Vehicle Undercarriage Scanning for use in Crash Reconstruction

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THE FOCUS SCANNERS are being used by law enforcement and those in the private industry to routinely document vehicle crash sites and vehicle damage.

Overview

The use of the FARO Laser Scanners (including the FARO Focus³ᴰ X120 and Focus³ᴰ X 330) has proliferated throughout many industries and disciplines, including vehicle crash reconstruction. The Focus scanners are used by law enforcement and those in the private industry to routinely document vehicle crash sites and vehicle damage. This document will discuss a best-practice workflow for scanning the undercarriage of the vehicle, including the exterior.

Background

During a vehicle crash reconstruction, it is often helpful to have accurate vehicle damage data, including crush measurements and deformation information. This damage data can be used to help calculate damage energy, vehicle closing speeds and vehicle impact speeds. The damage data can also be used to draw a damage profile, which will help assess PDOF (Principal Direction of Force) and vehicle match-up in a collision. This methodology is presented in classes taught by Northwestern University Center for Public Safety (NUCPS).

At times it is also helpful to assess undercarriage damage and be able to accurately measure undercarriage dimensions. Uses can include, but not be limited to: matching undercarriage components to gouge marks on a roadway, assessing structural deformation during a crash or assessing vehicle component defect/performance claims.

In order to accurately document the location of various undercarriage components to the rest of the vehicle, one must be able to reference the undercarriage scan data points back to the exterior scan data points. In order to reference the undercarriage scan points back with the exterior scan data points, common points between the undercarriage scans and the exterior scans must be established and identified.

Vehicle Lifts

One must remember that a "normal' vehicle scan will take place with the vehicle resting on the ground. Therefore, the vehicle undercarriage will not be visible and will not normally be scanned. In order to scan the undercarriage of a vehicle, it must be visually accessible and in a position to be scanned. A widely available method for accessing the undercarriage of a vehicle is an automotive lift used in the repair and maintenance of vehicles. These lifts are commonplace and available worldwide in many vehicle inspection and repair facilities. An example of a twin-post lift is shown below in *Figure 1*. These lifts are typically hydraulically operated and can raise vehicles to different user-selectable heights. These lifts can be broken down into adjustable arm type lifts and drive-on type lifts. An adjustable arm type lift has arms that

Figure 1. Twin-post vehicle lift

are either raised by twin posts that are on either side of the vehicle or by a single post that is located under the vehicle. The single post lift would obscure much of the vehicle undercarriage and may not be suitable for use in vehicle undercarriage scanning.

Another example of a device that can be used to access the undercarriage of a vehicle is a fabricated vehicle

Figure 2. Fabricated vehicle stand

stand. These stands are often found at insurance salvage pools and/or insurance auction sites. An example of a fabricated vehicle stand is shown in *Figure 2*. The disadvantages of this type of stand include the inability to adjust the height, potential scan interference by the ramps and that a forklift or other lifting device must be used to place the vehicle onto the stand.

Other methods to access the undercarriage include vehicle repair "pits", where the vehicle is driven over a recessed workplace in the floor of a facility. These pits are often found at oil-change facilities and are not as commonplace as twin post lifts so they may not be as readily available for vehicle undercarriage scanning use. Further, the width of the pit may limit or hinder the scanning process.

CAUTION: Users should be familiar with all of the safety requirements of any lifting devices and should ensure that any devices used are in good working order. Users should follow all lifting device instructions and warnings. Proper lift arm placement is important for vehicle balance and stability while the vehicle is in the air. For more information, please see ANSI/ALI ALCTV (current edition), "American National Standard for Automotive Lifts - Safety Requirements for Construction, Testing and Validation", ANSI/ALI ALOIM (current edition) "Safety Requirements for the Operation, Inspection, and Maintenance of Automotive Lifts" and ANSI/ALI ALIS (current edition) "Safety Requirements for the Installation and Service of Automotive Lifts". The vehicle owner's manual and/or service manual should also be consulted regarding manufacturer suggested lift arm placement.

Referencing Common Points

In order to properly align the undercarriage scans with exterior scans, common point of reference must be used to align the scans. The use of cloud-to-cloud processing is not recommended for this usage, as the object to be scanned (the vehicle) will be moved vertically relative to it's surroundings during the scanning process. Several other methods of referencing common points are available, but this article will discuss the use of spheres. The spheres used are shown below in **Figure 3**. These custom made spheres are
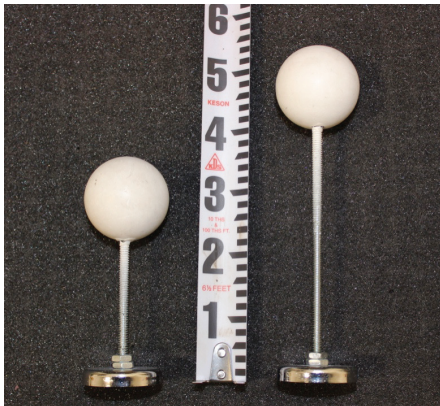

Figure 3. Custom made small spheres

constructed using table tennis balls, threaded rod and readily available round magnets. The table tennis balls were painted, first with a coat of primer, then with flat white paint and affixed to the threaded rod with glue. Theses spheres have a radius of 0.065616 ft. The advantages of using spheres of this size include easy portability and the sphere itself obscures less of the scanned object. The disadvantage is the range - you must be within about 15 feet of the spheres to be able to scan enough points on the sphere for easy recognition at a ¼ resolution setting. Other spheres, such as a commercially available 0.22802 ft. radius sphere could also be used.

Thoughtful and proper pre-scan planning is essential for locating the positions of the spheres on

the vehicle. The spheres must be able to be "seen" by the scanner with the vehicle on the ground and with the vehicle raised in the air. It may be helpful to initially place the spheres on the vehicle to assess the visibility with the vehicle on the ground, then raise the vehicle in the air and reassess the sphere visibility with the vehicle raised in the air. Any sphere location adjustments can be made at this time, prior to the scanning process. The sphere locations for this project are shown below in **Figures 4 and 5**.

Figure 4. Sphere location on upper portion of vehicle

Figure 5. Sphere location on lower portion of vehicle

Since the FARO scanners offer the ability to have preset user-defined profiles, it is helpful to have an undercarriage profile saved in the profile menu. An undercarriage scan profile will shorten the time necessary to scan the undercarriage and will also shorten the time necessary for post-processing scan cleanup. The undercarriage profile set up is shown below in **Figures 6 and 7**.
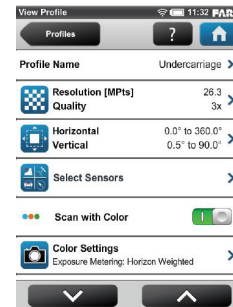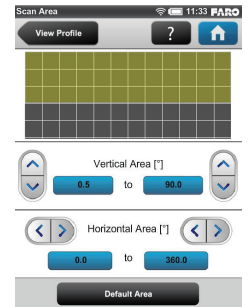

Figure 6. "Undercarriage" profile settings

Figure 7. "Undercarriage" profile settings

The undercarriage profile has the lower vertical limits set to just above 0 degrees and the upper vertical limit at 90 degrees. Of course, there is no requirement that the vertical limits be changed; it was simply done to be more efficient.

Please note that the use of a vehicle lift with arms will result in areas of the undercarriage potentially being blocked from being scanned. See **Figures 8 and 9** for examples.

Figure 8. Vehicle undercarriage being scanned

Figure 9. Twin-post lift arms on vehicle undercarriage

The lift arms are yellow and can be seen supporting the vehicle. Therefore, additional scans may be necessary to ensure all areas of interest on the undercarriage are being scanned. Furthermore, if the vehicle is raised by a twin arm lift, the suspension will be unloaded and will drop down, unless supported by tall jack stands. Therefore, if the user wants the suspension components to be in their normal, loaded, position, either the use of jack stands or a different type of lift (such as a drive-on lift) is recommended.

It is recommended that the user place a ruler in one of the scans or that another method of providing a reference measurement (such as being able to measure a known object length) is planned.

It does not matter whether the undercarriage is scanned first or if the exterior is scanned first.

Once all of the undercarriage and exterior scans have been performed, the data was downloaded and processed in following manner as outlined below.

FARO SCENE Workflow

Once the vehicle has been scanned, the user should proceed with downloading the scans into the FARO Scene software. It is assumed that the user is familiar with Scene software.

Once the scene is processed and the scan results are acceptable to the user, the scan can then be cleaned up to remove any extraneous points or objects not needed. The results of a vehicle scan are shown below in *Figures 11 and 12*. These images show the locations of the various scanner positions used to complete the final project.
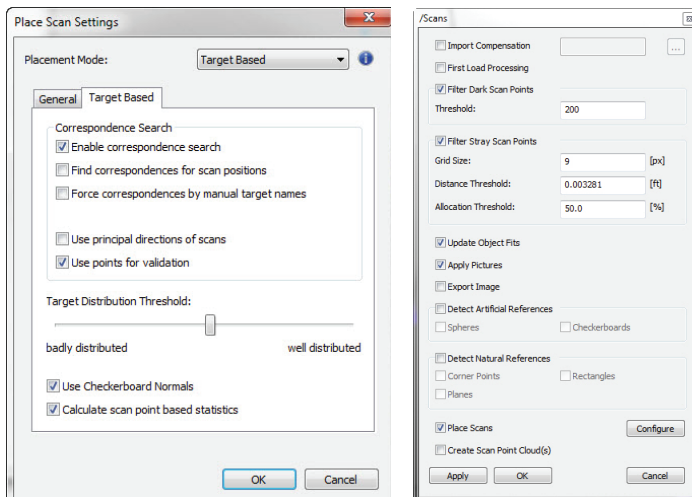

Figure 10. FARO Scene Software screenshots

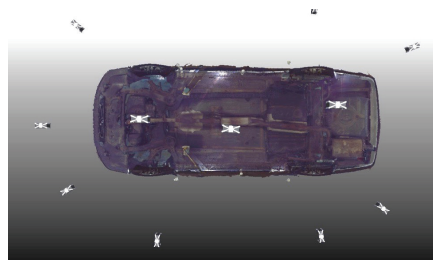Figure 11. Vehicle scan results with scanner locations

Figure 12. Vehicle undercarriage scan results with scanner locations

Recommended steps are listed below:

1. **Download Scene Software**
2. **Load all scans**
3. **Set sphere size for the smaller spheres:**
   - In Scene, go to: Tools – Options – Matching Tab
   - Select Match Sphere Settings:Enter 0.065616' for the sphere radii. Note that this was the sphere size used in this example. The user should enter the appropriate sphere size that they used.
4. **Manually locate the spheres in the planar view of each scan.** It is recommended that the user manually locate the spheres since automatic sphere recognition may result in the software automatically locating many more "spheres" than are actually being used, due to the small sphere size chosen.
5. **Process the scans:**
   - Right click on Scans folder in the workspace
   - Then select: Operations – Preprocessing - Preprocess Scans
   - Process Scans using the Target Based method

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FARO SCENE Workflow (continued)

Figures 13 and 14 show the scanned vehicle with the scanner locations turned off. Note that the unsprung wheels, tires and suspension arms have been removed from the undercarriage scans.

Figure 13. Vehicle scan results without scanner locations

Figure 14. Vehicle undercarriage scan results without scanner locations

Conclusion

Vehicle undercarriage scanning can be useful for many reasons in the field of crash reconstruction. A best-practice method of vehicle undercarriage scanning is presented here, along with alternative sized sphere construction suggestions. There are potentially other methods that can be used that would result in satisfactory results for the user.

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