

Case Report

Reconstruction of a Shooting Incident to Determine Position of Shooter and Timing of Each Shot Fired

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Abstract

This case report presents the engineering analysis and findings related to a litigated matter. This matter involved an altercation between a member of law enforcement and the driver of an automobile. Multiple shots were fired by the law enforcement individual, striking both the vehicle and the driver. Based on the physical evidence (location of the driver's bullet wounds, bullet holes in the car, and cartridge casings at the scene), standard shooting incident reconstruction techniques were used to determine the position of the shooter with respect to the vehicle when each shot was fired. In addition, based on the vehicle's acceleration, the laws of physics were used to determine the speed of the vehicle and the temporal sequence of the shots fired.

INTRODUCTION

Events involving the use or misuse of firearms often raise many questions, such as who fired the shot(s), where did the shot(s) come from, how many shots were fired, and what was the timing of each shot. Standard shooting incident reconstruction techniques involving the use of trajectory rods and string line [1], knowledge of the relatively predictable behavior of bullets/projectiles and their discharged casings, and certain fundamental laws of physics can often be used by the expert to answer such questions. The issues addressed by a shooting reconstruction are often central to opinions on causation. Because causation is often the key to determinations of who is at fault, the findings of such a reconstruction can be the deciding factor in many wrongful death and criminal cases. This case report illustrates the methods used to reconstruct a shooting incident in which many of the above issues were in dispute.

CASE PRESENTATION

This case report presents the engineering analysis and findings related to a litigated matter that involved an altercation between a member of law enforcement and the driver of a 1991 Pontiac Grand Am (Figure 1). The central question in this case was whether the car was being aggressively driven directly at the law enforcement individual when the driver was shot. Four shots were fired, using a 9-mm Glock semi-automatic handgun, by the law enforcement individual who was initially standing in front of the stopped car (with its engine running). As the vehicle was accelerated towards the shooter, the first shot was fired through the front windshield and into the driver's left upper chest. The shooter then jumped out of the way as the vehicle continued to

accelerate forward, and the second shot was fired through the driver's side window and into the left side of the driver's torso. The third and fourth shots struck the vehicle's left

C-pillar and trunk lid, respectively, as the vehicle was driven away from the shooter. Based on the physical evidence, standard shooting incident reconstruction techniques, involving the use of trajectory rods and string line, were used to determine the position of the shooter with respect to the vehicle when each shot was fired. In addition, based on the vehicle's acceleration, the laws of physics were used to determine the speed of the vehicle and the temporal sequence of the shots fired.

A surrogate study was performed to determine the position of the shooter with respect to the vehicle when the first shot was fired. Two human surrogates were used. The first surrogate was



Figure 1 Vehicle photographs. The first shot was fired through the front windshield. The second shot was fired through the driver's side window. The third and fourth shots struck the vehicle's left C-pillar and trunk lid, respectively.

of the approximate height and weight of the driver (5'7", 146 lbs), and the second surrogate was of the approximate height and weight of the shooter (5'11", 200 lbs). The two bullet entry wounds were marked on the surrogate driver's torso, based on their anatomical location/measurements documented in the autopsy report. The surrogate driver was then asked to sit in the actual car. To reconstruct the trajectory of the first shot, a wooden dowel was placed between the bullet hole in the front windshield and the entry wound marked on the surrogate driver's chest (Figure 2). The 3D angle of the wooden dowel was measured using photographs and a digital inclinometer [2]. The surrogate shooter was then asked to assume a typical shooting posture while standing in front of the vehicle. A replica handgun was aimed towards the windshield, such that the gun barrel was in line with the dowel. This was verified by "extending" the wooden dowel using both trigonometry calculations and by connecting a string line between the two objects [1], after accounting for downward deflection of the bullet as it passed through the windshield. As stated by Haag and Haag (2011) [3], "Common pistol bullets fired into typical automotive windshields from positions in front of the vehicle frequently show consistent downward deflection of 1° - 5°." Based on this analysis, the shooter was positioned approximately 7 feet in front of the vehicle (and slightly off-center towards the passenger side) when the first shot was fired.

Next, the surrogate shooter and actual car were placed at the scene of the incident, consistent with the cluster of cartridge casings documented and measured at the scene by the investigating officers. Glock semi-automatic handguns, such as that used by the shooter, have been shown to eject cartridge casings to the right and rear of the shooter when fired with the barrel parallel to the ground [4-6]. Haag (1998) [7] also demonstrated that casings landed to the right and rear of the shooter when the barrel was parallel to the ground, but when the barrel was pointed more towards the ground, the casings landed to the right and either directly to the side or in front of the shooter. Thus, the location of the cartridge casings provided a means for estimating the position of the surrogate shooter at the scene.

The vehicle's acceleration and the laws of physics [8] were then used to determine the speed of the vehicle and the temporal sequence of the shots fired. As noted, the shooter was 7 feet in



Figure 2 Photograph showing a wooden dowel placed between the bullet hole in the front windshield and the entry wound marked on the surrogate driver's chest.

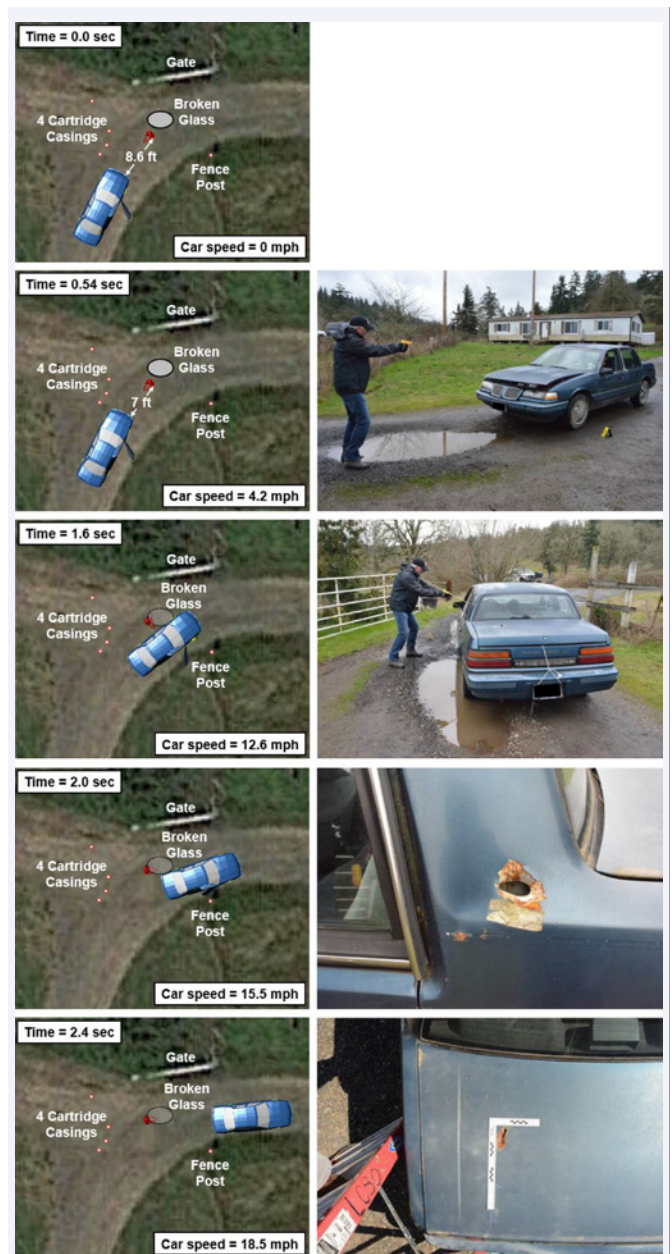


Figure 3 Sequence of events, with the photos on the right being taken at the scene, using a surrogate shooter and the actual car. The shooter was 8.6 ft in front of the car when it began accelerating towards the shooter (time = 0.0 sec). At time = 0.54 sec, the first shot was fired through the windshield. The shooter was 7 ft in front of the car, which had accelerated to 4.2 mph. At time = 1.6 sec, the second shot was fired through the driver's side window and the car was going 12.6 mph. At time = 2.0 sec, the third shot was fired into the left C-pillar and the car was going 15.5 mph. At time = 2.4 sec, the fourth shot was fired into the trunk lid and the car was going 18.5 mph.

front of the vehicle when the first shot was fired through the windshield, in response to the vehicle accelerating towards the shooter. According to several eye witnesses, the driver "floored it" as the vehicle accelerated forward. The shooter's trigger finger was initially on the "slide" of the gun, and not placed on the trigger until the shot was actually fired. Under these conditions (finger on "slide" with the target sighted), it takes the shooter

approximately 0.54 seconds to react to the accelerating vehicle and fire the first [9]. Therefore, the vehicle began to accelerate towards the shooter (i.e. time zero) 0.54 seconds before the first shot was fired. Under the rapid acceleration (0.35 g per vehicle specification data), the vehicle went from 0 to 4.2 mph (calculated using Equation 1, where v_f = final velocity, v_i = initial velocity, a = acceleration, t = time), and traveled 1.6 ft during this 0.54 seconds (calculated using Equation 2, where d = distance).

$$v_f = v_i + at \quad (1)$$

$$d = v_i t + \frac{1}{2} at^2 \quad (2)$$

After the first shot was fired, the shooter jumped to the right and out of the way as the vehicle continued to accelerate forward, and the second shot was fired through the driver's side window and into the left side of the driver's torso. The window was shattered, leaving broken glass on the ground that was documented and measured at the scene by the investigating officers. The broken glass provided evidence of the vehicle's location when the second shot was fired. The vehicle traveled 15 feet between the first and second shots. The vehicle was traveling at 12.6 mph when the second shot was fired (calculated using Equation 3). The second shot was fired 1.6 seconds after the vehicle initially accelerated forward towards the shooter (calculated using Equation 4). After the second shot was fired, the vehicle continued to accelerate forward, and the right front door (which was open) struck a fence post as the vehicle exited the scene (consistent with damage noted on the door). Based on witness accounts, the last shots were fired when the back of the car was just outside the driveway gate. Therefore, the vehicle traveled 17.5 feet between the second and fourth shots, and was traveling at 18.5 mph when the fourth shot was fired through the trunk lid (calculated using Equation 3). The fourth shot was fired 0.8 seconds after the second shot (calculated using Equation 4).

$$v_f = \sqrt{v_i^2 + 2ad} \quad (3)$$

$$t = \frac{v_f - v_i}{a} \quad (4)$$

As for the third shot, the firing rate for a 9-mm Glock is 0.34 seconds between consecutive shots [10]. Therefore, the third shot was fired approximately midway between the second and fourth shots, or 0.4 seconds after the second shot was fired. The vehicle was traveling 15.5 mph when the third shot was fired into the left C-pillar (calculated using Equation 1).

To summarize the above findings (Figure 3), the law enforcement individual was initially standing approximately 8.6 feet in front of the car when it came to a complete stop after repeatedly lurching forward. In response to the car then rapidly accelerating towards the law enforcement individual, the individual fired the first shot through the windshield. The front bumper of the car was only 7 feet away from the shooter when the first shot was fired. The shooter then fired three more shots into the car as it continued to accelerate. With respect to the approximate timing of each shot, once the car began to accelerate towards the law enforcement individual (i.e. this is when the clock starts, or time = 0.0 sec), the first, second, third, and fourth shots were fired at 0.54 sec, 1.6 sec, 2.0 sec, and 2.4 sec, respectively. This science-based analysis contributed to the outcome of this case at trial by proving that the car was being aggressively driven directly at the law enforcement individual when the driver was shot.

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