Ballistic Trajectory Analysis

Case Details, Eye Witness Testimony, and Analysis
A shooting occurred on July 7, 2015, when a couple drove together to a home in Vallejo. An argument ensued and tensions rose. The driver and passenger attempted to leave the scene but were caught in a crossfire of bullets fired from an AK-47 in full auto mode. The driver of the vehicle, a female, died due to a gunshot wound to the head.

Under the “provocative act” doctrine, which allows prosecutors to file murder charges against people who don’t physically commit killings but somehow incite them, the passenger of the vehicle, rather than the AK-47 shooter, was charged with second degree murder.

We were brought in on the case a year after the incident took place and asked to analyze the evidence in order to answer the following:

1. Where was the 2003 Mercedes Benz C240 located when it was struck by Bullet #1 and Bullet #2?
2. What is the line of sight from the porch, based upon a person’s height of 5’8” to the Mercedes Benz when the vehicle was struck by Bullet #1 and Bullet #2?
3. What is the line of sight from the front passenger position of the Mercedes Benz C240 as it was struck by Bullet #1 and Bullet #2 to the porch?
4. Was the vehicle stationary or moving? If the vehicle was moving, can you reverse-engineer the vehicle’s speed?
5. Can you reverse engineer the order of the bullets fired, two in the vehicle and two in the house across the street?
Step 1: Data Collection
Data received:
1. Police report
2. Coroner report
3. Photos from the crime scene
4. Still images from a police camera

Data we collected:
1. Laser scan of 2003 Mercedes Benz C240 involved in the shooting
2. Laser scan of the incident area surrounding the shooting location
Step 2: Bullet Trajectory Analysis

In analyzing the 3D laser scan of the 2003 Mercedes Benz C240, we were able to measure the 3D angle of Bullet #1 into the roof of the vehicle:

- Left to right angle = 18°
- Up to down angle = 23°

Analyzing the data on Bullet #2 in the rear window of the vehicle:

- Left to right angle = 20°
- Up to down angle = 22°

Our analysis reveals that each bullet was shot from the same angle. This indicates that the shooter was standing in the same location while firing both shots.

The distance between bullet entrances 1 and 2 is 2.7 feet. This distance means that either the person firing had moved 2.7 feet between shot 1 and 2 or the vehicle had moved 2.7 feet between shot 1 and 2.
Analysis Movement of Shooter:

The gun used in this incident was described as an “AK-47” assault rifle and, based upon testimony of the shooter, the gun was in a “full auto” setting. This firearm is a gas-powered rifle, meaning that it uses the gas created by firing of the first bullet to reset the firing pin, load the next bullet and fire without having to pull the trigger again. When this weapon is cold, it is rated at a speed of 10 rounds per second. Based on the testimony, the shooter would have had to move to his right 2.7’ in a 1/10 of a second while maintaining the identical shooting position. This is forensically improbable and also does not match the testimony of the shooter.
Question #1: Where was the 2003 Mercedes Benz C240 located when it was struck by Bullet #1 and Bullet #2?

In order to determine the location of the vehicle when it was shot, we needed to analyze the bullet hole trajectories in the vehicle. We started by laser scanning the vehicle and the surrounding area. Using the Leica p30 laser scanner we measured millions of data points to create an accurate 3D model of the 2003 c240 involved in this incident.

A scan of the vehicle:
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A scan of the surrounding area:
Question #1: Where was the 2003 Mercedes Benz C240 located when it was struck by Bullet #1 and Bullet #2?

We started analyzing the scan data from the vehicle by finding the bullet trajectory paths of Bullet #1 and Bullet #2.
Question #1: Where was the 2003 Mercedes Benz C240 located when it was struck by Bullet #1 and Bullet #2?

Bullet #1 entered the roof of the vehicle at an 18° angle, left to right and a 23° angle, top to bottom.
Question #1: Where was the 2003 Mercedes Benz C240 located when it was struck by Bullet #1 and Bullet #2?

Bullet #2 entered the top corner rear windshield at a 20° angle, left to right, and a 22° angle, top to bottom, then exited the rear driver side door.
Question #2: What is the line of sight from the porch, based upon a person’s height of 5’8”, to the Mercedes Benz C240 when the vehicle was struck by Bullet #1 and Bullet #2?

Through our analysis of the laser scan data, along with the location of the vehicle traveling down Broadway, we concluded that a 5’8” person standing on the porch would be able to see a person sitting in the front passenger seat of a 2003 Mercedes Benz C240 as it drove by the shooter’s home.
Question #3: What is the line of sight from the front passenger position of the Mercedes Benz C240 as it was struck by Bullet #1 and Bullet #2 to the porch?

Through our analysis of the laser scan data, along with the location of the vehicle traveling down Broadway, we concluded that a person sitting in the front passenger seat of the Mercedes could see only the head of a 5’8” person standing on the porch just outside the front door.
Question #4: Was the vehicle stationary or moving? If the vehicle was moving, can you reverse-engineer the vehicle’s speed?

Analysis of Vehicle Moving:

Based upon the speed of fire of the firearm used in this incident and the distance between the two bullet holes in the vehicle, the vehicle would have had to move 2.7’ within 1/10 of a second. That would’ve given the vehicle a traveling speed of 18 mph while bullet 1 and 2 were fired. Based upon testimony (there is conflicting testimony), the 2003 Mercedes Benz C240 was located at the entrance of the alleyway, next to the home where the shooter was standing on the porch, when it started to drive past the shooter.

The distance between that alleyway and the location of the vehicle when struck is approximately 54 ft. At an acceleration rate of 0.2G, the vehicle would hit a speed of 18 mph in 54ft taking 4.1 seconds. (This rate is a standard acceleration rate for a vehicle leaving a green light). Our analysis tells us that 18 mph not only fits the distance between both shots but also matches a standard acceleration rate of this sedan.
Question #5: Can you reverse-engineer the order of the bullets fired, two in the vehicle and two in the house across the street?

The police report states that two bullets were fired into the Mercedes Benz C240 and two bullets fired into the house across the street from where the shooter was standing. There were two bullet hole patches in that house, which were captured by the Leica P30 laser scanner. The analysis shows these two shots had the following angles:

Bullet #3:
Left to right = 21 degrees
Up to down = 9 degrees

Bullet #4:
Left to right = 21.5 degrees
Up to down = 7 degrees

Based upon the position of the shooter, the Mercedes Benz and the location of holes in the house across from where the shooter was standing, we were able to reverse-engineer the order in which each bullet was fired.

Bullet 1 = Roof of Mercedes Benz
Bullet 2 = Rear window of Mercedes Benz
Bullet 3 = Lower bullet in the house across the street
Bullet 4 = Upper bullet in the house across the street
In the end, our analysis of evidence helped the jury understand the truth. The jury came back and acquitted the passenger of the vehicle on all charges, finding the passenger of the vehicle not guilty.

The jury did not believe beyond a reasonable doubt that he possessed a gun nor did they believe that he pointed or fired a gun.