

CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

**CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA10037**

VEHICLE: 2009 MITSUBISHI GALANT RALLIART

LOCATION: NORTH CAROLINA

CRASH DATE: OCTOBER 2010

Contract No. DTNH22-07-C-00043

Prepared for:

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

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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

1. Report No. CA10037		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Calspan On-Site Rollover Crash Investigation Vehicle: 2009 Mitsubishi Galant Location: North Carolina				5. Report Date: February 2011	
				6. Performing Organization Code	
7. Author(s) Crash Data Research Center				8. Performing Organization Report No.	
9. Performing Organization Name and Address Calspan Corporation Crash Data Research Center P.O. Box 400 Buffalo, New York 14225				10. Work Unit No.	
				11. Contract or Grant No. DTNH22-07-C-00043	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590				13. Type of Report and Period Covered Technical Report Crash Date: October 2010	
				14. Sponsoring Agency Code	
15. Supplementary Note An investigation of the roadside departure rollover crash of a 2009 Mitsubishi Galant.					
16. Abstract This on-site investigation focused on the rollover crash of a 2009 Mitsubishi Galant and the injury sources for the two restrained occupants of the vehicle. The Mitsubishi was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, side impact Inflatable Curtain (IC) air bags, and side impact air bags located in the front seatbacks. The Mitsubishi was traveling in the right lane of a three-lane divided roadway when a non-contact vehicle traveling in the center lane attempted to change lanes to its right. The Mitsubishi driver steered right in an avoidance maneuver and the vehicle entered a steering-induced clockwise (CW) yaw on the roadway. The vehicle departed the roadway to the right and then tripped into a 4-quarter turn left side leading rollover. The right IC and right side impact air bag deployed during the crash sequence. The restrained 27-year-old male driver of the Mitsubishi and the restrained 30-year-old male front right passenger were both transported to a regional trauma center for treatment of their injuries.					
17. Key Words Roadside departure Rollover Moderate and Minor Injury				18. Distribution Statement General Public	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 11	22. Price

TABLE OF CONTENTS

BACKGROUND 1

SUMMARY 2

Vehicle Data - 2009 Mitsubishi Galant 2

Crash Site 3

Crash Sequence 3

 Pre-crash 3

 Crash 4

 Post-Crash 4

2009 Mitsubishi Galant 4

 Exterior Damage 4

 Interior Damage 5

 Manual Restraint Systems 6

 Frontal Air Bag System 6

 Side Impact Air Bag System 7

Driver Demographics/Data 8

 Driver Injuries 8

 Driver Kinematics 8

Front Right Passenger Demographics/Data 9

 Front Right Passenger Injuries 9

 Front Right Passenger Kinematics 9

Crash Schematic 11

CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA10037
VEHICLE: 2009 MITSUBISHI GALANT RALLIART
LOCATION: NORTH CAROLINA
CRASH DATE: OCTOBER 2010

BACKGROUND

This on-site investigation focused on the rollover crash of a 2009 Mitsubishi Galant (**Figure 1**) and the injury sources for the two restrained occupants of the vehicle. The Mitsubishi was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, side impact Inflatable Curtain (IC) air bags, and side impact air bags located in the front seatbacks. The Mitsubishi was traveling in the right lane of a three-lane divided roadway when a non-contact vehicle traveling in the center lane attempted to change lanes to its right. The Mitsubishi driver steered right in an avoidance maneuver and the



Figure 1: Front right oblique view of the 2009 Mitsubishi Galant.

vehicle entered a steering-induced clockwise (CW) yaw on the roadway. The vehicle departed the roadway to the right and then tripped into a 4-quarter turn left side leading rollover. The right IC and right side impact air bag deployed during the crash sequence. The restrained 27-year-old male driver of the Mitsubishi and the restrained 30-year-old male front right passenger were both transported to a regional trauma center for treatment of their injuries.

The crash was identified through a visit to a regional vehicle salvage facility on November 16, 2010. Based on the rollover of the late model year vehicle and the level of roof intrusion, this case was assigned by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) to the Calspan Special Crash Investigations team (SCI) for an on-site investigation on November 19, 2010. The on-site portion of this investigation was initiated on November 23, 2010. This investigation involved the inspection and documentation of the Mitsubishi and the crash site, and a detailed interview with the owner/driver of the Mitsubishi.

SUMMARY

Vehicle Data - 2009 Mitsubishi Galant

The 2009 Mitsubishi Galant was manufactured in March, 2008 and was identified by the Vehicle Identification Number (VIN) 4A3AB76T39E (production sequence deleted). The vehicle was purchased new by the driver/owner and had been driven 30,706 km (19,080 mi) at the time of the crash. The front-wheel drive Mitsubishi was powered by a 3.8-liter, V6 engine linked to a five-speed automatic transmission. The braking system consisted of power-assisted front and rear disc brakes with four-wheel antilock and Electronic Brakeforce Distribution (EBD). The Mitsubishi was also equipped with a direct Tire Pressure Monitoring System (TPMS) and traction control. The driver stated in the interview that the TPMS warning light was not illuminated and the traction control was not disabled prior to the crash. The case vehicle was equipped with four Goodyear Eagle RS-A tires in size P235/45R18. This matched the vehicle manufacturer's recommended tire size. The tires were mounted on OEM 10-spoke alloy wheels. The vehicle manufacturer's recommended cold tire pressure was 221 kPa (32 PSI) for the front and rear. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	Tire Flat	6 mm (7/32 in)	Wheel rim abraded
Left Rear	Tire Flat	7 mm (9/32 in)	Wheel rim abraded and deformed
Right Front	179 kPa (26 PSI)	5 mm (6/32 in)	None
Right Rear	Tire Flat	8 mm (10/32 in)	None

The interior of the Mitsubishi was configured with leather-surfaced, five-passenger seating. The front bucket seats were separated by a center console. The front head restraints were height adjustable. The front left head restraint was located 2 cm (0.8 in) above the full-down position. The front right head restraint was in the full-down position at the time of the SCI inspection. The driver's seat track was operational post-crash and was in a full-rear track position. The driver's seatback angle measured 24 degrees aft of vertical. The front right seat in a mid-track position, 9 cm (3.5 in) forward of full-rear. The seatback angle measured 22 degrees aft of vertical. The second row consisted of a three-passenger bench seat with a folding back. The rear outboard positions were equipped with integral head restraints.

The Mitsubishi's occupant safety systems consisted of manual 3-point lap and shoulder belts for all five designated seating positions, front seat safety belt retractor pretensioners, CAC dual-stage frontal air bags, side impact air bags located in the outboard aspect of the front seatbacks, and roof side rail-mounted side impact IC air bags that provide protection for the four outboard positions.

Crash Site

This crash occurred during early morning hours on a north/south three-lane urban roadway divided by a 5.9 m (19.5 ft) wide grass median. The environmental conditions were clear, dry and dark but lighted. **Figure 2** depicts the northbound approach to the crash site. The roadway was straight and had a level grade throughout the area in which the crash occurred. The right travel lane measured 4.0 m (13.1 ft) in width and the center and left travel lanes were 3.3 m (10.8 ft) in width. The east side of the roadway was bordered by a concrete barrier curb

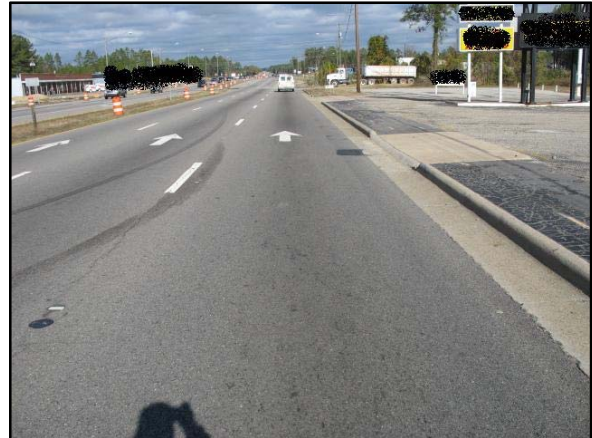


Figure 2: Northbound approach to the crash site.

15 cm (6 in) in height. This barrier curb transitioned to a concrete driveway apron in several areas along a northbound path of travel. The driveway aprons provided access to the asphalt public parking lot that was located east of the roadway. The Mitsubishi departed the roadway at a driveway apron and entered a 5.0 m (16.4 ft) wide section of the grass roadside. Outboard this grass area, the roadside transitioned to the asphalt parking lot. North of the rollover area, an east/west gravel road intersected the primary road forming a three-leg intersection. The speed limit on the primary roadway was 72 km/h (45 mph). A schematic of the crash is included as **Figure 7** at the end of this report.

Crash Sequence

Pre-crash

The restrained 27-year-old male driver of the Mitsubishi was operating the vehicle in a northbound direction on the three-lane roadway. He was traveling in the right (outboard) lane at a driver estimated speed of 81 km/h (50 mph). The police-reported speed of the vehicle was 72 km/h (45 mph). A non-contact vehicle described by the driver as a “small blue car” was northbound in the center lane adjacent to the Mitsubishi. As both vehicles travelled north, the non-contact vehicle attempted to change lanes to its right. The driver of the Mitsubishi sounded his vehicle’s horn and the other vehicle returned to the center lane and increased its speed. The other vehicle then suddenly changed lanes to the right. The driver of the Mitsubishi initiated a right steering input to avoid the vehicle that was encroaching into his lane. There was no physical evidence indicating that contact between the two vehicles had occurred.

The Mitsubishi entered a CW yaw and continued forward on a northeast trajectory. As the Mitsubishi yawed and departed the roadway, the front wheels traveled over curb and the concrete apron that bordered the east side of the roadway. Skid marks attributed to the front tires of the Mitsubishi defined the vehicle’s trajectory. As the yaw continued, the left rear wheel impacted a section of barrier curb, deforming the alloy wheel rim and debanding the tire. The left tires and

wheels of the vehicle furrowed into the soft soil of the grass roadside. The Mitsubishi had rotated approximately 130 degrees CW at this time.

Crash

The furrowed tires tripped the Mitsubishi into a left side leading rollover. As the vehicle rolled the initial 2-quarter turns, the right A-pillar area and roof impacted the asphalt parking lot. The right side impact air bag and right IC air bag deployed. The vehicle rolled two additional quarter turns and came back onto its wheels. The total uninterrupted roll distance was 18 m (59 ft). The Mitsubishi then slid 4 m (13.1 ft) coming to rest straddling the south edge of the intersecting gravel roadway.

Post-Crash

The driver and front right passenger of the Mitsubishi were both conscious after the crash. The driver opened the left front door and exited the vehicle under his own power. He went to the right side of the vehicle where he found the front right passenger partially ejected with his head and right arm through the disintegrated right front window. The deployed right IC air bag was on top of his head. He lifted the IC and told the passenger not to move. The driver had first-aid training and applied pressure to heavily bleeding wounds on the passenger's head and told him to remain still until first responders arrived. Police, Emergency Medical Services (EMS) and tow personnel responded to the crash site. EMS personnel removed the front right passenger from the vehicle due to perceived serious injuries. The driver and front right passenger were transported by ground ambulance to a regional trauma center where they were treated in the emergency department and released the same day. The Mitsubishi was towed from the scene due to disabling damage. The vehicle was then transferred from the local tow yard to a regional vehicle salvage facility, where it was inspected.

2009 Mitsubishi Galant

Exterior Damage

The Mitsubishi's top and right planes sustained severe damage as a result of this rollover (**Figure 3**). On the top plane, direct damage began at the front right edge of the hood and extended rearward 414 cm (162.9 in) to the rear right taillight area. Laterally, the direct damage extended 104 cm (40.9 in) across the full width of the roof. The longitudinal direct damage to the greenhouse extended 232 cm (91.3 in) from the base of the right A-pillar to the backlight header. The maximum vertical deformation was located on the right side of the windshield

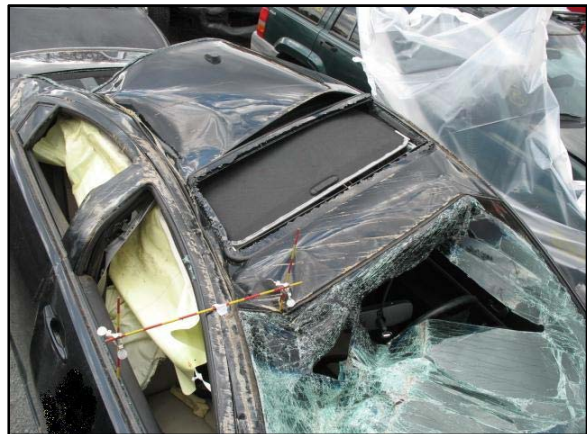


Figure 3: View of the Mitsubishi's roof damage from above, right.

header, 17 cm (6.7 in) inboard of the right roof side rail. The residual vertical deformation measured 33 cm (13 in). The maximum lateral deformation was located at the right A-pillar area, 65 cm (25.6 in) forward of the upper rear corner of the door (using the B-pillar as a reference). The residual lateral deformation measured 13 cm (5.1 in). The Collision Deformation Classification (CDC) assigned for the rollover event was 00TDDO4.

All four doors remained closed throughout the rollover. Despite the crush to the right roof side rail, all four doors were operational post-crash. The driver confirmed in the interview that he was able to open the driver’s door and exit the vehicle, and EMS was able to open the right front door at the scene. The windshield was completely fractured and had sagged post-crash. Both of the right windows, the backlight, and the sunroof glazing disintegrated during the rollover. The right rear quarter window and all the left windows remained intact.

Interior Damage

The Mitsubishi sustained moderate severity interior damage that was attributed to passenger compartment intrusion, occupant contact and air bag deployment. There was a scuff mark on the fabric sunroof cover located 4-20 cm (1.6-7.9 in) aft of the front edge of the cover and 5-20 cm (2-7.9 in) left of the cover’s right edge. This scuff mark was attributed to the driver’s head. There was a large blood transfer on the interior aspect of the right B-pillar that extended the full width of the pillar and extended from 9-31 cm (3.5-12.2 in) below the right roof side rail. This post-crash transfer was attributed to the front right passenger’s head injuries. **Figure 4** depicts contact evidence observed during the SCI inspection. The following table lists the passenger compartment intrusion:



Figure 4: Interior contact evidence in the Mitsubishi.

Position	Component	Direction	Magnitude
Row 1 Left	Windshield header	Vertical	10 cm (3.9 in)
Row 1 Left	Roof	Vertical	9 cm (3.5 in)
Row 1 Center	Windshield header	Vertical	20 cm (7.9 in)
Row 1 Center	Roof	Vertical	25 cm (9.8 in)
Row 1 Right	Windshield header	Vertical	33 cm (13 in)
Row 1 Right	Roof	Vertical	31 cm (12.2 in)
Row 1 Right	B-pillar	Lateral	15 cm (5.9 in)
Row 1 Right	A-pillar	Lateral	12 cm (4.7 in)
Row 1 Right	Roof side rail	Lateral	13 cm (5.1 in)

Position	Component	Direction	Magnitude
Row 1 Right	Door – Rear upper quadrant	Lateral	5 cm (2 in)
Row 2 Left	Roof	Vertical	3 cm (1.2 in)
Row 2 Left	Backlight header	Vertical	4 cm (1.6 in)
Row 2 Center	Roof	Vertical	13 cm (5.1 in)
Row 2 Center	Backlight header	Vertical	15 cm (5.9 in)
Row 2 Right	Roof	Vertical	23 cm (9.1 in)
Row 2 Right	Backlight header	Vertical	24 cm (9.4 in)
Row 2 Right	Roof side rail	Lateral	13 cm (5.1 in)
Row 2 Right	C-Pillar	Lateral	10 cm (3.9 in)

Manual Restraint Systems

The Mitsubishi was equipped with manual 3-point lap and shoulder safety belts for all five designated seating positions. All belt systems utilized continuous loop webbing and a sliding latch plate. The D-rings for the front seats were height adjustable. The driver's D-ring was in the full-up position and the front right D-ring was in the full-down position. The driver's belt retracted onto an Emergency Locking Retractor (ELR). All other belts retracted onto switchable ELR/Automatic Locking Retractors (ALR). The front safety belts utilized retractor pretensioners which actuated during the rollover sequence. The belt webbing for both positions was stowed at the time of the inspection. During the SCI inspection, both front belts would extend and retract but had a noticeable amount of drag when the belt was being moved. Both safety belts were in use at the time of the crash, based on evidence observed on the webbing. The front left belt webbing contained a 4 cm (1.6 in) frictional abrasion attributed to the latch plate. This abrasion was located 78-82 cm (30.7-32.3 in) above the lower floor anchor. The front right belt webbing contained scuff marks and blood located 112-148 cm (44.1-58.3 in) above the lower floor anchor.

Frontal Air Bag System

The Mitsubishi was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual-stage driver and front right passenger air bags, seat track positioning sensors, front seat retractor pretensioners, safety belt buckle switches and a front right occupant weight sensor.. The manufacturer of the Mitsubishi certified that this vehicle was compliant with the advanced air bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The driver's frontal air bag was concealed within the center hub of the four-spoke steering wheel. The front right passenger's frontal air bag was mounted within the upper aspect of the right instrument panel. The frontal air bags did not deploy in this crash.

Side Impact Air Bag System

The Mitsubishi was equipped with front seat-mounted side impact air bags and roof side rail-mounted side impact IC air bags. The right side impact air bag and the right IC deployed during the rollover event. The left side impact air bag and IC did not deploy.

The side impact air bag deployed from a 30 cm (11.8 in) long seam in the outboard aspect of the front right seatback. The air bag measured 46 cm (18.1 in) in height and 18 cm (7.1 in) in width. There was smeared blood on the lower left aspect of the inboard side. The side impact air bag was vented by a single vent port at the forward 9 o'clock position. There were no tethers present in the side impact air bag. The right side impact air bag (**Figure 5**) was free from crash related damage.



Figure 5: Inboard side of the right side impact air bag.



Figure 6: Blood evidence on the outboard side of the right IC air bag.

The right IC deployed from the right roof side rail. It was manufactured by Life Curtain Technology and identified by the following nomenclature: Pattern 775, Design 77511380. The IC measured 146 cm (57.5 in) in length and was 38 cm (15 in) in height at the front and rear right seating positions. Vertically, the curtain air bag extended below the belt line in each row. The right IC provided protection from a location that measured 42 cm (16.5 in) aft of the top of the right A-pillar rearward the right C-pillar. The open triangular area located forward of the IC measured 26 cm (10.2 in) in height at the IC, 14 cm (5.5 in) in height at the base of the A-pillar, and was 42 cm (16.5 in) in length. The right IC was tethered to the right A-pillar by a web strap 36 cm (14.2 in) in length. The right IC is depicted in **Figure 6**.

There was a smeared blood transfer on the outboard side of the right IC that extended across the full height of the IC. The blood transfer began 40 cm (15.7 in) aft of the forward aspect of the IC and extended rearward 24 cm (9.4 in). The transfer was located adjacent to the right B-pillar. This blood transfer was attributed to the front right passenger's head and right hand.

Driver Demographics/Data

Driver Age/Sex: 27-year-old/Male
Height: 170 cm (67 in)
Weight: 99 kg (219 lb)
Eyewear: None
Seat Track Position: Full-rear
Manual Safety Belt Use: Lap and shoulder
Usage Source: SCI vehicle inspection
Egress from Vehicle: Exited the vehicle under his own power
Mode of Transport from Scene: Ground ambulance
Type of Medical Treatment: Treated in a trauma center emergency department and released the same day

Driver Injuries

Injury	Injury Severity (AIS 2005/08)	Injury Source	Confidence
Thoracic spine compression fracture; T11, 10 to 15%, with thoracic back strain noted	Moderate (650432.2,7)	Seat cushion	Probable
Lumbar back strain	Minor (640678.1,8)	Seat cushion	Probable

Source of Injury Data: Discharge Summary

Driver Kinematics

The 27-year-old restrained driver of the Mitsubishi was seated in a full-rear track position as he operated the vehicle on the outboard northbound lane of roadway. A non-contact vehicle entered his travel lane from the center lane, over the Mitsubishi's left lane line. The non-contact vehicle returned to the center lane and then changed lanes to its right a second time. The driver of the Mitsubishi initiated a steering input to the right to avoid the non-contact vehicle. The sudden steering input resulted in a CW yaw and the Mitsubishi departed the roadway to the right. The Mitsubishi's left tires furrowed into the soft soil of the grass roadside and the vehicle tripped into a left side leading 4-quarter turn rollover. The safety belt's ELR locked the belt system at the initiation of the rollover.

As the vehicle rolled left around the driver, he initiated a right trajectory within the front left seating position. The driver loaded the locked safety belt with his pelvis and chest. The vehicle rolled 2-quarter turns and the right A-pillar area/roof impacted the ground which resulted in the roof intrusion. This impact resulted in the deployment of the right IC air bag, the right side impact air bag and in the actuation of the pretensioners. While inverted, the driver's head impacted the sunroof cover depositing a scuff mark but not resulting in an objective injury. The vehicle then rolled an additional 2-quarter turns back onto its wheels. As the vehicle landed in

an upright orientation, the driver rebounded down into the driver seat resulting in the thoracic compression fracture and lumbar spine strain.

The driver came to rest within the driver seat. He was able to open the left door and exit the vehicle under his own power. He provided assistance to the front right passenger and kept him in the front right seating position until EMS arrived. The driver was then placed on a backboard and transported to a regional trauma center where he was treated in the emergency department and released approximately 7 hours post-crash.

Front Right Passenger Demographics/Data

Driver Age/Sex: 30-year-old/Male
 Height: 175 cm (69 in)
 Weight: 77 kg (170 lb)
 Eyewear: None
 Seat Track Position: Mid-track, 9 cm (3.5 in) forward of full-rear
 Manual Safety Belt Use: Lap and shoulder
 Usage Source: SCI vehicle inspection
 Egress from Vehicle: Removed due to perceived serious injuries
 Mode of Transport from Scene: Ground ambulance
 Type of Medical Treatment: Treated in a trauma center emergency department and released the same day

Front Right Passenger Injuries

Injury	Injury Severity (AIS 2005/08)	Injury Source	Confidence
Laceration to right parietal scalp	Minor (110600.1,1)	Contact with ground	Certain
Abrasions to right parietal and occipital scalp	Minor (110202.1,0)	Contact with ground	Certain
Contusions to right parietal occipital scalp	Minor (110402.1,0)	Contact with ground	Certain
Laceration to dorsal aspect of the right hand	Minor (710602.1,1)	Contact with ground	Certain

Source of Injury Data: Discharge Summary

Front Right Passenger Kinematics

The 30-year-old male front right passenger of the Mitsubishi was seated in a mid-track position 9 cm (3.5 in) forward of the full-rear position. He was restrained by the 3-point manual lap and shoulder belt system. As the Mitsubishi tripped into the left side leading rollover, the front right passenger initiated a right trajectory and loaded the locked safety belt system with his pelvis. As

the vehicle rolled to the left around him, his upper body extended to the right. When the roof impacted the ground, the roof and windshield header intruded vertically into the passenger compartment and the right front glazing disintegrated. The front right passenger responded to the impact with a right trajectory and the passenger's head and right arm were partially ejected through the disintegrated front right window. When the Mitsubishi rolled onto its right side, the passenger's head and right hand contacted the ground, resulting in the right parietal scalp laceration, and the multiple abrasions and contusions to the scalp. The right hand was also lacerated due to the ground contact.

The impact to the right roof area resulted in the actuation of the retractor pretensioner and the deployment of the right IC and the right side impact air bag. The right IC came down onto the passenger's neck and may have held him partially ejected from the vehicle. His position resulted in the blood on the outboard side of the IC and on the right B-pillar. The Mitsubishi completed the 4-quarter turn rollover and came to rest on its wheels.

The front right passenger came to rest with his torso and lower body restrained in the front right seat with his head and right arm outside the vehicle. The driver exited the vehicle and came to its right side. The driver lifted the IC and applied pressure to the front right passenger's bleeding wounds until EMS arrived. EMS personnel removed the front right passenger from the vehicle due to perceived serious injuries. He was then transported by ground ambulance to a regional trauma center where he was treated in the emergency department for the soft tissue injuries. He was released approximately 9 hours post-crash.

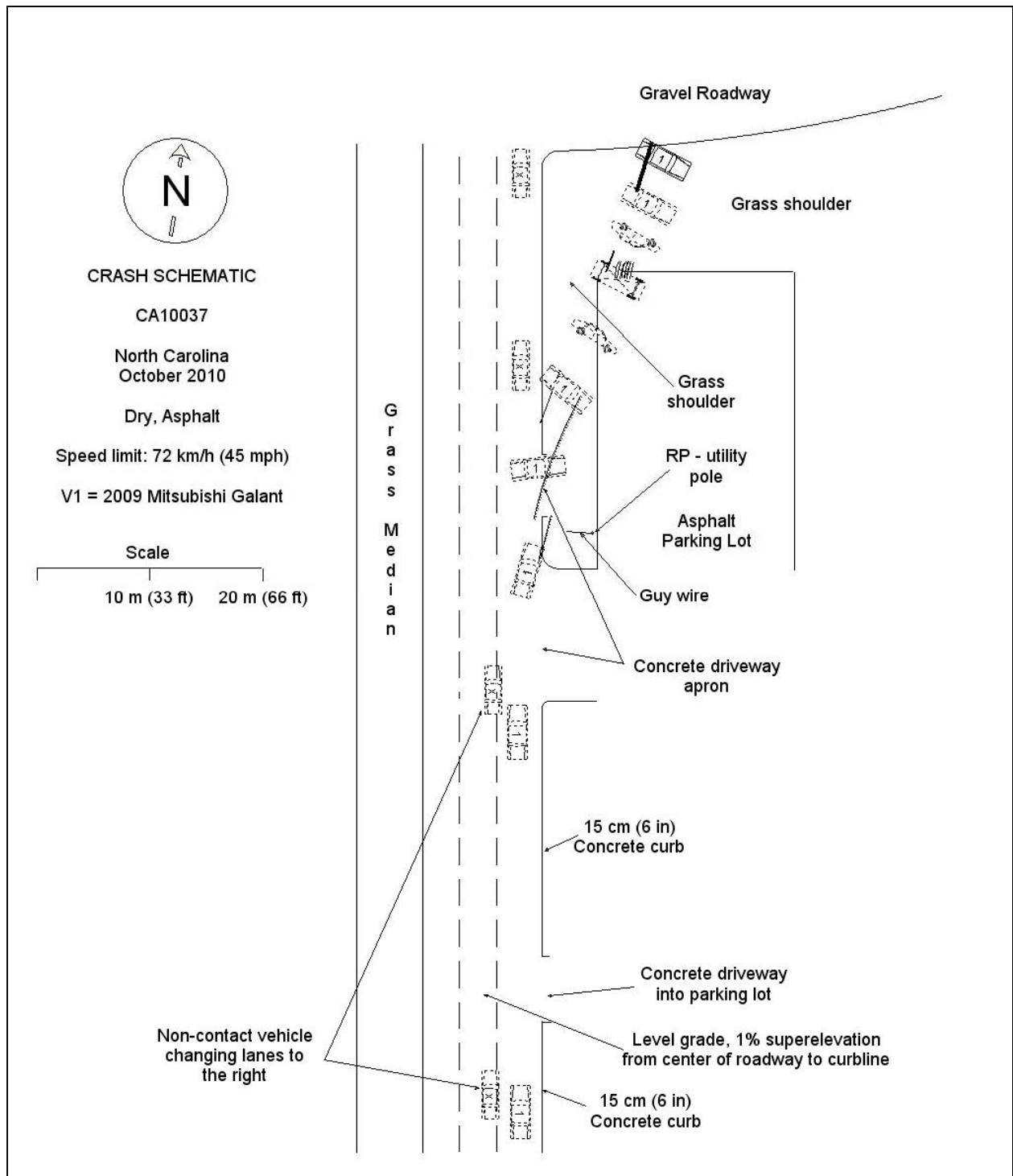


Figure 7: Crash Schematic