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TRANSPORTATION SCIENCES CENTER
ACCIDENT RESEARCH GROUP

Division of Calspan SRL Corporation
[redacted] New York [redacted]

CALSPAN ON-SITE NON-DEPLOYED AIR BAG INVESTIGATION
CALSPAN CASE NO. 96-4
LOCATION: CONNECTICUT
VEHICLE: 1995 CHEVROLET K1500 PICKUP TRUCK

Contract No. DTNH22-94-D-07058

Prepared for:

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

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

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

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15. *Supplementary Notes* On-site investigation of a moderately severe frontal crash sequence that involved an air bag equipped 1995 Chevrolet pickup truck in which the driver's side air bag did not deploy.		

16. *Abstract*

This on-site investigation focused on a 1995 Chevrolet K1500 pickup truck that was involved in a moderate severity collision sequence with the right side mounted wing plow of a state highway truck. The crash occurred on a snow covered rural expressway during nighttime hours. The driver of the pickup truck was attempting to pass the slower moving snow plow truck on the right. His view of the wing plow was obscured by flying snow that was displaced from the front and side mounted plows. The front left and center areas of the pickup truck struck the trailing edge of the wing plow which resulted in a barrier equivalent speed of 23 km/h (14 mph). The deceleration was below the 26 km/h (16 mph) upper limit threshold required for deployment, therefore the SIR did not deploy.

The driver and right front passenger were not wearing the manual 3-point lap and shoulder belt systems. The driver impacted the windshield and rear view mirror which resulted in a laceration with abrasion to the mid superior aspect of the forehead. The passenger contacted the glove box door, upper instrument panel, and right A-pillar which resulted in multiple soft tissue contusions.

17. *Key Words* On-site investigation Moderate severity frontal collision Supplemental Inflatable Restraint System (SIR) Non-deployment Minor severity injuries	18. *Distribution Statement* General Public

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CALSPAN CASE NO. 96-4
VEHICLE: 1995 CHEVROLET K1500 PICKUP TRUCK
LOCATION: CONNECTICUT

SUMMARY

This on-site investigation was directed at a crash that involved a 1995 Chevrolet K1500 pickup truck which was equipped with a driver's side Supplemental Inflatable Restraint system (SIR). The pickup truck struck the trailing edge of a side mounted wing snow plow as the driver attempted to pass the plow unit on the right. The impact crushed the front bumper to a depth of 28.2 cm (11.1") which resulted in a barrier equivalent speed of 23 km/h (14 mph). The deceleration was below the required threshold, therefore the SIR did not deploy. The driver and his right front passenger were not restrained by the manual belt systems and as a result of the crash, they sustained minor (AIS-1) severity injuries.

The investigation was initiated as a result of the vehicle's owner notifying NHTSA's Office of Defects Investigation and reporting the non-deployment event. An on-site investigation was initiated approximately 1 month following the crash as the vehicle remained in its damaged condition.

The driver/owner of the 1995 Chevrolet K1500 pickup truck had purchased the vehicle as new in [redacted] 1995 for both business and personal use. The vehicle was an extended cab configuration with a 1.8 m (6.0') cargo box on a 4X4 chassis with a 359.4 cm (141.5") wheelbase. In addition to the supplemental driver's side air bag system, the Chevrolet pickup truck was equipped with the Z71 off-road package, 4-wheel anti-lock brakes (ABS), alloy wheels, LT265/75R16 mud and snow tires, front bucket seats, power windows, power door locks, tilt steering, and a 4-speed automatic overdrive transmission with a column mounted selector lever. The vehicle was manufactured on [redacted]/95 and was identified by the following vehicle identification number: 2GCEK19K3S1 (production number deleted). At the time of the crash, the vehicle's odometer had recorded 36,903 km (22,931 miles).

The struck snow plow truck was 1985 International conventional chassis that was equipped with a dump body, a front mounted snow plow and a right side mounted wing plow. A hopper and rotary spreader was mounted in the dump body which was filled with a road deicing compound. The wing plow was removed from the vehicle following the crash and was repaired prior to the on-site investigation. The truck had been driven to a repair facility for repairs not associated with this crash and was not available. It should be noted that this was the only truck in the state fleet that was equipped with a wing-type plow unit.

The crash occurred during nighttime hours in [redacted] 1996, on a rural four-lane divided expressway. The asphalt road surface was covered with 5-8 cm (2.0-3.0") of light snow. In the vicinity of the crash site, the roadway was straight and level with a posted speed limit of 89 km/h (55 mph). The travel lanes were bordered by asphalt shoulders with cable guardrail systems parallelling both shoulders.

The driver of the snow plow truck had stopped at the local highway garage to refill the hopper with road deicing compound. Following this task, he and the wing plow operator (right front passenger) re-entered the vehicle and departed the garage facility, traveling in a westerly direction to the on-ramp for the rural expressway. The operator entered the ramp and proceeded in a westerly direction with the front mounted plow and the right wing plow in the down positions to clear the snow from the road surface. As the driver accelerated to an estimated speed of 64-72 km/h (40-45 mph), he merged from the on-ramp acceleration lane into the outboard westbound travel lane. The light snow that was displaced by the plows created a cloud-like effect around the plow truck which partially obscured the vehicle from approaching westbound traffic.

The 24 year old male driver of the Chevrolet pickup truck was traveling in a westerly direction in the outboard travel lane of the expressway at a driver estimated speed of 89-97 km/h (55-60 mph). He was traveling with the vehicle in the four-wheel drive, high range mode. As he approached the slower moving snow plow truck, the driver of the pickup truck determined that the plow truck was straddling the centerline of the westbound travel lanes. He therefore, attempted to pass the vehicle on its right. The flying snow obscured the driver's view of the right side mounted wing plow as he initiated the passing maneuver. The driver stated that he did not attempt avoidance action prior to impact.

The front left and center area of the Chevrolet pickup truck impacted the trailing edge of the right side mounted wing snow plow. The direct contact damage began 13.3 cm (5.25") left of center and extended 76.2 cm (30.0") to the pickup truck's left bumper corner. The impact deformed the entire frontal structure of the vehicle and crushed the left corner of the front bumper to a maximum depth of (11.1"). The front-to-rear impact configuration resulted in a force direction of 12 o'clock to the pickup truck (CDC of 12-FYEW-1). The impact deformed the plow, damaged the tubular mounting arm, and fractured a dampening spring that was affixed to the telescoping arm. Although the collision conditions were outside the scope of computer reconstruction programs due to the yielding object, a barrier equivalent speed of 23 km/h (14 mph) was computed by the damage algorithm of the SMASH program.

The offset frontal impact sequence induced a counterclockwise yaw to the pickup truck as the vehicle's center of gravity continued in a westerly direction. The pickup truck traversed the westbound travel lanes and yawed approximately 80 degrees CCW before departing the left (inboard shoulder. The frontal area impacted the cable guardrail system in an endswipe configuration. Two distinct cable imprints extended horizontally across the damaged frontal area of the vehicle between the bumper and headlamp assemblies. The vehicle separated from the guardrail and rotated an additional 260 degrees CCW on the shoulder before impacting the guardrail with the left rear quarter panel area. The subsequent guardrail impact resulted in minor damage to the panel and bumper corner as the vehicle came to rest engaged with the guardrail.

The struck snow plow truck was redirected to its left by the impact sequence with the pickup truck. The vehicle crossed the inboard travel lane and left shoulder in a tracking mode and impacted the cable guardrail system with the front mounted snow plow. Although no damage occurred to the truck and plow unit, the operator stated that three guardrail posts were displaced by the impact. The

investigating police officer noted on his report that approximately (200') of guardrail was damaged by the collision which included impacts from both vehicles. The guardrail was repaired prior to our investigation.

The involved vehicles came to rest on the left (inboard) shoulder facing in a westerly direction. The pickup truck came to rest approximately 90 m (300') forward of the final rest position of the plow vehicle. All occupants exited their respective vehicles unassisted and waited for the arrival of police assistance.

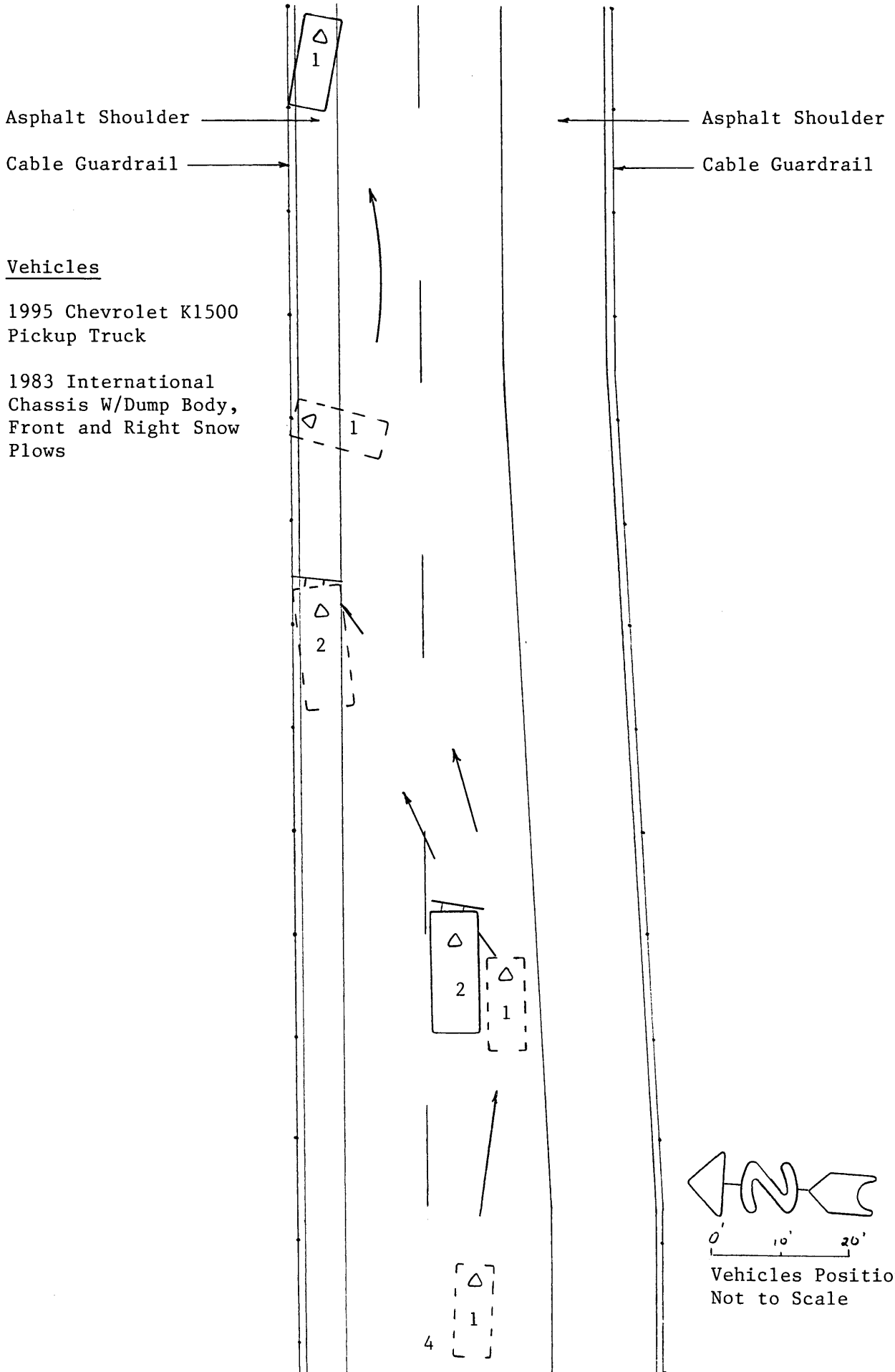
The driver of the pickup truck was not wearing the manual belt system. At impact with the snow plow, he initiated a forward trajectory as the vehicle rotated in a CCW direction. The driver's left thoracic area probably contacted the right side of the steering wheel rim as he continued forward. His thoracic region contacted and fractured the column mounted transmission selector lever, however, the contact sequence did not result in injury. The driver's forehead contacted the rear view mirror which displaced the mirror to the right and cracked the mirror glass. His head continued forward and impacted the laminated windshield. The forehead contact cracked the glazing and produced tissue and skin oil transfers to the windshield left of center. As a result of mirror and windshield contact, the driver sustained a laceration with abrasion of the mid superior forehead (AIS-1). His right hand or arm contacted and displaced the center mounted pull-out cup holder. No injury resulted from the latter contact sequence.

The right front passenger of the Chevrolet pickup truck was a 24 year old male. He was not restrained by the manual belt system. The passenger initiated a forward trajectory, however, as the vehicle rotated CCW, he moved forward and to the right and impacted the glove box door, right upper instrument panel and the right A-pillar. As a result of the contact sequence, the passenger sustained bilateral knee contusions (AIS-1) and a contusion across the anterior right shoulder (AIS-1).

Following the on-scene police investigation, the driver of the pickup truck was transported by ambulance to a local hospital where he was treated for his forehead injury and released. The passenger walked from the scene to his residence. The pickup truck sustained disabling damage which required towing from the scene. The snow plow truck was driven from the scene.

The Chevrolet K1500 series pickup truck was equipped with a SIR system that utilized two front mounted discriminating (crash) sensors and an arming (safing) sensor. The discriminating sensors were mounted to the outboard aspect of the front frame rails between the forward crossmember and the body mounts. The arming sensor was mounted to the left side of the crossmember that extended between the frame rails forward of the B-pillars. The diagnostic energy reserve module (DERM) which monitored the SIR did not contain stored faults and indicated through the SIR lamp that the system was armed and operational, therefore the impact induced deceleration of 23 km/h (14 mph) was below the upper threshold of 26 km/h (16 mph) that is required for deployment.

CRASH SCHEMATIC
CALSPAN CASE NO. 96-4



Vehicles

#1 - 1995 Chevrolet K1500 Pickup Truck

#2 - 1983 International Chassis W/Dump Body, Front and Right Snow Plows

Vehicles Positions
Not to Scale

CALSPAN ON-SITE NON-DEPLOYED AIR BAG INVESTIGATION
CALSPAN CASE NO. 96-4
VEHICLE: 1995 CHEVROLET 1500 PICKUP TRUCK
LOCATION: CONNECTICUT

CRASH DATA

Location:	U.S. Route
State:	Connecticut
Area/Type:	Rural/Undeveloped
Crash Date/Time:	[redacted] 1996, nighttime hours
Crash Type:	Pickup truck/Snow plow, front-to-side configuration (same direction of travel)
Air Bag Vehicle Occupant Injury Severity:	Driver - Minor (AIS-1) Passenger - Minor (AIS-1)

AMBIENCE

Viewing Conditions:	Dark, lighted
Weather:	Overcast
Precipitation:	Snow
Road Surface:	Snow covered
Temperature:	-4 degrees C (25 degrees F)

HIGHWAY

Type:	Divided rural expressway
Number of Lanes:	5, divided, inclusive of a westbound acceleration lane
Width:	11 m (36'), westbound lanes

HIGHWAY (CONT'D.)

Surface:	Asphalt
Median:	Wide median with trees
Edge:	North - 1.8 m (6.0') asphalt shoulder South - 4.6 m (15.0') asphalt shoulder
Vertical Alignment:	Level
Horizontal Alignment:	Straight
Estimated Coefficient of Friction:	.45
Traffic Density:	Sparse

TRAFFIC CONTROLS

Signals:	None
Signs:	None pertinent
Markings:	Broken white lane lines, solid white edge lines
Speed Limit:	89 km/h (55 mph)

VEHICLES

	Air Bag Vehicle	Vehicle #2
Description:	1995 Chevrolet 1500 series 4 x 4 pickup truck, extended cab, 2.0 m (6.5') cargo box, 359.4 cm (141.5") wheelbase	1983 International chassis with dump body, vehicle equipped with front and right side mounted wing snow plows (not inspected)
V.I.N.	2GECEK19K3S1(production number deleted)	Unknown
Color:	Blue	Orange

VEHICLES (CONT'D.)

	Air Bag Vehicle	Vehicle #2
Odometer:	36,903 km (22,931 miles)	Unknown
Engine:	V-8, 5.7 liter	Diesel, unknown displacement
Automatic Restraints:	4-speed automatic overdrive, column mounted transmission selector lever	
Tow Status:	Power-assisted	
Brakes:	Power-assisted front disc/ rear drum, with four-wheel anti-lock (ABS)	
Padding:	Upper and mid instrument panel, soft-edged steering wheel rim and air bag module cover, sunvisors, side door panels and armrests, adjustable head restraints	
Manual Restraints:	3-point lap and shoulder belts in the four outboard seated positions, center rear lap belt, all shoulder belts have fixed upper anchorages (D-rings)	
Automatic Restraints:	Supplemental Inflatable Restraint (SIR) system which consisted of a driver's side air bag that did not deploy	
Tow Status:	Towed due to vehicle damage	N/A, driven from scene

VEHICLE DAMAGE

	Air Bag Vehicle	Vehicle #2
Exterior:	The 1995 Chevrolet 1500 series pickup truck sustained moderate frontal damage as a result of its initial impact sequence with the wing snow plow that was mounted to the right side of vehicle #2. Maximum crush was 28.2 cm (11.1") located at the left corner of the front bumper. The direct contact damage began 13.3 cm (5.25") left of center and extended 76.2 cm (30.0") to the left bumper corner. The off-set frontal impact deformed the entire width of the frontal structure resulting in a combined induced and direct damage length (Field L) of 170.2 cm (70.0"). Crush values at bumper level were as follows: C_1 =28.2 cm (11.1"), C_2 =25.1 cm (9.9"), C_3 =23.1 cm (9.1"), C_4 =9.5 cm (3.75"), C_5 =0.6 cm (0.25"), C_6 =0 cm (-2.9").	Vehicle #2 was a tandem axle dump truck that was equipped with a front mounted snow plow and a right side mounted wing plow. The wing plow was 3.2 m (10.6') in length and 0.6 m (2.0') in height and was attached to the truck at three points. The inboard attachment point allowed the plow to pivot in both a fore and aft direction and vertically. Two tubular arms were affixed to the outboard third of the wing plow which stabilized the plow and provided the operator with the adjustment of the unit. In addition, the truck was equipped with a hopper that was mounted in the dump body of the vehicle. A spreader was affixed to the rear of the hopper to disperse road salt and sand onto the travel lanes.
	Damaged components from the frontal impact sequence included the bumper, grille, left headlamp assembly, hood, aftermarket bug deflector, radiator support panel, radiator and air conditioning condenser, left front fender, and the left frame rail (vertical and rearward displacement).	The Chevrolet pickup truck impacted the trailing edge of the right side mounted wing plow as the pickup truck attempted to pass the snow plow on the right. The impact deformed the outboard edge of the plow and the vertical reinforcements (refer to Photograph Nos. 34 and 35).

VEHICLE DAMAGE (CONT'D.)

Air Bag Vehicle

The secondary damage to the Chevrolet pickup truck resulted from an impact sequence with a cable guardrail system. Following the initial crash with the snow plow, the Chevrolet pickup truck yawed in a counterclockwise (CCW) direction and crossed the westbound travel lanes. The vehicle departed the travel lanes and struck the cable system with the frontal area. Although the guardrail system consisted of three individual cables, only two cable imprints were visible across the frontal area of the vehicle (refer to Photograph No. 10). The cable contact extended 168.9 cm (66.5") across the full width of the vehicle and was located at grille height between the bumper and headlamp assemblies. The cable gouges were spaced on 3.8 cm (1.5") centers. There was no evidence of guardrail post contact to the bumper of the pickup truck.

The pickup truck separated from the cable guardrail as it continued to rotate in a CCW direction. The left rear quarter panel area of the vehicle subsequently struck the guardrail system which

Vehicle #2

Although the plow was removed from the vehicle and repaired prior to our inspection, the driver stated that the upper arm was deformed by the impact sequence and that the dampening spring was fractured.

The impact displaced the snow plow truck to its left as it crossed the inboard travel lane and departed the inboard shoulder. The front mounted snow plow subsequently contacted the cable guardrail system and displaced three of the 7.6 x 5.7 cm (3.0 x 2.25") I-beam posts. There was no damage reported to the plow or truck from the subsequent impact sequence.

VEHICLE DAMAGE (CONT'D.)

Air Bag Vehicle

Exterior (Cont'd.)	resulted in minor sideswipe-type damage to the quarter panel and rear bumper corner. The damage began 64.8 cm (25.5") rearward of the left rear axle position and extended 51.8 cm (20.4") to the left rear bumper corner. Maximum crush was 1.3 cm (0.5") located on the quarter panel at the rub strip (refer to Photograph No. 15).		
CDC/TDC:	Primary -	12-FYEW-1	Snow plow units are outside the scope of TDC
	Secondary -	09-FDMS-9 11-LBES-1	
Repair Costs:	Total loss per insurance		Unknown

Interior (Air Bag Vehicle):

The interior of the Chevrolet pickup truck sustained moderate damage that was associated solely with occupant contact. There was no interior component intrusion or deformation associated with the exterior damage. The driver was not wearing the manual 3-point lap and shoulder belt system. At impact with the snow plow, he initiated a forward trajectory and contacted the right side of the steering wheel rim and the column mounted transmission selector lever. Although no wheel damage occurred, the contact sequence fractured the selector lever from the steering column. It should be noted that there was no compression of the energy absorbing steering column. The driver's forehead subsequently contacted the rear view mirror and windshield. As a result of the forehead contact, the mirror glass was cracked and the laminated windshield was cracked 2.5 cm (1.0") left of center and 17.8 cm (7.0") above the upper instrument panel. Surrounding the windshield crack was a tissue transfer with an oily smudge which extended 8.3-13.3 cm (3.25-5.25") left of center and 14.0-17.1 cm (5.5-6.75") above the upper panel. The driver's right hand and/or arm contacted and separated the pull-out cup holder from the center mid instrument panel. No damage occurred to the plastic cup holder or the slide mechanism.

VEHICLE DAMAGE (CONT'D.)

Interior (Air Bag Vehicle):

The right front passenger of the vehicle was not restrained by the manual 3-point lap and shoulder belt system. His left knee contacted and scuffed the mid aspect of the glove box door 43.2-47.0 cm (17.0-18.5") right of center and 10.8-14.0 cm (4.25-5.5") below the upper instrument panel. The passenger's right knee contacted the right side of the glove box door at the right air vent louver. This contact did not result in damage, however, the louver cover had separated from the mid panel. His right shoulder subsequently contacted the right upper A-pillar and passenger assist handle. The latter contact sequence did not produce interior damage.

Both occupants rebounded into their respective seat backs where they came to rest. The driver's rebound contact rotated the seat back in a counterclockwise direction (CCW) and loosened the seat track assembly resulting in fore and aft movement of the seat assembly. The passenger's rebound contact did not produce deformation to the seat frame, however, the track mechanism was loosened similar to the driver's side.

AUTOMATIC RESTRAINT SYSTEM

The 1995 Chevrolet pickup truck was equipped with a Supplemental Inflatable Restraint (SIR) system which did not deploy as a result of the vehicle's impact sequences with the snow plow and cable guardrail system. The SIR consisted of a driver's side air bag module that was housed in a typical configuration within the four-spoke steering wheel and a knee bolster mounted across the lower instrument panel of the driver's position. The air bag module assembly, which contained the inflator and the folded air bag, was concealed behind an I-configuration flap system which, when deployed, opens across the top and bottom seams and the center horizontal seam. The flaps therefore, are hinged at the outboard edges when the wheel is in a straight 12/6 o'clock position.

In addition to the driver's side air bag module assembly, the SIR system consisted of two front mounted discriminating (crash) sensors and a arming (safing) sensor. The discriminating sensors were located on the outboard aspect of the front frame rails between the crossmember and the forward body mounts. The arming sensor was mounted to the left side of the frame crossmember that was positioned immediately forward of the B-pillars. (A schematic of the SIR component locations is included as Attachment C of this report.) The SIR system was monitored by an on-board (passenger compartment positioned) diagnostic energy reserve module (DERM) which provides data relating to stored faults and deployment events (i.e., sensor closures). The DERM performs a diagnostic check of the SIR at each ignition cycle and translates its operational modes through an instrument panel mounted SIR indicator lamp.

AUTOMATIC RESTRAINTS (CONT'D.)

A General Motors representative stated that the indicator lamp flashes a sequence of six flash cycles at the on-set of ignition in a normal operational SIR system. In the event of a deployment, or a fault in the SIR system, the GM representative noted that the indicator lamp will remain on, or flash a continuous sequence indicating a DERM recorded fault. This test was performed on the crash involved Chevrolet pickup truck. At ignition, the SIR indicator lamp flashed the sequential cycle and went off and remained off. This diagnostic test was performed on eight (8) ignition cycles and yielded the same six flash sequence, insicating a normally operative system. The GM representative stated that if the normal flash sequence occurred at ignition, a DERM readout would not provide additional data to support SIR system faults. The DERM readout mode is available only by authorized GM personnel.

As previously noted, the SIR in this pickup truck did not deploy following the vehicle's frontal impact sequence with the right side mounted wing snow plow. Deployment thresholds for this vehicle ranged from longitudinal barrier equivalent speeds of 16-26 km/h (10-16 mph). This range indicates that at barrier equivalent speeds of less than 16 km/h (10 mph), the SRS will not deploy, however, at barrier equivalent speeds of $\geq$ 26 km/h, all systems will deploy. This crash resulted in a SMASH generated barrier equivlent speed of 23 km/h (14 mph) which was below the upper threshold required for deployment.

COLLISION SEQUENCE

Pre-Crash:

The state operated snow plow truck (vehicle #2) was equipped with a front mounted plow and a right side mounted wing plow. In addition to the plows, the vehicle was also equipped with a hopper and spreader unit that was mounted within the dump body of the heavy truck. The operator had stopped at the local highway garage to refill the hopper with road deicing compound. Following the completion of this task, he departed the facility and traveled approximately 0.8 km (0.5 miles) to the entrance ramp for the rural expressway. The snow plow operator entered the on-ramp and proceeded in a westerly direction with both the front plow and right side wing plow in the down positions to clear approximately 5-8 cm (2-3") of light snow from the asphalt road surface. As the driver accelerated to an estimated speed of 64-72 km/h (40-45 mph), he merged from the on-ramp acceleration lane into the outboard westbound travel lane. The light snow displaced by the plows created a cloud-like effect around the heavy truck and partially obscured the vehicle from approaching westbound traffic.

The air bag equipped 1995 Chevrolet pickup truck was traveling in a westerly direction on the outboard travel lane at a driver estimated speed of 89-97 km/h (55-60 mph). The driver stated that he observed the snow plow ahead of his position and determined that the vehicle was straddling the centerline of the westbound travel lanes. Due to the speed differential between the two vehicles, the driver of the Chevrolet pickup truck attempted to pass the slower moving snow plow truck. The outboard travel lane widened for the on-ramp

COLLISION SEQUENCE (CONT'D.)

Pre-Crash (Cont'd.)

acceleration lane, therefore the driver attempted to pass the plow truck to its right. The snow obscured the driver's view of the right side mounted wing plow. As he began to pass the truck, the Chevrolet pickup truck struck the extended wing plow. The driver of the Chevrolet pickup truck stated that he observed the wing snow plow immediately prior to impact, however, he did not initiate avoidance action (i.e., braking).

Crash:

The front left and center area of the Chevrolet pickup truck struck the trailing edge of the wing snow plow which was angled rearward from the right side of the truck. The front to rear impact configuration resulted in force directions of 12 and 6 o'clock respectively for the pickup truck and the struck plow unit. The impact displaced the plow in a forward direction and crushed the frontal structure of the Chevrolet pickup truck to a maximum depth of 28.2 cm (11.1"). Although the collision conditions were outside the scope of the SMASH program (yielding object), a barrier equivalent speed of 23 km/h (14 mph) was computed for the Chevrolet by the damage algorithm of the program. The pickup truck's SRS did not deploy during this crash event.

The initial impact displaced the snow plow truck to its left as the vehicle continued in a probable tracking mode in a forward direction as it traversed the inboard travel lane and shoulder. The front mounted snow plow subsequently struck the cable guard rail system as the truck traveled to final rest. The driver reported that three posts were damaged as a result of the impact sequence. The guardrail system consisted of three cables at heights of 66.0, 73.7, and 81.3 cm (26.0, 29.0, and 32.0") and I-beam posts (weak post design) that were spaced on 4.6 m (15.0') centers.

The initial impact sequence with the wing snow plow blade induced a CCW yaw to the Chevrolet pickup truck's westbound trajectory. The vehicle rotated approximately 80 degrees in the CCW direction as it traversed the westbound travel lanes and inboard shoulder. The frontal area of the pickup truck impacted the cable guardrail system that was located 0.3 m (1.0') outboard of the 1.8 m (6.0') wide inboard shoulder. The guardrail impact resulted in a lateral impact force of 3 o'clock. Residual damage consisted of minor gouges across the support brackets for the grille and turn signal assemblies and the leading edges of the front fenders, between the previously deformed bumper and hood face. As a result of the pickup truck's engagement with the guardrail, the vehicle continued to rotate CCW as its center of gravity continued in a westerly direction. Following separation from the cable guardrail, the pickup truck rotated an additional 260 degrees (approximate) in a CCW direction and contacted the cable guardrail with the left rear quarter panel area as it came to rest on the inboard shoulder. The investigating police officer noted on his report that approximately 61 m (200') of cable guardrail was damaged by the involved vehicles.

COLLISION SEQUENCE (CONT'D.)

Post Crash:

Final Rest - The Chevrolet pickup truck came to rest on the inboard (left) shoulder with the left rear of the vehicle engaged with the cable guardrail. At rest the vehicle was facing in a westerly direction. The snow plow truck also came to rest against the inboard guard rail system, facing in a westerly direction. Although there was no physical evidence at the crash site to support final rest positions, both drivers of the involved vehicles stated that the Chevrolet pickup truck came to rest approximately 90 m (300') west of the final rest position of the snow plow truck.

Driver Activities - The driver of the snow plow truck used his on-board radio to notify his department of the crash. He and the right front passenger who operated the wing plow exited the vehicle to check on the condition of the occupants of the pickup truck. The driver and right front passenger of the Chevrolet pickup truck exited the vehicle from their respective doors and waited for the arrival of the police.

Police Activities - The investigating police officer arrived on-scene and initiated his report of the crash. The officer observed a laceration to the forehead of the driver of the Chevrolet pickup truck and requested an ambulance for on-scene treatment and transport. The right front occupant of the pickup truck complained of pain, but refused medical treatment. He resided near the crash scene and walked from the scene to his residence. Following the on-scene investigation, the officer issued the driver of the Chevrolet pickup truck a citation for traveling too fast for conditions.

Rescue Activities - The driver of the Chevrolet pickup truck was transported to a local hospital by ambulance where he was treated for the forehead laceration and released. In addition to the medical treatment, he submitted to a blood test for alcohol which yielded results that were below the legal limit of driving under the influence.

Scene Clearance - The Chevrolet pickup truck sustained disabling damage and was towed from the crash scene. The snow plow truck sustained damage to the wing plow unit and was driven from the scene to the highway garage.

HUMAN DEMOGRAPHICS/OCCUPANT DATA

Air Bag Vehicle

Driver:	24 year old male
Height:	172.7 cm (68.0")
Weight:	68.0 kg (150.0 lb)
Manual Restraint:	
System Usage:	None, 3-point lap and shoulder belt was available
Usage Source:	Vehicle inspection, driver interview
Eyeware:	None
Vehicle Familiarity:	8 months
Route Familiarity:	Frequent travel
Trip Plan:	Returning to residence
Mode of Transport From Scene:	Ambulance
Type of Medical Treatment:	Treated at a local hospital and released

DRIVER INJURIES

Injury	Injury Severity (AIS-90)	Injury Mechanism
Laceration mid superior aspect of forehead with surrounding abrasion	Minor (200602.17, 200202.17)	Windshield
Neck pain	N/A	Induced from head contact with windshield

DRIVER KINEMATICS

The driver of the 1995 Chevrolet pickup truck was in a normal upright posture at impact with his seat track adjusted to a mid track position. The tilt mechanism for the steering wheel was adjusted to the first position below the center adjustment point. The adjustable head restraint was set to a mid position, above the top surface of the seat back support. The manual belt system was equipped with a fixed upper anchorage (D-ring) and the common latchplate for the separate lap and shoulder belt webbing had evidence of routine usage (wear marks), however, the driver stated that he was not wearing the belt system on this particular trip.

As a result of the off-set, 12 o'clock direction of force impact, the Chevrolet pickup truck was decelerated in a longitudinal direction and rotated in a counterclockwise (CCW) direction. The unrestrained driver responded to the impact force by initiating a forward trajectory as the vehicle rotated CCW, therefore his contact points were located to the right of a 12 o'clock non-rotational trajectory. The driver's left thoracic area probably contacted the right side of the steering wheel rim as he continued to move forward and to the right with respect to the vehicle. His thoracic area subsequently contacted and fractured the transmission selector lever from the steering wheel mounting point. No injury resulted from his thoracic contacts.

DRIVER KINEMATICS (CONT'D.)

The driver continued forward to the right of the steering wheel rim and impacted the rearview mirror with his forehead. The contact fractured the glass of the mirror and displaced the mirror to the right. His head continued forward and impacted the laminated windshield with sufficient force to crack the glazing 2.5 cm (1.0") left of the vehicle's centerline and 17.8 cm (7.0") above the upper instrument panel. In addition to the crack, a tissue transfer was noted to the glazing 1.3-7.4 cm (0.5-2.9") left of center and 13.3-16.5 cm (5.25-6.5") above the instrument panel. Adjacent to the tissue transfer was a skin oil transfer located 8.3-13.3 cm (3.25-5.25") left of center and 14.0-17.1 cm (5.5-6.75") above the referenced panel (refer to Photograph Nos. 26). As a result of the windshield contact, the driver sustained a laceration with abrasion to the mid superior forehead.

The driver's right hand or arm contacted the center pull-out cup holder that was extended from the center mid instrument panel (refer to Photograph No. 29). The contact separated the cup holder from the slide mount, however, there was no damage to the components. He rebounded into the left front seat back where he came to rest. The driver's rebound contact rotated the seat back in a clockwise direction and loosened the seat track mechanism which resulted in fore and aft movement of the seat assembly.

The subsequent impact sequence with the cable guardrail system did not significantly displace the driver. No additional interior contact points were noted to the Chevrolet pickup truck. Immediately following the crash, the driver opened the left front door and exited the vehicle to check the severity of damage to his vehicle. Following police arrival, the driver was transported by ambulance to a local hospital where he was treated for his forehead laceration and released.

RIGHT FRONT PASSENGER

Age/Sex:	24 year old male
Height:	167.6 cm (66.0")
Weight:	74.8 kg (165 lb)
Manual Restraint Usage:	None, 3-point lap and shoulder belt was available
Usage Source:	Vehicle inspection, occupant interview
Mode of Transport From Scene:	Walked to residence
Type of Medical Treatment:	None

RIGHT FRONT PASSENGER INJURIES

Injury	Injury Severity (AIS-90)	Injury Mechanism
Bilateral knee contusions	Minor (890402.11, 890402.12)	Glove box door and right vent louver
Contusion across right shoulder	Minor (790402.11)	Right upper A-pillar/ passenger assist handle

RIGHT FRONT PASSENGER KINEMATICS

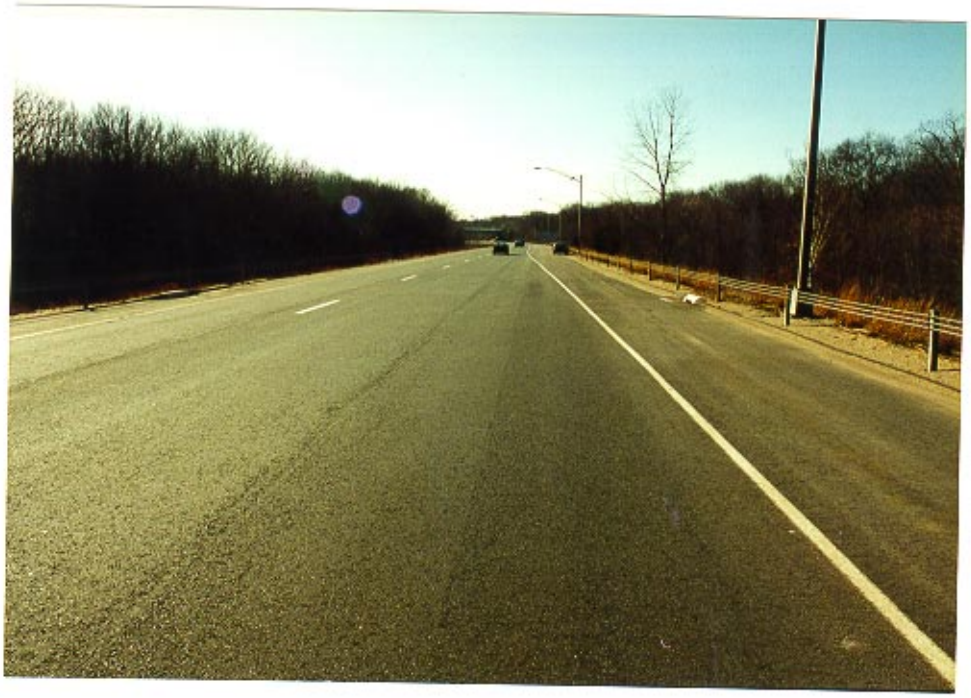
The right front passenger of the Chevrolet pickup truck was in a normal seated position at impact with the snow plow truck. He was not wearing the manual 3-point lap and shoulder belt system. The passenger responded to the 12 o'clock impact force by initiating a forward trajectory as the vehicle rotated in a CCW direction. His left knee contacted and scuffed the mid aspect of the glove box door 43.2-47.0 cm (17.0-18.5") right of center and 10.8-14.0 cm (4.25-5.5") below the upper instrument panel. The passenger's right knee contacted the right side of the glove box door at the air vent louver 68.6 cm (27.0") right of center and 10.2 cm (4.0") below the upper panel. Although no direct contact evidence was visible to the plastic component, the vent louver separated from the mid panel. As a result of knee loading, the passenger sustained bilateral contusions of the knees.

The passenger stated that immediately prior to impact, he probably raised his left hand to shield his head and face from possible windshield contact. As he continued forward, the passenger's right shoulder contacted the upper right A-pillar and assist handle which contused the anterior shoulder area. There was no evidence of contact to the pillar/assist handle.

The passenger rebounded into the right front seat back where he came to rest. The rebound contact did not result in injury, however, the seat assembly was loosened (similar to the driver's seat) in a fore and aft direction. Following the crash sequence, the passenger exited the vehicle from the right door and waited with the driver for police and emergency response. He subsequently walked from the scene to his residence and did not seek medical treatment.

ATTACHMENT A

Color Photographs
Calspan Case No. 96-4

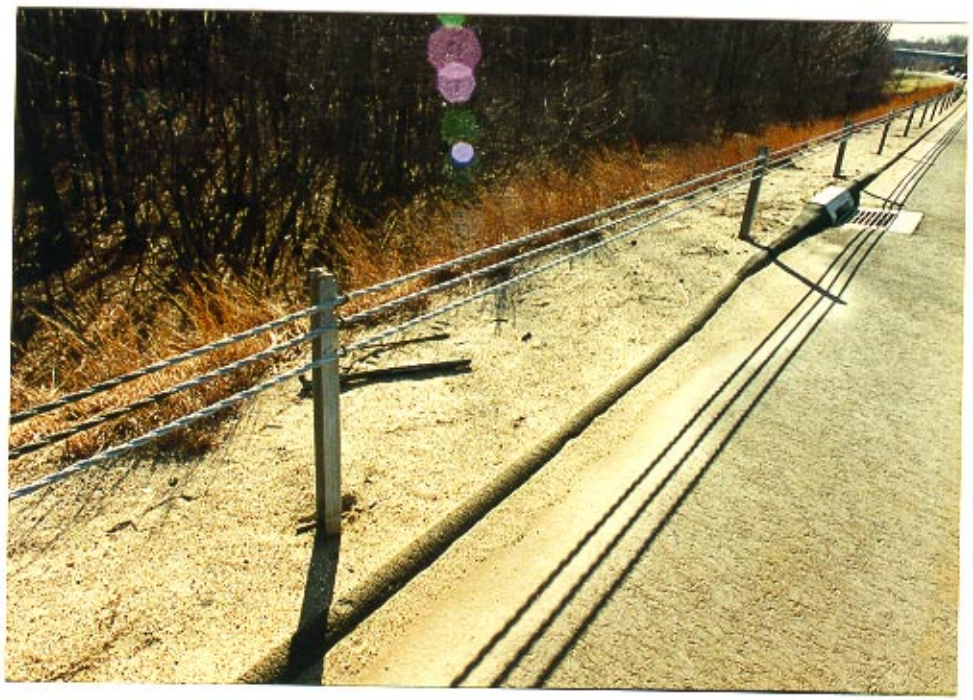


1. Pre-crash trajectories of the involved vehicles.

2. Area where the Chevrolet pickup truck attempted to pass the snow plow.

3. Post-impact trajectory of the snow plow.

4. Cable guardrail and posts (replaced) struck by the snow plow.



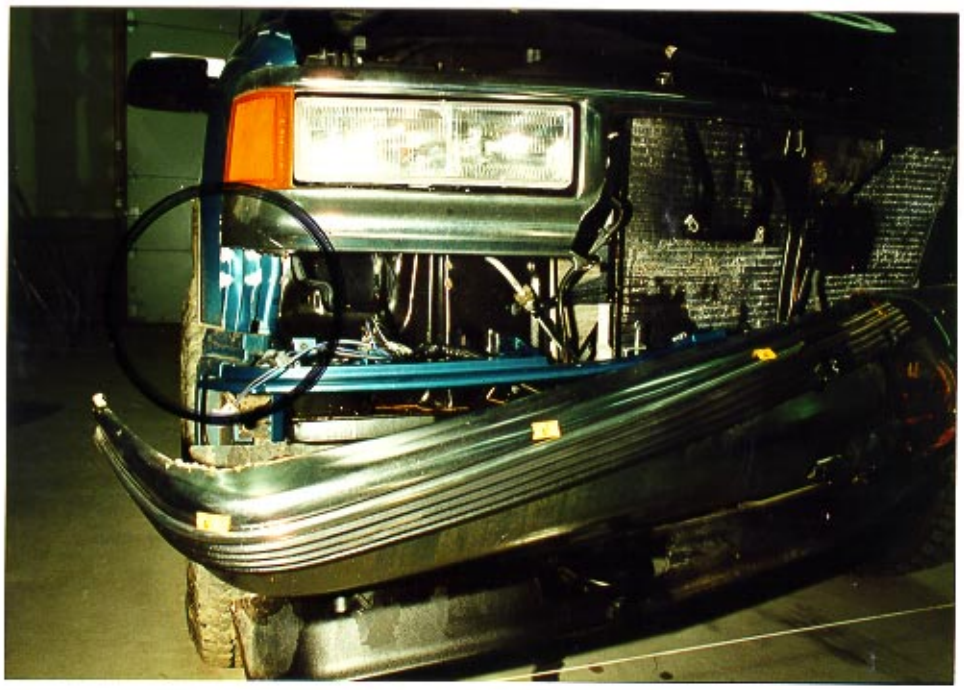
5. Cable guard rails and post struck by the frontal area of the Chevrolet pickup truck.

6. Final rest area of the Chevrolet pickup truck.

7. Lookback view of the crash scene.

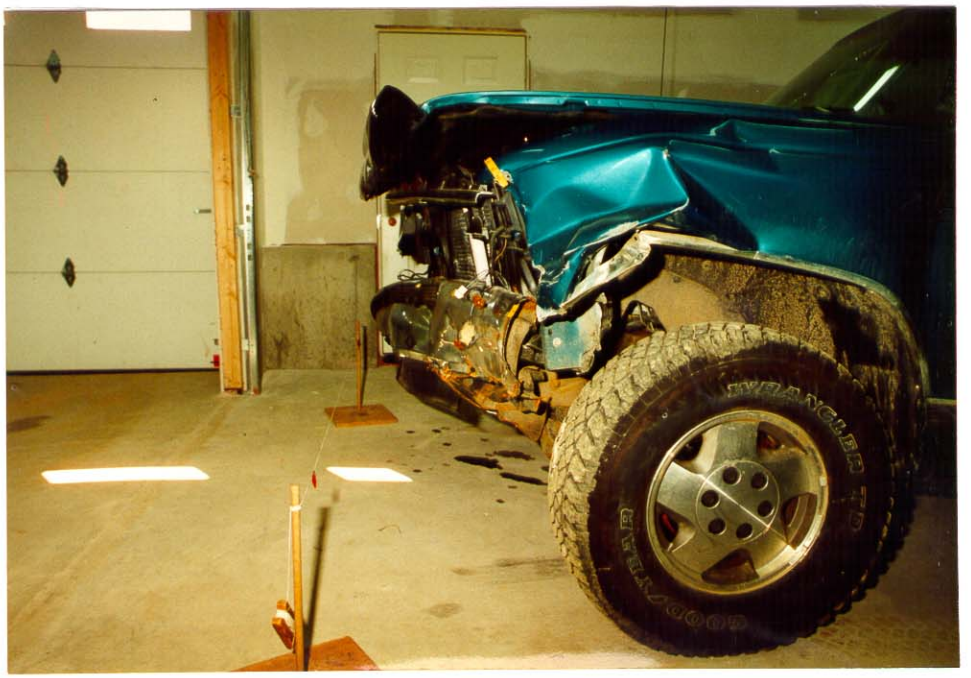
8. Frontal damage to the Chevrolet pickup truck.

9. Close-up view of the of the damage that resulted from contact with the snow plow.

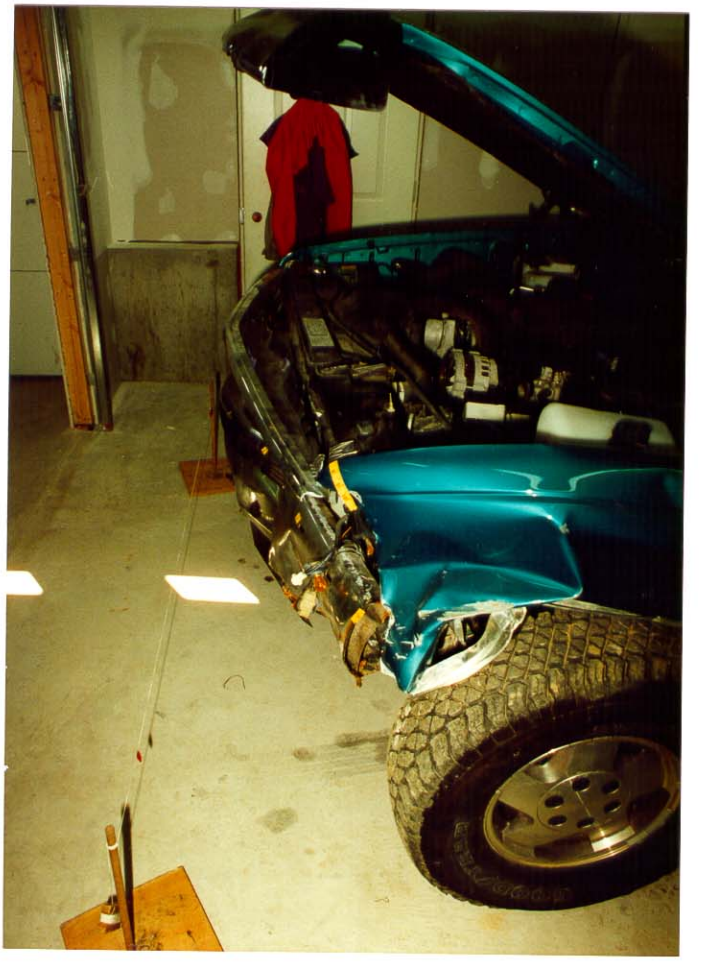


10. Cable guardrail damage (circled) across the front of the Chevrolet pickup truck.

11. Left front three-quarter view of the Chevrolet pickup truck.



12. Profile view documenting the extent of frontal crush.



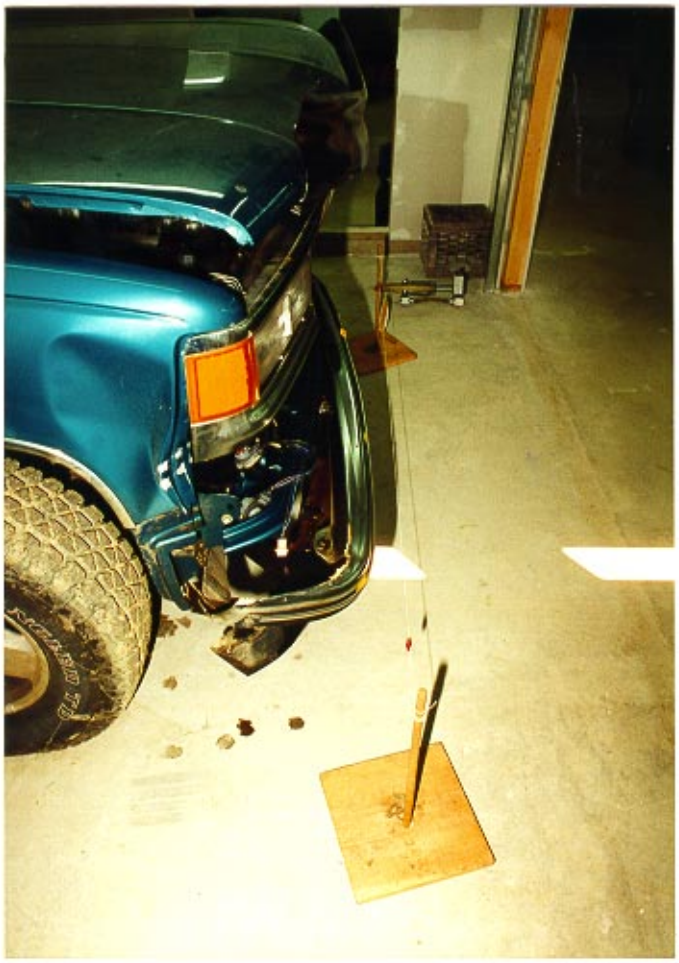
13. Additional profile view documenting the frontal damage pattern.

14. Left side view of the Chevrolet pickup truck.

15. Secondary guardrail contact damage to the left rear side area.

16. Right side view (undamaged) of the Chevrolet pickup truck.

17. Right front three-quarter view.



18. Right profile view documenting the frontal damage patterns.

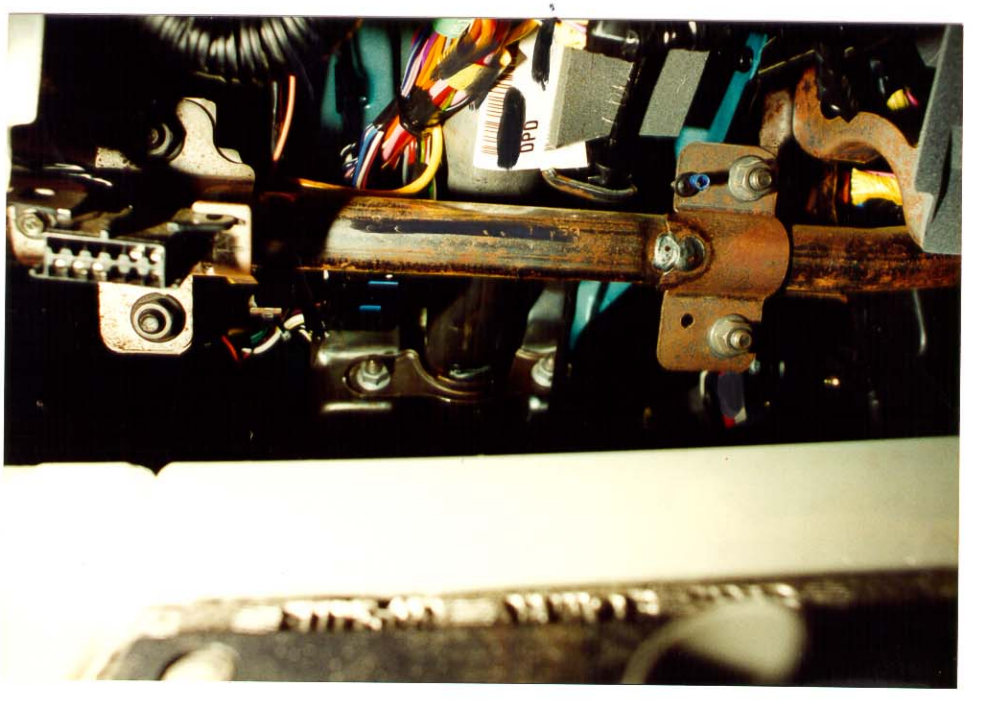
19. Overall view of the interior and occupant contacts points within the Chevrolet pickup truck.

20. Non-deployed driver's side air bag module.

21. Trajectory and contact points of the unrestrained driver of the pickup truck.

22. Knee bolster; no evidence of driver contact.

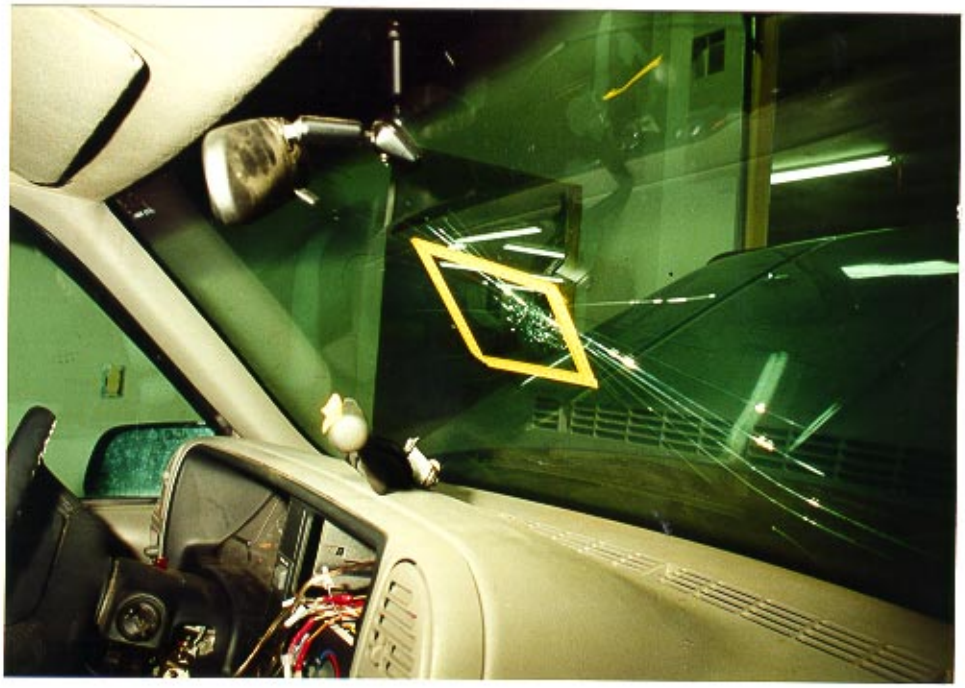
23. Back side of the knee bolster with no evidence of damage.



24. Energy absorbing steering column; no compression.

25. Trajectory of the driver as viewed from the second seat area.

26. Driver's head contact to the rear view mirror and windshield.



27. Head contact damage and tissue transfers to the windshield.

28. Driver's left thoracic contact and subsequent separation of the transmission selector lever from the steering column.

29. Probable right hand contact to the instrument panel mounted pullout cup holder.

30. Right front occupant's trajectory and subsequent contact points.

31 & 32. Right front occupant's knee contacts to the glove box door and vent louver.

33. View across the interior from the right door area.

34. View of the struck right side mounted wing plow.

35. Repaired damage to the outboard aspect of the wing plow.

36. Frontal view of the repaired wing plow.

ATTACHMENT B

SMASH Barrier Equivalent Output

Summary of Results Using Damage

96-4

	Speed Change (Damage)
Vehicle #1	
Total	23 km/h (14 mph)
Longitudinal	-23 km/h (-14 mph)
Latitudinal	-0 km/h (-0 mph)
PDOF Angle	0 °
Energy Dissipated	= 47719 Joules (35191 Ft-Lb)
Barrier Equivalent Speed	= 22.9 km/h (14.2 mph)
Calculated using crush coefficients entered by the user.	
Vehicle #2	
Total	0 km/h (0 mph)
Longitudinal	0 km/h (0 mph)
Latitudinal	0 km/h (0 mph)
PDOF Angle	0 °
Energy Dissipated	= 0 Joules (0 Ft-Lb)
Barrier Equivalent Speed	= 0.0 km/h (0.0 mph)
Calculated using size and stiffness categories.	

General Information

	Vehicle #1	Vehicle #2
Year	1995	1900
Make	chevrolet	
Model	K1500	
CDC	12FYEW1	BARRIER
Side Damaged	F	
PDOF Angle	360 °	0 °
Heading Angle	0 °	0 °

Calculation method:	Vehicle's Crush Coeff.	Size and Stiffness
Size Category	**	11
Stiffness Category	**	11
Vehicle Weight	**	453592 kgs (999999 lbs)
d0 crush coeff.	105.71 sqrt(N)	***** sqrt(N)
d1 crush coeff.	7.98 sqrt(N)/cm	***** sqrt(N)/cm

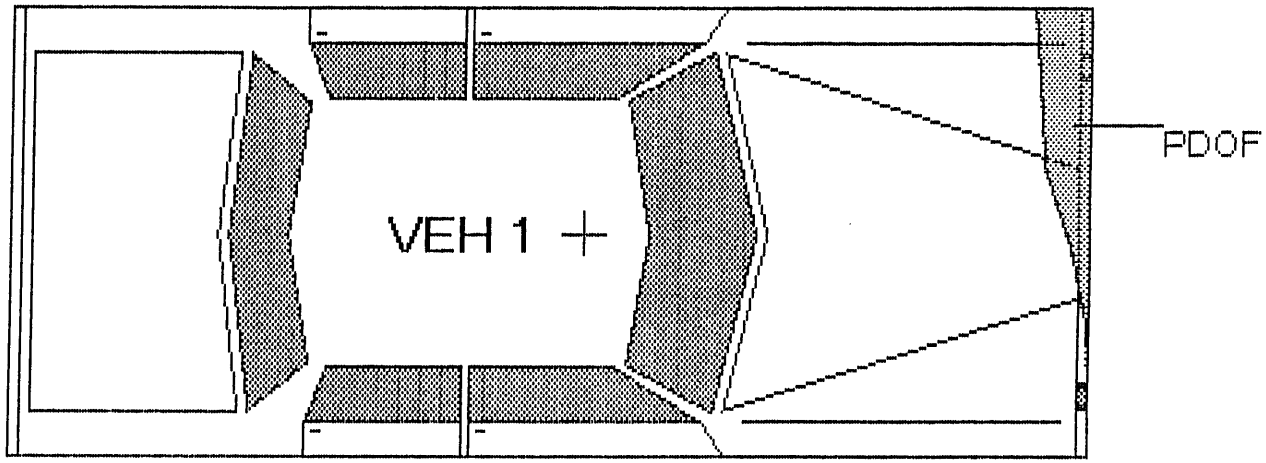
Damage Information

	Vehicle #1	Vehicle #2
Vehicle Damage Known	Yes	Yes
Crush Length	170.2 cm (67 in)	0.0 cm (0 in)
C1	28.2 cm (11 in)	0.0 cm (0 in)
C2	25.1 cm (10 in)	0.0 cm (0 in)
C3	23.1 cm (9 in)	0.0 cm (0 in)
C4	9.5 cm (4 in)	0.0 cm (0 in)
C5	0.6 cm (0 in)	0.0 cm (0 in)
C6	0.0 cm (0 in)	0.0 cm (0 in)
D	-10.8 cm (-4 in)	0.0 cm (0 in)
D'	-45.6 cm (-18 in)	0.0 cm (0 in)

Vehicle Dimensions

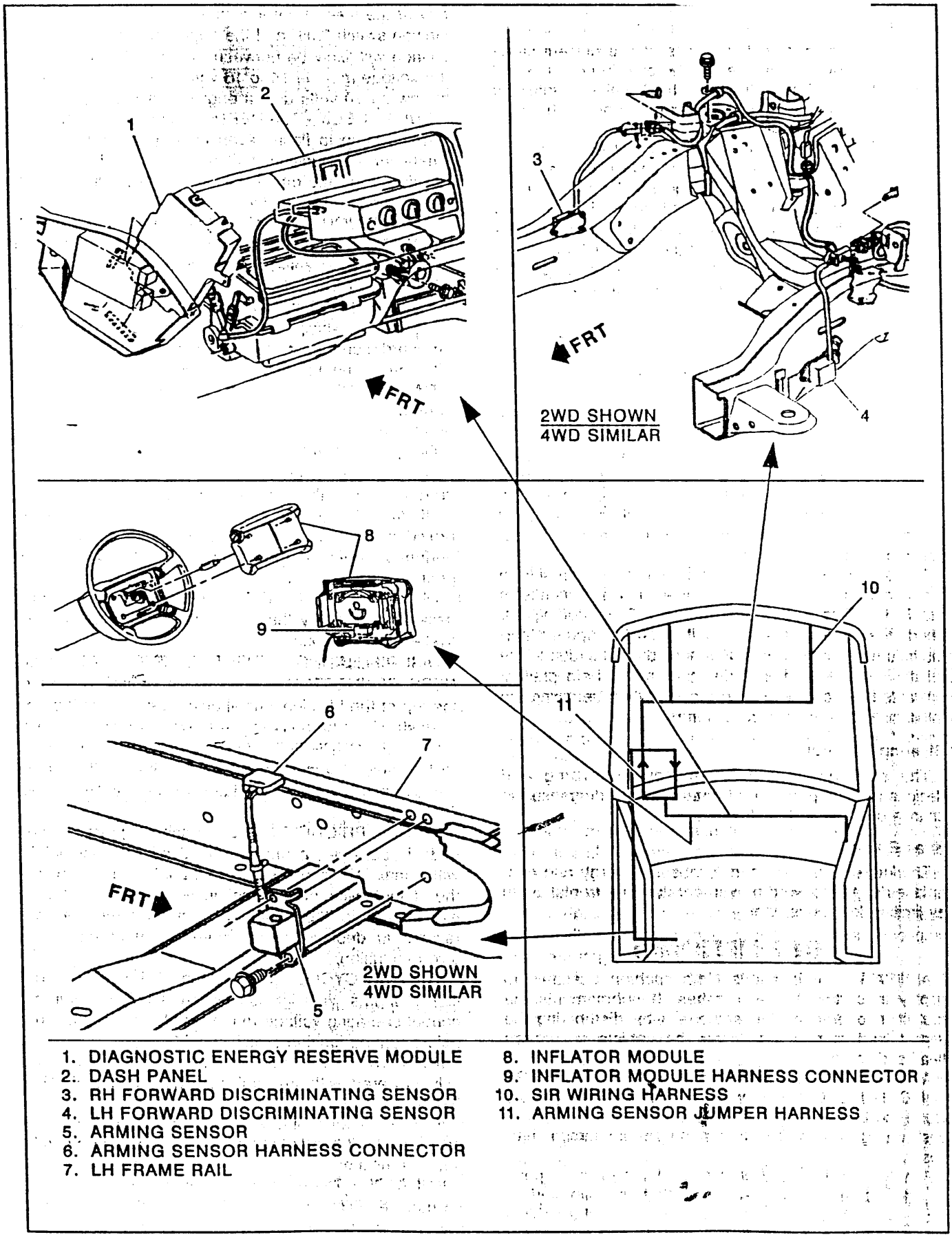
	Vehicle #1	Vehicle #2
Length	554.7 cm (218 in)	0.0 cm (0 in)
Width	193.0 cm (76 in)	0.0 cm (0 in)
Wheelbase	359.4 cm (141 in)	254.0 cm (100 in)
Weight	2183 kgs (4813 lbs)	453592 kgs (999999 lbs)
CG to Front of Veh	264.7 cm (104 in)	127.0 cm (50 in)
Engine Displacement	5.7 liters	0.0 liters
Moment of Inertia	606759 kgs (53705 lbs)	29375740821 kgs (2600101632 lbs)
Vehicle Mass	2183 kgs (12.5 lb-s^2/in)	453515 kgs (2600.1 lb-s^2/in)

1995 chevrolet K1500



ATTACHMENT C

SIR Component Schematic



1. DIAGNOSTIC ENERGY RESERVE MODULE
2. DASH PANEL
3. RH FORWARD DISCRIMINATING SENSOR
4. LH FORWARD DISCRIMINATING SENSOR
5. ARMING SENSOR
6. ARMING SENSOR HARNESS CONNECTOR
7. LH FRAME RAIL
8. INFLATOR MODULE
9. INFLATOR MODULE HARNESS CONNECTOR
10. SIR WIRING HARNESS
11. ARMING SENSOR JUMPER HARNESS

Figure 4—SIR Component and Wiring Location View