TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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GENERAL DYNAMICS REMOTE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 03-41-043B

VEHICLE – 2003 CHEVROLET SILVERADO
LOCATION - STATE OF FLORIDA

CRASH DATE – FEBRUARY 2003

Contract No. DTNH22-01-C-17002

Prepared for:

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

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

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16. Abstract This remote investigation focused on the performance of the Certified Advanced 208-Compliant safety system in a 2003 Chevrolet Silverado. The manufacturer of this vehicle has certified that this 2003 Chevrolet Silverado meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The system included dual stage frontal air bags, seat track position sensors for the front left and front right seats, and an occupant presence sensor for the front right seat. The Chevrolet was also equipped with an Event Data Recorder (EDR) that was not downloaded due to the lack of the appropriate software at the time of the NASS investigation. The Chevrolet was involved in a multiple impact collision with a 1993 Oldsmobile Cutlass Ciera and a 1997 Hyundai Accent. As a result of the initial impact against and the rear of the Oldsmobile, the frontal air bags deployed in the Chevrolet. The Chevrolet was occupied by a 28-year-old male driver, a 24-year-old female front right occupant, a 4-year-old female rear left occupant, and a 2-year-old male rear right occupant. It should be noted that the child occupants were not restrained in child safety seats. The 24-year-old female front right occupant was not listed on the police report; however, the driver stated to the NASS researcher that this occupant was in the vehicle at the time of the crash. The driver and the two child occupants of the Chevrolet were not injured. The front right occupant sustained a forehead contusion and was transported to a local hospital were she was treated and released. The Oldsmobile was occupied by an 80-year-old female driver who was fatally injured in the crash. The Hyundai was occupied by a 36-year-old female driver that sustained police reported non-incapacitating injuries. The driver of the Hyundai was transported to a local hospital were she was treated and released. All three vehicles sustained disabling damage and were towed from the crash scene.			
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NASS/SCI COMBO CASE NO. 03-41-043B
SUBJECT VEHICLE – 2003 CHEVROLET SILVERADO
LOCATION - STATE OF FLORIDA
CRASH DATE – FEBRUARY 2003

BACKGROUND

This remote investigation focused on the performance of the Certified Advanced 208-Compliant safety system in a 2003 Chevrolet Silverado. The manufacturer of this vehicle has certified that this 2003 Chevrolet Silverado meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The system included dual stage frontal air bags, seat track position sensors for the front left and front right seats, and an occupant presence sensor for the front right seat. The Chevrolet was also equipped with an Event Data Recorder (EDR) that was not downloaded due to the lack of the appropriate software at the time of the NASS investigation. The Chevrolet **(Figure 1)** was involved in a multiple impact collision with a 1993 Oldsmobile Cutlass Ciera and a 1997 Hyundai Accent. As a result of the initial impact against and the rear of the Oldsmobile, the frontal air bags deployed in the Chevrolet. The Chevrolet was occupied by a 28-year-old male driver, a 24-year-old female front right occupant, a 4-year-old female rear left occupant, and a 2-year-old male rear right occupant. It should be noted that the child occupants were not restrained in child safety seats. The 24-year-old female front right occupant was not listed on the police report; however, the driver stated to the NASS researcher that this occupant was in the vehicle at the time of the crash. The driver and the two child occupants of the Chevrolet were not injured. The front right occupant sustained a forehead contusion and was transported to a local hospital were she was treated and released. The Oldsmobile was occupied by an 80-year-old female driver who was fatally injured in the crash. The Hyundai was occupied by a 36-year-old female driver that sustained police reported non-incapacitating injuries. The driver of the Hyundai was transported to a local hospital were she was treated and released. All three vehicles sustained disabling damage and were towed from the crash scene.

Figure 1. 2003 Chevrolet Silverado.

This crash was initially selected for investigation by PSU 41 of the National Automotive Sampling System (NASS) as Case No: 2003-41-043B. The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) assigned a combined investigative effort of the crash to the General Dynamics SCI team due to the agency's interest in the field performance of the Certified Advanced Compliant safety

system in the 2003 Chevrolet Silverado. This remote effort involved a review of the NASS EDCS file and the preparation of this narrative report.

SUMMARY

Crash Site

This three-vehicle crash occurred during the morning hours of February 2003 in the state of Florida. At the time of the crash, there were no adverse weather conditions and the asphalt road surface was wet. The crash occurred on the northbound lanes of a three-lane turnpike **(Figure 2)**. The northbound roadway was configured with three through traffic lanes and a one-lane on-ramp. A painted gore with white lines divided the on-ramp and northbound roadway. The roadway was bordered with concrete shoulders on the east and west road edge. A concrete "Jersey" median divided the north/south roadway. The northbound lanes curved left at the crash site with a slight positive grade. The advisory speed for the on-ramp was 48 km/h (30 mph). The posted speed limit for the turnpike was 105 km/h (65 mph). The NASS scene schematic is included as **Figure 11** of this report.

Figure 2. Crash site three-lane turnpike.

Vehicle Data – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was identified by the Vehicle Identification Number (VIN): 2GCEC19V93 (production sequence omitted). The odometer reading was unknown due to the lack of power to the vehicle at the time of the inspection. The Silverado was a rental vehicle therefore the history was unknown. The vehicle was a four-door pick-up that was equipped with a 4.8-liter, eight-cylinder engine with rear wheel drive, 4-speed automatic transmission, and 4-wheel disc brakes with ABS. The Chevrolet was equipped with Goodyear Wrangler S\T radial tires, size P235/75R16. The maximum pressure for these tires was 303 kpa (44 psi). The manufacture recommended tire pressure for this vehicle was 241 kpa (35 psi). The specific tire data is listed in the table below:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	262 kpa (38 psi)	8 mm (10/32)	No	None
LR	269 kpa (39 psi)	8 mm (10/32)	No	None
RF	269 kpa (39 psi)	9 mm (11/32)	No	None
RR	262 kpa (38 psi)	7 mm (9/32)	No	None

The Chevrolet was configured with a three-passenger spilt bench front seat with a center folding seat/armrest. The front outboard seats were equipped with height adjustable head

restraints that were adjusted to the full-down position at the time of the NASS inspection. The rear seat was configured with a three-passenger bench seat with height adjustable head restraints. The rear right head restraint was adjusted to the full-down position at the time of the inspection. The rear left head restraint was adjusted to the full-up position at the time of the inspection.

1993 Oldsmobile Cutlass Ciera

The 1993 Oldsmobile Cutlass Ciera was identified by the Vehicle Identification Number (VIN): 1G3AG55N3P (production sequence omitted). The odometer reading was 184,032 kilometers (114,352 miles) at the time of the inspection. The vehicle was a four-door sedan that was equipped with a 3.3-liter, six-cylinder engine, front-wheel drive and a 4-speed automatic transmission. The Oldsmobile was configured with front and rear bench seats. The Oldsmobile was equipped with Bridgestone B420 radial tires, size P185/75R14. The maximum pressure for these tires was 303 kpa (44 psi). The manufacture recommended tire pressure for this vehicle was 221 kpa (32 psi). The specific tire data is listed in the table below:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kpa	7 mm (9/32)	Yes	None (Air out)
LR	283 kpa (41 psi)	9 mm (11/32)	No	None
RF	269 kpa (39 psi)	6 mm (8/32)	No	None
RR	214 kpa (31 psi)	2 mm (3/32)	No	None

1997 Hyundai Accent

The NASS researcher was refused permission to inspect the Hyundai by the driver; therefore the vehicle was not inspected.

Crash Sequence

Pre-Crash

The 28-year-old male driver of the 2003 Chevrolet Silverado was operating the vehicle northbound on the on-ramp approaching the turnpike **(Figure 3)**. The driver of the 1993 Oldsmobile was operating the vehicle northbound on the turnpike in the left lane approaching the end of the painted gore. The driver of the Hyundai was operating the vehicle northbound on the turnpike in the center lane approaching the on-ramp. The police reported that the Chevrolet was traveling at a high rate of speed on the on-ramp. As the Chevrolet approached the painted gore, the Chevrolet traversed the gore and onto the northbound

Figure 3. Chevrolet's approach to impact area.

roadway. The Chevrolet entered the turnpike and began to travel in a northwesterly direction across the right and center lanes.

Crash

As the Chevrolet entered the center lane, the driver began to steer right in an attempt to maintain his lane. The vehicle drifted across the lane line into the outboard lane, impacting the rear of the Oldsmobile. The front left area of the Chevrolet impacted the rear right aspect of the Oldsmobile **(Figure 4)**. The resultant directions of force were within the 11 o'clock sector for the Chevrolet and 5 o'clock for the Oldsmobile. The resultant damage was of sideswipe-type for the Chevrolet and severe override for the Oldsmobile. Based on the sideswipe-type engagement, a common velocity was not obtained; therefore the WINSMASH program was out of scope and not used to determine a delta V. This impact resulted in the frontal air bag deployment in the Chevrolet.

Figure 4. Area of impacts between Chevrolet, Oldsmobile, and Hyundai.

The impact induced a clockwise (CW) rotation to the Oldsmobile and the Chevrolet. The Oldsmobile began to travel in a northwesterly direction while rotating and subsequently departed the west road edge. The Oldsmobile rotated approximately 250 degrees as it departed the west road edge. The front right area of the Oldsmobile impacted the "Jersey" median barrier. The median barrier impact induced a counterclockwise (CCW) rotation to the Oldsmobile. The Oldsmobile began to travel in a northerly direction on the roadside facing south. The Chevrolet entered the west road edge as the Oldsmobile began to travel to final rest. The left rear aspect of the Chevrolet impacted the front left aspect of the Oldsmobile on the west road edge. The resultant directions of force for this impact was within the 9 o'clock sector for the Chevrolet and 11 o'clock sector for the Oldsmobile. Due to the overlapping damage to the frontal aspect of the Oldsmobile, a WINSMASH missing vehicle algorithm was used to determine the delta V for this impact. The total delta V calculated for the Chevrolet was 5.0 km/h (8.0 mph). The longitudinal and lateral components for the Chevrolet were -1.0 km/h (0.6 mph) and 5.0 km/h (8.0 mph), respectively. The total calculated delta V for the Oldsmobile was 9.0 km/h (5.6 mph). The longitudinal and lateral components for the Oldsmobile were -7.0 km/h (4.3 mph) and 6.0 km/h (3.7 mph), respectively.

The Oldsmobile came to rest on the west road edge beyond the second impact with the Chevrolet. The secondary impact with the Oldsmobile redirected the Chevrolet onto the roadway. The Chevrolet began to travel east across the turnpike. As the Chevrolet entered the right lane, the frontal area of the Hyundai impacted the right side aspect of the Chevrolet. The resultant directions of force for this impact were within the 11 o'clock sector for the Hyundai and 3 o'clock sector for the Chevrolet. The Hyundai was not inspected; therefore a WINSMASH missing vehicle algorithm was used to determine the

delta V for this impact. The total calculated delta V for the Chevrolet was 7.0 km/h (4.3 mph). The longitudinal and lateral components were -1.0 km/h (0.6 mph) and -7.0 km/h (4.3 mph), respectively. The total calculated delta V for the Hyundai was 18.0 km/h (11.2 mph). The longitudinal and lateral components for the Hyundai were -17.0 km/h (10.6 mph) and 6.0 km/h (3.7 mph), respectively. This impact caused the Chevrolet to rotate in a CW manner and come to rest on the roadway facing southeast straddling the center and right lanes. The Hyundai rotated CW and came to rest on the roadway facing northwest straddling the center and right lanes.

Post-Crash

The driver and the two child occupants of the Chevrolet were not injured or transported to a hospital. The front right occupant of the Chevrolet was not listed on the Police Accident Report. She sustained minor injuries and was transported to a local hospital where she was treated for her injuries and released. The driver of the Oldsmobile was fatally injured as result of the crash. The driver of the Hyundai sustained police reported non-incapacitating injuries and was transported to a hospital were she was treated and released. All three vehicles sustained disabling damage and were towed from the crash scene.

Vehicle Damage

Exterior Damage – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado sustained minor frontal damage **(Figure 5)** as a result of the initial impact with the 1993 Oldsmobile Cutlass Ciera. The direct contact damage width measured 10.0 cm (3.9”) and began on the front left bumper corner and extended 10.0 cm to the right. The damage consisted of a longitudinally and laterally right displaced bumper and left front fender. Maximum crush was located at the front left bumper corner and measured 6.0 cm (2.4”). Six crush measurements were documented on the front bumper using a combined direct and induced damage width of 171.0 cm (67.3”), and were as follows: C1= 6.0 cm (2.4”), C2= 1.0 cm (0.4”), C3= 1.0 cm (0.4”), C4= 0.0, C5= 0.0, C6= 0.0. The Collision Deformation Classification (CDC) for this impact was 12-FLES-4.

Figure 6. Damaged area from impact with the Oldsmobile.

The second impact between the Chevrolet and the Oldsmobile consisted of the front of the Oldsmobile impacting the left rear quarter panel area of the Chevrolet **(Figure 6)**. The direct damage began on the left rear bumper corner and extended 93.0 cm (36.6”) forward. Maximum crush was located at C3 and measured 14.0 cm (5.5”). Six crush

Figure 5. Damage from second impact with the Oldsmobile.

measurements were documented on the left rear aspect using a combined direct and induced damage width of 106.0 cm (41.7”), and were as follows: C1= 10.0 cm (3.9”), C2= 5.0 cm (2.0”), C3= 14.0 cm (5.5”), C4= 9.0 cm (3.5”), C5= 2.0 cm (0.8”), C6= 0.0. The CDC for this impact was 09-LBEW-2.

The third impact to the Chevrolet was the front of the Hyundai impacting the right side of the Chevrolet **(Figure 7)**. The direct contact damage measured 146.0 cm (57.5”) and was located at the sill area of the right rear door and the forward aspect of the bed. The direct contact damage began 158.0 cm (62.2”) forward of the right rear bumper corner and extended 304.0 cm (120.0”) forward. Six crush measurements were documented along the sill level using a combined direct and induced damage width of 162.0 cm (63.8”) and were as follows: C1= 5.0 cm (2.0”), C2= 30.0 cm (11.8”), C3= 29.0 cm (11.4”), C4= 2.0 cm (0.8”), C5= 0.0, C6= 0.0. The CDC for this impact was 03-RZLW-3.

Figure 7. Damage from impact with the Hyundai.

Interior Damage – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado sustained minor interior damage as a result of occupant contacts. No intrusions were present in the Chevrolet. The occupant contact points consisted of a scuff to the lower right instrument panel from the front right occupants right knee. Also noted was an oily residue on the top right instrument panel from contact with the front right occupants head.

Exterior Damage – 1993 Oldsmobile Cutlass Ciera

The 1993 Oldsmobile Cutlass Ciera sustained moderate severity rear damage as a result of the impact with the Chevrolet **(Figure 8)**. The damaged consisted of the right rear fender being longitudinally and vertical displaced from the Chevrolet overriding the rear of the Oldsmobile. The damage also consisted of the trunk being displaced downward and laterally left. In addition, the trunk was buckled forward and the forward left corner of the trunk contacted and disintegrated the rear glazing. The direct contact damage began at the right corner of the bumper and extended 22.0 cm (8.5”) left. Maximum crush was located at the rear right bumper corner and measured 13.0 cm (5.1”). Six crush measurements were documented at the bumper level and above bumper level using a combined direct and induced damage with of 164.0 cm (60.6”). The average crush for both levels was C1= 3.0 cm (1.2”), C2=

Figure 8. Damage area from impact with the Chevrolet.

4.0 cm (1.6”), C3= 0.0 cm, C4= 0.0, C5= 2.0 cm (0.8”), C6= 1.0 cm (0.4”). The CDC for this impact was 05-BREE-5.

The second event to the Oldsmobile was the front impacting the “Jersey” median barrier. The direct contact damage began at the front left bumper corner and extended 149.0 cm (58.7”) to the front right bumper corner. The damage consisted of a longitudinally displaced front bumper, hood, and both front fenders. The frontal area was also displaced laterally left from the angular impact with the median barrier. Maximum crush was located at C1 and measured 49.0 cm (19.3”). Six crush measurements were documented along the front bumper using a combined direct and induced damage width of 149.0 cm (58.7”) and were as follows: C1= 49.0 cm (19.3”), C2= 47.0 cm (18.5”), C3= 43.0 cm (16.9”), C4= 44.0 cm (17.3”), C5= 43.0 cm (16.9”), C6= 40.0 cm (15.7”). The CDC for this impact was 81-FDEW-2 with a 1’clock direction of force that was incremented 80 for the lateral left shift.

The third impact to the Oldsmobile was the front of the Oldsmobile impacting the rear left aspect of the Chevrolet. This damage overlapped the previous event and could not be separated; therefore no crush measurements were obtained. The CDC for this impact was 99-F999-9.

Certified Advanced 208-Compliant Safety System - 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was equipped with a Certified Advanced 208-Compliant safety system. The system consisted of dual stage frontal air bags, seat track position sensors for the front left and front right seats, and an occupant presence sensor for the front right seat. The system was controlled by a Sensing and Diagnostic Module (SDM). The SDM deploys the appropriate safety system dependant on crash severity, seat track position, and front right occupant presence. In this crash, the SDM commanded the deployment of the frontal air bags **(Figure 9)**. The deployment stage was not known for this crash.

The front left air bag was located in the steering wheel hub **(Figure 10)**. Two symmetrical I-configuration cover flaps that measured 6.0 cm (2.4”) in height and width concealed the front left air bag. The air bag membrane was cut out of the vehicle prior to the inspection by the NASS researcher; therefore the air bag size, tethers, occupant contacts, and vent ports were unknown.

Figure 9. Overall view of the instrument panel and deployed air bags.

Figure 10. Driver's air bag module. Note air bag was cut out prior to inspection.

The front right air bag was mid-mounted in the right instrument panel **(Figure 11)**. The air bag was concealed by a single cover flap that measured 19.0 cm (7.5”) in height and 39.0 cm (15.4”) width. The air bag membrane was cut out of the vehicle prior to the inspection by the NASS researcher; therefore the air bag size, tethers, and vent ports were unknown. Additionally, no occupant contact evidence could be determined.

Figure 11. Front right air bag module. Note air bag was cut out prior to inspection.

Event Data Recorder – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was equipped with an EDR that was located under the front left seat. At the time of the vehicle inspection, the EDR was not supported by the available version of the EDR download software. Therefore, the NASS researcher was unable to download the EDR data.

Manual Restraint System – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was equipped with manual 3-point lap and shoulder belts for the outboard seating positions. The front center and rear center seats were configured with manual 2-point lap belts. The front left safety belt was integrated into the seat back **(Figure 12)** and configured with a sliding latch plate and an Emergency Locking Retractor (ELR). The front center safety belt was configured with a locking latch plate and no retractor. The front right safety belt was integrated into the seat back and configured with a sliding latch plate and switchable ELR/Automatic Locking Retractor (ALR). The two rear outboard safety belts were configured with sliding latch plates and switchable ELR/ALR retractors. The rear center safety belt was configured with a locking latch plate and no retractor.

Figure 12. Front left integrated safety belt.

Occupant Demographics – 2003 Chevrolet Silverado

Driver

Age/Sex:	28-year-old male
Height:	175.0 cm (69.0”)
Weight:	72.0 kgs (159.0 lbs)
Seat Track Position:	Full rear
Manual Restraint Use:	Integrated manual 3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Not injured

Driver Kinematics

The 28-year-old male driver of the 2003 Chevrolet Silverado was seated in a presumed upright posture and was restrained by the vehicle’s integrated manual 3-point lap and shoulder belt. The seat track was adjusted to a full rear track position. At impact with the Oldsmobile, the front left air bag deployed and the driver initiated a forward and left trajectory towards the left instrument panel. No loading or contact evidence was noted to the safety belt or interior components. The driver was not injured or transported to a hospital as a result of the crash. The combination of the safety belt usage and frontal air bag deployment protected the driver from contact with frontal components, thus preventing possible injury.

Front Right Passenger

Age/Sex:	24-year-old female
Height:	170.0 cm (67.0”)
Weight:	59.0 kgs (130.0 lbs)
Seat Track Position:	Mid track
Manual Restraint Use:	Integrated manual 3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Treated and released

Front Right Passengers Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Contusion mid forehead	Minor (290403.1,7)	Grab handle on top of front right instrument panel

Injury source: Driver

Front Right Passenger Kinematics

The 24-year-old female front right passenger of the 2003 Chevrolet Silverado was seated in a presumed upright posture and was restrained by the vehicle’s lap and shoulder belt. This occupant was not listed on the police report. The driver advised the NASS researcher of the presence of a front right occupant; however, he would not disclose any further information. The front right seat track was adjusted to a mid-track position. At

impact with the Oldsmobile, the front right air bag deployed and the front right passenger initiated a forward and left trajectory toward the right instrument panel. The safety belt usage and air bag deployment protected the passenger from possible contact with interior components.

As the vehicle continued to final rest the Hyundai impacted the Chevrolet on the right side. This impact induced and CCW rotation to the Chevrolet. At this point, the frontal air bags deflated. The vehicles rotation and rearward trajectory induced a forward momentum to the passenger. This forward movement caused the passenger's head to flex over the shoulder belt. The air bag's deflating status allowed the passenger's head to contact the grab handle on the top of the right instrument panel, resulting in the mid forehead contusion. The front right passenger was transported to a local hospital were she was treated and released. Due to the limited information for this occupant, medical records could not be requested or obtained. The injury described for this occupant was stated to the NASS researcher by the driver.

Rear Left Passenger

Age/Sex:	4-year-old female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Not adjustable
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Not injured

Rear Left Passenger Kinematics

The 4-year-old female rear left occupant of the 2003 Chevrolet Silverado was seated in an unknown posture and was restrained by the vehicle's lap and shoulder belt. At impact with the Oldsmobile, the rear left passenger initiated a forward and left trajectory and loaded the vehicle safety belt. No loading evidence was noted to the safety belt. The rear left child occupant was not injured or transported as a result of the crash.

Rear Right Passenger

Age/Sex:	2-year-old male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Not adjustable
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Not injured

Rear Right Passenger Kinematics

The 2-year-old male was seated in the vehicles rear right position. He was seated with an unknown posture and was restrained by the vehicle's lap and shoulder belt. Based on the

child's age, he should have been restrained in a forward facing child safety seat. At impact, the child initiated a forward and left trajectory in response to the 11 o'clock direction of force. The child rode down the force of the crash by loading the safety belt with his torso. The child was not injured or transported as a result of the crash.

Figure 11. NASS Scene Schematic.