# Semi-Automated Crush Determination Using Coded and Non-Coded Targets with Close-Range Photogrammetry

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## ABSTRACT

Vehicle crush measurements have typically been done using either offset methods or punctual survey methods such as with a total station or using photogrammetry. While offset grid methods are functional in determining 2-D displacement along the x and y-axis, vertical movement along the z-axis is much harder to achieve. Using a total station to complete crush measurements around a vehicle can yield accurate measurements along all 3-axis but will require multiple station set-ups to traverse around a vehicle. Depending on the total station being used a second person may also be required to move a prism to each measurement location around the vehicle. In both the offset and total station methods, all points of interest must be measured at the time of the vehicle inspection. Using photogrammetry to determine 3-D deformation of a vehicle can result in the accuracy of a total station with only one operator and allows the versatility of measuring any number of points at any time using the available photographs. A system has been created that utilizes photogrammetric technology but greatly increases productivity by automating the camera orientation and point marking process through the use of coded and non-coded targets. This system, utilizing some of the features available in Eos System's PhotoModeler software, will decrease the time required to map a damaged or exemplar vehicle, increase the total number of points mapped in that time and automate the process of matching the two vehicles for crush determination. For approximately 1/2 to 1/3 of the cost of a low-end total station, the collision reconstructionist can have a system that will determine a greater number of 3-D measurements in less time than required for a total station. The same principles and equipment can also be used to complete many of the scene measurement requirements of a collision reconstructionist.

## INTRODUCTION

While completing vehicle crush determination using traditional measurement methods yield acceptable results, improvements can be made in the measurement time required, accuracy of point measurements and total number of points mapped. Using a total station, documented points are restricted to the ones measured at the time of the vehicle inspection. If additional point measurements are required, the investigator must revisit the vehicle, if it still exist, to document these. After completing a project using photogrammetry, any number of points can be added from the photographs at any time during the investigation. Assuming that there is a time reduction in mapping identical points, using this photogrammetric system versus a total station will either take less time to map the same points or leave more time to increase the number of points mapped.

## PROCEDURE

Using a well known and commonly used soft-copy photogrammetry software package, PhotoModeler Pro5 with the additional coded targets module, a bench mark project will be discussed. The basics of close range photogrammetry, as it applies to collision reconstruction, have been covered in numerous publications[1][2][3][4][5]. The same basic photogrammetric principles apply in this application. Proper photo coverage and points that are commonly visible on multiple photographs are still required. Using a calibrated camera, the PhotoModeler coded targets module and some custom targets, a large portion of the project set-up and point marking can be automated, resulting in a reduction in overall time to create the project.

In almost every instance, coordinating a series of 3-dimensional points using photogrammetry requires the points to be visible, marked and referenced in a minimum of two images. Points can either be targets or natural features. Once common points are referenced between photographs their 3-dimensional coordinates can be determined.

TARGETS – Using circular coded targets, consisting of a circular center point and a surrounding segmented ring (Figure 1) the software can identify, mark and reference individual points between images. Each target has a point identifier coded into the outer ring that is assigned a unique point number within the software. If individual coded targets are visible on more than one photograph then this results in them being automatically marked and referenced. If enough of these coded points are visible in each of the images then the process of orienting the cameras can be automated. The result is a notable reduction in the time required to complete a project.

Figure 1 – Coded target example

The software can also identify and mark other high contrast targets, in this case reflective circular targets were used. Dimensions of the targets, both coded and non-coded ones, are dependent on their distance from the camera and the resolution of the camera, if digital, or scanned resolution of a film print. For this study only digital images were used. The coded targets were created with the center circle having a 25 mm diameter. The same 25 mm diameter was used for the initial circular non-coded target size. All of the targets were created from white retro-reflective vinyl.

TARGET MOUNTS – Following basic photogrammetric principles, at least six points must be visible between images to compute camera orientation. There are exceptions to that rule but ensuring that any project consistently has six or more common points will ensure increased accuracy. A strong photogrammetric solution also requires the points to be spread across the entirety of the images. With these rules in mind, a series of coded target jigs were designed for use in vehicle measurement projects. One set of targets, with two coded targets per set, were placed at each corner of the vehicle at or near the ground. A larger series of six targets, three sets of two vertical targets, were placed on the top of vehicle and visible on all sides. Refer to Figure 2a for target location around the vehicle.

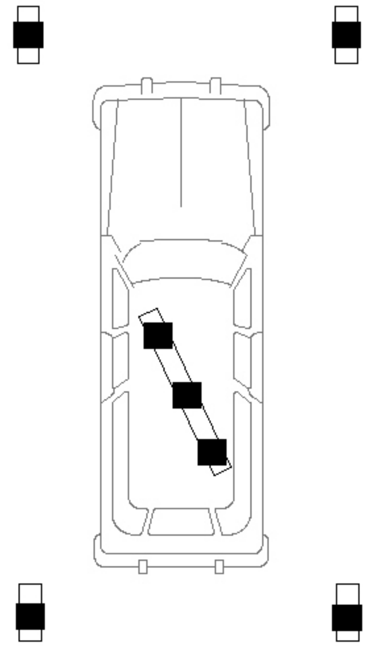

Figure 2a – Target placement at four corners and on top of vehicle.

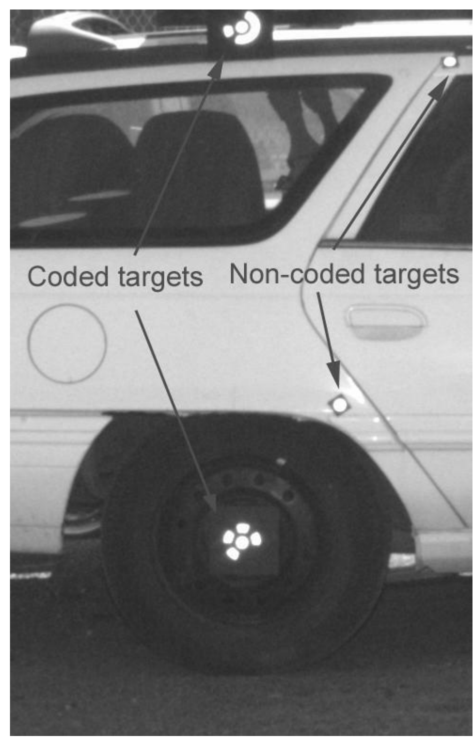


Figure 2b – Coded and non-coded targets.

The coded targets were mounted on both sides of 3 mil. thick matte black plastic strips. Dimensions of the strips were 15 cm by 30 cm. Care was taken to place identical targets at precisely that same location on each side of the plastic strips. The targets were placed two high along a vertical axis (Figure 3) since the plastic strips would be mounted on a swivel and rotated for optimal visibility from all camera stations (vertical axis in Figure 3). This placement of the coded targets created a system which would allow the software to automatically mark and reference the targets and orient the camera locations around the vehicle. For a photogrammetric solution to be solved, identical points must be marked and referenced on multiple photographs. High contrast targets allow PhotoModeler to automatically mark points. An individual code around the target allows the software to reference points with identical codes as the same point. Removing the need for the operator to mark targeted points manually and then reference identical points across multiple photographs results in an overall reduction in time to complete a project. Four other individual coded targets were mounted on one side of the 3 mil. plastic, cut into squares. These individual coded targets (two of which are sown in Figure 2b) were used for correlation of the damaged vehicle to the exemplar vehicle. Further discussion of target placement is included in the CASE STUDY section and targets locations are seen on Figure 4.

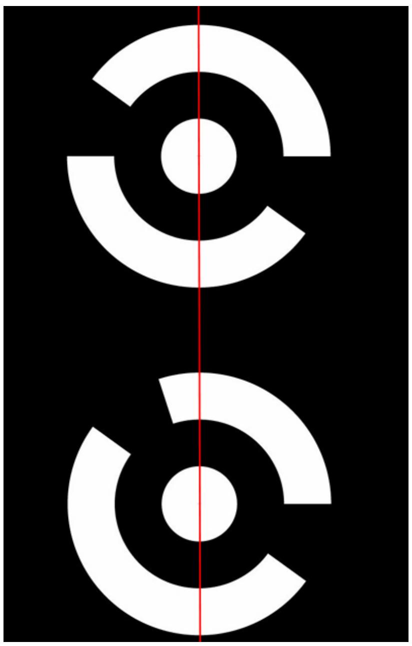

Figure 3 – White coded target mounting configuration on black plastic, rotate about the vertical axis.

Figure 4 – Targeted test vehicle.

The circular non-coded targets were mounted on flexible magnetic strips. This white on black mounting ensured that the retro-reflective targets had sufficient contrast on any color vehicle. The non-coded targets were used to mark locations of interest, such as deformation and overall vehicle profile. The software is capable of automatically identifying and marking these high contrast targets.

CAMERA EQUIPMENT – All of the images were taken using a Nikon D100 camera body at 3008 x 2000 pixel resolution. The camera was equipped with a Nikkor 28 – 80 mm 1:3.5-5.6D lens and a Nikon SB 80 DX flash. All imagery was completed with the lens set to its widest angle (28 mm) setting. The camera and lens combination had previously been calibrated using the PhotoModeler calibration feature.

CASE STUDY – Using combinations of these coded and non-coded targets a system of target placements was devised that would enable the user to:

1. Create a 3-dimensional model of a crushed vehicle (1995 Ford Taurus 5-door wagon).
2. Create a 3-dimensional model of a exemplar vehicle (1995 Ford Taurus 5-door wagon).
3. Merge the two models together to automatically orient the two models for comparison and crush determination.

All of these tasks are possible using a total station but this method will be shown to be faster and easier to measure additional points.

The basic procedure has already been explained for the target placement but some clarity is still required to implement the system. Dealing with the creation of the 3-dimensional crushed vehicle model first, the coded targets were placed at the described locations. Targets were placed far enough out from the corners of the Taurus 5-door wagon so that images taken from each end of the vehicle would have all four sets of ground targets visible. At any location around the Taurus a minimum of 12 coded targets were visible. Eight images, consisting of the four corners, two ends and two sides, were taken in a “ring” fashion around the Taurus. As the camera was moved around the Taurus, the coded targets were rotated about their vertical axis to maximize visibility at all camera stations. Also mounted at locations around the Taurus were the non-coded circular targets. All of the images used in this project are included in Appendix A.

After capturing the required imagery, a coded targets project was started in PhotoModeler Pro5. The project set-up process allows for settings to be preset and saved for future use. In this case, the scale of the project had been predetermined using two of the furthest separated targets on the roof jig. This resulted in no scale measurements being required during the imagery process. Even with the scale being preset, it is advisable to take some scale measurements when documenting a vehicle as a back-up and to use for accuracy checking. In this project, all of the targeted points, minus the coded target jigs, were measured using a Sokkia Set 4C total station to complete a thorough comparison of the measured points. Four manually measured distances were also taken on the damaged Taurus using a steel measuring tape.

Four other coded targets, which had been mounted on one side of individual pieces of plastic, were also positioned on the Taurus at locations reproducible on both the damaged and undamaged Taurus. These targets served many purposes. They were used to orient the model along two axes, measure specific points and most importantly, these targets were used to create common points for used in the merging of the crushed and exemplar vehicle models. This will be addressed again but at this point it will suffice to know that the points were placed on undamaged portions of the crushed Taurus that would be identifiable on the exemplar Taurus. As was explained earlier, the coded targets have unique number identifiers and each coded target, irrespective of location or project, will be marked as identical points. In this project, these four targets (referred to as “orientation coded targets” for the remainder of the paper) were placed on the rear wheel centers and along the roof rail, directly above the rear wheels.

Moving onto the creation of the exemplar vehicle model, the same targeting procedure was used as with the crushed vehicle model with one alteration, a different set of coded targets were used in the target jig. Since the software would identify each target as unique and label them with the same number, the same targets could not be used in the target jigs between the crushed and exemplar vehicle. Another set of different coded targets was mounted into the jigs and everything was placed in the same approximate orientation as the crushed vehicle project. A set of 10-bit targets, created in the software, results in 44 unique targets. Each set of vehicle jigs uses 14 coded targets (2 at each vehicle corner and 6 targets on top). The non-coded circular targets were placed around the vehicle to map of the overall vehicle profile. Finally the same four orientation coded targets were mounted at the same locations on the exemplar Taurus (rear wheel centers and roof rail vertically above the wheels). While this seems like an involved procedure, it was easy to follow and about as intricate as leveling a total station. The time required to target the vehicle’s was less the five minutes each. Once the images were taken, also less than five minutes per vehicle, the project was ready to begin in the software.

Using the PhotoModeler coded target set-up with previously saved scale and orientation settings, a project was began for the crushed Taurus. In the initial set-up of the coded targets project the user is prompted to select what portions of the project will be automated. In this case the coded targets were marked (and by virtue of being coded they were automatically referenced), the project processed to solve for camera positions and coordinates of the coded target points. The software then moved onto marking the non-coded circular targets. Since the camera positions had already been solved at this point, the marked non-coded targets could be automatically referenced between images but this was not completed in this project. Once these points were marked the initial project set-up was complete. The initial set-up, once the images had been downloaded from the camera, took three minutes of user interaction and then the software and computer (a Pentium 4 1.7 GH with 756 Mb RAM) began the target marking mentioned above. It took the computer five minutes to mark the coded target points, process the project and then mark the non-coded target points on eight photographs. The decision to manually reference the automatically marked non-coded targets was to incorporate some user error control. The automatic non-coded target recognition of the software is quite robust but can also mark some other high contrast portions of the image that may not be the desired target. Also some non-coded targets that were far away from the camera or on an oblique angle to the camera could sometimes be missed since they occupied a small number of pixels. Since the camera positions had already been solved and the points marked, referencing the points was a simple process with the assistance of the epi-polar line and auto-point drop feature in PhotoModeler. Once camera positions are determined and a basic photogrammetric model is created, photogrammetric principles allow estimation of a point along a plane perpendicular to the film/image plane. Since the plane is perpendicular to the image surface the user looks along the edge of the surface and it appears as a line. The point being marked will fall on or very close to the line if the overall photogrammetric solution is solid. This is commonly referred to as an epi-polar line. Once a point is marked and referenced in two images, an estimation of the point location can be calculated on subsequent images prior to actual point marking. This is completed by reducing the intersection of two epi-polar lines (from the second and third image) into a point location[6]. PhotoModeler will automatically position the user’s mouse cursor at the point estimation. Once the user verifies visually that this point is accurate it can be placed and further points marked and referenced. Total point clean-up time and referencing was ten minutes. After processing again the result was a 3-dimensional model of the crush and profile of the Taurus (refer to Figure 5).

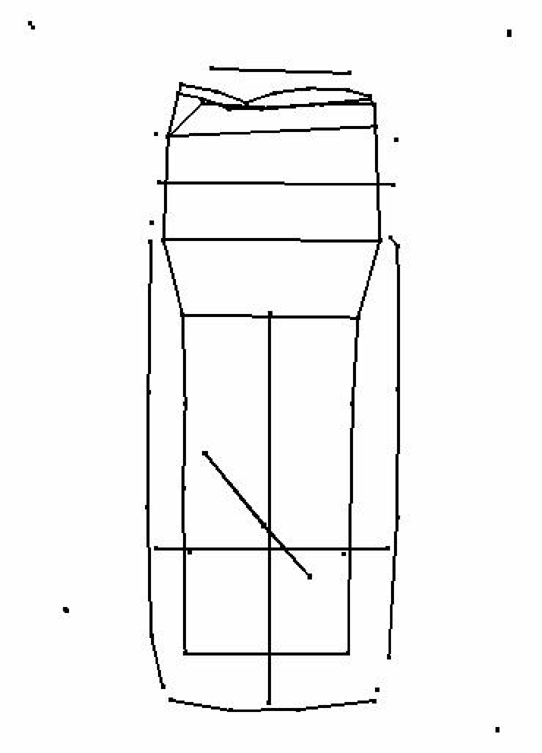

Figure 5 – Crushed Taurus model

The same procedure was followed for completing the exemplar Taurus project. A separate PhotoModeler project was completed and saved with the exemplar Taurus model. The results were included in Figure 6.

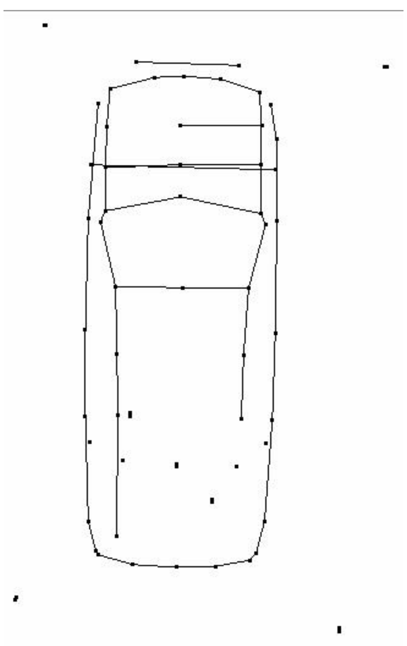

Figure 6 – Exemplar Taurus model.

Remembering that the crushed Taurus and exemplar Taurus projects each have 14 unique coded targets (28 between the two projects) but four common coded targets (the orientation coded targets) a merge of the two projects was completed within the software. To merge projects, common points are taken from each project and the models are matched using a "best fit" orientation of the common points. In this instance the common points were four coded targets that were placed on the rear wheel centers and vertically above at the roof rail on both vehicles. The process of merging projects is quite simple and took two minutes. The result was a crushed Taurus model matched to the exemplar Taurus model (Figures 7 and 8) that could then be exported to a CAD package for further analysis. The model at this point allowed for analysis of front-end deformation in all directions as well as a comparison of any marked component in the model.

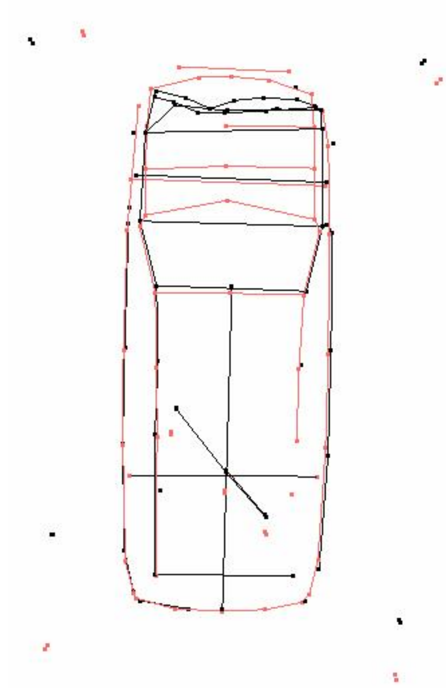

Figure 7 – Crushed and exemplar Taurus models merged.

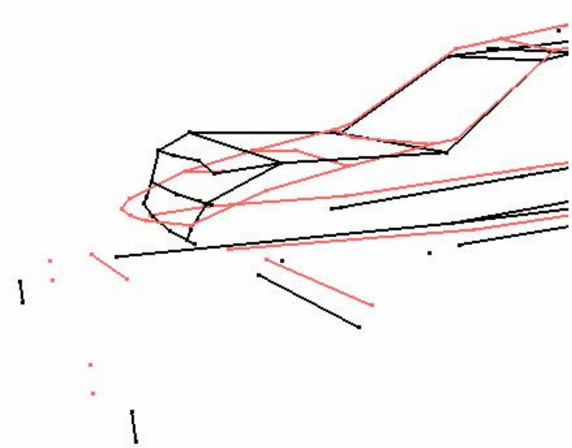

Figure 8 – Front end of crushed and exemplar Taurus models.

## DISCUSSION

ACCURACY – To determine the overall accuracy of this measurement method the crushed Taurus was also measured using a total station. The accuracy of the software has previously been studied[7] so this project was designed to evaluate the accuracy of this semi-automated method. Detailed point coordinate results were included in Appendix B. The results of the photogrammetric model were adjusted to have a "best fit" with the total station model. Small error could be present in the total station model from location of the micro prism relative to the center point of each target and multiple station set-ups but for simplicity the total station results were considered to be a standardized baseline. Given that the total station and the method used to traverse the Taurus are commonly used and their results accepted this served as an appropriate base line. When the results were compared the largest point residual between the total station model and the photogrammetry model was 2.1 cm with the majority of the point residuals falling within the 1-2 cm accuracy range. As extra verification, four manual measurements were taken using a steel measuring tape. Both the steel tape and PhotoModeler results are included in Figures 9a – 9c. The largest difference in check distance was 1 cm at the right wheel base shown in Figure 9c. For all types of collision analysis 1-2 cm accuracy in vehicle crush is well within the required tolerance[8].


Figure 9a – Left side check measurements.

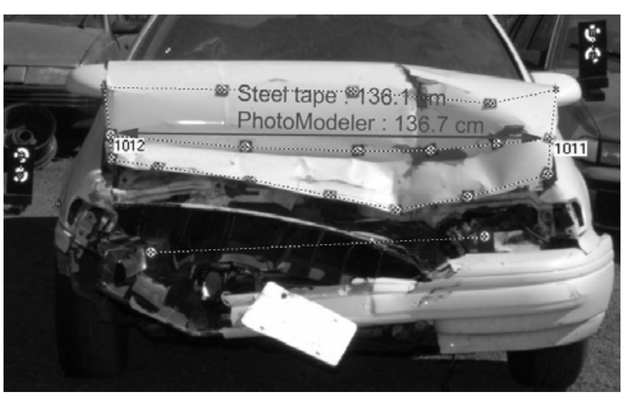


Figure 9b – Front check measurement.


Figure 9c – Right side check measurement.

TIME REDUCTION – Overall there was a large reduction in the time spent creating the two vehicle models and merging them together in PhotoModeler versus using the Set 4C. Both of the authors are proficient at using the total station and were confident that the time spent measuring the crushed Taurus was efficient. Only the crushed Taurus was measured with the total station since that was to be used for the accuracy portion of the study.

Total time spent measuring the crushed Taurus with the total station was 53 minutes. A breakdown of this time would be:

| Task | Time Spent |
|---|---|
| Station 1 set-up (set-up and leveling of the total station and job creation) | 5 minutes |
| Measurement of 34 points on the left side and front of the Taurus | 19 minutes |
| Station 2 set-up | 5 minutes |
| Measurement of 23 points on the right side and rear of the Taurus | 15 minutes |
| Put away of equipment | 3 minutes |
| Download of total station and import into CAD | 6 minutes |
| **Total time spent creating model of crushed Taurus.** | **53 minutes** |

The total time spent solving the same model using PhotoModeler with the coded targets module was 35 minutes (30 minutes if the time is that the user is doing something else while the computer works is subtracted).

| Task | Time Spent |
|---|---|
| Set-up of coded target jigs and targeting of Taurus | 5 minutes |
| Photography of the Taurus (8 photographs used) | <5 minutes |
| Download of camera and review of images for the project | 5 minutes |
| Set-up of the initial coded targets project | <5 minutes |
| Automated processing | 5 minutes |
| Point clean-up and referencing (59 points), processing and export to CAD | 10 minutes |
| **Total time spent creating model of crushed Taurus.** | **35 minutes** |

Creating the second exemplar model yielded similar times and the merging of the two projects was comparable in time to overlaying two total station vehicle files in CAD.

Some of the time spent cleaning up automatically marked non-coded targets could be reduced in future projects by increasing the size of the targets. The 25 mm target size was chosen to keep the targets small enough to fit into deformed portions of the vehicle easily. Projects completed with 50 mm circular targets have resulted in less erroneous points being automatically marked and a reduction in the time spent in point clean-up. Future work will be completed using both sized targets to reap both benefits. Whenever possible the larger targets will be used to enable easier point recognition and the smaller ones will be used when the larger targets will not fit into a location.

## CONCLUSION

In this example the overall time spent solving these measurements using PhotoModeler with the coded targets module was only 56-66% of the time that was spent completing the same task using a total station. The cost of purchasing PhotoModeler Pro5, add-on coded targets module and creating the targets (<$2000 US) was much less than the cost of purchasing a new total station (starting at $4000-5000 US and increasing quickly). With time and cost efficiency, as well as acceptable accuracy, this system is a useful tool for the collision reconstructionist's tool box.


## ACKNOWLEDGMENTS

The authors would like to acknowledge Dr. Michael Chapman and Michael Szarmes for use of a simple and effective absolute orientation program for comparison of the total station and photogrammetry models.


## REFERENCES


1. Fenton, S., Johnson, W., LaRocque, J., “Using Digital Photogrammetry to Determine Vehicle Crush and Equivalent Barrier Speed (EBS),” SAE paper 1999-01-0439.

2. Husher, S., Varat, MS., Kerkhoff, JF., “Survey of Photogrammetric Methodologies for Accident Reconstruction,"” Canadian Multidisciplinary Road Safety Conference VII Proceedings, Vancouver, British Columbia, 1991

3. Pepe, MD., Sobeck JS., Huett GJ., “Three Dimensional Computerized Photogrammetry and its Application to Accident Reconstruction,” SAE paper 890739.

4. Rentschler, W., “Digital Photogrammetry in Analysis of Crash Tests,” SAE paper 1999-01-0081.

5. Walford, A. (section author), McGlone, CJ. (editor), “Manual of Photogrammetry”, Section 14.6, Fifth Edition, American Society for Photogrammetry and Remote Sensing.

6. McGlone, CJ. (editor), “Manual of Photogrammetry”, Section 14.6, Fifth Edition, American Society for Photogrammetry and Remote Sensing.

7. Switzer, DA., Candrlic, TM., “Factors Affecting the Accuracy of Non-Metric Analytical 3-D Photogrammetry, Using PhotoModeler,” SAE paper 1999-01-0451.

8. Tumbas, NS., Smith, RA., “Measuring Protocol for Quantifying Vehicle Damage from an Energy Basis Point of View,” SAE paper 880072.


## CONTACT

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## APPENDIX A – PROJECT IMAGES









SHOCKS
BRAKES
DAYTON
AMSM-817


AMSM-817


AMSM-817


AMSM-817


AMSM-817

## APPENXIX B – COORDINATE TRANSOFRATION OF PHOTOGRAMMETRY MODEL

| | PHOTOMODELER COORDINATES (meters) | | | TOTAL STATION COORDINATES (meters) | | | RESIDUALS (meters) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PT. | X | Y | Z | X | Y | Z | Dx | Dy | Dz | Overall Residual |
| 12 | -8.907 | 11.551 | -1.292 | -8.920 | 11.560 | -1.300 | 0.013 | -0.009 | 0.008 | 0.018 |
| 13 | -9.491 | 10.248 | 1.489 | -9.490 | 10.260 | 1.500 | -0.001 | -0.012 | -0.011 | 0.016 |
| 14 | -9.079 | 11.233 | -0.166 | -9.070 | 11.230 | -0.170 | -0.009 | 0.003 | 0.004 | 0.010 |
| 15 | -9.615 | 9.992 | 0.372 | -9.620 | 9.990 | 0.370 | 0.005 | 0.002 | 0.002 | 0.006 |
| 1013 | -6.252 | 8.952 | 0.693 | -6.260 | 8.940 | 0.690 | 0.008 | 0.012 | 0.003 | 0.015 |
| 1016 | -6.387 | 9.290 | 0.748 | -6.400 | 9.280 | 0.740 | 0.013 | 0.010 | 0.008 | 0.018 |
| 1018 | -6.243 | 9.451 | 0.793 | -6.260 | 9.440 | 0.790 | 0.017 | 0.011 | 0.003 | 0.020 |
| 1019 | -6.477 | 8.809 | 0.867 | -6.490 | 8.820 | 0.860 | 0.013 | -0.011 | 0.007 | 0.018 |
| 1023 | -6.031 | 9.906 | 0.881 | -6.040 | 9.920 | 0.890 | 0.009 | -0.014 | -0.009 | 0.019 |
| 1024 | -6.258 | 9.716 | 0.928 | -6.250 | 9.730 | 0.930 | -0.008 | -0.014 | -0.002 | 0.016 |
| 1025 | -6.408 | 9.428 | 0.920 | -6.420 | 9.420 | 0.910 | 0.012 | 0.008 | 0.010 | 0.018 |
| 1026 | -6.049 | 10.088 | 0.989 | -6.060 | 10.100 | 0.980 | 0.011 | -0.012 | 0.009 | 0.019 |
| 1027 | -6.499 | 9.218 | 0.924 | -6.510 | 9.210 | 0.920 | 0.011 | 0.008 | 0.004 | 0.014 |
| 1028 | -6.573 | 8.824 | 0.969 | -6.570 | 8.840 | 0.960 | -0.003 | -0.016 | 0.009 | 0.019 |
| 1030 | -6.519 | 8.999 | 0.960 | -6.530 | 8.990 | 0.950 | 0.011 | 0.009 | 0.010 | 0.017 |
| 1031 | -7.580 | 9.161 | 1.052 | -7.580 | 9.170 | 1.040 | 0.000 | -0.009 | 0.012 | 0.015 |
| 1032 | -6.891 | 8.912 | 1.099 | -6.900 | 8.900 | 1.090 | 0.009 | 0.012 | 0.009 | 0.017 |
| 1074 | -6.580 | 9.047 | 1.072 | -6.570 | 9.030 | 1.070 | -0.010 | 0.017 | 0.002 | 0.020 |
| 1075 | -6.860 | 8.778 | 0.700 | -6.870 | 8.770 | 0.690 | 0.010 | 0.008 | 0.010 | 0.016 |
| 1115 | -6.253 | 9.812 | 1.101 | -6.250 | 9.800 | 1.110 | -0.003 | 0.012 | -0.009 | 0.015 |
| 1150 | -6.453 | 10.518 | -1.312 | -6.460 | 10.510 | -1.310 | 0.007 | 0.008 | -0.002 | 0.011 |
| 1166 | -6.191 | 10.391 | -0.962 | -6.200 | 10.400 | -0.970 | 0.009 | -0.009 | 0.008 | 0.015 |
| 1170 | -6.892 | 10.727 | -1.013 | -6.900 | 10.730 | -1.020 | 0.008 | -0.003 | 0.007 | 0.011 |
| 1180 | -7.834 | 11.149 | -0.991 | -7.840 | 11.150 | -1.000 | 0.006 | -0.001 | 0.009 | 0.011 |
| 1185 | -8.686 | 11.510 | -0.980 | -8.690 | 11.520 | -0.990 | 0.004 | -0.010 | 0.010 | 0.015 |
| 1191 | -6.264 | 10.234 | -0.504 | -6.250 | 10.240 | -0.510 | -0.014 | -0.006 | 0.006 | 0.016 |
| 1193 | -6.089 | 10.165 | -0.577 | -6.100 | 10.170 | -0.580 | 0.011 | -0.005 | 0.003 | 0.012 |
| 1196 | -7.561 | 10.670 | -0.287 | -7.550 | 10.680 | -0.290 | -0.011 | -0.010 | 0.003 | 0.015 |
| 1203 | -6.868 | 10.639 | -1.028 | -6.860 | 10.650 | -1.020 | -0.008 | -0.011 | -0.008 | 0.016 |
| 1232 | -10.241 | 11.439 | -1.129 | -10.250 | 11.430 | -1.120 | 0.009 | 0.009 | -0.009 | 0.016 |
| 1235 | -10.448 | 10.998 | -1.140 | -10.460 | 10.990 | -1.150 | 0.012 | 0.008 | 0.010 | 0.018 |
| 1257 | -9.706 | 11.543 | -0.289 | -9.690 | 11.550 | -0.300 | -0.016 | -0.007 | 0.011 | 0.021 |
| 1263 | -8.582 | 9.795 | 1.439 | -8.570 | 9.800 | 1.430 | -0.012 | -0.005 | 0.009 | 0.016 |
| 1279 | -9.866 | 11.889 | -0.968 | -9.870 | 11.880 | -0.970 | 0.004 | 0.009 | 0.002 | 0.010 |
| 1280 | -9.961 | 11.889 | -1.118 | -9.970 | 11.900 | -1.110 | 0.009 | -0.011 | -0.008 | 0.016 |
| 1281 | 0.645 | -1.075 | 0.765 | 0.659 | -1.069 | 0.759 | -0.014 | -0.006 | 0.006 | 0.016 |
| 1315 | 0.014 | -0.701 | 1.013 | 0.003 | -0.696 | 1.010 | 0.011 | -0.005 | 0.003 | 0.012 |
| 1318 | 0.086 | -1.084 | 0.167 | 0.077 | -1.093 | 0.176 | 0.009 | 0.009 | -0.009 | 0.016 |
| 1331 | -0.102 | 2.230 | 0.277 | -0.114 | 2.222 | 0.267 | 0.012 | 0.008 | 0.010 | 0.018 |
| 1332 | -0.116 | 1.134 | 0.270 | -0.122 | 1.135 | 0.261 | 0.006 | -0.001 | 0.009 | 0.011 |
| 1333 | -0.117 | 0.295 | 0.270 | -0.121 | 0.305 | 0.260 | 0.004 | -0.010 | 0.010 | 0.015 |
| 1472 | -0.043 | 0.453 | 1.074 | -0.033 | 0.436 | 1.072 | -0.010 | 0.017 | 0.002 | 0.020 |
| 1482 | 1.084 | 1.022 | 1.409 | 1.074 | 1.014 | 1.399 | 0.010 | 0.008 | 0.010 | 0.016 |
| 1483 | 1.532 | -0.756 | 0.747 | 1.535 | -0.768 | 0.756 | -0.003 | 0.012 | -0.009 | 0.015 |
| 1486 | 0.941 | 3.316 | 0.767 | 0.931 | 3.308 | 0.757 | 0.010 | 0.008 | 0.010 | 0.016 |
| 1489 | -0.014 | 2.692 | 0.006 | 0.000 | 2.698 | 0.000 | -0.014 | -0.006 | 0.006 | 0.016 |
| 1490 | -0.086 | -0.625 | 0.308 | -0.097 | -0.620 | 0.305 | 0.011 | -0.005 | 0.003 | 0.012 |
| 1494 | -0.113 | 2.348 | 0.248 | -0.105 | 2.359 | 0.256 | -0.008 | -0.011 | -0.008 | 0.016 |
| 1496 | 1.339 | 3.246 | 0.919 | 1.334 | 3.244 | 0.917 | 0.005 | 0.002 | 0.002 | 0.006 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1497 | 0.537 | 1.646 | 1.243 | 0.529 | 1.634 | 1.240 | 0.008 | 0.012 | 0.003 | 0.015 |
| 1498 | 1.279 | 3.469 | 0.647 | 1.268 | 3.460 | 0.637 | 0.011 | 0.009 | 0.010 | 0.017 |
| 1501 | 0.049 | 0.654 | 1.425 | 0.049 | 0.663 | 1.413 | 0.000 | -0.009 | 0.012 | 0.015 |
| | | | | | RMS | VALUES | 0.012 | 0.012 | 0.009 | |