

Studying Fired Bullet Performance in a Unique Environment

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Abstract: Many studies have been conducted about the evaluation and reconstruction of fired bullet paths delivered in indoor scenes (1-4). Typically, the shooting environment for such training is achieved by the construction of temporary walls, artificial matrices, or other simulated surfaces so that shots of known origin can be safely delivered and the properties studied while on an active shooting range. During this study an abandoned and vacant structure, the University of Colorado Hospital building, was made available for delivering live shots within the office areas.

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Introduction

During the 2009 Association for Crime Scene Reconstruction (ACSR) annual conference, an opportunity to conduct shooting experiments in a controlled indoor setting was offered. Test shots were delivered inside some available office space at the abandoned University of Colorado hospital in downtown Denver, CO. Conference attendees were then offered a workshop that tasked them with documenting evaluating and reconstructing the fired bullet paths.

The area included a carpeted floor (over concrete) with multiple offices each which had functioning solid wooden doors. Six separate test shots were delivered in this environment from known positions and conference attendees were tasked with documenting and recording the location, horizontal and vertical trajectories represented

by each shot. A review of each known will be presented and discussed for this report.

Materials

- A Sig Sauer, .40 S&W caliber semiautomatic pistol
- A Glock, .40 S&W caliber semiautomatic pistol
- Winchester, .40 S&W, 180 grain full metal jacket* (FMJ) flat point ammunition
- Speer, .40 S&W, 165 grain jacketed hollow point (JHP) ammunition
- Miscellaneous trajectory rods, tape measures and protractors
- A Nikon model D80 digital camera

*Note: Full metal jacket bullets exhibit an exposed lead base



Methods

After assuring that all areas at and adjacent to the shooting paths were vacant, each of six different shots was delivered as described below. Shots were delivered from known positions and directed in a path to incorporate multiple intermediate targets. Horizontal angles were recorded from left to right (as one reads a book) such that facing the wall would be read as 90 degrees. Vertical angles were recorded as (+) upward or (-) downward where a level path would be assigned as zero degrees. After each shot, the fired bullet was located but left in

position to simulate a real scene and to allow the examination of the bullet for trace information that may help reconstruct the bullet path. For demonstrative purposes, two additional shots were delivered through a reinforced thick glass window located on an interior door of the scene and the bullets captured in an appropriately positioned ballistic vest.

Results

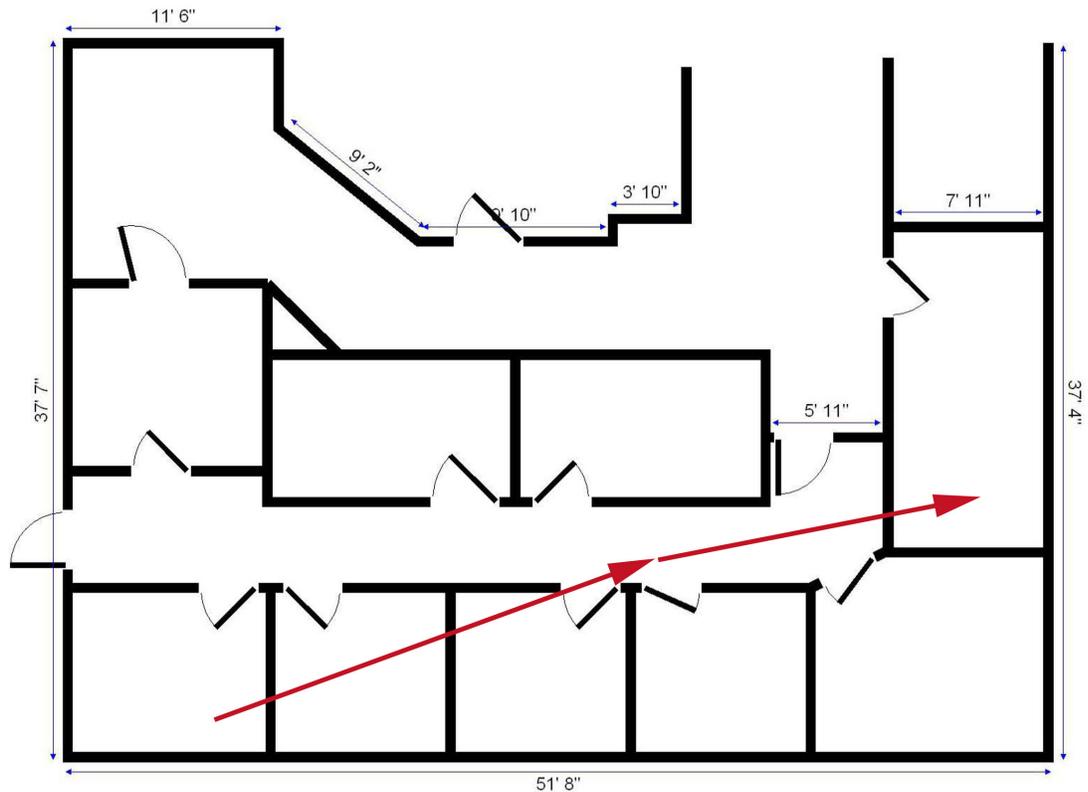
Test Shot #1

- FIREARM: Sig Sauer .40 S&W caliber semi-automatic pistol
- AMMUNITION: Winchester 180 grain FMJ flat point ammunition
- HORIZONTAL FIRING ANGLE: 108 degrees
- VERTICAL FIRING ANGLE: -10 degrees
- BULLET PATH: This fired bullet perforated two layers of drywall, crossed a vacant office, perforated two more layers of painted drywall, exited through an open door, ricocheted off the carpet and perforated two more layers of painted drywall.

Figure 1: Fired bullet from test shot 1, the nose of the bullet was smashed inward.



Test Shot #1





◀ Figure 2: Fired bullet from test shot 2. As was anticipated, the initial impact to a hard surface (the carpeted concrete floor) caused a flat smooth area on the side of the bullet. Also, the hollow point cavity smashed partially closed (and ultimately filled with drywall) thus did not expand as designed. The inability of the “non-hydraulic” compressed drywall to push the walls of the hollow point outward resulted in the bullet not “mush-rooming” as designed.

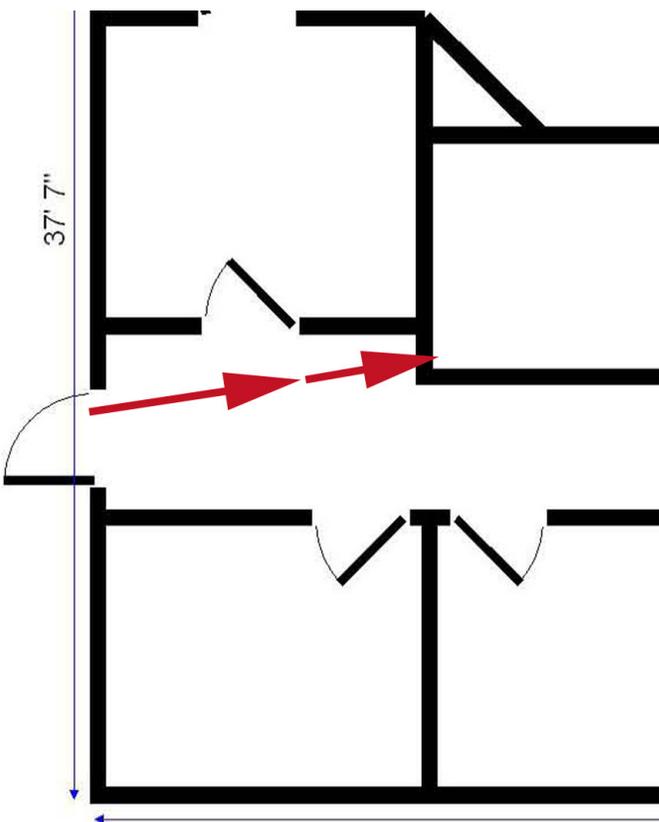
The shot originated from inside the first office, through two layers of painted drywall and across a second adjacent office; through two more layers of painted drywall and into a third office exiting out the open office door where the bullet ricocheted off of the carpeted floor. The bullet continued after the ricochet down the hall and perforated two more layers of painted drywall into a fourth office where the bullet ultimately came to rest. The entire distance covered by this projectile was approximately 45 feet.

Figure 1 shows the appearance of the fired bullet. The initial horizontal angle was approximately 108 degrees (reading out from the wall from left to right) and the initial vertical angle was approximately -10 degrees (10 degrees downward relative to zero being straight into the wall). Upon impact with the carpet glued over concrete floor, the bullet ricocheted and deflected down the hall and into the office.

Test Shot #2

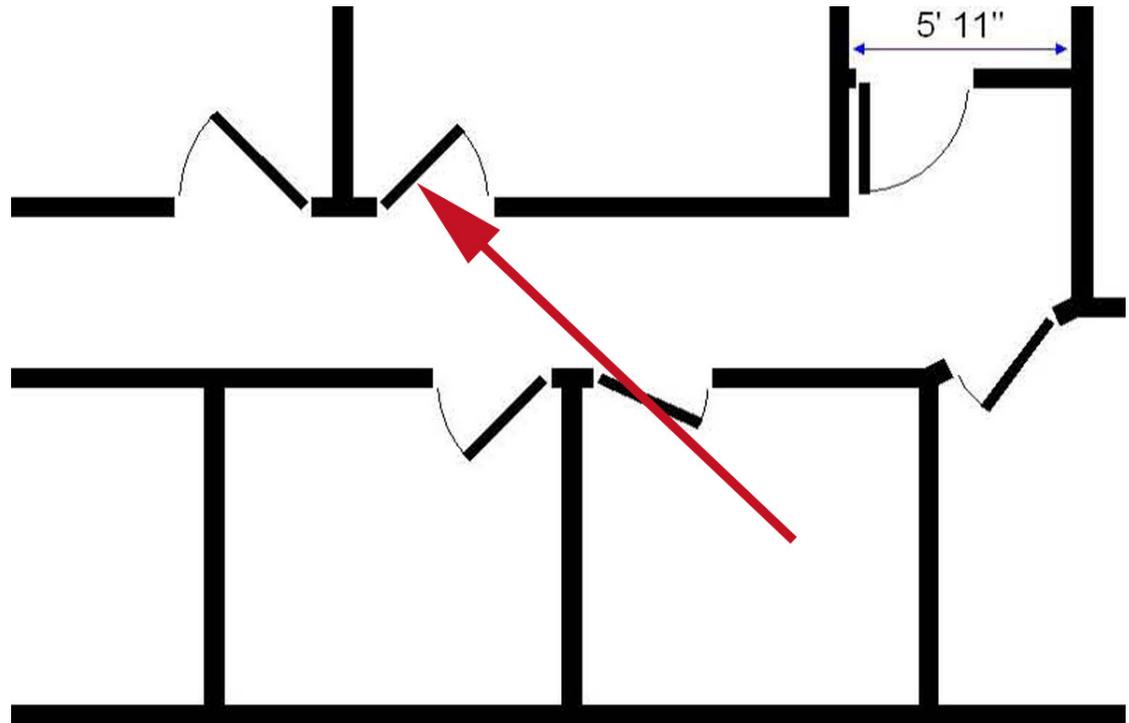
- FIREARM: Sig Sauer .40 S&W caliber semi-automatic pistol
- AMMUNITION: Speer 165 grain JHP ammunition
- HORIZONTAL FIRING ANGLE: 110 degrees
- VERTICAL FIRING ANGLE: -24 degrees
- BULLET PATH: This fired bullet was fired directly toward the carpeted floor, ricocheted and continued to perforate a layer of painted drywall and impact a secondary layer of drywall where it was lodged into a ballistic vest.

This shot was delivered from an open doorway in the hall downward toward the floor. The fired bullet ricocheted from the carpeted floor and perforated an adjacent interior wall into an office. The exit side of the wall to the office was lined with a ballistic vest supported by a 60 pound sand bag



◀ Test Shot #2





so as to capture the fired bullet against the wall. The bullet ricocheted and deflected, and continued to perforate the next set of walls and was ultimately captured by the supported vest.

The examiners attempted to reconstruct the ricochet angle and found that connecting the perforations in the final two wall surfaces DID NOT point back to the ricochet damage into the floor from which it was known to have originated. Because it is impossible for the ricocheted bullet to have dramatically changed its direction in mid-flight, the lack of alignment through the defects to the secondary wall surfaces were misleading.

Upon further consideration and inspection it was observed that the final impact position of the bullet had “bulged” the drywall before allowing perforation. This was likely due to the supported nature of the drywall (with a vest and sand bag). Connecting the secondary entry through the wall with the bulge and distorted perforation with a rod (into the final surface which was supported by a vest and 60 pound sand-bag) resulted in an incorrect reconstruc-

tion of the ricochet (departure) bullet path. Using the mathematical formula based on measuring the legs of a right triangle would have provided the more accurate ricochet angle. This observation exemplified that one must always consider what is being impacted by the fired bullet and the potential for inaccurate angles to occur if distortion to the final impact location has occurred.

As was anticipated, the initial impact to a hard surface (the carpeted concrete floor) caused a flat smooth area on the side of the bullet. Also, the hollow point cavity smashed partially closed (and ultimately filled with drywall) thus did not expand as designed. The inability of the “non-hydraulic” compressed drywall to push the walls of the hollow point outward resulted in the bullet not “mushrooming” as designed.

Test Shot #3

- FIREARM: Sig Sauer .40 S&W caliber semi-automatic pistol
- AMMUNITION: Speer 165 grain JHP ammunition
- HORIZONTAL FIRING ANGLE: 144 degrees

- VERTICAL FIRING ANGLE: -7 degrees
- BULLET PATH: This fired bullet was fired directly into a solid wooden door (the door was opened approximately 8 inches at the time of the shot). Upon exiting the bullet crossed the hall and penetrated a second solid wooden door (this bullet was not recovered).

This shot was delivered from within an office through a solid core wooden door that was opened approximately 8 inches. The fired bullet continued across the hall and into a second solid core wooden door that was closed at the time the shot was delivered. The fired bullet did not exit the second door and was not recovered for purposes of these experiments.

One of the interesting properties of the solid wooden door was that the interior of the bullet path through the door nearly completely closed behind the bullet. The filling in of the bullet path was so complete that only after forcing through a .22 caliber trajectory rod with multiple “stabs” could the angle be accurately assessed. Once the rod was forced through the path opening a channel, reconstructed measurements were accurate for the known bullet path. The amount of force required to reestablish and open the bullet channel was significantly more than this author would feel comfortable with on a real crime scene. Measuring the entry and exit positions along with

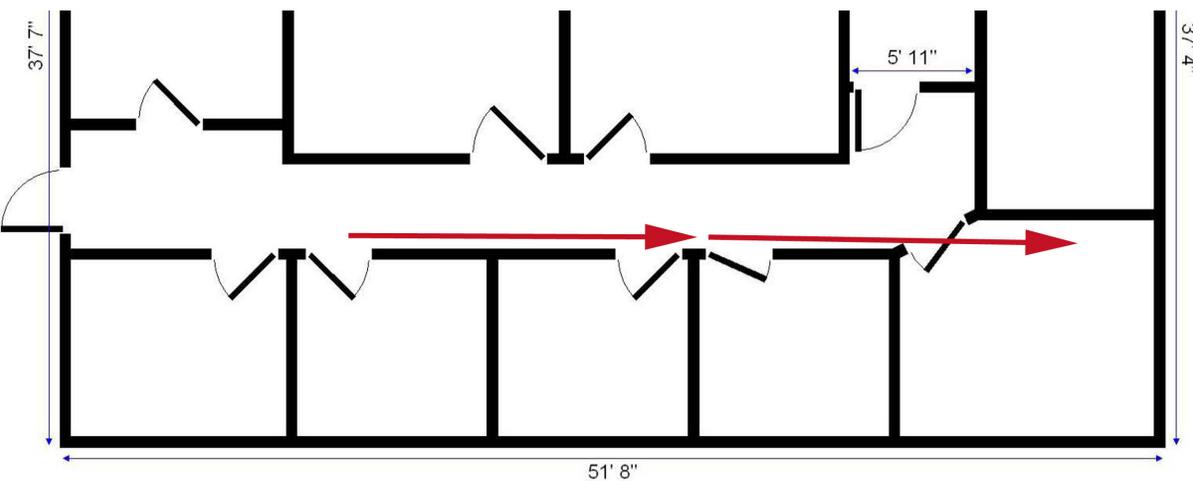
the thickness of the door and then calculating the trajectory would be the process best suited to determine this angle without further damaging the door and potentially changing or influencing the true bullet path. Also, it should be noted that attempting to determine the caliber of the bullet from the “closed-up” bullet hole would have provided a wrong caliber determination.

Test Shot #4

- FIREARM: Sig Sauer .40 S&W caliber semi-automatic pistol
- AMMUNITION: Speer 165 grain JHP ammunition
- HORIZONTAL FIRING ANGLE: 90 degrees
- VERTICAL FIRING ANGLE: -15 degrees
- BULLET PATH: This fired bullet was fired directly toward the carpeted floor, ricocheted and continued to perforate a solid wooden door. The bullet came to rest in the office beyond the door.

This shot was delivered down the hall toward the floor. The fired bullet ricocheted and deflected off of the carpeted floor through a closed solid wooden door at the end of the hall. The bullet perforated the door and was located inside the office near the door.

This shot exhibited both ricochet and deflection (toward the right). Because of the



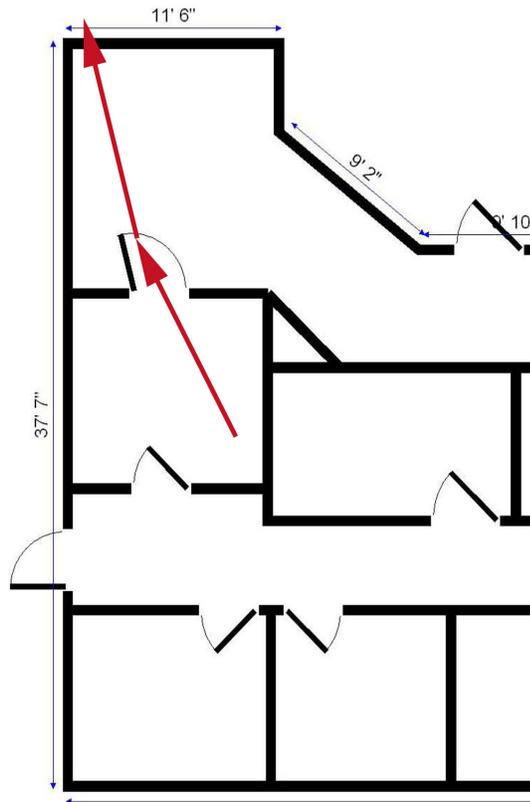
◀ Test Shot #4



Figure 3: The fired bullet from test shot #4 again exhibits a smooth flat side, no hollow point expansion, and the presence of wood fibers from the perforation of the solid core door.



Test Shot #5



deflection and the ability to move the door that intercepted this fired bullet, the original position of the door could not be accurately reconstructed. This exercise again exemplified the importance of considering deflection as well as ricochet when a fired bullet impacts an intermediate surface. One could open the secondary door to a position where a ricochet without deflection could be aligned—if attempted, this process would not correctly reflect the original position of the door at the time the shot was delivered.

Test Shot #5

- FIREARM: Sig Sauer .40 S&W caliber semi-automatic pistol
- AMMUNITION: Speer 165 grain JHP ammunition
- HORIZONTAL FIRING ANGLE: 115 degrees
- VERTICAL FIRING ANGLE: -20 degrees
- BULLET PATH: This bullet was fired through two thin plastic fluorescent light covers and continued to perforate a solid core wooden door before ricocheting off of the carpeted floor. The bullet continued to perforate 2 layers of painted drywall and came to rest in the adjacent office.

For this shot, two plastic fluorescent light covers were acquired from another part of the building. The shot was delivered directly through the two plastic covers while they were leaned against a doorway. The bullet continued through the closed solid core wooden door and impacted the carpeted floor behind the door. The bullet ricocheted, deflected and continued to perforate two layers of drywall before it came to rest in an adjacent office.

One of the challenges of this shot was that after the shot, the door was opened completely thereby removing one of the intermediate targets. Because of the fragile nature of the plastic light covers and their



◀ Figure 4: Approximate direction of travel for test shot #5 with ricochet into opposing wall.



inability to support a trajectory rod, the bullet path was best reconstructed using a laser. Careful alignment of a laser through the perforated plastic fixtures onto the ricochet damage approximated the true bullet entry path fairly well; however, it did not include any influence of the solid door. The laser would not have been able to shine through the wooden door if the door were included as an intermediate barrier in the exercise.

◀ Figure 5: Profile of the impact to the opposing wall after the ricochet of shot #5. Note the distinct shape of the defect from the bullet having impacted sideways after being upset and tumbling from the prior ricochet. Again, the hollow point did not expand due to the hard “non-hydraulic” nature of the objects impacted followed by the tumbling of the bullet (left middle and bottom).

Test Shots #6 (two shots)

- FIREARM: Glock .40 S&W caliber semiautomatic pistol
- AMMUNITION: Speer 165 grain JHP ammunition
- HORIZONTAL FIRING ANGLE: 36 degrees and 41 degrees
- VERTICAL FIRING ANGLE: +15 degrees and +24 degrees
- BULLET PATH: Each of these shots were delivered upward and eclipsed an outward facing corner before continuing into the ceiling (they were not recovered).

Two nearly parallel shots were delivered such that they each eclipsed an out-



Test Shot #6 ▶

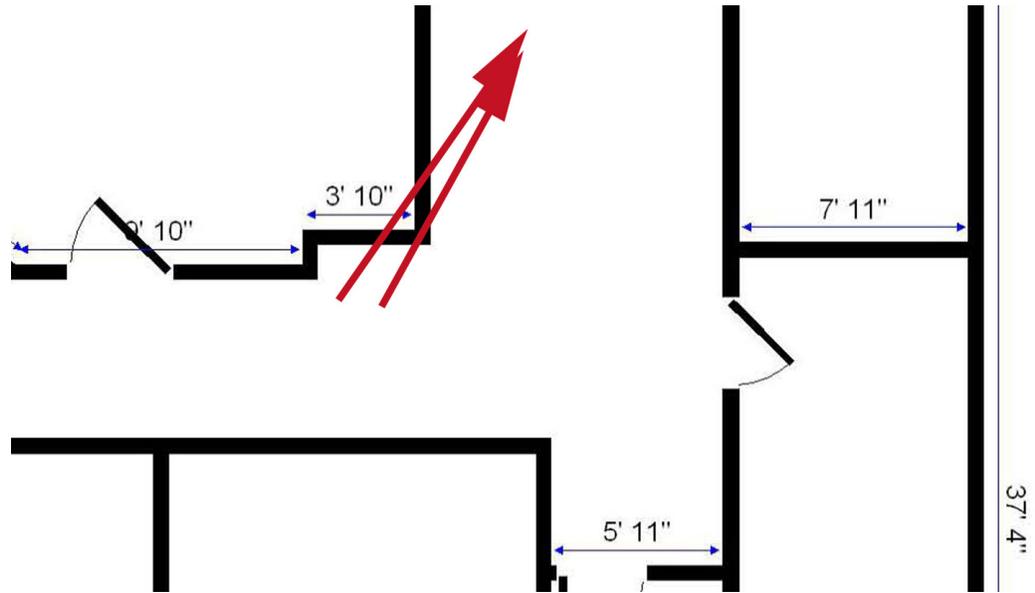


Figure 6: Two nearly parallel upward shots demonstrated with trajectory rods and a plumb line.

ward corner of two intersecting walls. These fired bullets continued into the ceiling and were not recovered.

Figure 6 shows the correct positioning of trajectory rods and the use of centering cones to support the rods in position. A plumb line has been suspended from one of the rods so a reliable vertical reference marker was captured in photographs.



Figure 7: Two .40 caliber bullet holes through reinforced glass. Notice that radial fractures propagated much farther along the internal wire supports and that despite the bullet starting as a .40 inch projectile, the hole was nearly .75 inches in diameter.



Other--Two shots through a reinforced glass window.

A .40 S&W caliber FMJ and JHP bullet were each fired from the same distance/angle through the reinforced window and each captured in a ballistic vest. The recovered bullets were then examined visually to see how each performed.

Participants were challenged to determine which had originally started as a JHP and which had started as an FMJ. Figure 8 shows the appearance of each fired bullet.



◀ Figure 8: The bullet on the left (top and bottom) was a .40 caliber FMJ, the bullet on the right (top and bottom) was a .40 caliber JHP. Neither bullet “expanded” rather both were smashed flat at the nose due to the interaction with the solid glass barrier. Notice the solid copper plug on the left and the remnants of the “petals” from the hollow point on the right.

Conclusions

Table 1 below summarizes the approximate original angles and measured vertical departure angles present. Due to time constraints and class sizes horizontal deflection angles were not generally captured. A wide range of experience was demonstrated by the students-some had never documented a trajectory before and some had processed many scenes involving this type of data.

Demonstrated Effects of Ricochet: Of note was that generally the departure ricochet angles from carpet glued over concrete were similar to the entrance angles. While smooth concrete, a hard unyielding surface, can produce low departure angles, the addition of the carpeted surface likely contributed to increasing the departure angle. This observation supports that care must be exercised if trying to predict ricochet and deflection performance without actual testing of the surfaces involved. Despite the consistency of some of the entry/exit angles listed above, the departure angle DOES NOT always equal the entry angle of ricochets.

Bullet Behavior: Bullet performance is typically a function of the matrix in which the bullet interacts. During this study, none

of the hollow point bullets expanded. This is due to what was being struck (hard, unyielding building materials). When evaluating a shooting scene where hollow point bullets do not expand, the examiner should consider why they did not perform as designed and look for secondary or ricochet impacts.

Morphology of Bullet Defects: The bullet hole made by the perforation of bullet #5 through the secondary wall (painted drywall) demonstrated the side profile of a bullet rather than a circular “nose-first” appearance. When faced with this observation, every effort should be made to determine what caused the bullet to tumble (or enter sideways) prior to impact. Also, as demonstrated with the diameter of the hole through glass, determining caliber based on the dimension of a bullet impact site through such an unyielding surface can produce the wrong result. Always consider what has been impacted and test the performance of such material prior to offering an opinion as to caliber of a projectile based on bullet hole size alone.

Additional Research Topic: When the shooter delivered the shots for test shot #6, an ear-witness was positioned outside of the building to determine if the report



Table 1 ►

Shot	Weapon	Ammunition	Horizontal Angle	Vertical (entry) Angle	Ricochet (departure vertical) Angle
1	Sig Sauer	.40 S&W caliber 180 gn FMJ	108°	-10°	+10°
2	Sig Sauer	.40 S&W caliber 165 gn JHP	102°	-21°	+12°
3	Sig Sauer	.40 S&W caliber 165 gn JHP	144°	-7°	Penetration
4	Sig Sauer	.40 S&W caliber 165 gn JHP	90°	-15°	+12°
5	Sig Sauer	.40 S&W caliber 165 gn JHP	115°	-20°	+21°
6A	Glock	.40 S&W caliber	36°	+15°	Penetration
B		165 gn JHP	41°	+24°	Penetration

of the shot could be heard when the shots were delivered. The ear witness knew that shots were to be delivered, but that witness reported that they would not have recognized the reports of those two shots as gunshots. Observations of others on the street (unaware of shots being delivered inside the building) made no response to the area of the shots when they were delivered. The perception, accountability, and recollection of witnesses hearing shots would be a worthy avenue of study for future testing.

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Amy Jagmin an ACSR board member and forensic scientist from the Washington State Patrol Crime Laboratory who assisted

throughout the set-up, during both sessions of the workshops, and in coordinating many of the test shots generated for this exercise. Her commitment and flexibility in working with the participants assured that everyone had a chance to learn.

Tom Adair, his planning committee, and ACSR for hosting the 2009 conference in Denver, Colorado during which this workshop was conducted.

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