

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

CALSPAN CASE NO.: CA06-020

LOCATION: NORTH CAROLINA

VEHICLE: 2005 FORD FREESTAR

CRASH DATE: JULY 2006

Contract No. DTNH22-01-C-17002

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

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

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TABLE OF CONTENTS

BACKGROUND	1
SUMMARY	2
CRASH SITE	2
VEHICLE DATA	2
2005 FORD FREESTAR	2
CRASH SEQUENCE	3
PRE-CRASH	3
CRASH	3
POST-CRASH	4
VEHICLE DAMAGE	5
EXTERIOR	5
INTERIOR	7
CERTIFIED ADVANCED 208-COMPLIANT SAFETY SYSTEM	8
OCCUPANT DEMOGRAPHICS/DATA	9
DRIVER	9
DRIVER INJURIES	9
DRIVER KINEMATICS	10

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BACKGROUND

This on-site investigative effort focused on the crash severity, rollover dynamics, and injury sources for a crash involving 2005 Ford Freestar (**Figure 1**) and its 26-year-old female driver. The Ford was involved in an eight-quarter turn rollover crash sequence that resulted in moderate damage to the vehicle. The Ford was occupied by an unrestrained 26-year-old female driver. The vehicle was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system for the driver and front right positions. The



Figure 1. Subject vehicle 2005 Ford Freestar.

The manufacturer of this vehicle has certified that this 2005 Ford Freestar meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS) 208. The CAC safety system consisted of dual stage frontal air bags, an occupant presence sensor for the front right seat, safety belt buckle switch sensors to monitor belt usage, and buckle mounted safety belt pretensioners. The driver's frontal air bag deployed during the crash. The driver's safety belt was not in use at the time of the crash and the buckle pretensioner did not fire. The Ford was descending a long grade on a straight segment of road approaching an intersection. The 26-year old female driver approached the intersection where she relinquished directional control and the vehicle departed the right road side where it furrowed and tripped into a left side leading roll event. The driver of the Ford sustained multiple fractures and a spleen laceration and was transported to a local hospital for treatment. The Police Accident Report (PAR) codes indicated unknown for ejection and entrapment. Based on the lack of interior occupant contacts and the severity of the driver's injuries, she was probably ejected during the rollover sequence. The driver was charged with a drug related offense and refused and SCI interview.

This crash was identified through weekly sampling of PAR's by the National Automotive Sampling System (NASS). The PAR was forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) by the Calspan Special Crash Investigations (SCI) team due to agency's interest in rollover crashes. The Ford was located and cooperation was established with the salvage facility to inspect in the vehicle. An on-site investigation was assigned to the Calspan SCI team on August 14, 2006. The vehicle and scene inspection took place on August 15, 2006.

SUMMARY

Crash Site

The crash occurred on the south road side of an east/west roadway at a four-leg intersection in a rural, undeveloped area during nighttime hours July 2006. The east/west bound travel lanes were 3.7 meters (12.1 feet) and 3.1 (10.2 feet) meters wide, respectively. A long downhill grade was present for eastbound travel. The travel lanes were separated by a double yellow center line and were bordered by white fog lines. A 0.5 meters (1.6 feet) asphalt shoulder extended beyond the fog line. Located adjacent to the shoulder was a shallow grass embankment. The north/south legs of the intersection consisted of two travel lanes that were separated by a double yellow centerline that transitioned to a raised concrete/dirt center median. Traffic for east/west bound traffic was controlled by overhead flashing amber lights with a yellow reflective sign that warned of vehicles entering the intersection from the north/south legs. The north/south legs were controlled by stop signs. The southeast quadrant of the intersection consisted of a grassy area, stop sign, and a utility pole that was supported by two guy wires. The posted speed limit was 89 km/h (55 mph). The scene schematic is included as **Figure 12** of this report.

The SCI on-site inspection took place six weeks post-crash due to the delay in crash notification. This passage of time hampered the identification of the probable crash-related roadside physical evidence due to its erosion and exposure to the weather. Observations at the scene indicated that road construction had recently taken place at the intersection. The asphalt surface of the intersecting north/south road was recently milled for resurfacing and the remains of the asphalt debris were scattered throughout the southwest quadrant of the intersection. Numerous construction related gouges and tracks were observed. It was deemed unlikely that the construction zone existed during the time of the crash and there was no reference to a construction zone cited on the PAR. Additionally, the roadside grass was recently mowed further removing potential evidence of the vehicle's pre-crash trajectory.

Vehicle Data

2005 Ford Freestar

The subject vehicle in this crash was a 2005 Ford Freestar. The Ford was identified by the Vehicle Identification Number (VIN) 2FMZA5161BA (production number deleted). The odometer reading at the time of the SCI inspection was unknown due to an expended battery. The vehicle was a four-door minivan equipped with a 3.9 liter V-6 engine linked to a four-speed automatic transmission. The service brakes were four-wheel disc with anti-lock. The vehicle was equipped with Michelin Symmetry P225/60R16 tires on OEM steel rims with plastic wheel covers. The manufacturer recommended tire pressure was 241 kPa (35 PSI). The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	241 kPa (35 PSI)	2 mm (2/32")	None
Left Rear	165 kPa (24 PSI)	7 mm (9/32")	None
Right Front	193 kPa (28 PSI)	2 mm (2/32")	None
Right Rear	221 kPa (32 PSI)	6 mm (8/32")	None

The interior of the Freestar was configured with cloth surfaced front bucket seats, second row captain seats, and a third row three-passenger bench seat. The front seats were equipped with integrated head restraints. The second and third row seats were equipped with height adjustable head restraints. The second row head restraints were adjusted to the full-up position and third row were adjusted to the lower third position at the time of the SCI inspection.

Crash Sequence

Pre-Crash

The crash occurred on the south roadside of an east/west roadway during night time hours. The 26-year-old female driver of the Ford was operating the vehicle eastbound (**Figure 2**) approaching the intersection at police reported speed of 113 km/h (70 mph). The driver allowed the Freestar to drift off the right road side and enter the south roadside at a shallow angle of approximately five degrees. As the vehicle entered the roadside, it began a clockwise rotation. The Ford reached a rotation angle of approximately 75 degrees as it traveled down the shallow embankment.



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

Crash

The front bumper and undercarriage of the Ford contacted the ground as it reached the transition point of the embankment and the level aspect of the ground (**Figure 3**). This impact was evidenced by a gouge that was located 4.8 meters (15.7 feet) south of the south road edge and 25 meters (82 feet) west of the intersection. The ground impact resulted in moderate non-horizontal damage to the frontal undercarriage area. The ground contact in conjunction with the lateral forces resulted in disengagement of the right front drive axle. This impact resulted in the



Figure 3. Area of ground contact with front undercarriage and trip.

deployment of the driver's frontal air bag. Although the Ford was equipped with buckle pretensioners, the driver did not use the safety belt; therefore the pretensioner did not fire.

As the Ford continued its travel on the roadside, the left side tires probably furrowed which tripped the vehicle into a left side leading roll. The furrows could not be located at the crash site due to the post-crash activity that included and was not limited to road construction and weather.

The left front fender of the Freestar impacted the ground during the first quarter turn which was located approximately 25 meters (82 feet) from the road departure and approximately 7 meters (23 feet) south of the south road edge. The impact area was supported by a 1.1 meter (3.6 feet) wide gouge. The Freestar then continued to roll an additional seven quarter turns impacting the ground with the roof and right side and undercarriage planes.

As the Ford traversed the north/south bound travel lanes and departed the east roadside the vehicle was returning to its wheels completing the eight quarter-turns. The rollover sequenced was interrupted as the left front door area of the vehicle impacted and disengaged a guy wire that was located 6 meters (19.7 feet) west of the west road edge and 18 meters (59 feet) south of the south road edge. The Ford traveled an additional 2.6 meters (8.5 feet) and impacted a second guy wire with the left rear door area. The second guy wire arrested the roll of the Ford and it came to final rest against the guy wire. **Figure 4** depicts the area of final rest for the Freestar.

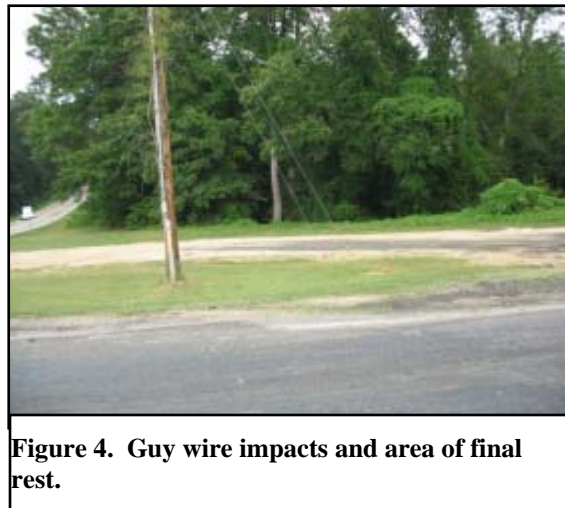


Figure 4. Guy wire impacts and area of final rest.

Analysis of this crash was beyond the scope of the WINSMASH model; therefore, a delta-V was not calculated. The interrupted roll event precluded speed analysis of the crash through traditional engineering methods.

Post-Crash

Emergency Medical Service (EMS) and police personnel responded to the crash site. The driver of the Ford was sustained moderate severity injuries and was transported to a local hospital for treatment. The Ford was towed from the crash site and consequently deemed a total loss by the insurance company. The investigating police officer coded unknown for ejection and entrapment on the accident report. Based on the driver's injuries, (See Driver Injury Section) it was possible that she was ejected from the vehicle.

Vehicle Damage

Exterior

The Ford sustained moderate damage to all four planes as a result of the eight quarter-turn rollover event and impacts to the two guy wires. The first impact in this crash sequence involved the front bumper and frontal undercarriage contacting the ground. This impact resulted in vertical and longitudinal displacement of the front bumper system and disengagement of the right drive axle. **Figures 5 and 6** depict the front and undercarriage damage. The direct contact damage measured 104 cm (41.0") and began 36 cm (14.0") left of the centerline and extended to the right. The crush was measured across the full frontal width of the bumper beam of 122 cm (48.0"), using six equidistant crush measurements. The crush was as follows: C1 = 4 cm (1.6"), C2 = 0 cm, C3 = 3 cm (1.2"), C4 = 1 cm (0.4"), C5 = 4 cm (1.6"), C6 = 2 cm (0.8"). The Collision Deformation Classification (CDC) for this impact was 00-UFDW-2.



Figure 5. Frontal damage.



Figure 6. Undercarriage damage.

The rollover event resulted in damage to all four planes. Crush was evident on the front fenders and the right rear roof area. The resultant crush to the fenders was both vertical and lateral in scope and was documented at six equidistant points on the fenders. The direct contact damage on the left fender measured 80 cm (31.5") which began at the forward edge and extended 38 cm (15.0") rear of the left front axle. The left fender crush (**Figure 7**) profile was as follows: C1 = 0 cm, C2 = 0 cm, C3 = 8 cm (3.0"), C4 = 11 cm (4.5"), C5 = 14 cm (5.5"), C6 = 17 cm (6.7").



Figure 7. Left fender damage from rollover event.

The direct contact damage on the right fender measured 102 cm (40.0") and began at the leading edge and terminated on the forward aspect of the right front door. The crush to this component (**Figure 8**) was as follows: C1 = 0 cm, C2 = 1 cm (0.4"), C3 = 3 cm (1.3"), C4 = 5 cm (2.0"), C5 = 12 cm (4.7"), C6 = 38 cm (5.9").



Figure 8. Right fender damage.

The rear right roof area sustained vertical and lateral crush as a result of contact with the ground during the rollover event. The direct contact damage measured 122 cm (48.0") and extended from the left D-pillar to the right D-pillar. A crush profile was documented along the full width of the rear roof which was 122 cm (48.0") (**Figure 9**). The six crush measurements were as follows: C1 = 0 cm, C2 = 0 cm, C3 = 10 cm (4.0"), C4 = 10 cm (3.8"), C5 = 9 cm (3.6"), C6 = 9 cm (3.5").



Figure 9. Rear roof crush profile.



Figure 10. Maximum vertical and maximum lateral crush at the right D-pillar area.

The greatest extent of crush occurred within the right rear D-pillar area which resulted in maximum lateral crush of 30 cm (12.0") and maximum vertical crush of 9 cm (3.5") (**Figure 10**).

The rear left corner of the rear bumper system impact the ground during the rollover which resulted in longitudinal crush to this component. The area of direct contact began 70 cm (27.6") left of the centerline and extended to 81 cm (31.9") left to the end of the bumper beam. The crush profile for was measured along the full width of the bumper beam of 150 cm (59.0") and was as follows: C1 = 3.8 cm (1.5"), C2 = 0 cm, C3 = 0 cm, C4 = 0 cm, C5 = 0 cm, C6 = 0 cm. The CDC that captures the damage for the rollover event was 00-TDDO-2.

The left front door sustained minor damage from the yielding impact with the first guy wire. This impact did not disintegrate the partially opened left front glazing; however, the deformation jammed the left front door in the closed position. The direct contact damage measured 36 cm (16.0") and was contained within the center of the left front door. A crush profile was used to capture the deformation and was as follows: C1 = 3 cm (1.2"), C2 = 5 cm (1.9"), C3 = 7 cm (2.8"), C4 = 8 cm (3.1"), C5 = 6 cm (2.4"), C6 = 4 cm (1.6"). The CDC for this impact was 09-LPAN-2.

The left rear sliding door impacted a second guy wire resulting in minor damage to this component. The direct contact damage extended vertically from the sill to the left roof rail and was biased to the rear of the vehicle consistent with the angle of the guy wire. This impact disintegrated the tempered glazing and jammed the left rear door in a closed position. The direct contact damage measured 13 cm (5.0") and was located diagonally from top to bottom on the center of the door. The crush for this impact was follows: C1 = 3 cm (1.2"), C2 = 8 cm (3.1"), C3 = 11 cm (4.3"), C4 = 15 cm (5.9"), C5 = 10 cm (3.9"), C6 = 5 cm (1.9"). The CDC for this impact was 09-LPAN-2.



Figure 11. Left front and left rear door damage from the guy wire impacts.

Figure 11 is an overall view of the left front door and left rear door damage from the guy wire impacts.

The right front door glazing was closed and remained intact. The right rear, left rear, and backlight glazing were disintegrated. The windshield was fractured and remained in place; however, due to the heat exposure the lamination was distorted allowing the glazing to separate and sag. The right side doors remained closed during the crash and were operational post-crash. The tailgate did open due to the force of the crash; however, it found opened. Due to the deformation at the top of the tailgate, the opening was restricted to approximately 30 cm (12.0") and would not close due to misalignment of the locking mechanism.

Interior

The interior of the Ford was free of occupant contact points. Dark colored fluid was dispersed throughout the interior components which consisted with the contents of a soft drink container that was located on the front right floor area. There was no damage to the steering column and its components or damage to the knee bolster.

The driver's seat was in the full-forward position at the time of the SCI inspection; however, the seat track was probably moved post-crash.

The interior of the Ford sustained moderate interior damage that was attributed to passenger compartment intrusion. The intrusions are listed in the following table:

Seat Position	Intruded Component	Magnitude	Direction
Second Row Left	Roof Side Rail	1 cm (0.4")	Vertical
Second Row Left	Roof	2 cm (0.8")	Vertical
Second Row Center	Roof	6 cm (2.4")	Vertical
Second Row Right	Roof	6 cm (2.4")	Vertical
Second Row Right	Roof Side Rail	2 cm (0.8")	Vertical
Third Row Left	Roof Side Rail	1 cm (0.4")	Vertical
Third Row Left	Roof	10 cm (3.9")	Vertical
Third Row Center	Roof	25 cm (9.8")	Vertical
Third Row Right	Roof	28 cm (11.0)	Vertical
Third Row Right	Roof Side Rail	19 cm (7.5")	Vertical

Certified Advanced 208-Compliant Safety System

The 2005 Ford Freestar was equipped with a Certified Advanced 208-Compliant (CAC) frontal safety system. The manufacturer of this vehicle has certified that this 2005 Ford Freestar meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The system consisted of dual stage frontal air bags, an occupant presence sensor for the front right seat, and safety belt buckle switch sensors to monitor belt usage. The CAC system was monitored and controlled by the Air Bag Control Module (ACM), which measured and predicted the crash severity and commanded deployment of the appropriate safety system.

In the subject crash, the driver's frontal air bag was commanded to deploy; however, the stage was unknown. The driver's air bag was conventionally located in the center of the steering wheel hub and was concealed by three cover flaps. The top cover flap measured 13 cm (5.3") in width and 5 cm (2.0") in height. The two lower cover flaps measured 7 cm (2.8") in width and 9 cm (3.5") in height. The driver's air bag measured 51 cm (20") in diameter in its deflated state. The air bag contained two tethers at the 3 and 9 o'clock positions and was vented by two vent ports at the 11 and 1 o'clock positions. There was no damage or occupant contact points present on the air bag membrane; however the membrane was soiled from post-crash handling.

Manual Safety Belt Systems

The Freestar was equipped with three-point lap and shoulder belt systems for the seven seated positions.

The front safety belt consisted of continuous loop webbing with sliding latch plates, height adjustable D-rings that were in the full-down position at the time of the SCI inspection, and buckle mounted pretensioners. The driver's safety belt retracted onto an

Emergency Locking Retractor (ELR) and the front right retracted onto a switchable ELR/Automatic Locking Retractors (ALR).

The front left safety belt was found in the stowed position and was operational within the retractor. The driver did not use the safety belt in the crash which was supported by the lack of loading evidence on the webbing, latch and D-ring. Additionally, the buckle pretensioner did not fire which was indicative of the safety belt's unbuckled status during the crash.

The two second row safety belts were lap and shoulder restraints with adjustable D-rings. The left D-ring was in the full-down position and right D-ring was in the full-up position at the time of the SCI inspection. Both safety belts were equipped with sliding latch plates and retracted onto a switchable ELR/Automatic Locking Retractors (ALR).

The third row was equipped with lap and shoulder belts for all three positions. The center belt system consisted of a detachable shoulder belt. All three belts contained sliding latch plates and retracted onto a switchable ELR/Automatic Locking Retractors (ALR).

Occupant Demographics/Data

Driver

Age/Sex: 26 year old/Female
 Height: Unknown
 Weight: Unknown
 Seat Track Position: Unknown (moved post-crash)
 Eyewear: Unknown
 Manual Safety Belt Usage: None
 Usage Source: Vehicle inspection
 Egress from Vehicle: Probable ejection
 Mode of Transport from Scene: Transported by ambulance to a hospital
 Type of Medical Treatment: Hospitalized for eight days

Driver Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Comminuted fracture of the proximal right humeral (with displacement and angulation posteriorly involving the humeral neck and proximal diahysis)	Serious (752604.3,1)	Probable ground contact
Anterior left acetbulum fracture	Moderate (852602.2,2)	Probable ground contact
Inferior left pubic ramus fracture	Moderate (852602.2,5)	Probable ground contact
Posterior fracture of the left ribs 10-12	Moderate (450220.2,2)	Probable ground contact

Injury	Injury Severity AIS90/Update 98	Injury Source
Grade I spleen laceration	Moderate (544222.2,2)	Probable ground contact
Right parietal scalp laceration and hematoma	Minor (190402.1,1 190600.1,1)	Probable ground contact
Right mandible fracture	Minor (250600.1,1)	Probable ground contact
Multiple teeth fractures	Minor (251404.1,8)	Probable ground contact
Abrasions to the left hand and right arm	Minor (790202.1,3)	Probable ground contact
Abrasion to the mid-back	Minor (690402.1,4)	Probable ground contact

Source = Medical records

Driver Kinematics

The 26-year old female driver of the 2005 Ford Freestar was seated in an upright driving posture and was not restrained by the safety belt system. The lack of belt usage was determined by the inspection of the belt system which did not reveal loading evidence and the non-fired status of the buckle pretensioner.

The initial impact with the ground resulted in the deployment of the frontal air bag system. The driver initiated a slight forward trajectory and loaded the deployed air bag. The vehicle tripped and rolled into a left side leading eight quarter turn rollover event.

There were no occupant contact points within the interior to support driver motion and loading. The investigating police officer coded unknown for entrapment and ejection on the police accident report. Additionally, the driver refused an interview with the SCI investigator. Given the severity of the driver's injuries and the lack of interior occupant contacts the driver was probably ejected through the left front door window opening during the later stages of the rollover sequence. The multiple fractures, spleen laceration, and the soft tissue injuries probably resulted from ground contact.

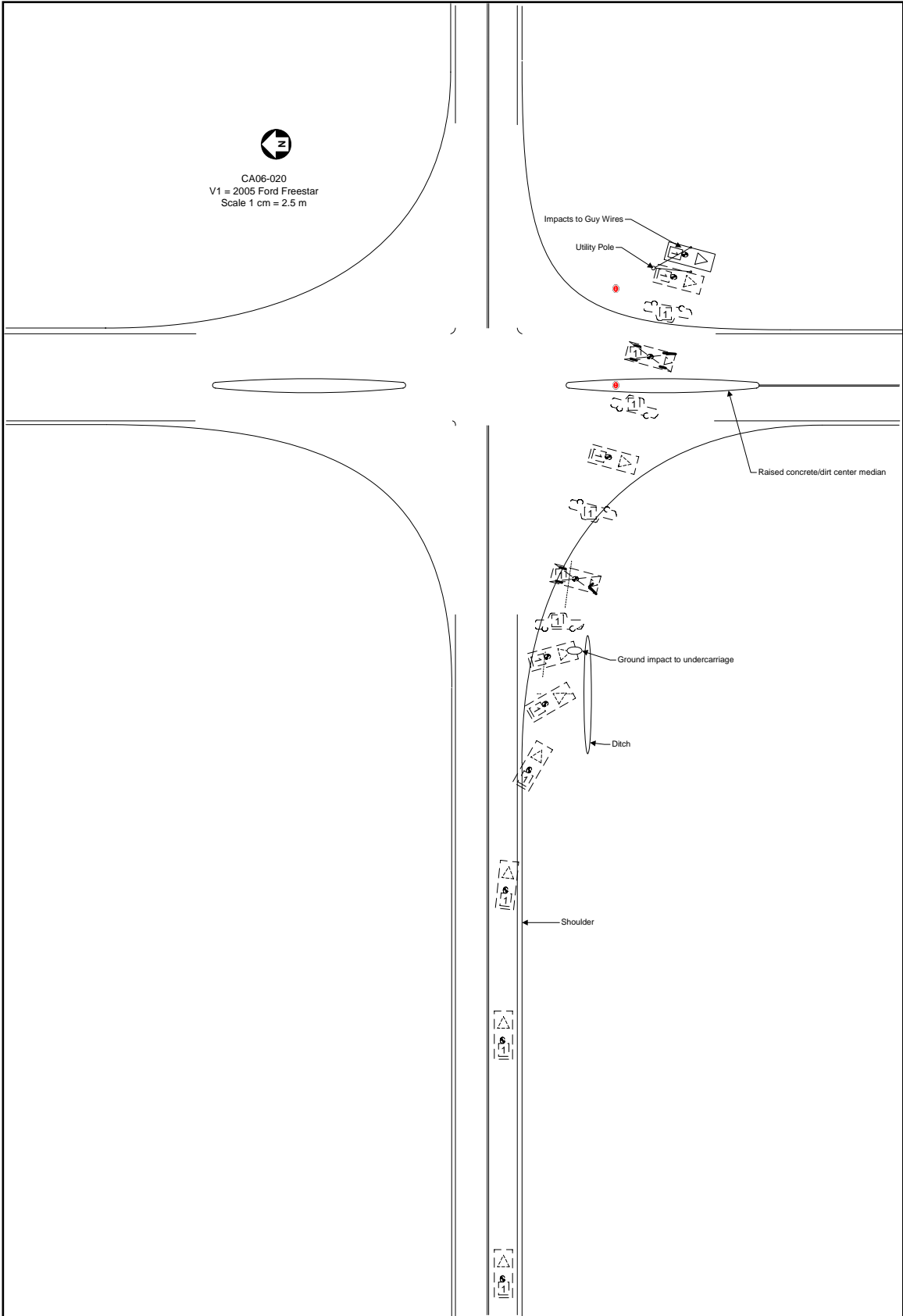


Figure 12: Scene Schematic