

RATIONALE

This SAE Information Report outlines a procedure for acquiring a set of photographic images to permit preparation of a 3D crush model and determination of the exterior 3D residual crush damage of a vehicle involved in a collision with accuracy sufficient for accident reconstruction purposes.

1. SCOPE

The 3D crush model can be obtained by any suitable photogrammetry method using this image set and is intended to graphically represent in photographs the shape and orientation of the damaged surface(s) relative to the undamaged, or least damaged, portion of the vehicle. The procedure is intended to provide an image set sufficient to determine, with the use of photogrammetric methodologies, the 3D location of points on the crushed surface of the damaged vehicle.

Measurement of the exterior damaged surface(s) on a vehicle is a necessary step in quantifying the deformation caused by a collision and the energy dissipated by the deformation process. The energy analysis is sometimes called a crush analysis. Evaluation of the energy dissipated is useful in reconstructing the change in the velocity of the vehicles (delta-V) involved in a collision.

This guideline is intended for use by investigators who do not have photogrammetry expertise, special equipment or training and may be constrained to a short time period for photography. The person who captures the image set is not expected to perform the photogrammetry or to necessarily understand how it is accomplished. It may be used by law enforcement personnel, safety officials, insurance adjusters, and other interested parties.

This guideline has a written body which explains the foundation for the procedure and an appendix which specifies the procedure with accompanying diagrams. Appendix A is intended to be used as a separable field guide.

This procedure recommends capturing more images than are absolutely necessary rather than specifying the criteria for selecting the absolute minimum set.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

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2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

1. Kerkhoff, J., "Photographic Techniques for Accident Reconstruction," SAE Technical Paper 850248, 1985, <https://doi.org/10.4271/850248>.
2. Pepe, M., Sobek, J., and Zimmerman, D., "Accuracy of Three-Dimensional Photogrammetry as Established by Controlled Field Tests," SAE Technical Paper 930662, 1993, <https://doi.org/10.4271/930662>.
3. Tumbas, N., Kinney, J., and Smith, G., "Photogrammetry and Accident Reconstruction: Experimental Results," SAE Technical Paper 940925, 1994, <https://doi.org/10.4271/940925>.
4. Switzer, D. and Candric, T., "Factors Affecting the Accuracy of Non-Metric Analytical 3-D Photogrammetry, Using PhotoModeler," SAE Technical Paper 1999-01-0451, 1999, <https://doi.org/10.4271/1999-01-0451>.
5. Peck, L. and Cheng, M., "The Accuracy of an Optimized, Practical Close-Range Photogrammetry Method for Vehicular Modeling," *SAE Int. J. Trans. Safety* 4(2):245-266, 2016, <https://doi.org/10.4271/2016-01-1462>.
6. Fenton, S., Johnson, W., LaRocque, J., Rose, N. et al., "Using Digital Photogrammetry to Determine Vehicle Crush and Equivalent Barrier Speed (EBS)," SAE Technical Paper 1999-01-0439, 1999, <https://doi.org/10.4271/1999-01-0439>.
7. Randles, B., Jones, B., Welcher, J., Szabo, T. et al., "The Accuracy of Photogrammetry vs. Hands-on Measurement Techniques used in Accident Reconstruction," SAE Technical Paper 2010-01-0065, 2010, <https://doi.org/10.4271/2010-01-0065>.
8. Terpstra, T., Voitel, T., and Hashemian, A., "A Survey of Multi-View Photogrammetry Software for Documenting Vehicle Crush," SAE Technical Paper 2016-01-1475, 2016, <https://doi.org/10.4271/2016-01-1475>.
9. Neal, J., Funk, C., and Sproule, D., "The Accuracy of Vehicle Modeling When Using an Inversely Calibrated Camera in PhotoModeler," SAE Technical Paper 2021-01-0883, 2021, <https://doi.org/10.4271/2021-01-0883>.

3. SIGNIFICANCE

The magnitude and character of the crush damage to a vehicle may be useful for the reconstruction of the collision orientation and speeds of the vehicles and in evaluating the factors that may have contributed to the cause of a collision. Photographs taken by early observers may capture important information and are usually helpful, but they may not be sufficient for collision reconstruction. So, there is a benefit to collision analysts for a guideline that would assist early observers to capture sufficient photographic images of damaged vehicles to permit measurements for collision reconstruction to be accomplished later by appropriately trained analysts.

3.1 Camera Type and Settings

Any digital camera is suitable for the purposes of this document including cellular phone cameras. It is important to document the device used to capture the photographic images and the camera make, model, and serial number should be recorded. However, in general, higher quality cameras will deliver better quality results for the analyst performing photogrammetry. Refer to Reference 8.

The camera should be set to the highest resolution with the flash triggered for every image. If the camera has a zoom lens, it should be set to wide view. The zoom setting should not be changed during this procedure and should be periodically checked to verify it remains at the widest possible view angle. This will facilitate capturing acceptable images in the event of restricted space around the subject vehicle.

3.2 Additional Equipment

The use of a tripod may improve the quality of the captured images. Tie point objects of uniform size, such as small spheres for placement on the roof of the vehicle or background targets, may improve the accuracy of subsequent analysis of the captured images.

3.3 Subject Vehicle

If objects around the vehicle restrict access so that any of the camera positions in Figure A1 cannot be obtained, try to arrange to move the vehicle to a location with sufficient access space around it.

4. METHODOLOGY

4.1 Step One - Preparation

1. Document the date, time, and location of the photography session. Document the vehicle year, make, model, license number, and VIN if possible.
2. The camera should be set to the highest available resolution as the accuracy of the 3D model is improved by higher resolution of the image.
3. Ensure sufficient storage capacity for 23 or more images.
4. Set the camera flash to be triggered to add light to dark shadows for every image.
5. If the camera has a zoom lens, it should be set to the wide view (minimum focal length in angle millimeters). The zoom setting should not be changed during this procedure and should be periodically checked to verify it remains at the widest view angle.
6. If available, place an object(s) on the roof of the vehicle, or somewhere it can be seen in in multiple views, as a tie point for the various photos. See 3.2.
7. If available, place an item of obvious or commonly known length on the vehicle or ground such that it will appear in at least three views. The length of this item can be used to adjust the photogrammetric model to the correct scale but does not necessarily need to be included.

4.2 Step Two - Tie Point Object

Place one or more objects on the roof of the vehicle such that the object can be seen from multiple positions around the vehicle and the object(s) will not move while the images are being collected. Examples of objects could be a small plastic cone, a rock, a tape measure extended upward several inches. These objects provide a common tie point as an important link between all the overall images.

4.3 Step Three - Overall Images

Capture eight overall views from the approximate camera positions illustrated in Figure A1 with the camera held at normal standing height. In each view the camera should be positioned so that the side edges of the image are just beyond the vehicle limits. These images will be used to locate three or more reference points on the undamaged portion of the vehicle and link them to the damage area, a necessary relationship to determine the crush magnitude.