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Forensic Engineering Investigation of a Police Shooting

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Abstract

In the line of duty, it is sometimes the unfortunate circumstance that a police officer must fire a weapon at a suspect. Occasionally, evidence demonstrates that the shot suspect is not the perpetrator and the issue of why such force was utilized comes into question. This paper analyzes an incident involving a group of police officers as they fired into a vehicle being driven by a person suspected of firing a gun in a downtown nightclub district. The lack of a weapon on the suspect and evidence later discovered indicated that the actual shooter was someone else. Civil litigation on behalf of the estate of the deceased suspect ensued. The officers involved all provided similar statements as to the rationale for the shooting, claiming that the suspect placed his vehicle in neutral and depressed the accelerator to perform a "jack rabbit" start by placing the vehicle in the drive gear with the engine revved. According to the officers, this was perceived as the use of the vehicle as a deadly weapon and they feared for their own lives as well as the lives of their comrades. This author was hired by the plaintiffs and tasked with determining when key events occurred in time and whether the physical evidence lent credibility to the officer's claim that the driver was attempting to perform a "jack rabbit" start. A line of sight study was also requested to determine if the gear shifter could be seen by someone standing in front of the suspect vehicle. This case was filed in federal court in Texas and a formal report was issued and the author's deposition taken. The case settled favorably for the plaintiffs following the deposition of the author.

Key Words

Police shooting; dash cam; video analysis; electronic data recorder; line of sight; airbag; audio analysis, accident reconstruction

Background

This event occurred in a downtown nightclub district very near the time at which the serving of alcohol had to cease by law. The streets were crowded with patrons who were leaving the bars. Several police officers, including the four defendants in this case, had been dispatched to the area to control the crowds leaving the bars and disrupt several fights which had occurred. As the officers were performing their duties several shots were heard coming from the vicinity of a night club on the south east side of the district. Just south of this night club was a vacant lot used by the night club for parking. As more shots were fired, it was suspected that the shooter or shooters were in the parking lot. The parking lot was bordered on the north and south sides by buildings. Vehicles utilizing the lot parked facing the buildings. The center of the lot was used for traffic.

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Officer 1 entered the lot alone to investigate and to protect bystanders. He continued to hear gunfire and see muzzle flash, but could not determine its origin. Officer 1 saw a black sport utility vehicle (SUV) facing east and stopped in the center of the parking lot. As officer 1 was approaching the SUV from the rear, the driver began driving in reverse, necessitating that the officer sidestep to the right to avoid being struck. The SUV clipped his ballistic vest, rotating him. The officer responded by striking the right rear cargo window of the SUV with the butt of his duty weapon, possibly breaking it. Officer 1 followed the SUV toward the street shouting commands for the SUV to stop.

Officer 2 independently entered the parking lot on the north side and stayed close to the south wall of the night club. He crouched next to a vehicle and encountered a few females crawling to safety. The females informed Officer 2 that the shooter was in the "Black Suburban." Officer 2 spotted the black SUV (not a Chevrolet Suburban, but a Suburban-like vehicle) and believed he had seen muzzle flashes coming from its vicinity. As he saw the SUV drive in reverse toward the street, he ran back toward other officers in the street shouting to them that the shooter was in the black SUV. The relative locations of Officers 1 and 2 are depicted in figure 1.

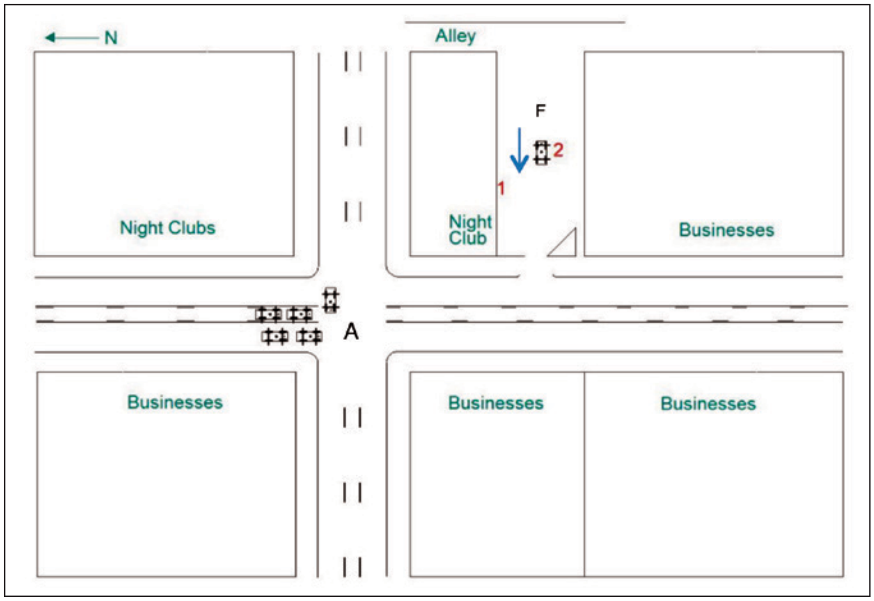

Figure 1
Depicts the initial locations of Officers 1 and 2 relative to the SUV prior to the shooting. The vehicles in the area, "A," are parked police vehicles which point in the vicinity of the "A." The "F" in the image corresponds to the front of the SUV and the arrow depicts the direction of travel.

The black SUV drove rearward onto the roadway and performed a "j" turn by backing out to the south, as if to drive to the north. As the SUV did so, it drove past Officer 3 who saw the damaged right rear window and believed it may have been the result of shots being fired from within.

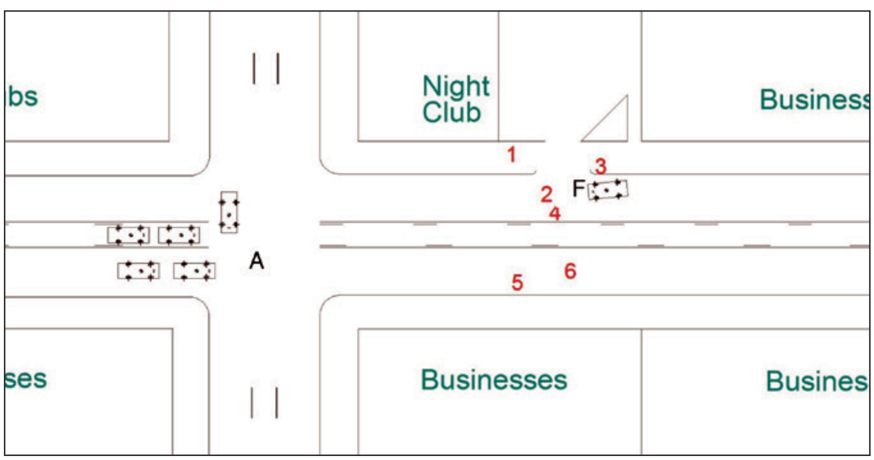

Figure 2
Depicts the relative locations of the officers and the SUV prior to shooting. It also shows the line of police cars blocking the roadway to the north. The SUV has backed out of the parking lot and is facing the police cars. The vehicles in the area, "A," are parked police vehicles which point in the vicinity of the "A." The "F" in the image corresponds to the front of the SUV. In this image, the SUV has backed out of the parking lot and stopped.

Officer 4 was in the roadway when the SUV pulled out of the parking lot and was reportedly almost struck. Officer 4 also believed the right rear window to have been shot out. All of the officers on the scene heard Officer 2 shout that the shooter was in the "Suburban," so focus was given to the SUV. Figure 2 shows the approximate locations of each of the officers after the SUV came to a stop.

After the SUV began to move forward again, Officers 1 and 4, who were in front of the vehicle, reportedly feared for their lives and began firing at the driver. Officers 3 and 5 did not know if the shots were coming from officers or from the suspects, so they also fired at the SUV. All of the officers claimed that the SUV accelerated rapidly toward them. Officers 2, 4, 5 and 6 all testified that the vehicle sounded as if the driver was revving the engine with full throttle before moving the gear into drive to perform a rapid "jack rabbit" start. Officer 5 testified to seeing the rear tires "smoke" and Officer 6 testified to hearing the rear tires "squeal," but this was not corroborated by and, in one case, was contradicted by the other officer's versions.

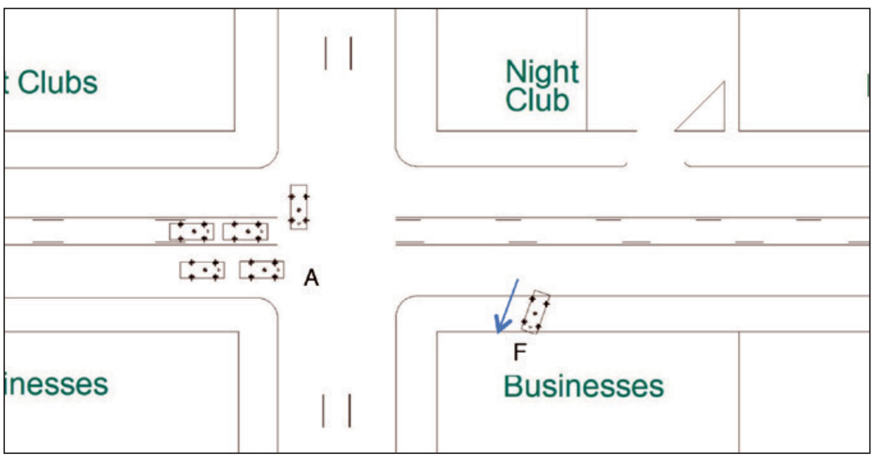

Figure 3
Depicts the final rest location of the SUV after it struck a building across the street. The front of the SUV actually struck a corner of a column in the storefront. The vehicles in the area, "A," are parked police vehicles which point in the vicinity of the "A." The "F" in the image corresponds to the front of the SUV and the arrow depicts the direction of travel.

As the SUV moved forward, the officers collectively fired 40 times. As the driver lost the ability to control the vehicle, it rolled westward across the street and impacted a column on the front of a building. Figure 3 shows the final rest location of the SUV. These events and officer locations were determined from official police investigation files and deposition transcripts of the officers at the scene.

The driver of the SUV succumbed to his injuries later that evening. No evidence was found which could tie the passengers of the SUV to the shootings. Another officer at the scene, but not involved in the shooting, witnessed a suspect in the parking lot toss a gun under a vehicle. The gun was warm and matched shell casings found at the scene. He was also wearing a red shirt, which, until the focus was turned to the black SUV, was the description of the shooter which was broadcast over the police radios. The decedent's survivors filed civil charges against the officers who fired their weapons.

Preface

Plaintiffs in this case questioned the veracity of the claim that the suspect driver attempted a "jack rabbit" start. They requested a timeline of events which were seen in video recorded by a dash cam recorder from the police vehicle parked on the northwest corner of the intersection. According to Officer 4, he and the driver were staring at each other prior to the SUV moving forward. He claimed to see some activity which he believed was the driver moving the gearshift in a manner consistent with a "jack rabbit" start. Therefore, a line of sight study was also requested.

Prior to analysis, this author was allowed to inspect the subject SUV at a police evidence holding facility and inspect and map the incident scene. Dash cam video which recorded the incident from a police vehicle on the northwest corner of the intersection was provided. Dash cam video from a police vehicle parked facing away from the incident was also available. The data from the SUV's electronic data recorder was downloaded for analysis. The deposition transcripts of all officers at the scene were reviewed prior to analysis.

Line of Sight Analysis

During inspection of the SUV a laser inclinometer was used to place an accurate straight line between the top of the steering column mounted gear shift and the dash. A finger diameter allowance of 1 inch was added to the measurements to account for the thickness of the driver's fingers. The height of the laser dots on the wall of the facility were marked and measured to further validate the measurements. The presence of the laser dots on the wall allowed multiple measurements to be taken which accounted for all possible viewing locations in front of the SUV. Measurements of the dash, steering column and vehicle interior were also taken.

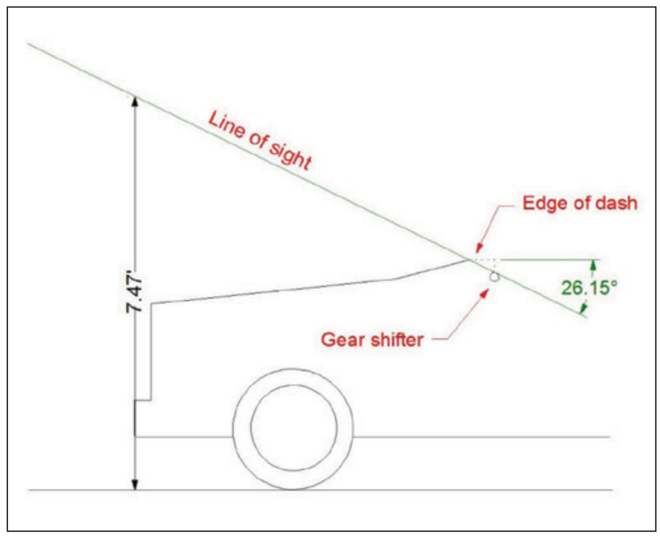

Figure 4
Results of the line of sight analysis.

The gear shifter's highest position was park, followed in descending order with reverse, neutral and drive. Since the SUV had just completed a maneuver in reverse gear, the height of that gear shift position was the most conservative and realistic and was used for analysis. Considering all of the measurements taken, the most conservative measurement revealed that a person standing at the front bumper of the SUV must have an eye height of 7.5 feet in order for that person to see a one inch diameter finger wrapped around the gearshift handle (figure 4). This does not preclude someone

Photograph 1
The gear shifter in "Reverse" position.

standing in front of the vehicle from seeing the driver's shoulder move, but an onlooker's interpretation of shoulder movement is much more subjective than being able to actually see the motions and locations of the gear shifter.

Timing Analysis

The events which transpired during this incident were recorded in various ways and varying degrees by electronic recording devices. These devices include a dash cam video of the incident, a dash cam video which only recorded the sounds of the gun shots, and the SUV's electronic data recorder (EDR). This data was analyzed to provide a sequence of events which ties together the video data, the EDR data and witness statements.

In the dash cam video that recorded the events, the SUV can be seen backing out of the parking lot and onto the roadway. The moment at which the SUV's tail lamp can be seen in the video was taken to be time zero and all other times were reported relative to this. The data from the dash cam was enhanced to remove glare. The frame rate of the video was 30 frames per second which provides 1 still image every 1/30 sec. Time between events was determined by counting the number of frames between events.

After the emergence of the SUV into the video, the first point of interest was the amount of time it took for the SUV to come to a stop. As the SUV backed into its "j" turn, the headlamps were followed frame by frame to determine when motion ceased. This was done by extracting individual and sequential frames from the video and placing them into a layered format. In this case, Adobe Photoshop was used. Once the layers were imported and time stamped, a series of frames in which the left headlamp was at rest was found. A horizontal guide was placed over the image at the edge of the headlamp. Motion is detected when the light moves toward or away from the guide. It is very important to verify motion for a series of frames before drawing a conclusion. The light in this video was very dynamic, because of the blinking red traffic signals and the multitude of police vehicle strobe lamps. False positives can occur when a person or object moves near the light source, such that it is partially obscured, but the obscuring object is not visible. Hence the need for multiple frames of motion to verify that what is detected is actually motion and not an artifact. Figure 5 illustrates the method.

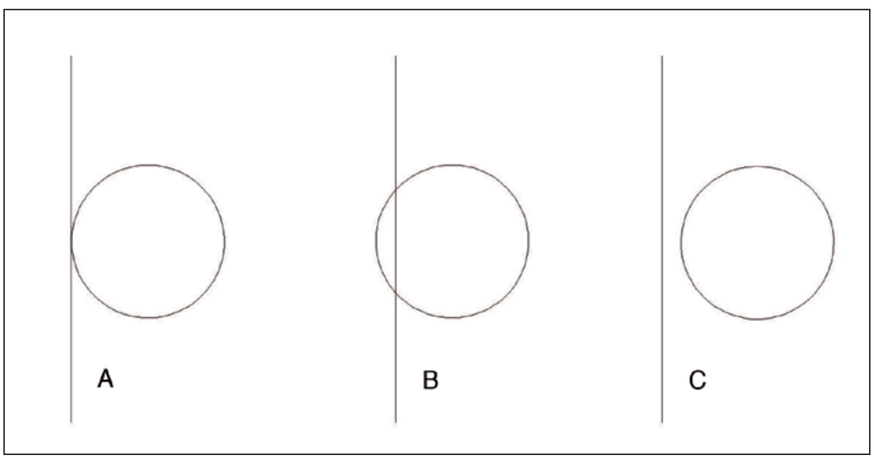

Figure 5
When detecting motion from video captured with a non-moving camera, place guides next to the object to be tracked. Example A shows a guide lined up next to an object to track. Examples B and C illustrate motion. This can be done with horizontal guides to detect vertical motion, as well.

Utilizing this technique, the SUV was determined to come to a stop at 133 frames past the reference point, indicating that the SUV came to rest 4.43 seconds after time zero. Utilizing the same methodology, a slight vertical pitch was detected at 221 frames, 7.37 seconds, after time zero. The impact with the column in front of the building across the street was determined to occur at 426 frames, 14.2 seconds after time zero.

The SUV EDR recorded a near-deployment event when the SUV struck the building across the street. When a vehicle's airbag control module, (ACM) senses a pre-programmed negative acceleration it "wakes up" and monitors the event to determine whether an airbag deployment is warranted. The moment when the ACM wakes up is called Algorithm Enable (AE). A near deployment event is a negative acceleration event which activates AE, but is not severe enough to warrant an airbag deployment. The EDR in the SUV recorded the crash pulse and information from the five seconds prior to AE. Figure 6 displays the data from the crash pulse and figure 7 displays the data from the five seconds prior to AE. The time is listed in seconds prior to AE. In addition to the data shown in figure 7, brake status was given for 8 seconds prior to AE. The brake status was always OFF.

Time (ms)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-0.62	-0.62	-1.24	-1.55	-1.86	-2.17	-2.79	-3.1	-3.72	-4.34	-4.65	-4.65	-4.65	-4.65

Figure 6
The crash pulse data from the near-deployment event.

The crash pulse data is reported as a velocity change and not as an absolute velocity. In other words, this is the velocity lost during the crash pulse. It is very interesting to note that at 120 ms after AE, the recorded velocity change is constant, -4.65 mph. This indicates that the SUV was traveling at a constant velocity for the last 30 to 40 ms. The video clearly shows the vehicle come to a complete stop and therefore, the constant velocity is 0 mph.

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	8	1536	26	OFF
-4	11	1280	0	OFF
-3	11	1216	0	OFF
-2	10	896	0	OFF
-1	11	1600	0	OFF

Figure 7
The EDR data for 5 seconds prior to Algorithm Enable.

It is logical to question why a speed change of -4.65 mph is recorded as the crash pulse, yet at 1 second prior to AE, the vehicle is recorded as moving 11 mph. This is because the speed change which occurred over the prior (maximum) 0.85 seconds was due to crushing of soft components. It was not until the rigid structures became engaged that the negative acceleration was significant enough to cause AE. The portion of the building which the front end of the SUV struck was a square column, which it struck on a corner. This corner impact occurred between the front bumper mounts and so the softer

Photograph 2
Damage to the front end of the SUV. Notice the damage profile is vertical and slender, consistent with an impact with a corner.

structures did not cause as rapid of a negative acceleration as when the bumper and frame became engaged. Photograph 2 shows the front end of the SUV. Notice that the impact is basically vertical and slender, consistent with a corner impact.

Analysis of the data reveals that the EDR data and the video data both share a common data point – the time at which the SUV came to a complete stop. This is recorded as 14.2 seconds after time zero in the video data and is recorded as 120 seconds after AE in the EDR data.

The EDR data shows an interesting speed reduction at 2 seconds prior to AE where the vehicle speed reduces from 11 mph to 10 mph and then increases back to 11 mph at -1 second from AE without throttle or brake inputs. In the video, this corresponded to a curb impact by the SUV just prior to impact with the building. Utilizing the frame by frame analysis techniques used above, the curb impact was determined to occur at 12.08 seconds past time zero. This is 2.12 seconds from the time the SUV came to a complete stop. From the EDR data it is known that the SUV was traveling at 10 mph at 2.012 seconds prior to the vehicle coming to a complete stop. This is a difference of 0.108 seconds. The EDR data has a resolution of 10 ms, while the video data has a resolution of 33 ms, so a difference of 0.088 is more than expected, but given the quality of the video and the lack of direct knowledge of the actual ACM algorithm, this is a very good correlation. All time measurements can be considered true within +/- 0.11 sec.

The next time of interest was the moment that the first shot was fired. By analyzing the audio track separately from the video track, it is possible to visually identify a loud and distinct event. Using this technique the first shot was determined to have occurred 7.9 seconds after time zero.

The duration of the gunfire was also requested, but the audio in the dash cam video was obscured by the yelling of detainees in the police vehicle back seat. However, there was a dash cam video that did not record the visual events, but did record the shots without noise from voices. Exporting the audio into an audio editing program allowed for the audio data to be deleted prior to the initial shot and truncated at the start of the last shot. The temporal length of the remaining file is the duration of the gunfire, 4.62 seconds.

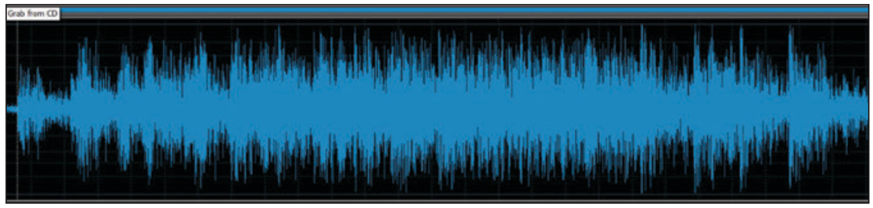

Figure 8
The audio waveform of the gunfire.

Based upon the initial motion of the headlamps, the trajectory of the SUV, after steering inputs were likely lost, and the proximity of the vehicle to the intersection, it appears the driver had turned the steering wheel to the left and was possibly attempting to perform a U-turn.

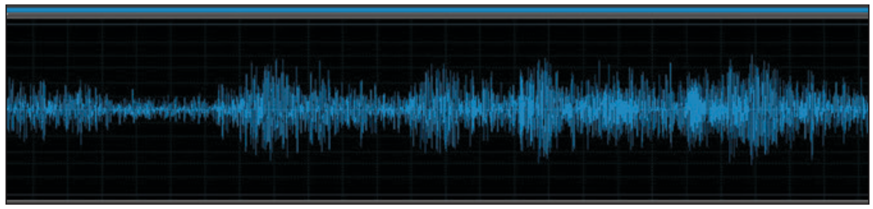

Figure 9
An enlarged section of the gunfire audio waveform to show separate shots.

Speed Analysis

In order to evaluate the defendant's claims that the driver of the SUV was revving the engine in order to perform a "jack rabbit" start, an analysis of the SUV's initial acceleration was necessary. The SUV began moving forward from a complete stop at 6.71 seconds prior to Algorithm Enable (AE). From the EDR it was known that at 5 seconds prior to AE the SUV was traveling 8 mph with 25% throttle. Since it is known from the video data that the SUV started from a complete stop, an average acceleration which will result in a speed of 8 mph after accelerating for 1.71 seconds was calculated to be 6.9 feet per second squared (fpss). Expert Autostats, an electronic reference commonly used by accident reconstructionists to obtain vehicle statistics, reported the SUV to be capable of accelerating at 14.7 fpss, a value over twice that was calculated for the SUV.

Results

From the line of sight analysis, it was apparent that the gear shifter could not be seen by a person of normal height from in front of the SUV. This, however, would not preclude someone outside the vehicle from seeing the driver's shoulder moving while shifting gears.

Figure 10 displays the results of the timing and speed analysis. While the analysis was performed with respect to a time zero which corresponded to a distinct event in the video, this chart uses the moment the SUV began moving forward as time zero to make it easier to understand. The chart is left blank during the column impact, because little was done to reconstruct the shape of that portion of the curve. The portion of the speed curve which corresponds to the calculated acceleration from the start was filled in, because a linear acceleration curve should be a good model, especially since not much speed was ever gained by the SUV. In fact, from the way the speed curve increases without throttle inputs and regains speed after the curb impact, it appears that the this SUV never reached its steady state idle speed prior to the driver

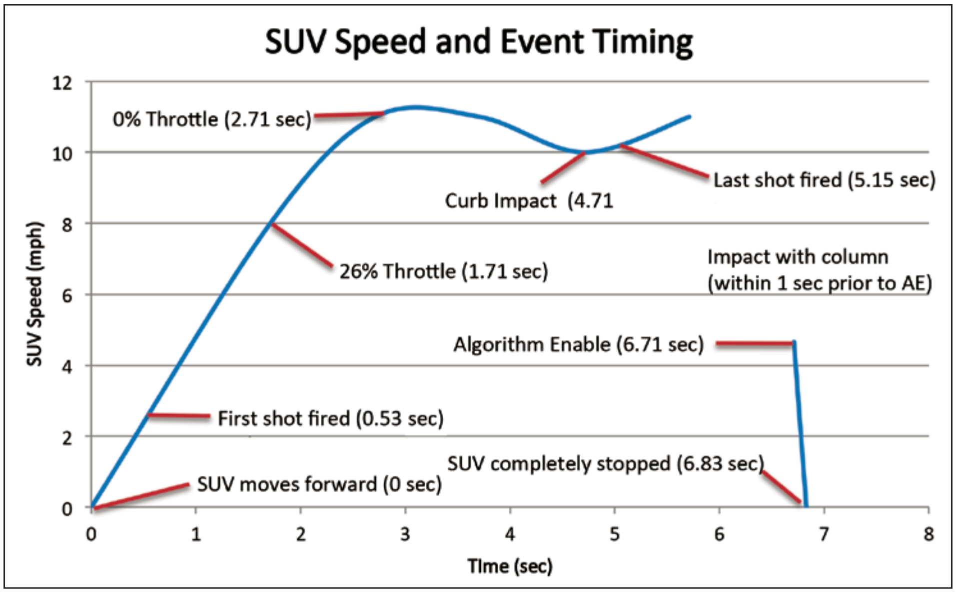

Figure 10

being shot. The timeline of speeds and events, as pieced together from the video and EDR data, did not support a theory that the driver of the SUV was attempting an aggressive "jack rabbit" start. An average acceleration of 6.9 fpss will cause a vehicle to accelerate from 0 to 60 mph in 12.8 seconds, which is very average performance.

The brake status data was given for 8 seconds prior to AE and it was always OFF. This means that prior to moving forward, the SUV was stationary without braking inputs for 1.29 seconds. This does imply that the SUV was in neutral prior to moving into drive. In fact, the SUV was stationary for 2.94 seconds prior to moving forward. This means that prior to 8 seconds before AE, there were 1.65 seconds for the driver to move out of reverse gear and take his foot off of the brake. This does not imply that the driver was attempting an aggressive "jack rabbit" start. Another explanation is that, while attempting to flee an area with a man shooting a gun, the driver accidentally put his SUV in neutral and then pressed on the gas in order to leave, but then waited for the engine to slow down before engaging the drive gear. While briefly mentioned above, but not elaborated upon, because of the difficulty in quantifying it, there was a slight vertical pitch noticed when the SUV began moving forward. This pitch was very slight and less than expected by the author for an aggressive high acceleration start.

Another interesting consideration, which is beyond the scope of this paper is the visual human factors. The driver likely pulled out facing the direction he wished to drive. Upon doing so, he was confronted with the street being blocked by several police vehicles with their lights flashing. This, in addition to at least 2 gun mounted lights aimed at his face could have been visually confusing or debilitating for the driver.

Disposition

This case settled favorably for the Plaintiff.