Case Report

Bullet Trajectory Reconstruction on Vehicles

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Abstract: Numerous challenges are faced when reconstructing bullet trajectories fired at a vehicle because of the irregular surfaces of the vehicle, impacts through open windows, and deflections. Creating and using baselines around a vehicle allows for measuring trajectory angles in relation to each other, the vehicle itself, and the angle of declination.

Introduction

A suspect shooting a high-powered assault rifle fired upon an individual driving a vehicle. The suspect's and victim's vehicles crossed in opposite directions. When the suspect began firing at the victim, the suspect's vehicle stopped, and the victim accelerated away from the area. The victim was struck several times and succumbed to his injuries.

When bullets strike a flat surface, the dowel rod or string methods [1] can be used to demonstrate the angle and to calculate the angle needed for the trigonometric calculations [2] necessary to document the shooting reconstruction. But when the surface is curved, like most exterior surfaces on a vehicle, trajectory

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angles from the surface are imprecise. Establishing two sets of parallel baselines around the vehicle (on a level surface) will provide consistent reference points for the reconstruction and documentation. Rectangular coordinates can then be established and easily understood by a jury.

Materials and Method

The following tools are necessary for this type of reconstruction:

Trajectory rods with centering cones

Protractor

Clinometer (vertical angle measuring device)

Plum bob

Colored string

Chalk line

Tape measure

Carpenter’s square

Combination square

4' straight edge

Torpedo level

3D laser level

Camera

Tripod with level

To create the baselines around the vehicle, the vehicle was placed in a garage with a flat, level surface. Two issues needed to be addressed: (1) Was the car level during the shooting (i.e., did it have any pitch or roll that may have affected the impact angles?), and (2) Did the road crown change the angle of the vehicle in relation to a horizontal plane? From the scene topography and witnesses at the scene, we determined that the road crown was minimal (less than 1°) and that the car's pitch or roll was not severe enough to dramatically change the trajectory estimations. (If these factors do exist, the reconstruction should take place at the scene, or the angles should be factored into the recreation using jacks at a garage or other secure location.)

Multiple bullet paths struck the interior (via an open window) and exterior of the vehicle. These paths were documented using trajectory rods with centering cones. The paths that did not first strike the exterior of the vehicle were projected using colored strings attached to the rods; therefore, all the paths were clearly visible for photographs. Numbered papers, with the trajectory designations, were placed on the rods and string for photographic purposes only; the analysis of the trajectory angles took place without these papers (Figure 1).

Figure 1

Numbered papers, with the trajectory designations, were placed on the rods and strings for photographic purposes.

Technicians determined that a baseline should be drawn five inches parallel to the center of the wheels. This distance cleared all angles and surfaces of the vehicle and was a good approximation to the vehicle to use standard rods. (Five inches is not an absolute and will vary depending on the vehicle's make and model.) This line (baseline 1) was snapped on the floor, then a self-leveling three-dimensional laser level was used to project a beam from the baseline up to a trajectory rod held in place by a tripod. The rod was clamped to a bracket on the tripod so that the rod was level (Figure 2).

Baseline 2 was drawn perpendicular to baseline 1 from the center point of the back bumper (Figure 2). Line 3 was drawn perpendicular to baseline 1 from the center point of the front bumper. The point where baselines 1 and 2 intersect was where the distance measurements used for the trajectory distance and height diagram began. To determine the distance from baseline 2, investigators projected a beam that was level with each impact point and perpendicular to the vertical extension of baseline 1. This provided points that could be measured along baseline 1 to the intersecting baseline 2 (Figure 3).

With the same laser leveling device previously used, the point where the perpendicular rod intersected the imaginary plane extending upwards from baseline 1 was determined, allowing for a height measurement for each trajectory (Figure 4).

Figure 2

Baselines 1 and 2 are parallel to the left side and rear of the vehicle.

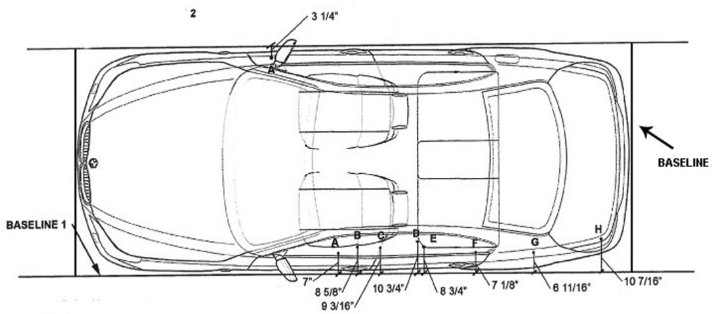

Figure 3

Distances from baseline 2 at the rear of the vehicle.

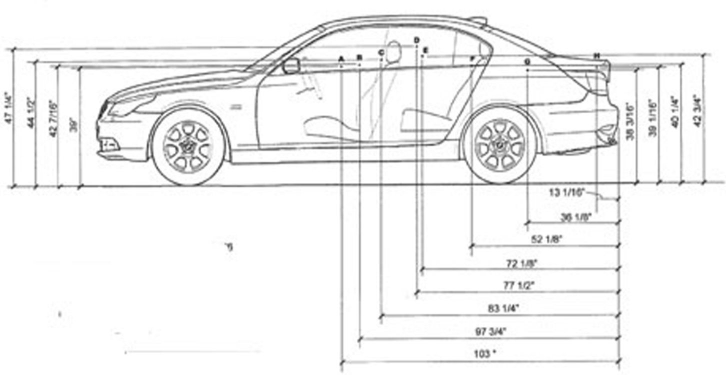

Figure 4

Trajectory distance from baseline 2 (at the rear of the vehicle) and height.

The angle of impact of each of the points was documented in two directions: the vertical angle up from the ground as one faced the side of the car, and its angle out from the vehicle as one viewed the vehicle from overhead. The vertical angle was established by placing an angle finder on the string or rod extending from each point (Figure 5). The overhead angles were established using a protractor placed on or alongside the string or rod that extended from each point and measured against the adjacent baseline (Figure 6).

To determine the point in three-dimensional space where the bullet traveled through an open window, a straight edge was held across both window mullions and moved either up or down until meeting a string projecting out (points A and B on Figures 5 and 6).

Discussion

The material composition of motor vehicles causes concern when reconstructing bullet trajectories. Deflections from metal, glass, and plastic can occur during the bullet's path through a vehicle. One must take these deflections into consideration, especially when dealing with smaller caliber bullets.

Investigators obtained vehicle schematics from the auto manufacturer for this case. Generic vehicle templates are not adequate in this day of technology; juries want accurate representations of any vehicles and structures.

The limitations of using strings during any shooting reconstruction must be understood [2]. Rose determined that string reconstruction beyond 20 feet has the potential for a large margin of error. In this case, the strings did not go past 10 feet [3].

Finally, as discussed earlier, the exact position in three-dimensional space of vehicles in motion cannot be precisely replicated. Pitch, roll, yaw, road crown, and unequal tire pressures may prevent a precise reconstruction of the trajectories. When facing these issues, investigators and attorneys must understand that this procedure, in essence, is a documentation, and the trajectory angles determined are the best estimates possible.

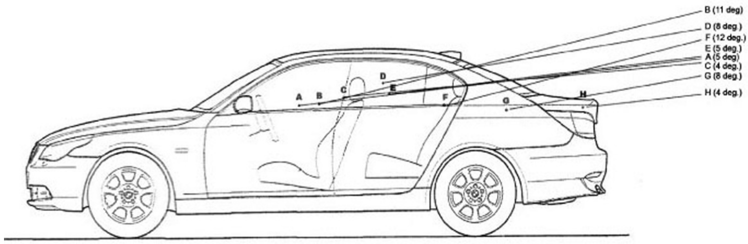

Figure 5

Vertical trajectory angles.

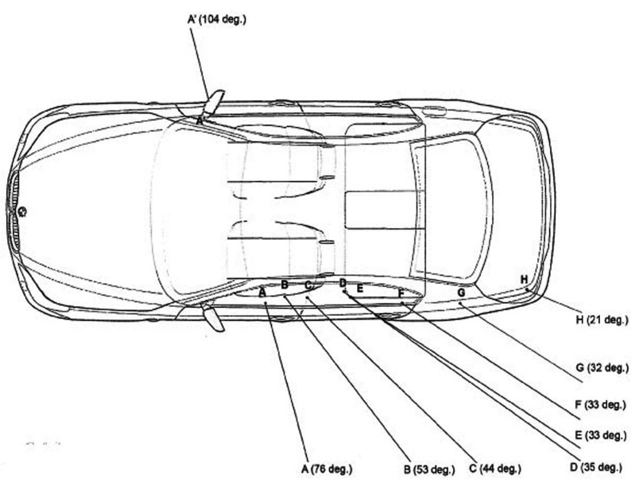

Figure 6

Horizontal trajectory angles calculated from side baselines.

Acknowledgments

This reconstruction was performed by forensic technicians from a multi-jurisdictional homicide task force.

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2. Rose, D.; Ekleberry, T.; Wilgus, G. Introduction to the Trigonometric Shooting Reconstruction Method. *J. For. Ident*. **2004**, *54* (6), 637-643.
3. Rose, D. Establishing a Maximum Effective Range for String Shooting Reconstructions. *J. For. Ident*. **2005**, *55* (5), 611-617.