CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE ADVANCED OCCUPANT PROTECTION SYSTEM CRASH INVESTIGATION

SCI CASE NO.: CA06-030

LOCATION: MICHIGAN

VEHICLE: 2006 LEXUS IS250

CRASH DATE: DECEMBER 2006

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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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BACKGROUND

This on-site investigative effort focused on the Advanced Occupant Protection System (AOPS) in a 2006 Lexus IS250 **(Figure 1)**. The AOPS system consisted of a dual stage frontal air bag system, front and rear outboard safety belt retractor pretensioners, and knee bolster air bags. In addition, the Lexus was equipped with a side impact air bag system that consisted of front seatback mounted air bags and curtain air bags. The vehicle was occupied by a restrained 73-year-old male driver. The frontal air bag system and knee bolster air bags deployed and the front and rear outboard safety belt pretensioners fired as a result of a severe right side impact with a 2003 Ford F-350. The side impact air bag system did not deploy in the crash. The driver of the Lexus sustained severe injuries and was transported to a local hospital where he was admitted for treatment for 16 days. He was transferred to a hospice facility where he expired approximately one month post-crash.

Figure 1. Subject vehicle 2006 Lexus IS250.

This crash was identified by the Michigan Primary Sampling Unit (PSU) of the National Automotive Sampling System (NASS). The crash information was provided to the Calspan Special Crash Investigations (SCI) team which was reviewed and forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA). Due to the deployment of the frontal AOPS air bag system and the severe injuries sustained by the driver, the case was assigned as an on-site investigation on December 14, 2006. The vehicles and the crash site were inspected during the week of December 18, 2006.

Summary

Crash Site

This intersection crash occurred during the daylight hours of December 2006. At the time of the crash, the weather was clear with no adverse conditions. The crash occurred within the southwest quadrant of a four-leg intersection. The north/south legs of the roadway were configured with four travel lanes that were surfaced with asphalt and separated by double yellow centerlines. The travel lanes were bordered by white fog lines and asphalt shoulders extended beyond the fog lines. The east/west legs consisted

of two travel lanes that were separated by double yellow centerlines and were bordered by white fog lines. The east and west roadside terrain was grass with shallow ditches. Stop signs controlled the east/west traffic. The posted speed limit for the north/southbound lanes was 89 km/h (55 mph). The Crash Schematic is included as **(Figure 12)** of this report.

Vehicle Data– 2006 Lexus IS250 AWD

The 2006 Lexus IS250 was identified by the Vehicle Identification Number (VIN): JTHCK262965 (production sequence omitted) and was manufactured on 06/06. The odometer reading at the time of the inspection was unknown due to the expended vehicle battery. The vehicle was a four-door sedan that was equipped with a 2.5-liter, V6 engine, 6-speed automatic transmission, all-wheel drive, power assisted front and rear disc brakes with anti-lock, electronic brakeforce distribution with brake assist, vehicle stability control and vehicle dynamics control integrated management. The Lexus was equipped with OEM alloy wheels with Bridgestone Potenza RE92 tires, size P225/45R17. The maximum pressure for these tires was 352 kpa (51 psi). The vehicle manufacturer recommended front and rear tire pressure was unknown. The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	276 kPa (40 PSI)	6 mm (8/32)	No	None
LR	241 kPa (38 PSI)	6 mm (8/32)	No	None
RF	0 kPa	6 mm (8/32)	No	14 cm (5.5”) rim fracture
RR	269 kPa (39 PSI)	7 mm (9/32)	No	None

The seating positions in the Lexus consisted of front buckets seats with height adjustable head restraints. The front left head restraint was adjusted 3 cm (1.0”) above the seatback and the right head restraint was adjusted to the full-down position. The second row seat was a three-passenger bench seat with height adjustable head restraints. The rear head restraints were adjusted to the full-down positions at the time of the SCI inspection.

Vehicle Data– 2003 Ford F-350

The 2003 Ford F-350 was identified by the Vehicle Identification Number (VIN): 1FTSW31P63E (production sequence deleted). The odometer reading at the time of the inspection was unknown due to the digital odometer and expended vehicle battery. The vehicle was a large full frame pickup truck that was equipped with a 6.0-liter, V-8 diesel engine, 4-speed automatic transmission, 4-wheel drive, and power-front and rear disc brakes with anti-lock. The Ford was equipped with OEM steel wheels with BF Goodrich Rugged Trail T/A tires, size P265/75R16. The maximum pressure for these tires was 552 kpa (80 psi). The vehicle manufacturer recommended front and rear tire pressure was 345 kpa (50 psi) and 552 kpa (80 psi), respectively. The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	10 mm (13/32)	No	De-beaded
LR	496 kPa (72 PSI)	7 mm (9/32)	No	None
RF	359 kPa (52 PSI)	11 mm (14/32)	No	None
RR	496kPa (72 PSI)	7 mm (9/32)	No	None

Figure 2. Left rear oblique view of the trailer.

The Ford was towing a single axle trailer **(Figure 2)** that was home-built by the owner of the vehicle. The trailer was connected to the Ford using a receiver hitch with a pintle hook hitch system. The receiver hitch had a maximum tongue weight of 136 kg (300 lbs). The trailer was constructed of square steel box beam. The sides and the ramp were skirted with steel grating and the floor consisted of wood planks. The trailer's contents included landscaping tools, wire spools, and a trenching machine. The police investigators weighed the trailer and its contents which yielded a total weight of 1,134 kgs (2,500 lbs).

Crash Sequence

Pre-Crash

Figure 3. Lexus's northbound travel direction.

The restrained 73-year-old male driver of the Lexus was operating the vehicle northbound approaching the four-leg intersection **(Figure 2)**. The driver of the Ford was traveling in the opposite direction in the outboard lane. Adjacent to the Ford was a tractor-trailer that was traveling southbound. As the Lexus approached the intersection, the driver applied a left steering input and initiated a shallow turn across the path of the tractor-trailer. As the Lexus continued its left turn maneuver, the Ford passed the tractor-trailer as it neared the intersection. The relative positions of the Ford and the tractor-trailer obscured the Ford from the vision of the Lexus's driver. As the Lexus encroached the outboard southbound lane, the driver of the Ford observed the turning Lexus and applied a right steering input in an attempt to avoid the collision.

Crash

The front left corner of the Ford initially impacted the right front side area of the Lexus within the southwest quadrant of the intersection **(Figure 4)**. The initial impact resulted in a 1 o'clock direction of force to the Lexus. This longitudinal direction of force and the predicted crash severity by the vehicle's air bag control module deployed the frontal air bag system, inclusive of the knee bolster air bags, and fired the front and rear safety belt pretensioners. As the vehicles continued to crush, the Lexus rotated counterclockwise. At maximum engagement, the full frontal aspect of the Ford was in contact with the right front and center sections of the Lexus. The continued engagement and rotation of the Lexus subsequently increased the direction of force to 3 o'clock for the Lexus. The average force direction of 2 o'clock direction of force (50 degrees) was used to calculate the delta V for the Lexus using the damage algorithm of the WINSMASH program. The total calculated delta-V for the Lexus was 42 km/h (26.1 mph) and the Ford was 16 km/h (9.9 mph). The longitudinal and lateral components for the Lexus were -27 km/h (-16.8 mph) and -32.2 km/h (-20 mph), respectively. The longitudinal and lateral components for the Ford were -16 km/h (-9.9 mph) and 0 km/h, respectively. The side impact air bag system in the Lexus did not deploy.

Figure 4. Area of impact and post-impact physical evidence.

The vehicles disengaged from the impact and began to travel in a southwesterly direction. A secondary impact occurred during the post-crash travel as the front of the Ford contacted the right quarter panel of the Lexus. This contact resulted in minor damage to the Lexus. Numerous gouges from the undercarriage of the Lexus and a locked left front tire scuff from the Ford evidenced the area of impact and post-impact travel of the vehicles across the intersection.

Figure 5. Post-impact off-road travel of the Lexus.

The Ford and Lexus departed the southwest corner of the roadway and entered the shoulder area. A fluid spill and scuffmarks from the front right tire of the Lexus and the left rear wheel of the trailer were documented on the shoulder. Two rotating tire marks (front tires) from the Lexus continued onto the grass roadside and extended in a southwest trajectory to final rest **(Figure 5)**. The left front tire mark

measured 30.4 meters (99.7 feet) and the right front tire mark measured 36.1 meters (118.4 feet). The post-impact travel distance for the Lexus was 49 meters (160 feet).

The Ford entered the grass roadside and began rotating in a clockwise direction. This rotation allowed the left rear tire of the Ford and the left tire of the trailer to furrow into the soft surface. The Ford's left rear tire mark measured 14.5 meters (47.6 feet) and the trailer's left tire mark measured 12.2 meters (40 feet). The furrowing tires resulted in a tripping mechanism as the Ford entered a shallow ditch. The Ford rolled over left side leading three-quarter turns and came to rest on its right side. The trailer subsequently disengaged from the hitch with separation of the safety chains. The trailer remained upright and came to rest near the Ford. The Ford traveled approximately 40 meters (131 feet) from impact to final rest.

Post-Crash

Police, fire department, and emergency medical personnel responded to the crash site. The fire department cut the left side doors and B-pillar away from the Lexus to facilitate the extrication of the driver. The 73-year-old driver sustained severe injuries and was transported by ambulance to a local hospital where he was admitted for treatment. The driver of the Lexus expired approximately one month post-crash at a Hospice facility.

Vehicle Damage

Exterior Damage – 2006 Lexus IS250 AWD

The 2006 Lexus IS250 sustained severe right side damage as a result of the initial impact with the Ford **(Figure 6)**. The direct contact damage began at the leading edge of the right fender and measured 212 cm (83.5"), terminating 71 cm (28") forward of the right rear axle. The damage consisted of severe lateral deformation of the right fender, doors, sill, and roof side rail. Maximum crush was located 8 cm (3") forward of the center aspect of the right front door and measured 64 cm (25.2"). Six crush measurements were documented at the mid-door level using a combined direct and induced damage width of 224 cm (88") and were as follows: C1 = 11 cm (4.3"), C2 = 13.8 cm (14.6"), C3 = 64 cm (25.2"), C4 = 32 cm (12.6"), C5 = 35 cm (13.8"), C6 = 19 (7.5"). The Collision Deformation Classification (CDC) for this impact was 01-RYAW-4.

Figure 6. Resultant right side damage from the impact with the Ford.

The Lexus sustained minor damage to the right rear quarter panel as a result of the secondary impact with the Ford. The total length of the direct damage was 119 cm (47"). The direct contact damage began 53 cm (21") forward of the right rear axle and terminated 66 cm (26") rear of the axle. The damage consisted of abrasions and a

localized dent at the rear wheel opening. The maximum deformation was 5 cm (2”). The assigned CDC for this impact was 03-RZEW-1.

Exterior Damage –2003 Ford F-350

The Ford sustained moderate severity damage as a result of the impact with the Lexus **(Figure 7)**. The direct contact damage measured 178 cm (70”) and extended the full width of the front bumper. The maximum crush measured 20 cm (7.9”) and was located at the front right bumper corner. A crush profile was documented along the bumper and the crush was as follows: C1 = 0 cm, C2 = 0 cm, C3 = 19 cm (7.5”), C4 = 20 cm (7.9”), C5 = 4 cm (1.6”), C6 = 20 cm (7.9”). The CDC for this impact was 12-FDEW-1.

Figure 7. Frontal damage to the 1993 Ford F-350.

The front of the Ford contacted the right rear quarter panel area of the Lexus. This damage was masked by the overlapping frontal damage. A partial CDC of 12-FL99-9 was assigned for this event.

The windshield header area of the Ford sustained moderate damage as result of the rollover event. The direct contact damage from this event measured 136 cm (53.5”) and was located from the left A-pillar to the right A-pillar. A crush profile was documented at the header and was follows: C1 = 0 cm, C2 = 0 cm, C3 = 0 cm, C4 = 4 cm (1.5”), C5 = 5 cm (2”), C6 = 6 cm (2.5”). In addition to the crush profile, the maximum vertical and lateral crush was identified at the right A-pillar area which were 6 cm (2.5”) and 8 cm (3”), respectively. The CDC for this impact was 00-TPDO-2.

The Ford was towing a trailer which was home-built by the driver of the Ford. The trailer damage was limited to the separation of the safety chains.

Interior Damage – 2006 Lexus IS250 AWD

The interior damage to the Lexus was severe and was attributed to occupant contact points and intrusion of the passenger compartment. The front right seating area was nearly eliminated by the dynamic intrusion of the front right door structure. The static lateral post-crash distance from the center console to the right front door measured 14 cm (5.5”). The undeformed distance for this area measured 74 cm (29”). The additional passenger compartment intrusions were as follows:

Seat Position	Intruded Component	Magnitude	Direction
Front Right	A-pillar	33 cm (13”)	Lateral
Front Right	Door	39 cm (15.5)	Lateral
Front Right	Side rail	20 cm (8”)	Lateral
Front Right	B-pillar	18 cm (7”)	Lateral
Right Rear	Door	3 cm (1”)	Lateral
Right Rear	Side rail	10 cm (4”)	Lateral

The driver’s contact points consisted of a head strike that was evidenced by tissue and hair, located on the right grab handle and right side rail forward of the B-pillar. Tissue, body fluid, and abrasions were noted on the top aspect of the inner door panel from subsequent contact with the driver’s head. A blue scuffmark was present on the forward edge of the B-pillar at the height of the beltline. The driver’s right hip area contacted the center console/armrest which displaced the console to the right. Additionally, body fluid was located on the top of the console.

Side Impact Air Bag System – 2006 Lexus IS250 AWD

The 2006 Lexus IS250 was equipped with seatback mounted side impact air bags for the front seats and curtain air bags for the left and right outboard seating positions **(Figure 8)**. The manufacturer’s safety systems data indicated that the air bag system was designed to deploy in certain types of severe side impacts. The right side impact air bag system did not deploy in this crash

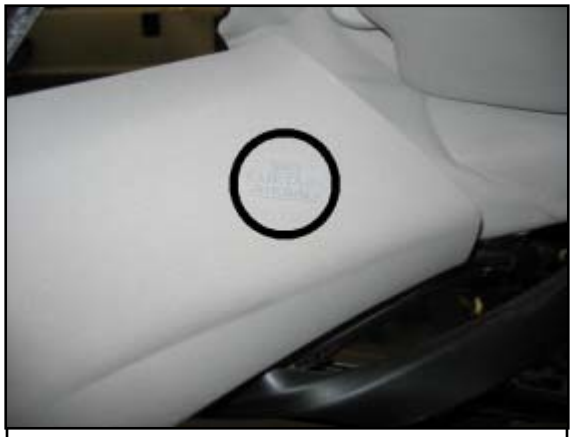

Figure 8. Right A-pillar curtain air bag label.

Frontal Air Bag System – 2006 Lexus IS250 AWD

The Lexus was equipped with an Advanced Occupant Protection System (AOPS) consisting of dual-stage frontal air bags and knee bolster air bags for the driver and front right positions. The driver’s frontal air bag was conventionally located in the center of the steering wheel hub. The air bag was concealed by three cover flaps. The top cover flap measured 12 cm (4.75”) in width and 9 cm (3.5”) in height. The lower cover flaps were symmetrical and measured 6 cm (2.5”) in width and 9 cm (3.5”) in height. The

Figure 9. Deployed driver's frontal air bag system.

membrane was tethered by two wide band tethers at the 3 and 9 o'clock positions and was vented by two unconventionally shaped ports on the rear panel at the 11 and 1 o'clock sectors. The vent ports measured 2 cm (0.75") in height and 0.6 cm (0.25") in width. The air bag membrane measured 56 cm (22") in diameter in its deflated state and was free of damage and occupant contacts. Spattered body fluid was noted on the face of the membrane extending across the 6 and 9 o'clock sectors. **Figure 9** is a view of the deployed driver's frontal air bag system.

The driver's knee bolster air bag deployed from the lower knee bolster. The air bag was concealed by two symmetrical cover flaps that measured 25 cm (9.75") in width and 3 cm (1.25") in height. The air bag membrane was a semi-circular shape with dimensions of 64 cm (25") in width and 30 cm (12") in height. The air bag was internally vented and contained a single stitch tether that was located at the top aspect. No damage or occupant contact points were present.

The front right air bag was located in the top instrument panel and deployed as a result of the crash sequence with the Ford **(Figure 10)**. The cover flaps were concealed by the gross intrusion of the right A-pillar and door and were not inspected. The air bag membrane was a unique design which contained two separate membranes that formed dual-chambers. The membranes were stitched together at the deployed face using a 13 cm (5") semi-circle fabric section. The chambers were independently vented by a single vent port on the side panels at the 9 and 3 o'clock sectors. The vent ports were located 18 cm (7") rear of the forward seam and were 5 cm (2") in diameter. Both chambers were tethered by oval shaped tethers that measured 7 cm (2.75") in width and 10 cm (4") in height and were sewn to the side panels of the air bag. The air bag was free of damage and occupant contact points.

Figure 10. Deployed dual-chamber front right air bag.

The front right position also contained a knee bolster air bag. Due to the gross intrusion to this area, this air bag could not be inspected.

Manual Restraints Systems – 2006 Lexus IS250 AWD

The Lexus IS250 was equipped with manual 3-point lap and shoulder safety belts for all five seating positions. The driver's safety belt **(Figure 11)** consisted of a sliding latch plate, Emergency Locking Retractor (ELR), height adjustable D-ring, and a retractor mounted pretensioner that fired during the crash. The safety belt was cut at three locations by fire department personnel. The lap portion of the webbing was cut 37 cm (14.5") above the floor anchor. This webbing section was free of crash related evidence. The central section of the webbing measured 155 cm (61") and would have been

positioned across the driver's torso and lap. Examination of the webbing revealed occupant loading evidence in the form of waffling throughout this section. The upper section measured 79 cm (31"). Rescue personnel cut the B-pillar and deflected it downward exposing the retractor. The upper section of the cut belt was measured from the exposed retractor. This section of webbing contained possible loading evidence that appeared to be transferred plastic from the interior trim panel. The latch plate was found fastened in the buckle. A full width frictional abrasion to the plastic surface was identified.

Figure 11. Driver's safety belt.

The front right safety belt was equipped with a sliding latch plate, switchable ELR/Automatic Locking Retractor (ALR), and a retractor pretensioner which fired. The second row safety belts consisted of sliding latch plates and retracted onto switchable ELR/Automatic Locking Retractor's. Additionally, the outboard safety belts were equipped with retractor pretensioners that fired during the crash.

Occupant Demographics

Driver

Age/Sex:	73-year-old/Male
Height:	Unknown
Weight:	Listed as obese in the medical records
Seat Track Position:	Rear third track position
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Prescription eyeglasses
Type of Medical Treatment:	Hospitalized for 16 days and transferred to a hospice facility where he expired approximately one month following the crash.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Large parenchymal hematomas involving the right and left temporal lobes, occipital lobes, and right and left frontal lobes	Critical (140646.5,3)	Right roof side rail
Severe bilateral frontal lobe contusions	Critical (140626.5,3)	Right roof side rail
Subdual hematomas	Severe (140650.4,9)	Right roof side rail

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Bilateral subarachnoid hemorrhages	Serious (140684.3,1 140684.3,2)	Right roof side rail
Fractures extending through the right side of the sphenoid sinus and through the left posterior sphenoind sinus and through the left and right posterior clinoid process	Serious (150200.3,8)	Right roof side rail
Fracture of the right supreorbital rim extending toward optic nerve with retrobulbar hematoma and right medial orbital wall fracture; non-displaced lateral wall	Moderate (251202.2,1)	Right roof side rail
Fractures of the frontal wall of both maxillary sinuses with minimally displaced fractures of both posterior walls	Moderate (250800.2,3)	Right roof side rail
Slightly diastatic fracture extending through the zygomatic process of the right frontal bone through the orbital plate of the right frontal bone lateral and minimally displaced through the orbital plate of the left frontal bone	Moderate (251800.2,1)	Right roof side rail
Slightly depressed right nasal fracture	Moderate (251004.2,4)	Right roof side rail
Non-displaced left fracture of the bony orbital lateral wall	Moderate (251202.2,2)	Right roof side rail
Minimally displaced left inferior pubic ramus fracture	Moderate (852602.2,5)	Lap belt
Right ulna fracture	Moderate (753200.2,1)	Right door panel
Serosal tear of the cecum	Moderate (540822.2,8)	Center console
Multiple small facial lacerations	Minor (290602.1,0)	Disintegrated side glazing
2 cm (0.8”) laceration of the right parietal scalp	Minor (190602.1,1)	Right roof side rail
Ecchymossis over both eyes	Minor (297402.1,1 297402.1,2)	Right roof side rail
3 cm (1.2”) right forearm laceration	Minor (790602.1,1)	Right door panel

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Left flank contusion	Minor (590402.1,2)	Lap belt

Source = Medical records/discharge summary

Driver Kinematics

The 73-year old male driver of the Lexus was seated in a presumed upright postured with the seat adjusted to a rear third track position and the head restraint adjusted 3 cm (1") above the seat back. Although his height and weight were not reported, the medical records listed the driver as an obese adult male. He was restrained by the manual 3-point lap and shoulder belt system. Belt usage was supported by the locked position of the belt webbing due to the firing of the retractor pretensioner, the cut sections of the webbing by rescue personnel, and the loading evidence on the webbing and latch plate.

The initial impact between the Ford and the Lexus involved a shallow angle engagement at the right front fender area of the Lexus resulting in an initial 1 o'clock impact force. The vehicle's air bag control module sensed the longitudinal impact force and based on its prediction of the crash severity, deployed the AOPS frontal air bag system. This included the firing of the driver's retractor pretensioner. As a result of the initial impact force, the driver responded in a forward trajectory. The driver loaded the lap belt which resulted in the left pubic ramus fracture and the left flank contusion.

The driver responded to the impact force by initiating a forward and lateral right trajectory. During the early stages of his movement, the F-350 continued forward and rotated the Lexus counterclockwise. The Ford subsequently engaged the right side of the Lexus translating the direction of force through the 2 o'clock sector into the 3 o'clock sector. As the Lexus rotated, the driver continued on his trajectory. His motion with respect to the vehicle changed to a lateral right trajectory due to this rotation and the subsequent side engagement. During the right side engagement, the right side glazing disintegrated and was displaced within the passenger compartment contacting the driver resulting in the multiple small facial lacerations.

The driver loaded the belt system as evidence by the frictional abrasion of the latch plate and the waffling of the shoulder belt webbing. His left shoulder probably slid out from the belt webbing due to his lateral right trajectory. The driver's right hip engaged the center arm rest, displacing the armrest laterally right. Additionally, the loading resulted in the serosal tear of the cecum.

The center armrest and lap belt arrested the lateral motion of the driver's lower body which resulted in an arcing trajectory of his head and upper torso. His head impacted the intruding right side roof side rail evidenced by the tissue transfer and hair on the grab handle. This contact resulted in the soft tissue injuries to the face and scalp, multiple skull fractures, and the brain injuries described in the above table.

The driver's right arm subsequently struck the top of the intruding right front door panel, evidence by tissue, skin oil, and abrasions to the leather trimmed panel. This contact resulted in the right forearm laceration and the right ulna fracture. He came to rest against the intruding right side components.

The driver was removed from the Lexus by rescue personnel and was transported by ambulance to a local hospital where he was admitted for treatment of his injuries.

Medical Treatment

The driver's treatment included surgical repair of the cecum tear, draining of the excess brain fluid from the hemorrhages and numerous medical intervention to stabilize his injuries. The driver was hospitalized for 16 days. During the hospitalization, no improvement of his condition was noted and the family of the driver requested a transfer to a hospice facility. The driver succumbed to his injuries approximately one month post-crash.

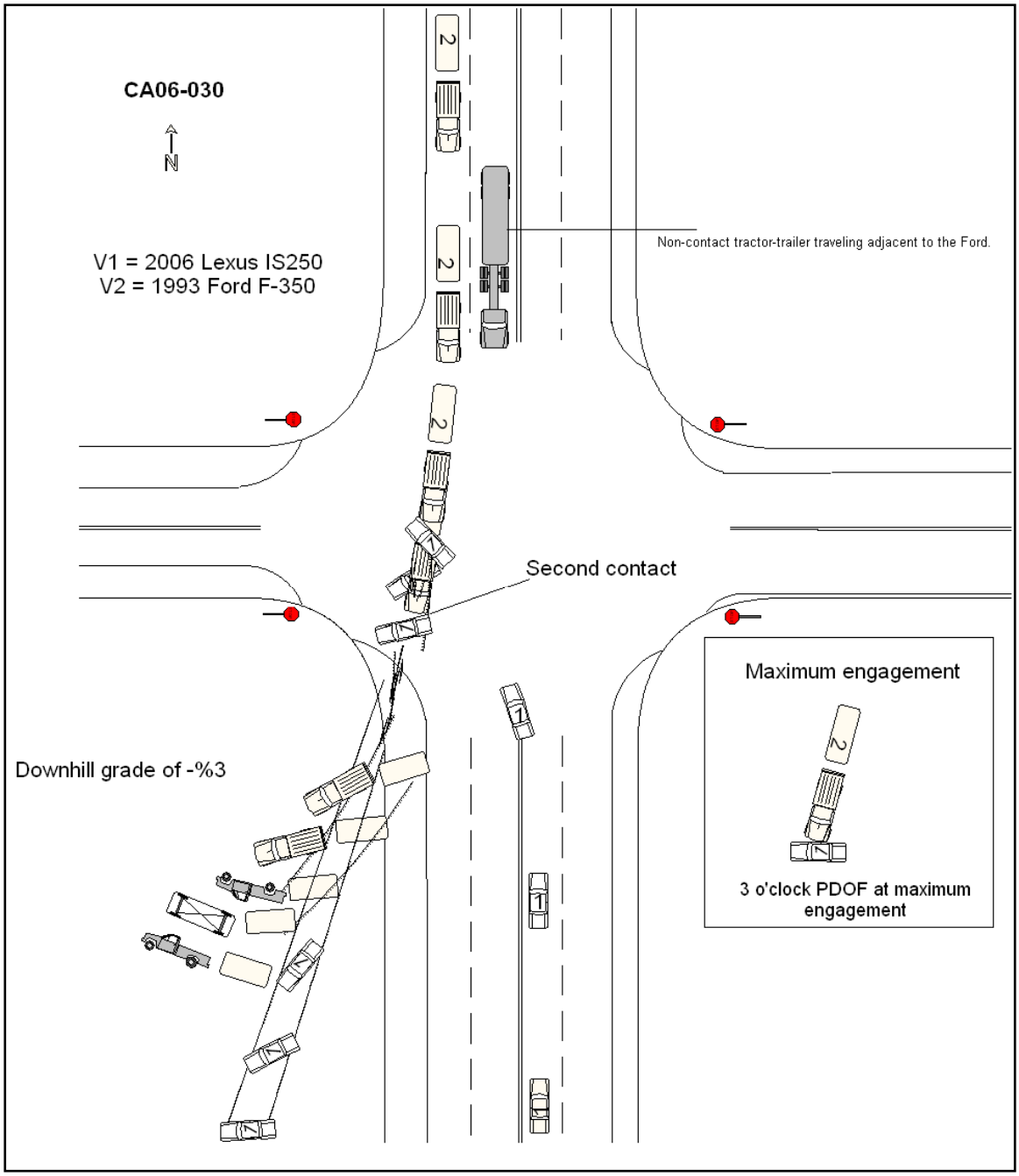

Figure 12: Crash Schematic