

# Close-Range Photogrammetry as a Routine Crash Reconstruction Tool within the Florida Highway Patrol

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## Background:

Law enforcement agencies utilize the principles of traffic crash reconstruction for analyzing the dynamics of collision events. Often the police officers reconstruction work is used in trial and other litigation.

Police have traditionally employed a range of dimensional measurement techniques for traffic crash reconstruction. These include the roll wheel, steel tape and more recently the electronic distance measuring total station. The total station has resulted in more comprehensive scene measurements and better diagrams than traditional methods employed in the past. However, often times, delays in getting the total station to the scene can quickly negate its effectiveness. Even with quick response, the time from incident occurrence to completion of both the traditional baseline tape method or the total station, can often be over two hours and as high as four, or in some cases even more. It is clear that no measurement tool is “perfect” in accident reconstruction and that a “tool kit” of devices is best utilized to perform the task.

## New Approach:

In 2002, the Florida Highway Patrol (FHP) and the Florida Department of Transportation (FDOT) agreed on goals of opening Florida highways within 90 minutes from the time the first officer arrived at the crash scene. This new course of incident management was identified as the “*Open Roads Policy*”<sup>1</sup>.

Goals of the *Open Roads Policy* include improved officer safety in crash investigation by reducing the amount of time the roadway is closed and to reduce traffic delays, including concerns of secondary crashes.

To support these objectives, FDOT and FHP representatives researched and attended numerous incident management presentations offered by other successful state police agencies around the country that had implemented a technology called “*close-range photogrammetry*”. During the 2002 FDOT / FHP investigation, the teams consensus was that close-range photogrammetry allows troopers to reduce their on scene time by photographing the crash and later “mapping the crash” using a computer back in the office.

While the Florida *Open Roads Policy* does not apply to homicide scenes, the FHP has felt the need to quickly process the crash scene and begin opening highway lanes as soon as possible. Regardless of the severity of the crash scene specifics, motorists are generally impatient in ‘long backups’ and expect the roads reopen as quickly as possible. This situation is exacerbated by the need for more accurate scene documentation for the integrity of the investigation, and successful prosecutions. As a result, FHP investigators now find themselves having to collect more comprehensive and accurate data in a shorter period of on scene time.

Utilizing a digital camera on scene, as a *measuring and mapping tool*, the FHP has found that photogrammetry is value-added in supporting the *Open Roads Policy*; resulting is less time on the road verses other measurement methods used in the past.

**The Photogrammetry Approach:**

The term “*photogrammetry*” is derived from three Greek words; photos meaning light, gramma meaning to drawn, and metron meaning to measure. It is the science and technology of generating 3D information from 2D measurements, nowadays mostly from digital camera images. The process entails taking pictures (either analog film or digital camera images) from different overlapping view perspectives. These multiple image perspectives are imported into a PC-based photogrammetry software program where the same entity, using two or more images, are marked i.e., “cross referenced” to each other. The 3D coordinate information is derived via a process

called photogrammetric bundle triangulation; where the 3D points are computed automatically without operator intervention<sup>2</sup>.

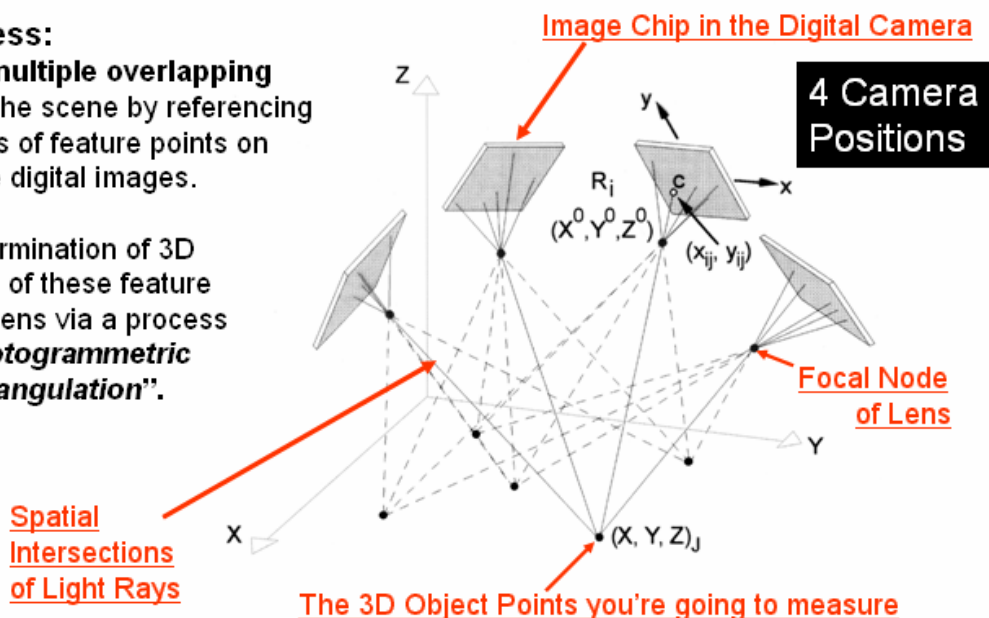
The photogrammetric process solves for the camera positions and 3D coordinates. The technology also offers the capability of computing lines and non-contact measured polylines. The operator can add point names to the measured entities, scale the project units, assign a specific coordinate system and ‘mathematically level’ the coordinate system to gravity. The result of the image-based measurement work is typically exported in the Drawing Interchange Format (DXF) for diagramming use in a CAD drawing program.

As part of the implementation process, the FHP had tried different low-cost commercially sold close-range photogrammetry software systems and ultimately selected the *iWitness™* program [www.iwitnessphoto.com](http://www.iwitnessphoto.com).

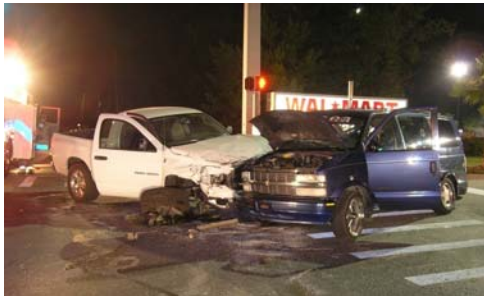
Close Range Photogrammetry (*inside and outside the camera*)

**The Process:**

1. Record **multiple overlapping images** of the scene by referencing 2D positions of feature points on two or more digital images.
2. The determination of 3D coordinates of these feature points happens via a process called “**Photogrammetric Bundle Triangulation**”.



Although the FHP has successfully demonstrated that photogrammetry can be used on scenes that are tens of meters in overall length, the following example illustrates a two-car crash at night that blocked a busy intersection. The incident involved a violation of right-of-way, where one of the drivers involved was arrested for driving without a valid driver's license. This case was later resolved in a conviction and the "scene mapping" was important in the litigation.



This crash scene comprised largely of measuring photogrammetric "natural feature points", being the crosswalks, signage, vehicles, tire markings, and other critical scene evidence.

Photogrammetric "markers" were also used in the measurement process. The markers can be used to "measure evidence", however, if the officer can photograph discrete points of interest, those features can be 3D measured by *natural feature point marking*. The markers assist in fast and accurate orientation of the cameras from where the pictures were physically taken from.



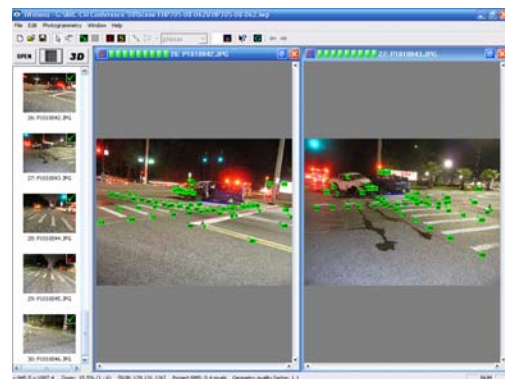
Markers: courtesy of [www.iwitnessphoto.com](http://www.iwitnessphoto.com)

### Crash Scene Mapping Time:

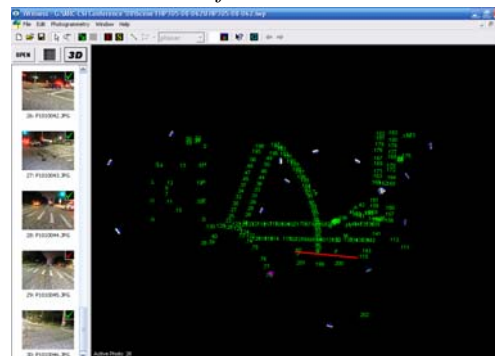
It took the FHP trooper 13 minutes to acquire the pictures of the crash scene that was 193' long by 127' wide. In addition to "imaging time", it took another 5 minutes to set the photogrammetric markers in the scene before the imaging. Following the crash scene work, it took 3 hours of office time by one trooper to do the photogrammetry and CAD diagram computer work.

All (night images) were taken with the camera being tripod mounted, using time exposures on average of 5 seconds each, which produced good image exposure. Seventeen images were used in the photogrammetry work, on a PC, back in the office. Two hundred and two 3D points were measured in iWitness to an accuracy of 1/4" RMS, as verified by scene check distances as well as the program's auditing tools.

### Marking the digital images in iWitness

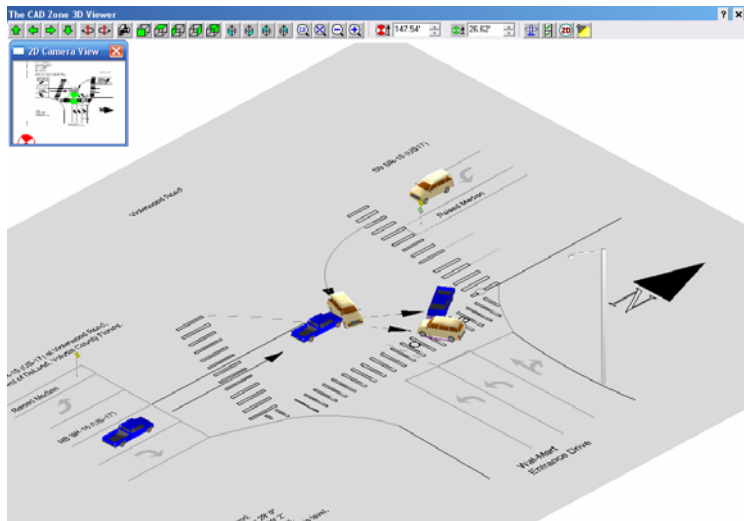
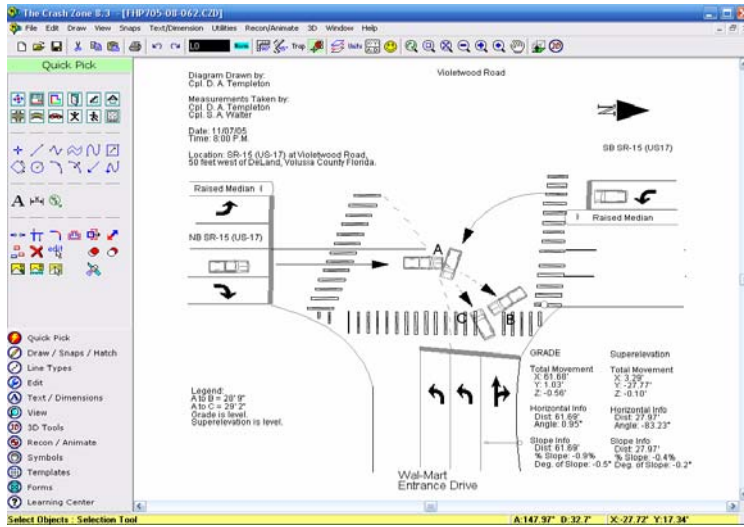


### PLAN VIEW of 3D measured entities



The iWitness work was then exported into the Crash Zone (diagramming software) [www.cadzone.com](http://www.cadzone.com) where vehicles and other symbols were also added to complete the crash scene diagram.

based photogrammetry technology, where it is used as an accurate, fast and easy-to-use “tool” in crash scene mapping investigations.



***A snapshot of  
Photogrammetry***

Close-range photo-grammetry is non-contact measurement requiring multiple pictures captured at the scene for measuring feature points of interest. The technology is best applied by using a good quality digital camera for fast, accurate and permanent 3D data recording.

***Some Photogrammetry applications in Accident Reconstruction are:***

- Crash scene mapping
- Vehicle crush profiling
- Homicide scene mapping
- Aerial 3D diagramming
- Bullet trajectory
- Mapping road and surface defects
- Using others (bystanders) pictures for extracting critical measurements
- Used cooperatively with other measurement technologies for scene diagramming

**Concluding remarks:**

Close-range photogrammetry has proven to be a value-added tool for the Florida Highway Patrol’s mapping capabilities.

Although the traditional baseline approach, as well as the total station is still employed within the FHP, it is noteworthy that over 200 FHP troopers have been trained in the *iWitness* image-

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