TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

Veridian Engineering (Calspan Operations)
Buffalo, New York 14225

VERIDIAN ON-SITE FAIL-TO-DEPLOY INVESTIGATION
VERIDIAN CASE NO. CA98-60
VEHICLE: 1998 HONDA CIVIC EX
LOCATION: PENNSYLVANIA
CRASH DATE: OCTOBER, 1998

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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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16. *Abstract* This on-site investigation focused on issues related to the non-deployment of the frontal air bag system in a 1998 Honda Civic. The vehicle was involved in off-road frontal impacts with a picket fence, utility pole guy wire, and a large diameter [68.6 cm (27.0")] tree. The frontal impact with the tree resulted in severe damage to the Honda Civic, but failed to deploy the vehicle's frontal driver and right front passenger air bag system. The Honda was operated by an unrestrained 24 year old male. The driver loaded the steering assembly during the impact with the tree. This loading resulted in severe deformation of the steering wheel and in multiple internal injures of the abdomen (AIS-5) and thorax (AIS-4). The driver survived these injuries and was hospitalized for 137 days.			
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BACKGROUND

This on-site investigation focused on issues related to the non-deployment of the frontal air bag system in a 1998 Honda Civic. The vehicle was involved in off-road frontal impacts with a picket fence, utility pole guy wire, and a large diameter [68.6 cm (27.0")] tree **(Figure 1)**. The frontal impact with the tree resulted in severe damage to the Honda Civic, **(Figure 2)** but failed to deploy the vehicle's frontal driver and right front passenger air bag system. The Honda was operated by an unrestrained 24 year old male. The driver loaded the steering assembly during the impact with the tree. This loading resulted in severe deformation of the steering wheel and in multiple internal injures of the abdomen (AIS-5) and thorax (AIS-4). The driver survived these injuries and was hospitalized for 137 days.

Figure 1. Impact trajectory of the Honda Civic.

Figure 2. Frontal view of the impact damage to the 1998 Honda Civic.

The crash occurred in October, 1998, during nighttime hours. The investigating officer notified NHTSA of the non-deployment crash on October 21st. The case was subsequently assigned to Calspan's Special Crash Investigation (SCI) team on that same date. Due to a requirement that the vehicle examination be conducted in conjunction with a Technical Specialist from Honda North America and from NHTSA's Office of Defects Investigation (ODI), Calspan scheduled an examination date that was acceptable to all parties and the field investigation portion of this case was completed on October 28th. A private consultant was present to document the vehicle for an attorney who represented the owner of the Honda.

SUMMARY

Crash Site

The crash occurred in a suburban location on a minor arterial roadway with a posted speed limit of 56 km/h (35 mph). The Honda Civic approached the crash site traveling in the first northbound lane of a six lane divided roadway **(Figure 3)**. In the immediate vicinity of the crash site, the roadway transitioned from a

six lane divided configuration to a four lane undivided configuration. In addition, northbound traffic entered and tracked a curve to the left while traversing a slight positive grade. At the time of the crash, it was dark, the weather was clear, the asphalt road surface was dry, and the roadway was lighted.

Figure 3. Profile view of the vehicle's damage pattern.

Pre-Crash Phase

The Honda Civic approached the crash site traveling in a northerly direction in the first northbound travel lane at an estimated travel speed of 72-77 km/h (45-48 mph). The Honda driver who had been drinking, apparently fell asleep as the vehicle entered a transition area and began tracking a curve to the left. The driver relinquished steering control, allowing the vehicle to drift to the right and exit the right edge of the northbound travel lanes at a shallow departure angle (estimated at 3-5 degrees). The Honda traveled approximately 30 m (98') from the point where it exited the roadway to the point of initial impact. During this interval the vehicle crossed the mouth of a roadway which intersected its travel path from the right, crossed a turning apron associated with the intersecting roadway, and then exited the west edge of the turning apron approximately 13 m (42') north of the intersecting roadway.

Crash Phase

The front of the Honda struck and penetrated a wooden picket fence located 0.6 m (2.0') outboard of the west edge of the turning apron **(Figure 4)**. The direction of force for this impact was 12 o'clock. While penetrating through the fence, the Honda sheared off two 10x10 cm (4x4") support posts which anchored the fence. After penetrating through the fence, the center frontal area of the vehicle struck and sheared a utility pole guy wire **(Figure 5)** that was anchored into the ground 1 m (3.3') inside of the fenced area.

Figure 4. Overall view of the crash site.

Figure 5. Struck guy wire and tree.

Following the second impact, the Honda continued in a northerly direction in a tracking altitude for a distance of approximately 7 m (23') where its left frontal area impacted a large tree **(Figure 5)** that was 68.6 cm (27.0") in diameter. The direction of force for this third impact was, again, 12 o'clock. The vehicle's impact speed was computed at 67.8 km/h (42.1 mph). The associated total and longitudinal delta V was computed at 60.0 km/h (37.3 mph). These values were derived using the damage and

trajectory algorithm of the WinSMASH program. This impact induced a counterclockwise rotation in the Honda which rotated off the tree, spinning approximately 180 degrees, and then came to rest approximately 3.5 m (11.4') west of the tree, facing in a southerly direction. The crash schematic is attached as **Figure 11 (Page 12)** of this summary report.

The 24 year old male driver of the subject vehicle was not using the available restraint system. Following the impact with the tree, he moved directly forward. Both of his knees contacted and shattered the intruded mid panel and knee bolster to the left and right of the steering column. His abdomen and chest contacted and severely deformed the steering assembly. The driver's left wrist contacted the upper instrument panel behind the steering wheel and his right hand contacted the upper instrument panel near the center of the vehicle. Following these contacts, the driver rebounded into the seat and then slumped forward.

Post-Crash Phase

The Honda driver remained in his vehicle after the vehicle came to rest. The first police unit responding to this call arrived on scene within five minutes of the crash. This officer reported that the driver was in a semi-conscious state upon his arrival. He noted that the driver was not wearing the available restraint system and that there was a noticeable odor of alcohol within the vehicle. When he asked the driver if he was in pain, the driver pointed to his chest without providing a verbal response.

A rescue unit arrived several minutes after the first police unit. Emergency medical technicians (EMTs) from this unit provided first aid treatment while the driver was being extricated from the vehicle. Recognizing the severity of the driver's injuries, transport procedures were initiated in an expeditious manner. The driver was transported by ambulance to a local hospital located approximately 15 minutes from the crash site where he was admitted for treatment of his injuries. Emergency surgery was performed to repair multiple lacerations and ruptures of abdominal organs. Numerous follow-up surgeries were required. He was subsequently discharged 137 days following the crash.

VEHICLE DATA

The subject vehicle in this case was a 1998 Honda Civic EX, two door coupe. The manufacture date of the vehicle was 9/98 and the vehicle identification number was IHGEJ824XWL (production number deleted). The vehicle was equipped with a front disc/rear drum braking system, a 4 cylinder transverse mounted engine, an automatic transmission with a console mounted transmission selector lever, and frontal air bags for the driver an right front passenger seated positions. The vehicle had been purchased as a new vehicle on September 23, 1998, by the father of the driver. At the time of vehicle inspection, the odometer reading was 2,499 km (1,553 miles).

VEHICLE DAMAGE

The Honda Civic was towed from the scene of the crash and stored in a secure police impound lot. The vehicle was subsequently inspected at that location 11 days after the crash sequence occurred.

Exterior Damage

The exterior damage sustained by the Honda Civic in the crash sequence was severe in nature **(Figure 6)**. Maximum frontal crush was 83.3 cm (32.8") located at the left corner position. Direct contact damage sustained as a result of striking the tree initiated 29.2 cm (11.5") to the left of the vehicle's centerline and extended 44.4 cm (17.5") to the left corner of the vehicle. The field L dimension for the crush envelope was 83.8 cm (33.0") as measured from the left corner to the right. The impact with the tree separated the bumper fascia and the reinforcement bar from the vehicle, therefore the crush profile was documented at the lower radiator support panel. The crush profile for the full crush envelope were measured as follows:

Figure 6. Overhead view of the crush profile.

C_1 = 82.0 cm (32.3")

C_2 = 70.9 cm (27.9")

C_3 = 59.2 cm (23.3")

C_4 = 41.7 cm (16.4")

C_5 = 17.3 cm (6.8")

C_6 = 9.7 cm (3.8")

In addition to the crush dimensions noted above, the left wheelbase dimension was reduced 33 cm (13") and the right wheel base dimension was elongated 2.3 cm (0.9"). The Collision Deformation Classification (CDC) assigned to the tree impact was 12-FLEW-4 and the delta V for this impact was computed by the SMASH program at 60.0 km/h (37.3 mph).

Clearly, the severity level of the left frontal tree impact exceeded the threshold level of air bag deployment and the system should have deployed during the crash sequence. During the vehicle inspection conducted for this effort, Honda representatives were unable to successfully download stored data from the single point diagnostic control unit for the air bag system.

The first fence post impacted by the vehicle crushed the hood face to a depth of approximately 2.5 cm (1.0"). The damage pattern was located 4.4-12.7 cm (1.75-5.0") right the vertical centerline. The second fence post impact and the guy wire contact was masked by the subsequent tree impact damage. The CDC for the fence impact was 12-FZEW-1 while the CDC for the guy wire impact was estimated at 12-FCEN-1. These minor severity impacts did not alter the trajectory, or significantly decelerate the vehicle prior to the tree impact.

Interior Damage

Interior damage to the Honda Civic was rated as moderately severe and was associated with a combination of impact induced deformation and occupant contact. The passenger compartment was reduced in size by intrusion of frontal components which included the windshield, the left upper A-pillar, the instrument panel, the steering assembly, and the toe pan **(Figure 7)**. The A dimension (as measured from the steering wheel hub to the backlight header) was reduced 16.3 cm (6.4"). Other intrusion extents were measured

as follows:

Component	Interior Extent
Left corner of mid-instrument panel	12.2 cm (4.8")
Lower left A-pillar	12.2 cm (4.8")
Upper left A-pillar	12.2 cm (4.8")
Left toe pan	38.1 cm (15.0")
Center mid-instrument panel (@ radio)	15.0 cm (5.9")

Figure 7. Interior damage/driver loading of the steering wheel.

Figure 8. Non-deployed air bag and driver loading of the steering assembly.

Driver contact was noted to the steering assembly and the instrument panel **(Figure 8)**. The driver loaded all aspects of the steering assembly including the rim, spokes, and the air bag module assembly (NOTE: At the time the driver initiated loaded the steering wheel, it was positioned in a straight 12/06 o'clock position, however, due to engagement against the tree, the wheel rotated approximately 260 degrees counterclockwise). The lower rim at the left spokes was deformed 17.8 cm (7.0") forward and the upper rim was deformed 7.6 cm (3.0") forward. The steering column shear capsules were completely separated with 1.8 cm (0.7") of separation noted for the left capsule and 2.8 cm (1.1") of separation noted for the right capsule.

The driver's left knee contacted and shattered the left mid-instrument panel and his lower leg contacted and shattered the knee bolster. His left knee penetrated 15.2 cm (6.0") into the instrument panel substructure. The contact was located 53.3-71.1 cm (21.0-28.0") to the left of the vehicle's centerline and extended from 5.1 cm (2.0") below the top of the instrument panel to 30.5 cm (12.0") below the top of the panel. A similar pattern was noted for his right knee and leg which contacted and shattered the instrument panel to the right of the steering column. This second contact was located 12.7-20.3 cm (5.0-8.0") to the left of the vehicle's centerline and extended from 20.3 cm (8.0") to 30.5 cm (12.0") below the top surface of

the instrument panel.

In addition, two contacts were noted to the upper surface of the instrument panel. The first contact was located behind the deformed upper steering wheel rim and consisted of a tissue transfer imbedded in a gouge on the upper surface of the instrument panel **(Figure 9)**. The contact extended from 49.0-55.9 cm (19.3-22.0") to the left of the vehicle's centerline. The contact point was associated with the driver's left wrist. The second contact to the upper panel surface was located to the right of the steering wheel at the leading edge of the instrument cowl. This contact extended from 8.9-17.3 cm (3.5-6.8") to the left of the vehicle's centerline and consisted of a deformation (compression) of the padded surface. The contact was assigned to the driver's right hand.

Figure 9. Tissue transfer to the upper instrument panel.

Briefly, the Honda driver moved forward following impact with the tree. His knees and lower legs loaded the mid-instrument panel and knee bolster to the left and right of the steering column. His abdomen and thorax loaded the steering wheel. His left wrist contacted the upper surface of the instrument panel behind the deformed upper steering wheel rim and his right hand contacted the upper instrument panel to the right of the steering wheel. As the Honda rotated counterclockwise off the tree impact, the driver initially rebounded into the left front seat back support and then slumped forward where he came to rest.

MANUAL RESTRAINT SYSTEMS

The subject vehicle was equipped with manual 3-point lap and shoulder belts for the front seated positions. These systems utilized a continuous loop belt webbing with dual mode locking retractors. Both front belts incorporated energy management loops. These loops, which were 10.7 cm (4.2") in length, would have added 21.3 cm (8.4") to the belt length (when deployed) providing a ride-down effect to the occupant. The energy management loops and were located 17.3 cm (6.8") above the lower sill anchorage. These loops were concealed within a lower belt sleeve. The energy management loop on the driver's belt system did not exhibit evidence of loading. The upper belt anchorage (D-rings) on both front belts were fixed to the B-pillar and were not adjustable.

No evidence of loading or other stress was noted to the driver's belt system. The investigating officer noted that the driver was semi-conscious when he arrived on scene and was not restrained by the belt system. This assessment was supported by the driver's contact patterns within the vehicle and the lack of loading stress on the belt system.

AUTOMATIC RESTRAINT SYSTEM

The 1998 Honda Civic involved in this crash sequence was equipped with a Supplemental Restraint System (SRS) that consisted of frontal air bag modules for the driver and front right passenger seated positions. It should be noted that although this Honda was a 1998 model year, it was not equipped with redesigned air bags. The system did not deploy as a result of the left frontal impact with a tree even though the delta

V level associated with that impact [60.0 km/h (37.3 mph)], indicated that deployment was warranted.

The driver air bag module was mounted within a 4-spoke steering wheel. The spokes were located at the 9/7 and 3/5 o'clock positions. The air bag was concealed behind H-configuration module cover flaps that were symmetrical with a 13.5 cm (5.3") horizontal tear seam. An identification label on the module assembly provided the following information:

SRS

HJJP7F494

M/D 0998

6040 P

77800-S01-A700

The passenger air bag module was a top mount design which incorporated a single flap that opened upward toward the windshield. The module flap was measured at 34.9 cm (13.8") laterally and 16.0 cm (6.3") longitudinally. The module tag for this assembly provided the following information:

PJJ7B7420 J01

SRS M/D 0998

PS01AC14 7

6040

77850-S01-A800

The single point diagnostic control unit for the air bag system was located at the forward aspect of the center console. The unit was installed in a horizontal orientation and was accessed from the right side panel of the console. The module tag for this unit provided the following information:

SRS Model# 77960-S02A830-M3

SRS unit

5K4321 A CJJA6BWYE 33/98

When power was supplied to the vehicle during the inspection, the ignition key was turned to the on-position and the SRS indicator lamp came on and stayed on. Normally, this indicator lamp should light for seven seconds and then go out as the diagnostic cycle is completed. The Honda representative connected the diagnostic scan tool (Honda PGM Tester) to the SRS control unit to test for stored fault or trouble codes. He was unsuccessful in his attempts to download data from the control unit. The test unit used to interrogate the control unit repeatedly showed 16 lines of 0 codes indicating that the test unit was not communicating properly with the control unit.

A second test procedure was initiated which involved plugging a jumper wire into the service check connector for the SRS. With the wire in place, a flash code of 2-1 was displayed through the SRS indicator light. The code indicated the front passenger air bag circuit was open. No additional data could be extracted from the system.

The Honda representative noted that the he could remove the SRS control unit from the vehicle and return it to Honda where a bench test could be performed to read the stored codes. Attorneys representing the driver's father (vehicle owner) declined to allow the unit to be removed from the vehicle and placed in Honda's possession. Honda council declined to allow a non-neutral party to maintain possession of the control unit, therefore the unit remains in the vehicle with no plan to test the unit and determine the root cause of the non-deployment.

DRIVER DEMOGRAPHICS

Age/Sex:	24 year old male
Height:	172.7 cm (68.0")
Weight:	62.6 kg (139.0 lbs)
Manual Restraint Usage:	None, 3-point lap and shoulder belt was available
Usage Source:	Vehicle inspection, observations of on-scene emergency personnel
Eyeware:	Unknown
Vehicle Familiarity:	Unknown
Route Familiarity:	Unknown

DRIVER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Large blow-out lesion (rupture) at the second and beginning of the third portion of the duodenum	Critical (541028.5,7)	Steering wheel rim
Large blow-out lesion (rupture) of the hepatic flexure of the colon and transverse colon	Severe (540826.4,8)	Steering wheel rim
Large Grade IV laceration of the right lobe of the liver which extended from the gallbladder fossa to near the level of the inferior vena cava	Severe (541826.4,1)	Steering wheel rim
Near complete transection of the head of the pancreas at thwe right side of the mesenteric vessels	Severe (542830.4,7)	Steering wheel rim
Intimal tear of the thoracic aorta	Severe (420202.4,4)	Steering wheel hub/air bag module assembly
Large rent in the right hepatic vein	Serious (521602.3,1)	Steering wheel rim
Contained right perinephric hematoma	Moderate (541699.2,1), *{defaulted to a kidney contusion NFS as no other code applies}*	Steering wheel rim
Small tear at the capsule of the spleen at the level of the inferior pole	Moderate (544222.2,2)	Steering wheel rim
Hemoperitoneum, 11cc	Not coded under AIS 90	Steering wheel rim

Injury	Injury Severity (AIS 90)	Injury Mechanism
Lateral fractures of right ribs 2-4 with pulmonary edema	Moderate (450220.2,1)	Steering wheel hub/air bag module
Extensive scalp edema consistent with anasarca	Minor (190402.1,9)	Impact force
Gallbladder injury, surgically removed (not further specified)	Moderate (541299.2,7)	Steering wheel rim
Small laceration of the lower lip	Minor (290602.1,8)	Self inflicted (probable)
Abrasion right groin	Minor (590202.1,8)	Steering wheel rim
Abrasion right thigh	Minor (890202.1,1)	Knee bolster panel/instrument panel substructure
Laceration (NFS) with abrasion over left knee	Minor (890600.1,2; 890202.1,2)	Knee bolster panel/instrument panel substructure
Laceration (NFS) with abrasion over the left wrist	Minor (790600.1,2; 790202.1,2)	Left upper instrument panel

DRIVER KINEMATICS

The driver was probably seated in an normal driving posture with both hands on the steering wheel. Since he apparently fell asleep and allowed the vehicle to exit the right edge of the roadway, his head may have slumped forward or to either side. At the time of vehicle inspection, the driver's seat track was adjusted to a position that was 5.8 cm (2.3") forward of the full rear position and 18.0 cm (7.1") rearward of the full forward position. The driver did not use the available restraint system.

It is likely that the Honda driver began moving forward as a result of the two initial impacts with the fence and the guy wire. It is also likely that these two closely spaced impacts woke the driver. Following the left frontal impact with the tree, he moved directly forward **(Figure 10)**. His knees and lower legs impacted and penetrated the mid-instrument panel and knee bolster to the left and right of the steering column. These contacts resulted in a laceration with abrasion over the left knee and an abrasion to the left thigh.

Figure 10. Overall view of the driver's trajectory and contact points.

The lack of restraint usage and the penetration of the knees allowed the driver to partially submarine the steering assembly as he began to load the wheel rim with his abdomen and thorax. The abdominal loading to the lower steering wheel rim produced 17.8 cm (7.0") of forward rim deformation at the left spokes. As a result of the wheel rim

loading, the driver sustained an abrasion over the right groin, ruptures of the duodenum and colon, large Grade IV laceration of the right lobe of the liver, a near transection of the head of the pancreas, a large rent of the right hepatic vein, a contained right perinephric hematoma, hemoperitoneum, a tear of the capsule of the spleen, and a gallbladder injury. His chest loaded the non-deployed air bag module and upper steering wheel rim which deformed the upper rim to a depth of 7.6 cm (3.0"). This contact sequence produced lateral fractures of the right 2-4 ribs with pulmonary edema, and an intimal tear of the thoracic aorta. The driver's head traveled over the steering assembly without direct impact to the windshield or the left A-pillar. The impact force associated with his trajectory resulted in extensive scalp edema an a probable self-inflicted laceration of the lower lip. His left hand separated from the steering wheel rim which allowed his left wrist to contact the top surface of the instrument panel forward of the steering wheel. This contact produced a large tissue transfer to the upper panel and a laceration with abrasion to the wrist. As the vehicle rotated off the tree, the driver rebounded into the left front seat back support and then slumped forward.

The investigating officer reported that when he arrived on scene, the driver was semi-conscious and appeared to lapse in and out of consciousness during the time interval he remained at the scene. A rescue unit arrived on scene several minutes after the first police unit. The left front door was pried opened and EMTs began administering first aid treatment. Extrication procedures were initiated in an expeditious manner and the driver was transported to a local hospital located approximately 15 minutes from the scene. He was admitted for treatment of his injuries and released 137 days following the October crash.

CONCLUSIONS

1. The 1998 Honda Civic was equipped with frontal air bags for the driver and right passenger positions. The vehicle was involved in a severe frontal impact sequence with a tree that resulted in a longitudinal velocity change of 60.0 km/h (37.3 mph). This 12 o'clock direction of force impact should have deployed the frontal air bag system. There was an apparent malfunction in the air bag system that prevented deployment. Due to the lack of complete diagnostic analysis of the air bag system, the root cause of the failed deployment remains unknown.

2. Although the driver was not restrained by the available lap and shoulder belt system, the deployed driver air bag may have provided the driver with sufficient restraint to reduce his loading force against the steering assembly, and possibly reducing the severity of his injuries.

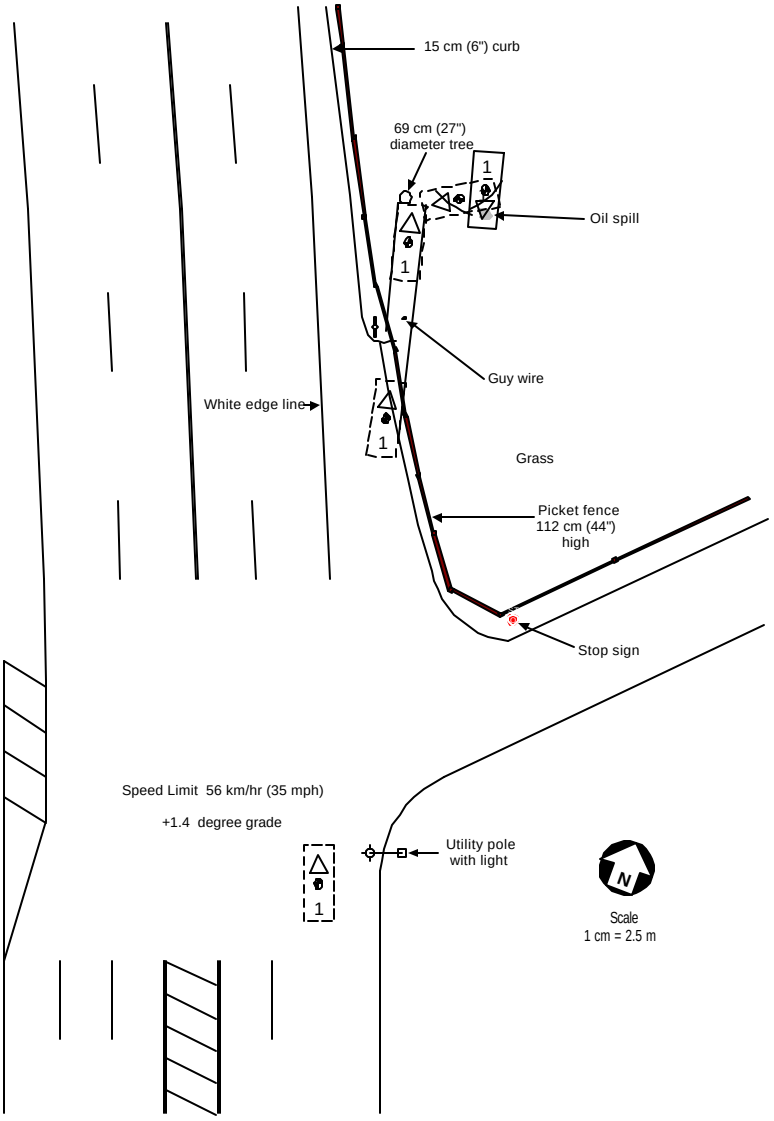

Figure 11. Crash Schematic