PSI PRECISION SIMULATIONS

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A Case Study: 3D Laser Scanning, Photogrammetry and the 3D Working Model Officer Involved Shooting

3D Laser Scanning and Photogrammetry

Case Study of the use of 3D Computer Simulations and Analytical Techniques to Accurately Reconstruct and Illustrate an Event.

Challenge

How to develop an accurate reconstruction of an event when key pieces of physical evidence (such as a skid mark) were poorly measured but are documented in a photograph?

Solution

Reconstruction of physical evidence that is missing from the accident, fire or crime scene is often required to create a complete reconstruction. Using photogrammetry, 3-D laser scanning and a proprietary software analytical system, PSI can accurately place within a computer generated working model of the scene evidence that exist on a photograph, but is no longer at the scene.

Scenario

At the end of a high-speed chase, in a busy intersection in a large metropolitan area, the driver of a stolen vehicle, stuck in traffic, quickly backs up into a peace officer's car crushing an officer. Other peace officers open fire and kill the driver. The family members of the driver file suit against the municipality and the officers, alleging that the officers used excessive force. There were many witnesses to the incident and their accounts differ in important aspects.

The challenge for the defense attorney is to determine if the physical evidence supports the officers' version of the events.

Measurements at the scene were sparse. The skid mark left by the stolen vehicle as it backed up and collided with the peace officer's car and the resting positions of the stolen car and peace officer's car were key pieces of evidence but were not sufficiently measured to allow for a complete reconstruction. Fortunately, there were many photos of the scene and one of them showed the skid mark. Other photos showed all the vehicles in their post-collision positions.

Both the peace officer's vehicle and the stolen vehicle were impounded and available for further measurements and analysis.

Incident Site Overview

Photo of Stolen Car. *Note: Skid Mark.*

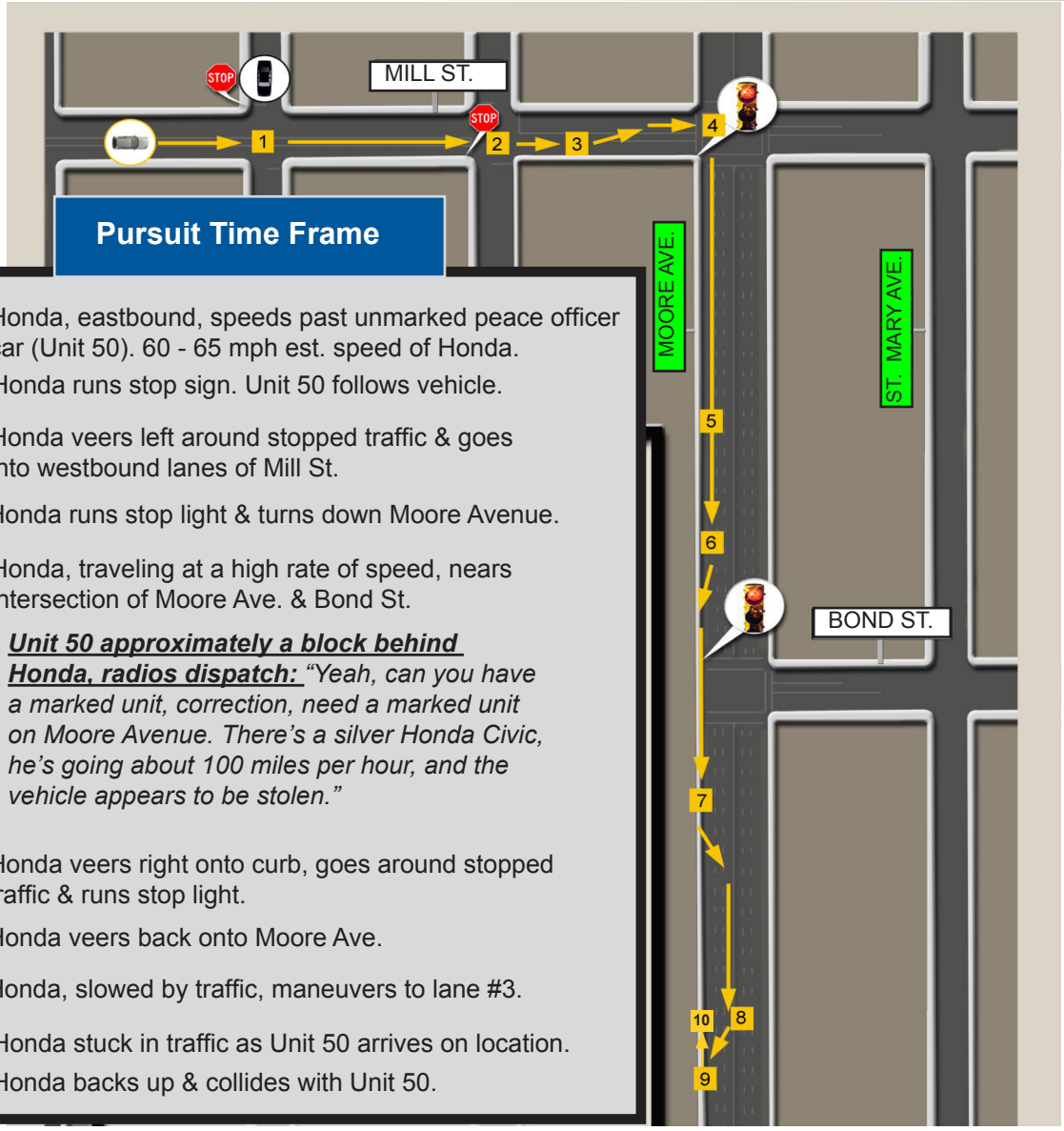
Photo of Stolen Car [Silver Vehicle] in it's at-rest position after colliding with peace officer cruiser.

The above photos were the best of the many that were available of the scene.

From these photos, PSI was able to accurately reconstruct critical pieces of evidence. Using laser-assisted photogrammetry combined with proprietary systems, PSI developed a precise and comprehensive computer generated 3D working model of the crime scene. Using this working model, PSI and an expert reconstructionist were able to develop an accurate reconstruction of the events which ended with the shooting.

We will describe the process used to develop an accurate reconstruction even when critical evidence was not properly documented and no longer exists.

Summary of Events Leading Up To Shooting



Pursuit Time Frame

1. Honda, eastbound, speeds past unmarked peace officer car (Unit 50). 60 - 65 mph est. speed of Honda.
2. Honda runs stop sign. Unit 50 follows vehicle.
3. Honda veers left around stopped traffic & goes into westbound lanes of Mill St.
4. Honda runs stop light & turns down Moore Avenue.
5. Honda, traveling at a high rate of speed, nears intersection of Moore Ave. & Bond St.

   Unit 50 approximately a block behind Honda, radios dispatch: *"Yeah, can you have a marked unit, correction, need a marked unit on Moore Avenue. There's a silver Honda Civic, he's going about 100 miles per hour, and the vehicle appears to be stolen."*

6. Honda veers right onto curb, goes around stopped traffic & runs stop light.
7. Honda veers back onto Moore Ave.
8. Honda, slowed by traffic, maneuvers to lane #3.
9. Honda stuck in traffic as Unit 50 arrives on location.
10. Honda backs up & collides with Unit 50.

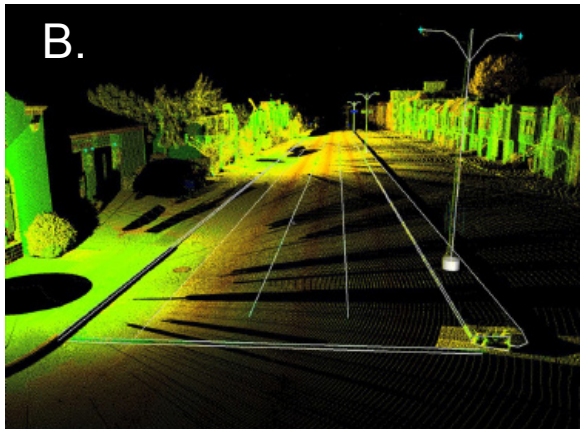
To determine if the officers' use of deadly force was warranted, the physical scene had to be recreated and the actions of the participants reconstructed in real time with a sufficient level of accuracy to be admitted to the court, and be compelling to a jury.

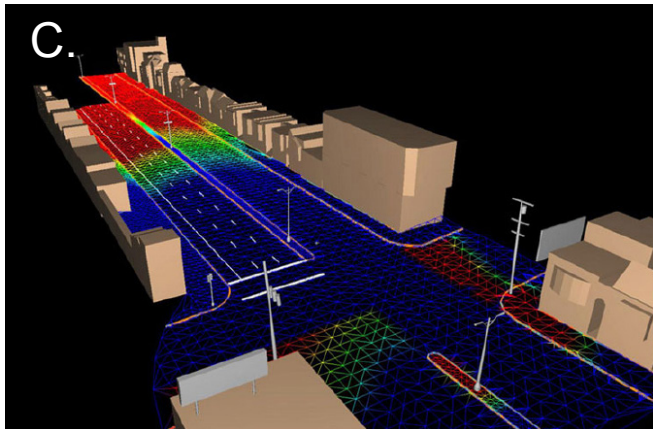
However, the incomplete documentation at the scene combined with the busy traffic made an accurate reconstruct very difficult. PSI was asked to determine the dimensions and positions within the crime scene of the following evidence:

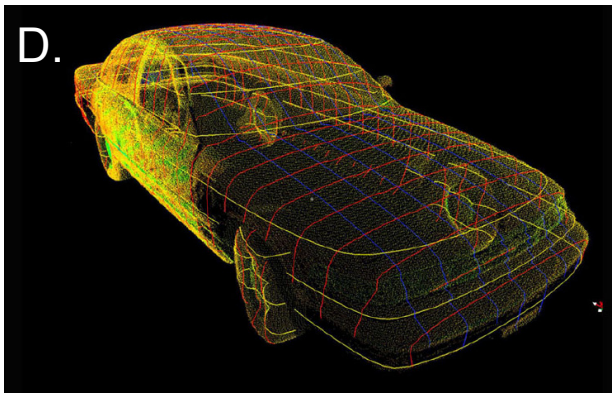
a. The skid mark left by the stolen vehicle as it backed into the peace officer's car
b. The peace officer's car in the position it was in when it was struck by the stolen vehicle
c. The starting position for the stolen vehicles rearward trajectory
d. The position of the stolen vehicle after it came to rest against the peace officer's car.

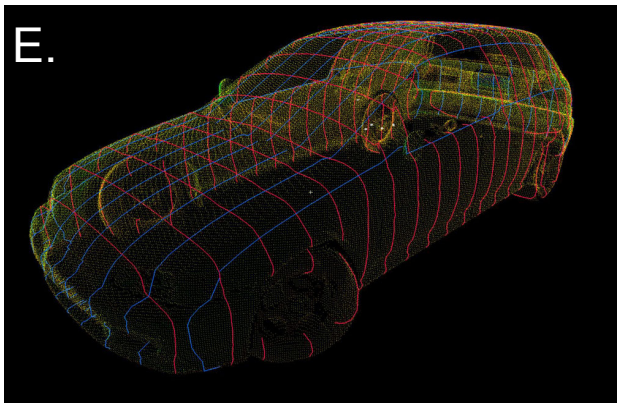
PSI was also requested to assist the expert to design an off-site reconstruction of the crime.

The 3D Working Model









A = Cyra Laser Scanner
B = Laser Scan Image of Street
C = Computer Model with Laser Scan Data Overlay
D = Laser Scan of Peace Officer's Vehicle
E = Laser Scan of Stolen Vehicle

PSI first developed an accurate 3D working model of the crime scene using the 3D laser scanner and a proprietary system of software. The laser scanner was selected because it could measure, document and model the entire intersection while cars and people moved through it with an accuracy of ¼ inch, from a remote point outside of the flow of traffic.

The stolen vehicle and peace officer's vehicle were also scanned to accurately measure their dimensions and the collision damage - another key set of evidence.

The results of these laser scans were very accurate (to 1/4 inch) 3D models of the crime scene and both vehicles.

Laser-Assisted Photogrammetry

Using the accurate data derived from the 3D laser coupled with advanced least-squares algorithms and the detail available in a photograph, important features from a photograph (even those now missing from the physical scene) can be placed within a computer generated working model of a crime accident or fire scene. The accuracy of the measurements available from laser-assisted photogrammetry provide not only the necessary foundation for a valid reconstruction, but also a very realistic, detailed and compelling animation of the fire, crime or accident scene. Many photos of evidence taken at the scene can be precisely reconstructed using these techniques.

The photogrammetry process: the above photo shows the peace officer's cruiser and the stolen vehicle at their respective points of rest, after the collision. The yellow "wireframes" of each vehicle depict the resting position of the vehicles in the 3D model, as determined via laser-assisted photogrammetry. *Note the accuracy of the match.*

The lower photo shows the derived positions of the 3-D models in the 3D scene.

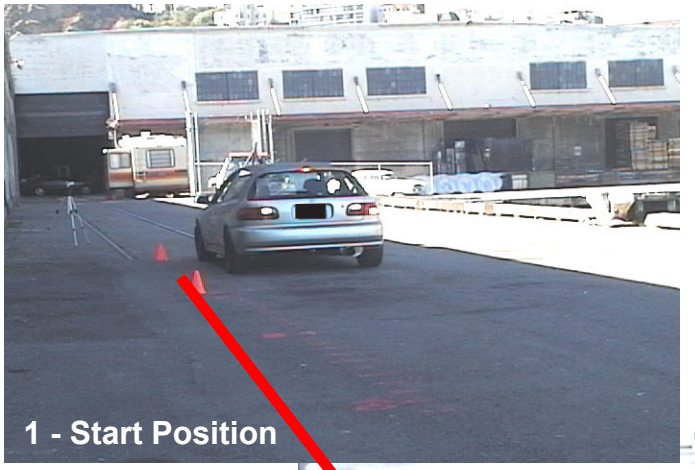
First: Off-Site Reconstruction

Once the 3-D models of the accident scene and vehicles had been created and validated, the vehicles had to be placed in their final resting place. Using laser-assisted photogrammetry (see pg 6), the peace officer's car, by-standing cars and the stolen car were precisely placed in their actual resting places in the working model.

To determine acceleration, direction, terminal velocity, elapsed time of motion and initial location of the stolen car, the erased skid mark was vital. Because the skid mark was no longer at the scene, it also had to be recreated and placed in the working model, using the laser-assisted photogrammetry technique. Using the single photo of the skid mark, PSI was able to determine its accurate length and precisely place the skid mark in its correct position in the working model.

The computer-generated working model now contained an accurate model of the crime scene, accurate placement of the vehicles involved and the skid mark left by the stolen vehicle during its rearward acceleration into the peace officer's vehicle.

Road Testing Impounded Stolen Vehicle



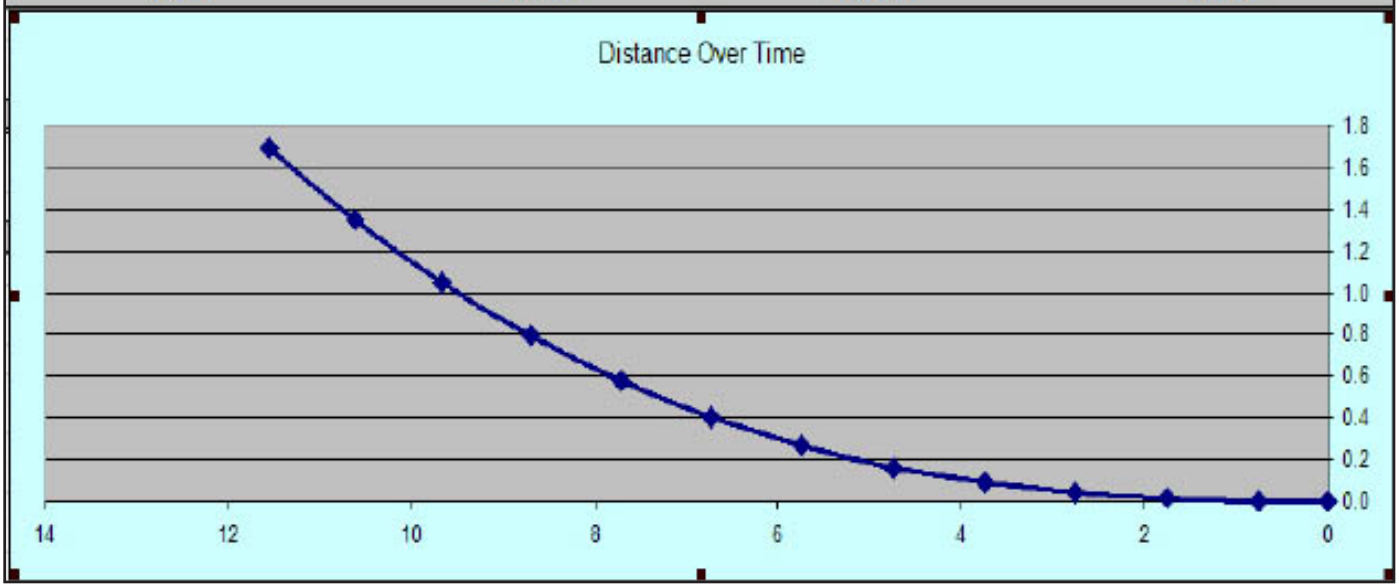
1 - Start Position

2 - Accelerating in reverse, leaving skid mark.

Second: Data Gathering and Analysis

Using measurements derived from the working model, the expert was able to reconstruct the crime scene off-site, including the skid mark and the starting position of the stolen car. The expert then drove the actual stolen vehicle, accelerating in reverse, in an effort to determine if the skid mark length derived from the photogrammetry could be created by this specific vehicle under similar conditions. The tests were recorded with video and analyzed frame-by-frame to determine acceleration, velocity and elapsed time of the stolen car while leaving the skid mark. The testing revealed that the car did in fact leave skid marks of the length determined by PSI.

Time	Speed - ft/s	Speed - mph	Avg. g's
1.400	25.71	17.53	0.57
1.367	26.34	17.95	0.60
1.330	27.07	18.45	0.63
1.330	27.07	18.45	0.63
1.357	**26.546**	**18.096**	**0.608**

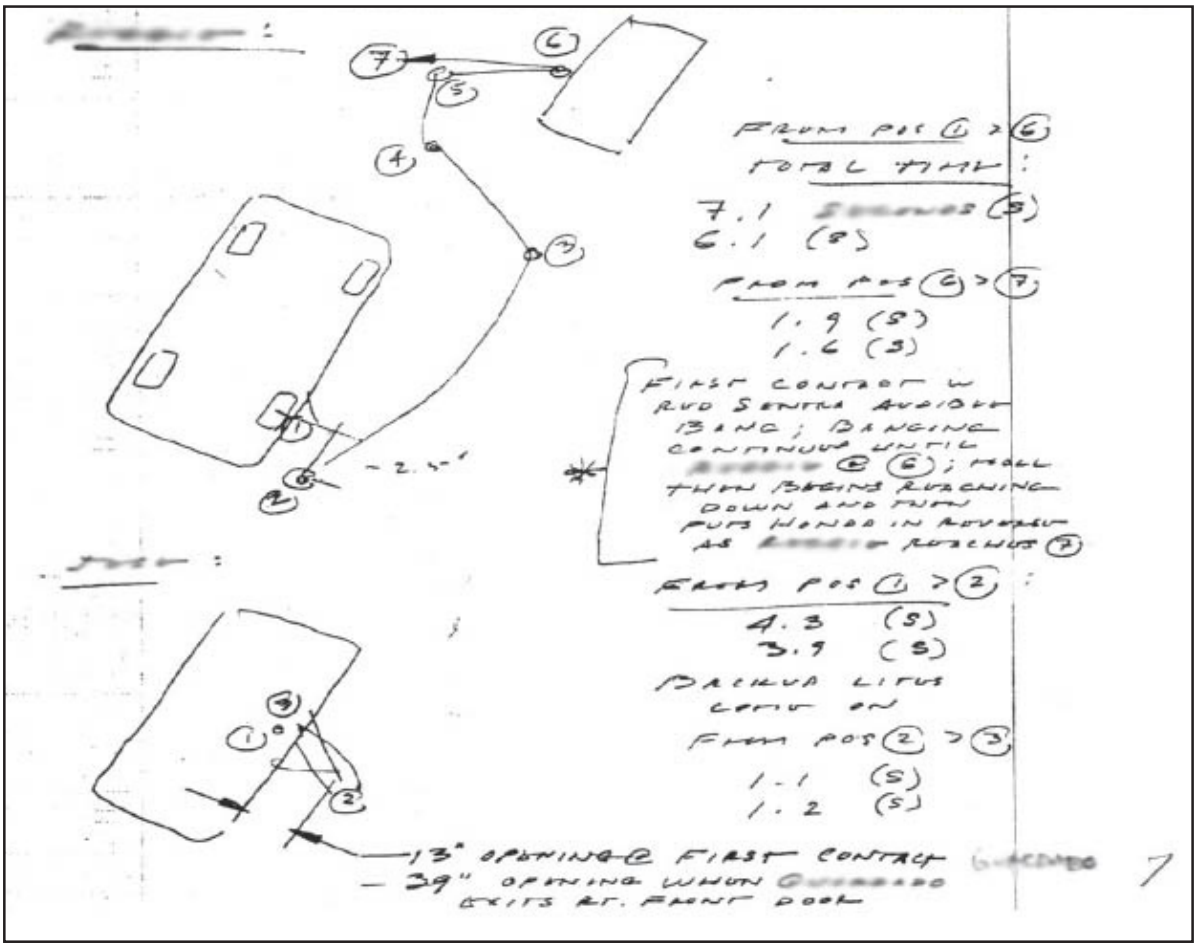


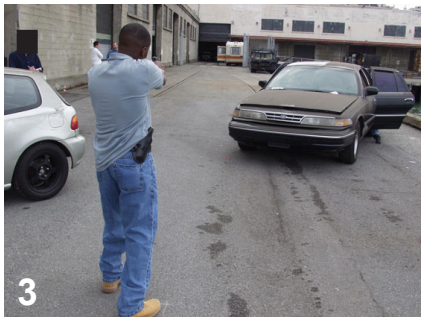
Once the acceleration, elapsed time and velocity were determined, the expert, working with PSI, used the working model to determine the specific path of the stolen vehicle as it backed up and collided with the peace officer's vehicle. This was accomplished by animating the vehicle as per the derived performance data (see above) and matching the positions of the known impact points and paint transfers on each vehicle.

The result was an accurate recreation of the stolen vehicle's motion as it collided with the peace officer's vehicle, based upon a solid technical foundation of measurements, derived speeds and available physical evidence.

Third: Complete Off-Site Reconstruction

The working model now needed the movements and timings of the peace officers before and during the shooting to complete the reconstruction. PSI and the expert setup a second off-site reconstruction. The stolen vehicle and peace officer's vehicle were placed in their proper positions. In this recreated scene, the officers re-enacted their movements as they were documented with photos and timed with a stopwatch. The expert derived accurate motions for each officer, as below.





Peace Officer Re-enactment

1) Officer exits his car 2) Officer approaches driver of stolen car 3) Officer demonstrates firing-position when driver shifted vehicle into reverse & sped back toward peace officer car where a second peace officer was standing in the oncoming path (second peace officer not shown).

Reconstruction Complete

Throughout this process, each of the following hadbeen determined and modeled:

a. Dimensions of scene
b. Dimensions and positions of each vehicle
c. Speeds and motions of each vehicle
d. Speeds and motions of each officer

All the elements are combined to create an accurate, time-synchronized recreation of the event. The final result can now be animated and viewed from any perspective, including that of the firing officer.

Conclusion

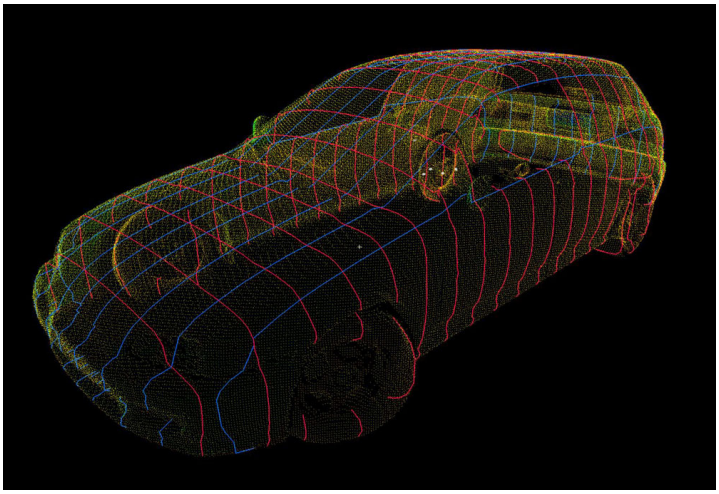
The RESULT? An accurate, technically sound visualization of the officer's perspective when he made the decision to fire his weapon.

The defense attorney, assisted by the expert's comprehensive reconstruction, and PSI's computer generated simulation, was able to determine that the physical evidence corroborated the peace officers' version of the incident and conclusively established that the officers' use of deadly force was reasonable.

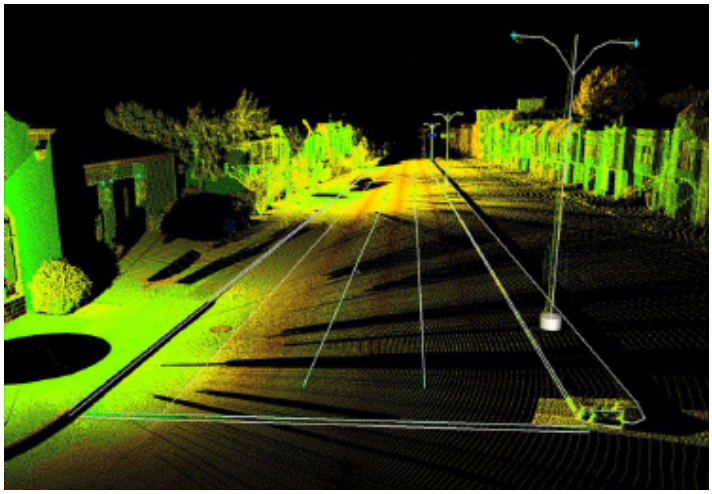
"PSI's analyses resulted in a visualization so powerful, and so precise, that I could have obtained a defense verdict with it alone" **- Defense Attorney**

Gallery

Scene from Animation



Laser Scan Cross Section of Honda



Laser Scan of Scene

Scene from Animation

Scene from Animation

Scene from Animation

Original Scene Photo