C22 Load Shift vs. Jackknife—The Use of Photogrammetry in Accident Reconstruction

Harold E. Franck, MSEE, PE, and Darren H. Franck, BSCE, Advanced Engineering Assoc., 4713 MacCorkle Avenue, SE, Charleston, WV*

Participants will learn how vehicle wire frame models may be photogrammetrically superimposed on accident scene photographs. These photogrammetric techniques can then be used to assess whether a vehicle lost control as a result of a weight shift or because the driver jack-knifed the tractor trailer.

In the early morning hours, a tractor with box trailer overturned on a gentle curve. The tractor remained on the road surface while the box trailer carrying rolls of paper proceeded over an embankment. The driver sustained permanent injuries to his right hand. The next day, the driver's father photographed the tire marks deposited on the road surface that were produced by the tractor-trailer as it lost control. The driver claimed that the paper load in the box trailer shifted causing the loss of control and ensuing accident.

The authors were asked to investigate this incident to substantiate the claims of the tractor-trailer driver. From a preliminary review of the police report and the photographs taken by the driver's father, it was revealed that the accident was not produced by a load shift. Counsel for the driver was informed that the physical evidence did not support the load shift hypothesis. Further analysis was not performed until a few days before the ensuing trial.

As the trial date approached, counsel for the driver provided the authors with the defense expert's report and asked if the defense scenario of the accident matched the physical data. The attorney for the plaintiff had, in the intervening time period, obtained a trucking expert who supported the weight shift scenario. Upon review of the opposing expert's report, it was determined that the defense reconstruction was consistent with the physical data, within engineering accuracy, obeying the laws of physics, and descriptive of the accident scenario. When informed of the authors' findings, plaintiff's counsel was still not satisfied and asked for further analysis. Since the defense reconstruction was deemed to be correct, photogrammetric techniques were used to show the plaintiff's attorney why the defense reconstruction was correct.

In order to show the vehicle path in a more dramatic fashion, the scene was accurately reconstructed in a virtual three-dimensional environment. The virtual scene was not rendered and animated in order to save expenses. The scene, including the tractor-trailer, was drawn in wire frame so that it would become transparent when superimposed on photographs. In this manner, plan views of the procession of the accident could be compared to camera views of the tire marks deposited by the tractor-trailer. The camera views were photogrammetrically aligned to the photographs taken by the driver's father.

In order to accurately align the wire frame camera views on the photographs, an accurate survey of the road surface must be made. The survey may be accomplished with a laser transit that stores the appropriate azimuth elevation, depression, and distance readings. The data may be stored electronically and downloaded into AutoCAD and 3D Studio Max. The data is used to construct the wire frame rendition of the road, guardrails, poles, and any other pertinent information. The wire frame rendition of the tractor-trailer is then added to the scene. The photogrammetric alignment of the camera view in wire frame then takes place. This alignment uses the horizon or zenith lines in the photograph along with the inclination angle of the oblique angle photographs and is governed on the road surface by the following equations.

$$\theta = \tan^{-1}\left(\frac{k_o}{f'}\right) \qquad (1)$$

$$\alpha_a = \tan^{-1}\left(\frac{x_a}{f'\sec\theta - y_a\sin\theta}\right) \qquad (2)$$

$$\beta_a = \tan^{-1}\left(\frac{y_a\cos\theta}{(f'\sec\theta - y_a\sin\theta)\sec\alpha_a}\right) \qquad (3)$$

Where

θ = angle of inclination
α_a = azimuth angle
β_a = depression angle

This process must be carried out for each photograph for proper camera - scene alignment. After the process is completed, the wire frame rendition of the vehicle is superimposed on the wire frame photograph. In

 ** Presenting Author*

this manner, the vehicle's path is determined and an evaluation of the loss of control is then made.

The conclusion of this type of analysis revealed that the tractor-trailer driver most probably fell asleep or became inattentive as the vehicle veered toward the right berm. The driver over-corrected and caused the tractor to be misaligned with the trailer (jack knife configured). The action produced the accident. Given the right circumstances and data, Photogrammetry may be used in a variety of ways to support or contradict accident scenarios. The combination of Photogrammetry and wire frame renditions gives incident reconstructionists a powerful visualization method for the progression of an accident.

Photogrammetry, Wire Frame Rendition, Incident Reconstruction

 ** Presenting Author*