrees rearward from vertical. The seat cushion had a designed incline which measured 22 degrees.

The right front seat was adjusted 2.2 cm (0.875") rear of the full forward position **(refer to Figure 6)**. This placed the leading edge of the seat cushion 6.0 cm (2.375") rearward from the vertical surface of the instrument panel and 27.3 cm (10.75") above the floor pan. The longitudinal dimension of the seat cushion measured 51.4 cm (20.25") with a measured designed incline of 20 degrees.

The right front seat back support was located 90.8 cm (35.75") rearward from the leading edge of the air bag module flap at a height of 53.3 cm (21.0") above the junction with the seat cushion. The seat back support angle measured 26 degrees rearward from vertical. There was a 2.5 cm (1.0") scrape and puncture of the vinyl head restraint covering which was attributed to contact by the posterior portion of the child's head during her rearward trajectory following the crash sequence.

The windshield had a highly visible transfer mark which was located 29.2 cm (11.5") right of the vehicle centerline and 17.1 cm (6.75") below the windshield header **(refer to Figure 7)**. The transfer measured 8.9 cm (3.5") vertically and 13.3 cm (5.25") laterally which appeared to be of an oil/grease texture with a striated pattern. This transfer was attributed to contact by the child's head during the crash sequence. Directly above this area was a 22.2 cm (8.75") wide particulate field that extended upper to the windshield header. This was attributed to bodily tissue dispersed from the air bag fabric during the air bag expansion.

Figure 7- View of the oil/grease transfer mark on the windshield of the Acura

A 11.4 cm (4.5") vertical transfer on the windshield located 53.3 cm (21.0") right of the vehicle centerline was attributed to contact by the expanding front right air bag. A vinyl type transfer near the base of the windshield which was located 44.4 cm (17.5") right of the vehicle centerline was attributed to contact by the air bag module cover during the deployment sequence.

A faint imprint of a hand was noted along the surface of the instrument panel located left of the front right air bag module cover and 26.7 cm (10.5") right of the vehicle centerline **(refer to Figure 8)**. This was attributed to contact by the right front occupant's left hand due to bracing prior to the crash.

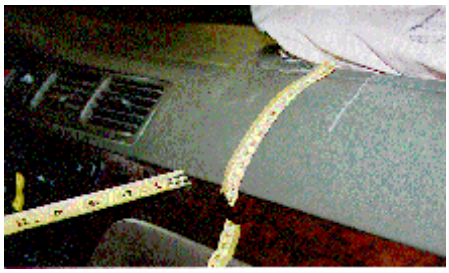


Figure 8- Left hand imprint on the instrument panel by the right front occupant in the Acura

There was a 3.8 cm (1.5") vertical scuff mark on the vertical surface of the right instrument panel which was located 40.0 cm (15.75") right of the vehicle centerline. There were two adjacent vertical scuff marks which appeared light in color and located 33.0 cm (13.0") right of the vehicle centerline. These scuff marks were attributed to contact by the child's upper torso during the interaction with the deploying front right air bag.

The louver and grille panel for the right air vent was dislodged from it bracket. This was attributed to contact by the child's right hand during the crash sequence.

There was a light blue fabric transfer along the lower instrument panel edge which measured 3.8 cm (1.5") wide and was located 31.8 cm (12.5") right of the vehicle centerline. The same color fabric transfer was noted directly behind this area on the surface of an electrical connector. The fabric transfer was attributed to contact by the child's left leg during the crash.

The front right air bag exhibited a heavy tissue transfer near the center of the front surface which was attributed to contact with the right front occupant's neck and facial area during the SRS deployment cycle. The largest area of transfer which measured 15.2 cm (6.0") in length and 10.8 cm (4.25") in width was located 33.0 cm (13.0") from the inflator unit. A second tissue transfer area was noted 19.1 cm (7.5") below the first transfer and measured 5.0 x 3.8 cm (2.0 x 1.5"). It appeared to be consistent in texture and alignment with the first transfer and indicated that the air bag was in an unfolding motion when it contacted the child's neck facial area.

The driver was carrying a cup of coffee in a ceramic cup at the time of the crash. During the crash, the coffee sprayed around the interior of the vehicle with concentrations noted to the center instrument panel, center console, the in-board surface of the right front seat, and the in-board side surface of the front right air bag.

Exterior - 1979 Ford Econoline (Vehicle #2):

The 1979 Ford Econoline cargo van which was used for commercial enterprise was in poor overall condition prior to the crash **(refer to Figure 9)**. The front bumper had been removed from the vehicle prior to the crash which left the two frame rail ends exposed. During the crash, the right frame rail contacted the left front bumper of the Acura resulting in a battering ram box type damage pattern.

Figure 9 - Left corner view of the 1979 Ford Econoline cargo van

The right frame rail end was deformed rearward 2.2 cm (0.875") while the left frame rail was deformed 3.8 cm (1.5"). Given the poor condition of the vehicle, it was not determinable whether these displacement values were entirely the result of this crash.

The grille panel was fractured and displaced rearward during the crash. The maximum crush measured 31.8 cm (12.5") and was located 5.1 cm (2.0") left of the vehicle centerline. Crush measurements were obtained along the lower area of the grille panel which are contained in the following table:

Frontal Crush Profile	C_1 = 10.8 cm (4.25")	C_2 = 13.3 cm (5.25")	C_3 = 23.2 (9.1")
	C_4 = 20.3 cm (8.0")	C_5 = 13.3 cm (5.25")	C_6 = 6.5 cm (16.5")

CDC: 12-FDEW-3

The braking system had been compromised prior to the crash where the rear brakes had been rendered inoperable. The metallic hydraulic brake line for the rear brakes had been cut near the tandem master cylinder **(refer to Figure 10)**. Road dirt build-up at the site of the cut indicated that the line had been cut previous to the crash and that it was not severed during the crash. There was no hydraulic fluid in the front chamber of the tandem master cylinder which was consistent with the severed rear brake line **(refer to Figure 11)**. The front brakes were operable, but the brake pedal had a long throw with an infirm feel. Reportedly a mechanic assessed the brake system at the request of the police department and reported that the rear brake shoes were missing and the front brake pads were defective.

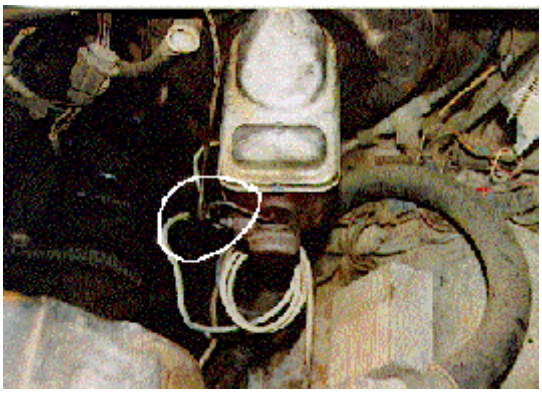


Figure 10- View of the master cylinder and the severed rear brake line looking from the front of the vehicle rearward

Figure 11- View of the master cylinder from the left side of the vehicle showing the empty forward brake chamber (designated for the rear brakes) and the severed brake line highlighted by the white circle

Other mechanical deficiencies not related to the crash involved the engine and windshield. Several vacuum lines associated with engine performance were defeated. The windshield was cracked in several areas with the highest concentration fracture sites located on the right side of the vehicle.

Interior - 1979 Ford Econoline (Vehicle #2):

The interior was that of a cargo van which was equipped with two front bucket seats. There were several business related items strewn about the inside. The driver seat was worn with the vinyl seat covering separated along the seam line. The lap and shoulder manual restraint belts for both front seats were present, but neither exhibited any indication of recent use. The rubberized brake pedal pad was missing and from the obvious wear pattern on the medal pedal it was assumed that the pad had been missing for a long period of time. The covering along the top portion of the steering wheel rim was missing and appeared to be previous to the crash. There were no visible driver contact evidence to the instrument panel or windshield related to the crash.

SPEED RECONSTRUCTION

The damage and trajectory algorithm routines of the SMASH speed reconstruction program were utilized to determine impact speed and delta V. An averaged crush profile was used for the Ford Econoline

due to the absence of the front bumper at the time of the crash. The results appeared reasonable and are contained in the following table:

SMASH Speed Reconstruction	1996 Acura TL 2.5	1979 Ford Econoline
Impact speed	17 km/h (10 mph)	27 km/h (17 mph)
Total delta V	24 km/h (15 mph)	19 km/h (12 mph)
Longitudinal delta V	-24 km/h (-15 mph)	-19 km/h (-12 mph)
Lateral delta V	0 km/h	0 km/h
Energy	27,554 joules (20,320 ft-lb)	33,596 joules (24,776 ft-lb)
Barrier equivalent speed	21.5 km/h (13.2 mph)	21.0 km/h (13.1 mph)

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The Supplemental Restraint System (SRS) in the 1996 Acura TL 2.5 was designed with a single point sensing system and dual front air bags. The impact with the Ford Econoline van was sufficient to actuate the deployment sequence.

Front Left Driver Air Bag

The front left air bag module cover opened in the prescribed "H" pattern where the upper flap measured 11.4 cm (4.5") vertically and the lower flap measured 5.7 cm (2.25") vertically. The lateral width of the common tear seam line measured 14.6 cm (5.75"). There were no apparent occupant contact points on the cover surface.

The front left driver air bag was constructed with four tethers. There were two 3.2 cm (1.25") diameter vent ports located on the rear surface of the air bag at the 11 o'clock and 1 o'clock positions. The vent ports were 15.9 cm (6.25") apart and located 16.5 cm (6.5") inboard from the perimeter of the air bag. There were no visible driver contact evidence observed on the air bag. The air bag identification number is as follows:

BBNJ023
4SS952601
080295
(S)
2004643

The driver seat was located 5.1 cm (2.0") rearward from a full forward track position. In this position, the seat back support measured 53.3 cm (21.0") rearward from the air bag module cover at a height of 41.9 cm (16.5") above the junction of the seat cushion.

Front Right Passenger Air Bag

The front right passenger air bag module was a top mount design which incorporated a single flap that opened upward toward the windshield. The air bag module measured 34.3 cm (13.5") laterally and 12.7 cm (5.0") longitudinally along the right side and 15.2 cm (6.0") along the left side. The left side of the module was located 21.0 cm (8.25") right of the vehicle centerline.

The front right air bag module flap measured 25.7 cm (10.125") laterally and 7.9 cm (3.125") longitudinally. The leading opening edge of the flap was located 14.6 cm (5.75") forward of the vertical surface of the right instrument panel. The vinyl flap was deformed downward 15.9 mm (0.625") over a 17.8 cm (7.0") lateral area which began at the left leading edge corner. Additionally, the vinyl surface beyond the flap hinge point was deformed in an upward direction over a length of 19.1 cm (7.5"). Both areas of deformation were attributed to the opening mechanism of the flap and not attributed to occupant contact.

The front right air bag was nontethered and contained two 5.1 cm (2.0") diameter vent ports located on both the in-board and outboard side surfaces of the air bag which were positioned 24.1 cm (9.5") below the inflator unit. The air bag material was a white color nylon and constructed of a fine fabric weave. The lateral dimension of the air bag measured 47.0 cm (18.5"). The longitudinal excursion of the air bag measured 67.3 cm (26.5") from the air bag module cover toward the seat back rest **(refer to Figure 12)**. The seat back rest was located 90.8 cm (35.75") from the air bag module cover measured at a height of 53.3 cm (21.0") above the junction of the seat cushion.

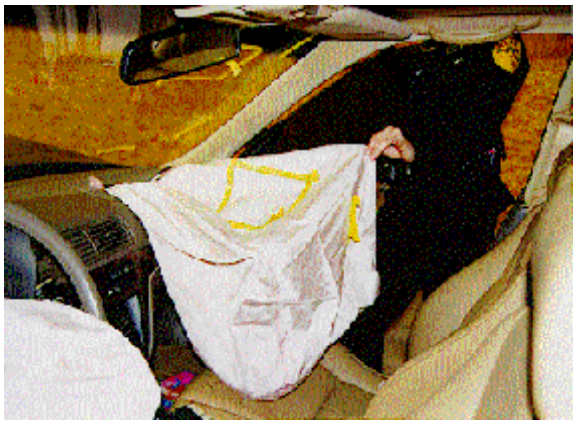


Figure 12- Excursion of the front right air bag in the Acura

Figure 13- Areas of tissue transfer on the front right air bag of the Acura

The face of the passenger side air bag exhibited two linear artifact fields of tan color deposits **(refer to Figure 13)** which were associated with tissue transfer from the right front occupant's neck and facial areas. The first area measured 15.2 cm (6.0") in length and 10.8 cm (4.25") in width. It began 33.0 cm (13.0") below the inflator unit and located in the center of the air bag. The second area of tissue transfer was located 67.3 cm (26.5") below the inflator unit which measured 5.1 cm (2.0") by 3.8 cm (1.5"). When the air bag was refolded along the predeployment fold lines during the vehicle inspection, these two areas aligned to form a continuous tissue transfer field. This indicated that the child's upper body was well forward and located within the expansion zone of the air bag at the time of SRS actuation.

INJURY DATA

The 7 year old female right front occupant in Vehicle #1, who had a medically listed weight of 19 kg (42 lbs.), reportedly lacked vital signs upon arrival of a witness to the crash. The witness initiated CPR procedures when a police officer and a nurse arrived. They reportedly evaluated the child's condition and subsequently continued with CPR.

Rescue responded on-site and noted that the child did not respond to visual, verbal, or motor stimuli. resulting in a Glasgow Coma Scale (GCS) rating of 3. She was subsequently transported via life flight helicopter to a local trauma center and arrived forty-two minutes after the police reported time of the crash. She arrived in an unconscious state at the emergency room, but regained consciousness within 12-24 hours.

An ICP monitor was placed after arrival in the emergency room. The readings were low when the patient regained consciousness. There were no gross elevations in intracranial pressure (remained less than 20) and by 2-3 days post injury, the ICP readings remained below 10 consistently. After the child was awake and responded to commands, the ICP monitor was subsequently discontinued.

The child sustained a complete spinal cord injury at C1-C2 with quadriplegia (AIS-6), a subarachnoid hemorrhage (AIS-3), a closed head injury (AIS-4), intraventricular hemorrhage (AIS-4), a left pulmonary contusion (AIS-3), superficial laceration of the right upper eyelid (AIS-1), abrasion over both eye lids (AIS-1), soft tissue abrasions and swelling of the anterior neck (AIS-1), and abrasions of the submental region (AIS-1). These injuries were attributed to contact with the deploying front right air bag during the SRS deployment sequence.

The child was transferred via air flight five days after the crash to another trauma hospital for surgical fusion of C1 and C2 and rehabilitation. This strategy was implemented following the sudden demise of the attending neurosurgeon.

INJURY	AIS-90 INJURY CODE	INJURY SOURCE
1. Closed head injury	160210.40	Front right air bag
Supplemental discussion: child unconscious upon arrival, regained consciousness within 12-24 hours, unconscious and apneic at extrication, CPR initiated by bystanders, GCS=3		
2-5. Superficial contusions of the face, eyes, neck, and anterior chest	297402.11 297402.12 390402.15 490402.10	Front right air bag
6. Superficial laceration of the right upper eyelid	297602.11	Front right air bag
7. Right subjunctival hemorrhage	240416.11	Front right air bag
8. Soft tissue abrasions and swelling of the anterior neck	390202.15	Front right air bag

INJURY	AIS-90 INJURY CODE	INJURY SOURCE
9. Abrasions of the submental region	290202.18	Front right air bag
10-11. Abrasion over both eye lids	297202.11 297202.12	Front right air bag
12. Left pulmonary contusion/atelectasis with tension pneumothorax	441406.32	Front right air bag
13. Subarachnoid hemorrhage within basilar cisterns	140684.39	Front right air bag
14. Intraventricular hemorrhage	140678.49	Front right air bag
15. Complete spinal cord injury C1-C2 with quadriplegia	640236.66	Front right air bag
Supplemental discussion: No response to painful stimuli from neck down, flaccid and areflexic from neck down, 1.5 cm anterior subluxation C1 on C2 with marked compromise of spinal canal, ligamental instability, odontoid fracture		

Driver #1, who was 160.0 cm (63.0") tall and weighed 52.2 kg (115.0 lbs), reportedly was not injured in the crash. The four year old child in the left rear seat was also reportedly not injured. Driver #2 complained of a wrist injury.

OCCUPANT KINEMATICS

Driver #1 indicated to police that her daughter was wearing the lap and shoulder belt in the right front seat even though the driver did not visually see her daughter engage the belt system. It appeared likely that if the restraint belt system was used that the torso belt was placed behind the child. This assessment was based on the following considerations:

- The child was not only small stature, but was wearing a backpack. These conditions would more than likely have resulted in her sitting forward on the seat cushion. In this position, the torso belt would have been located high on her upper torso in the neck and head area making it uncomfortable to wear.
- The seat was adjusted in a forward position which would have accentuated the high position of the torso belt on the child.
- The torso belt height adjustment at the D-ring was in the full up position which would have also increased the height of the torso belt relevant to the child's upper torso and thus resulting in a potentially higher discomfort level if used.
- The soft tissue injury pattern on the child's face, neck, and chest with the correlating tissue transfer field on the front right air bag indicated that the child's upper body moved forward and was close to the air bag at the time of deployment.

During pre-impact braking, the child's upper torso moved forward in response to the deceleration force. Her left arm was extended outward in an effort to brace herself against the instrument panel as evident by a 8.9 cm (3.5") wide smudge mark on the instrument panel which was located 17.8 cm (7.0") right of the vehicle centerline and just below the inboard side of the front right air bag module cover. She continued to move forward and was in close proximity to the instrument panel at the time of the SRS deployment sequence.

The expanding front right air bag contacted the child's neck and chin resulting in heavy tissue transfers on the front surface of the air bag with correlating soft tissue injuries to the child's neck and facial areas. She was subsequently elevated upward by the air bag where her head contacted the windshield as noted by the striated hair grease transfer mark on the glazing. She continued in a rearward trajectory and contacted the inboard surface of the right front seat head restraint resulting in a scrape and small puncture marks in the vinyl covering. The child's upper body rebounded forward and came to rest in a slumped forward position.

The mother of the child removed her from the vehicle through the right front door and reportedly attempted to awake her by rocking her before placing her on the ground. A witness traveling behind Vehicle #2 arrived and initiated CPR on the child. Shortly after, a police officer and a nurse who happened to be in the vicinity arrived took over and continued CPR until rescue arrived.

The 4 year old child in the left rear seat of Vehicle #1 was restrained in a child safety seat which was secured to the vehicle by the manual restraint belt system. She was not injured in the crash.

During the crash, Driver #1 moved forward and contacted the knee bolster with both knees resulting in minor deformation and scuff marks on the bolster. The steering column shear plate was displaced forward from the right shear capsule a distance of 3.2 mm (0.125"). This movement indicated that the driver loaded the air bag during the crash sequence.

Although there were no visible signs of crash related restraint belt usage (e.g., stretching, fabric transfers, D-ring transfers, etc.), it appeared reasonable that the driver was using the lap and shoulder belt at the time of the crash. This was based on the police report which indicated that the driver was wearing the lap and shoulder belt and from the inferential evidence that if the children were restrained, then the driver was very likely using her restraint belt. Additionally, the forward adjusted position of the seat placed the driver closer to the steering wheel so that her upper torso may have interacted more with the expanding air bag then with the restraint belt.

Driver #1 rebounded back against the seat back support where she came to the final rest position. According to witnesses, the driver remained in the vehicle for what appeared to be an extended period of time. She exited the vehicle under her own power and went to the aid of her 7 year old daughter.