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Forensic Engineering Investigation of a Three-Vehicle Accident

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Abstract

An accident involving three vehicles resulted in serious injuries to one of the drivers. It was alleged that the driver was injured because both of the other operators were inattentive and made driving errors. Through the use of electronic data retrieval and computer crash simulation, it was shown that only one of the non-injured drivers made a driving error.

A computer-aided dynamic crash simulation program (PC-Crash) was used to show the motion of the vehicles after impact. Because no formal police report was completed for the accident, electronic data retrieval and computer-aided engineering methods were needed to fill in the data voids. Witness statements, in conjunction with the reconstructed data, allowed a better understanding of the mechanisms involved in both the primary and secondary collisions.

Keywords

Forensic engineering, accident reconstruction, EDR, crash simulation, distracted driving, perception reaction time

Introduction

The accident involved three vehicles and two related crashes. Only one driver was seriously injured. The attorney for the injured driver initially brought suit against the other two parties involved. Subsequently, accident reconstructions were needed to determine causative factors and discover the mechanisms of the accident. Experts were hired by two of the three involved parties. Vehicle position, speed, and trajectory were needed for all three vehicles to properly reconstruct the physics of the accident. Fortunately, two of the three involved vehicles were preserved and had airbag sensing and diagnostic module (SDM) or electronic control unit (ECU) data available for download. Unfortunately, no substantive police report or scene photos were available, and one of the vehicles was disposed of prior to the initiation of legal proceedings.

Accident Location

The crash occurred on a four-lane state highway with a two-way center left turning lane. The highway was straight in the vicinity of the accident with clear sight lines along the highway in both directions of travel. Entrance sight lines from side roads, businesses, and residences varied from very good

to obstructed. Roadway conditions were dry. The accident occurred during the daytime in a 45 mph to 55 mph transition regulatory speed zone southbound and a 55 mph to 45 mph transition regulatory speed zone northbound. Businesses and a few residences were located on both sides of the highway, which consisted of two 12-foot-wide travel lanes and a 4-foot-wide outside shoulder in each direction separated by a 12-foot center two-way left turning lane. **Figure 1** shows the highway looking in the northbound direction.



Figure 1
NY Route 78 looking northbound.

Description of Accident

The driver of a silver 2000 Saturn was pulling out of a modular home residence (The Woodlands – shown in **Figure 1**) and collided with a black 2011 Toyota Camry traveling northbound in the right travel lane on NY State Route 78. As a result of the collision, the Toyota Camry crossed the left northbound lane as well as the center two-way left turning lane and was involved in a subsequent impact with a black 2008 Chevrolet Impala traveling in the southbound left travel lane. During the first collision, the forensic engineer determined from photographic evidence and vehicle inspections that the Saturn’s front bumper contacted the right front wheel of the Camry. During the subsequent impact, the Camry and Impala met essentially head-on, involving the full-frontal widths of the Camry and Impala.

There were three witnesses — all in moving vehicles, each of whom had slightly different information to supply to the investigation. Witness A said that the Impala driver appeared to be texting and was not paying attention to the road in front of her vehicle. Witness B said the second collision happened so quickly after the first that the driver of the Impala “didn’t stand a chance.” Witness C said that he saw the Camry going southbound after the first collision.

In addition, the involved drivers had different accounts of the accident. The driver of the Saturn said the Camry “came out of nowhere” and was traveling very fast. The Camry driver said she saw the Saturn pulling out to make a left-hand turn to go southbound and slowed down,

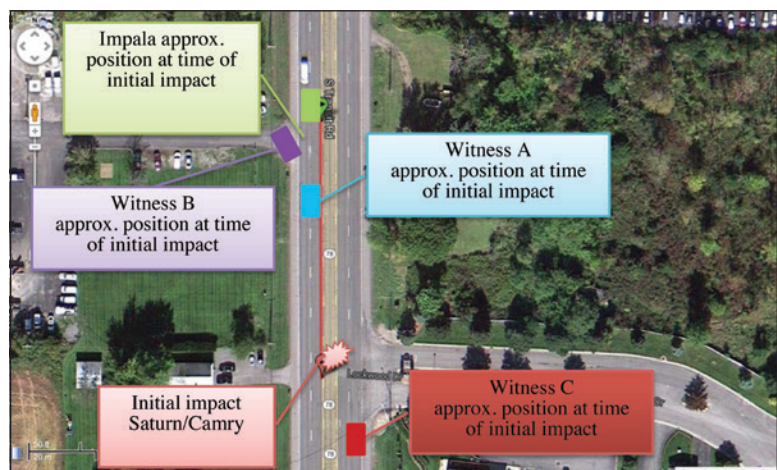


Figure 2
Vehicle and witness positions prior to the first collision.¹

veering to the left to avoid a collision. The driver of the Impala said she never saw the Camry before the second collision. The driver of the Camry said she saw the Impala driver looking right at her just before the second impact. **Figure 2** indicates vehicle and witness positions prior to the first collision.

Evidence Available for Review

The following items were available for engineering review:

- Basic police accident report, New York Form MV104
- Bosch crash data retrieval (CDR) downloads from the Impala and Camry
- Physical vehicle inspection of Camry and Impala
- Witness statements, depositions, and affidavits
- Driver statements and depositions (all three drivers)
- Several photos of the damaged Saturn
- Cell phone records from the Impala driver

The police accident report was very basic; it did not include any photos and contained only a simple sketch of the first collision.

The Impala and Camry were physically inspected, and the Bosch CDR system (versions 4.3 and 5.0, respectively) was used to download data recorded in the Impala's SDM and the Camry's airbag ECU. These devices contained information about each vehicle's speed, seat belt usage, and brake/throttle positions leading up to the time of the collisions. The Saturn vehicle was not available for inspection or download.

The Impala SDM download revealed the following information that was used in the reconstruction. Much of the data was used during the simulation process using PC-Crash². Ranging is used to acknowledge the error band inherent in SDM data due to various factors, such as tire wear, tire slip, analog to digital conversion, etc.³

- Longitudinal Delta V was approximately 36 mph.
- Lateral Delta V was approximately 8 mph.
- Principal direction of force (PDOF) was between 11 and 12 o'clock.
- Approximate vehicle speed 2.5 seconds prior to crash = 55 to 61 mph.
- Approximate vehicle speed 2.0 seconds prior to crash = 55 to 61 mph.
- Approximate vehicle speed 1.5 seconds prior to crash = 55 to 61 mph.
- Approximate vehicle speed 1.0 seconds prior to crash = 54 to 60 mph.

- Approximate vehicle speed 0.5 seconds prior to crash = 54 to 60 mph.
- Accelerator pedal position 2.5 seconds prior to crash was approximately 19% depressed.
- Accelerator pedal position 2.0 seconds prior to crash was approximately 12% depressed.
- Accelerator pedal position 1.5 seconds prior to crash was not depressed.
- Accelerator pedal position 1.0 seconds prior to crash was approximately 7% depressed.
- Accelerator pedal position 0.5 seconds prior to crash was not depressed.

The Camry ECU download revealed the following significant information that was used in the reconstruction. Much of the data was used during the simulation process using PC-Crash. Again, ranging is used to acknowledge the error band inherent in SDM data due to various factors, such as tire wear, tire slip, analog to digital conversion, etc.³

- Elapsed time between initial and subsequent impacts was 2.1 (+/- 0.05) seconds.
- Longitudinal Delta V for initial impact was approximately 5 mph.
- Lateral Delta V for first impact was approximately 5 mph.
- PDOF for first impact was between 1 and 2 o'clock.
- Approximate vehicle speed 4.6 seconds prior to first impact = 52 to 58 mph, no brake.
- Approximate vehicle speed 3.6 seconds prior to first impact = 50 to 56 mph, no brake.
- Approximate vehicle speed 2.6 seconds prior to first impact = 50 to 56 mph, no brake.
- Approximate vehicle speed 1.6 seconds prior to first impact = 50 to 56 mph, no brake.
- Approximate vehicle speed 0.6 seconds prior to first impact = 49 to 55 mph, braking.
- Approximate vehicle speed around initial impact = 37 to 43 mph, braking.
- Longitudinal Delta V for subsequent impact was around 35 mph.
- Lateral Delta V for subsequent impact was around 3.5 mph.
- PDOF for subsequent impact was near 12 o'clock.
- Approximate vehicle speed 4.7 seconds prior to second impact = 50 to 56 mph, no brake.
- Approximate vehicle speed 3.7 seconds prior to second impact = 50 to 56 mph, no brake.
- Approximate vehicle speed 2.7 seconds prior to second impact = 49 to 55 mph, braking.
- Approximate vehicle speed 1.7 seconds prior to second impact = 26 to 32 mph, braking (speed reduced significantly by initial impact).
- Approximate vehicle speed 0.7 seconds prior to second impact = 19 to 25 mph, braking.
- Approximate vehicle speed around subsequent impact = 12 to 18 mph, braking.

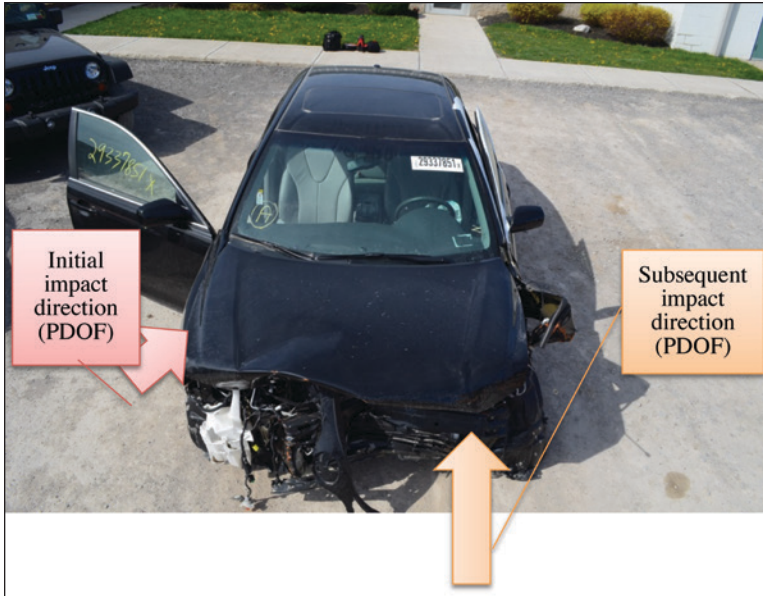


Figure 3
Damage to Camry.



Figure 4
Damage to Impala.



Figure 5
Damaged Saturn (note wheel mark on bumper).

A physical inspection of the Camry indicated significant crush damage to the front of the vehicle. Damage at the front right corner of the vehicle indicated that the initial impact with the Saturn was focused at this location. The Camry was first impacted by the Saturn at a 1 to 2 o'clock position. The physical crush found in the vehicle inspection for the initial impact is consistent with the airbag ECU data PDOF information. The relatively uniform crush along the remaining portion of the front of the vehicle also agreed well with airbag ECU data PDOF information. In other words, the subsequent impact with the Impala was at the 12 o'clock position relative to the Camry. **Figure 3** indicates the Camry damage and PDOF.

A physical inspection of the Impala indicated significant crush damage at the front left corner of the vehicle. This indicated, by this forensic engineer's judgment, an impact that was from the 11 to 12 o'clock position relative to the Impala. This correlated well with the airbag SDM data collected from the Impala. The SDM data provided lateral and longitudinal accelerations that were used to calculate the PDOF directions. Inside the vehicle, it appeared as though a liquid (perhaps coffee) was splashed about the front seating area and dashboard. **Figure 4** provides vehicle damage and PDOF for the Impala.

Photos of the Saturn indicate tire contact with the front bumper. **Figure 5** shows the damaged Saturn.

Using PC-Crash and airbag ECU, data locations and orientations for the initial and subsequent impacts were estimated. **Figures 6 and 7** provide these locations and orientations.

In reviewing the witness statements, depositions, and affidavits, the following key information was collected:

From Witness A (male):

- Witness A was driving a 2011 GMC Terrain SUV.
- He passed the Impala on the right and pulled in front of it after passing.
- While passing, he claimed he saw the driver's head down, allegedly texting.
- In his first affidavit, he claimed that the driver looked at him as he was passing – “I noticed her glance up to look straight ahead for a brief moment, then look down at her lap area again, and then look at me on her right as I passed her.”

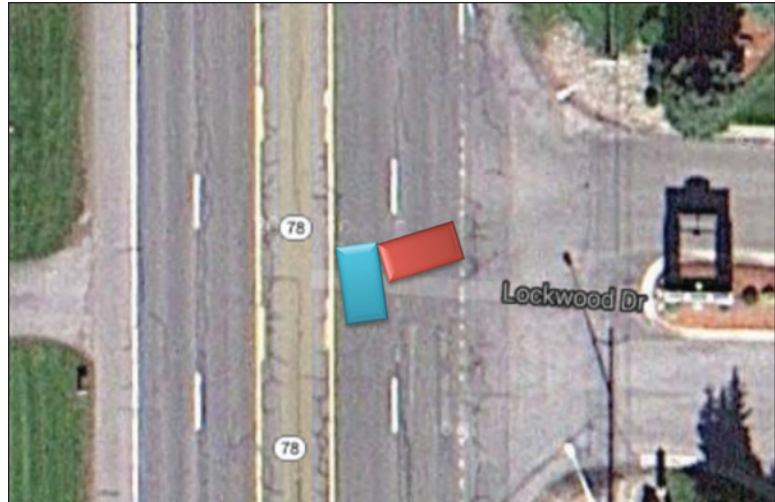


Figure 6

Determined probable location and orientation of the Saturn (red) and Camry (blue) during the initial impact.



Figure 7

Determined probable location and orientation of the Camry (blue) and Impala (green) vehicles at the subsequent impact (from PC-Crash simulation and airbag ECU data).

- In his prior statements to investigators, he claimed that “it appeared that it looked like she was maybe texting and looking down, but that’s not a 100 percent...”
- In his second affidavit, the witness modified his statement, again saying, “My observations as I passed the operator of the black Impala were very brief and only limited to her at times looking down or at me.”
- Witness A mentioned that he witnessed the first impact between Saturn and Camry “split seconds” after pulling in front of the Impala. He further mentioned that perhaps his SUV blocked the view of the first impact from the driver of the Impala.
- He said that nothing the driver of the Impala could have done would have avoided the accident.
- He also claimed that he was maybe 30 yards in front of the Impala at the time of the second impact.

From Witness B (male):

- He mentioned that he had just pulled out of a bowling lane parking lot when the second impact occurred.
- He mentioned that it would have been impossible for the driver of the Impala to avoid the accident.

From Witness C (male):

- The Camry was southbound. (The statements made by this witness regarding the Camry being southbound on NY Route 78 did not agree with the physics of the accident nor other witness statements.)
- Witness C said that the driver of the Impala "... was pretty much defenseless in the whole accident."

Cell phone records pulled by the cellular carrier for the driver of the Impala indicated that the driver was making a cellular call within approximately 0 to 5 minutes prior to the accident. The route stated by the driver did pass several lights, so it is possible that the phone was being used while the vehicle was not in motion. The driver stated that she was not using her phone at the time of the second impact; however, there was no way to verify this statement. There was a claim made by the opposition that the use of a cell phone impaired the driver's ability to react to the Camry. In the opinion of this author, it was unclear whether or not a cell phone was being used at the time of collision.

Driver Perception and Reaction Time

Perception and response (PRT) generally takes place in four steps: detection, identification, decision, and response. Under normal conditions, 85% of drivers complete the PRT cycle in less than 1.5 seconds⁴. However, Olson⁵ has concluded that there are many things that can affect PRT, one of which is expectancy. In the case of a surprise situation, such as a car moving through a center two-way left turning lane and entering oncoming traffic, it may take significantly longer for a driver to perceive and react to the situation.⁴ In addition, if a driver is checking mirrors or is distracted by a vehicle passing on the right, PRT may be lengthened by as much as 1 second per mirror glance.⁵ In this accident, it would not be unexpected for the "normal" 1.5 second time to be exceeded. If the driver of the Impala had glanced at a single mirror — or been distracted by the vehicle passing on the right — her PRT could have been at least 2.5 seconds.

Forensic Engineering Reconstruction

The downloaded vehicle airbag data, the results of the physical vehicle inspections, witness statements, and human factors were used — along with generally accepted engineering principles and PC-Crash simulation software — to establish an accident reconstruction of the collision event. The following main points summarize the reconstruction:

- Both the Camry and the Impala were traveling at or about the posted roadway speed limit (determined from airbag data).
- The Saturn entered the Camry's travel lane from a driveway access, and the Camry driver had insufficient time to avoid a collision and impacted the Saturn (determined from witness and driver statements).
- The Impala was approximately 253 feet away from the location of the initial impact between the Camry and Saturn when the initial impact occurred (determined from PC-Crash and kinematic calculations).
- After colliding with the Saturn, the Camry proceeded to subsequently travel through the center two-way left turning lane into the southbound oncoming traffic. The Camry traveled approximately 78 feet (2.1 seconds) between the initial impact and the subsequent impact (determined from airbag data, PC-Crash, and kinematic calculations).
- The total distance traveled by the Impala between the time of the initial impact (between the Camry and Saturn) and when it collided with the Camry was approximately 175 feet (determined from PC-Crash and kinematic calculations).
- The Impala had just been passed by Witness A, who had immediately pulled to the left directly in front of the Impala. The potential exists that the Impala driver's view of the initial impact was obscured or partially obscured by Witness A's SUV. If the view of the initial impact was obstructed, the driver of the Impala would have had less time to react (determined from driver and witness statements).
- At the time of the initial impact, Witness B was waiting to pull out onto NY State Route 78. He was to the right of the Impala and may have created a distraction for the Impala driver, potentially contributing to a delayed reaction by the Impala driver not observing the initial impact between the Saturn and Camry (determined from driver and witness statements).
- PRT could have been at least 2.5 seconds for the Impala driver. Because only 2.1 seconds elapsed between the time of the initial and subsequent impacts, if PRT was 2.5 seconds (or more), there would not have been enough time for the Impala driver to do anything that would have caused her to miss or mitigate the severity of the collision. Data retrieved from the Impala indicated that the driver had taken her foot off of the accelerator approximately 0.5 seconds before impact but had not yet applied the brakes (determined from PRT evaluation and airbag data).

Several "what-if" scenarios were explored conceptually:

- What if the Saturn driver saw the Camry and did not enter the roadway?
 - No accident would have occurred.

- What if the Camry driver was able to swerve around the Saturn?
 - If the Camry driver maintained control of the vehicle, no impact would have occurred.
 - If Camry control was lost, the accident could have involved more or less vehicles with more or less severity — but specific scenarios would be difficult to predict.
- What if the Impala driver observed the first impact just as it occurred? Total PRT (normally) would be around 1.5 seconds.
 - She would have had $2.1 - 1.5 = 0.6$ seconds to exert a change.
 - She may have quickly steered to the right, potentially striking the vehicle of Witness B, who was waiting to enter the roadway from the right.
 - She may have quickly steered to the left, potentially causing the Camry vehicle to strike her vehicle in a more “broad-side” orientation or striking yet another vehicle not previously involved.
 - With full braking, she could potentially have reduced her speed by approximately 4 mph. With a 4 mph reduction in speed, the impact would have still occurred at nearly the same severity level.

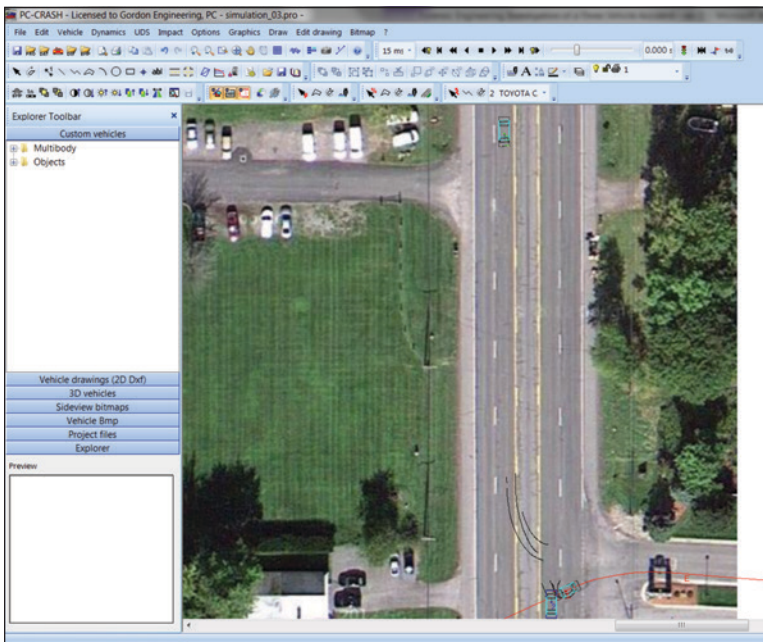


Figure 8
Screen shot of PC-Crash simulation.²

Using data obtained by airbag SDM and ECU downloads, along with witness statements, a 3D computer simulation was created using PC-Crash. The simulation shows that the Camry would not have spun after the initial impact but would have been pushed off-course, resulting in a trajectory that would have taken the Camry through the center left-hand turning lane and into the oncoming Impala. It was determined there was enough spacing for the Camry to miss Witness A’s SUV and strike the Impala. Through the simulation, it was also determined that the driver of the Camry was probably trying to move her vehicle back into the

northbound lanes (a steering input was required in PC-Crash) when the subsequent impact occurred. **Figure 8** represents a screen shot of the crash simulation using PC-Crash.

Conclusions

- If the Saturn driver would have observed the Camry and not entered the roadway until the traffic lanes were clear, the accident sequence would not have happened.
- If the Camry driver could have avoided the Saturn, there would have been no first accident.
- The Impala driver could not avoid the subsequent impact with the Camry once the initial impact with the Saturn occurred.
- The Impala driver did not have any probable safer options available to avoid impact with the Camry.

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