

CRASH DATA RESEARCH CENTER

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

SCI CASE NO. – CA06-029

SUBJECT VEHICLE – 2005 FORD ESCAPE

LOCATION – STATE OF MICHIGAN

CRASH DATE – SEPTEMBER 2006

Contract No. DTNH22-01-C-17002

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

<p>1. Report No. CA06-029</p>	<p>2. Government Accession No.</p>	<p>3. Recipient's Catalog No.</p>	
<p>4. Title and Subtitle Calspan On-Site Side Impact Inflatable Occupant Protection System Investigation Vehicle: 2005 Ford Escape Location: State of Michigan</p>		<p>5. Report Date: January 2007</p>	
		<p>6. Performing Organization Code</p>	
<p>7. Author(s) Crash Data Research Center</p>		<p>8. Performing Organization Report No.</p>	
<p>9. Performing Organization Name and Address Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225</p>		<p>10. Work Unit No. C00410.0000.0373</p>	
		<p>11. Contract or Grant No. DTNH22-01-C-17002</p>	
<p>12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. Type of Report and Period Covered Technical Report Crash Date: September 2006</p>	
		<p>14. Sponsoring Agency Code</p>	
<p>15. Supplementary Note This on-site investigative effort focused on the side impact inflatable occupant protection system in a 2005 Ford Escape and the injury sources that contributed to the death of the 31-year-old male driver.</p>			
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<p>17. Key Words Rollover crash Side impact inflatable occupant protection system</p>		<p>18. Distribution Statement General Public</p>	
<p>19. Security Classif. (of this report) Unclassified</p>	<p>20. Security Classif. (of this page) Unclassified</p>	<p>21. No. of Pages 11</p>	<p>22. Price</p>

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BACKGROUND

This on-site investigative effort focused on the side impact inflatable occupant protection system in a 2005 Ford Escape and the injury sources that contributed to the death of the restrained 31-year-old male driver (**Figure 1**). The side impact inflatable occupant protection system consisted of canopy air bags that deployed from the roof side rails and seatback mounted side impact air bags. The system was designed to deploy in a side impact or rollover crash. The Ford was also equipped with a Certified Advanced 208-Compliant air bag system that included dual-stage



Figure 1. Subject vehicle 2005 Ford Escape Limited.

frontal air bags and safety belt buckle pretensioners for the front positions. The Ford was involved in a run-off road frontal impact with a concrete median barrier with a subsequent rollover event. As a result of the crash, the left and right canopy air bags, left front seatback mounted air bag, and the driver's frontal air bag deployed. Additionally, the driver's pretensioner fired. The driver sustained massive and multiple injuries of the head from contact with the road surface. He expired at the scene and was transported to the medical examiners office for autopsy.

This crash was identified by the Calspan General Estimate System (GES) through the review of Police Accident Reports (PAR). The Calspan Special Crash Investigations (SCI) team forwarded the PAR to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) due to the deployed canopy air bags and fatal injuries sustained by the driver. The Ford was located at an auto parts facility and cooperation was established to inspect the vehicle. This investigation was assigned to the Calspan SCI team on November 9, 2006. The on-site investigation was conducted on November 14, 2006.

***Summary
Crash Site***

This run-off crash occurred during the evening hours of September 2006. At the time of the crash, the weather was clear with no adverse conditions. The crash occurred on the north roadside of an east/west interstate. The eastbound roadway was configured with three travel lanes that were surfaced with concrete. The travel lanes were bordered by a

yellow fog line on the north roadside and white fog line on the south. Concrete shoulders extended beyond the fog lines. The east/westbound traffic lanes were physically separated by a concrete median barrier. A slight left curve was present for eastbound travel. The posted speed limit for the east/west roadway was 104 km/h (65 mph). The Crash Schematic is included as **(Figure 11)** of this report.

Vehicle Data– 2005 Ford Escape Limited

The 2005 Ford Escape was identified by the Vehicle Identification Number (VIN): 1FMCU94175K (production sequence omitted). The odometer reading at the time of the inspection was unknown due to the expended vehicle battery. The vehicle was a compact, four-door sport utility that was equipped with a 3.0-liter, V6 engine, 4-speed automatic transmission, 4-wheel drive, power-front and rear disc brakes with anti-lock, OEM alloy wheels, power-steering, and a tilt steering wheel that was adjusted to the mid position. The Ford was also equipped with a Reverse Sensing System which aids in backing parking maneuvers. The Ford was equipped with Continental ContiTrac tires size, P235/70R16. The maximum pressure for these tires was 303 kPa (44 psi). The vehicle manufacturer recommended front and rear tire pressure was 207 kPa (30 psi). The specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	6 mm (8/32)	No	De-beaded
LR	241 kPa (35 PSI)	8 mm (10/32)	No	None
RF	221 kPa (32 PSI)	6 mm (7/32)	No	None
RR	228 kPa (33 PSI)	9 mm (11/32)	No	23 cm (9.1") section of rim bead fractured

The seating positions in the Ford were configured with front buckets seats with height adjustable head restraints. The front left head restraint was adjusted to 3 cm (1.0") above the seatback and the right head restraint was adjusted to 4 cm (1.75") above the seatback. The second row seat was configured as a three-passenger split bench (60/40) seat with height adjustable head restraints. The rear head restraints were not with the vehicle at the time of the SCI inspection.

Crash Sequence

Pre-Crash

The restrained 31-year-old male driver of the Ford was operating the vehicle eastbound in the outboard lane **(Figure 2)** on the three-lane divided interstate roadway. As the vehicle approached the slight left curve, the driver relinquished directional



Figure 2. Ford’s eastbound pre-crash travel.

control of the Ford. The vehicle began a northeast travel path and traversed the three travel lanes, departed the north roadside and traveled across the north shoulder.

Crash

The front left corner of the Ford impacted the concrete median barrier which induced a rapid counterclockwise rotation as the vehicle remained engaged with the barrier. As the vehicle rotated, the full frontal aspect of the Ford engaged the median barrier. This impact resulted in a direction of force of 1 o'clock. It should be noted that the initial impact force was in the 12 o'clock sector; however, as the vehicle rotated counterclockwise, it rotated through the 1 o'clock sector separating from the barrier at a 3 o'clock force direction. The average of 1 o'clock was used for this impact. The WINSMASH



Figure 3. Approximate area of the median barrier impact, rollover, and final rest of the Ford.

program was used to compute a delta-V for this crash. The total calculated delta-V for the Ford was 30 km/h (18.6 mph). The longitudinal and lateral components for the Ford were -28 km/h (-17.5 mph) and -10 km/h (-6.4 mph), respectively. This impact resulted in the deployment of the driver's frontal air bag and the firing of the buckle pretensioner.

As the Ford disengaged the barrier, the right rear tire folded under the alloy wheel exposing the rim bead to the concrete road surface. The right rear rim bead contacted the concrete surface which induced a tripped rollover event. The rim contact was confirmed by a 23 cm (9") section of the rim bead that was fractured during the ground contact. The Ford began a right side leading rollover event which triggered the deployment of the left and right side canopy air bags. The left seatback mounted side impact air bag deployed during probable ground contact; however, the timing of the deployment was unknown within the rollover sequence. The vehicle rolled ten-quarter turns and came to final rest on its roof facing a westerly direction. **Figure 3** is a view of the approximate area of the median barrier impact, rollover, and final rest.

Post-Crash

Police and emergency medical personnel responded to the crash site. The driver of the Ford was pronounced deceased at the scene. His body was transported to the medical examiner's office for autopsy. The Ford sustained severe damage and was towed from the crash and subsequently deemed a total loss by the insurance company. The vehicle was sold at auction to a local auto parts dealer where it was inspected for this investigation.

Vehicle Damage

Exterior Damage

The 2005 Ford Escape sustained moderate severity frontal damage as a result of the impact with the median barrier (**Figure 4**). The direct contact damage extended from the front left bumper corner to the front right bumper corner and measured 140 cm (55.1"). The damage consisted of abrasions and deformation of the front bumper fascia, bumper beam, upper and lower radiator supports, and the hood. Maximum crush was located at the front left end of the bumper beam and measured 40 cm (15.7"). Six crush measurements were documented across the bumper beam using a combined direct and induced damage width of 115 cm (45.2") and were as follows: C1 = 40 cm (15.7"), C2 = 37 cm (14.6"), C3 = 29 cm (11.4"), C4 = 24 cm (9.4"), C5 = 17 cm (6.7"), C6 = 11 (4.3"). The Collision Deformation Classification (CDC) for this impact was 01-FDEW-2.



Figure 4. Resultant frontal damage.

The Ford sustained severe damage as a result of the rollover event. The damage consisted of abrasions to all planes and vertical crush to the roof and windshield header area (**Figure 5**). A vertical crush profile was used to document the crush along the windshield header. The crush was as follows: C1 = 0 cm, C2 = 0 cm, C3 = 0 cm, C4 = 0 cm, C5 = 3 cm (1.2"), C6 = 9 cm (3.5"). The maximum vertical and lateral crush was located at the right A-pillar and were (**Figure 6**): 19 cm (7.5") and 34 cm (13.4"), respectively. The CDC for this impact 00-TDDO-3.

The Ford's side, rear and roof glazing were disintegrated. It should be noted that the sunroof was in the closed position at the time of the crash. The windshield appeared to be damaged during the crash; however, it was cut from the vehicle. The side doors and the hatch remained closed during the crash. Post-crash, the right side doors and hatch remained operational. The left side doors were jammed closed. The left front door was pried open by rescue.



Figure 5. Vertical crush profile at the windshield header.



Figure 6. Location of maximum vertical and lateral crush at the A-pillar area.

Interior Damage

The interior damage to the Ford was moderate and was attributed to occupant contact points and intrusion of the passenger compartment. The driver’s contact points consisted of several areas of body fluid on the windshield header. These contact points were considered probable due to the spattering of the body fluid. An area of body fluid which appeared to be from contact with the driver’s head was located at the front left corner of the sunroof. This area appeared to be the final rest position of the driver’s head as the body fluid was saturated into the headliner. Located at the centerline of



Figure 7. Overall view of the front roof and windshield header contact points.

the windshield header was an overhead map light. This component contained smeared body fluid which was from probable contact with driver’s hand. The plastic trim panel on the center stack and the plastic panel under the steering column were displaced from contact with the driver. **Figure 7** is an overall view of the front roof and windshield header contact points. Numerous areas of the headliner were soiled and damaged from post-crash handling and storage of components that were separated from the vehicle during the crash. The passenger compartment intrusions were as follows:

Seat Position	Intruded Component	Magnitude	Direction
Front Left	Roof	4 cm (1.5)	Lateral
Front Left	Floor	19 cm (7.5)	Vertical
Front Right	Windshield header	14 cm (5.5”)	Vertical
Front Right	Roof	22 cm (8.5”)	Vertical
Front Right	A-pillar	22 cm (8.5”)	Lateral
Front Right	Roof side rail	17 cm (6.5”)	Lateral
Front Right	B-pillar	9 cm (3.5)	Lateral
Right Rear	Roof side rail	20 cm (8.0”)	Lateral
Right Left	Seatback	5 cm (2.0”)	Longitudinal
Rear Center	Seatback	8 cm (3.0”)	Longitudinal
Rear Right	Seatback	8 cm (3.0”)	Longitudinal

Safety Canopy Air Bag System

The 2005 Ford Escape was equipped with safety canopy 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 canopy air bags were designed to deploy in the event of a side impact or rollover crash. The air bags were designed to remain inflated for a period of approximately six seconds following deployment. The left and right canopy air bags deployed as result of the rollover event. The left and right air bags were rectangular in shape and measured 53 cm (21”) vertically from the roof side rail and



Figure 8. Outboard aspect of left side canopy air bag.

152 cm (60”) in length. The air bags were tethered by rope-type tethers at the A- and C-pillars. The A-pillar tether measured 42 cm (16.5”) in length and the C-pillar tether measured 8 cm (3.0”) in length. **Figure 8** is the outboard aspect of the left canopy air bag. The front tether of the right side air bag was cut by rescue personnel 5 cm (2”) forward of the air bag membrane. No occupant contacts were noted to the canopy air bags. The outboard aspects of the left and right air bags contained body fluid which was probably displaced onto the air bags when the vehicle was up righted from its final rest position on its roof. No damage or failures were noted to the canopy air bags. The following nomenclature was located on the outboard center aspect of the air bag membranes:

Life Curtain Technology
By Milliken
Pat 167S
US Patent 6,220,309

The following nomenclature was located on the outboard forward aspect of the air bag membranes:

TRW
0344705E

Side Impact Air Bag System

The Ford was equipped with seatback mounted side impact air bags. The left seatback mounted side impact air bag deployed (**Figure 9**) during probable ground contact; however, the timing of the deployment was unknown within the rollover sequence. The air bag was concealed in the outboard aspect of the left seatback. The air bag deployed through a 31cm (12”) vertical tear seam. The air bag membrane measured



Figure 9. Deployed driver's seatback mounted side impact air bag.

32 cm (12.5") in width and 25 cm (10") in height. An area of body fluid which began 9 cm (3.5") rear of the forward edge and measured 10 cm (4") in length was noted on the outboard aspect of the membrane. There was no damage noted to this air bag.

Frontal Air Bag System

The 2005 Ford Escape was equipped with a Certified Advanced 208-Compliant front air bags system. The manufacturer of this vehicle has certified that this 2005 Ford Escape meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The driver's frontal air bag deployed as result of the impact with median barrier (**Figure 10**). The driver's frontal air bag was conventionally located in the center of the steering wheel hub. The air bag was concealed by two cover flaps. The



Figure 10. Driver's frontal air bag.

The top cover flap measured 15 cm (6") in width and 8 cm (3") in height. The lower cover flap measured 15 cm (6") in width and 5 cm (2") in height. The membrane was tethered by two wide band tethers at the 3 and 9 o'clock positions and was vented by two vent ports on the rear panel at the 3 and 9 o'clock sectors. An area of body fluid that contained strands of hair was noted on the face of the air bag. The body fluid/hair was located 9 cm (3.5") above the center and 9 cm (3.5") right of center. The front right seat was not occupied during the crash; therefore, the front right air bag was not commanded to deploy.

Manual Restraints Systems

The Escape was equipped with pillar mounted manual 3-point lap and shoulder safety belts for the four outboard seating positions. The second row center seat was an integrated lap and shoulder safety belt. The driver's safety belt consisted of a sliding latch plate, Emergency Locking Retractor (ELR), height adjustable D-ring that was adjusted to 2 cm (0.75") above the full-down position, and a buckle mounted pretensioner that fired during the crash. The driver used the safety belt in the crash which was supported by full width loading abrasions to the latch plate and D-ring. Additional evidence consisted of loading to the webbing which measured 15 cm (6") in length and was located from 165-180 cm (65-71") above the stop button. Furthermore, the safety belt was cut and the latch plate was found in the buckle.

The front right safety belt consisted of a sliding latch plate, a switchable ELR/Automatic Locking Retractor (ALR), an adjustable D-ring, and buckle pretensioner. The front right seat was not occupied during the crash; therefore, the front right pretensioner did not fire. The second row safety belts consisted of sliding latch plates and retracted onto switchable ELR/Automatic Locking Retractor's.

Occupant Demographics

Driver

Age/Sex: 31-year-old/Male
 Height: 185 cm (73")
 Weight: 78 kg (171 lbs)
 Seat Track Position: Presumed rear track position based on demographics (Seat found in the mid-track at the time of the SCI inspection)
 Manual Restraint Use: Manual 3-point lap and shoulder belt
 Usage Source: Vehicle inspection
 Eyewear: Unknown
 Type of Medical Treatment: Transported to the medical examiner's office

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Focal pinpoint hemorrhages less than 0.1 cm (0.3") in the mid brain	Critical (140210.5,8)	Road surface
Left temporal lobe laceration, NFS	Severe (140688.4,2)	Road surface
Hinge fracture at the base of the skull through left side frontal bone, lesser wing of sphenoid, sella turcica, and petrous ridge of the right temporal bone	Severe (150206.4,8)	Road surface
Diffuse subdural hemorrhage	Severe (140650.4,9)	Road surface
Duffuse subarachnoid hemorrhage	Serious (140684.3,9)	Road surface
Comminuted fractures of the right temporal and parietal bones and a 3 cm (1") complete linear fracture of the right temporal and parietal region	Serious (150404.3,1)	Road surface
Contusions along the length of the supero-medial right frontal and temporal lobes	Serious (140611.3,9)	Road surface
W-shaped stellate gaping lacerations to the right temporal and parietal scalp	Moderate 190604.2,1)	Road surface
3 cm (1") crescent shaped laceration to the right temporal and parietal scalp	Minor (190602.1,1)	Road surface
8 cm (3") abrasion to the right temporal and parietal scalp	Minor (190202.1,1)	Road surface

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
3 cm (1.25") abrasion to the right frontal region	Minor (190202.1,5)	Road surface
Diffuse subgaleal contusions, right front and parietal regions	Minor (190402.1,1)	Road surface
Subconjunctival hemorrhages of the right eye	Minor (240416.1,1)	Indirect road surface
Diastatic fracture of the left coronal suture	Minor (150402.2,2)	Road surface
Left neck linear contusion 6 cm (2.5") in length and multiple smaller contusions ranging from 0.6 cm (0.25") to 2 cm (0.75")	Minor (390402.1,2)	Shoulder belt
Abrasions to the left side of the neck	Minor (390202.1,2)	Shoulder belt
Lateral left arm and left hand abrasions ranging from 3 cm (1") to 23 cm (9")	Minor (790202.1,2)	Road surface
Multiple broad abrasions to the medial right arm and right hand	Minor (790202.1,1)	Headliner
Multiple contusions ranging from 3 cm (1") to 18 cm (7") to the left arm and left hand	Minor (790402.1,2)	Road surface
Multiple contusions to the right arm and right hand	Minor (790402.1,1)	Headliner
Multiple abrasions ranging from 0.6 cm (0.25") to 4 cm (1.5") diffusely over both legs and feet	Minor (890202.1,3)	Knee bolster and below
Multiple contusions ranging from 0.6 cm (0.25") to 5 cm (2") diffusely over both legs and feet	Minor (890402.1,3)	Knee bolster and below
3 cm (1.25") laceration on the anterior aspect of the left leg	Minor (890602.1,2)	Knee bolster

Source – Autopsy

Driver Kinematics

The 31-year-old male driver of the 2005 Ford Escape was seated in an upright posture with the seat track adjusted to a presumed rear track position based on his demographics. The seat track was in the mid position at the time of the SCI inspection. The driver of the Escape was restrained by the 3-point lap and shoulder belt system. Belt usage was supported by the width loading abrasions to the latch plate, D-ring, and the webbing.

At impact with the median barrier, the driver's frontal air bag deployed and the safety belt pretensioner fired. The driver initiated a forward and right trajectory in response to the 1 o'clock direction of force and loaded the safety belt system and possibly the frontal

air bag. His forward motion was minimal due to the safety belt usage, fired pretensioner, and the frontal air bag deployment.

As a result of the median barrier impact, the vehicle rotated counterclockwise and was tripped into a right side leading rollover event. The rollover event triggered the deployment of the canopy and side impact air bag system. The driver responded to the crash forces by moving vertically and laterally within the front left area of the vehicle. He loaded the shoulder belt which resulted in a 6 cm (2.5") left neck linear contusion with abrasions of the left neck.

As the roof of the vehicle contacted the road surface during the rollover sequence, the sunroof disintegrated. The driver moved vertically upward with respect to the vehicle which resulted in the partial ejection of his head through the sunroof opening and consequently contacted the road surface. The head contact with the road surface resulted in the soft tissue injuries to the scalp, a hinge fracture at the of base of the skull through left side frontal bone, sphenoid wing, sella turcica, and the petrous ridge of the right temporal bone. Additionally, the driver sustained comminuted fractures of the right temporal and parietal bones, a 3 cm (1") complete linear fracture of the right temporal and parietal region, diastatic fracture of the left coronal suture, and a laceration and hemorrhages of the brain. The subconjunctival hemorrhages of the right eye were indirectly caused by the severe skull fractures.

The left front door glazing was disintegrated which resulted in the partial ejection of the driver's left hand and arm through the front aspect of the left window frame forward of the canopy air bag. His left hand and arm contacted the ground resulting in the lateral left arm and left hand abrasions ranging from 3 cm (1") to 23 cm (9"), multiple contusions ranging from 3 cm (1") to 18 cm (7") to the left arm and left hand. His right hand, arm, both legs, and feet contacted the headliner and the knee bolster, respectively. These contacts resulted in the multiple broad abrasions and contusions to the medial right arm and right hand, multiple abrasions diffusely over both legs and feet, and the 3 cm (1.25") laceration on the anterior aspect of the left leg.

The Ford rolled a total of ten-quarter turns prior to final rest. At rest, the driver's head was in contact with the headliner as he was supported vertically by the manual belt system. Due to the massive head injuries, the driver expired at the scene. His body was transported to the medical examiners' office for autopsy.

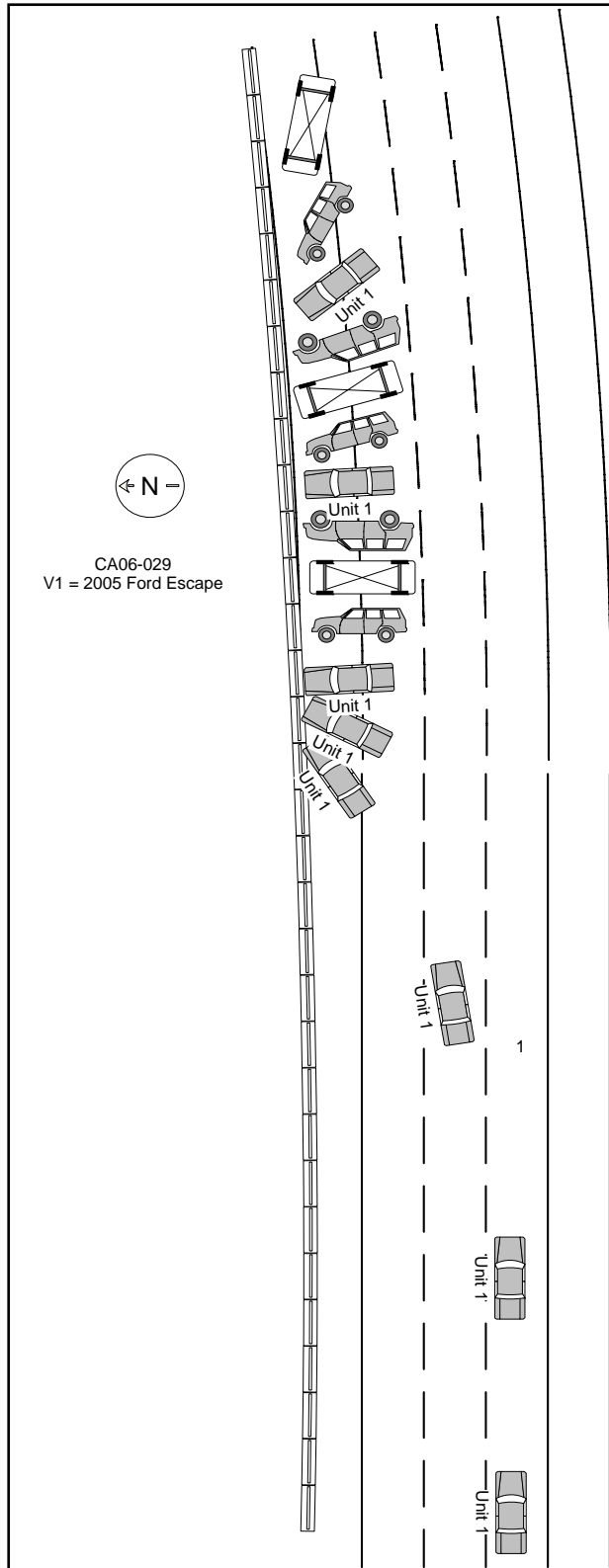


Figure 11: Crash Schematic