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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-023
LOCATION - OKLAHOMA
VEHICLE - 1996 GMC SAFARI CARGO VAN
CRASH DATE - August, 1997

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

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15. <i>Supplementary Notes</i> On-site air bag deployment investigation involving a 1996 GMC Safari, cargo van, with manual, three-point, safety belts and dual front air bags, and two horses.					
16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 1996 GMC Safari, cargo van (case vehicle) and two horses. This crash is of special interest because the out-of-position ("in-lap"), front right passenger (3-year-old male) sustained a critical injury from the deploying front right passenger air bag, resulting in his death. The 1996 GMC Safari was traveling west in the outside westbound lane on a four-lane, divided, U.S. trafficway (i.e., both the east and westbound roadways had two through lanes). Several unattended horses were attempting to cross the trafficway, going from north to south. The crash occurred in the outside lane of the westbound roadway. The front of the 1996 GMC Safari struck two horses, causing the 1996 GMC Safari's driver and front right passenger supplemental restraints (air bags) to deploy. The 1996 GMC Safari's "in-lap", front right passenger was seated in a reclined posture, cradled between the front right passenger's (34-year-old father) left arm and chest. The front right seat track was in its rearmost position. This "in-lap" passenger was improperly restrained by the available, active, three-point, lap-and-shoulder, safety belt system. The lap belt portion was around both of the front right passengers, and the shoulder portion was worn only by the father. The 3-year-old sustained, according to his medical records, a critical nonanatomic brain injury, a chin laceration, and contusions to his neck, chest, abdomen, and right forearm. According to his father, he was told that his son had a neck fracture. The driver (45-year-old male) was seated in an upright posture with his seat track located in its rearmost position, and the tilt steering wheel was located in its middle position. The driver was not wearing his available, active, three-point, lap-and-shoulder, safety belt system. He sustained, according to his medical records and interview, a non-displaced fracture of his left distal radius; multiple rib contusions; a laceration in the submandibular area of his mid-neck; abrasions to his forehead, chin, neck, and left hand; and a contusion across his abdomen. The front right passenger was seated in an upright posture, and he sustained, according to his interview, a dislocated right elbow and multiple lacerations to both arms. The two rear cargo area passengers [Left: 13-year-old male; Right: 14-year-old male) were seated in the cargo van on milk crates behind the front seats, respectively. Both sustained minor soft tissue injuries (i.e., lacerations and/or contusions).					
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This on-site investigation was brought to NHTSA's attention on August 5, 1997 by NHTSA's Regional office. This crash involved a 1996 GMC Safari, cargo van (case vehicle) and two horses. The crash occurred in August, 1997, at 11:05 p.m., in Oklahoma and was investigated by the applicable police agency. This crash is of special interest because the out-of-position ("in-lap"), front right passenger [3-year-old, White (non-Hispanic) male] sustained a critical injury from the deploying front right passenger air bag, resulting in his death. This contractor inspected the scene and vehicle on August 7, 1997. This contractor interviewed the front right passenger of the 1996 GMC Safari on Thursday, August 7, 1997, and the driver during 1998. This report is based on the Police Crash Report; interviews with the 1996 GMC Safari's driver, front right passenger, and the investigating police officer; scene and vehicle inspections; occupant kinematic principles; occupant medical records; and this contractor's evaluation of the evidence.

SUMMARY

The 1996 GMC Safari was traveling west in the outside westbound lane on a four-lane, divided, U.S. trafficway and intended to continue traveling westbound (i.e., both the east and westbound roadways had two through lanes). Several horses from a nearby farm had wandered out of an open gate and, subsequently, were attempting to cross the trafficway, going from north to south. The trafficway was not illuminated, and the 1996 GMC Safari's driver did not observe the horses until they appeared a few meters in front of the vehicle. The 1996 GMC Safari's driver attempted to steer to the right and brake, trying to avoid the horses. The crash occurred in the outside lane of the westbound roadway; see **CRASH DIAGRAM** below. Based on the Police Crash Report and the 1996 GMC Safari's driver, the 1996 GMC Safari was going approximately 97-105 km.p.h. (60-65 m.p.h.) prior to the crash.

The front of the 1996 GMC Safari struck two horses, causing the 1996 GMC Safari's driver and front right passenger supplemental restraints (air bags) to deploy. The available evidence indicates that the two horses were traveling side-by-side, with one horse ahead of the other. The 1996 GMC Safari continued slightly to its right, traveling in a west-northwesterly direction before coming to rest heading essentially west-northwestward, straddling the edge line that separated the north roadside from the outside westbound lane, 24.7 meters (81 feet) west of the point of impact. The two horses were knocked westward. One horse came to rest in the outside westbound lane 41.1 meters (135 feet) west of impact, and the other horse came to rest on the north roadside 48.5 meters (159 feet) west of impact.

The 1996 GMC Safari's "out-of-position" front right passenger [104 centimeters and 16 kilograms (41 inches, 35 pounds)] was improperly restrained by the available, active, three-point, lap-and-shoulder, safety belt system. The "in-lap" front right passenger was seated between the front right passenger's (i.e., father's) legs with the lap belt portion around the both of them. The shoulder portion was worn only by the father. Furthermore, there was evidence of bruising to the "in-lap" front right passenger's abdomen, most likely caused by a combination of the lap portion of the safety belt system and the loading to this occupant's abdomen/pelvic area sustained from the momentum of his father (i.e., the front right passenger) who was seated behind him. In

addition, the inspection of the front right seat belt webbing, "D"-ring, and latch plate showed an excessive amount of blood on both the lap and shoulder belt webbing towards the latch plate, as well as stretching to the webbing of the torso portion only. This latter evidence indicates definite usage by the father during the crash.

The 1996 GMC Safari's driver was attempting to steer to the right and brake, trying to avoid the crash. However, because of the short time duration between recognition of the impending danger (i.e., the horses) and the driver's (or any driver's) ability to implement these avoidance actions, the vast majority (if not all) of the 1996 GMC Safari's deceleration and rightward movement occurred at and/or post-crash. As a result of these delayed attempted avoidance maneuvers and the nonuse of the torso/shoulder portion of the front right safety belt, the "in-lap" front right passenger's pre-impact body position did not change just prior to impact. The 1996 GMC Safari's impact with the two horses enabled the 1996 GMC Safari's "in-lap" front right passenger to continue forward with his pelvic/abdominal area loading the lap portion of the safety belt system while his unrestrained torso rotated (i.e., jack knifed) rapidly forward and slightly upward as the 1996 GMC Safari decelerated. This contractor believes that the deployment of the 1996 GMC Safari's dual front air bags was slightly delayed, and the almost simultaneous impact of the second horse was what achieved the deployment threshold. This delayed reaction has been previously found in other Special Crash Investigation cases involving deer or underride type impacts when there is an uneven crush pattern (i.e., damage above bumper is much greater than at bumper). In fact, the front right passenger stated that he thought one horse had already struck the windshield prior to the air bags deploying. The delayed deployment put the "in-lap" front right passenger's forward movement even closer to the front right air bag module just prior to its deployment. The lap belt portion of the front right safety belt system kept him from getting into the path of the deploying front right air bag module's cover flaps and from being lifted by the deploying air bag over the dash and into the windshield. In addition, the lap belt portion kept him from being thrown upwards into the roof and front right header as the air bag expanded. When the front right air bag deployed, it struck the child under his chin, in his neck, and in his chest, knocking him back into the seated front right passenger (i.e., father). Both of them were knocked back into the seat back. At final rest the child was leaning back on the front right passenger's chest still facing forward.

The front right "in-lap" occupant was transported by ambulance to the hospital. He sustained critical injuries and was pronounced dead at the hospital one hour and nine minutes post-crash. Based on the emergency room records, the injuries sustained by the out-of-position ("in-lap"), front right passenger included: a critical nonanatomic brain injury, a chin laceration, and contusions to his neck, chest, abdomen, and right forearm. In addition, the emergency medical technicians noted crepitus to his posterior cervical region and blood coming from his left ear, nose, and mouth. Because the three-year-old child was in full cardiopulmonary arrest up to his arrival (43 minutes post-crash) at the hospital emergency room, the doctors focused upon stabilizing and resuscitating the child. Unfortunately, there is no evidence that radiographs or tomographs were taken, and little documentation was made regarding this passenger's specific injuries. According to his father, he was told that his son had a neck fracture (unknown location). No post mortem examination was performed.

The 1996 GMC Safari was a rear wheel drive, 4x2, ½-ton, extended cargo van (VIN: 1GTDM19W7TB-----). The 1996 GMC Safari was not equipped with anti-lock brakes. The 1996 GMC Safari was towed from the scene due to damage. Due to the almost simultaneous horse impacts, which resulted in masked damage, the combined CDC for the 1996 GMC Safari is: **12-FDHW-6 (0)** [maximum crush was 39 centimeters (15.4 inches) above the bumper at C₂]. The WinSMASH reconstruction program, barrier algorithm, was used on the 1996 GMC Safari's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.7 km.p.h. (17.2 m.p.h.), -27.7 km.p.h. (-17.2 m.p.h.), and 0 km.p.h. (0 m.p.h.).

The 1996 GMC Safari's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, but their width is unknown. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 65 centimeters (25.6 inches). There was contact evidence readily apparent on the driver's air bag (i.e., a vertical skin transfer on the right side of the air bag and scattered blood spots on both the front and back surfaces; in addition, there were scratches on the top of the back surface, near the one o'clock position, from contact with the intruding windshield glazing).

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 44 centimeters (17.3 inches) and a width of approximately 58 centimeters (22.8 inches). There was contact evidence readily apparent on the fabric of the front right air bag. The inspection revealed an area of lateral blue cloth transfers, primarily in the top left quadrant of the front surface. In addition there were scattered blood spots to the top and front portions of the air bag, and there was an area of skin transfer which began on the left portion of the top surface and continued downward onto the left side of the front surface.

The inspection of the 1996 GMC Safari's interior revealed hair on the armrest of the driver's door and indentations and scuff marks to areas below both the center and right instrument panels, presumably from knee contacts. The rearview mirror was askew and the top portion of the steering wheel rim was bent forward, towards the windshield. Finally, there was an area of contact on the back side of the driver's seat, presumably from contact by the rear passenger seated (i.e., on a milk carton crate) on the left side of the cargo area.

Immediately prior to the crash, the out-of-position ("in-lap"), front right passenger was seated in a reclined posture, cradled between the front right passenger's left arm and chest, with his feet dangling over the front edge of the seat's cushion, angled downward, and both arms in his lap. The front right seat track was in its rearmost position.

The 1996 GMC Safari's driver [45-year-old, White (non-Hispanic) male] was seated in an upright posture with his back against the seat back, his left foot on the floor, his right foot moving between the accelerator and the brake, and both hands on the steering wheel. His seat track was located in its rearmost position, the seat back was upright, and the tilt steering wheel was located in its middle position. The 1996 GMC Safari's driver [188 centimeters and 113 kilograms (74 inches, 250 pounds)] was not wearing his available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the hospital. He sustained moderate injuries and was treated and released; however, he subsequently had additional treatment including an outpatient surgery. According to his medical records and interview, the injuries sustained by the 1996 GMC Safari's driver included: a non-displaced fracture of his left distal radius; multiple rib contusions; a laceration in the submandibular area of his mid-neck; abrasions to his forehead, chin, neck, and left hand; and a contusion across his abdomen.

The 1996 GMC Safari's front right passenger [34-year-old, White (non-Hispanic) male] was seated in an upright posture with his back against the seat back, both feet on the floor, and his left arm holding his "in-lap" son. The exact position of his right arm/hand just prior to impact is unknown. His seat track was located in its rearmost position, and the seat back was upright. The 1996 GMC Safari's front right passenger [178 centimeters and 82 kilograms (70 inches, 180 pounds)] was improperly restrained by his available, active, three-point, lap-and-shoulder, safety belt system. The lap portion was also around his three-year-old son who was seated between his legs. The front right passenger was transported by ambulance to the hospital. He sustained minor injuries and was treated and released. According to his interview, the injuries sustained by the front right passenger included: a dislocated right elbow and multiple lacerations to both arms.

The 1996 GMC Safari's two cargo area passengers [**Left:** 13-year-old, White (non-Hispanic) male; **Right:** 14-year-old, White (non-Hispanic) male] were seated in the cargo area of the van on milk crates behind the front seats, respectively. Both were leaning forward, but exactly which way they were facing is unknown, with their feet on the floor and their arms resting on their knees. The 1996 GMC Safari's cargo area left passenger [160 centimeters and 50 kilograms (63 inches, 110 pounds)] and cargo area right passenger [157 centimeters and 50 kilograms (62 inches, 110 pounds)] had no restraints available to them. Both were transported by ambulance to the hospital. They sustained minor injuries and were treated and released. According to the interview with his father (i.e., driver) and his ambulance records, the 1996 GMC Safari's cargo area left passenger sustained multiple contusions and lacerations. According to the interview with his father (i.e., driver), the cargo area right passenger sustained multiple lacerations.

CRASH CIRCUMSTANCES

The 1996 GMC Safari was traveling west in the outside westbound lane on a four-lane, divided, U.S. trafficway (**Figure 1**) and intended to continue traveling westbound (i.e., both the east and westbound roadways had two through lanes). Several horses from a nearby farm had wandered

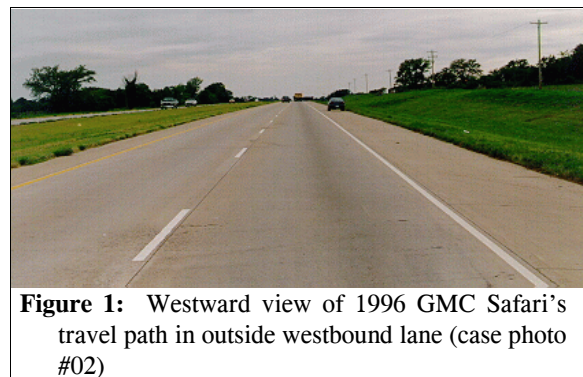


Figure 1: Westward view of 1996 GMC Safari's travel path in outside westbound lane (case photo #02)

out of an open gate and, subsequently, were attempting to cross the trafficway, going from north to south. The trafficway was not illuminated, and the 1996 GMC Safari's driver did not observe the horses until they appeared a few meters in front of the vehicle. The 1996 GMC Safari's driver attempted to steer to the right and brake, trying to avoid the horses. The crash occurred in the outside lane of the westbound roadway; see **CRASH DIAGRAM** below. Based on the Police Crash Report and the 1996 GMC Safari's driver, the 1996 GMC Safari was going approximately 97-105 km.p.h. (60-65 m.p.h.) prior to the crash.

The U.S. highway was straight and level at the area of impact (i.e., actual slope was 1.5%, positive to the west). The pavement was concrete, and the width of the both westbound travel lanes was 3.7 meters (12 feet). The shoulders were improved (i.e., bituminous). The north side of the westbound road had a 3.2 meters (10.5 feet) paved shoulder and the south side had a 1.3 meters (4.3 feet) paved shoulder, prior to the 10 meter (33 feet) wide unprotected grassy median. Pavement markings consisted of a single solid yellow edge line on the south side of the roadway, a single solid white edge line on the north side of the roadway, and the two westbound lanes were divided by a dashed white line. The estimated coefficient of friction was 0.75 when dry. There were no visible traffic controls. The posted speed limit was 105 km.p.h. (65 m.p.h.). At the time of the crash the light condition was dark, the atmospheric condition was clear and the road pavement was dry. Traffic density was light, and the site of the crash was primarily of rural undeveloped farm land with periodic industrial/commercial buildings. In addition, there was a residential/farm driveway within approximately 30 meters (100 feet) of the crash site (**Figure 2**).



Figure 2: 1996 GMC Safari's westward travel path in outside westbound lane looking eastward from just west of point of impact; Note: divided trafficway, minimal upgrade toward west, and driveway intersecting from north (case photo #04)



Figure 3: 1996 GMC Safari's frontal damage viewed from front with contour gauge present and showing bumper level crush (case photo #06)



Figure 4: Overhead view of 1996 GMC Safari's frontal damage with contour gauge present showing above bumper crush and uneven crush profile (case photo #11)

The front of the 1996 GMC Safari (**Figures 3 and 4** above, and **Figures 5 and 6**) struck two horses (**Figure 7**), causing the 1996 GMC Safari's driver and front right passenger supplemental restraints (air bags) to deploy. The available evidence indicates that the two horses were traveling side-by-side, with one horse ahead of the other. The 1996 GMC Safari continued slightly to its right, traveling in a west-northwesterly direction before coming to rest heading essentially west-northwestward, straddling the edge line that separated the north roadside from the outside westbound lane, 24.7 meters (81 feet) west of the point of impact. The two horses were knocked westward. One horse came to rest in the outside westbound lane 41.1 meters (135 feet) west of impact, and the other horse came to rest on the north roadside 48.5 meters (159 feet) west of impact.



Figure 5: 1996 GMC Safari's frontal, uneven, crush profile from impacting two horses, viewed from left of front, with contour gauge set at bumper level (case photo #07)



Figure 6: 1996 GMC Safari's frontal, uneven, crush profile from impacting two horses, viewed from right of front, with contour gauge set at bumper level (case photo #17)

CASE VEHICLE

The 1996 GMC Safari was a rear wheel drive, 4x2, ½-ton, two-passenger, three-door, extended cargo van (VIN: 1GTDM19W7TB-----) equipped with power-assisted, worm-and-gear steering, a 4.30L, CFI, V-6 engine, and a four-speed automatic transmission with overdrive. Braking was achieved by a power-assisted, front disc and rear drum, four-wheel anti-lock system. The 1996 GMC Safari's wheelbase was 282 centimeters (111.0 inches), and the odometer reading at inspection is unknown because the 1996 GMC Safari was equipped with an electronic odometer.

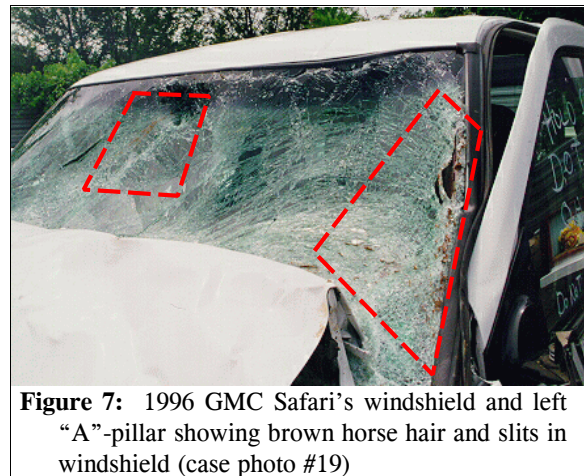


Figure 7: 1996 GMC Safari's windshield and left "A"-pillar showing brown horse hair and slits in windshield (case photo #19)

Inspection of the vehicle's interior revealed electronic window and door locks; adjustable, box-mounted, front bucket seats with integral head restraints; and continuous loop, three-point, lap-and-shoulder, safety belt systems at the front outboard positions. There were no other designated seating positions in the vehicle. The rear cargo area (i.e., sheet metal floor and sides)

Case Vehicle (Continued)

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had 4.825 cubic meters (170.4 cubic feet) of space. The front seat belt systems were equipped with manually operated height adjusters for the “D”-rings. The vehicle was equipped with knee bolsters for both the driver and front right passenger, both of which had evidence of knee contact (i.e., scuffing but no deformation). Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both front seat air bags deployed as a result of the 1996 GMC Safari’s frontal impact with the two horses (**Figure 8**).



Figure 8: 1996 GMC Safari’s deployed driver and front right passenger air bags; Note: blood on both air bags, contact evidence on windshield, and distorted rearview mirror (case photo #26)



Figure 9: Close-up of interior surface of 1996 GMC Safari’s left windshield showing black plastic transfer from steering wheel rim contact and possible skin transfer from driver’s hand contact (case photo #30)

The inspection of the 1996 GMC Safari’s interior revealed a black plastic transfer to the lower left windshield (**Figure 9**) from the upper half of the steering wheel rim, which had been bent forward approximately 3 centimeters (1.2 inches) towards the intruding windshield (**Figure 10**). This interaction resulted from two forces. First, the steering wheel rim was bent backwards as a result of the driver loading the deploying driver’s air bag causing the air bag to expand backwards bending the steering wheel rim. Second, at least one of the two horses struck the left and center portions of the windshield causing the windshield’s glazing to intrude longitudinally inward toward the steering wheel rim. The interior inspection also revealed skin and hair on the armrest of the driver’s door, most likely from the driver’s left arm; scuffs to both the driver and



Figure 10: Vertical lateral view of 1996 GMC Safari’s steering wheel rim from left showing deformation to top of rim from loading (case photo #25)

front right passenger knee bolsters, one from the driver's right knee and the other from the front right passenger's right knee (**Figure 11**); a scuff to the right side of the center instrument panel, most likely from the front right passenger's left knee (**Figure 11**); a skin and blood transfer to the windshield on the driver's side from the driver's left hand contact at impact (**Figure 9** above); and the rearview mirror was askew. The shear capsules on the steering column were most likely moved, but the exact amount was not documented during the inspection. Finally, there was an area of contact on the back side of the driver's seat, presumably from contact by the rear passenger seated (i.e., on a milk carton crate) on the left side of the cargo area (**Figures 12 and 13**).



Figure 11: Contact evidence on 1996 GMC Safari's right knee bolster and right side of center instrument panel (case photo #34)



Figure 12: 1996 GMC Safari's rear cargo area showing one of the milk crates used as seats by the two cargo area passengers; Note: contact to back of driver's seat back (case photo #45)

CASE VEHICLE DAMAGE

The 1996 GMC Safari's direct contact with the two horses involved parts of the entire front bumper fascia. This contact was sporadic since it only involved the legs of the horses. The 1996 GMC Safari's entire frontal plane, above the bumper, showed direct contact from the torso of the horses, giving the uneven crush pattern. Direct damage began at the front right bumper corner and extend a measured distance of 172 centimeters (67.7 inches) across the 1996 GMC Safari's front end. The direct damage width happened to be the same width as the field L (**Figures 3 and 4** above). Maximum crush was measured as 39 centimeters (15.4 inches) above the bumper at C₂. The wheelbase on the 1996 GMC Safari's left side was unchanged while the right side was shortened 1 centimeters (0.4 inches). The 1996 GMC Safari's front bumper, bumper fascia, grille, hood, and both the right and left headlight and turn signal assemblies were directly damaged and crushed rearward. The hood was folded back to the windshield with direct damage from one of the horses extending up to the windshield header on the driver's side with both "A"-pillars (i.e., brown horse hair) being contacted (**Figure 7** above). The 1996 GMC Safari's left front tire was physically restricted, but

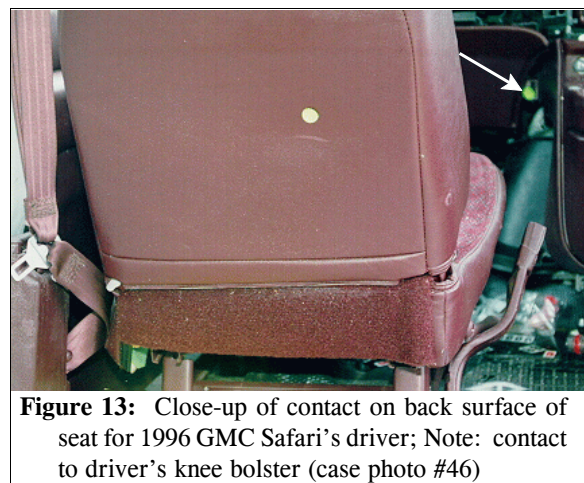


Figure 13: Close-up of contact on back surface of seat for 1996 GMC Safari's driver; Note: contact to driver's knee bolster (case photo #46)

the tire was not damaged, deflated, or rotated (i.e., in or outwards). The 1996 GMC Safari sustained induced damage as well to both the right and left fenders. Remote buckling was also found on the left portion of the 1996 GMC Safari's roof just above the driver's door.

Due to the almost simultaneous horse impacts, which resulted in masked damage, the combined CDC for the 1996 GMC Safari is: **12-FDHW-6 (0)**. The WinSMASH reconstruction program, barrier algorithm, was used on the 1996 GMC Safari's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.7 km.p.h. (17.2 m.p.h.), -27.7 km.p.h. (-17.2 m.p.h.), and 0 km.p.h. (0 m.p.h.). The 1996 GMC Safari was towed from the scene due to damage.

AUTOMATIC RESTRAINT SYSTEM

The 1996 GMC Safari was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both air bags deployed as a result of the frontal impact with the two horses. The 1996 GMC Safari's driver air bag was located in the steering wheel hub. The module cover consisted of three cover flaps made of thick vinyl. The top cover flap had dimensions of 22 centimeters (8.7 inches) at the horizontal seam and 6 centimeters (2.4 inches) vertically. The bottom part of the module cover was designed in a symmetrical "I"-configuration with dimensions of 10 centimeters (3.9 inches) at the left and right horizontal seams and 10 centimeters (3.9 inches) vertically.



Figure 14: 1996 GMC Safari driver air bag module's three cover flaps (i.e., top, left, and right) showing no occupant contact evidence (case photo #24)



Figure 15: 1996 GMC Safari's deployed driver air bag showing vertical skin transfer (yellow tape) and blood spots on right side of bag (case photo #28)

An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps (**Figure 14**). The driver's air bag was designed with two tethers, but their width is unknown. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 65 centimeters (25.6 inches). There was visible contact evidence readily apparent on the driver's air bag, primarily to the right half of the air bag. The evidence consisted of a vertical skin transfer on the right side of the air bag and scattered blood smears and

blood drainage spots which extended from the top edge to just above the bottom edge (Figure 15 above and see SELECTED PHOTOGRAPHS, Figure 22 below). There was blood splatter to the backside of the air bag on the upper portion. In addition, there were scratches on the top of the back surface, near the one o'clock position, from contact with the intruding windshield glazing.

The front right passenger's air bag was located in the middle of the instrument panel (Figure 16). The module cover consisted of asymmetrical "H"-configuration cover flaps made of thick vinyl over a sheet metal frame/liner which acted as the hinge point for the deploying flaps. The flap's dimensions were: 32 centimeters (12.6 inches) at the horizontal seam and 6 centimeters (2.4 inches) vertically for the upper flap and 7 centimeters (2.8 inches) vertically for the lower flap. The top hinged flap was not capable, due to its height, of contacting the windshield in this crash. The profile of the 1996 GMC Safari's instrument panel resulted in a 0 centimeter (0.0 inch) setback of the hinged edge of the bottom cover flap relative to the protruding right instrument panel. In addition, there was a 4 centimeter (1.6 inch) set back from the leading edge of the instrument panel to the hinged edge of the top cover flap. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps (Figure 17). The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 44 centimeters (17.3 inches) and a width of approximately 58 centimeters (22.8 inches).



Figure 16: Vertical view of 1996 GMC Safari's deployed front right passenger air bag showing blood evidence on air bag; Note: passenger handle-type grip above top cover flap (case photo #36)

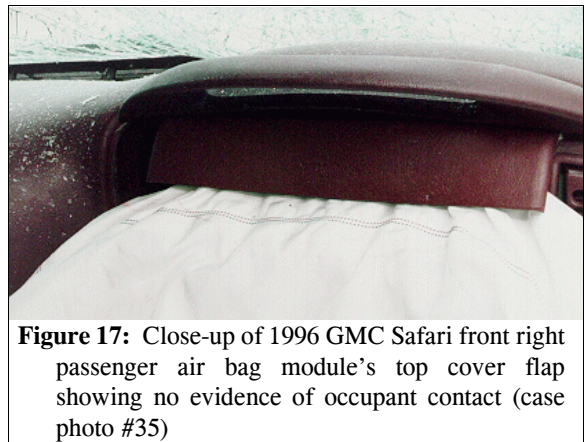


Figure 17: Close-up of 1996 GMC Safari front right passenger air bag module's top cover flap showing no evidence of occupant contact (case photo #35)

There was contact evidence readily apparent on the fabric of the front right air bag. The inspection revealed an area of lateral blue cloth transfers, primarily in the top left quadrant of the front surface. The blue cloth transfers most likely came from the out-of-position passenger's shirt

during the deployment sequence. The lateral blue cloth transfers started just above the top horizontal edge and continued down the front of the air bag for an additional 15 centimeters (5.9 inches). Further, there were scattered blood spots to the top and front portions of the air bag (Figure 18). There was a large blood spot approximately 7 centimeters (2.8 inches) in diameter, towards the center of the air bag, approximately 37 centimeters (14.6 inches) from the left edge. In addition, there was an area of skin transfer which began on the left portion of the top surface (Figure 19 and see **SELECTED PHOTOGRAPHS, Figure 23** below) and continued downward onto the left side of the front surface. The skin evidence at the top of the air bag was approximately 7 centimeters (2.8 inches) wide and started 9 centimeters (3.5 inches) to the right of the left edge of the air bag and just 10 centimeters (3.9 inches) down from the top cover flap hinge. The skin evidence extended forward (towards passenger) 28 centimeters (11.0 inches) to the top horizontal edge of the air bag. The skin evidence continued down the front of the air bag 29 centimeters (11.4 inches) and as it ended the width increased to 14 centimeters (5.5 inches).



Figure 18: 1996 GMC Safari's front right passenger air bag showing cloth and skin transfer along with blood to front portion (case photo #37)



Figure 19: Skin transfer to top portion of 1996 GMC Safari's front right passenger air bag from contact by "in-lap" passenger (case photo #40)

CASE VEHICLE FRONT RIGHT "IN-LAP" PASSENGER KINEMATICS

Immediately prior to the crash, the out-of-position ("in-lap"), front right passenger [3-year-old, White (non-Hispanic) male] was seated in a reclined posture, cradled between the front right passenger's left arm and chest, with his feet dangling over the front edge of the seat's cushion, angled downward, and both arms in his lap. The front right seat track was in its rearmost position.

The 1996 GMC Safari's "out-of-position" front right passenger [104 centimeters and 16 kilograms (41 inches, 35 pounds)] was improperly restrained by the available, active, three-point, lap-and-shoulder, safety belt system. The "in-lap" front right passenger was seated between the front right passenger's (i.e., father's) legs with the lap belt portion around the both of them. The shoulder portion was worn only by the father.



Figure 20: 1996 GMC Safari's front right seat belt showing blood on and stretching to webbing which indicates usage (although improper) during crash (case photo #44)

Furthermore, there was evidence of bruising to the “in-lap” front right passenger’s abdomen, most likely caused by a combination of the lap portion of the safety belt system and the loading to this occupant’s abdomen/pelvic area sustained from the momentum of his father (i.e., the front right passenger) who was seated behind him. In addition, the inspection of the front right seat belt webbing, “D”-ring, and latch plate showed an excessive amount of blood on both the lap and shoulder belt webbing towards the latch plate, as well as stretching to the webbing of the torso portion only (**Figure 20** above). This latter evidence indicates definite usage by the father during the crash.

The 1996 GMC Safari's driver was attempting to steer to the right and brake, trying to avoid the crash. However, because of the short time duration between recognition of the impending danger (i.e., the horses) and the driver’s (or any driver’s) ability to implement these avoidance actions, the vast majority (if not all) of the 1996 GMC Safari’s deceleration and rightward movement occurred at and/or post-crash. As a result of these delayed attempted avoidance maneuvers and the nonuse of the torso/shoulder portion of the front right safety belt, the “in-lap” front right passenger’s pre-impact body position did not change just prior to impact. The 1996 GMC Safari’s impact with the two horses enabled the 1996 GMC Safari’s “in-lap” front right passenger to continue forward with his pelvic/abdominal area loading the lap portion of the safety belt system while his unrestrained torso rotated (i.e., jack knifed) rapidly forward and slightly upward as the 1996 GMC Safari decelerated. This contractor believes that the deployment of the 1996 GMC Safari’s dual front air bags was slightly delayed, and the almost simultaneous impact of the second horse was what achieved the deployment threshold. This delayed reaction has been previously found in other Special Crash Investigation cases involving deer or underride type impacts when there is an uneven crush pattern (i.e., damage above bumper is much greater than at bumper). In fact, the front right passenger stated that he thought one horse had already struck the windshield prior to the air bags deploying. The delayed deployment put the “in-lap” front right passenger’s forward movement even closer to the front right air bag module just prior to its deployment. The lap belt portion of the front right safety belt system kept him from getting into the path of the deploying front right air bag module’s cover flaps and from being lifted by the deploying air bag over the dash and into the windshield. In addition, the lap belt portion kept him from being thrown upwards into the roof and front right header as the air bag expanded. When the front right air bag deployed, it struck the child under his chin, in his neck, and in his chest, knocking him back into the seated front right passenger (i.e., father). Both of them were knocked back into the seat back. At final rest the child was leaning back on the front right passenger’s chest still facing forward.

CASE VEHICLE “IN-LAP” FRONT RIGHT PASSENGER INJURIES

The front right “in-lap” occupant was transported by ambulance to the hospital. He sustained critical injuries and was pronounced dead at the hospital one hour and nine minutes post-crash. Based on the emergency room records, the injuries sustained by the out-of-position (“in-lap”), front right passenger included: a critical nonanatomic brain injury, a chin laceration, and contusions to his neck, chest, abdomen, and right forearm. In addition, the emergency medical technicians noted crepitus to his posterior cervical region and blood coming from his left ear, nose, and mouth. Because the three-year-old child was in full cardiopulmonary arrest up to his arrival

(43 minutes post-crash) at the hospital emergency room, the doctors focused upon stabilizing and resuscitating the child. Unfortunately, there is no evidence that radiographs or tomographs were taken, and little documentation was made regarding this passenger’s specific injuries. According to his father, he was told that his son had a neck fracture (unknown location). No post mortem examination was performed.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with loss of consciousness, GCS=3, pupils fixed and dilated, asystole, and apnea ¹	160824.5 critical	Air bag, front right passenger’s	Certain	Emergency room records
2	Fractured {broken} neck ²	650216.2 moderate	Air bag, front right passenger’s	Probable	Interviewee (other occupant)
3	Laceration under chin involving the subcutaneous tissue with swelling	390600.1 minor	Air bag, front right passenger’s	Probable	Emergency room records
4	Contusion {ecchymosis} and redness neck, not further specified	390402.1 minor	Air bag, front right passenger’s	Probable	Emergency room records
5	Contusion {ecchymosis} and redness chest, not further specified	490402.1 minor	Air bag, front right passenger’s	Certain	Emergency room records
6	Contusion {ecchymosis} and redness abdomen, not further specified	590402.1 minor	Lap belt portion of front right safety belt system ³	Probable	Emergency room records
7	Contusion {ecchymosis} and redness right forearm, not further specified	790402.1 minor	Air bag, front right passenger’s	Probable	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

The 1996 GMC Safari’s driver [45-year-old, White (non-Hispanic) male] was seated in an upright posture with his back against the seat back, his left foot on the floor, his right foot moving between the accelerator and the brake, and both his hands on the steering wheel. His seat track

¹ The following terms are defined in DORLAND’S ILLUSTRATED MEDICAL DICTIONARY as follows:
apnea (ap’ne-a): 1. cessation of breathing. 2. asphyxia.
asystole (a-sis’to-le): cardiac standstill or arrest; absence of a heartbeat.

² According to the emergency medical technicians, crepitus was noted to the posterior cervical region during their evaluation of this patient. In this contractor’s opinion, this child most likely sustained an air bag deployment-related cervical spinal cord lesion with cervical fracture and/or dislocation; however, because no post-mortem examination was performed and no radiographs (i.e., x-rays) or tomographs (i.e., CT/CAT scans) were taken, there is no substantiation.

³ The bruising to the “in-lap” front right passenger’s abdomen was most likely caused by a combination of the lap portion of the safety belt system and the loading to this occupant’s abdomen/pelvic area sustained from the momentum of his father (i.e., the front right passenger) who was seated behind him.

was located in its rearmost position, the seat back was upright, and the tilt steering wheel was located in its middle position. The 1996 GMC Safari's driver [188 centimeters and 113 kilograms (74 inches, 250 pounds)] was not wearing his available, active, three-point, lap-and-shoulder, safety belt system. In addition, there was no evidence of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading or blood evidence which both would have been present had it been in use during the crash (**Figure 21**). The shoulder belts upper anchorage was adjusted in the full down location.



Figure 21: 1996 GMC Safari's outstretched driver seat belt showing no evidence of usage during crash (case photo #32)

The 1996 GMC Safari's driver was attempting to steer to the right and brake, trying to avoid the crash. However, because of the short time duration between recognition of the impending danger (i.e., the horses) and the driver's (or any driver's) ability to implement these avoidance actions, the vast majority (if not all) of the 1996 GMC Safari's deceleration and rightward movement occurred at and/or post-crash. As a result of these attempted avoidance maneuvers and nonuse of his safety belt restraints, the driver's pre-impact body position did not change just prior to impact. The 1996 GMC Safari's impact with the two horses enabled the 1996 GMC Safari's driver to continue forward towards the steering wheel assembly as the 1996 GMC Safari decelerated. As discussed above this contractor believes that the deployment of the 1996 GMC Safari's dual front air bags was slightly delayed. The delayed deployment put the driver's forward movement even closer to the driver's air bag module just prior to its deployment. Almost simultaneously the driver took his left hand off the steering wheel and put it up towards the windshield, attempting instinctively, according to the driver, to keep the horse from coming through the windshield. As the horse contacted the windshield and the windshield intruded into the interior, the back (i.e., dorsal surface) driver's left hand contacted the windshield momentarily abrading it and fracturing his left distal radius (i.e., there was skin and blood on the windshield above the steering wheel rim; **Figure 9** above). The large [i.e., 113 kilograms (250 pounds)], unrestrained driver loaded the deploying driver's air bag with such force that the air bag expanded backwards causing the upper portion of the steering wheel rim to be bent forward into the intruding windshield. In addition, the driver's impact into the deploying air bag caused the lower portion of the air bag to become deflated, enabling him to bruise his lower ribs, bilaterally, and contuse his abdomen. As a result of the interior contacts, the force of the deploying air bag, and the rightward steering maneuver that took effect post-impact, the driver rebounded backwards and slightly to his left into his seat back. During this movement the driver's bleeding left hand subsequently contacted the arm rest pad of the driver's door depositing blood and hair. The exact final rest position of the driver is unknown.

CASE VEHICLE DRIVER INJURIES

IN97-023

The driver was transported by ambulance to the hospital. He sustained moderate injuries and was treated and released; however, he subsequently had additional treatment including an outpatient surgery. According to his medical records and interview, the injuries sustained by the 1996 GMC Safari's driver included: a non-displaced fracture of his left distal radius; multiple rib contusions; a laceration in the submandibular area of his mid-neck; abrasions to his forehead, chin, neck, and left hand; and a contusion across his abdomen.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture, non-displaced, left distal radius	752802.2 moderate	Windshield reinforced by exterior object: weight of an underridden horse	Certain	Emergency room records
2	Contusions to ribs with pain from approximately 6 th rib down bilaterally	450202.1 minor	Steering wheel hub/spokes and rim	Probable	Emergency room records
3	Abrasion, superficial, 5 x 1.5 cm (2.0 x 0.6 in) left forehead	290202.1 minor	Air bag, driver's	Certain	Emergency room records
4	Abrasion, superficial, 3 x 3 cm (1.2 x 1.2 in) to chin	290202.1 minor	Air bag, driver's	Certain	Emergency room records
5	Abrasion, superficial, 4 x 2 cm (1.6 x 0.8 in) anterior neck	390202.1 minor	Air bag, driver's	Certain	Emergency room records
6	Laceration in submandibular area of mid-neck	390600.1 minor	Noncontact injury: flying glass	Probable	Emergency room records
7	Ecchymosis across mid-abdomen	590402.1 minor	Steering wheel rim	Probable	Emergency room records
8	Abrasion, superficial, 2 cm (0.8 in), dorsal, proximal left hand	790202.1 minor	Windshield, left	Probable	Emergency room records

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The 1996 GMC Safari's front right passenger [34-year-old, White (non-Hispanic) male] was seated in an upright posture with his back against the seat back, both feet on the floor, and his left arm holding his "in-lap" son. The exact position of his right arm/hand just prior to impact is unknown. According to the front right passenger's interview, his right arm was holding onto the hand rail mounted on the dash. Upon reflection, the front right passenger most likely reached for the hand rail as a result of the crash, attempting to brace himself against his forward movement which resulted from the crash forces. This scenario could explain the front right passenger's recollection of where his right arm/hand was. His seat track was located in its rearmost position, and the seat back was upright. The 1996 GMC Safari's front right passenger [178 centimeters and

82 kilograms (70 inches, 180 pounds)] was improperly restrained by his available, active, three-point, lap-and-shoulder, safety belt system. The lap portion was also around his three-year-old son who was seated between his legs. The inspection of the front right seat belt webbing, "D"-ring, and latch plate showed evidence of heat abrasion to the "D"-ring, an excessive amount of blood on both the lap and shoulder belt webbing towards the latch plate, and stretching to the webbing of the torso portion only (**Figure 20** above). The upper anchorage for the front right shoulder belt portion was adjusted to the full-up position.

The 1996 GMC Safari's driver was attempting to steer to the right and brake, trying to avoid the crash. However, because of the short time duration between recognition of the impending danger (i.e., the horses) and the driver's (or any driver's) ability to implement these avoidance actions, the vast majority (if not all) of the 1996 GMC Safari's deceleration and rightward movement occurred at and/or post-crash. As a result of these attempted avoidance maneuvers and independent of the improper use of his front right safety belt system, the front right passenger's pre-impact body position did not change just prior to impact. The 1996 GMC Safari's impact with the two horses enabled the 1996 GMC Safari's front right passenger to continue forward as the 1996 GMC Safari decelerated. As discussed above this contractor believes that the deployment of the 1996 GMC Safari's dual front air bags was slightly delayed. The delayed deployment enabled the front right passenger to load and lock-up his safety belt system and limit his forward movement toward the front right air bag module just prior to its deployment. This passenger's only direct interaction with the deploying front right air bag most likely occurred when his right arm, which was reaching for the hand rail on the right dash, was deflected back and to the right dislocating his right elbow from the sudden rotational force or enabling his right elbow to impact the right instrument panel or the right front door panel causing the lesion. The deploying front right air bag subsequently knocked the "in-lap" passenger back into this passenger's chest knocking this passenger back into his seat back. The exact position of the front right passenger at final rest is unknown, but he was most likely facing forward near his original seating posture.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right passenger was transported by ambulance to the hospital. He sustained minor injuries and was treated and released⁴. According to his interview, the injuries sustained by the front right passenger included: a dislocated right elbow and multiple lacerations to both arms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Dislocation right elbow, not further specified	750630.1 minor	Right instrument panel	Possible	Interviewee (same person)

⁴ The front right passenger and the two cargo area passengers were transported in the same ambulance. The medical facility to which they were initially taken refused them for specific reasons and they were subsequently treated at another facility. During the interview their treating facilities were incorrectly identified and signed medical releases were obtained for the wrong hospitals. By the time this contractor had figured out what had happened, it was decided not to pursue their medical records because of the time lapse that had already occurred.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Lacerations {cuts}, multiple, to bilateral arms, not further specified	790600.1 minor	Noncontact injury: flying glass	Probable	Interviewee (same person)

CASE VEHICLE CARGO AREA LEFT PASSENGER KINEMATICS

The 1996 GMC Safari's cargo area left passenger [13-year-old, White (non-Hispanic) male] was seated in the cargo area of the van on a milk crate behind the driver's seat. He was leaning forward, but exactly which way he was facing is unknown, with his feet on the floor and his arms resting on his knees. The 1996 GMC Safari's cargo area left passenger [160 centimeters and 50 kilograms (63 inches, 110 pounds)] had no restraints available to him.

The 1996 GMC Safari's driver was attempting to steer to the right and brake, trying to avoid the crash. However, because of the short time duration between recognition of the impending danger (i.e., the horses) and the driver's (or any driver's) ability to implement these avoidance actions, the vast majority (if not all) of the 1996 GMC Safari's deceleration and rightward movement occurred at and/or post-crash. As a result of these attempted avoidance maneuvers and independent of the availability of any safety restraints, the cargo area left passenger's pre-impact body position did not change just prior to impact. The 1996 GMC Safari's impact with the two horses enabled the cargo area left passenger to continue forward as the 1996 GMC Safari decelerated. He contacted the back of the driver's seat (**Figure 13** above) and the floor. In addition, he may have contacted his brother (i.e., the cargo area right passenger) and/or the dash prior to rebound back towards the cargo area. At final rest he was lying on the floor in the rear cargo area.

CASE VEHICLE CARGO AREA LEFT PASSENGER INJURIES

The 1996 GMC Safari's cargo area left passenger was transported by ambulance to the hospital. He sustained minor injuries and was treated and released. According to the interview with his father (i.e., driver) and his emergency medical service treatment records, the 1996 GMC Safari's cargo area left passenger sustained multiple contusions and lacerations.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {bruise} mid-shaft left tibia with erythema	890402.1 minor	Seat, back support, driver's	Probable	EMS treatment record
2	Contusions {bruises}, assorted, all over	990400.1 minor	Unknown contact mechanism	Unknown	Interviewee (driver)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Lacerations {cuts} to forehead, not further specified	290600.1 minor	Noncontact injury: flying glass	Possible	Interviewee (driver)
4	Lacerations {cuts} to face, not further specified	290600.1 minor	Noncontact injury: flying glass	Possible	Interviewee (driver)
5	Lacerations {cuts} to bilateral arms, not further specified	790600.1 minor	Noncontact injury: flying glass	Possible	Interviewee (driver)

CASE VEHICLE CARGO AREA RIGHT PASSENGER KINEMATICS

The 1996 GMC Safari's cargo area right passenger [14-year-old, White (non-Hispanic) male] was seated in the cargo area of the van on a milk crate behind the front right seat. He was leaning forward, but exactly which way he was facing is unknown, with his feet on the floor and his arms resting on his knees. The 1996 GMC Safari's cargo area right passenger [157 centimeters and 50 kilograms (62 inches, 110 pounds)] had no restraints available to him.

The 1996 GMC Safari's driver was attempting to steer to the right and brake, trying to avoid the crash. However, because of the short time duration between recognition of the impending danger (i.e., the horses) and the driver's (or any driver's) ability to implement these avoidance actions, the vast majority (if not all) of the 1996 GMC Safari's deceleration and rightward movement occurred at and/or post-crash. As a result of these attempted avoidance maneuvers and independent of the availability of any safety restraints, the cargo area right passenger's pre-impact body position did not change just prior to impact. The 1996 GMC Safari's impact with the two horses enabled the cargo area right passenger to continue forward as the 1996 GMC Safari decelerated. He contacted the front right seat back and the floor. In addition, he may have contacted his brother (i.e., cargo area left passenger) and possibly the dash prior to rebounding back towards the cargo area. At final rest he was lying on the floor in the rear cargo area.

CASE VEHICLE CARGO AREA RIGHT PASSENGER INJURIES

The 1996 GMC Safari's cargo area right passenger was transported by ambulance to the hospital. He sustained minor injuries and were treated and released. According to the interview with his father (i.e., driver), the cargo area right passenger sustained multiple lacerations.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Lacerations {cuts} to face, not further specified	290600.1 minor	Noncontact injury: flying glass	Possible	Interviewee (driver)
2	Lacerations {cuts} to bilateral arms, not further specified	790600.1 minor	Noncontact injury: flying glass	Possible	Interviewee (driver)



Figure 22: Close-up of skin transfer and blood smear along right side of 1996 GMC Safari's driver air bag to left of yellow tape (case photo #29)



Figure 23: Close-up of skin transfer to top portion of the 1996 GMC Safari's front right passenger air bag from contact by "in-lap" passenger (case photo #41)

