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CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION

SCI CASE NO: CA05-046

VEHICLE: 2005 ISUZU ASCENDER
LOCATION: FLORIDA
CRASH DATE: MAY, 2005

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.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract

This investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in 2005 Isuzu Ascender and the fatal injury sources for the 46 year old female driver. The CAC system was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switches, and a front right occupant detection sensor. A CAC vehicle is certified by the manufacturer to be compliant with the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Isuzu was also equipped with roof-rail mounted inflatable side curtains and a rollover sensor. The vehicle's Sensing and Diagnostic control Module (SDM) tailored the deployment of the air bags based the crash severity and inputs from the sensors. The SDM was located on the center tunnel immediately aft of the transmission selector. The SDM had the capability to record pre-crash vehicle systems and crash event data. This data was downloaded during the SCI investigation as a supplement to the investigation. The Isuzu was northbound in the inboard lane of a two-lane divided interstate highway and was driven by a 46 year old restrained female driver. For unknown reasons, the driver lost control of the vehicle and entered a counterclockwise yaw. The police investigation documented approximately 51.8 m (170.0 ft) of tire marks attributed to the right side tires of the Isuzu prior to its roadside departure. The vehicle departed the left side of the highway, entered the center median, traveled through a brush line and impacted a tree located 16.7 m (55.5 ft) west of the road edge. The force of the crash resulted in the deployment of the vehicle's frontal air bag. The inflatable side curtains also deployed during the crash sequence. The driver sustained blunt trauma to the head and torso and was pronounced deceased at the scene of the crash.

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BACKGROUND

This investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in 2005 Isuzu Ascender and the fatal injury sources for the 46 year old female driver. The CAC system was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switches, and a front right occupant detection sensor. A CAC vehicle is certified by the manufacturer to be compliant with the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Isuzu was also equipped with roof-rail mounted inflatable side curtains and a rollover sensor. The vehicle's Sensing and Diagnostic control Module (SDM) tailored the deployment of the air bags based the crash severity and inputs from the sensors. The SDM was located on the center tunnel immediately aft of the transmission selector. The SDM had the capability to record pre-crash vehicle systems and crash event data. This data was downloaded during the SCI investigation as a supplement to the investigation.

Figure 1: Left front oblique view of the Isuzu.

The Isuzu was northbound in the inboard lane of a two-lane divided interstate highway and was driven by a 46 year old restrained female driver. For unknown reasons, the driver lost control of the vehicle and entered a counterclockwise yaw. The police investigation documented approximately 51.8 m (170 ft) of tire marks attributed to the right side tires of the Isuzu prior to its roadside departure. The vehicle departed the left side of the highway, entered the center median, traveled through a brush line and impacted a tree located 16.7 m (55.5 ft) west of the road edge. The force of the crash resulted in the deployment of the vehicle's frontal air bag. The inflatable side curtains also deployed during the crash sequence. The driver sustained blunt trauma to the head and torso and was pronounced deceased at the scene of the crash.

The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) identified this crash through the police reporting system. The CID subsequently assigned an on-site investigation of the crash to the Calspan Special Crash Investigations (SCI) team on July 29, 2005 due to its interest in the performance of the advanced safety systems installed on current model year vehicles. The Calspan SCI team initiated follow-up investigation with the vehicle's insurance carrier and located the Isuzu at an insurance salvage facility. The

vehicle was available for inspection. The on-site portion of the investigation took place during the week of August 8, 2005.

SUMMARY

VEHICLE DATA

2005 Isuzu Ascender

Figure 2 is a view of an exemplar 2005 Isuzu Ascender. The subject Isuzu Ascender was identified by the Vehicle Identification Number (VIN): 4NUDS13S7527 (production sequence deleted). The five passenger, four-wheel sport utility vehicle was configured on a 287 cm (113 in) wheelbase. The power train consisted of a 4.2 liter/V6 engine linked to a four-speed automatic transmission. The service brakes were a four-wheel disc system with ABS. The cloth upholstered interior was configured with two front row bucket seats and a second row 60/40 split bench seat. The manual restraint system consisted of three-point lap and shoulder belts in all five seat positions. The front restraints were equipped with retractor pretensioners. The advanced driver and front right passenger air bags were compliant with the advanced FMVSS 208. The Isuzu was also equipped with roof-rail mounted inflatable side curtains. The driver air bag and the inflatable side curtains deployed in the crash. The vehicle's date of manufacture was unknown. The manufacturer's VIN tag attached to the driver's door was damaged during the removal of the door and the label was illegible. The digital odometer could not be read at the time of the inspection due to impact damage to the vehicle's electrical system. The Isuzu was equipped with Continental Conti-Trac TR P245/65R17 tires on OEM alloy wheels. The specific measured tire data was as follows:

Figure 2: View of an exemplar Isuzu Ascender.

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	10 mm (13/32)	Yes	Tire cut by impact, rim fractured
LR	7 kPa (1 PSI)	10 mm (12/32)	No	Grass embedded in bead
RF	228 kPa (33 PSI)	10 mm (12/32)	No	None
RR	221 kPa (32 PSI)	10 mm (12/32)	Yes	None

CRASH SITE

This single vehicle crash occurred during the nighttime hours of May 2005. At the time of the crash, it was dark without artificial lighting and the weather was not a factor. The crash occurred within the center median of a north/south interstate highway in a rural area of the state. At the crash site, the asphalt northbound roadway was straight and level and consisted of two 3.7 m (12 ft) traffic lanes. The lanes were separated by a broken white center line. The west (inboard) edge of the travel lane was bordered by a solid yellow line and a 1.3 (4.3 ft) wide shoulder. Rumble strips were incorporated into the construction of the road shoulder. West of the paved shoulder was a 9.1 m (30 ft) wide area of grass that terminated into a line of small diameter trees

and brush. The grass terrain had an average negative slope of 16 percent over its 7.3 (24 ft) width and then leveled at the brush line. A 38 cm (15 in) diameter coniferous tree was located beyond the brush line in an open area. The tree was located 18.3 m (60 ft) west of the pavement edge and was the point of impact. The tree was scarred from the ground to a height of 213 m (84 in) about 75 percent of its circumference due to the crash. There was a paved median crossover 102 m (335 ft) south of the point of impact that served as the reference point. **Figure 3** is a northbound view of the highway in the area of the road side departure. **Figure 4** is a trajectory view at the point where the Isuzu penetrated the brush line. The posted speed limit in the area of the crash was 113 km/h (70 mph).

Figure 3: Northward view of the crash site.

Figure 4: Trajectory view at the point where the Isuzu entered the brush.

CRASH SEQUENCE

Pre-Crash

The 46 year old female driver of the Isuzu was operating the vehicle on the inboard northbound lane of the interstate. For unknown reasons, the driver lost directional control and the Isuzu began to yaw counterclockwise. The police investigation documented a 52.4 m (172 ft) right front yaw mark and a 46.3 m (152 ft) right rear yaw mark in left traffic lane prior to the vehicle's road side departure. The investigating police officer documented the location of the yaw marks with road paint which was still visible at the time of the SCI scene inspection. However due to the passage of time between the date of the crash and SCI notification, the yaw marks were not visible at the time of the SCI scene inspection. Referencing the police documentation and the point of entry into the brush line, the SCI reconstruction of the crash determined the Isuzu left the road at a relative angle of approximately 10 – 15 degrees to the travel direction. The data downloaded from the Isuzu's Event Data Recorder (EDR) indicated the vehicle's speed was 142 km/h (88 mph) five seconds prior to Algorithm Enable (AE) and decelerated to 138 km/h (86 mph) one second prior to AE. The brake circuit switch status indicated the brakes were not applied during the five second pre-crash recording. The Isuzu then traversed across and down the negative slope of the terrain west of the pavement and penetrated the brush line. The Isuzu passed through the 3 m (10 ft) wide brush line and entered as open area beyond the brush. The density and over-growth of the brush line concealed the Isuzu's trajectory to passing motorist.

The Isuzu was not found until the day following the crash. A schematic of the crash is included at the end of this report as **Figure 11**.

Crash

Figure 5 is a view of the point of impact. The crash occurred with the Isuzu impacting the 38 cm (15 in) diameter tree with its left corner. The initial engagement was located outboard of the vehicle's left frame rail at the extreme left end of the bumper reinforcement bar. The principle direction of the impact force was in the 11 o'clock sector. The force of the impact separated the left front wheel assembly from the lower suspension and drove those components rearward into the lower A-pillar and cowl. The vehicle pitched down and the tree pocketed in the deformation with the direct contact extending onto the roof. The Isuzu remained in contact with the tree and rotated approximately 60 degrees clockwise coming to rest facing northeast.

Figure 5: View of the point of impact.

Due to the dynamics of the corner impact and the resultant two planes of direct contact damage, analysis of this crash through the use of the WINSMASH model was not possible. The EDR recorded total delta V of the crash was 87 km/h (54.1 mph). The longitudinal and lateral components of the delta V were -77 km/h (-47.75 mph) and +41 km/h (+25.47 mph), respectively. The recorded delta V of the crash was consistent with the vehicle's damage and the crash dynamics.

Post-Crash

The police and ambulance personnel were summoned to the crash site the day following the crash. The driver was pronounced deceased at that time by a paramedic. She was removed from the vehicle and transported to the medical examiner's office for autopsy. The Isuzu was towed from the scene and deemed at total loss.

2005 ISUZU ASCENDER

Exterior Damage

The Isuzu Ascender, **Figure 6**, sustained direct contact damage to the front and left side planes as a result of the crash. The direct contact began at the left corner extending rearward beyond the windshield header and inboard to the approximate centerline of the vehicle. The impact resulted in pocketing damage at the left aspect of the cowl.

Figure 6: Left oblique view of the damaged Isuzu.

The direct contact on the front plane began 55 cm (21.8 in) left of center and extended 34 cm (13.2

in) to the left corner. The combined width of the direct and induced damage extended across the vehicle's entire 178 cm (70 in) end width. The bumper fascia separated during the impact and was located at the scene. The residual crush of the front bumper was as follows: C1 = 72 cm (28.3 in), C2 = 31 cm (12.2 in), C3 = 27 cm (10.6 in), C4 = 16 cm (6.3 in), C5 = 11 cm (4.3 in), C6 = 16 cm (6.3 in). The maximum crush was located at the left corner.

As the vehicle continuted forward, the left front fender and left front wheel assembly engaged the tree. **Figure 7** is a left side view of the Isuzu. The left front wheel assembly separated at the lower control arm and the drive shaft and was crushed rearward into the cowl. The rim fractured and the tire was cut. The left frame rail was bowed inboard between the left front suspension and the left B-pillar. The maximum lateral deformation measured approximately 10 cm (4 in). The left aspect of the cowl, immediately forward of the driver's position, was deformed 33 cm (13 in) rearward from direct contact. This area of the vehicle was deformed into a U-pattern that measured 33 cm (13 in) in width. The windshield was in place and totally fractured. There was direct contact between the tree and the windshield header, **Figure 8**. The roof was buckled and exhibited direct contact that extended 99 cm (39 in) rearward of the deformed header. The direct contact damage to the header began 16 cm (6.2 in) inboard of the left corner and extended 60 cm (23.5 in) to the right. The direct contact damage ended 10 cm (4 in) right of center. The maximum crush measured 41 cm (16.1 in) and was located 10 cm (4 in) left of center. The residual crush across the windshield header was as follows: C1 = 72 cm (28.3 in), C2 = 31 cm (12.2 in), C3 = 27 cm (10.6 in), C4 = 16 cm (6.3 in), C5 = 11 cm (4.3 in), C6 = 16 cm (6.3 in). The left wheelbase was reduced 42 cm (16.7 in). The right wheelbase lengthened 4 cm (1.5 in) due to frame distortion. The longitudinal deformation of the left B-pillar measured 6 cm (2.3 in). The left doors were jammed shut due by impact damage. The left front door was removed during the driver's extrication. The left rear door over lapped the C-pillar 5 cm (2 in). The welds along the left lower sill and floor pan separated to the C-pillar due to overload. The right doors remained operational but could not be latched due to body deformation. The Collision Deformation Classification (CDC) of the impact was 11-FLAE9.

Figure 7: Left side view of the Isuzu.

Figure 8: Front view of the damage header.

Interior Damage

The interior damage to the Isuzu consisted of the severe intrusion of the frontal components, the deployments of the driver air bag and inflatable side curtains and the driver contact points. The energy of the impact was directed from the front left of the vehicle along the 11 o'clock PDOF into the driver's space. This resulted in intrusion of the frontal components to the forward edge of the driver seat, which itself was intruded into the second row. The intrusion into the driver's position is summarized in the table below:

Row 1 Left Position		
Component	*Magnitude*	*Direction*
Left lower A-pillar	51 cm (20 in)	Longitudinal
Driver knee bolster	86 cm (34 in)	Longitudinal
Toe pan (center aspect)	109 cm (43 in)	Longitudinal
Steering wheel	67 cm (26.5 in)	Longitudinal
Driver seat	46 cm (18 in)	Longitudinal
Windshield header	41 cm (16 in)	Longitudinal

The center aspect of the instrument panel fractured due to the impact and the penetration of the tree. The center and right aspects of the instrument panel rotated counterclockwise (outboard right). The center instrument stack was on top of the front right seat cushion. The front right passenger air bag was facing the right side plane.

Figure 9 is a view of the driver's seat. The driver seat was adjusted to a mid-track position 8 cm (3.1 in) forward of full rear. The total seat track travel measured 21 cm (8.3 in). The track position of the driver seat was determined through the use of exemplar measurements. The floor pan forward of the driver seat was buckled. The driver seat was pitched down. The angle of the deformed seat cushion measured zero degrees. The seat back was vertical.

Figure 9: Left front interior view.

The steering wheel assembly fractured at the knuckle of the tilt mechanism and the steering wheel was suspended by the electrical harness. The horizontal distance from the seat back to the knuckle at the end of the steering column measured 27 cm (10.5 in). The top sector of the steering wheel rim was deformed forward. The deformation in the 12 o'clock sector measured 3 cm (1 in). There was no separation of the steering column's shear capsules.

The intruded knee bolster was in contact with the driver seat cushion. The left aspect of the bolster exhibited two scuffs from contact with the driver's lower extremities. The most outboard scuff mark measured 5 cm x 5 cm (2 in x 2 in). The scuff mark was located 38 cm (15 in) left of the steering column center line and 13 cm (5 in) below the top edge of the bolster. An 8 cm (3 in) diameter scuff mark was located 30 cm (12 in) left of the steering column center line and 3 in below the top edge of the bolster.

Manual Restraint Systems

The manual restraint systems in the Isuzu Ascender consisted of three-point lap and shoulder belts in all five seat positions. The restraints in the front row were integrated into the seat backs of the driver and front right passenger seat and utilized retractor pretensioners. The pretensioners for both the driver's position and the (unoccupied) front right passenger position fired in the crash.

The driver's restraint consisted of continuous loop webbing, sliding latch plate and an Emergency Locking Retractor (ELR). Initial observation at the time of the inspection revealed the webbing had been cut in two places. The webbing was cut 8 cm (3 in) beyond the integrated belt guide at upper left aspect of the driver seat and immediately above the outboard anchor. The latch plate was still latched in the buckle. The webbing was not with the vehicle. The retractor was locked by the fired pretensioner. Examination of the latch plate revealed evidence of historical use. The friction surface of the latch plate was abraded across its full width indicative of driver loading. The observations of the SCI inspection determined the driver was restrained at the time of the crash. The downloaded EDR data indicated the driver's belt was buckled at the time of the crash and reported the pretensioner as fired.

The front right passenger restraint was stowed in its retractor upon inspection and the retractor pretensioner had fired. The webbing was under tension and could not be spooled from the retractor. The downloaded ER data reported that this restraint was unbuckled and that its pretensioner had fired.

Certified Advanced 208-Compliant Air Bag System

The Certified Advanced 208-Compliant (CAC) frontal air bag consisted of advanced dual stage/dual threshold air bags for the driver and front right passenger, seat track position sensors, front safety belt buckle switches, front safety belt buckle pretensioners and a front right occupant detection sensor. The frontal air bag system was certified by the manufacturer to have met the requirements of the advanced Federal Motor Vehicle Safety Standard 208. The system was controlled and monitored by a Sensing and Diagnostic control Module (SDM) located under the center console. The SDM had Event Data Recorder (EDR) capability. The EDR recorded five seconds of pre-crash vehicle systems data and crash-related event data. The EDR was downloaded during the course of the SCI inspection. Refer to the *Event Data Recorder* section of this report for further detail regarding the data.

The driver air bag, **Figure 10**, deployed as designed from an I-configuration module mounted in a conventional manner in the center of the steering wheel rim. The symmetrical cover flaps measured 8 cm x 11 cm (3 in x 4.5 in), width by height, respectively. The flaps opened at the designed tear seams during the deployment

Figure 10: Driver air bag.

sequence and were not damaged. There was no evidence of occupant contact to the flaps. The deployed driver air bag measured 61 cm (24 in) in diameter. The bag was tethered by two 10 cm (4 in) wide straps in the 3/9 o'clock sectors and was vented by two 3 cm (1.2 in) diameter ports located in the 11/1 o'clock sectors. The 10 o'clock sector of the air bag was soiled from its post-crash exposure to the elements. There was no residual evidence of occupant contact identified on the air bag.

The front right passenger air bag module was a mid-mount design housed within the right aspect of the instrument panel. This air bag was not commanded to deploy in this crash. It was suppressed by the front right occupant detection sensor due to the unoccupied status of the front right seat.

Roof Rail Mounted Inflatable Side Curtains

The Isuzu Ascender was equipped with inflatable side curtains mounted in the respective roof rails of the vehicle. The side curtains were designed to provide head protection during a side impact crash by deploying the curtain o the struck side of the vehicle. Additionally, in a rollover crash both side curtains were designed to deploy in conjunction with the firing of the seat belt pretensioners. The SDM controlled the deployment of the side curtains based on inputs from crash sensors within the module and from an external rollover sensor mounted on the center tunnel. The roll sensor was designed to measure the vehicle's roll rate and roll angle. Deployment of these inflatable devices was commanded once the design threshold of these parameters was exceeded.

Based on the SCI reconstruction of the subject crash and analysis of the downloaded EDR data, the side curtains deployed 3.56 seconds prior to the impact with the tree. At this time the Isuzu was in the early stages of its yaw trajectory approximately 107 m (350 ft) from the tree impact. The curtains were commanded to deploy based on a predicted imminent rollover. Given that the vehicle did not rollover in this crash, the side curtains were commanded to deploy based on a low roll angle combined with a high roll rate. The roll sensor reported the vehicle's roll attitude was between 0 to ¼ turn. Had the vehicle remained on the roadway, it may have tripped and a rollover crash may have occurred. However, the subsequent off-road trajectory of the Isuzu in the subject crash and its dynamics altered the vehicle's roll dynamics leading to the run–off road crash event. Refer to the *Event Data Recorder* section below.

The inflatable side curtains deployed downward from the respective roof rails. The curtain provided coverage that extended from the A- to C-pillars. The gross overall dimensions of each curtain measured 173 cm x 51 cm (68 in x 20 in), length by height respectively. The curtain was tethered at the A-pillar and to the roof rail behind the C-pillar. The surface of the deployed left curtain was soiled from its exposure. There was no evidence of driver contact to the surface of the left curtain.

Event Data Recorder

The Event Data Recorder (EDR) was downloaded at the time of the SCI inspection utilizing the Vetronix Crash Data Retrieval (CDR) tool and software version 2.718. The data was retrieved

by connecting the CDR tool directly to the SDM. The downloaded data is attached to the end of this report as *Attachment A.* The EDR recorded a Deployment and a Deployment Level event on ignition cycle 178. The data download occurred on ignition cycle 179. Analysis of the data indicated the Deployment event was related to a predicted roll event that fired the pretensioners and commanded of the inflatable curtains. The Deployment Level event 3.56 seconds after the Deployment event and was related to the impact with the tree. Data flags within the record indicated that a Non-Deployment event occurred after the Deployment Level event. This Non-Deployment was not recorded due to the EDR's storage limitations. This Non-Deployment event was probably related to the post-crash rotation of the Isuzu.

The data table of the Deployment Level event (the focus of the SCI investigation) indicated the SIR warning lamp was "On" at the time of the tree impact and a series of Diagnostic trouble codes existed. These flags were consistent with the commanded Deployment event of the inflatable side curtains. The record further indicated the driver's safety belt was buckled consistent with the physical evidence and the SCI reconstruction. The Isuzu's frontal impact commanded a Stage 1 deployment of the driver's air bag 35 milliseconds after Algorithm Enable (AE) and a disposal of Stage 2. The front right air bag deployment was suppressed by the occupant presence detection system. The maximum EDR recorded longitudinal and lateral delta V's were -77 km/h (-47.75 mph) and 41 km/h (25.47 mph), respectively. The maximum delta V occurred 210 milliseconds after AE. These values yielded a calculated total delta V of 87 km/h (54.1 mph) with a Principle Direction of Force PDOF in the 11 o'clock sector. The EDR reported PDOF was consistent with the vehicle's damage.

DRIVER DEMOGRAPHICS

	Driver
Age/Sex:	46 year old / Female
Height:	163 cm (64 in)
Weight:	51 kg (112 lb)
Seat Track Position:	Mid-track, 8 cm forward of full rear
Manual Restraint Use:	Three-point lap and shoulder belt
Usage Source:	SCI inspection, observations of the first responders, EDR
Medical Treatment:	None, fatally injured

DRIVER INJURY

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
Atlanto-axial dislocation with extensive muscular hemorrhage and ligamentous injury	Serious (650206.3,6)	Steering wheel (indirect)
Single fracture to the right sided lamina of C5 with associated broad dislocation and distraction of C5 on C6	Serious (650224.3,6)	Steering wheel (indirect)

Complete laceration of the C5/C6 intervertebral disc. Disc laceration also involves the C6/C7 joint with associated underlying mild to moderate epidural hemorrhage, without identifiable spinal cord contusion or laceration	Moderate (650299.2,6)	Steering wheel (indirect)
Thin subarachnoid hemorrhage over the frontal poles of the brain	Serious (140684.3,1) (140684.3,2)	Steering wheel
Displaced transverse fracture of the right femur (overlying contusion noted and coded separately)	Serious (851814.3,1)	Steering wheel (indirect)
Right hip fracture dislocation with extensive acetabular fracture and distraction of the pelvic fracture fragments	Serious (852604.3,1)	Steering wheel (indirect)
Left hip joint dislocation without fracture with broadly dislocated left sacro-iliac joint	Moderate (850610.2,2)	Knee bolster
Medium length superficial laceration of the right lobe of the liver 2 to 3 mm in depth, (25 ml hemoperitoneum with moderate hemorrhage especially about the region of the bladder)	Moderate (541822.2,1)	Safety belt
Right tibia mid-shaft fracture	Moderate (853420.2,1)	Knee bolster
Extensive compound fracture dislocation of the left ankle	Moderate (852002.2,2) (850210.2,2)	Toe pan
Contusion medial aspect right thigh	Minor (890402.1,1)	Steering wheel
Broad contusion of the right lower forehead extending into the right orbit	Minor (290402.1,7)	Steering wheel
Small abrasion of the mental protuberance of the chin	Minor (290202.1,8)	Deployed driver air bag
Cluster of scratches left side of face	Minor (290202.1,2)	Deployed driver air bag
Cluster of scratches over the right superior forehead at the hairline	Minor (290202.1,7)	Deployed driver air bag
Obliquely oriented band-like abrasion left side of neck extending anterio-medially and posterio-latterly	Minor (390202.1,2)	Safety belt
Small abrasion anterior left clavicle	Minor (790202.1,2)	Safety belt

Abrasion mid-chest	Minor (490202.1,4)	Safety belt
Abrasion and contusion upper left breast	Minor (490202.1,2) (490402.1,2)	Safety belt
Band like contusion left lower abdomen to the right groin	Minor (590402.1,0)	Safety belt
Two well defined contusions to the mid-aspect of the right buttock	Minor (590402.1,8)	Driver seat frame
Multiple abrasions and contusions of the upper extremities bilaterally	Minor (790202.1,3) (790402.1,3)	Instrument panel
Multiple abrasions, contusions and lacerations of the lower extremities bilaterally	Minor (890202.1,3) (890402.1,3) (890602.1,3)	Knee bolster and foot controls

The above injuries were identified in the Medical Examiner's Report of Autopsy.

Driver Kinematics

The 46 year old female driver was seated in a mid track position. She was restrained at the time of the crash by the vehicle's three-point lap and shoulder belt. For unknown reasons, the driver lost directional control of the Isuzu resulting in a steering induced counterclockwise yaw. As a result of these yaw dynamics, the seat belt pretensioners fired and inflatable side curtains deployed. The driver's safety belt system was locked at this time. The Isuzu departed the left side of the road and traveled 39 m (128 ft) to the frontal impact with the tree. The EDR reported that the frontal impact occurred 3.56 seconds after the firing of the pretensioners and inflatable side curtain deployment.

Upon impact, the driver air bag deployed. The driver responded to the 11 o'clock direction of the impact force by initiating a forward trajectory. The driver contacted and loaded the webbing of the manual restraint and began to ride down the force of the impact evidenced by neck, left shoulder, chest, and abdominal abrasions. As the crash developed, the driver's torso decelerated and the inertia of the head caused the neck to flex forward and down. The driver's face and upper chest contacted and loaded the deployed driver air bag. The driver's contact to the air bag was evidenced by the soft tissue abrasions to the face. The driver loaded through the air bag and her forehead contacted the steering wheel rim evidenced by a contusion. The impact of the head deformed the upper sector of the steering wheel rim and resulted in a cerebral subarachnoid hemorrhage. The seat belt overrode the skeletal structure of the driver's pelvis and loaded the soft tissue of the abdomen due to the continued loading. This resulted in the identified minor liver laceration.

Coincident to the driver's forward kinematic pattern, the structures forward of the driver were intruding rearward. The intrusion of the steering wheel began to force the head/neck into extension. The anatomical structures of the exceeded their natural limits resulting in the cervical atlanto-axial dislocation and the lower cervical fracture dislocation and associated connective

tissue injury. The driver's lower extremities contacted the bolster evidenced by the scuff marks to that component and the resultant bilateral abrasions, contusions and lacerations of the lower extremities. The intruding and deformed toe pan caused a fracture dislocation of the left ankle. The intruding bolster fractured the right tibia. As the bolster intruded, the driver's legs were driven upward and the driver's right femur contacted the steering wheel rim. This contacted further restricted the driver's movement. The intruding steering column fractured the driver's right femur and resulted in the fracture dislocation of the right hip. The force of this interaction caused the fracture of the tilt mechanism of the steering assembly. The driver came to rest in the driver seat entrapped within the vehicle due to the extent of the intrusion.

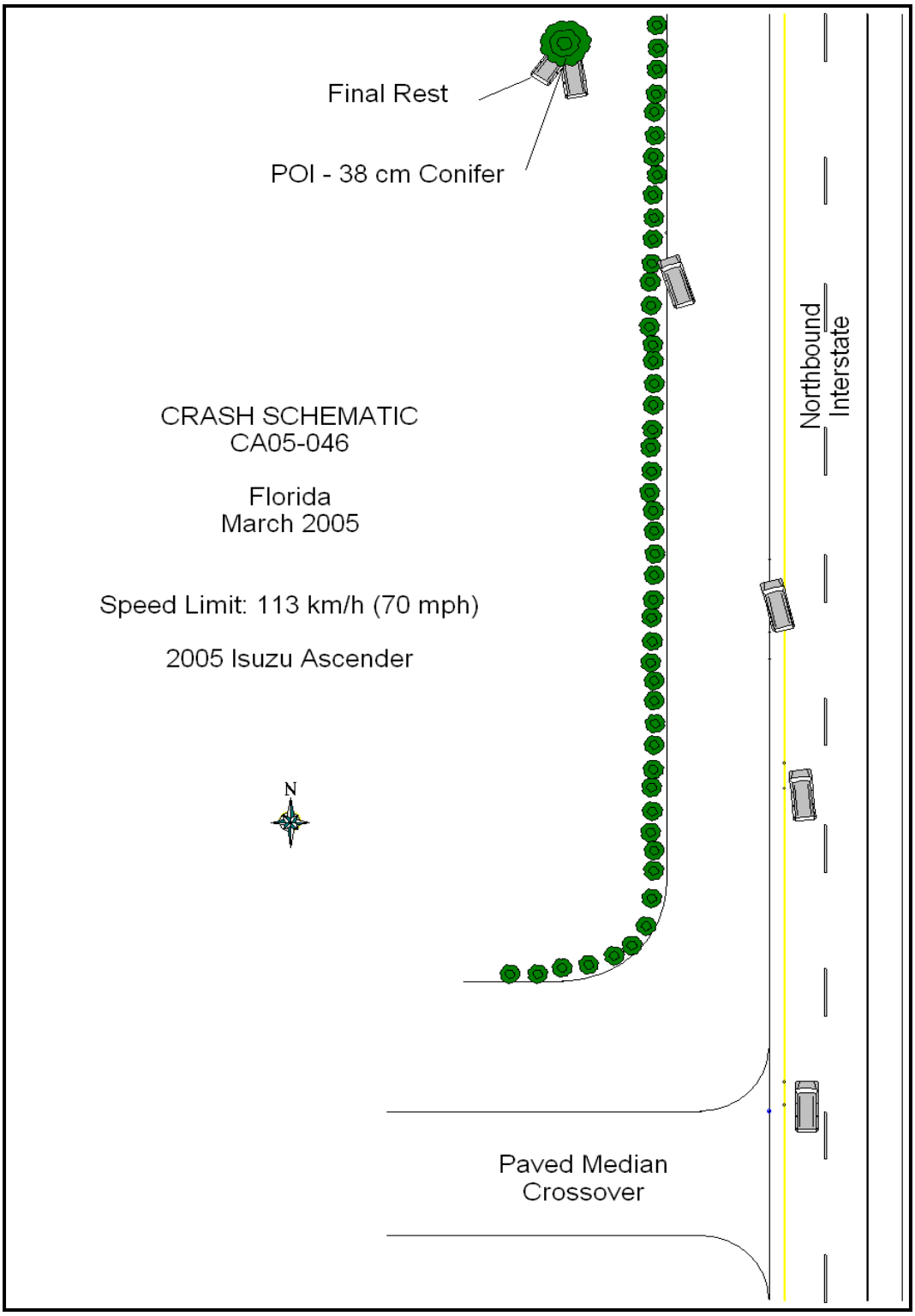


Figure 11: Crash schematic.

ATTACHMENT A

EDR Data

CDR File Information

Vehicle Identification Number	4NUDS13S752******
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	CA05-046 CDR.CDR
Saved on	Monday, August 15 2005 at 04:00:06 PM
Collected with CDR version	Crash Data Retrieval Tool 2.718
Collecting program verification number	2EDC82A4
Reported with CDR version	Crash Data Retrieval Tool 2.8045
Reporting program verification number	E9B7C0A4
Interface used to collected data	Block number: 00 Interface version: 44 Date: 07-18-05 Checksum: 2E00
Event(s) recovered	Deployment Deployment #2

SDM Data Limitations

SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. Deployment Events cannot be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the Non-Deployment Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 5 seconds before the Deployment Event unless a Deployment Level Event occurs within 5 seconds after the Deployment Event, then the Deployment Level Event will overwrite the Non-Deployment Event file.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For Deployment Events and Deployment Level Events, the SDM will record 230 milliseconds of data after deployment criteria is met and up to 70 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM will record up to the first 300 milliseconds of data after algorithm enable. The minimum SDM Recorded Vehicle Forward Velocity Change, that is needed to record a Non-Deployment Event, is 5 MPH.
-Maximum Recorded Vehicle Velocity Change is the maximum recorded velocity change in the vehicle's combine "X" and "Y" axis.
-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.
-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM receive an invalid message from the module sending the pre-crash data.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit.

-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 5 seconds, "N/A" is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded. -Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.
-Steering Wheel Angle data is displayed as a positive value, when the steering wheel is turned to the right, and a negative value, when the steering wheel is turned to the left.

SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
-The Belt Switch Circuit is wired directly to the SDM.

Multiple Event Data

Associated Events Not Recorded	1
An Event(s) Preceded the Recorded Event(s)	No
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	Yes
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	Yes

System Status At AE

Vehicle Power Mode Status	Off
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Inactive

System Status At 1 second

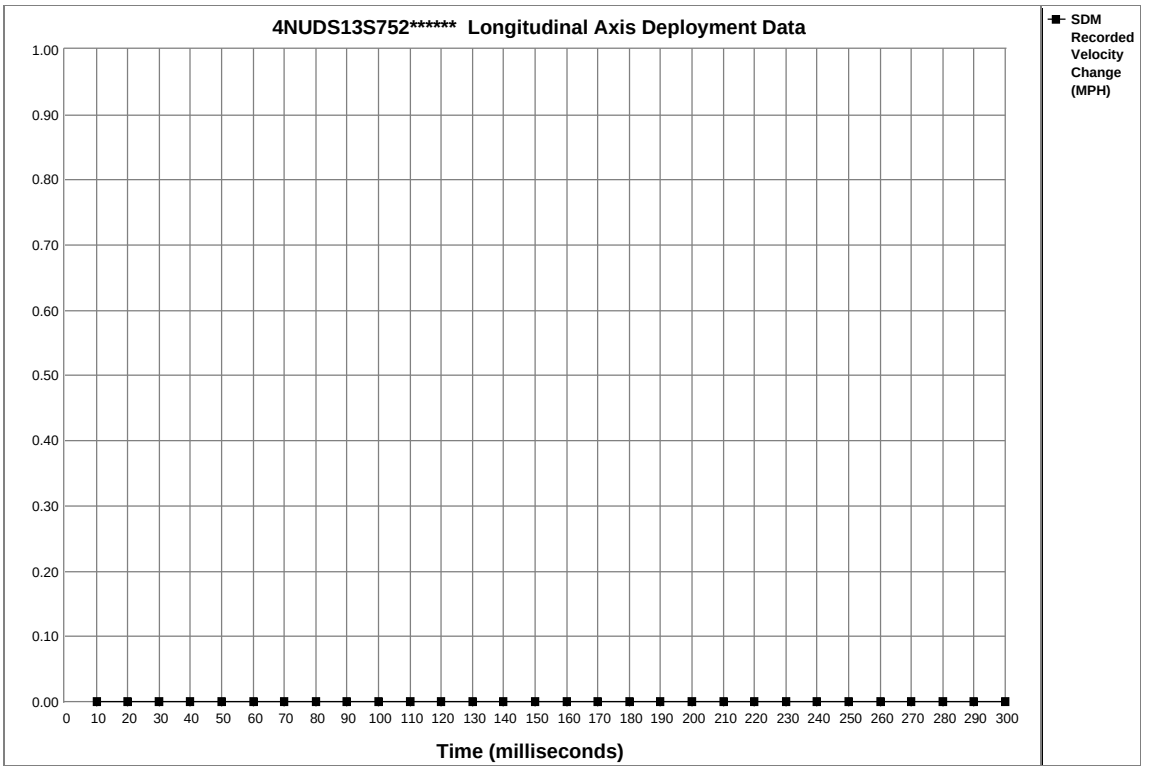
Left Front Door Ajar	No
Right Front Door Ajar	No
Left Rear Door Ajar	No
Right Rear Door Ajar	No

Pre-crash data

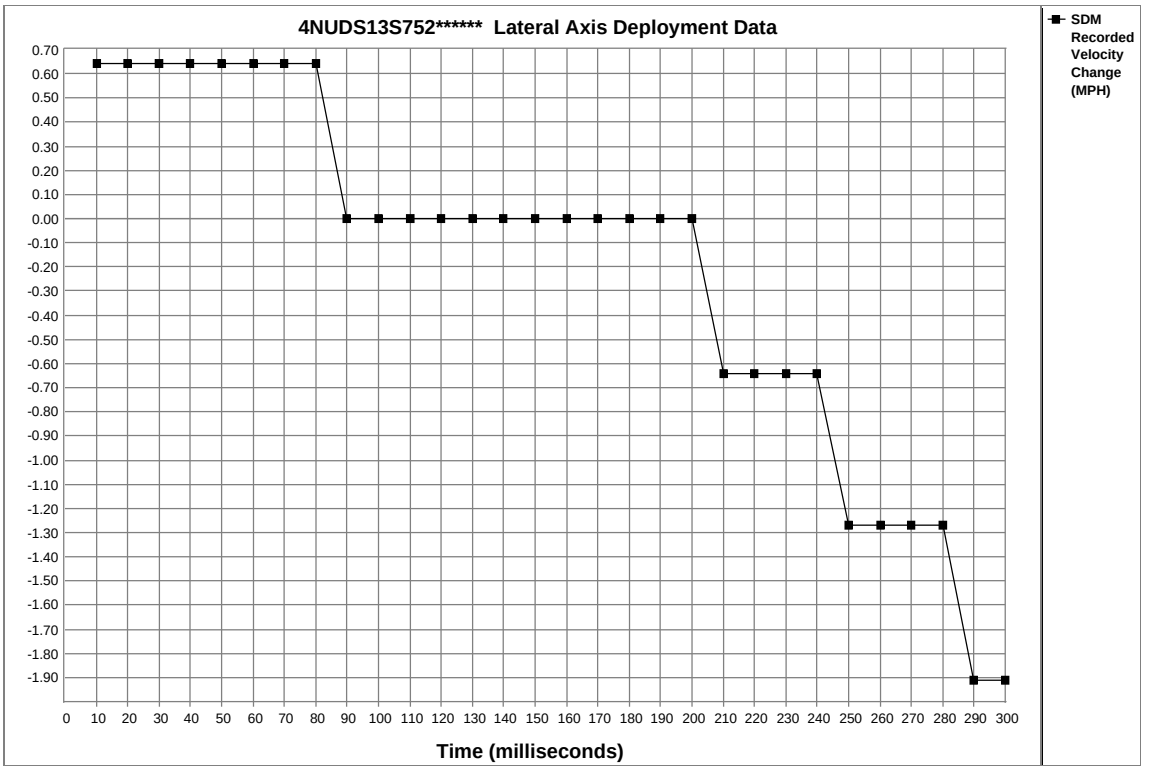
Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	88	88	88	88	86
Engine Speed (RPM)	2432	2432	2432	2432	2368
Percent Throttle	29	25	25	14	0
Brake Switch Circuit Status	OFF	OFF	OFF	OFF	OFF

System Status At Deployment

SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time Continuously (seconds)	145050
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	177
Ignition Cycles At Investigation	179
Ignition Cycles At Event	178
Ignition Cycles Since DTCs Were Last Cleared	177
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Driver Seat Position Switch Circuit Status	Rearward
Passenger Seat Position Switch Circuit Status	Rearward
Automatic Passenger SIR Suppression System Status (1 sec)	Air Bag Suppressed
Rollover Sensor Status	0 to 1/4 turns
Number of Consecutive Error Free Messages Received From Rollover Sensor	Last 128 Consecutive Message Were Error Free
SDM Synchronization Counter	247
Side Air Bag(s) Were First Commanded to Deploy Due to Side Impact Event	No
Side Air Bag(s) Were First Commanded to Deploy Due to Rollover Event	Yes
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Driver Thorax/Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	318.75
Passenger Thorax/Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	318.75
Driver 1st Stage Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	Yes
Driver Roof Rail/Head Curtain Loop Commanded (If Equipped)	Yes
Supplemental Deployment Loop #1 Commanded (If Equipped)	No
Passenger 1st Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	Yes
Passenger Roof Rail/Head Curtain Loop Commanded (If Equipped)	Yes
Supplemental Deployment Loop #2 Commanded (If Equipped)	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded (If Equipped)	No
Supplemental Deployment Loop #3 Commanded (If Equipped)	No
Second Row Right Side Deployment Loop Commanded (If Equipped)	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Supplemental Deployment Loop #4 Commanded (If Equipped)	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Diagnostic Trouble Codes at Event, fault number: 1	N/A
Diagnostic Trouble Codes at Event, fault number: 2	N/A
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Event Recording Complete	Yes



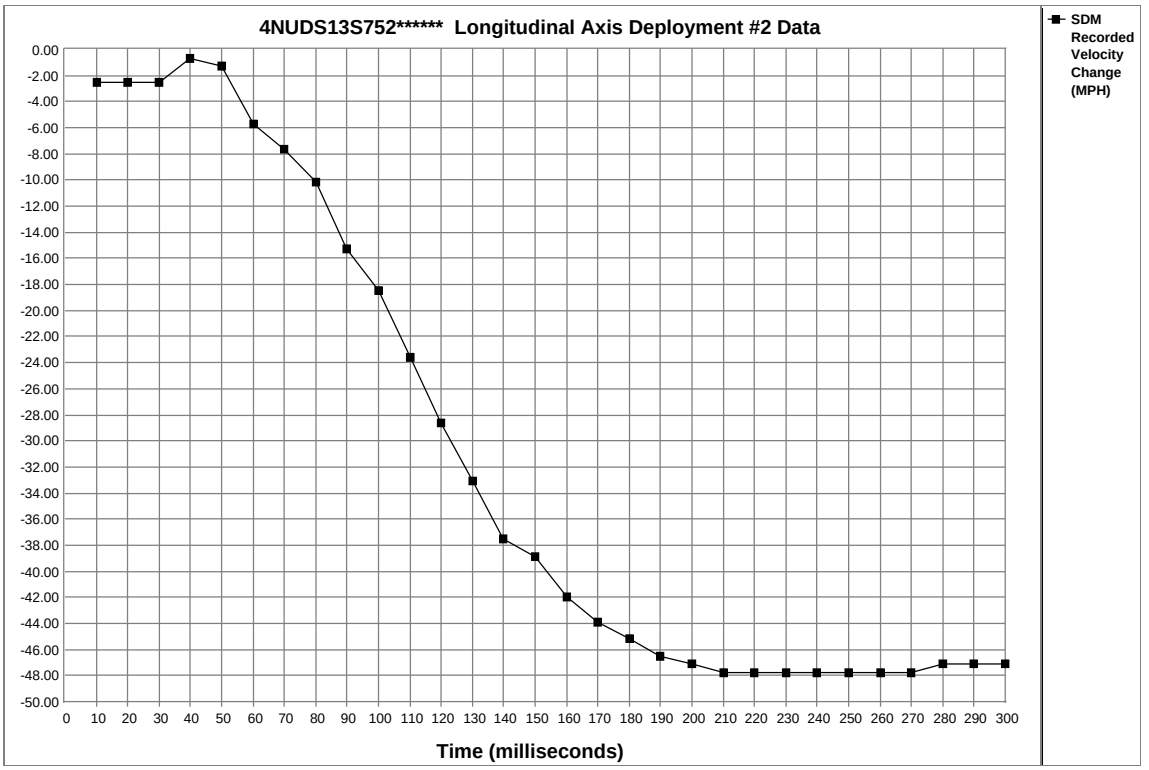
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Longitudinal Axis Recorded Velocity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Longitudinal Axis Recorded Velocity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



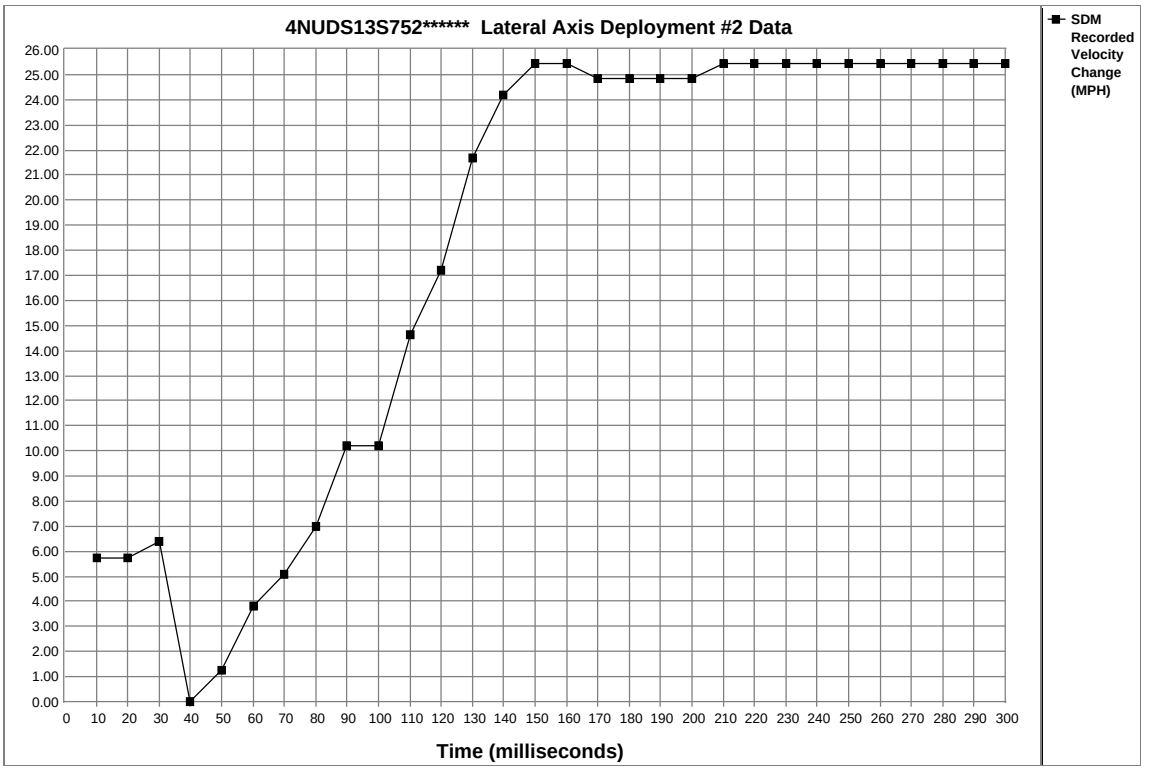
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Lateral Axis Recorded Velocity Change (MPH)	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	-0.64	-0.64	-0.64	-0.64	-1.27	-1.27	-1.27	-1.27	-1.91	-1.91

System Status At Deployment #2

SIR Warning Lamp Status	ON
SIR Warning Lamp ON/OFF Time Continuously (seconds)	0
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	0
Ignition Cycles At Investigation	179
Ignition Cycles At Event	178
Ignition Cycles Since DTCs Were Last Cleared	177
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Driver Seat Position Switch Circuit Status	Rearward
Passenger Seat Position Switch Circuit Status	Rearward
Automatic Passenger SIR Suppression System Status (1 sec)	Air Bag Suppressed
Rollover Sensor Status	0 to 1/4 turns
Number of Consecutive Error Free Messages Received From Rollover Sensor	Last 128 Consecutive Message Were Error Free
SDM Synchronization Counter	247
Side Air Bag(s) Were First Commanded to Deploy Due to Side Impact Event	No
Side Air Bag(s) Were First Commanded to Deploy Due to Rollover Event	Yes
Time Between Events (sec)	3.56
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	35
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Disposal
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Driver Thorax/Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	0
Passenger Thorax/Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	0
Driver 1st Stage Deployment Loop Commanded	Yes
Driver 2nd Stage Deployment Loop Commanded	Yes
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	No
Driver Roof Rail/Head Curtain Loop Commanded (If Equipped)	No
Supplemental Deployment Loop #1 Commanded (If Equipped)	No
Passenger 1st Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Passenger Roof Rail/Head Curtain Loop Commanded (If Equipped)	No
Supplemental Deployment Loop #2 Commanded (If Equipped)	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded (If Equipped)	No
Supplemental Deployment Loop #3 Commanded (If Equipped)	No
Second Row Right Side Deployment Loop Commanded (If Equipped)	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Supplemental Deployment Loop #4 Commanded (If Equipped)	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Diagnostic Trouble Codes at Event, fault number: 1	B0051
Diagnostic Trouble Codes at Event, fault number: 2	B0058
Diagnostic Trouble Codes at Event, fault number: 3	B0065
Diagnostic Trouble Codes at Event, fault number: 4	B0068
Diagnostic Trouble Codes at Event, fault number: 5	B0070
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Maximum SDM Recorded Velocity Change (MPH)	0.00
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	0
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	No
Event Recording Complete	Yes



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Longitudinal Axis Recorded Velocity	-2.55	-2.55	-2.55	-0.64	-1.27	-5.73	-7.64	-10.19	-15.28	-18.47	-23.56	-28.65	-33.11	-37.57	-38.84
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Longitudinal Axis Recorded Velocity	-42.02	-43.93	-45.21	-46.48	-47.12	-47.75	-47.75	-47.75	-47.75	-47.75	-47.75	-47.75	-47.12	-47.12	-47.12



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Lateral Axis Recorded Velocity Change (MPH)	5.73	5.73	6.37	0.00	1.27	3.82	5.09	7.00	10.19	10.19	14.64	17.19	21.65	24.20	25.47
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Lateral Axis Recorded Velocity Change (MPH)	25.47	24.83	24.83	24.83	24.83	25.47	25.47	25.47	25.47	25.47	25.47	25.47	25.47	25.47	25.47

Hexadecimal Data

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$02  00 00 00 00 F8 FF
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$04  00 F8 00 00 00 00
$05  3F 0C 00 67 C0 E2
$06  3F 0C 00 67 C0 E2
$07  00 00 C0 00 72 00
$08  00 08 08 50 50 00
$09  04 64 04 64 7F 00
$0A  00 00 00 00 00 00
$0B  00 FE 00 00 FE 00
$12  FF 7F 00 84 40 00
$17  07 07 07 07 00 00
$18  07 07 00 00 00 00
$19  00 07 07 00 00 00
$1A  00 00 00 00 00 00
$1B  01 01 00 00 00 00
$1C  01 01 00 01 00 01
$1D  2B 00 00 00 00 88
$1E  4F 00 00 00 00 88
$1F  8F 8F 0D 0D FC F0
$20  20 9F 03 00 00 00
$21  7E 7E 7D 7F 80 7F
$22  C0 00 00 00 00 00
$23  80 00 05 00 01 00
$24  FF B2 00 B3 00 00
$25  82 C0 00 00 00 00
$26  00 23 40 40 49 00
$27  00 01 01 01 01 01
$29  25 26 26 26 26 00
$2A  45 47 47 47 47 00
$2B  00 00 00 00 00 80
$2C  01 01 00 01 00 40
$2F  00 00 00 00 00 80
$30  00 00 00 00 00 80
$36  29 00 00 00 00 00
$37  C0 A5 00 00 00 00
$38  C0 00 00 00 00 00
$39  80 00 00 00 00 00
$3A  B1 00 B2 00 00 00
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$44  08 0B 10 10 17 1B
$45  22 26 28 28 27 27
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$48  00 00 00 00 00 00
$49  D0 00 00 50 00 00
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$4C  00 00 00 00 00 00
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$4F  00 00 00 00 00 00
$50  80 A5 00 00 00 00
$51  18 18 00 00 00 00
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```
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$53  B1 00 B2 00 00 00
$54  FF FF FF FF FF FF
$55  FF FF FF FF FF FF
$56  FF FF FF FF FF FF
$57  00 00 00 00 00 00
$58  00 00 00 00 00 00
$59  00 00 00 00 00 00
$5A  00 00 00 00 00 00
$5B  00 00 00 00 00 00
$5C  01 01 01 01 01 01
$5D  01 01 00 00 00 00
$5E  00 00 00 00 00 00
$5F  00 00 FF FF FF FF
$60  FE FE FE FE FD FD
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$62  D0 00 00 50 00 00
$63  00 80 00 F7 DC 00
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$80  00 00
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Comments