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**CALSPAN ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION
INVESTIGATION**

NASS/SCI COMBO CASE NO.: 2007-11-113E

LOCATION: MICHIGAN

VEHICLE: 2007 FORD ESCAPE

CRASH DATE: SEPTEMBER 2007

Contract No. DTNH22-07-C-00043

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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. <i>Report No.</i> 2007-11-113E	2. <i>Government Accession No.</i>	3. <i>Recipient's Catalog No.</i>	
4. <i>Title and Subtitle</i> Calspan On-site Side Impact Inflatable Occupant Protection Investigation Vehicle: 2007 Ford Escape Location: State of Michigan		5. <i>Report Date:</i> January 2008	
7. <i>Author(s)</i> Crash Data Research Center		6. <i>Performing Organization Code</i>	
9. <i>Performing Organization Name and Address</i> Calspan Corporation Crash Data Research Center P.O. Box 400 Buffalo, New York 14225		8. <i>Performing Organization Report No.</i>	
12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		10. <i>Work Unit No.</i> C00410.0000.0045	
15. <i>Supplementary Note</i> This on-site investigation focused on the side impact inflatable occupant protection system in a 2007 Ford Escape and two belt positioning booster child safety seats that were occupied by the vehicle's two 5-year-old male passengers.		11. <i>Contract or Grant No.</i> DTNH22-07-C-00043	
16. <i>Abstract</i> This on-site investigation focused on the deployed curtain air bag system in a 2007 Ford Escape and two belt positioning booster child safety seats that were occupied by the vehicle's 5-year-old male passengers. The Ford curtain air bag system was equipped with rollover sensing that was designed to deploy in the event of a side impact or rollover crash. The Ford Escape was involved in a rollover crash that resulted in the deployment of the vehicle's curtain air bag system. The Ford was also equipped with a Restraint Control Module (RCM) that had Event Data Recorder (EDR) capabilities. The RCM was downloaded by representatives of the Ford Motor Company during this on-site investigation. The recovered data was forwarded to the Calspan Special Crash Investigations Team (SCI) team and is included in this report. At the time of the crash, the Ford was occupied by a 32-year-old female driver, a 5-year-old male rear left passenger, and a 5-year-old male rear right passenger. As a result of the rollover crash, the driver and rear right child passenger sustained minor severity injuries and were transported to a local hospital where they were treated and released. The rear left passenger was not injured during the crash; however, he was transported to a local hospital where he was evaluated for possible injuries and released.		13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: September 2007	
17. <i>Key Words</i> Curtain Air Bag Deployment Rollover Belt Positioning Booster Child Safety Seats		14. <i>Sponsoring Agency Code</i>	
19. <i>Security Classif. (of this report)</i> Unclassified		18. <i>Distribution Statement</i> General Public	
20. <i>Security Classif. (of this page)</i> Unclassified		21. <i>No. of Pages</i> 12	22. <i>Price</i>

TABLE OF CONTENTS

BACKGROUND	1
SUMMARY	2
<i>CRASH SITE.....</i>	<i>2</i>
<i>CRASH SITE.....</i>	<i>2</i>
<i>VEHICLE DATA.....</i>	<i>2</i>
<i>2007 FORD ESCAPE</i>	<i>2</i>
<i>CRASH SEQUENCE.....</i>	<i>3</i>
<i>PRE-CRASH</i>	<i>3</i>
<i>CRASH</i>	<i>3</i>
<i>POST-CRASH.....</i>	<i>3</i>
<i>VEHICLE DAMAGE.....</i>	<i>4</i>
<i>EXTERIOR</i>	<i>4</i>
<i>INTERIOR</i>	<i>4</i>
<i>MANUAL RESTRAINT SYSTEMS.....</i>	<i>5</i>
<i>CURTAIN AIR BAG SYSTEM.....</i>	<i>6</i>
<i>SIDE IMPACT AIR BAG SYSTEM.....</i>	<i>7</i>
<i>RESTRAINT CONTROL MODULE.....</i>	<i>7</i>
<i>FRONTAL AIR BAGS</i>	<i>7</i>
<i>CHILD SAFETY SEATS</i>	<i>7</i>
<i>OCCUPANT DEMOGRAPHICS.....</i>	<i>9</i>
<i>DRIVER.....</i>	<i>9</i>
<i>DRIVER INJURIES</i>	<i>9</i>
<i>DRIVER KINEMATICS</i>	<i>9</i>
<i>REAR LEFT PASSENGER</i>	<i>10</i>
<i>REAR LEFT PASSENGER INJURIES.....</i>	<i>10</i>
<i>REAR LEFT PASSENGER KINEMATICS</i>	<i>10</i>
<i>REAR RIGHT PASSENGER</i>	<i>10</i>
<i>REAR RIGHT PASSENGER INJURIES.....</i>	<i>10</i>
<i>REAR RIGHT PASSENGER KINEMATICS</i>	<i>11</i>

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BACKGROUND

This on-site investigation focused on the deployed curtain air bag system in a 2007 Ford Escape (**Figure 1**) and two belt positioning booster child safety seats that were occupied by the vehicle's 5-year-old male passengers. The Ford curtain air bag system was equipped with rollover sensing that was designed to deploy in the event of a side impact or rollover crash. The Ford Escape was involved in a rollover crash that resulted in the deployment of the vehicle's curtain air bag system. The Ford was also equipped with a Restraint Control Module (RCM)



Figure 1. Rollover damage to the 2007 Ford Escape.

that had Event Data Recorder (EDR) capabilities. The RCM was downloaded by representatives of the Ford Motor Company during this on-site investigation. The recovered data was forwarded to the Calspan Special Crash Investigations Team (SCI) team and is summarized in this report. At the time of the crash, the Ford was occupied by a 32-year-old female driver, a 5-year-old male rear left passenger, and a 5-year-old male rear right passenger. As a result of the rollover crash, the driver and rear right child passenger sustained minor severity injuries and were transported to a local hospital where they were treated and released. The rear left passenger was not injured during the crash; however, he was transported to a local hospital where he was evaluated for possible injuries and released.

This crash was initially selected for research within the National Automotive Sampling System (NASS). The Police Accident Report (PAR) was forwarded to the Calspan Special Crash Investigations (SCI) team by the NASS researcher due to the rollover crash, usage of the child safety seats, and the deployment of the curtain air bag system. Details of the crash were forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) and subsequently, this crash was assigned as an on-site SCI investigation on October 23, 2007. The on-site investigation consisted of the inspection of the Escape and to facilitate the RCM download by Ford. The NASS data for the crash site and the child safety seats were used for this case as the child safety seats had been discarded by the family.

SUMMARY

Crash Site

This single vehicle crash occurred during the evening hours of September 2007 on the westbound lanes of an interstate roadway. At the time of the crash, it was dark and there were no adverse weather conditions. At the crash site, the westbound lanes of the interstate consisted of three lanes separated by a depressed grass median from the eastbound lanes. Adjacent to the westbound lanes were two additional lanes that merged into the westbound flow. The merge lanes paralleled the westbound lanes for an extended distance and were separated from the travel lanes by double white solid lines. The merge lanes transitioned into the interstate at the crash site. The north roadside consisted of a 2.9 meter (9.5 feet) wide asphalt shoulder. Outboard of the shoulder, the grassy roadside terrain sloped into a 1 meter (3 feet) deep ditch that ran parallel to the interstate. The centerline of the ditch was located 5 meters (16.4 feet) from the road edge. The posted speed limit of the interstate was 113 km/h (70 mph).

Vehicle Data

2007 Ford Escape

The 2007 Ford Escape XLS was identified by the Vehicle Identification Number (VIN): 1FMCU02Z77K (production sequence omitted). The Escape was manufactured in 11/06. The odometer reading was 26,004 kilometers (16,158 miles) at the time of the SCI inspection. The vehicle was a 4-door compact sport utility vehicle that was equipped with a 2.3-liter, four-cylinder engine linked to a four-speed automatic transmission, with front wheel drive. The tires on the Ford were General Graber AW, size P225/75R15, and were mounted on OEM alloy rims. The maximum pressure for these tires was 303 kPa (44 PSI). The vehicle manufacturer recommended cold tire pressure was 207 kPa (30 PSI). The specific tire data at the time of the NASS inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	214 kPa (31 PSI)	8 mm (10/32)	No	Rim abrasions
LR	214 kPa (31 PSI)	10 mm (12/32)	No	Rim abrasions
RF	83 kPa (12 PSI)	8 mm (10/32)	No	Rim abrasions
RR	214 kPa (31 PSI)	10 mm (12/32)	No	Rim abrasions

The Ford was configured with front bucket seats with height adjustable head restraints. The front left head restraint was adjusted to 4 cm (1.5") above the full-down position and the front right was adjusted to 6 cm (2.3") above the full-down position. The second row was equipped with a three-passenger split bench seat with folding seat backs (60/40), left side wide. The three rear seating positions were equipped with height adjustable head restraints. The left head restraint was located 6 cm (2.5") above the full-down position and the center and right head restraints were 3 cm (1") and 6 cm (2.5") above the full-down positions, respectively.

Crash Sequence

Pre-Crash

The restrained 32-year-old female driver of the Ford was operating the vehicle in a westerly direction on the outboard travel lane of the interstate roadway adjacent to the merge lanes. As the driver travelled west, she attempted to change lanes from left to right onto the merge lane for unknown reasons. The driver observed a tractor-trailer in her intended path and applied a left steering input to return the vehicle to the outboard lane of the interstate. At this point, a non-contact vehicle had entered the outboard travel lane. The driver of the Ford noted this vehicle and applied an aggressive right steering input, resulting in a loss of directional control. The rear tires of the Ford lost traction and the vehicle began a clockwise (CW) yaw and entered the merge lanes.

Crash

The Ford rotated approximately 110 degrees from its initial travel direction where the left side tires folded under the alloy wheels exposing the rims to the asphalt road surface. The left side rims contacted the asphalt surface of the outboard merge lane and the vehicle tripped into a left side leading rollover event (**Figure 2**). The road contact was confirmed by abrasions that were present on the outer edge of the rims. The rollover event triggered the deployment of the left and right side curtain air bags. The Ford rolled three quarter turns across the merge lanes and shoulder and entered the roadside. The vehicle rolled an additional two-quarter turns off-road coming to final rest on its left side on the roadside (**Figure 3**). The RCM data recorded the rollover angle at the time of the curtain air bag deployment. The accumulated roll angle at the time of deployment was -39 degrees (left). The angular roll rate was -133.6 degrees per second with a maximum angular rate of -208.3 degrees per second.



Figure 2. Approximate area of rollover.



Figure 3. Area of final rest position.

Post-Crash

Police and rescue personnel arrived on-scene shortly after the crash. The driver of the Ford sustained minor injuries and was transported to a local hospital where she was treated and released. The 5-year-old rear left passenger was not injured; however, he was transported to a local hospital where he was evaluated for possible injuries and released. The 5-year-old male rear right passenger sustained a minor scalp laceration and was transported to a local hospital where he was treated and released. The Ford was towed from the crash site and was later deemed a total loss by the insurance company. The

vehicle was transferred to an insurance salvage facility where it was inspected for this SCI investigation.

Vehicle Damage

Exterior

The 2007 Ford Escape sustained moderate severity damage as a result of the rollover crash. Damage was noted to all planes; however, the crush was localized to the front roof area. The direct contact damage consisted of laterally oriented abrasions that began at the right roof side rail and extended left 38 cm (15"). Vertically oriented abrasions were present on the right plane. On the right fender, the abrasions began at the leading edge and extended rearward 99 cm (39"). In addition to the abrasions, the top surface of the fender was crushed down approximately 5 cm (2"). Abrasions were present on the full height of the 64 cm (25") right A-pillar and extended 65 cm (25.5") rearward onto the right roof side rail. Abrasions were noted on the rear aspect of the right roof rail, right quarter panel, and localized abrasions on the right doors at the B-pillar area.

The top aspect of the left fender was crush downward approximately 5 cm (2") and contained laterally oriented abrasions. Direct contact to the left plane of the Ford consisted of abrasions to the left roof side rail. These abrasions began at the A-pillar and extended 215 cm (84.5") to the D-pillar.

The crush was localized to the windshield header area with the maximum crush measuring 8 cm (3.3") at the junction of the right A-pillar and the roof. The direct contact damage on the roof measured 38 cm (15") and began on the roof side rail and extended to the center of the roof. A crush profile was documented along the 101 cm (40") wide windshield header (**Figure 4**). The maximum vertical and lateral crush were located at the right A-pillar and were: 8 cm (3.3") and 0 cm, respectively (**Figure 5**). The Collision Deformation Classification (CDC) for this impact was 00-TDDO-3.



Figure 4. Roof crush profile



Figure 5. Maximum vertical and lateral crush.

Interior

The interior damage to the 2007 Ford Escape was moderate and attributed to passenger compartment intrusions. There were no occupant contact points present in the vehicle. The passenger compartment intrusions are listed in the table below:

Seat Position	Intruded Component	Magnitude	Direction
Front Left	Roof	0.8 cm (0.3")	Vertical
Front Center	Windshield Header	6 cm (2.3")	Vertical
Front Center	Roof	8 cm (3")	Vertical
Front Right	Windshield Header	9 cm (3.5")	Vertical
Front Right	Roof	3 cm (1")	Vertical
Front Right	Roof Side Rail	10 cm (4")	Vertical
Front Right	A-pillar	8 cm (3")	Vertical
Rear Right	Roof	4 cm (1.5")	Vertical

Manual Restraint Systems

The 2007 Ford Escape was equipped with manual 3-point lap and shoulder safety belts for the five seating positions.

The driver's belt was configured with continuous loop webbing, sliding latch plate, height adjustable D-ring that was located 3 cm (1") above the full-down position at the time of the SCI inspection, and a buckle mounted pretensioner that actuated during the crash. The buckle stalk was compressed 5 cm (2") by the actuated pretensioner. The driver's safety belt retracted onto an Emergency Locking Retractor (ELR). The driver used the safety belt in the crash which was supported by frictional abrasions on the latch plate (**Figure 6**) and D-ring.

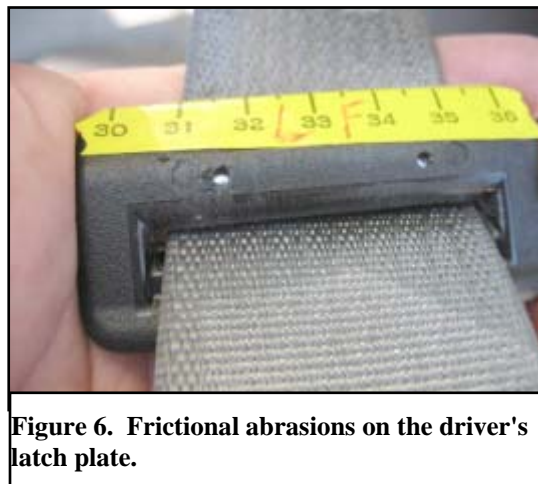


Figure 6. Frictional abrasions on the driver's latch plate.

The front right safety belt system retracted onto a switchable ELR/Automatic Locking Retractor (ALR) and was equipped with a sliding latch plate, height adjustable D-ring that was located 3 cm (1") above the full-down position at the time of the SCI inspection, and a buckle mounted pretensioner that did not actuate during the crash. This seating position was not occupied during the crash.

The second row safety belts were equipped with switchable ELR/ALR and sliding latch plates. The outboard safety belts were used by the 5-year-old male passengers. This was supported by the frictional abrasions on the latch plates and D-rings (**Figures 7 and 8**).



Figure 7. Left rear latch plate frictional abrasions.



Figure 8. Frictional abrasions on the rear right latch plate.

In addition to the manual restraints, the Ford was equipped with the Lower Anchors and Tethers for CHildren (LATCH) system for the rear outboard seating positions. The LATCH system was not used to install the safety seats.

Curtain Air Bag System

The 2007 Ford Escape was equipped with curtain air bags for the left and right outboard seating positions. The system consisted of curtain-type air bags that deployed from the roof side rails. The curtain air bags were designed to deploy in the event of a side impact or rollover crash. The left and right curtain air bags deployed as a result of the rollover event (**Figures 9 and 10**). The left and right air bags were rectangular in shape and measured 55 cm (21.5”) vertically from the roof side rail and 145 cm (57”) in length providing protection to the four outboard seating positions. The air bags were tethered by rope-type tethers at the A- and C-pillars. The A-pillar tether measured 40 cm (15.8”) in length and the C-pillar tether measured 8 cm (3.3”) in length. There were no occupant contact points present on the air bags. No damage or malfunctions were noted to the air bags. The following nomenclature was located on the center aspect of the air bag membranes:

Life Curtain Technology
Pat 167
US Patent 6,220,309
And others pending

The following nomenclature was located on the top forward corner of the air bag membranes:

TRW
30344705E



Figure 9. Deployed left side curtain air bag.



Figure 10. Interior view of the deployed right side curtain air bag.

Side Impact Air Bag System

The 2007 Ford Escape was equipped with front seatback mounted side impact air bags. This system was designed to deploy in the event of a side impact. The side impact air bag system functions independent of the rollover impact system. The seat back mounted side impact air bags did not deploy in this rollover crash.

Restraint Control Module

The 2007 Ford Escape was equipped with a Restraint Control Module (RCM) which monitored the vehicle's safety systems and commanded deployment of the appropriate safety systems dependant on the crash circumstances. In addition, the RCM had event data recording capabilities. The RCM module was downloaded by representatives of the Ford Motor Company during this on-site SCI investigation.

The RCM data recorded the front seat belt status, driver seat track position, and the status of the occupant detection system for the front right seat. This data indicated that the driver's safety belt was buckled and the seat track was in a forward position. The front right safety belt was recorded as unbuckled and the front right seat position was empty at the time of the event. The RCM data showed that the rollover criteria were met 810 ms after algorithm wake-up. The rollover sensor commanded the actuation of the front safety belt pretensioners and the deployment of the curtain air bag system 888 ms after algorithm wake-up. The recorded data showed that the accumulated roll angle at the time of deployment was -39 degrees (left). The angular roll rate at the time of deployment was -133.6 degrees per second with a maximum angular rate of -208.3 degrees per second.

Frontal Air Bags

The Ford Escape was equipped with a Certified Advanced 208-Compliant frontal air bag system. The manufacturer of this vehicle has certified that this 2007 Ford Escape meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The frontal air bag system did not deploy during this rollover crash.

Child Safety Seats

At the time of the crash, the vehicle was occupied by two 5-year-old male passengers in the second row that were seated in belt positioning booster seats and were restrained by

the vehicle's manual 3-point lap and shoulder belt systems. The rear left passenger was seated in a Cosco Complete Voyager high back belt positioning booster seat (**Figure 11**). A partial model number was visible on the torn placard and was 22-2- -TIM. The seat was manufactured on 3/5/2003. This safety seat was designed to be used by children that weigh between 14 and 36 kgs (30 and 80 lbs) and up to a maximum height of 132 cm (52"). The child that utilized this seat weighed 19 kgs (42 lbs) and was 109 cm (43") in height. The safety seat was equipped with three shoulder belt positioning slots. The driver stated that the middle slot was used at the time of crash and the belt system was snug against the shoulder and across the hips of the child passenger. **Figure 12** is a side view of the booster seat. There was no damage present on the safety seat.



Figure 11. Belt positioning booster seat used by the 5-year-old male rear left passenger.



Figure 12. Left side of the booster seat.

The rear right passenger was seated in a backless booster seat. This safety seat was discarded by the family after the crash; therefore an inspection was not conducted. The driver stated that safety seat was a Graco Turbo Booster, model number unknown. Based on the Graco manual, this safety seat can be used in a backless mode for children who weigh between 18 and 45 kgs and (40 and 100 lbs) and are between 101 and 145 cm (40 and 57") in height. The 5-year-old male passenger had a reported weight and height of 19 kgs (42 lbs) and 112 cm (44"), respectively. The lap and shoulder belt system was described as snug across the hips and against the shoulder of the child passenger.

Occupant Demographics

Driver

Age/Sex: 32-year-old/Female
Height: 157 cm (62")
Weight: 51 kg (112 lbs)
Seat Track Position: Forward track
Manual Restraint Use: Manual 3-point lap and shoulder belt
Usage Source: Vehicle inspection
Eyewear: Contact lenses
Type of Medical Treatment: Transported to a local hospital where she was treated and released.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Abrasion to the lateral left neck area	Minor (390202.1,2)	Shoulder belt
Superficial abrasion to the left knee	Minor (890202.1,2)	Door panel

Source of injury data – Emergency room records and driver interview

Driver Kinematics

The 32-year-old female driver of the Ford was seated in an upright driving posture and was restrained by the manual 3-point lap and shoulder belt. The seat track was adjusted to the forward position. Prior to departing the road, the vehicle was in a CW yaw which resulted in the driver initiating a left movement within the front left position. During this trajectory, the driver’s left knee contacted the door panel resulting in the superficial abrasion to the left knee.

As the vehicle tripped into the rollover event, the curtain air bag system deployed. The driver was minimally displaced and loaded the manual belt system. The loading of the safety belt system resulted in the abrasion to the left neck area. The driver was transported to a local hospital where she was treated and released for her minor injuries.

Rear Left Passenger

Age/Sex: 5-year-old male
Height: 109 cm (43")
Weight: 19 kg (42 lbs)
Seat Track Position: Not adjustable
Manual Restraint Use: High back belt positioning booster seat with the manual 3-point lap and shoulder belt
Usage Source: Vehicle inspection
Eyewear: None
Type of Medical Treatment: Transported to a hospital for evaluation

Rear Left Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Not injured	N/A	N/A

Source of injury data – Driver interview

Rear Left Passenger Kinematics

The 5-year-old male passenger was seated in the rear left seat in a high back belt positioning booster seat and was restrained by the vehicle’s 3-point manual belt system. The belt system was described as a snug fit on the passenger. The pre-impact steering minimally displaced this passenger. At the on-set of the rollover the curtain air bag system deployed. During the rollover event, the restrained passenger remained in the high back booster seat. This passenger was not injured during the crash; however, he was transported to a local hospital where he was evaluated and released.

Rear Right Passenger

Age/Sex: 5-year-old male
Height: 112 cm (44")
Weight: 19 kg (42 lbs)
Seat Track Position: Not adjustable
Manual Restraint Use: Backless belt positioning booster seat with the manual 3-point lap and shoulder belt
Usage Source: Vehicle inspection
Eyewear: None
Type of Medical Treatment: Transported to a local hospital where he was treated and released

Rear Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
0.1 cm (0.4") left temporoparietal laceration	Minor (190602.1,2)	Displaced toy

Source of injury data – Post-emergency room records

Rear Right Passenger Kinematics

The 5-year-old male passenger was seated in the rear right seat in a backless belt positioning booster seat and was restrained by the vehicle's three-point manual belt system. The driver stated that the lap and shoulder belt were snug across the passenger's hips and shoulder. The pre-impact steering resulted in minimal displacement of this passenger. The rollover event triggered the deployment of the vehicle's curtain air bag system. During the rollover event, the restrained passenger remained within the rear right seating position. Based on the driver interview, a loose toy that was in the interior of the vehicle was displaced and struck the child's head resulting in the left temporoparietal laceration. He was transported to a local hospital where he was treated for his minor head injury and was released.

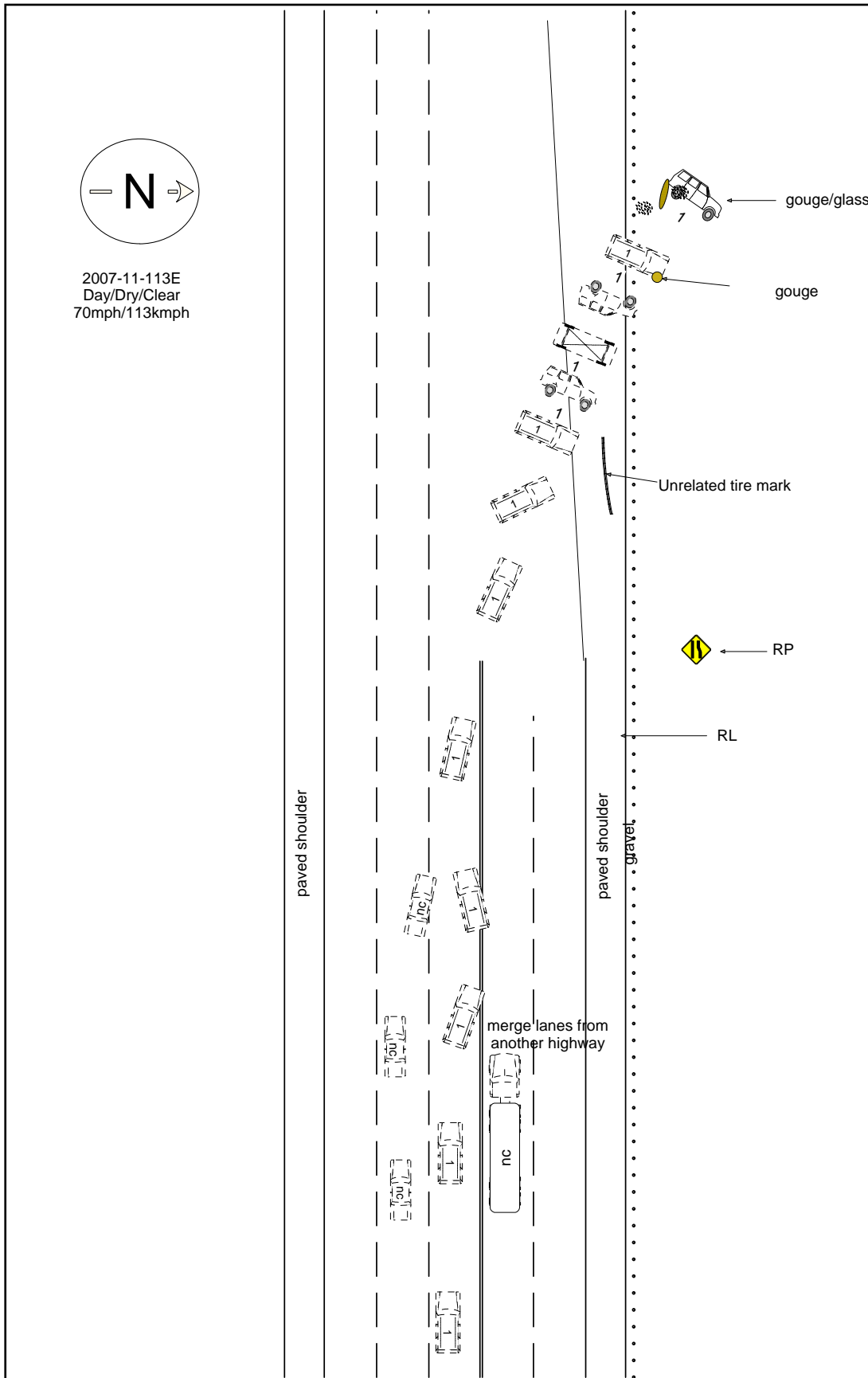


Figure 10. NASS Scene Schematic