

# BULLET TRAJECTORIES

## Misidentifying Converging Bullet Trajectories in Reconstruction

**P**ythagora's Theorem is the basis for establishing the area of origin in blood pattern analysis and is commonly used in shooting reconstruction for establishing bullet trajectories. In part, this method of triangulation works well in blood pattern analysis, because a specific blood pattern is created by a hemorrhaging event from a single source that casts spatter in directions away from the source point. By dissecting the central axis of the stains to find an area of convergence, and taking the arc sine of the ratio of representative stains, one may derive the degrees of the angle of incidence or impact. Converting that integer to its tangent and multiplying by the linear distance to the Area of Convergence allows one to ascertain the area of origin. The adjacent of the right triangle that is thereby created approximates the trajectory of the drop of blood that created the stain under consideration. By retracing the flight path of several stains, an area of origin can be fairly accurately isolated in three-dimensional space.

The theorem works well for ascertaining the origin of blood patterns that are created as the result of a single event. However, in shooting reconstruction, there is no guarantee that the bullet holes at a scene were fired by a stationary shooter, hence, the establishment of an area of convergence based on the Pythagora's Theorem is unreliable without independent supporting evidence to establish the position of the shooter. Plainly put, trajectories calculated from bullet holes by using trigonometry alone may create false Areas of Convergence where the trajectories intersect in flight. Using Pythagora's Theorem to calculate the area of origin from a false convergence would lead to an erroneous conclusion.

### Establishing a Linear Trajectory from a Single Bullet Hole

Diagram 1, below, illustrates a correct use of trigonometry in calculating the angle of the trajectory of a single bullet at a shooting scene. In this case, a shooter standing in front of the chair in a motel room fires a single shot that strikes the south wall in the bedroom just past the open door. The bullet strikes the wallboard and leaves a clean 2 x 3 mm elliptical hole. Dividing the width by the length of the hole,  $2/3$ , would give a ratio of 0.66, of which the arc sine is 41.8 or 42 degrees out from the plane of the wall. Tracing back from the hole in the wall in the bedroom will establish a linear (non-ricocheting) trajectory that leads to the chair in the seating room. The bullet, however, could have been fired anywhere along that trajectory line. Suppose that, in this instance, the first two feet from the wall may be ruled out as the shooter's position due to a lack of gunshot residue. The area behind the chair could be ruled out as inaccessible or inconveniently accessible. Most probably, the shot would then

have been fired in an area between the chair and the bedroom doorway. More evidence is needed to establish a more specific area. If the bullet hole in the wall is low, using Pythagora's Theorem—based on an imaginary adjacent side of a right angle suspended in space at the height of the hole—may help in approximating the position of the firearm when it was discharged. It would be based on the height of the hand of an average person holding a gun, but it cannot be established with any degree of certainty.

### Establishing an Area of Origin Using Theorem and Corroborating Evidence

The reconstruction becomes more complicated when there are multiple bullet holes. If there is no direct or other evidence to establish an area of convergence, it may not be possible to do so. Suppose that in Diagram 2 we have witnesses who say that the shooter fired from two positions, P1 and P2. By making calculations from the bullet holes in the seating room and the bedroom, the

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area of convergence for each burst pattern can be determined and the areas of origin estimated. The angles are calculated to be approximately 15, 20, and 30 degrees and form an area of convergence just inside the entrance door to the room. When the angles are strung and the area of convergence established, the height of the weapon may even be estimated with relative accuracy.

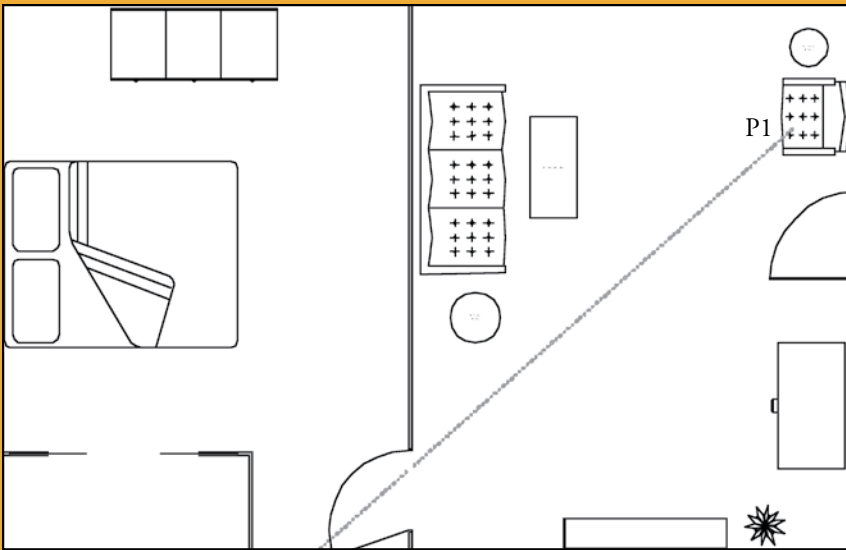
The same calculations can be made from the bullet holes in the north and east walls of the bedroom, and the area of convergence can be established there as well. What has to be noted, however, is that the area of convergence is not ascertained by the trigonometric calculation of the trajectories alone. The calculations of the angles of impact established only the linear trajectory, a line along which a bullet traveled for an undetermined distance. The witness testimony established that the points at which the trajectories crossed were the two positions of the shooter. From there, the Pythagora's Theorem can be used to calculate an area of origin. The mistake to be made in calculating the area of origin is in assuming that the area where the bullet trajectories converge establishes a de facto area of convergence as is done in blood pattern analysis. In fact, without corroborating or otherwise confirming supportive information, neither the area of convergence nor the origin can be ascertained.

## Multiple Bullet Hole Scenes with Crossing Trajectories

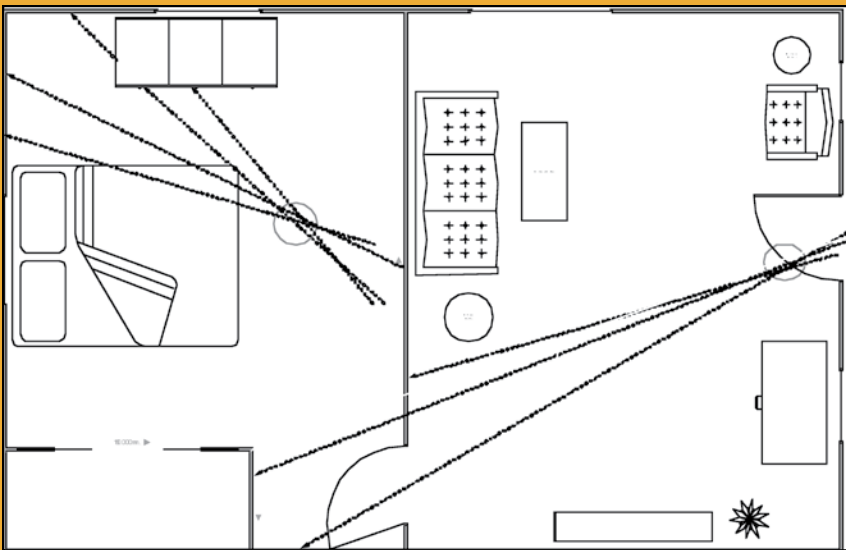
It helps to illustrate the point by using an example of non-converging trajectories that cross each other and give a false reading of an area of convergence. In this scene (see Diagram 3), the shooter moves and fires from five different positions. The first shot is fired from the doorway leading into the seating room. The second shot is from a foot or two to the shooter's left and slightly forward of the first position. The third shot is fired from a foot or two further to the shooter's left and slightly forward of the second position. Clearly, the shots cannot be traced

MCT photo by Terrence Antonio James

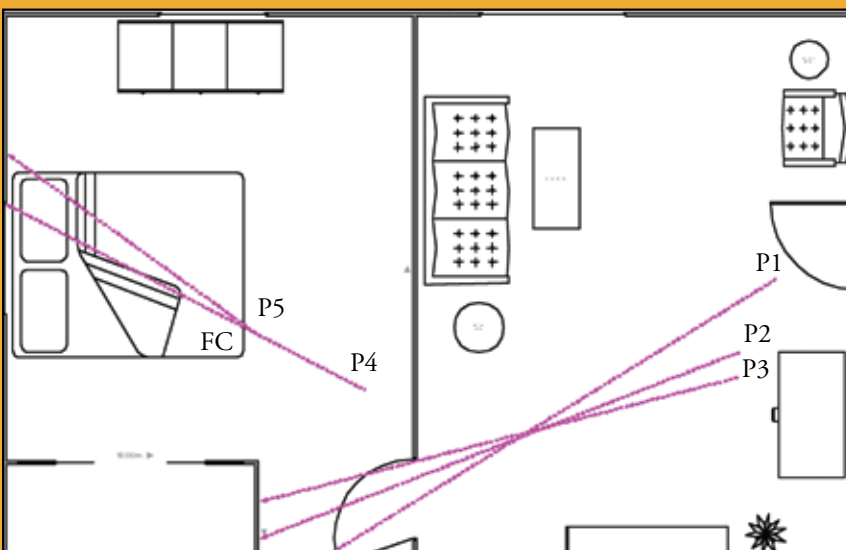




▲ Diagram 1. Single bullet hole trajectory from chair to bedroom wall.



▲ Diagram 2. Multiple bullet holes with trajectory areas of convergence established by independent corroborating evidence.



▲ Diagram 3. Multiple bullet holes with crossing directories.

back to a single firing position, because the shooter was moving laterally and forward. Yet if the reconstructor used Pythagora's Theorem to calculate the point of origin at the false area of convergence, the reconstruction would seem plausible, perhaps even convincing, but it would not be accurate. The same scenario is repeated in the bedroom with two shots fired from positions in line with each other. P4, FC, P2, FCA, P5, P3, P1

### Conclusion

Although Pythagora's Theorem is fundamental to blood pattern analysis in which several stains may be created by a single source in a blood-letting event, its use in shooting reconstruction is limited, because the shots that created the bullet holes may have been fired from different positions that created trajectories that cross by mere coincidence. Therefore, any time an area of convergence is established by the use of the blood pattern formulas, there must be independent corroborating evidence to support the trigonometric finding before it can be considered reliable. ■

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