Proving the Facts through Close Range Photogrammetry

By Lee DeChant,
DeChant Consulting Services – DCS Inc

Introduction

In accidents involving personal injury, digital photography often plays a critical role in determining the root cause of the incident. Close-Range Photogrammetry (CRP) techniques are used in accident scene reconstruction to derive accurate 3D measurements from photos taken at the time of the event. CRP is a proven measurement technique that can essentially extract three-dimensional information from two-dimensional photographic images.

This article investigates an actual accident were a metro bus hit a woman. The woman was standing on the sidewalk when an articulated bus approached a bus stop. CRP software was used to measure photographs taken at the scene, and to prove whether the bus driver was responsible for hitting the woman as the bus approached, or whether the woman actually stepped over the curb onto the street, hence no fault of the driver.

The Incident

A witness at the incident stated they saw a middle-aged woman talking on her cell phone, standing on the sidewalk, while waiting for a bus to arrive. The witness also said the woman was facing south, while the southbound metro bus was approaching the bus stop. The woman then changed her body direction from south to north, turning through east – the street direction. As the woman turned, the metro bus struck the woman in the face, leaving evidence of a 1.5" wide 'spider crack' in the lower-right hand corner of the bus' front windshield, as shown in Figure 1.

FIGURE 1

Witnesses state the woman was thrown off her feet from the impact, and landed a short distance away on the sidewalk. Witnesses also explain that the bus, while proceeding southbound, did *not* make an abrupt east-to-west lane change before the incident. The bus, after striking the woman, stopped thirty feet south of the actual collision area. The bus driver turned the front portion of the articulated bus away from the curb, at a slight angle, prior to stopping. The rear section of the articulated bus section, however, remained parallel to the street, as it tracked directly adjacent to the curb until its final rest position.

Local police arrived, interviewed witnesses, and documented the scene using an Olympus C5050 digital camera. The officers acquired about twenty digital pictures of the incident scene from different camera angles and perspectives. They also placed a 30 inch-high orange traffic cone next to where the woman was laying on the sidewalk after the impact. There was evidence of blood on the sidewalk where the woman fell. She received multiple broken bones to her face as a result of the impact with the bus windshield.

Ensuing Litigation

In deposition, the injured woman (plaintiff) stated she was standing on the sidewalk, but not at the position where the street meets the curb. In brief, she explained how the bus approached and struck her down while she stood on the sidewalk. The accident reconstruction expert hired by the plaintiff's counsel went to the scene after the incident, measured the along and across-road gradients (i.e. the slope of the roadway), as well as other hand measurements of the scene. Shown in their reconstruction diagram was a simple rectangular shape that represented the bus relative to the street, sidewalk and curbing. The report placed the length of the bus at a slight inward angle of about 85 degrees to the sidewalk where the woman was standing – thus indicated the cause of the incident. It was the reconstruction expert's opinion that based on his analysis; the bus had indeed broken the vertical plane of the curbing onto the sidewalk area where the woman was standing.

The defense hired their own accident reconstruction expert, who in turn teamed up with a photogrammetrist, and measured the incident from the police department's digital imagery captured at the scene.

Determining the Facts Using Close-Range Photogrammetry

Image-based measurement software was used to determine whether the bus had moved over the curb and encroached the sidewalk area. Due to the nature of the incident and the small area of interest, accuracy of the 3D photogrammetric measurements was critical – with tolerance required to be within a few tenths of an inch. Several steps were taken to ensure this required accuracy was achieved in the analysis.

The photogrammetrist received a CD of the digital imagery, in JPEG format, that was acquired by the police officers at the scene. These images were imported into the *iWitness*^{TM} http://www.iwitnessphoto.com photogrammetry software program and reviewed. *iWitness* automatically recognized the pictures were taken from an Olympus C5050 digital camera. The imagery was acquired at the widest possible angle for the camera (smallest focal length, or zoom). With this camera information, a preliminary analysis was conducted in *iWitness*, and it was determined that the imagery would provide accurate photogrammetric 3D modeling of the incident scene.

Five images were selected for measurement within *iWitness*. To achieve the best possible accuracy, the photogrammetrist visited the police department and calibrated the *actual* camera used at the time of the incident.

Further to the Olympus camera calibration, the actual bus, bus depot, sidewalk and street were also surveyed using a calibrated Nikon D70 digital camera and the *iWitness* photogrammetry software. Numerous distances were also measured with a steel tape for verification as 'check distances' used in scaling the digital imagery in the photogrammetry process.

The Photogrammetric Analysis

It was the defense expert witness' conclusion that the rear portion (articulated section) of the metro bus could *not* possibly have been closer to the sidewalk curbing, as it directly follows the front section of the bus. As the entire side of the bus is straight, it was possible to *'translate'* the evidence (i.e., spider crack of the windshield) back to the point of impact, regardless of the fact the bus driver had turned the front section of the bus at several degrees away from the sidewalk curbing before stopping. The front portion of the bus had not traveled far enough forward to change the angle of the rear-articulated section of bus. The rear articulated section of the bus and the adjacent curbing became key indexes for the photogrammetric analysis.

The photogrammetrist measured the front and the passenger side of the bus from the police digital images, as well as the aft-articulated section of the bus, as shown in Figure 2.

In addition, four key photo-grammetric points (as indicated by the white arrow in Figure 3) were measured on the top surface of the curbing close to where the impact occurred.

These points established the photogrammetric coordinate system by defining the curb's horizontal plane. This plane was extruded upwards in a CAD model – and this appears as a solid blue "monolith" in Figure 4. This monolith provides a three-dimensional vertically extended plane directly over the sidewalk/curbing and perpendicular to the street space.

iWitness photogrammetry software **FIGURE 2**

If the points measured on the bus encroached this area over the curbing, the bus would therefore have been responsible for violating the sidewalk space where the woman was standing. Conversely, if the measured articulated section of the bus was proven *not* to have entered this area, the woman must have had a portion of her body over the street area, hence she encroached the space of the approaching metro bus, and the bus would not be responsible.

The *iWitness* photogrammetric 3D model was imported into *The Crash Zone* CAD diagramming program to complete the analysis. Accuracy of numerous check distances that were previously measured with a steel tape and the Nikon D70 photogrammetric survey revealed the measurement accuracy of the police measured images was better than ¼" (RMS 1-sigma level). As Figure 2 illustrates, the green photogrammetric 'point tags' were measured on the articulated portion of the bus. These 3D points established the translation (i.e. the physical movement) of the 'spider crack', essentially projecting it back to the location of the woman at the time of the incident, which was close to the articulated section of the bus final rest position.

Figure 4 illustrates the extruded 'monolith' from the four points on the curb; the same location as indicated by the white arrow in Figure 3.

The photogrammetric measurements of the bus, relative to the sidewalk and curbing, prove the woman must have had her body leaning over the curb and into the street space.

The measurements, when imported into the CAD program, revealed the woman's face was at least three inches into the street space, hence the reason she was struck by the bus.

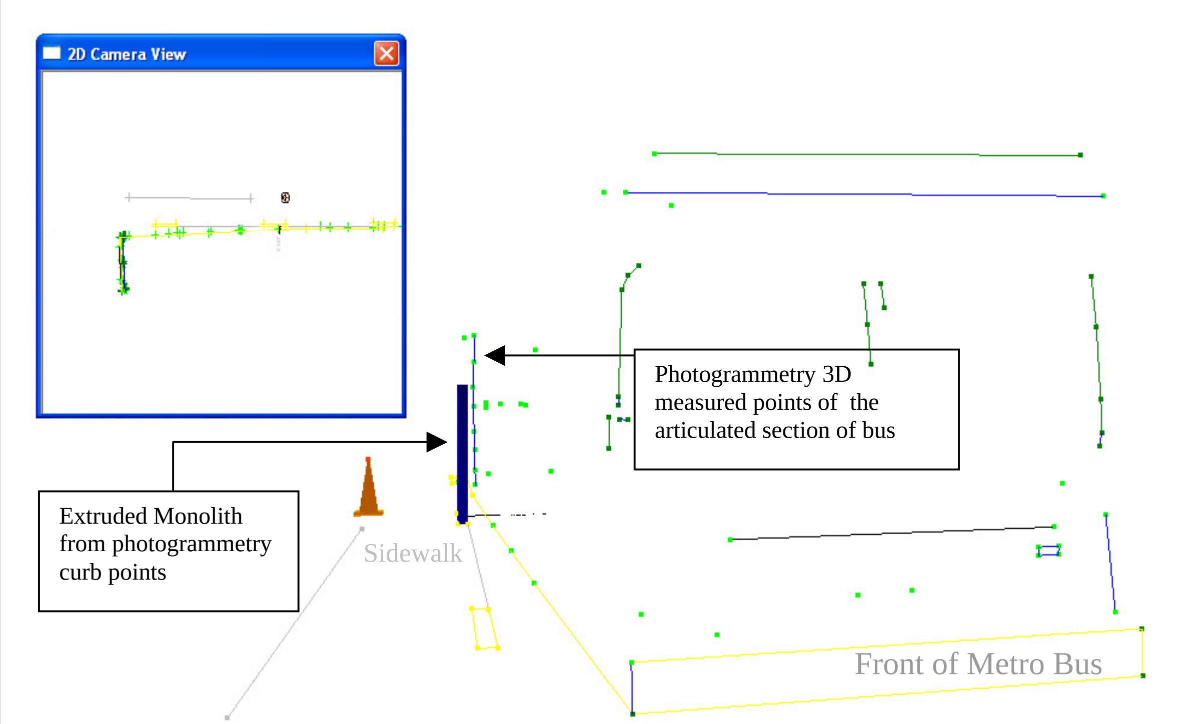
Conclusion

The digital imagery captured by the police, in addition to the *iWitness* close-range photogrammetry software, provided the necessary information to prove where the woman was standing when the bus arrived at its destination.

Photogrammetry has proven to be an invaluable tool in police forensic investigation and accident reconstruction mapping applications. However, it is critical that imagery is captured in way that is conducive to accurate measurement using photogrammetry. Primarily this involves multiple shots of the area of interest from different view points and perspectives, without changing the camera zoom. In this case, the police captured sufficient imagery of the incident to follow-up with an accurate photogrammetric mapping of the scene.

This case settled out of court, and the photogrammetric results played an integral role in avoiding further litigation.

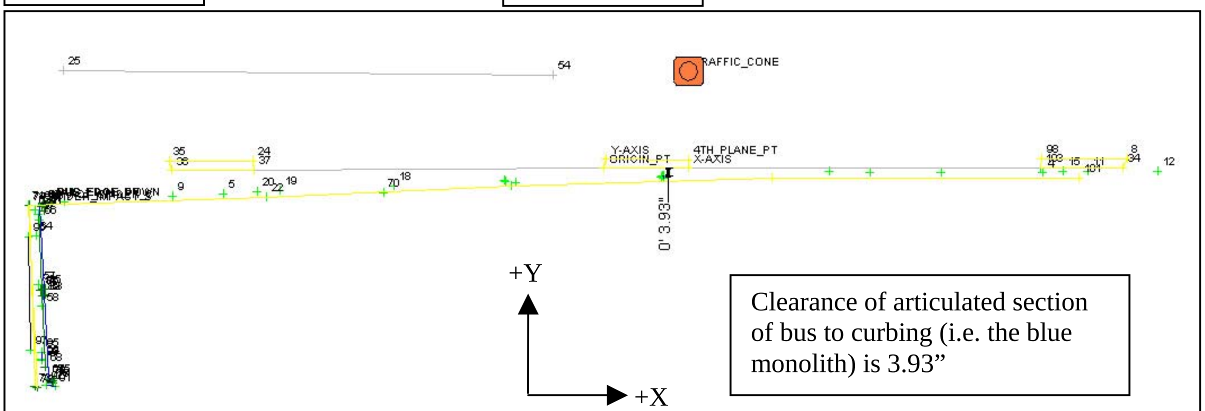
FIGURE 4



<u>Forward (Looking Aft)</u> at the measured 3D points and lines of the articulated section vs. the index plane being the navy blue monolith representing the street curbing

FIGURE 5

Plan View



About the author:
Mr. Lee DeChant is the President of DeChant Consulting Services (DCS) in Bellevue, WA. DCS provides photogrammetric image-based analysis services. Mr. DeChant can be reached at 425-637-1865, or email at lee@photomeasure.com

###