CRASH DATA RESEARCH CENTER
Calspan Corporation
Buffalo, NY 14225

ON-SITE AIR BAG RELATED CHILD FATALITY INVESTIGATION
CALSPAN CASE NO: CA04-027

VEHICLE – 1997 CADILLAC CATERA
LOCATION – FLORIDA
CRASH DATE – JUNE 2004

Contract No. DTNH22-01-C-17002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. CA04-027	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle On-Site Air Bag Related Child Passenger Fatality Investigation Vehicle: 1997 Cadillac Catera Location: Florida		*5. Report Date*: February 2006 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Calspan Corporation Crash Data Research Center P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* C00410.0000.0251 *11. Contract or Grant No.* DTNH22-01-C-17002	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Crash Date: June 2004 *14. Sponsoring Agency Code*	
15. Supplementary Note An investigation of a frontal impact with a 15 cm (5.75 in) curb with frontal air bag deployment in a 1997 Cadillac Catera resulting in the death of a 2 year old female seated on the lap of a 39 year old unrestrained male front right passenger.			
16. Abstract This investigation focused on the crash dynamics and fatal injury mechanisms of a 2 year old female seated on the lap of the front right passenger in a 1997 Cadillac Catera. The 1997 Cadillac was equipped with a Supplemental Inflatable Restraint (SIR) that consisted of driver and front right passenger air bags. The Cadillac was involved in a low speed undercarriage impact with a 15 cm (5.75 in) tall curb in a convenience store/service station parking lot. The driver misjudged the speed and position of the vehicle as it entered the parking stall and suddenly applied the brakes prior to impacting the curb. The crash pulse generated by the impact was sufficient to deploy the frontal air bags in the vehicle. The 2 year old was removed from the vehicle and was reportedly crying as she was carried into the store. The store manager reported that the child's condition deteriorated over the next several minutes. The child was transported to a Level 1 pediatric trauma center via helicopter and was admitted in critical condition. Medical efforts to revive the child over the course of her hospitalization were unsuccessful. The child expired two days post-crash of a Diffuse Axonal Injury to the brain (AIS 5). The child also sustained subdural and subarachnoid brain hemorrhages, bilateral lung contusions and multiple soft tissue facial injuries as a result of the expanding front right passenger air bag. The Cadillac's 18 year old female driver and 39 year old male front right passenger were not injured in the event.			
17. Key Words Frontal Air Bag….Seated on the lap Diffuse Axonal Brain Injury Subdural Hemorrhage Unrestrained……Front Right Passenger		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 15	*22. Price*

TABLE OF CONTENTS

ON-SITE AIR BAG RELATED CHILD PASSENGER FATALITY INVESTIGATION
CALSPAN CASE NO: CA04-027

VEHICLE: 1997 CADILLAC CATERA
LOCATION: FLORIDA
CRASH DATE: JUNE, 2004

BACKGROUND

This investigation focused on the crash dynamics and fatal injury mechanisms of a 2 year old female seated on the lap of the front right passenger in a 1997 Cadillac Catera, **Figure 1**. The 1997 Cadillac was equipped with a Supplemental Inflatable Restraint (SIR) that consisted of driver and front right passenger air bags. The Cadillac was involved in a low speed undercarriage impact with a 15 cm (5.75 in) tall curb in a convenience store/service station parking lot. The driver misjudged the speed and position of the vehicle as it entered the parking stall and suddenly applied the brakes prior to impacting the curb. The crash pulse generated by the impact was sufficient to deploy the frontal air bags in the vehicle. The 2 year old was removed from the vehicle and was reportedly crying as she was carried into the store. The store manager reported that the child's condition deteriorated over the next several minutes. The child was transported to a Level 1 pediatric trauma center via helicopter and was admitted in critical condition. Medical efforts to revive the child over the course of her hospitalization were unsuccessful. The child expired two days post-crash of a Diffuse Axonal Injury to the brain (AIS 5). The child also sustained subdural and subarachnoid brain hemorrhages, bilateral lung contusions and multiple soft tissue facial injuries as a result of the expanding front right passenger air bag. The Cadillac's 18 year old female driver and 39 year old male front right passenger were not injured in the event.

Figure 1: 1997 Cadillac Catera.

This fatal crash was identified through the news media by the Crash Investigation Division of the National Highway Traffic Safety Administration on June 7, 2004. NHTSA in-turn assigned an on-site investigation of the crash to the Special Crash Investigations team at General Dynamics the same day. The Calspan SCI team contacted and established cooperation with the law firm representing the family. The vehicle was being stored pending legal action in the matter and was available for SCI inspection. The on-site investigation took place June 17-18, 2004.

SUMMARY

Crash Site

This single vehicle/curb impact occurred during the daytime hours in June, 2004. At the time of the crash it was daylight and the weather was not a factor. The crash occurred in the parking lot of a commercial business located at the corner of a four-lane divided US route and a two-lane

divided local road in the state of Florida. This business consisted of a convenience store, a fuel island with twelve gas pumps, and a car wash. The convenience store measured 38.3 m x 23.6 m (97.4 ft x 60.0 ft) and was bordered on three sides by a 15 cm (5.75 in) tall concrete barrier curb and sidewalk. The long dimension of the building was oriented in the north/south direction. Traffic entered the property from the west off of the US route or from the east via the local road. Vehicles conducting business at the store maneuvered through the parking lot and parked perpendicular to the curb on the north and west sides of the building. The subject crash occurred directly in front of the entrance doors to the store on the west side of the building. The crash was captured on video by surveillance cameras covering the front of the store. **Figure 2** is an overall view of the convenience store. **Figure 3** is a view of the entrance doors and the point of impact. A schematic of the crash is attached to the end of this narrative report, **Figure 17**.

Figure 2: View of the convenience store looking eastward.

Figure 3: View of the point of impact at the store front.

Crash Sequence

Pre-Crash

The 1997 Cadillac Catera was driven by an 18 year old female. A 39 year old male was the front right passenger. A two year old female child occupied a convertible child safety seat (CSS) restrained in the vehicle's right rear position. The Cadillac entered the business from the east via the two-lane roadway and traveled westward along the south side of the convenience store. Reportedly during this time, the driver noted that the two year old had unbuckled herself from the CSS and was standing between the front seats. The driver elected to have the child come forward and sit on the lap of the front right passenger until the vehicle stopped. The driver then turned right, toward the front of the store, and turned right again in order to park. (Refer to the crash schematic, **Figure 17**.) For unknown reasons, the driver misjudged the speed and position of the vehicle during the parking maneuver. Reconstruction of the crash indicated the driver braked suddenly during the later stage of the pre-crash envelope, causing the front end of the Cadillac to pitch downward.

Crash

The front of the Cadillac pitched downward and the two tow hooks located 41 cm (16.0 in) aft of the front of the vehicle overrode the curb and contacted the sidewalk. This contact was evidenced by two scratch marks identified during the scene inspection. Refer to **Figure 4**. The left scratch mark began 20 cm (7.75 in) from the edge of the curb and measured 24 cm (9.4 in) in length. The right mark began 21 cm (8.25 in) from the curb edge and measured 23 cm (9.2 in) in length. The width between the marks measured 62 cm (24.5 in).

The Cadillac continued forward approximately 13 cm (5.0 in) at which time the front tires struck the curb. The kinetic energy of the curb impact resulted in a compression of the Cadillac's front tires and suspension. Due to the fact that a portion of the vehicle's weight was now supported by the front tow hooks, the suspension compression resulted in the tires moving vertically (rather than the front end pitching further downward). The compression of the tires and suspension exposed the vehicle's oil pan to the leading edge of the concrete curb. The estimated compression of the suspension was 10 cm (4.0 in).

The Cadillac's oil pan impacted the curb edge across its entire 43 cm (16.75 in) width. The edge of the concrete was chipped and fractured as a result of the impact and was identified by the evidence paint of the police investigation (**Figure 4**). This impact arrested the forward momentum of the vehicle and it came to rest. The vehicle's engine probably stalled at this time. The crash pulse (deceleration) generated during this impact was sufficient to cause the deployment of the vehicle's frontal air bags. The delta V of the impact was less than 16 km/h (10 mph).

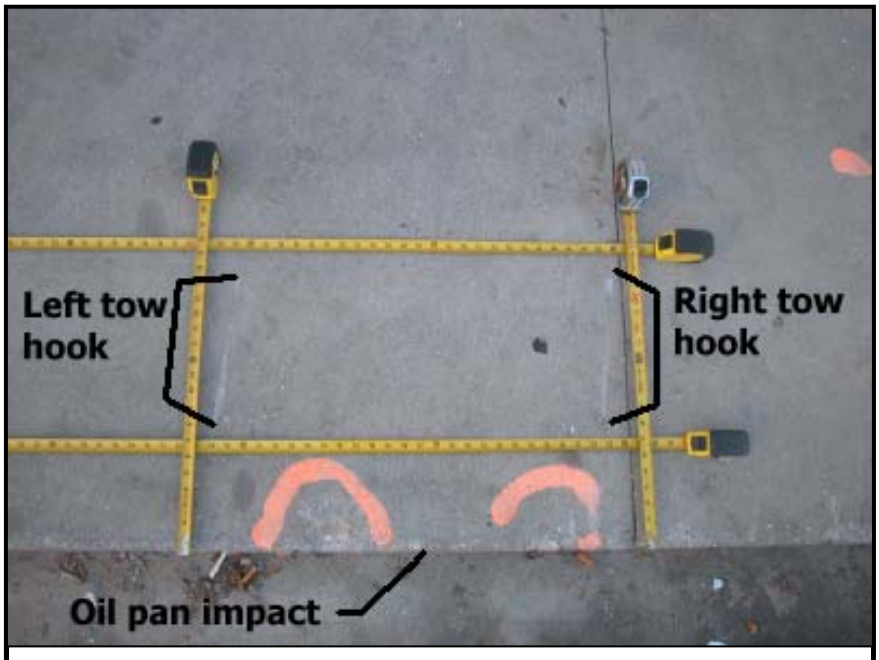

Figure 4: Contact evidence identified at the point of impact.

Post-Crash

The surveillance video revealed that the driver exited the left side of the vehicle and moved forward toward the store. At the same time, the front right passenger exited the vehicle from the right front door and was holding the child. The driver then took the child and entered the store. The store manager reported that the child was crying (whimpering). He indicated that the child appeared to be red about the face. The driver and child entered the women's restroom and then returned a short time later. In the interim, the police were notified of the crash via the 9-1-1 system. Upon returning from the restroom, the store manager indicated the child began to have labored breathing and her condition appeared to deteriorate.

While the occupants of the Cadillac were in the store, the vehicle began to roll backward. Apparently, the driver shifted the transmission of the (now stalled) vehicle into neutral after the crash. The ignition interlock would have prevented the transmission from a shift into park. By-standers ran out of the store, stopped the vehicle and then pushed it back to the curb. During this maneuver, the position of the vehicle was displaced approximately 0.8 m (2.7 ft) south relative to impact position. The position of the Cadillac documented by the police investigation (**Figure 3**) was not its position at the time of the impact or final rest.

The police and ambulance personnel arrived on-scene within 8 to 10 minutes of the 9-1-1 call. The child was flown to a regional pediatric trauma center via helicopter and was admitted in critical condition. She was hospitalized on life-support for a period of two days. Medical efforts to revive the child proved unsuccessful and she died upon removal from that support. The medical examiner reported that she died of a Diffuse Axonal Injury to the brain due to blunt head trauma. The driver and front right passenger were not injured in the event.

1997 CADILLAC CATERA

The 1997 Cadillac Catera was identified by the Vehicle Identification Number (VIN): W06VR54RXVR (production sequence deleted). The four-door sedan was manufactured in Germany by General Motors Opel subsidiary in March 1997. The rear-wheel drive model was powered by a 3.0 liter, V6 engine linked to a four-speed automatic transmission. The service brakes were four-wheel disc with ABS. The manual restraint system consisted of 3-point lap and shoulder belts in the four outboard positions. The front safety belts were equipped with buckle pretensioners. The center rear position was equipped with a lap belt. The Supplemental Inflatable Restraint (SIR) consisted of driver and front right passenger air bags. The front seats were equipped with seat back-mounted side impact air bags. The odometer had registered 190,353 km (118,283 miles). The Cadillac was equipped with Dayton Daytona HR P225/55R16 94H M&S tires on alloy wheels at all four positions. The tire size was the recommended size for the vehicle. The manufacturer

Figure 5: Front view of the Cadillac.

recommended tire pressure for both the front and rear positions were 220 kpa (32 psi). The specific measured tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	206.3 kpa (30.0 psi)	5.6 mm (7/32)	No	None
LR	213.1 kpa (31.0 psi)	3.2 mm (4/32)	No	None
RF	213.2 kpa (31.0 psi)	4.8 mm (6/32)	No	None
RR	154.7 kpa (22.5 psi)	4.0 mm (5/32)	No	None

Exterior Damage

The exterior damage to the Cadillac was limited to the identified contact/impact points to the vehicle's undercarriage. There was no impact damage to the front, back or side planes of the vehicle. There was no measurable change in the vehicle's wheelbase dimensions or overall length.

Figure 6 is a view of the Cadillac's forward undercarriage. The vehicle was raised by a hydraulic hoist to facilitate its inspection. Three areas of contact to the sidewalk and curb were identified and are depicted in the figure. The bottom of the tow hooks were abraded by direct contact with the surface of the sidewalk; and the oil pan was deformed across in entire 43 cm (16.75 in) width from a direct impact with the edge of the 15 cm (5.75 in) tall curb. It should be noted that the underside of the bumper fascia was abraded in several areas forward of the tow hooks. It was probable that these abraded regions occurred at the time of the crash. No structural damage or deformation to the undercarriage, other than the tow hook/oil pan damage was identified. The Collision Deformation Classification of the damage was 12-UFDW-1.

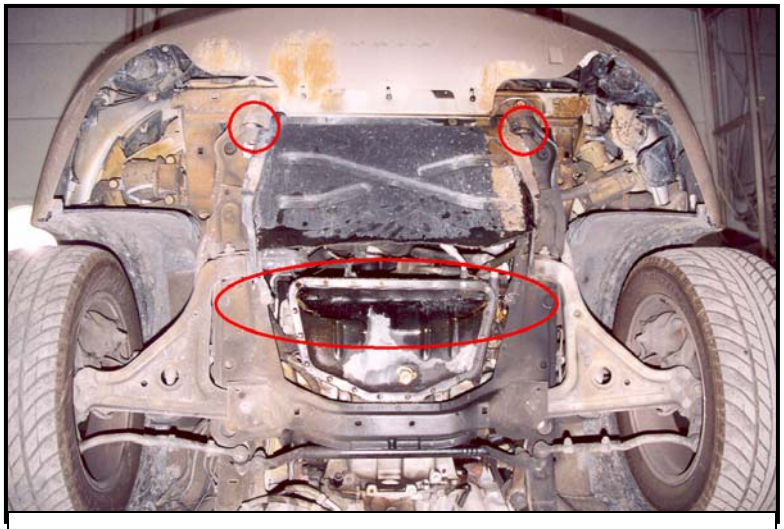

Figure 6: View of the Cadillac's forward undercarriage and the identified contacts.

Figures 7 and 8 are close-up views of the right and left tow hooks, respectively. The tow hooks were manufactured from 11 mm (7/16 in) diameter steel round stock formed into a "U" shape. The uprights of the "U" were centered 5 cm (2.0 in) apart. The height of the hook measured 4 cm (1.375 in). The hooks were located symmetrically, 41 cm (16.0 in) rearward of the furthest protrusion of the front bumper (measured on the vehicle's centerline). The lateral separation of the hooks measured 62 cm (24.375 in) (consistent with the physical evidence identified at the crash scene). The elevation of the bottom of the right hook measured 18 cm (7.0 in) above the ground. The elevation of the left hook measured 18 cm (7.25 in). All of the elevation (vertical) measurements were taken prior to lifting the vehicle. Inspection of the tow hooks determined that the bottom surface of each hook was abraded. The width of the each abrasion measured approximately 2 cm (0.6 in). The abrasion on the right tow hook appeared to have concrete dust embedded in the region. The abrasion on the left hook did not appear to be quite as distinct as compared to the right hook.

Figure 7: Close-up of the right tow hook.

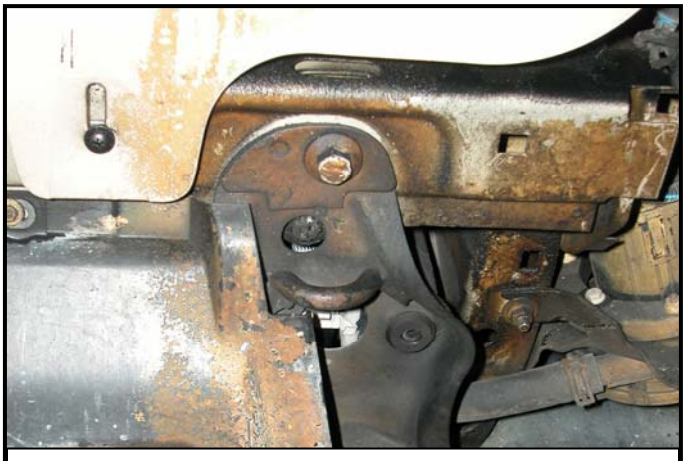

Figure 8: Close-up of the left tow hook.

Figures 9 and 10 are close-up views of the damaged oil pan viewed from the right and left, respectively. The front face of the oil pan was deformed across its entire width. The width of the deformation measured 43 cm (16.75 in). The height of the deformed face measured 8 cm (3.0 in). The estimated longitudinal crush of the oil pan was 4 cm (1.5 in). The elevation of the deformed oil pan above the floor measured 16 cm (6.25 in). This measurement was taken on the centerline of the Cadillac at deformed front face of the oil pan.

For reference, the bolt pattern located at the leading edge of the oil pan was located 75 cm (29.625 in) rearward of the front of the vehicle. At this plane, the bolt pattern falls rearward of the forward edge of the front tires. In other words, the oil pan would normally be protected from a curb strike by the tires. The plumb bob in **Figure 11** represents the location of this plane. In this crash however, due to the dynamics of the impact, the front tires and suspension compressed and exposed the face of the oil pan to the curb.

Figure 9: Right view of the deformed oil pan.

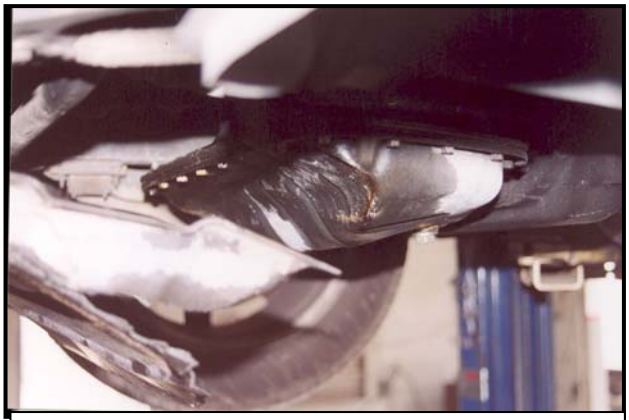

Figure 10: Left view of the deformed oil pan.

Figure 11: Depiction of the location of the oil pan's forward bolt line.

Interior Damage

The interior damage to the Cadillac consisted of the deployment of the vehicle's frontal air bags. There was no intrusion or interior damage related to the exterior force of the crash. There were no noted contacts or deformations to the respective bolsters. There was no movement of the steering column shear capsules and there was no deformation of the steering wheel rim.

The driver seat was located in a mid-track position that measured 10.4 cm (4.1 in) forward of full rear. The total seat track travel measured 20.3 cm (8.0 in). The seat back angle measured 32 degrees aft of vertical. The horizontal distance from the seat back to the steering wheel hub measured 58.4 cm (23.0 in). The horizontal distance was measured 40.6 cm (16.0 in) above the seat bight.

The front right seat was located in a rear track position that measured 4.6 cm (1.8 in) forward of full rear. The total seat track travel measured 21.1 cm (8.3 in). The seat back angle measured 35 degrees. The horizontal distance from the seat back to the front right passenger air bag module assembly measured 88.9 cm (35.0 in). The horizontal distance was measured 40.6 cm (16.0 in) above the seat bight.

Manual Restraint System

The manual restraint system in the Cadillac Catera consisted of 3-point lap and shoulder belts in the four outboard positions and a center rear lap belt. The front restraints were comprised of the following components: a B-pillar mounted inertial retractor, continuous loop webbing, sliding latch plate, adjustable D-ring, and a buckle pretensioner.

Figure 12: View of the driver's safety belt buckle.

The driver's restraint was stowed within the retractor at the time of the inspection and the retractor was operational. The D-ring was adjusted to the lowest position. Examination of the latch plate revealed historical use indicators consistent with the vehicle's age. There was no crash related evidence identified on any of the friction surfaces of the restraint system. The D-ring and hardware surfaces of the latch plate were free of abrasion. Extension and examination of the webbing was unremarkable. However, given the relative low severity of the impact, crash related loading evidence on the restraint webbing was not expected. The driver's buckle pretensioner had fired evidenced by the (now) visible warning label, **Figure 12**. Inspection of the fired pretensioner indicated that it had fully stroked. The fully stroked pretensioner was an indication that the driver was unrestrained at the time of the crash. Based on the evidence gathered at the time of the inspection, it has been determined the driver was unrestrained at the time of the impact.

The front right passenger restraint was stowed within its retractor upon inspection. The retractor was operational. The D-ring was adjusted to its lowest position. There was no crash related

evidence on the friction surface of the D-ring. The metal surface of the latch plate revealed historical use indicators. There was no identified crash related evidence on the friction surface of the latch plate's hardware. The webbing was extended from the retractor and examined. There was no crash related loading evidence present of the surface of the webbing. The front right seat belt buckle had fired exposing a warning label similar to the driver's pretensioner. Examination of the fired pretensioner indicated it had fully stroked. The fully stroked pretensioner indicated the front right passenger was unrestrained at the time of the crash.

Supplemental Inflatable Restraint

The Supplemental Inflatable Restraint (SRS) in the Cadillac Catera consisted of driver and front right passenger air bags that deployed as a result of the undercarriage impact, **Figure 13**. The vehicle was also equipped with seat back mounted side impact air bags. The SIR was monitored and controlled by a Sensing and Diagnostic control Module (SDM) that was mounted within the center console on the vehicle's centerline. The sensor measuring the severity of the crash was located within the SDM. There were no other external satellite sensors incorporated into the design of the SIR. This SDM was not compatible with the Vetronix Crash Data Retrieval Tool; therefore any crash related data that may have been recorded by the module could not be directly accessed.

Figure 13: View of the deployed frontal air bags.

The driver air bag deployed from an H-configuration module located in the center of the steering wheel rim. The cover flaps opened at the designed tear seams and did not exhibit evidence of occupant contact. The width of the flaps measured 19 cm (7.5 in). The height of the upper and lower flaps measured 6 cm (2.4 in) and 5 cm (2.1 in), respectively. The diameter of the deployed driver air bag measured 58 cm (23.2 in). It was tethered and internally vented. There was no evidence of occupant contact to driver air bag.

The front right passenger air bag module was a mid-mount design located in the right aspect of the instrument panel. The module was a "clam-shell" H-configuration design, **Figure 14**. During the deployment sequence, the cover flaps opened at the designed tear seams. There was no evidence of occupant contact to the surfaces of the flaps. The width of the center seam measured 35 cm (14.0 in). The height of the upper and lower flaps measured 15 cm (5.9 in) and 8 cm (3.0 in), respectively.

The face of the deployed front right passenger air bag, **Figure 15**, measured 57 cm x 64 cm (22.5 in x 25.0 in), width by height. The rearward excursion of the bag's face measured 51 cm (20.0 in) from the module. The face of the air bag was tethered by two 20 cm (8.0 in) wide straps. The perimeter dimensions of the tether stitching located on the face of the bag measured 22 cm x 11 cm (8.5 in x 4.4 in). The air bag was vented by two 3 cm (1.25 in) diameter ports located on the side panels. The face of the air bag exhibited minor evidence of contact in the upper left quadrant. The contact measured 14 mm (0.6 in) in diameter and was located 9 cm (3.4 in) right of the inboard side panel and 13 cm (5.1 in) below the top of the membrane. The contact was gray/black in color and was probably related to direct contact with the 2 year old child. There were no other contacts identified on the air bag.

Figure 14: View of the deployed front right air bag cover flap.

Figure 15: View of the deployed PAB.

Inspection of the front right interior space surrounding the deployed air bag did not reveal any evidence of an altered deployment. There was no evidence of air bag scuffing to the windshield, instrument panel or interior trim panels typical of the altered deployment. The altered air bag deployment typically occurs when the unrestrained occupant (moving forward in response to a pre-crash braking maneuver) impedes and deflects the deploying air bag forward into the interior structures of the vehicle. The expansion of the deflected air bag causes frictional contact between the bag's fabric and the interior and results in frictional transfers. In this crash, the absence of contact between the air bag and the interior, in conjunction with the minimal contact evidence on the air bag membrane, indicated the air bag deployed normally rearward and struck the child occupant prior to significant occupant motion.

CHILD SAFETY SEAT DATA

Figure 16 is a front view of the Century convertible child safety seat positioned in the right rear of the Cadillac. The seat was not restrained by the vehicle's safety belt system at the time of the inspection. Inspection of the seat revealed that all of the manufacturer's labeling had been removed. The child restraint was consistent with Century's 1500 STE series. The seat was equipped with a 5 point harness that was adjusted to the top slots. The shoulder straps were roped and appeared worn. The chest clip was missing. The absence of the chest clip would allow for greater lateral movement of the shoulder straps.

Figure 16: Century convertible CSS.

CHILD PASSENGER DEMOGRAPHICS

	Child Passenger
Age/Sex:	2 year old/Female
Height:	109 cm (43 in)
Weight:	12 kg (26 lb)
Seat Position:	On the lap of the front right passenger
Restraint Use:	None, unrestrained
Usage Source:	SCI inspection
Medical Treatment:	Hospitalized two days and then removed from life-support

CHILD PASSENGER INJURY

Injury	*Injury Severity (AIS 98 Update)*	*Injury Source*
Diffuse axonal brain injury	Critical (140628.5,9)	Deploying front passenger air bag
Non-volumetric subdural hemorrhage, bilateral	Critical (140654.5,3)	Deploying front passenger air bag
Non-volumetric subarachnoid hemorrhage (exact aspect unknown)	Serious (140684.3,9)	Deploying front passenger air bag
Diffuse cerebral edema (exact aspect unknown)	Serious (140660.3,9)	Deploying front passenger air bag
Bilateral lung contusions	Severe (441410.4,3)	Deploying front passenger air bag
Large, dry brown abrasion to the central aspect of the forehead	Minor (290202.1,7)	Deploying front passenger air bag
Short, small linear abrasion above the left eyebrow	Minor (290202.1,7)	Deploying front passenger air bag
Small, oval dry maroon abrasion to the right cheek	Minor (290202.1,1)	Deploying front passenger air bag
Large pale violet contusion to the left cheek	Minor (290402.1,2)	Deploying front passenger air bag
Two oval dry maroon abrasions to the left cheek (within the above contusion)	Minor (290202.1,2)	Deploying front passenger air bag

The above injuries were identified on the Radiology reports from the treating hospital and the Medical Examiner's Autopsy Report.

CHILD PASSENGER KINEMATICS

The 2 year old child was initially seated in the child safety seat located in the rear right position and reportedly moved forward into the lap of the front right passenger as the Cadillac entered the service station. The physical evidence on the front right passenger air bag indicated she was seated on the inboard aspect of the adult passenger's lap.

Immediately prior to the impact, the Cadillac driver rapidly applied the brakes. The child responded to this pre-crash braking event by exhibiting a forward trajectory. The front right adult passenger probably contacted the child's back and tightened his grasp of the child as they attempted to maintain their balance. At impact the frontal air bags deployed. The child responded to the 12 o'clock direction of the impact by responding further forward. She was probably loaded from behind by the front right adult. The deploying front right passenger air bag struck the child in the face and chest due to her forward position. The impact of the air bag caused the identified bilateral lung contusions and the subdural hemorrhage and its expansion caused the identified facial abrasions and contusions. The subarachnoid hemorrhage and the diffuse axonal injury resulted from the rapid acceleration of the brain within the skull due to the membrane's impact and expansion. The child came to rest within the front right occupant space in the adult passenger's arms. She was carried from the vehicle by the passenger and then transferred to the driver/mother.

Witnesses within the convenience store reported the child was initially whimpering/crying and was red about the face. The mother carried the child into the rest room and emergency services were called. Over time the extent of the child's injuries manifested and the child's breathing became labored. She was flown to a pediatric trauma center, where she was hospitalized and placed on life-support. She was removed from that support two days post-crash once recovery was ruled out and immediately expired.

DRIVER DEMOGRAPHICS

	Driver
Age/Sex:	18 year old/Female
Height:	173 m (68 in)
Weight:	66 kg (145 lb)
Seat Track Position:	Mid-track, 10 cm (4.1 in) forward of full rear
Manual Restraint Use:	None, unrestrained
Usage Source:	SCI inspection
Medical Treatment:	None, not injured

DRIVER INJURY

The 18 year old female driver was not injured in the event.

DRIVER KINEMATICS

Prior to the crash, the 18 year old driver was seated in a mid-track position and in an upright posture. She was not restrained by the manual safety belt. She was in the process of maneuvering the Cadillac through the service station and into a parking space in front of the convenience store.

As she entered the parking space, the driver misjudged the speed and position of the vehicle for unknown reasons. The speed of the Cadillac was an estimated 16 km/h (10 mph). After perceiving the vehicle was going to overrun the curb, the driver rapidly applied the brakes. The front of the vehicle pitched down and the vehicle's undercarriage struck the curb and adjacent sidewalk. The force of the impact into the curb edge was sufficient to cause the frontal air bags in the Cadillac to deploy.

During the braking maneuver, the driver resisted the deceleration through the bracing of her arms and lower extremities. At impact with the curb, the driver air bag deployed. The expansion of the membrane displaced the driver's arms from the steering wheel rim. She responded to the 12 o'clock direction of the impact force by initiating a forward trajectory. She loaded the expanded air bag with her upper torso and head and rode down the impact. She then rebounded into her seat and exited the vehicle after regaining her faculties. She was not injured in the event.

FRONT RIGHT PASSENGER DEMOGRAPHICS

	Front Right Passenger
Age/Sex:	39 year old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Rear-track, 4.6 cm (1.8 in) forward of full rear
Manual Restraint Use:	None, unrestrained
Usage Source:	SCI inspection
Medical Treatment:	None, not injured

FRONT RIGHT PASSENGER INJURY

The 39 year old male front right passenger was not injured in the event.

FRONT RIGHT PASSENGER KINEMATICS

The 39 year old male passenger was seated in a rear track position. He was not restrained by the vehicle's manual safety belt. The 2 year old female child was seated on the inboard aspect of his lap. His arms were probably around the child waist in order to balance/hold her in place.

The male passenger responded to the pre-crash braking maneuver by loading his lower extremities and rotating slightly forward at the waist. He probably contacted the back of the child passenger with a resultant action of hugging the child closer. Upon impact, the frontal air bags deployed. The front right passenger initiated a forward trajectory in response to the 12 o'clock direction of the impact force. The forward position of the lap seated child shielded the adult passenger from the deploying front right passenger air bag. The front right passenger loaded the expanded front right passenger air bag through the child passenger. He then rebounded back into the seat. He then exited the Cadillac via the front right door with the child in his arms. He was not injured in the event.

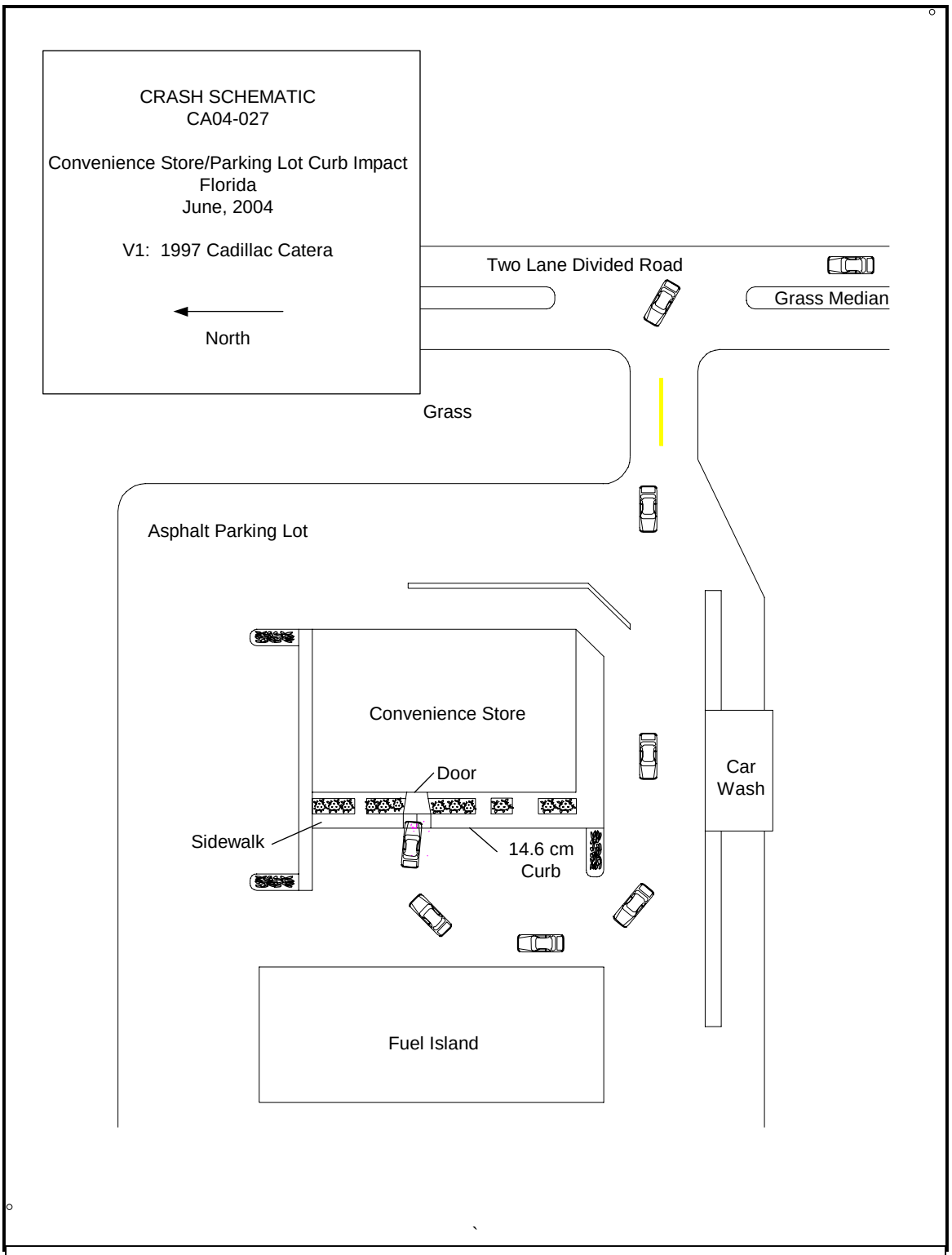

Figure 17: Crash Schematic