TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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ON-SITE REDESIGNED AIR BAG DEPLOYMENT INVESTIGATION

VERIDIAN CASE NO. CA99-05

VEHICLE - 1998 HONDA ACCORD

LOCATION - NEW YORK

CRASH DATE - APRIL 1999

Contract No. DTNH22-94-07058

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

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

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This task involved the on-site investigation of a severe head-on crash that resulted in non-life threatening injuries to the front seat occupants of a 1998 Honda Accord involved in a head-on crash with a 1982 Oldsmobile 88. Damage to both vehicles was rated as severe. The Honda was equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed during the crash. The 28 year old female driver of the Honda and her 28 year old male passenger were police reported as belted. The combination of seat belts and redesigned air bags protected the Honda's occupants from severe or possibly fatal injuries. The unrestrained front seat occupants of the Oldsmobile were hospitalized in critical condition and subsequently died from their respective injuries sustained in the crash.

The crash occurred in April, 1999, in a suburb of a major metropolitan area in New York State. Details of the crash were forwarded by the Veridian SCI team to Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) on the day after the crash. NHTSA in-turn assigned an on-site investigation of the crash as a redesigned air bag success story due to the severe vehicle damage.

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TABLE OF CONTENTS

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BACKGROUND

This task involved the on-site investigation of a severe head-on crash that resulted in non-life threatening injuries to the front seat occupants of a 1998 Honda Accord involved in a head-on crash with a 1982 Oldsmobile 88. Damage to both vehicles was rated as severe. The Honda was equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed during the crash. The 28 year old female driver of the Honda and her 28 year old male passenger were police reported as belted. The combination of seat belts and redesigned air bags protected the Honda's occupants from severe or possibly fatal injuries. The unrestrained front seat occupants of the Oldsmobile were hospitalized in critical condition and subsequently died from their respective injuries sustained in the crash.

The crash occurred in April, 1999, in a suburb of a major metropolitan area in New York State. Details of the crash were forwarded by the Veridian SCI team to Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) on the day after the crash. NHTSA in-turn assigned an on-site investigation of the crash as a redesigned air bag success story due to the severe vehicle damage.

SUMMARY

Crash Scene

The crash occurred during daylight hours of April, 1999 on a five lane east/west suburban roadway. The road was straight and level and configured with two travel lanes for each direction and a center turn lane. The asphalt road surface was wet due to a combination of mixed precipitation and freezing temperatures at the time of the crash. A two lane road intersected from the north approximately 28 m (92 ft) east of the point of impact, forming a three leg intersection. The speed limit in the area of the crash was 64 km/h (40 mph). **Figure 1** is an eastbound trajectory approaching the point of impact.

Figure 1: Eastbound trajectory view of the 1998 Honda Accord.

Pre-crash

The 1982 Oldsmobile Delta 88 was traveling westbound in the curb (outboard) lane, driven by a 23 year old female. The front right passenger was a 25 year old male. Both occupants of the Oldsmobile were unrestrained. Directly ahead of the Oldsmobile a westbound vehicle (unknown make/model) was slowing to make a right turn (northbound) on the intersecting side street. Stopped in the center turn lane was an eastbound 1994 Saturn SL1. It was the intention of the Saturn to turn left (north) and it had stopped, yielding to the westbound traffic. West of the intersection, a 1998 Honda Accord was traveling east in the curb (outboard) lane. The Honda was driven by a restrained 28 year old female. A restrained 28 year old male was the front right passenger.

The Oldsmobile was traveling westbound in the outboard lane of the roadway. The driver was apparently distracted and did not recognize the vehicle in front of her was slowing to turn right onto a intersecting side street. She applied a sudden counterclockwise (left) steering maneuver to avoid the vehicle. The Oldsmobile traversed the inboard westbound lane and crossed into the center turn lane, sideswiping the right front corner of the eastbound 1994 Saturn SL1. The Saturn was slowing and/or stopped to turn left onto the side street. The position of the Saturn probably confused the Oldsmobile's driver, thereby causing the Oldsmobile continue its leftward trajectory. The Oldsmobile traversed the inboard eastbound lane and then the driver began to counter-steer clockwise (back to the right.).

The Oldsmobile traveled approximately 35 m (115 ft) during its pre-crash trajectory. Speed reconstruction indicated the Oldsmobile was traveling at or above the 64 km/h (40 mph) speed limit. At this speed, the vehicle traveled the length of its pre-crash trajectory in approximately 2 seconds. Due to the short duration of the pre-crash phase, the respective drivers probably only began to initiate evasive maneuvers.

Crash

The Oldsmobile continued into the outboard eastbound travel lane where the impact occurred. The full frontal area on the Oldsmobile impacted and partially overrode the full frontal area of the Honda. The westward momentum of the Oldsmobile stopped and redirected the direction of the eastbound Honda to the west. The Honda slid westward approximately 9 m (30 ft) and rotated 90 degrees clockwise. The vehicle came to rest facing south, straddling the south roadside curb. The 12 o'clock direction of the impact force caused the deployment of the Honda's redesigned Supplemental Restraint System. Reconstruction analysis indicated the delta V of the Honda was 69 km/h (43 mph). Upon disengagement with the Honda, the Oldsmobile slid approximately 10 m (33 ft) southeastward. The vehicle came to rest facing southwestward, just off the south side of the road. The barrier equivalent delta V of the Oldsmobile was 80 km/h (50 mph). Refer to the crash schematic **Figure 2**.

Post-Crash

Police, fire and EMS personnel responded to the crash. The occupants of both vehicles required extrication and were transported to a Level 1 trauma center located within 16 km (10 miles) of the crash site. Both vehicles were towed from the scene and secured pending a police investigation.

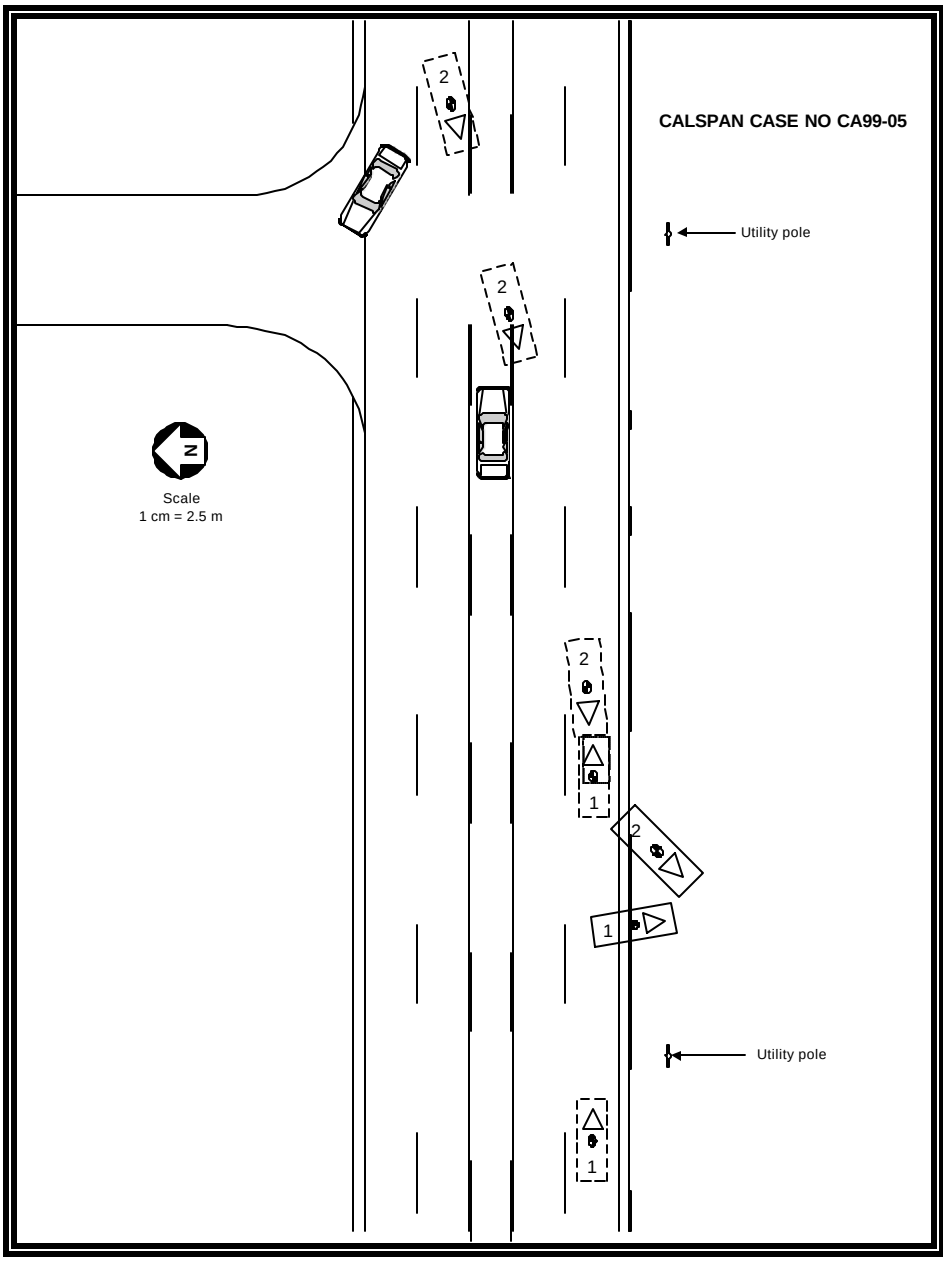

Figure 2: Crash Scene Schematic.

AIR BAG VEHICLE - 1998 Honda Accord

The 1998 Honda Accord, 2-door, was identified by the Vehicle Identification Number: 1HGCG3246WA (production sequence deleted). It was manufactured in February 1998. The vehicle was equipped with a 2.3 liter, I-4 engine linked to a 4-speed automatic transmission. The digital odometer could not be read at the inspection. The vehicle was equipped with manual 3-point lap and shoulder belt systems for the 4 outboard occupants. The Supplemental Restraint System consisted of redesigned frontal air bags for the driver and front right passenger.

Exterior Damage

Figures 3 and 4 are the front and left lateral views of the Honda. The vehicle sustained direct contact damage across the entire 147 cm (58 in) frontal end width. The crush profile measured at the elevation of the front bumper was as follows: C1=68.3 cm (26.9 in), C2=71.6 cm (28.2 in), C3= 76.7 cm (30.2 in), C4=69.9 cm (27.2 in), C5=49.5 cm (19.5 in), C6=46.7 cm (18.4 in). The energy of the impact was managed by the vehicle's primary structures forward of the instrument panel. The left and right wheelbases were fore-shortened 33.3 cm (13.1 in) and 25.7 cm (10.1 in), respectively. The left door was buckled and jammed shut by deformation. The right door remained close and was operational. The roof and left door were removed during the extrication of the occupants. The Collision Deformation Classification (CDC) of the vehicle was 12-FDEW-4. The Barrier Equivalent Speed (delta V) calculated by the barrier model of the WINSMASH program of the Honda was approximately 69 km/h (43 mph). The longitudinal and lateral components were -69 km/h (-43 mph) and 0 km/h, respectively.

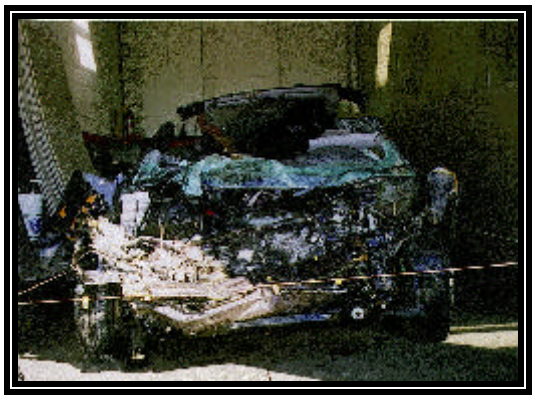

Figure 3: Front view of the Honda.

Figure 4: Left lateral view of the Honda.

VEHICLE 2 - 1982 Oldsmobile Delta 88

Figures 5 and 6 are the left and right side views of the 1982 Oldsmobile Delta 88, 2-door. The Oldsmobile was identified by the Vehicle Identification Number (VIN): 1G3AN37Y1CM (production sequence deleted). The vehicle's power-train consisted of 5.0 liter, V8 engine linked to a 3-speed automatic transmission. The odometer read 273,504 km (169,952 miles) at inspection. The front restraint system consisted of 3-point lap and shoulder belts for the outboard positions.

Exterior Damage

The vehicle sustained direct damage across the entire 165 cm (65 in) frontal end width. The front bumper was displaced from the vehicle by the force of the impact. The crush of the left and right frame rails measured approximately 107 cm (42 in) and 127 cm (50 in) respectively. The left and right wheelbases were foreshortened (19.5 in) and (21.8 in), respectively. The force of the impact deformed the forward third of the vehicle rearward and buckled the roof. The vehicular damage extended rearward to the rear axle. The rear wheel well openings were deformed and the body was displaced from the frame. The left side of the rear axle was dislodged from the differential. The CDC of the damage was 12-FDEW-4. The

barrier equivalent speed (delta V) calculated by the barrier model of the WINSMASH program was approximately 80 km/h (50 mph).

Figure 5: Left side view of the Oldsmobile.

Figure 6: Right side view of the Oldsmobile.

AIR BAG VEHICLE

Interior Damage

The occupant compartment and interior of the Honda Accord sustained moderate damage as a result of the external crash forces, **Figure 7**. The integrity of the occupant compartment was maintained during the crash, however the rescue operations required extrication of the occupants. The roof and left door were removed from the vehicle. Several interior occupant contacts were also identified during the course of the inspection.

The steering assembly consisted of a 4-spoke, tilt steering wheel. The steering wheel was rotated 90 degrees clockwise at inspection. There was no deformation of the steering wheel rim. Displacement of the steering column's shear capsules measured 6.9 cm (2.7 in), **Figure 8**.

Figure 7: View of the Honda interior.

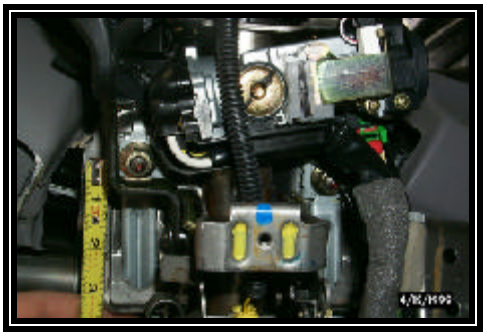

Figure 8: View of the shear capsule displacement.

The intrusion of the left aspect of the instrument panel measured 6.4 cm (2.5 in). The left toe pan intruded 36.3 cm (14.3 in). Two contacts from the driver's lower extremities were noted on the left side knee bolster. The driver's left knee contacted the bolster approximately 48 cm (19 in) left of vehicle centerline and penetrated approximately 10 cm (4 in) into the sub-panel. The right knee contacted the bolster 18 cm (7 in) left of vehicle center in an area that was backed up by a tubular structure. The deformations of the lower instrument panel contributed to the driver's lower extremity injuries.

The front seating system consisted of cloth covered, reclining bucket seats. Both seat backs were reclined rearward to their maximum positions. Presumably, the seat backs were adjusted during the rescue of the occupants. The left front seat track was adjusted to a position 5.3 cm (2.1 in) forward of full rear. The front right seat was adjusted to the full rear position. Two contacts were identified on the right knee bolster attributed to contact from the front right passenger's lower extremities. The contacts were located 24.1 cm (9.5 in) and 41.1 cm (16.2 in) right of vehicle centerline. Refer to **Figure 7**.

Manual Restraint System

The manual front restraint system in the 1998 Honda Accord consisted of a 3-point lap and shoulder belt system. The belt webbing was a continuous loop and spooled from a dual mode locking retractor located in the base of the B-pillar. The buckle was attached to the inboard aspect of the respective bucket seats. The upper anchorages (D-ring) were adjustable. (The roof was cut from the vehicle, therefore the D-ring adjustment was not documented.). The outboard restraints in the rear seat were also 3-point continuous loop lap and shoulder belts.

Inspection of both front restraints revealed positive evidence of usage during the crash. The left front restraint webbing was cut during driver extrication. A latch plate crease and abrasion was identified on the webbing. The webbing of the front right restraint heavily loaded the D-ring, abrading the plastic surface of the hardware. Additionally, the webbing was twisted and jammed in the forward edge of the D-ring**.**

Supplemental Restraint System

The 1998 Honda Accord was equipped with a Supplemental Restraint System that consisted of redesigned driver and front right passenger air bags. The air bags had deployed as a result of the crash. The SRS was controlled by a single point sensing control module located under the mid- aspect of the instrument panel. The control module was identified by the following identification numbers:

5WK4 184

8/02/98
Model No: 77960 S84 A83 M3
TJ CTJJ1ZZBW 06/98 01 19

The driver air bag was configured in the typical manner in the center hub of the steering wheel rim. The width of the H-configuration module cover flaps measured 13.2 cm (5.2 in). The height of the upper and lower flap measured 8.9 cm (3.5 in) and 4.6 cm (1.8 in), respectively. The bag measured 51 cm (20 in)

in its deflated state. It was tethered by two straps located in the 12/6 sectors and vented back through the module. The following identification numbers were embossed on the bag:

Honda
000 4882
26 11 97

The bag fabric was very soiled by the crash debris placed in the vehicle by the responding fire department. There did not appear to any direct evidence of occupant contact.

The front right passenger air bag was a top mount design located in the right aspect of the instrument panel. The air bag module cover flaps were designed in an H-configuration. The symmetrical cover flaps measured 5 cm (2 in) by 26.0 (10.3 in), width by height. The face of the bag measured 71 cm (28 in) by 71 cm (28 in) in its deflated state. The bag was not tethered and was vented by two 5 cm (2 in) diameter ports located in the upper aspect of the bag's side panels. The maximum rearward excursion of the air bag measured 58.9 cm (23.2 in) from the module 41.9 cm (16.5 in) from the instrument panel). The following identification was embossed onto the fabric:

Honda
000 4732
10 02 98

There did not appear to any direct evidence of occupant contact to the front right passenger air bag.

AIR BAG VEHICLE - Occupant Demographics

	Driver	Front Right Passenger
Age/Sex:	28 year old/female	28 year old/male
Height:	170 cm (67 in)	183 cm (72 in)
Weight:	58 kg (127 lb)	82 kg (180 lb)
Restraint Usage:	Restrained - 3-pt lap/shoulder	Restrained - 3-pt lap/shoulder
Usage Source:	SCI inspection/observation of the first responders	SCI inspection/observation of the first responders
Medical Outcome:	hospitalized 8 days	hospitalized 5 days

AIR BAG VEHICLE - Driver Injury

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Loss of consciousness - NFS	Moderate (160410.2,0)	Driver air bag
Right pillion fracture (distal end of the tibia)	Moderate (853404.2,1)	Floor pan/foot controls

Left navicular fracture	Moderate (852200.2,2)	Floor pan/foot controls
Multiple abrasions to lower extremities, bilateral - NFS	Minor (890202.1,1) Minor (890202.1,2)	Driver's knee bolster
Multiple lacerations to lower extremities, bilateral - NFS	Minor (890600.1,1) Minor (890600.1,2)	Driver's knee bolster
Chest abrasions - NFS, seat belt related	Minor (490202.1,9)	Inertial loading of seat belt
Abdominal abrasions - NFS, seat belt related	Minor(590202.1,9)	Inertial loading of seat belt
Bowel perforation (repaired surgically)	Serious (540824.3,8)	Inertial loading of seat belt
Sigmoid contusion	Moderate (540810.2,8)	Inertial loading of seat belt

The injuries noted above were referenced in the records of the driver's hospitalization.

AIR BAG VEHICLE - Driver Kinematics

Immediately prior to the crash, the driver of the Honda was seated in a presumed normal posture. She was both restrained by the vehicle's manual 3-point lap and shoulder belt. The driver's seat was adjusted to a mid to rear seat track position. Given the relatively short (2 second) duration of the Oldsmobiles pre-crash trajectory, it is unlikely the driver had time to react to the impending crash.

Upon impact, the force of the impact caused the Honda's redesigned frontal air bags to deploy. The driver responded to the 12 o'clock direction of the impact by exhibiting a forward trajectory. The driver's forward translation caused her to contact and load the manual 3-point restraint system. The forward trajectory of the driver displaced her lower extremities into contact with the knee bolster. These contacts resulted in the lower extremity abrasions and contusions. Coincident with the bolster contact, the forward structures of the vehicle deformed rearward causing the toepan intrusion. The rearward intrusion of the toepan and foot controls caused the driver's foot and ankle fractures. The inertial loading of the seat belts caused the thoracic and intra-abdominal injuries identified above.

As the driver's thoracic and pelvic regions decelerated, the head/neck complex flexed forward and down into contact with the deployed air bag. The occupant's upper chest and head were effectively restrained by the inflated air bags. Contact with the air bags did not result in any identified injury. The use of the manual 3-point restraint in combination with the redesigned Supplemental Restraint System provided the driver of the Honda very effective occupant protection in this high energy impact.

AIR BAG VEHICLE - Front Right Passenger Injury

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Abrasions of the eyelids, bilateral	Minor (297202.1,1) Minor (297202.1,2)	Deployed front passenger air bag
Abrasions of the nose	Minor (290202.1,4)	Deployed front passenger air bag
Chest abrasion - right shoulder to left hip, NFS, seat belt related	Minor (490202.1,9)	Inertial loading of seat belt
Abdominal abrasions - NFS, seat belt related	Minor(590202.1,9)	Inertial loading of seat belt
Mesenteric contusion	Moderate (542010.2,8)	Inertial loading of seat belt
Fracture of the L4 inferior end plate	Moderate (650630.2,8)	Inertial loading of seat belt probable
5 cm contusion right lower extremity	Minor (890402.1,1)	Right knee bolster

The injuries noted above were referenced in the records of the passenger's hospitalization.

AIR BAG VEHICLE - Front Right Passenger Kinematics

Immediately prior to the crash, the front right passenger of the Honda was seated in a presumed normal posture with his seat adjusted to a mid to rear seat track position. He was restrained by the vehicle's 3-point manual lap and shoulder belt. It was unlikely he had time to react to the impending crash considering the short duration (2 second) duration of the Oldsmobile's pre-crash trajectory.

Upon impact, the force of the impact caused the Honda's redesigned frontal air bags to deploy. The passenger responded to the 12 o'clock direction of the impact by exhibiting a forward trajectory. He contacted and then loaded the manual 3-point restraint system. The forward trajectory of the occupant displaced his lower extremities into contact with the knee bolster. These contacts resulted in the lower extremity abrasions and contusions. The inertial loading of the seat belts caused the thoracic and abdominal abrasions and mesenteric contusion identified above.

As the occupant's thoracic and pelvic regions decelerated, the head/neck complex flexed forward and down into contact with the deployed air bag. The occupant's upper chest and head were effectively restrained by the inflated air bags. Contact with the air bags resulted the bilateral eyelid abrasions and the nose abrasion. The combination of the manual 3-point restraint and the redesigned Supplemental Restraint System provided the front right passenger of the Honda very effective occupant protection in this high energy impact.

MEDICAL INTERVENTION

The Honda's occupants were extricated from the vehicle by the responding medical personnel. They were immediately transported via ambulance to a Level 1 trauma center located within 16 km (10 miles) of the crash site. Both individuals were alert and oriented upon admission. The driver was hospitalized for a period of 8 days. During this period, procedures to surgically repair her perforated bowel and bilateral ankle fractures were completed. The passenger was hospitalized primarily to detect the existence of any occult injuries and monitor his recovery from the crash trauma. He was released to home after a period of 5 days.

VEHICLE 2 - Occupant Demographics

	Driver	Front right passenger
Age/Sex:	23 year old/female	25 year old/male
Height:	unknown	unknown
Weight:	unknown	unknown
Restraint Usage:	Unrestrained	Unrestrained
Usage Source:	SCI/police inspection	SCI/police inspection
Medical Outcome:	died 5 days post-crash	died 8 days post-crash

VEHICLE 2 - Driver Injury

Injury	***Severity (AIS 90)***	***Injury Mechanism***
Unconscious on admission w/ neurological deficit, NFS	Severe (160804.4,0)	Steering wheel rim
Sub-arachnoid hemorrhage - left frontal parietal sulci	Serious (140684.3,2)	Steering wheel rim
Fracture of lateral wall of right orbit and right zygomatic arch	Moderate (251200.2,1) Moderate (251800.2,1)	Steering wheel rim
Fracture of lateral wall of left maxillary sinus	Moderate (250800.2,2)	Steering wheel rim
Fracture of bony nasal septum	Minor (251099.1,4)	Steering wheel rim
Nasal bridge laceration	Minor (290600.1,4)	Steering wheel rim
Broken teeth - NFS	Minor (251499.1,9)	Steering wheel rim

Contusion at the body of her pancreas - NFS	Moderate (542899.2,7)	Steering wheel rim
Tear of the transverse colon	Moderate (540820.2,8)	Steering wheel rim
Right hand avulsion - NFS	Minor (790800.1,1)	Unknown
Right closed femur fracture - NFS	Serious (851800.3,1)	Driver's knee bolster
Left open distal femur fracture	Serious (851818.3,2)	Driver's knee bolster

The injuries noted above were referenced in the records of the passenger's hospitalization.

VEHICLE 2 - Front Right Passenger Injury

Injury	***Severity (AIS 90)***	***Injury Mechanism***
Aortic rupture distal to the left subclavian arch	Critical (420210.5,4)	Inertial deceleration
Forehead laceration - left side	Minor (290600.17)	Windshield
Unspecified multiple facial lacerations and abrasions	Minor (290600.1,9) Minor (290202.1,9)	Windshield
Right distal radius fracture	Moderate (752800.2,1)	Unknown
Comminuted left femur shaft fracture	Serious(851814.3,2)	Right side knee bolster
Fracture involving junction of middle third and distal third of right tibia and fibula	Moderate (853420.2,1) Moderate (851606.2,1)	Right side knee bolster
Right third metatarsal fracture	Moderate (852200.2,1)	Toe pan
Chest contusion - NFS	Minor (490402.1,9)	Instrument panel
Fracture of the L4 vertebral body	Moderate (650630.2,8)	Inertial deceleration

The injuries noted above were referenced in the records of the passenger's hospitalization.

VEHICLE 2 - Occupant Kinematics

Immediately prior to the crash, the Oldsmobile's occupants were in the seated vehicle's front seat and unrestrained. At impact, the occupants responded to the 12 o'clock direction of the impact force and exhibited a forward trajectory. The unrestrained driver translated forward and her abdomen and chest contacted the steering wheel rim resulting in the multiple internal injuries referenced above. Her head/neck then flexed forward and down into contact with the steering wheel rim. This contact resulted in the facial

fractures and her closed head injury. Her lower extremities fractures occurred resultant to contact with the knee bolster. The front right passenger similarly translate forward and into contact with the windshield, instrument panel and bolster. His internal injuries were the result of the inertial deceleration associated to contact with the instrument panel.

The occupants of the Oldsmobile were emergently extricated from the vehicle and transported to a Level 1 trauma center. The driver was intubated and unresponsive upon arrival. Her closed head injury resulted in a deep coma. Her pulmonary condition progressed to the development of adult respiratory distress syndrome and she required continuous cardiovascular support. The driver subsequently developed acute renal failure and was listed by the family as DNR (Do not resuscitate). She died from her injuries 5 days post-crash.

Upon arrival the passenger was alert and in severe chest discomfort. A diagnostic angiogram identified an aortic rupture and he was emergently taken in for surgical graft repair. After aggressive resuscitation, he continued to bleed internally and a second surgery was performed. His severe lower extremity fractures resulted in occlusions of multiple lower extremity arteries. These occlusions resulted in eventual amputation of the left leg below the knee. Although aggressive resuscitation continued, the passenger developed renal failure and then multi-organ system failure. He succumbed to his injuries 8 days post-crash.