

# **Crash Scene Mapping of a Street Intersection with *iWitness* – Close-Range Photogrammetry**

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## **Background**

Photogrammetry is widely used in Law Enforcement in the documentation of crash scene evidence.

When a crash scene occurs, sometimes it's difficult to "link" the required scene pictures together, for creating the photogrammetric 3D model. This situation is exacerbated when emergency response vehicles are parked in the crash scene and evidence is temporarily occluded. As police investigators know, the problem of occluded line-of-sight during crash scene mapping is not limited to just photogrammetry, but 3D diagramming in general... if you can't see it, you simply cannot measure it.

In order for Close-Range Photogrammetry software to compute XYZ coordinates and solve the camera's aim point, it requires a minimum of seven conjugate markings in the first set of marked images (utilizing a photogrammetric procedure referred to as "referencing".) The third and subsequent images require a minimum of five referenced 3D points. These referenced "pairs" of features can be obtained from natural scene objects or using synthetic targeting. Synthetic targets are referred to as "Photogrammetric Markers" (or PMs) in this document. Natural Features are any objects in the photos or digital images that can be discretely marked in two or more images.

*iWitness* utilizes a powerful feature that allows one to "link" different sets of images from different coordinate systems (commonly referred to as "networks".) These networks are linked using the *iWitness* tool called *3D Transformation to Control* (or TTC.) The TTC process is documented and can be reviewed here for more information:

[http://www.iwitnessphoto.com/iwitness/images/3dtrans\\_to\\_control.pdf](http://www.iwitnessphoto.com/iwitness/images/3dtrans_to_control.pdf).

The referenced pairs of 3D points noted above, are considered a 'bare bones' minimum of required points per image, to mathematically solve the camera position and to triangulate XYZ 3D points, lines and polylines. It is advised that a quantity of twenty 3D points (or more) is marked in the initial reference pair of images, with at least a dozen referenced points in subsequent images.

## **Requirements in the Field and then on the Computer**

Some users of close-range photogrammetry programs expect to photograph the scene, upload the pictures to the photogrammetry software program, measure it and "be done". The fundamentals here are photogrammetric imaging requires enough discrete features that are efficiently and accurately reference-marked in order to *orient the camera position(s) in 3D space*. For

terrestrial-based imaging, it is much more efficient to utilize *Synthetic Targets* (PMs) in combination with marking *Natural Features*. The PMs are primarily used for camera orientation and in some instances for marking actual evidence; but it is a misnomer to classify PMs strictly as “evidence markers” because their deployment is better suited for accurate camera orientation.

### Recommended Scene Protocol

1. Set the PMs (eg. [www.iwitnessphoto.com/products/pm.html](http://www.iwitnessphoto.com/products/pm.html)) where the “white target dots” are all facing the same relative direction/orientation. This “clocking” of the PMs makes it easier (and faster) in the *Referencing* process within *iWitness*.



NOTE: in Figure 2, illustrated are a quantity of 5 PMs on the radii of the 4-way street intersection corners.

2. The 4 traffic cones illustrated in Figure 2 and Figure 3 are representative of Control Points (CPs). These CPs are “anchor points” that are *not moved* during imaging and are used to mathematically “link” two (or more) *iWitness* networks into the same coordinate reference system. An example of CPs using typical traffic cones and DCS “cone style markers” can be seen at: [http://www.iwitnessphoto.com/products/cone\\_rpms.html](http://www.iwitnessphoto.com/products/cone_rpms.html). It should be noted that CP’s often consist of natural features and also synthetic style PMs. However, PMs are typically measured much more accurate than natural features based on *iWitness*’ ability to semi-automatically “center” onto the PM dot (i.e., target centroiding feature).

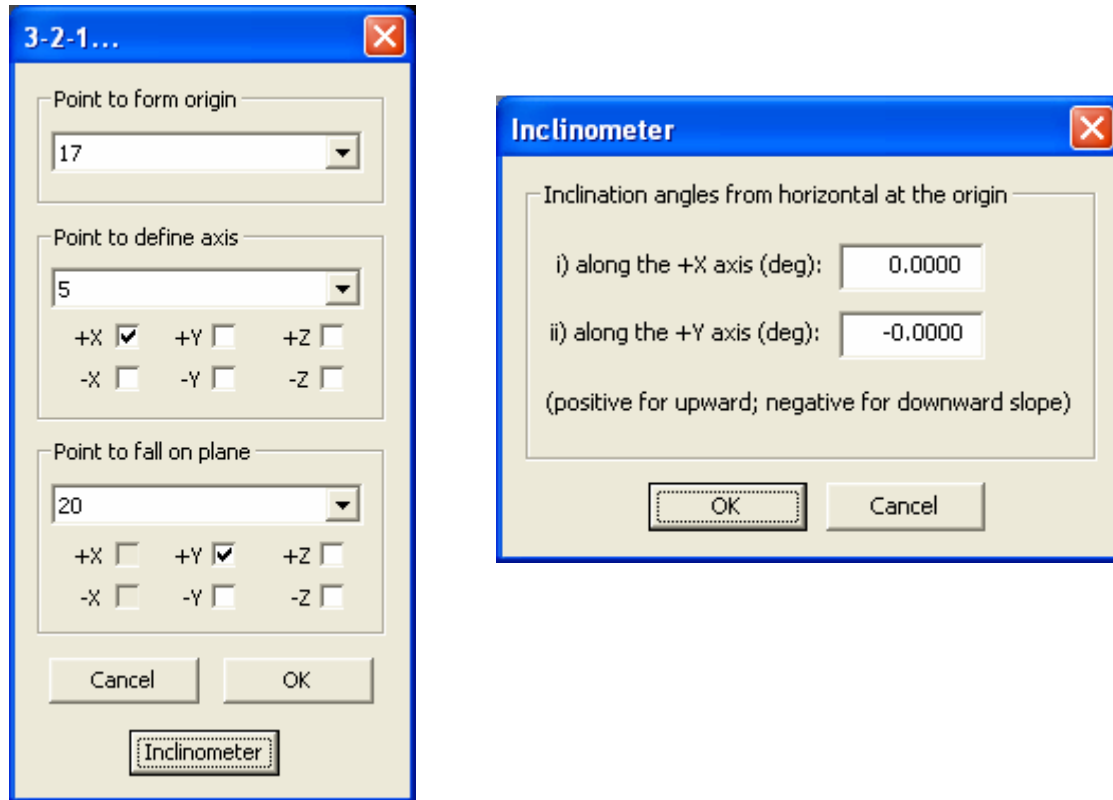
3. The PMs should be placed off to the sides of the roadway and in some instances used cooperatively to establish curbing and other features of interest. Space the PMs about every 10 to 50 feet – (it depends entirely on scene “mapping” overall distance.) The key is to spatially separate the PMs in a manner that permits at least a quantity of eight of them to be imaged within the cameras field-of-view and imaged from many different perspective angles. Each PM should be seen from a minimum of three, preferably four or more camera positions.

4. At least one (prefer two) scale distances must also be measured with an e.g. fiberglass tape and recorded at the scene. For example, one might place three PMs in the shape of an “L”, whereas the long leg of the “L” is tape measured as 30 feet, and the shorter leg is measured as 20 feet. These distances are used to scale the Units of the photogrammetric network.

5. As part of a Standard Operating Procedure for many police agencies, the police investigator will measure/record the roads gradient. In the case of measuring with an EDM total station, the instrument is leveled to gravity, so “Z height” measurements are “true” to gravity. For *iWitness*, it accomplishes the same “leveling” of the coordinate system to gravity by using a utility feature within the program called “*Inclinometer*”. At the scene, by

measuring two angles at the photogrammetric origin point, (ORIGIN) along the X and Y axis of the coordinate system, the two angles are input into the *Inclinometer* dialog box to “level” the XYZ coordinate system to gravity.

**Figure 1** illustrates the two dialog boxes within *iWitness* to establish the coordinate system, and “level” to gravity using the two inclinometer angles.



### Camera Geometry

As previously noted, close-range photogrammetry requires the same features imaged from different perspective angles. The best way to achieve this task is by moving the camera from left to right (or vice versa) working in a “semi ring pattern.” Additionally, taking pictures in “waves” of the aforementioned semi-ring pattern is also helpful for achieving the camera angles for the multi-image triangulation process. **Figure 2 and 3** *only* illustrate the overall “rings” of images. The key is to work in “waves” of images where feature points of interest are seen from many different angles with enough common features to “reference mark.”

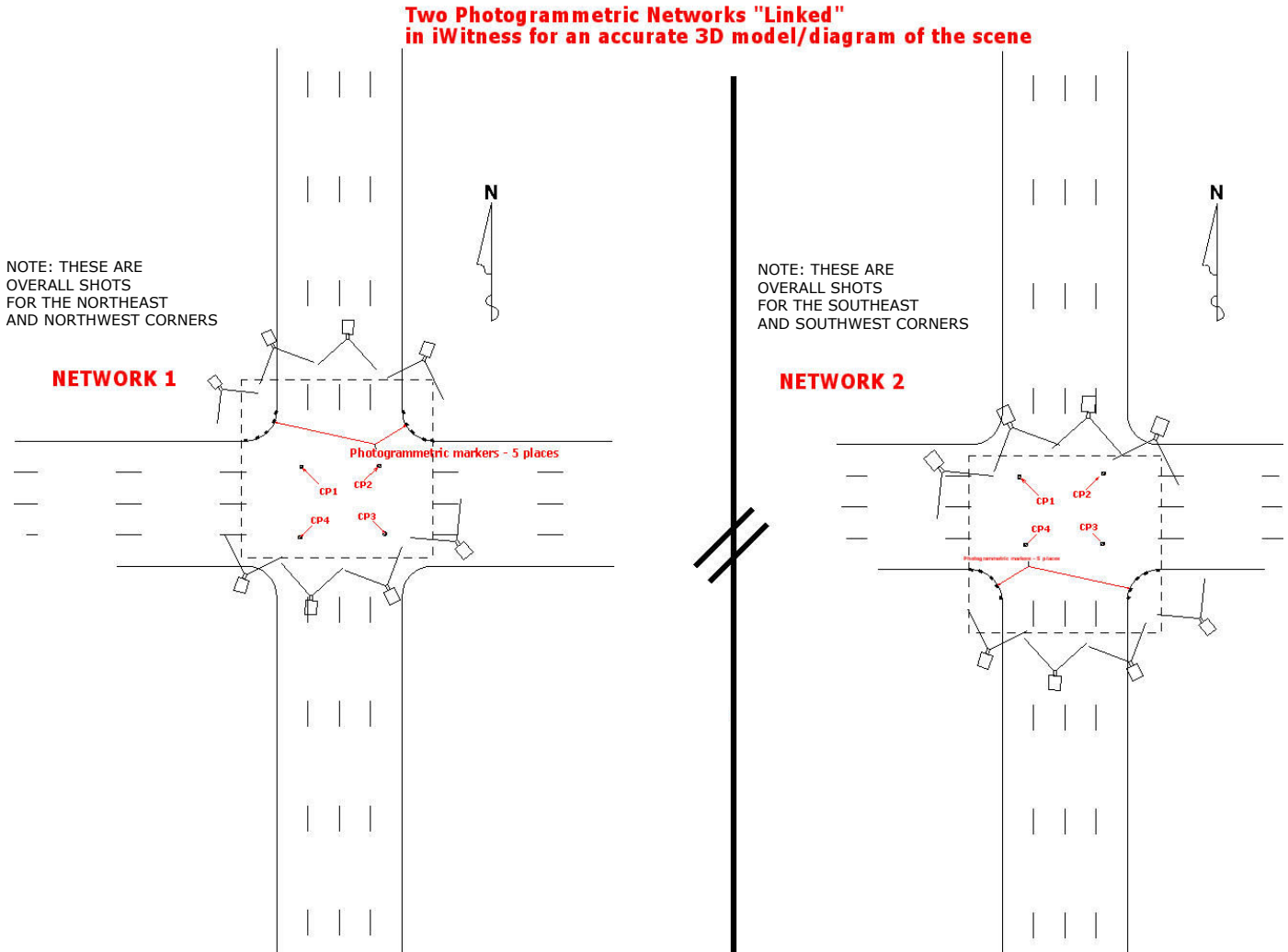
### Camera Settings

The camera should first be metrically calibrated using *iWitness*. The settings recommended are:

- (Assuming zoom lens) *widest* field of view (e.g. 18mm.)
- Focused at Infinity and Camera set at Manual Focus (MF.)
- ISO 400 (is fine)
- Image Resolution [Fine] or [Best] (name depends on manufacturer.)

- Format: Highest JPEG Resolution
- Flash: optional for day use; at night, not recommend, shoot long exposure on tripod.

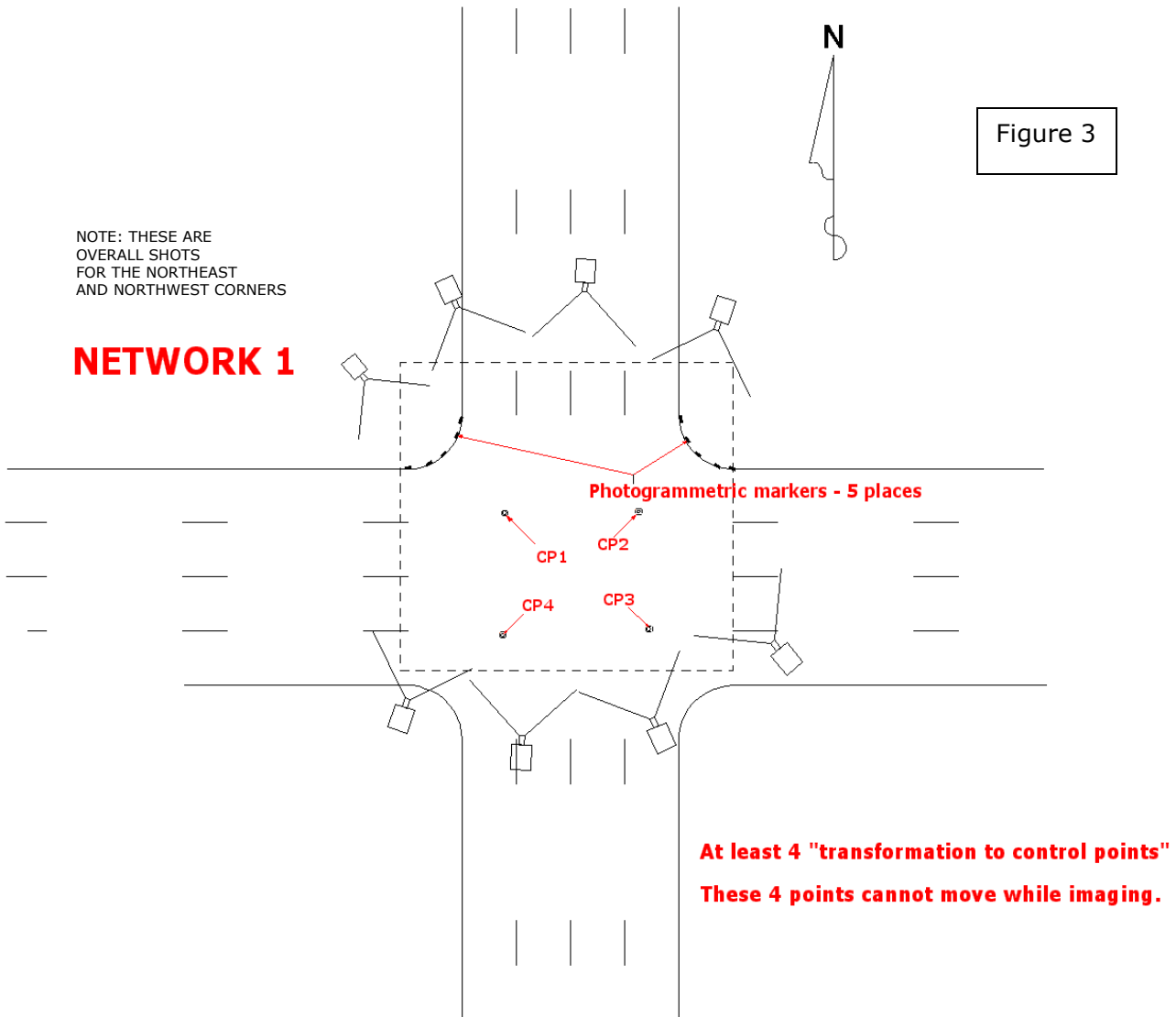
**Figure 2** (overview of two project networks encompassing an intersection and camera geometry)



**Figure 2** is the same intersection, with the dashed lines encompassing two of four quadrants of the intersection. In the center of the intersection are 4 CPs that constitute the "3D linking points" of both networks. As previously indicated this "linking" (TTC) procedure is already documented and noted in a link in this document.

**Figure 3** and **Figure 4** are expanded views of Figure 2 for ease of reviewing. The PMs are noted as thick black lines on the radius corners of the street intersection.

Figure 3



Notice how the camera positions do not encompass the southeast and southwest corners of the intersection. The intersection is 'broke' into two sections and Network 1 focuses attention on the north portion of the intersection. As long as four or more images of Network 1 image the CPs, it can be "linked" to Network 2 using *iWitness'* 3D transformation to control feature.

NOTE: THESE ARE OVERALL SHOTS FOR THE SOUTHEAST AND SOUTHWEST CORNERS

## NETWORK 2

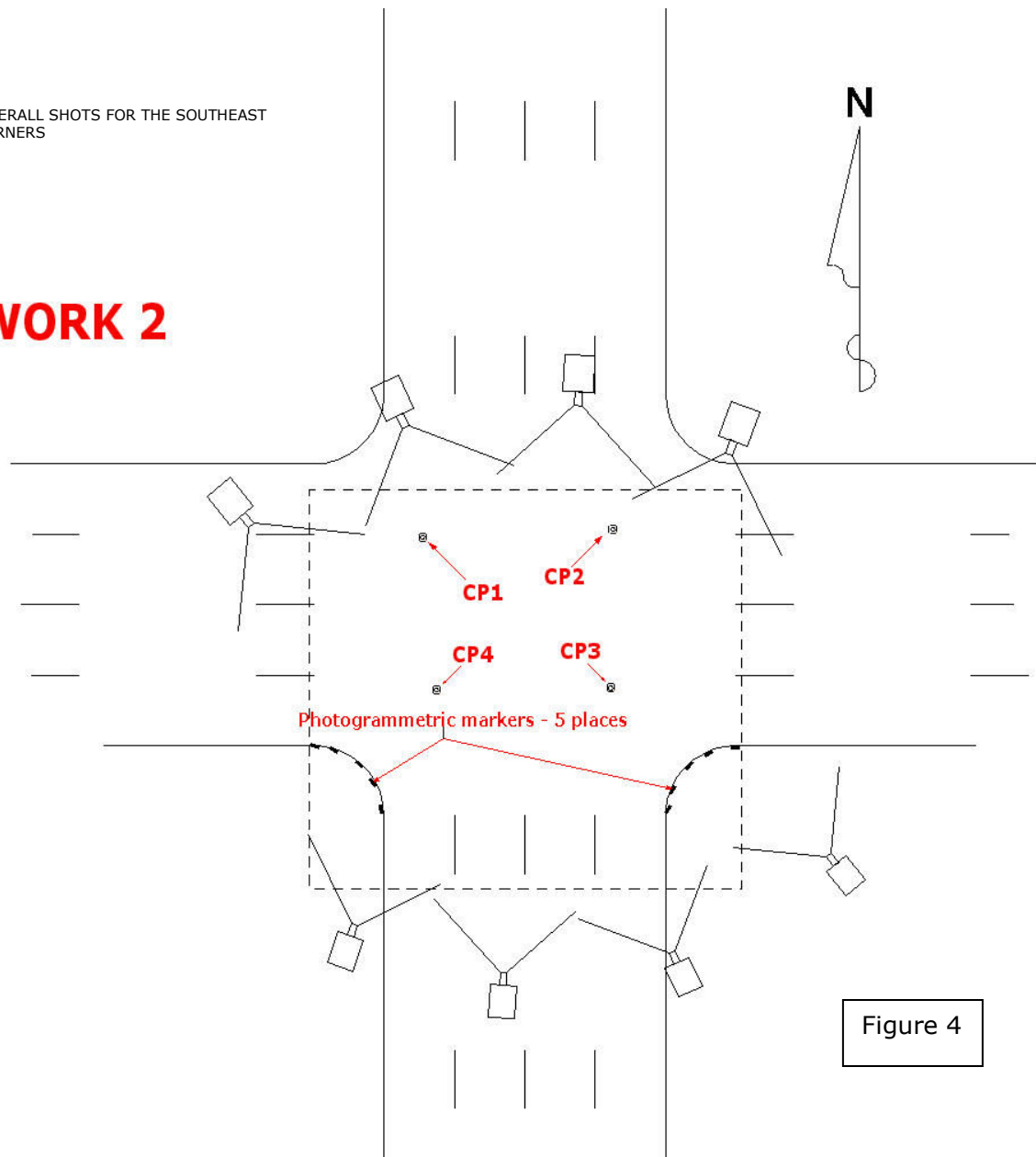


Figure 4

Notice how the camera positions focus on the southeast and southwest corners of the intersection.

### Recycling the PMs During Imaging

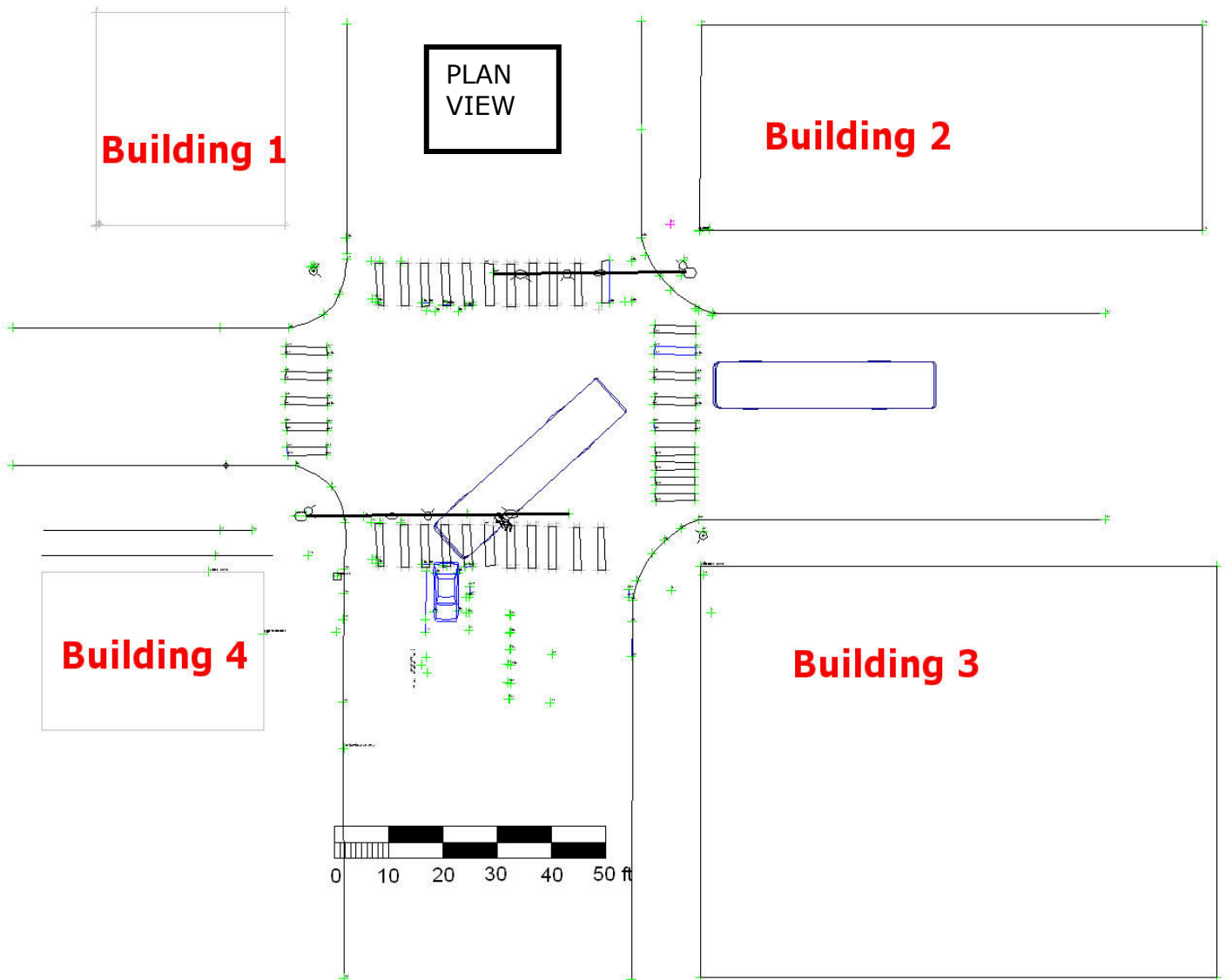
One might question that "in order to do the multiple networks it must require a vast quantity of PMs to do the task?" The solution is, once Network 1 is complete, the PMs should be "recycled" for use in Network 2. This keeps the linking process 'clean' by avoiding the same PMs measured twice, in two or more networks and it also cuts down on the requirement for a large amount of PMs on scene.

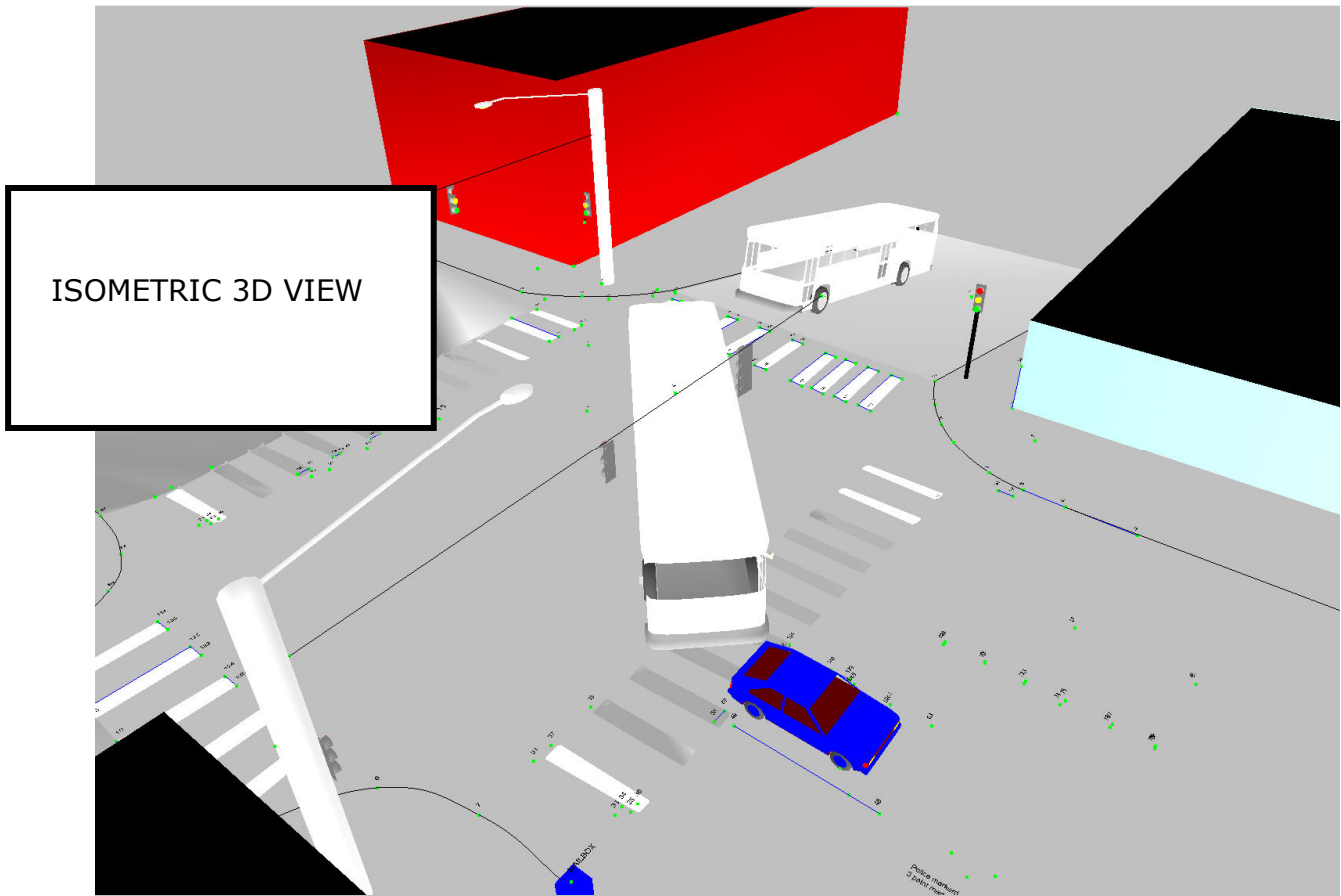
## Result

Once the two networks are measured, and TTC is used, the results of the intersection will be mapped to scale in the same coordinate system - ready for DXF export into your favorite CAD diagramming program. The 3D coordinates will also be "level to gravity".

## Real World Example

The *iWitness* project noted below was accomplished in a "live" intersection... the traffic was never interrupted. The photography was accomplished a day after the incident, which involved a bus and a pedestrian. The PMs were placed on the curbing and CP marking was accomplished from the overhead street lights as well as using a few PMs. The project imaging took place in 40F temperature and pouring rain. The pictures were acquired in 45 minutes. The photographer used the "crosswalks" to acquire some of the images in the street. The photogrammetric 3D point accuracy was .5" RMS.





### Summary

The method for mapping a street intersection with *iWitness* has been summarized here. The key is to use the environment to your advantage when accomplishing the scene imaging. When objects are occluded, or spread out over a large area, use the powerful software tools within *iWitness* to “link” subsets of projects (networks) together; be it a scene that is only 150’ in distance or as much as 1500’, or even longer.

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[www.iwitnessphoto.com](http://www.iwitnessphoto.com)

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