A QC (Quality Control) Study on Drone-based Accident Site 3D Modeling Platforms for Night Time Operations and Forensic Analysis

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ABSTRACT

This report presents a QC (Quality Control) study of the prevailing drone-based 3D modeling platforms for accident site reconstruction. A staged accident site is configured with real vehicles and common objects brought to accident sites at an intersection near the sports complex in Oceanside, CA. Four different 3D modeling platforms, including Leica BLK360, Leica BLK3D, Pix4D Mapper, and SkyeBrowse are used to reconstruct the staged accident site. The high-resolution 3D point cloud generated by Leica BLK360 using the LiDAR (Line Detection And Ranging), laser scanning technology, is used as the ground truth. Leica BLK3D, Pix4D Mapper, and SkyeBrowse are 3D models based on photos and video and will be compared in this QC study with the control point cloud data established with Leica BLK360. The team compares the measurement taken for nine pre-selected lines from the 3D point clouds generated by each platform and the measurement accuracy is compared.

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INTRODUCTION

In 2019, there were 36,096 fatalities in motor vehicle traffic crashes[1]. Fatalities in the second quarter of 2020, has already reached 8,870 people even with the traffic relief caused by the global Pandemic[1]. Major traffic accidents can cause road closures from 30 minutes to 3 hours or more. Studies have shown that for every minute spent in the accident investigation, 4-5 minutes are being wasted for the associated vehicles. Accelerating the accident site investigation can significantly reduce incident response delay, avoid secondary accidents, ensure the safety of response crews, and accelerate the incident recovery, and allow thorough off-site forensic investigation. Major developments in drone-based 3D modeling platforms, such as SkyeBrowse, Pix4D, DroneDeploy, and others, have made it feasible for law enforcement officers to conduct comprehensive accident site investigation without the need of extensive training on commercial survey-grade 3D modeling software packages.

One major challenge for first responders is investigating night time accidents. According to a 2005 NCSA (National Center for Statistics and Analysis) study, night time fatalities are similar to the number of daytime fatalities in traffic accidents[2]. With more single-vehicle fatalities at night time, law enforcement have to respond to more fatal accidents at night than during the day time. The passenger vehicle occupant fatality rate at night time is about three times higher than the daytime rate due to the limited illumination conditions and less-alerted or less-restrained drivers as shown in Figure 1[2]. For forensic investigation, night time drone images or video have less brightness, contrast, and details compared with daytime images or video. Platforms that perform well for daytime operations can become unreliable for night time crashes.

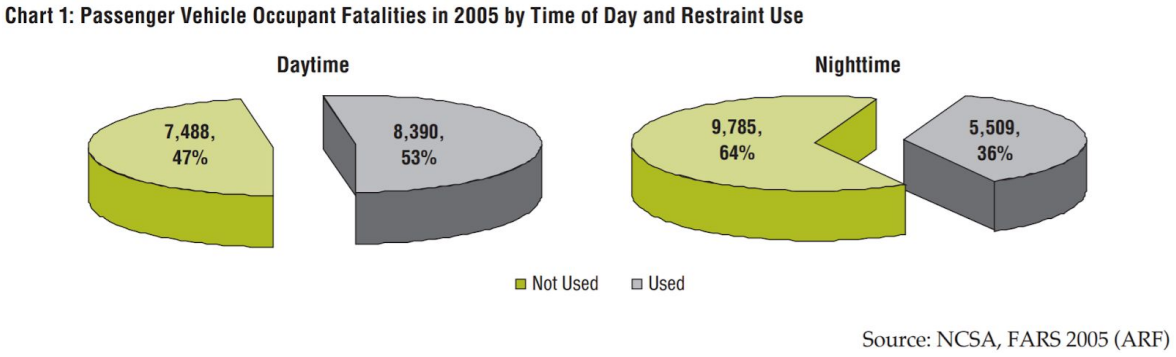


Figure 1. Daytime versus Night time Fatalities and Restraint Use in Fatal Accidents[2]

In this report, we present an evaluation study on two prevailing drone-based 3D modeling platforms versus high-resolution 3D LiDAR (Line Detection And Ranging) models for night time operations. Based on the evaluation results, SkyeBrowse outperforms Pix4D in terms of accuracy and resolutions for night time accident site investigation operations.

[1] National Highway Traffic Safety Administration (NHTSA), 2020, https://www.nhtsa.gov/press-releases/2019-fatality-data-traffic-deaths-2020-q2-projections.
[2] NHTSA, 2005, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/810637.

THE STATE OF THE PRACTICE OF DRONES IN PUBLIC AGENCIES

Public Safety Agencies

The integration of drones in the public safety operations has accelerated in recent years with the mass production and cost reduction of drone platforms and the corresponding development in aerial video analytic and 3D modeling platforms. As shown in Figure 1, based on a 2017 survey study of first responders, drone-based platforms have been adopted by many different public safety related departments and agencies. The agencies that adopted drones the most are the police and sheriff department. Fire departments are also the third largest agency category that adopts drone technologies. State and local first-responder agencies also actively deploy drone technologies in their operations around the US.

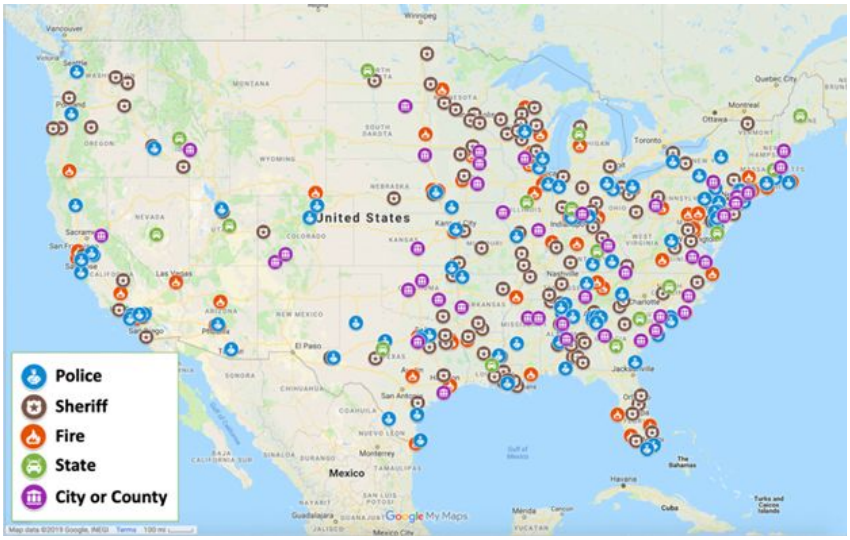


Figure 2. The Use of Drones in Public Safety Operations in the US (2017)[3]

Drones also play important roles in search and rescue operations in public safety. Figure 3 shows a snapshot of the interaction map of DJI, the largest drone manufacturer, showing the search and rescue events that used DJI drones around the world.

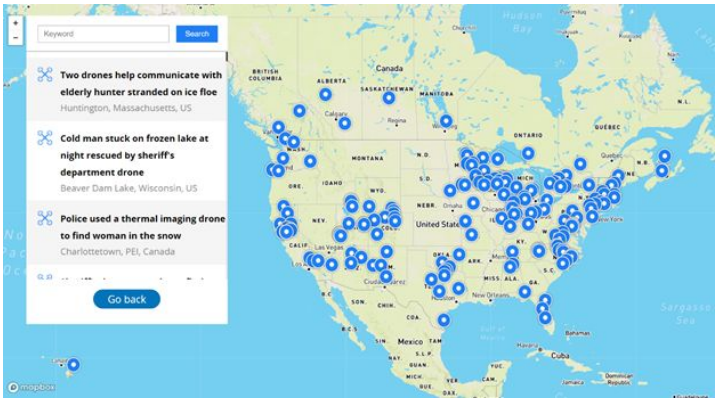


Figure 3. Map of Rescue Operations by Using DJI Drones (2020)[4]

[3] M. Robbins, Evidence Technology Magazine, Summer 2019
https://read.nxtbook.com/wordsmith/evidence_technology/summer_2019/drones_in_public_safety_agenc.html
[4] "Drone Rescues Mapped", DJI, 2020. https://enterprise.dji.com/drone-rescue-map/#map1610032623514

Transportation Agencies

Transportation agencies have also been piloting drone technologies for traffic operational applications such as remote video surveillance, traffic data collection, traffic incident management, infrastructure management. Some agencies have also explored the use of Drone and 3D modeling software for accident site reconstruction. In 2017, North Carolina Department of Transportation published a study on the evaluation of collision scene investigation and reconstruction technologies by staging a collision site with real vehicle damages at a public safety training facility [5].

Figure 4. Collision Scene Reconstruction and Investigation Experiment by NCDOT[5]

Commercial 3D Modeling Platforms

- ***Pix4D:*** A prominent 3D modeling platform is Pix4D. Pix4D uses a photogrammetric approach at developing 3D reconstruction models. Pix4D is very utile, such that from still images, it can develop a dense point cloud, 3D models, and orthophoto maps. To name some of the endless amount of applications are Aviation, Engineering, Computer Animations, and Remote Sensing. In the Point Determination procedure, Pix4D uses an Initial Processing tool. This tool is called the Manual Tie Points Manager (MTP). In calibrating the parameters, Pix4D takes the lower left corner of the target photo as the starting point. Additionally, Pix4D is able to calculate by default the coordinates of the main point position of the photo/image. Unfortunately, one of Pix4D drawbacks is that it does not have the feature of point counting. Therefore, separate software has to be added. Overall, Pix4D is a powerful 3D Modeling Platform that has proven to be very utile and functional at 3D model reconstruction.

- ***SkyeBrowse:*** One of the most popular and utile commercial 3D modeling platforms is SkyeBrowse. SkyeBrowse uses a videogrammetric approach at developing 3D reconstruction models of landscapes, buildings, and vehicles. Compared to other current commercial 3D

[5] "Collision Scene Reconstruction & Investigation Using Unmanned Aircraft Systems", North Carolina DOT 2017, https://connect.ncdot.gov/resources/Aviation%20Resources%20Documents/NCDOT_NCSHP_Collision_Study.pdf

modeling platforms, SkyeBrowse excels in the following areas: time in collecting video datasets, time in reconstructing the 3D model, simplicity of use, and cost efficacy. Some of the current areas of application are within Accident Investigation, Situational Awareness, Mission Pre-Planning, and Structure Fire Investigations. Overall, SkyeBrowse is seen as one of the best 3D Modeling Platforms on the market.

- ***DroneDeploy:*** The use of DJI Drones has grown exponentially in the area of Civil Infrastructure and Engineering through the feasibility of DroneDeploy mobile application. Combining DroneDeploy, DJI Drone, a performance camera, and flying at low altitudes, maps have been produced with the best linear measurement accuracy. In DJI Drones, using high resolution cameras, such as the Phantom 4 Pro, will increase measurement accuracy. Additionally, flying DJI Drones at low altitudes increases the measurement accuracy. Using Ground Control Points (GCP) through DroneDeploy reduces the average measurement error to 0.5 inches. Lastly, when using DJI Drones, altitude is a determining factor when mapping with Ground Control Points. Hence, the image resolution is severely affected and, therefore, making it difficult to mark the center of the GCP maker when processing the map in DroneDeploy. All in all, DroneDeploy's vast compatibility with many DJI Drones and high resolution cameras, make it one of the most competitive 3D Modeling Platforms on the market.

EXPERIMENTAL DESIGN

Experiment Site Location

The mock accident site is located at 3302 Senior Center Drive in Oceanside, CA. Some major structures/builds near the accident site location are the SoCal Sport Complex, a Courtyard by Marriott San Diego Oceanside Hotel, and Oceanside VA Clinic. These structures bring some volume of traffic to the nearby area, however, the accident site is distant from those areas. In terms of the actual road set up, there are only two lanes of traffic and there is a nearby perpendicular intersection. This precise location was chosen due to the low volume of traffic, as its nearest structure/building is the SoCal Sport Complex, which is not always active. Additionally, the low volume of traffic enabled this site to be perfect for a controlled environment and similar geometry of the pavement conditions of the road.

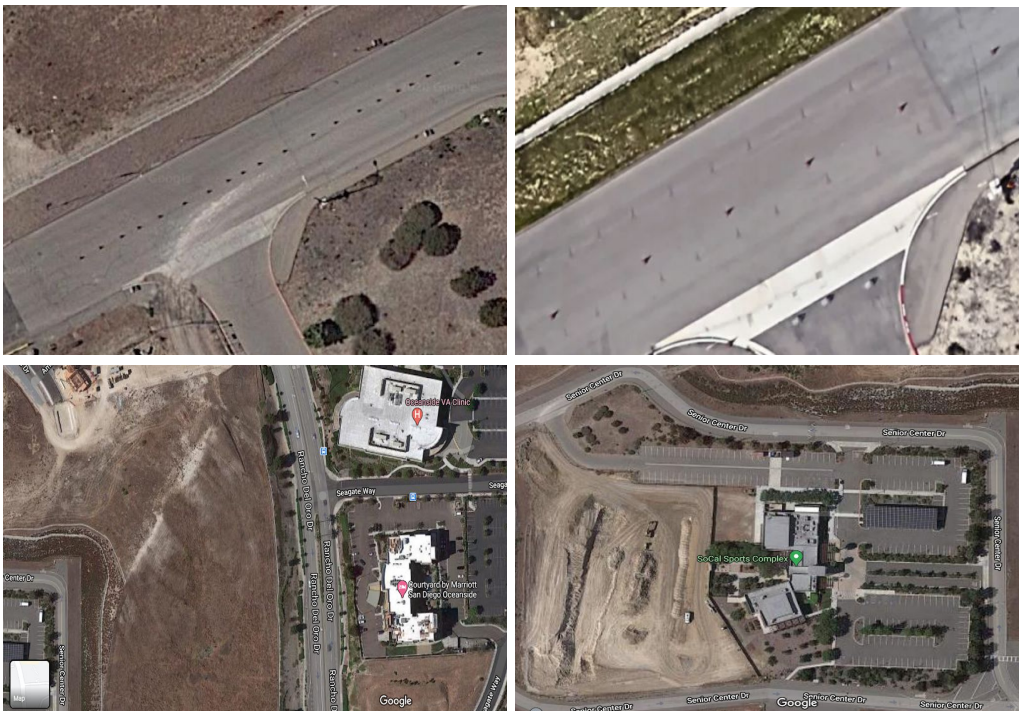
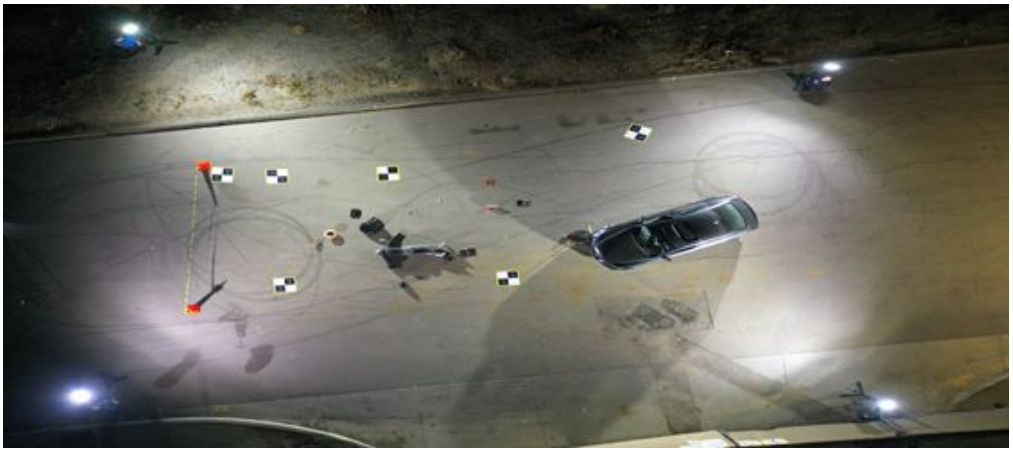


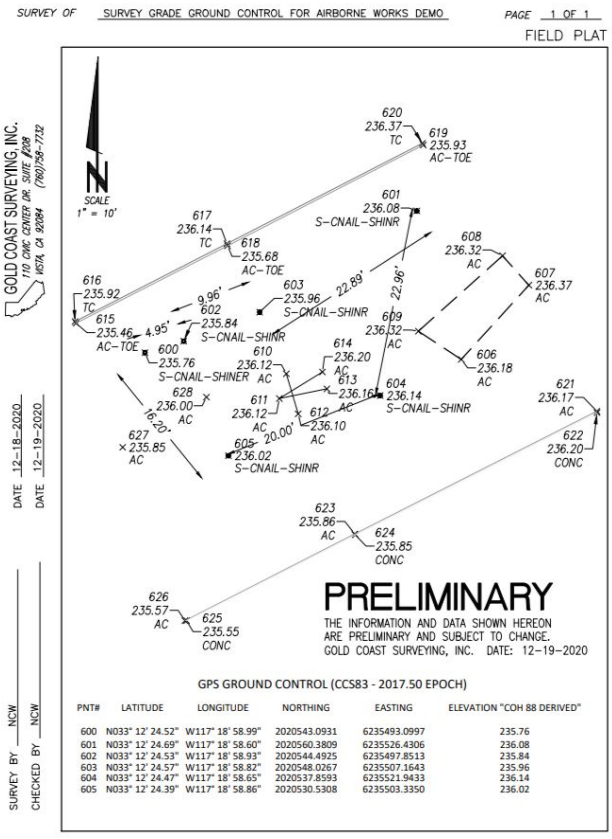
Figure 5 Accident Site and nearby structures in Satellite View Google Earth

The Configuration of the Staged Accident Site

The experimental site was staged to mimic an actual traffic accident site with objects commonly-found at accident scenes. Figure 6(a) shows the overview of the staged night-operational (NightOpt) accident site. Figure 6(b) is a CAD drawing of detailed measurement.



(a) Accident Site Objects



(b) CAD Drawing and Key Measurements of the Accident Site

Figure 6. Configuration and Measurements at the Staged Accident Site

Physical Objects at the Staged Accident Site

The team also placed commonly-found objects at accident sites at the experimental site. The detailed list of objects and their descriptions and functions are stated in the table below.

Table 1: Physical Objects Present in Accident Site

Item	Description	Function
Cone	Orange pyramid-style cone	Used to mark important distances in the study
Measuring Tape	Long yellow and black pieces of tape	Used to show lengths between oranges cones in the study
Motor Vehicle	Black motor vehicle. It is damaged in the right front side of the bumper	Used to recreate a possible accident scenario and record the damage on the car and anything else near it
Crash Dummy	A crash dummy dressed in human clothes laying on the ground	Used to recreate a possible accident that involves a human being struck by a motor vehicle
FoxFury Light Solutions	The Nomad 360 lights are self-contained, waterproof and able to illuminate where street / ambient and vehicle mounted lighting cannot reach	Nomad 360 scene lights were utilized to provide overhead illumination at this night-time test

Survey Grade GCP Data

All GCP markers were laid down by ***Gold Coast Surveying Inc***. Professional Land Surveying with years of experience in Land Surveying workflows from capture to final report. They used Carlson BRX6+ smart rover paired with Carlson Surveyor 2 data collector. They also tied into the State RTK system and used advanced RTK RTN "GNSS analysis" data collection methods in Surv CE to set aerial ground control and tie survey boundary control for Land Survey projects they have done. Also on site was a Leica Robotic model 1101 " calibrated by Leica the same type of precision total station used by police and other professionals.

3D Modeling Platform Tested

The descriptions of the hardware used during the night-ops QC study.

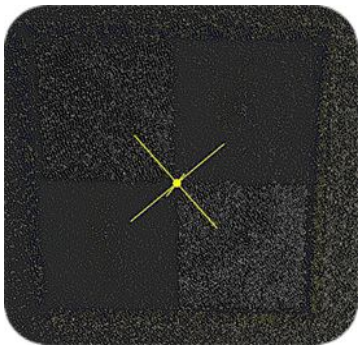
- **Leica BLK360:** Leica is the gold standard within 3D reality capture Lidar. Leica scanners (including the BLK360) are used globally and recognized in the field of forensics as providing very accurate and court ready data (subject to proper workflows). The BLK360 captures 360,000 points per second, panoramic HDR imagery, and has thermal imaging option capability with a usable range of 70' Within the point cloud. Post registration we are able to measure very accurately between any two points. It is fully compatible with the Leica Geosystems Cyclone suite of Reality Capture software including Map360 for Public safety forensics Reality Capture data. For this Study all images in this report are taken from Leica Cyclone Register 360. Our scanner was set for medium density with HD RGB imaging thermal turned off.
- **Leica BLK3D** is a calibrated twin optics sensor design. The Leica BLK3D is a real-time, in-picture 3D measurement solution. By combining measurement sensors, software, and on-device edge data processing capabilities, the Leica BLK3D makes in-picture measurements with professional-grade accuracy in real-time possible. Every image captured is a complete and precise 3D measurement record. Its edge computing capabilities eliminate the need for network connections and cloud services, ensuring professionals can make faster decisions within their daily workflows. Unlike the BLK360, the BLK3D only allows static view and does not allow for rotation pan and tilt view with single shot use case.
- **Pix4D Mapper** software: all data was processed by a certified Pix4D pilot and Mira Costa College drone instructor, Desi Ekstein (aka Drone Diva Desi) AUVSI Top Level 3 Pilot. This mission was a cross hatch mission at 110 AGL. Pix4D is the most commonly used drone mapping solution for accident 3D reality capture. Note: we only used the 3D model point cloud data for all imaging. We did not use the Ortho images as we wanted to compare it with the other point cloud solutions used in this study.
- **SkyeBrowse** is videogrammetry software that uses video. as opposed to photos (photogrammetry), which are orthomosaic images. SkyeBrowse is the brainchild of multiple research projects at Rutgers University funded by state and federal agencies. The research allowed the founding team to create the concept and IP behind SkyeBrowse. With years of experience in the public safety, startup, and university circles, SkyeBrowse provides a unique perspective on how drones will simplify emergency response.

Measurement Methods in 3D Point Clouds

To compare the accuracy among different 3D modeling platforms, the evaluation study uses distance measurements among GCPs (Ground Control Points), corner, and edge points of objects at the scene. The following are examples of line measurements that are commonly found in many accident or crime scenes from point A to point B all taken from the point clouds. All are from the same targets or subjects. To determine the locations of the GCPs, corner, or edge points, a typical "Pic-Point" method which identifies the center point of color transitions at the center of the GCP checkerboard pattern and at the midpoint of color transition on the edges or corners of objects[6]. Table 2 shows example "Pic-Point" perspectives and operations for each 3D modeling platform.

[6] All data screen shots in this report are subject to slight variations due to what laser point or pixel selected with each mouse click during the collection of measurements. Images in Table 2 with zoom of pic points for each solution. We took no less than 3 measurements for each data point taken in an effort to be as consistent as possible. In the case of Pix4D and SkyBrowse we took the measurement closest to the Leica BLK360 / BLK3D data as the control standard for this night-ops QC study.

Table 2. The Comparison of GCP "Pic-Point" Examples and Local Point Cloud Density

Platform	GCP "Pic-Point" Example	Zoom/Angle of View/Point Density
Leica BLK360		We are able to zoom and view from any angle due to the point-cloud with many pic points available in a given small area
Leica BLK3D		We are able to zoom, (pixilated). But we are not able to change the angle of view as the original image is a 2D image / non point cloud.
Pix4D		We are able to zoom and view from any angle due to the point-cloud data, very obvious pixels due to 110' AGL of mission.
SkyeBrowse		We are able to zoom and view from any angle due to the point-cloud data less pixelated due to lower 45' AGL of mission.

Performance Evaluation Methods

The performance of Leica BLK3D, Pix4D, and SkyeBrowse is evaluated by inspecting the accuracy of nine pre-defined measurements among GCPs, edge, and corner points of objects on the staged accident site. The team compared the measured distance of lines in the point cloud by using the "Pic-Point" method to select the starting and ending points. The raw measurements are taken in US units within the visualization interfaces that come with all platforms. Then the raw measurements are converted into metric units for further comparison. Two types of errors are reported including the numerical and percentage errors.

RESULT ANALYSIS

This section summarizes the major results and findings from the QC study. The result summary includes two parts. First, the visual comparison of the 3D model characteristics, resolution, and quality at each measurement location are presented. Second, a summary table of all the measurements conducted are presented.

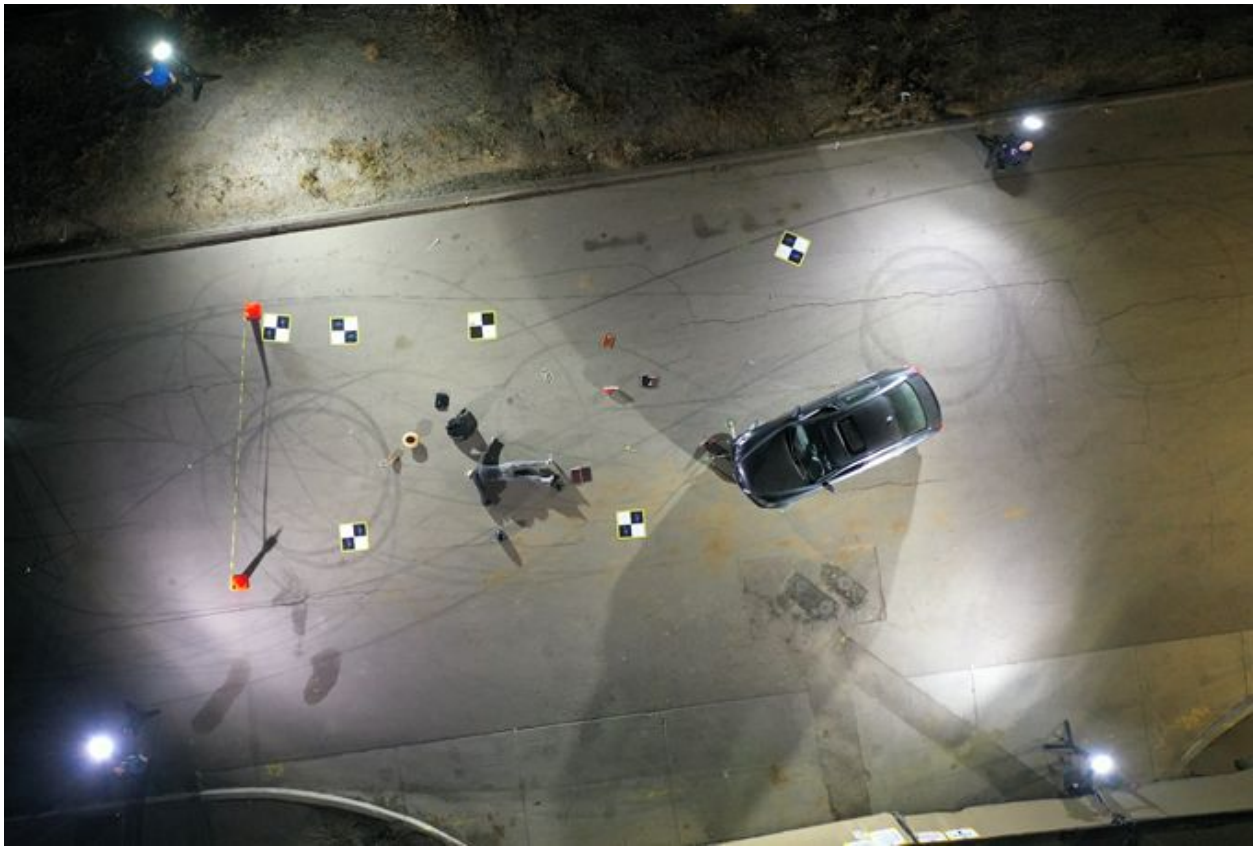
Visual Comparison of Measurements Taken at Different Platforms

Reference Control Site Image and Error Control Quality

Cyclone REGISTER 360
Registration Report

Night Ops QC Study
Dec 25, 2020

Certified by:
Marc Langley
CEO / Forenics lead
Airborne Works
www.airborneworks.com



Overall Quality

Error Results for Bundle 1

Setup Count:	8
Link Count:	28
Strength:	56 %
Overlap:	65 %

Bundle Error
0 ft 1/4 in ✓

Overlap
65 % ✓

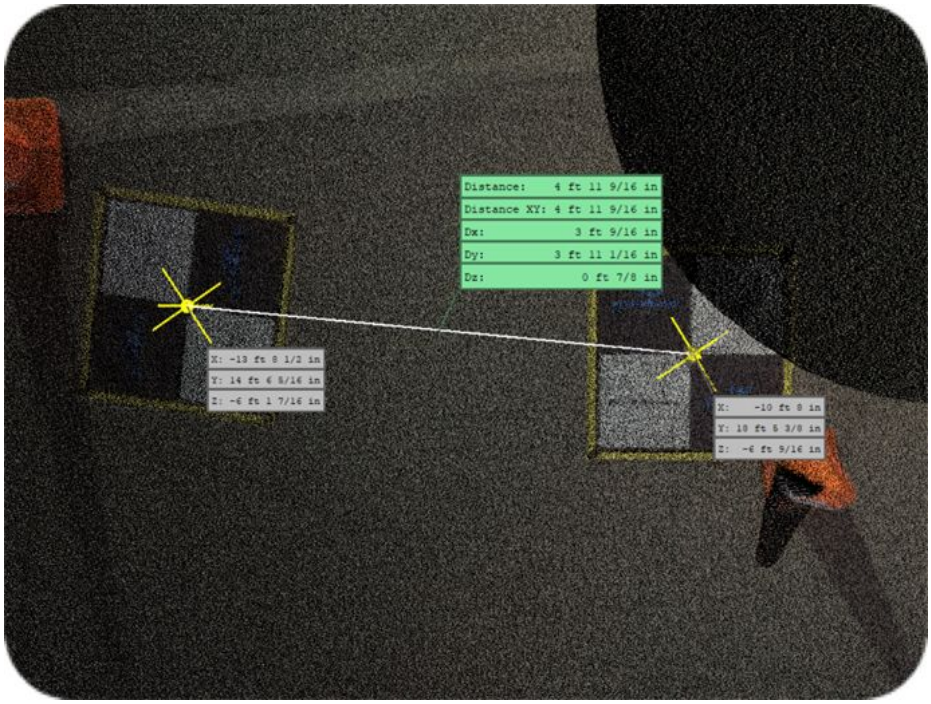
Strength
56 % ✓

The Comparison Results of GCP(Ground Control Point) Line Measurements

Tables 2-5 visually compare the measurements from all platforms at the GCP line locations. These measurements are taken between the centers of the checkerboard patterns of the GCPs laid at the site. Such measurement will provide the best-case scenarios of line measurements for all photogrammetry and videogrammetry platforms.

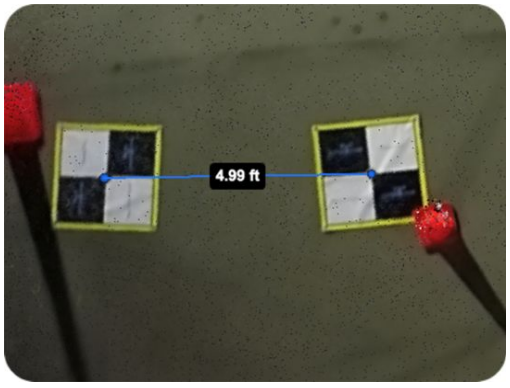
Table 2: Accident Site Line Measurement Comparison at Location 1: GCP1-GCP2

(For detailed images, See Appendix pages 29-32)

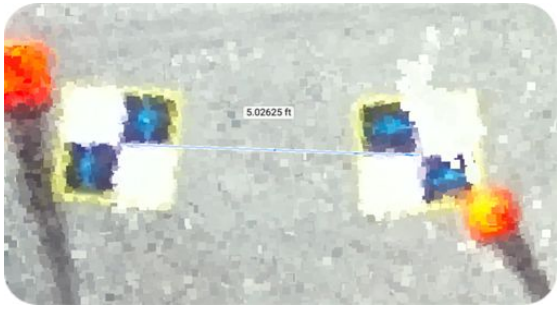


Leica BLK360 (Control Data)

Leica BLK3D



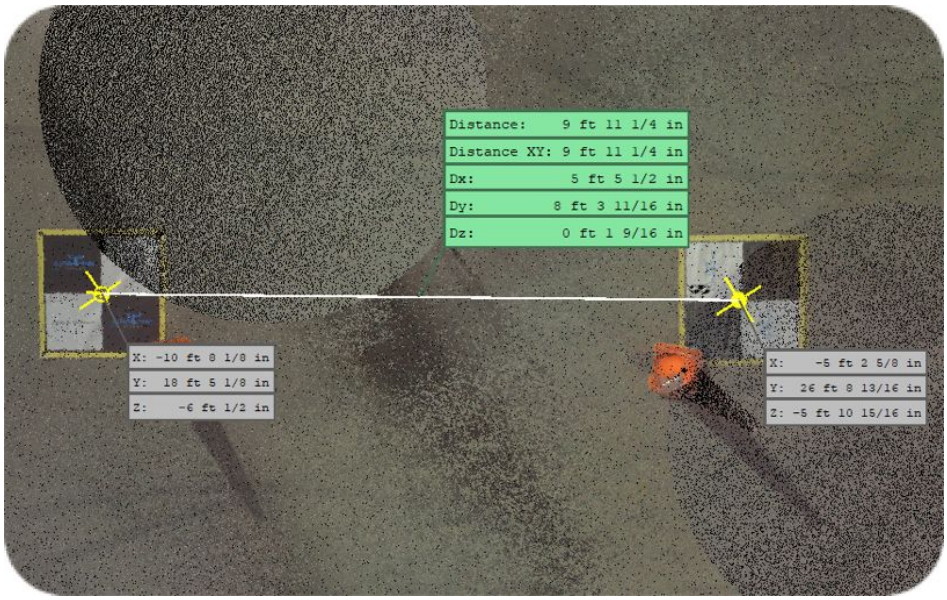
SkyeBrowse



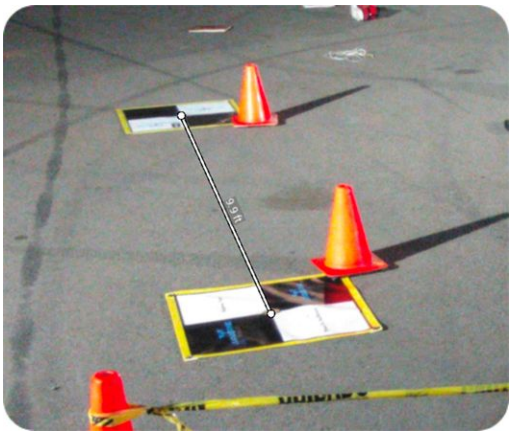
Pix4D Mapper

Table 3: Accident Site Line Measurement Comparison at Location 2: GCP2-GCP3

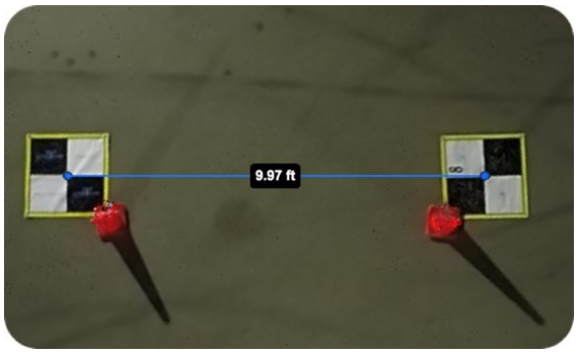
(For detailed images, see Appendix pages 33-36)



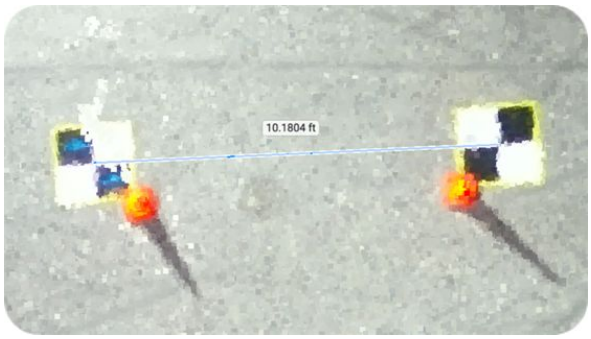
Leica BLK360 (Control Data)



Leica BLK3D



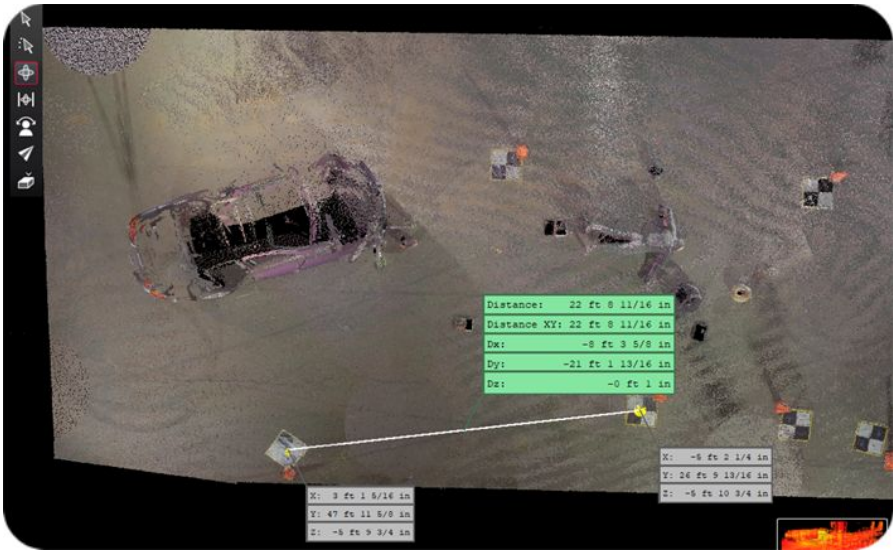
SkyeBrowse



Pix4D Mapper

Table 4: Accident Site Line Measurement Comparison at Location 3: GCP3-GCP4

(For detailed images, See Appendix pages 37-40)

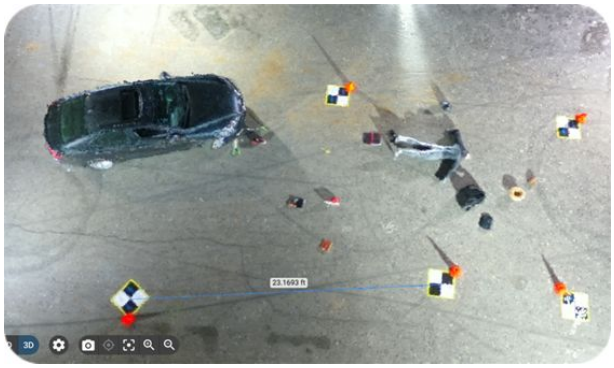


Leica BLK360 (Control Data)[7]

No data due to limited Field of View (FOV) on site.

Leica BLK3D

SkyeBrowse

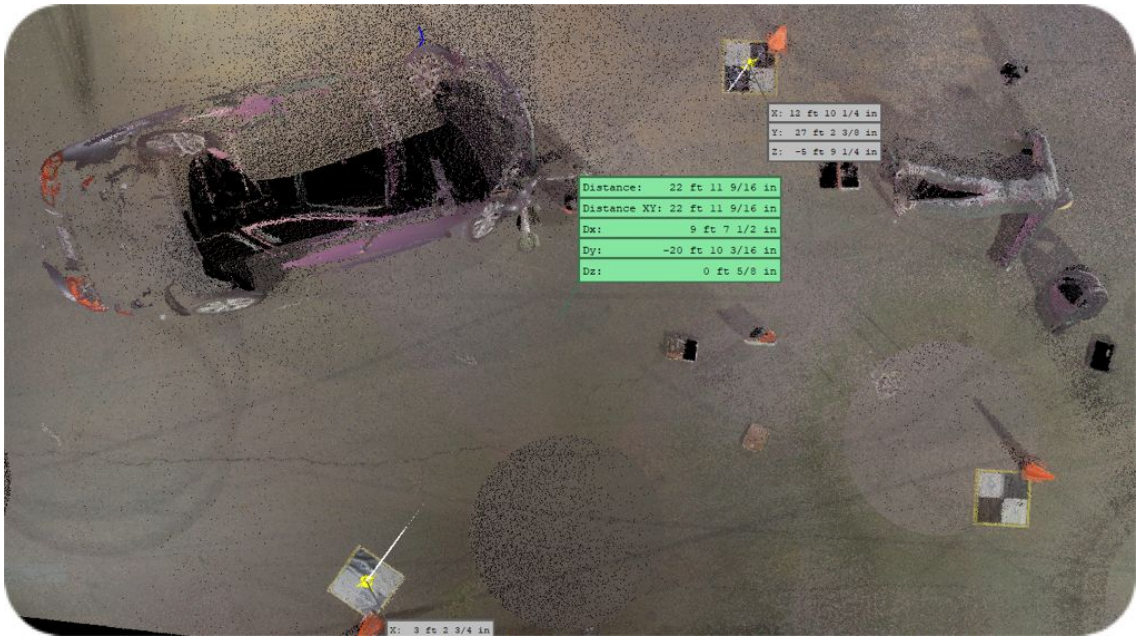


Pix4D Mapper

[7] FYI ~ BLK360 and other Lidar scanners have issues with capturing laser bounce back data from black shiny surfaces. A light colored car would have been better.

Table 5: Accident Site Line Measurement Comparison at Location 4: GCP4-GCP5

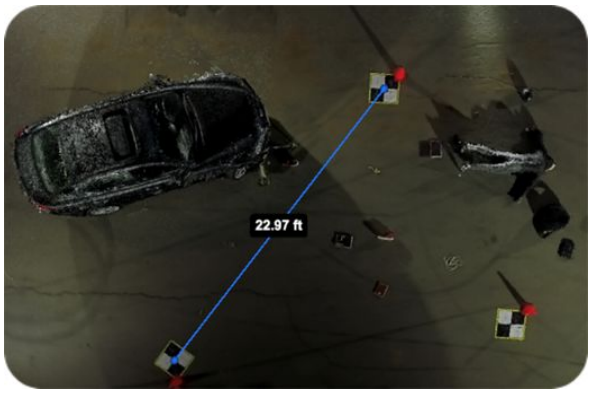
(For detailed images, see Appendix Pages 41-44.)



Leica BLK360 (Control Data)

No data due to limited Field of View (FOV) on site.

Leica BLK3D



SkyeBrowse

Pix4D Mapper

The Comparison Results of Complex Angular Measurements

Table 6-7 shows the measurement comparison among some point to point at challenging geometry that one might find the need for within any given forensics investigation. We need to know how software photogrammetry and videogrammetry stack up with advanced measurements at different joint angles and planes.

Table 6: Complex Angular Measurement Example: Location 5: Door to GCP4
(For the detailed images, See the Appendix pages 45-51.)

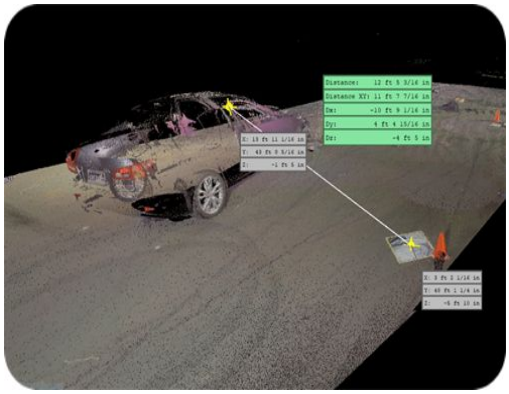
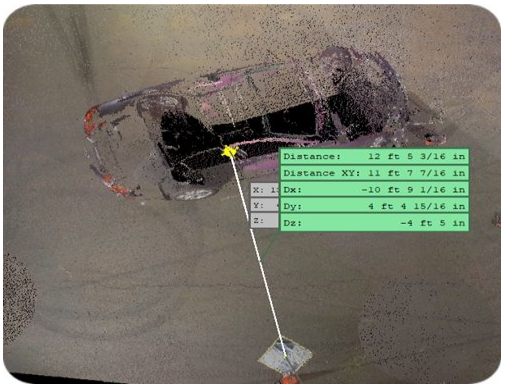
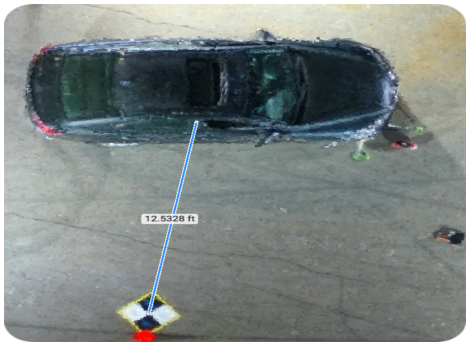
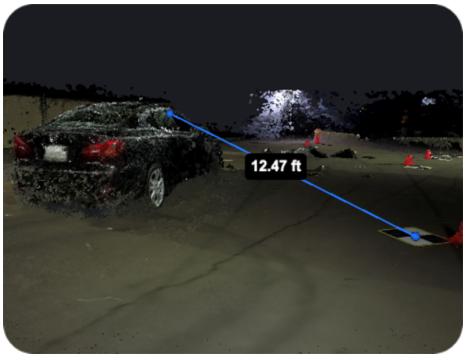
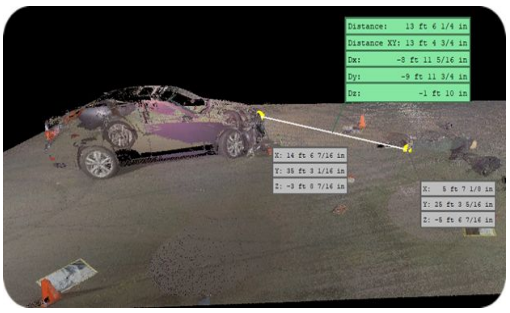
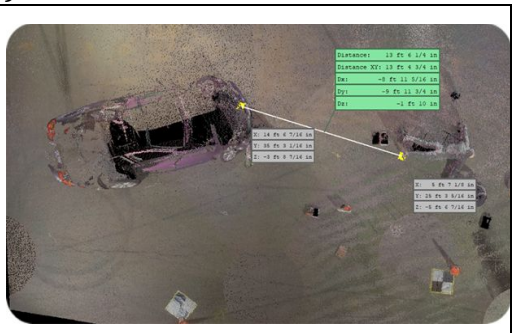
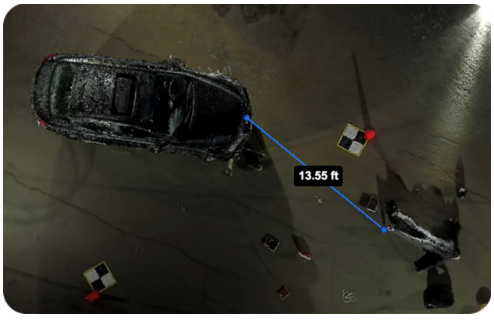
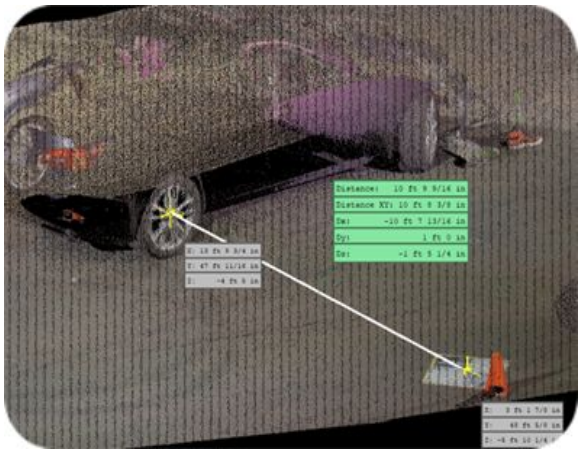
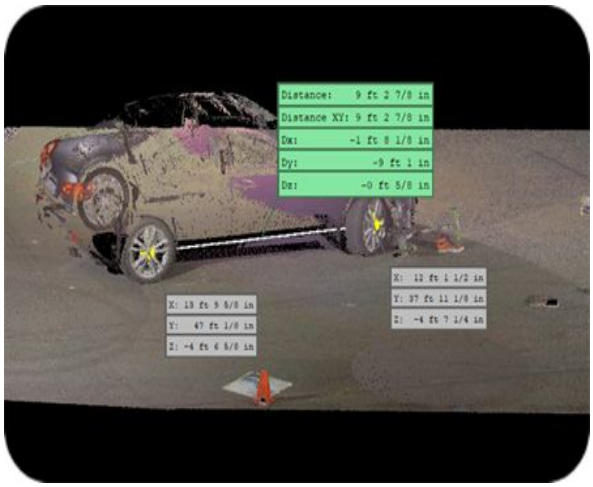
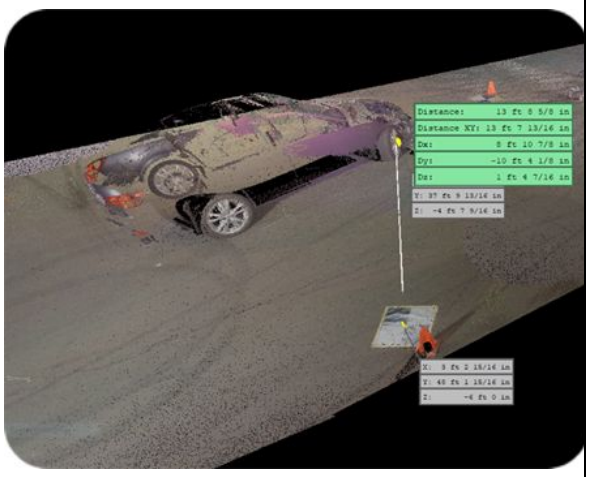
Leica BLK360		
Leica BLK3D	Because the BLK3D Is not point cloud based, we can only view it in one perspective for this example.	
Pix4D		
SkyeBrowse		

Table 7: Complex Angular Measurement Example: Location 6: Hood to Foot
(For the detailed images, See the Appendix pages 52-55)

Leica BLK360		
Leica BLK3D	Because the BLK3D Is not point cloud based, we can only view it in one perspective for this example	
Pix4D (Front of car to foot of victim dual perspective.)		
SkyeBrowse (Front of car to foot of victim dual perspective.)		

The Comparison Results of Integrated Complex Angular Measurements
Table 8-11 shows an integrated complex angular measurement among two wheels and the GCP4. Table 8 shows the ground truth data. Tables 9 and 11 show the detailed measurement results for Leica BLK3D, Pix4D, and SkyeBrowse.

Table 8: Integrated Complex Angular Measurement Example: Location 7-9: Wheel-Wheel-GCP4 Triangle
(For the detailed images, See the Appendix pages 56-58)

Leica BLK360 (Cyclone Register360) We took 3 distance measurements as shown to combine two angles and a horizontal point to point.	
	

Leica BLK3D Performance in the Integrated Complex Angular Measurements

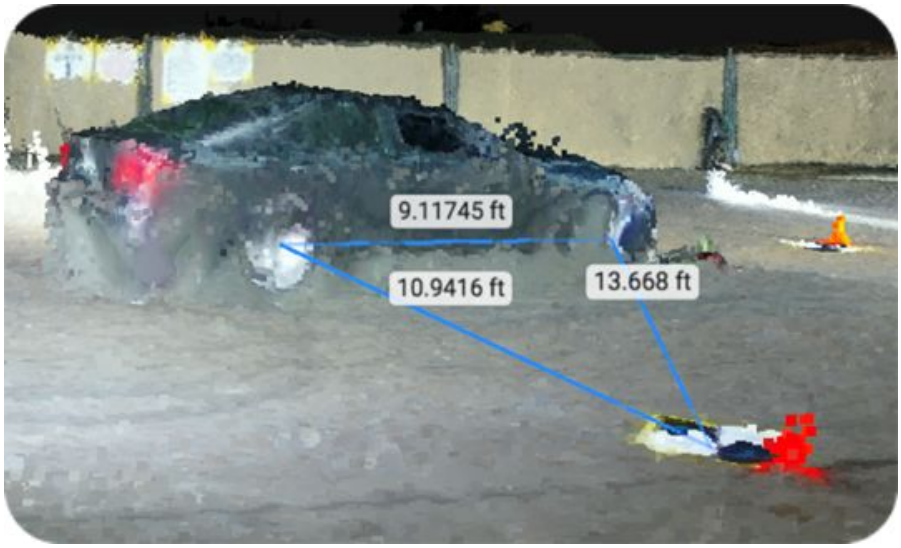
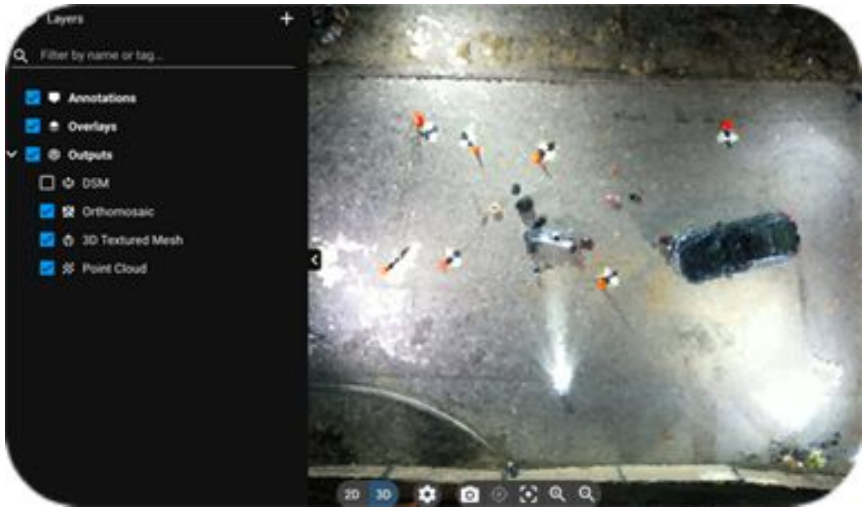
Table 9: Integrated Complex Angular Measurement of Leica BLK3D: Locations 7-9 Triangle (For the detailed images, See the Appendix page 59.)

Leica BLK3D Pic-Point/ 3 distance measurements as shown to combine two angles and a horizontal point to point.	

After determining the complex angular measurements, **Leica BLK3D** has proven to be an amazing option for fast and accurate measurements like this with clear imaging for reports and hard to get locations that will require detailed data, a very portable and affordable solution for many use cases.

Pix4D Performance in the Integrated Complex Angular Measurements

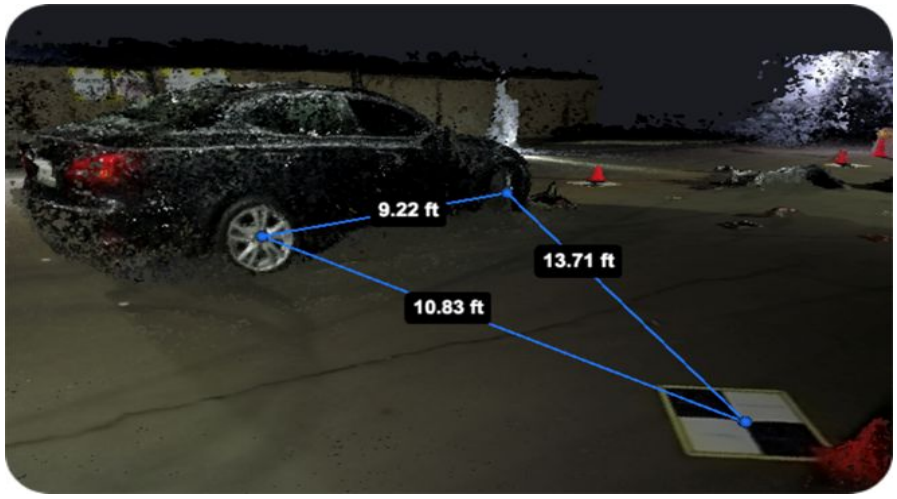
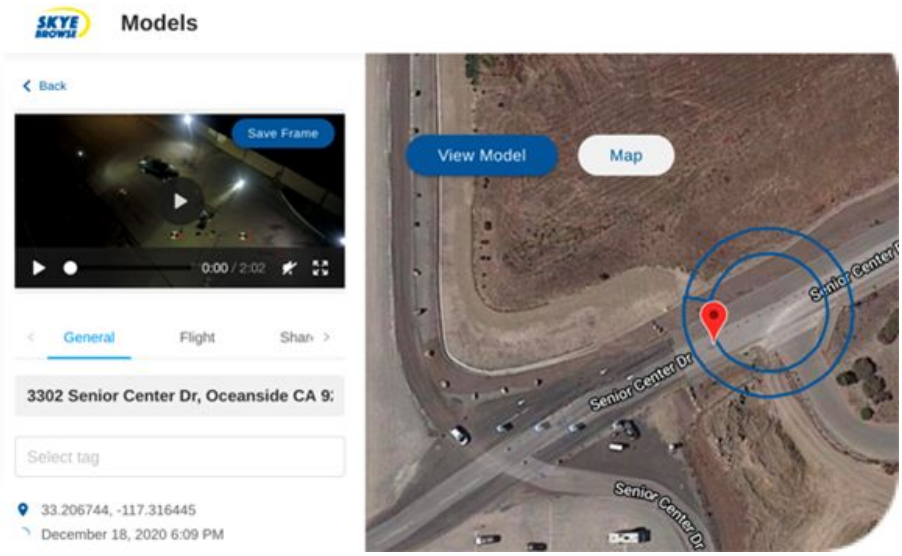
Table 10: Integrated Complex Angular Measurement of Pix4D: Locations 7-9 Triangle (For the detailed images, See the Appendix page 60.)

Pix4D Pic-Point/ 3 distance measurements as shown to combine two angles and a horizontal point to point.	 

Pic-points on the **Pix4D point cloud** are less clear and defined due to the AGL and lack of orbital data captured Nadir view only at 110 AGL. This data was flown in SAFE mode, in which the drone stops for each image. This is done to eliminate motion blur. The drone used a 20MP sensor. Higher resolution sensors would no doubt yield better data results. To obtain better pic-point details, drone flight at lower altitudes for better pixel detail and add orbit for better vertical details. This process would require more images for overlap, longer flight and processing time. Upload speed depends upon internet speed. Best to upload to software via Micro-SD card on the computer.

SkyeBrowse Performance in the Integrated Complex Angular Measurements

Table 11: Integrated Complex Angular Measurement of SkyeBrowse: Locations 7-9 Triangle (For the detailed images, See the Appendix page 61.)

SkyeBrowse Pic-Point / 3 distance measurements as shown to combine two angles and a horizontal point to point.	 

SkyeBrowse is very close to perfecting video 3D reality capture technology. The drone used had a 20MP sensor at 45AGL so the data is sharper and has better vertical detail as the drone flies two orbital paths around the subject. No Nadir imagery was captured in this flight. It took all of 2:02 minutes of flight and processed the final point cloud model in 25 minutes post upload. Upload speed like any data depends on internet speed.

The Measurement Error Comparison

Using the **Leica BLK360 data** as the most accurate control, we color coded the results below. All three photogrammetry and videogrammetry platforms have less than 3% measurement errors at the nine measurement locations. SkyeBrowse outperforms the other two platforms in eight of nine measurement locations. BLK3D was the closest measurement to the control in one of the nine measurement locations. SkyeBrowse has an error measure at the 1cm (0.39 inches) level at all but one measurement location.

Table 4: Summary of Measurement Results

Measurement/View	Unit	BLK360	BLK3D	Pix4D	SkyeBrowse	Best
GCP1-GCP2	US	4'11-9/16"	5' 0"	5' 0.3"	4' 11.9"	
	Metric	1.513m	1.524m	1.532m	1.521m	SkyeBrowse
	Error (%)		+0.011m (+0.73%)	+0.019m (+1.26%)	+0.008m (+0.008%)	
GCP2 - GCP3	US	9' 11-1/4"	9'10.8"	10' 2.1"	9' 11.6"	
	Metric	3.03 m	3.02m	3.10m	3.04m	SkyeBrowse
	Error (%)		-0.01m (-0.33%)	+0.07m (2.31%)	+0.01m (0.33%)	
GCP3 - GCP4	US	22' 8-11/16"	N/A	23' 2.0"	22' 10.8"	
	Metric	6.926m	N/A	7.061m	6.980m	SkyeBrowse
	Error (%)		N/A	+0.135m (+1.95%)	+0.054m (+0.78%)	
GCP4 - GCP5	US	22' 11-9/16"	N/A	23' 6.9"	22' 11.6"	
	Metric	6.999m	N/A	7.186m	7.000m	SkyeBrowse
	Error (%)			+0.187 (+2.67%)	+0.001 (+0.01%)	
Door to GCP4	US	12' 5-3/16"	12' 5"	12' 6.3"	12' 5.6"	
	Metric	3.789m	3.785m	3.818m	3.800m	BLK3D
	Error (%)		-0.004m (-0.11%)	+0.029m (+0.77%)	+0.011m (+0.29%)	
Hood to Foot	US	13' 6-1/4"	13' 5"	13' 9"	13' 6.6"	
	Metric	4.121m	4.089m	4.191m	4.130m	SkyeBrowse

	Error (%)		**-0.032m (-0.78%)**	**+0.07m (+1.70%)**	**+0.009m (+0.22%)**	
Triangle off car Wheel base	**US**	**9' 2-7/8"**	**9' 2"**	**9' 1.4"**	**9' 2.6"**	
	Metric	**2.816m**	**2.794m**	**2.779m**	**2.809m**	**SkyeBrowse**
	Error (%)		**-0.022m (-0.78%)**	**-0.037m (-1.31%)**	**-0.007m (-0.25%)**	
Rear Wheel to GCP4	**US**	**10' 9-9/16"**	**10'9"**	**10' 11.2"**	**10' 9.9"**	
	Metric	**3.291m**	**3.277m**	**3.332m**	**3.299m**	**SkyeBrowse**
	Error (%)		**-0.014m (-0.43%)**	**+0.041m (+1.25%)**	**+0.008m (+0.24%)**	
Front Wheel to GCP4	**US**	**13' 8-5/8"**	**13' 7"**	**13' 8"**	**13' 8.5"**	
	Metric	**4.181m**	**4.140m**	**4.166m**	**4.178m**	**SkyeBrowse**
	Error (%)		**-0.041m (-0.98%)**	**-0.015m (-0.36%)**	**-0.003m (-0.07%)**	

Color Coding Symbolism:

Good	**Better**	**Best**

Measurement Interface Comparison

Leica BLK360: Even with the **Leica BLK360 LiDAR** point cloud data, five different people could take the same measurement and get five slightly different results. Because these are point cloud and pixel based, all the solutions above are subject to different results.

SkyeBrowse: One thing that was discovered during this and other studies is that **SkyeBrowse** is the only solution that does not allow zoom to mouse point for more accurate pic post placement. **SkyeBrowse** requires the user to frame the two or more targets while picking points, however, post pick, you can zoom in and adjust it. It is a more involved workflow and could be better by allowing the user to zoom in on the pic no matter the location. Also, it would be good if the software allowed the user to relocate the measurements with an arrow function, so that measurement is out of the way of the evidence image.

Pix4D: Pix4D does a great job with this feature and allows us to zoom into the locations we want between any two points no matter the distance between them. Also, it would be good if the software allowed the user to relocate the measurements with an arrow function, so that measurement is out of the way of the evidence image.

ACKNOWLEDGEMENT

A huge thanks to the brands that helped Airborne Works stage and provide this QC study

- when it has to be right

Leica Geosystems

FoxFury Lighting Solutions

Drone Diva Desi

On The Go Video.biz!

Gold Coast Surveying, Inc.
Surveying, Mapping, GPS & Engineering Support Services

F1DRONE™

moss AI ANALYTICS

Brands subject of this study

PIX4D

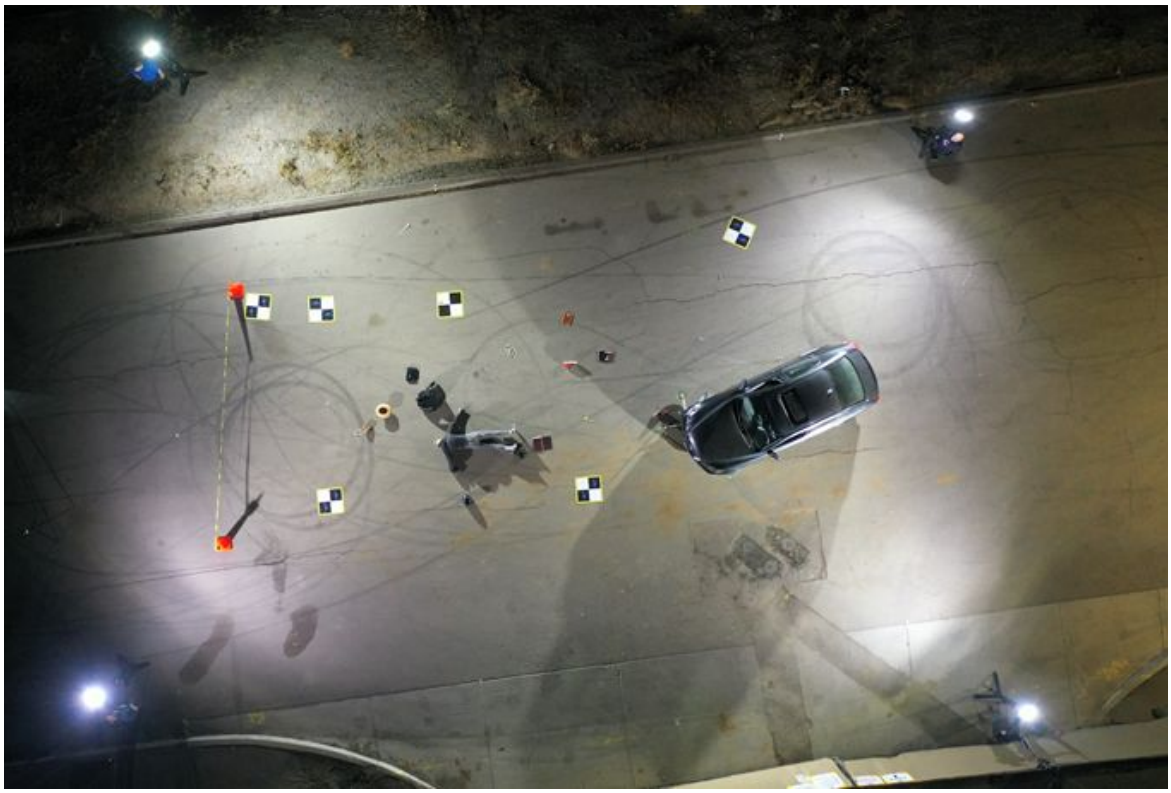
SKYE BROWSE

APPENDIX: AirBorne Works Detailed Site-by-Site Measurement Images

Cyclone REGISTER 360
Registration Report

Night Ops QC Study
Dec 25, 2020

Certified by:
Marc Langley
CEO / Forenics lead
Airborne Works
www.airborneworks.com



Overall Quality

Error Results for Bundle 1

Setup Count:	8
Link Count:	28
Strength:	56 %
Overlap:	65 %

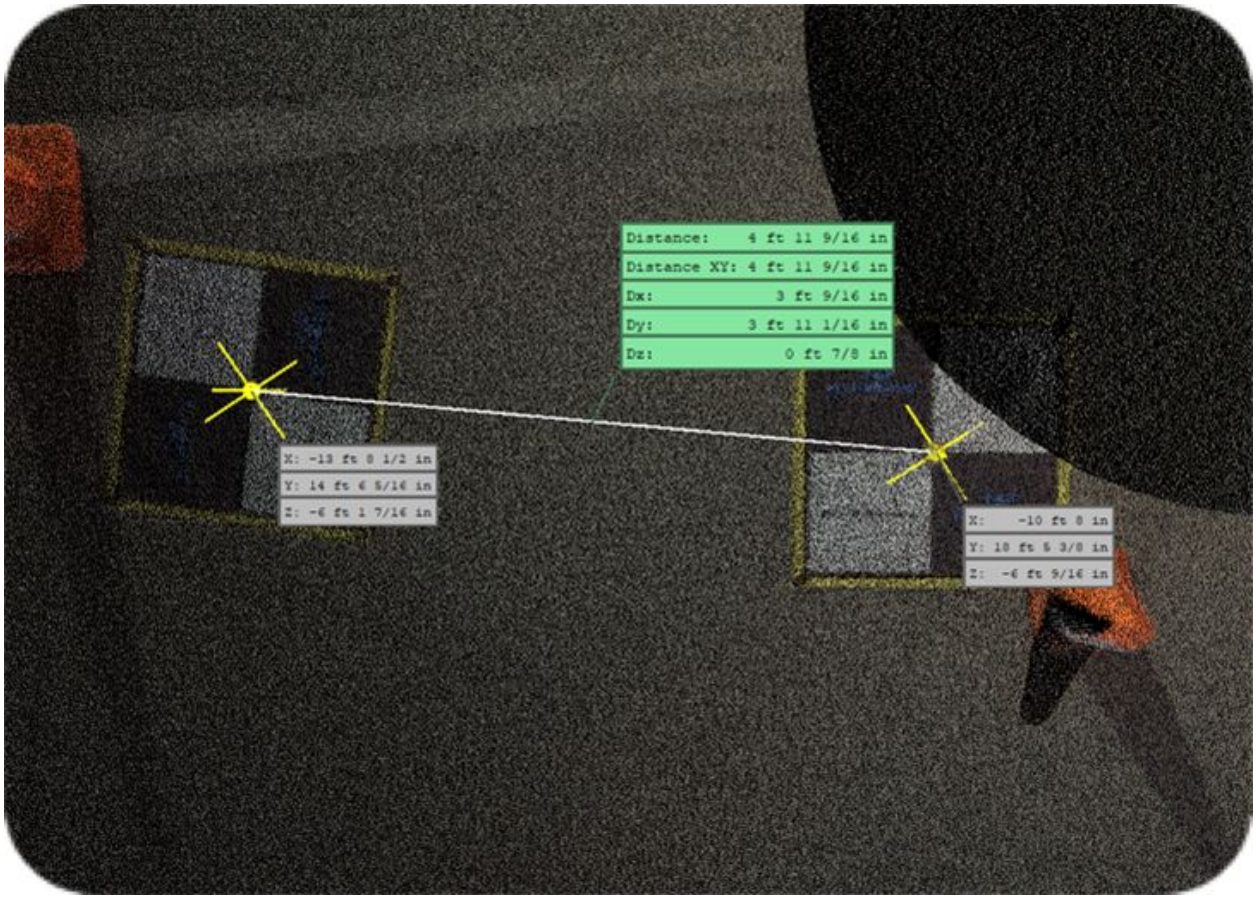
Bundle Error
0 ft 1/4 in ✓

Overlap
65 % ✓

Strength
56 % ✓

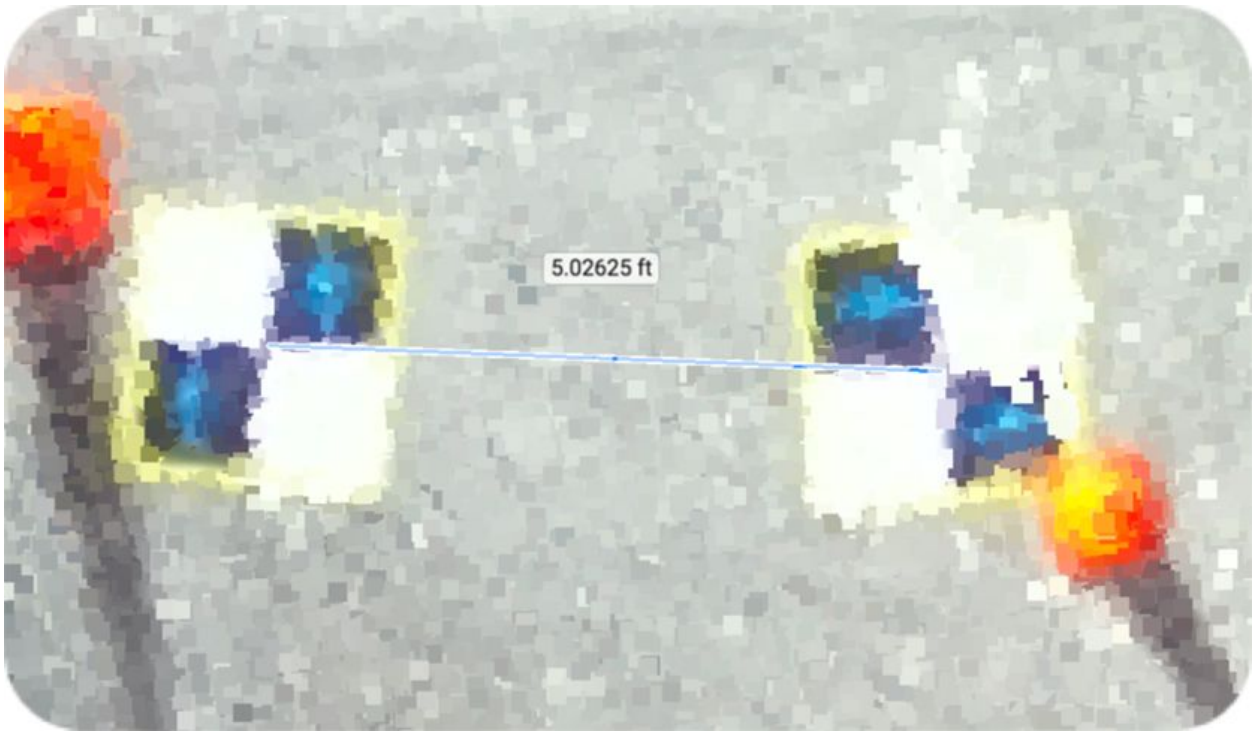
QC disclaimer statement: ***Airborne Works is an authorized dealer of Leica Geosystems and SkyBrowse brands. We are NOT paid for these QC studies from Pix4D, SkyBrowse or Leica Geosystems, or any other agency or company. The goal of each study we conduct is to help identify solutions that best meet the needs of public safety professionals for forensics investigations. We use the best possible tools available to our company to perform these detailed evaluations and share that data with industry professionals. Only then can they make an informed decision on solutions that will best meet their technical needs and budget.***

Leica BLK360 Pic-Point sample GCP1 - GCP2

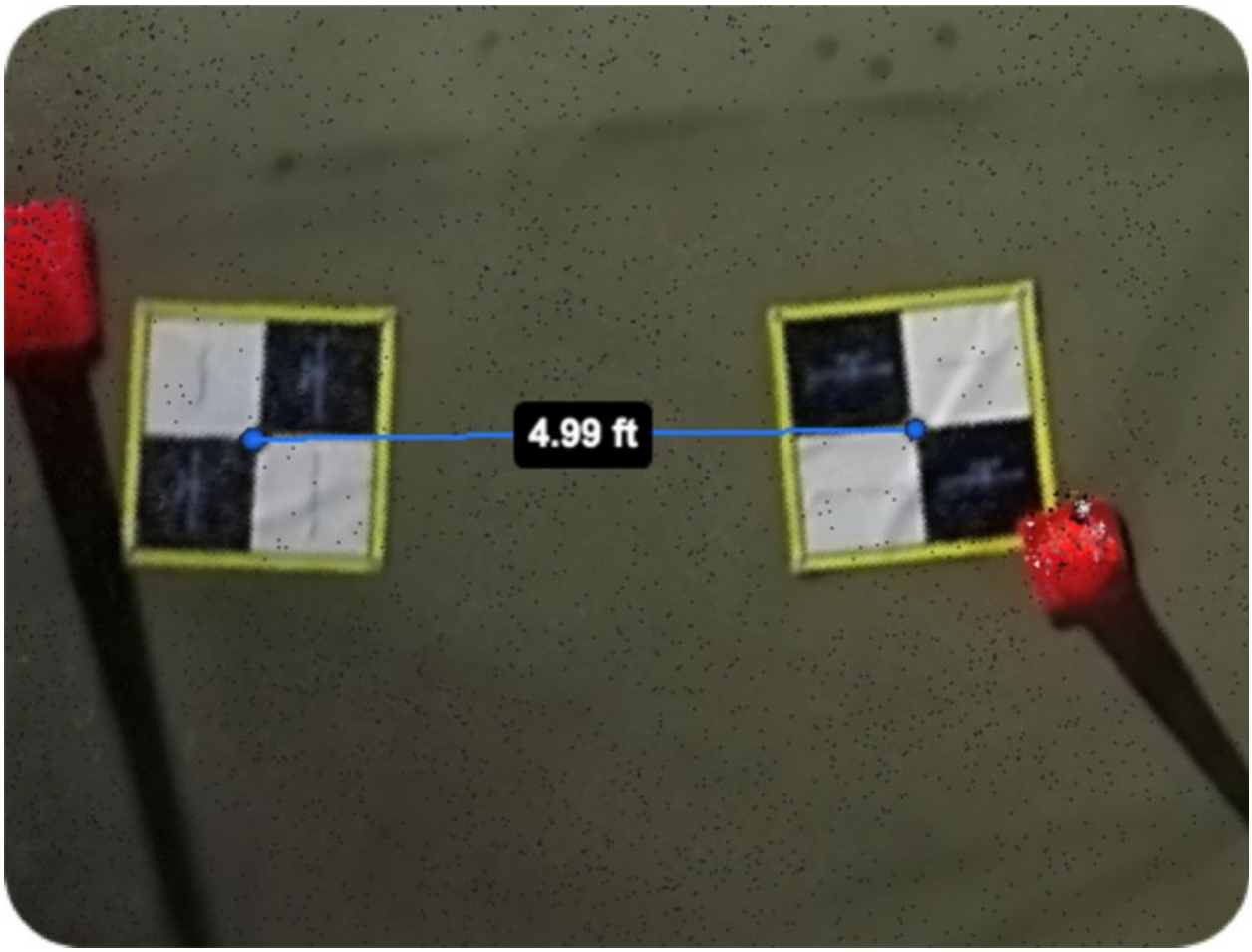


Leica BLK3D Pic-Point sample GCP1 - GCP2

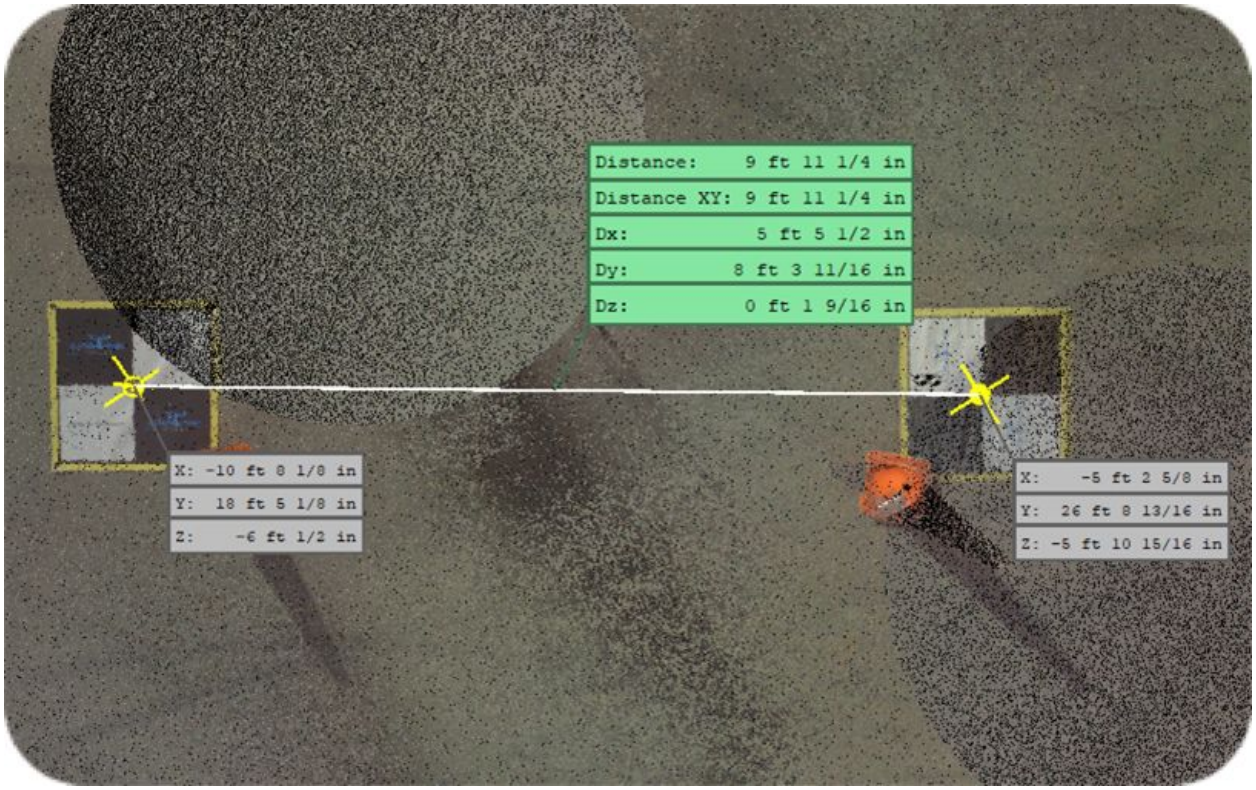
Pix4D Pic-Point sample GCP1 - GCP2



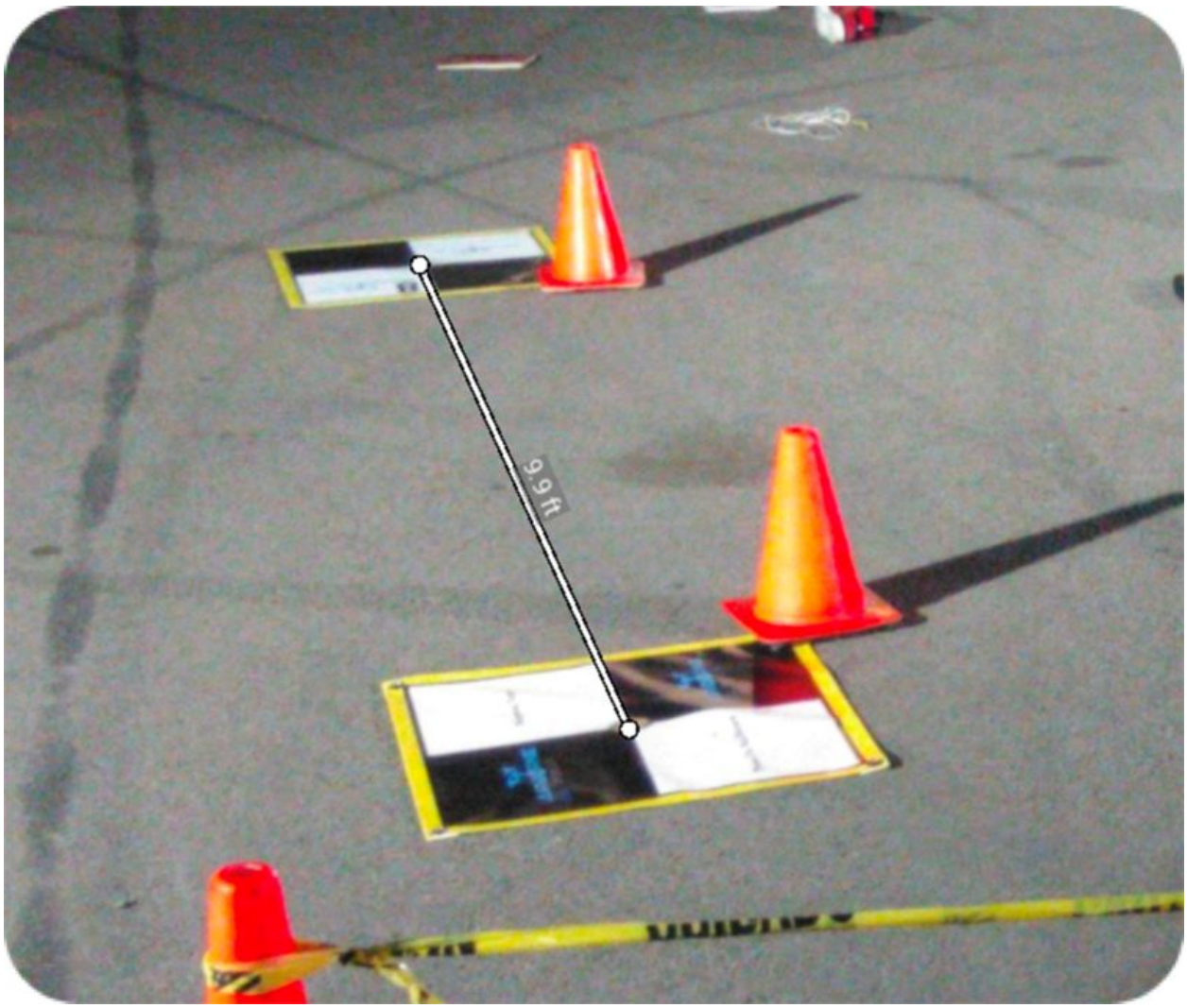
SkyeBrowse Pic-Point sample GCP1 - GCP2



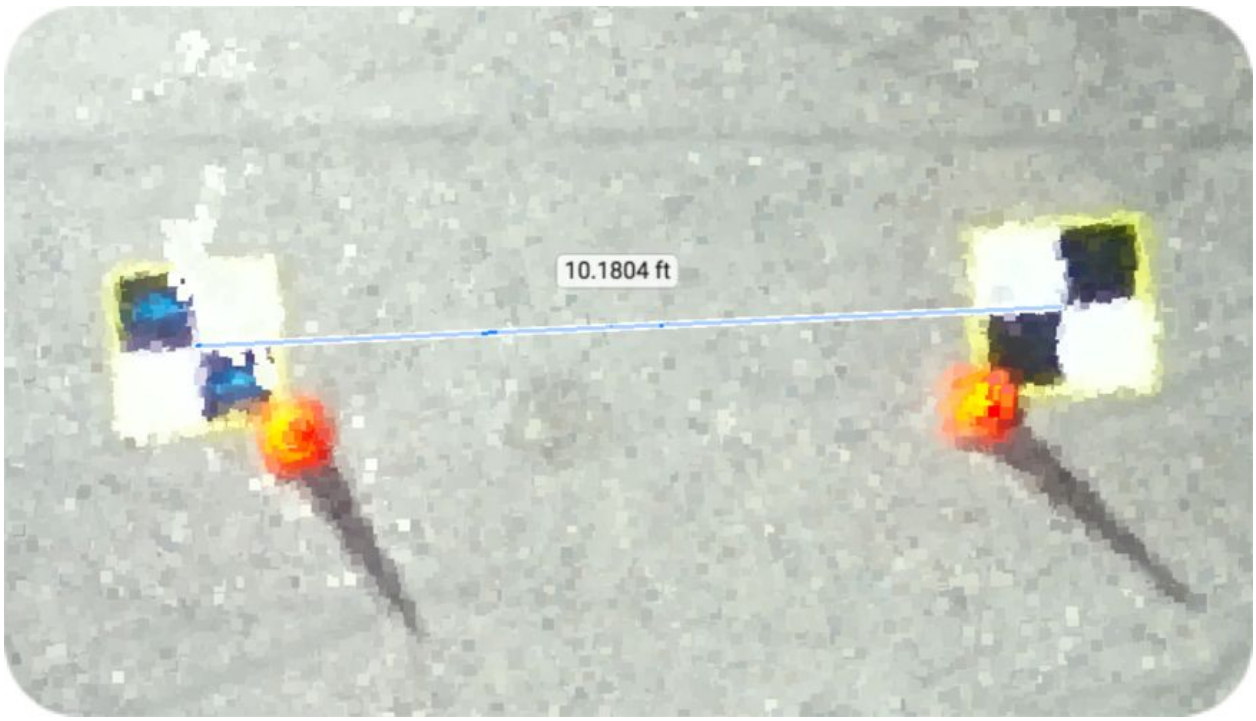
Leica BLK360 Pic-Point sample GCP2 - GCP3



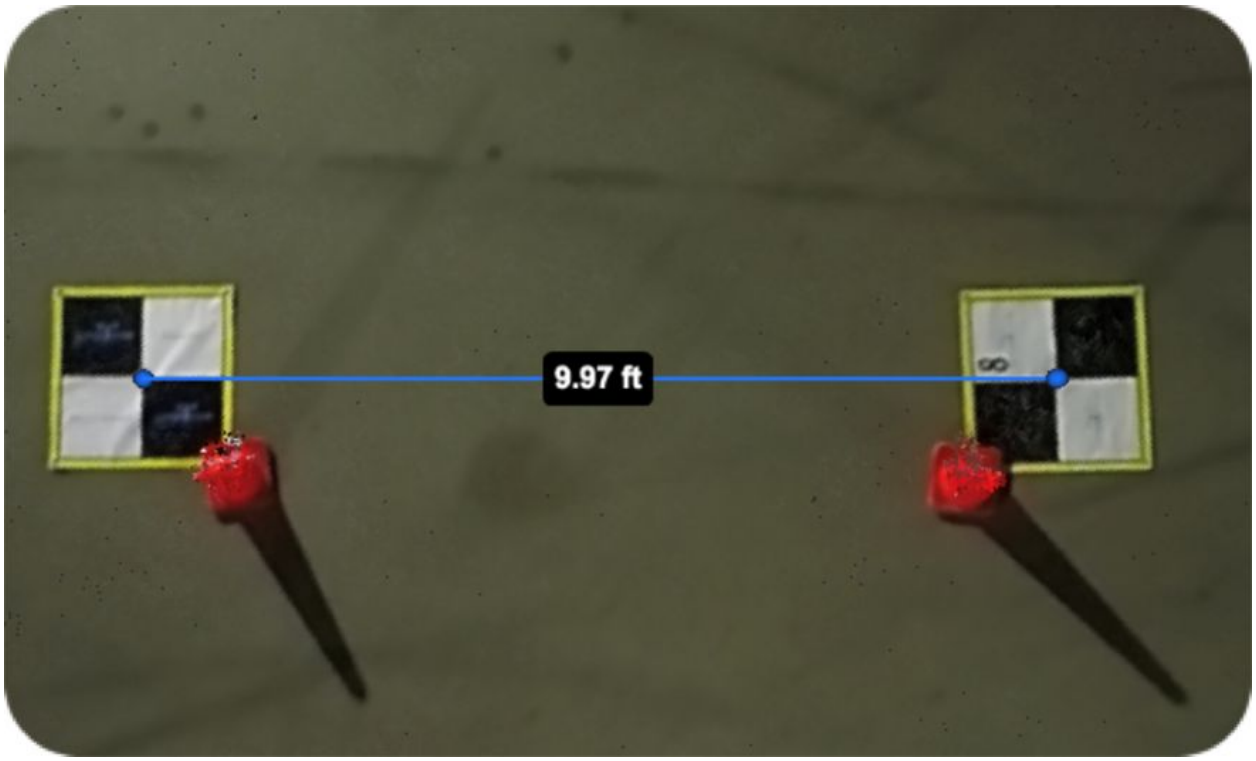
Leica BLK3D Pic-Point sample GCP2 - GCP3



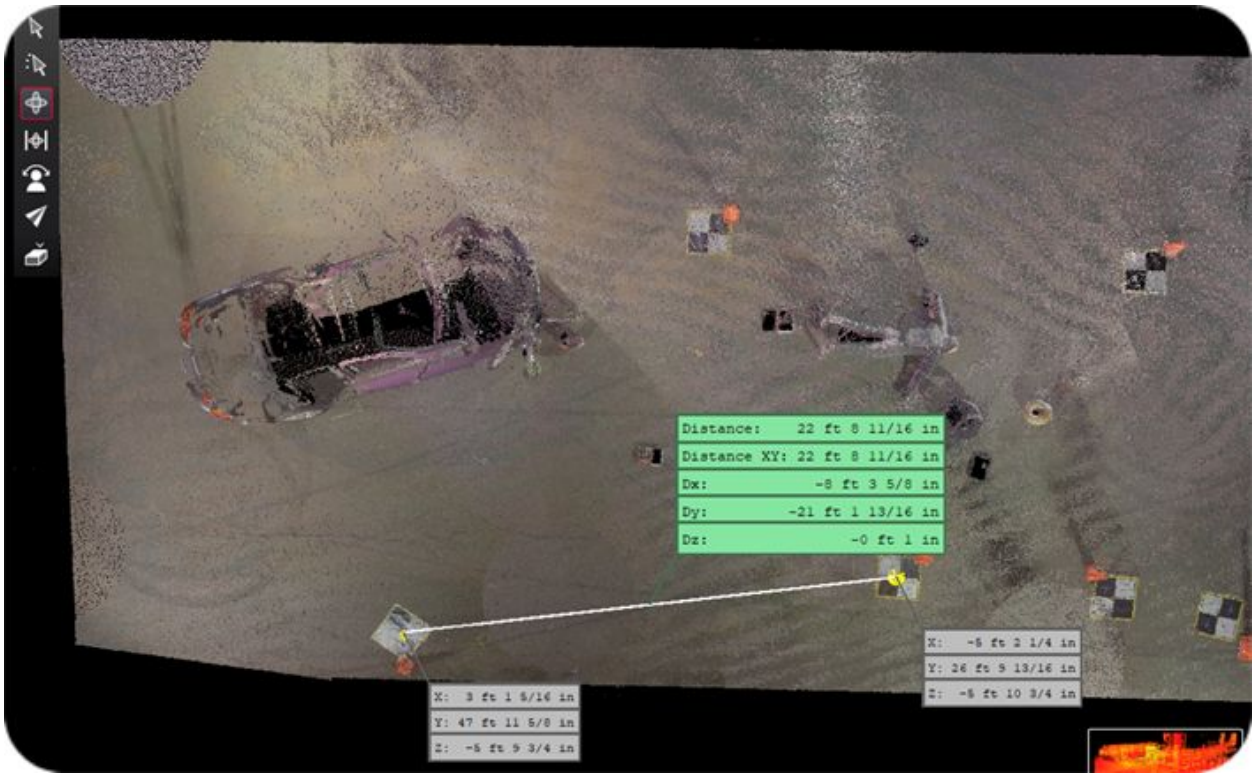
Pix4D Pic-Point sample GCP2 - GCP3



SkyeBrowse Pic-Point sample GCP2 - GCP3



Leica BLK360 GCP3-GCP4

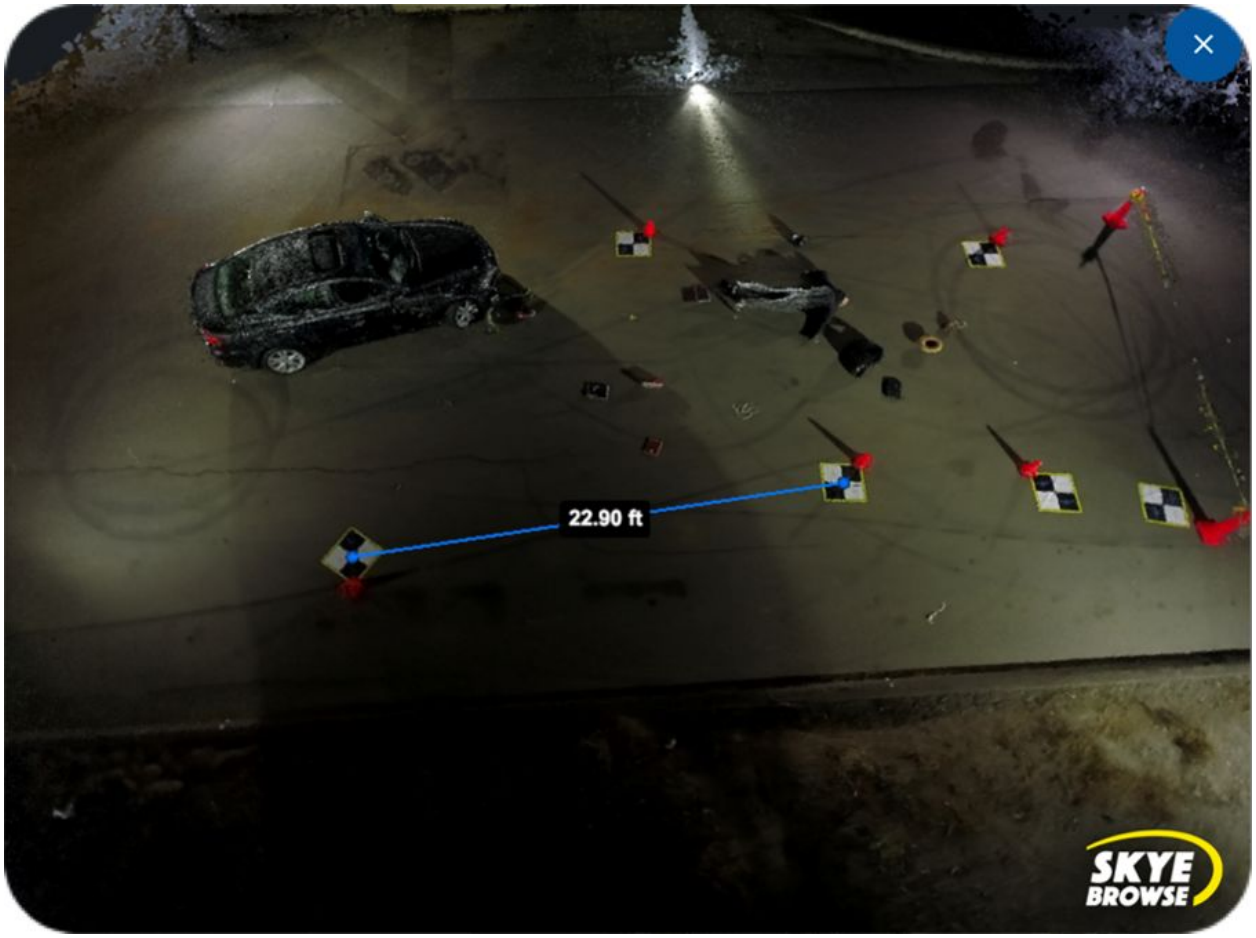


Leica BLK3D Pic-Point sample GCP3 - GCP4

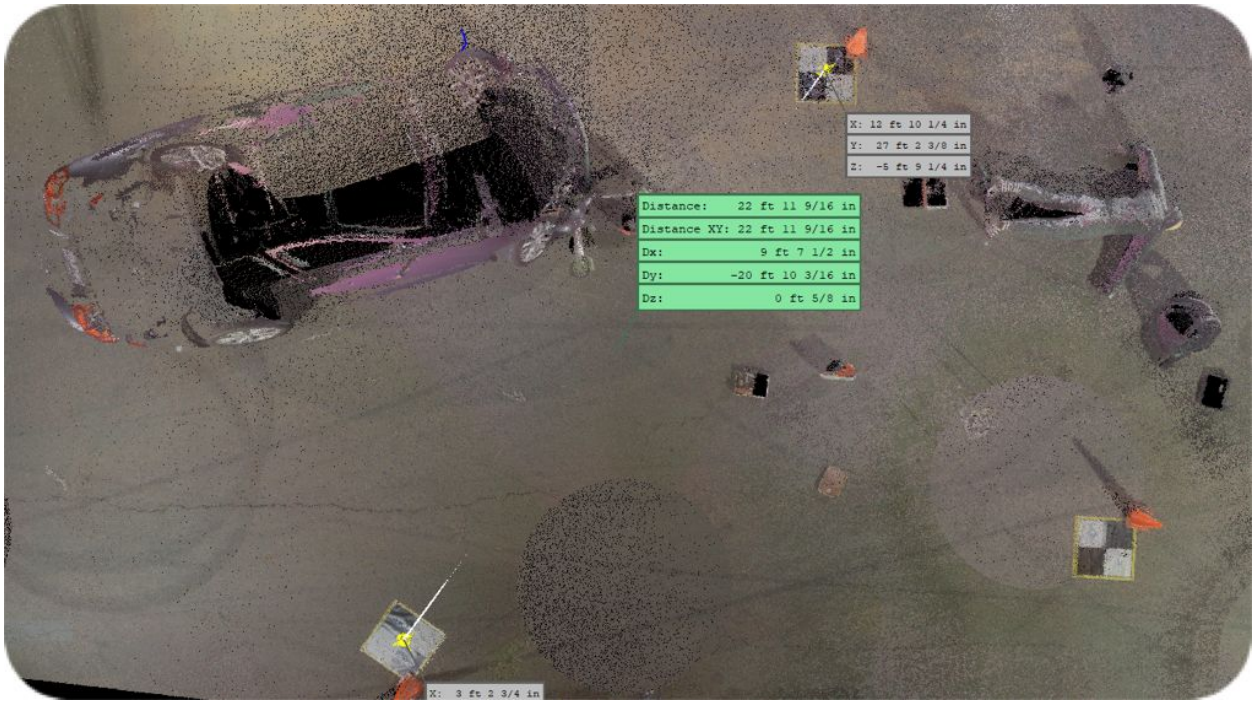
No BLK3D data for this pic point due to limited field of view (FOV) on site.

Pix4D Pic-Point sample GCP3 - GCP4

SkyBrowse Pic-Point sample GCP3 - GCP4



Leica BLK360 Pic-Point sample GCP4 - GCP5

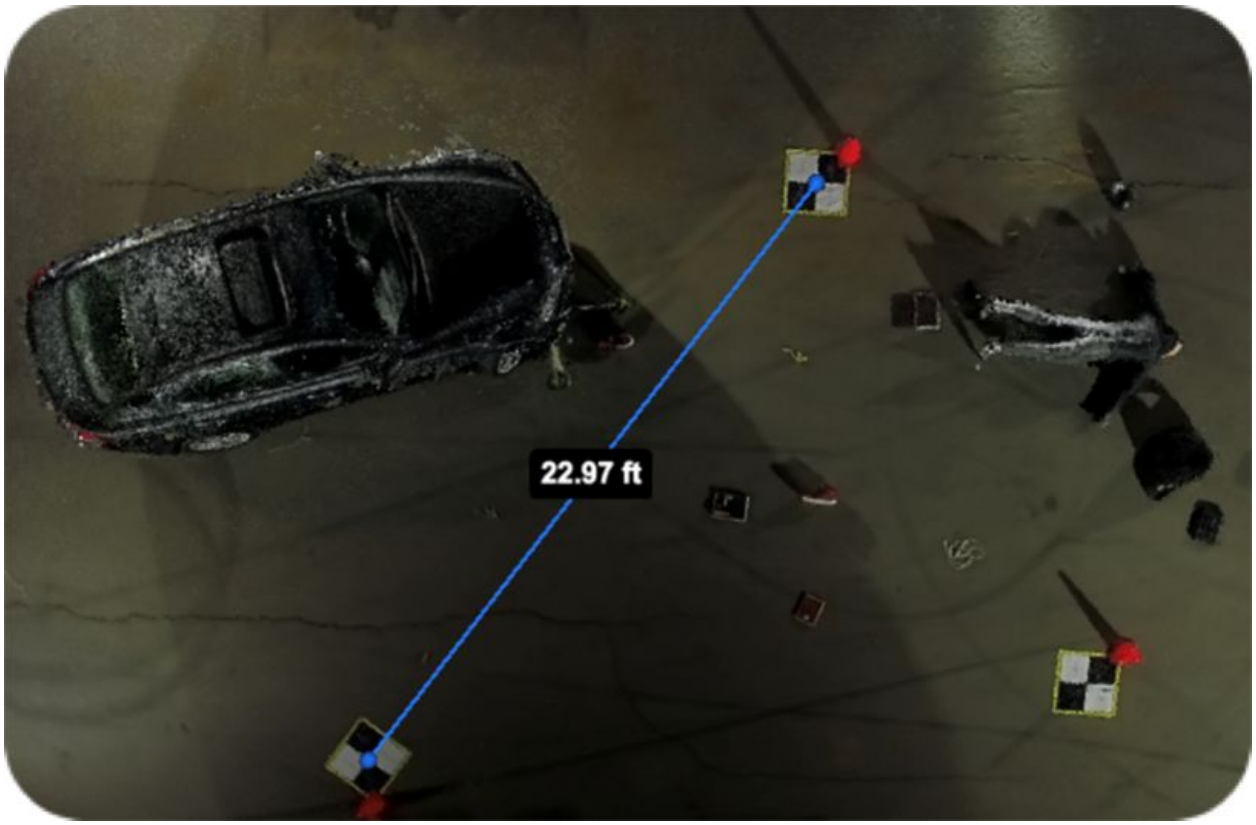


Leica BLK3D Pic-Point sample GCP4 - GCP5

No BLK3D data for this pic point due to limited field of view (FOV) on site.

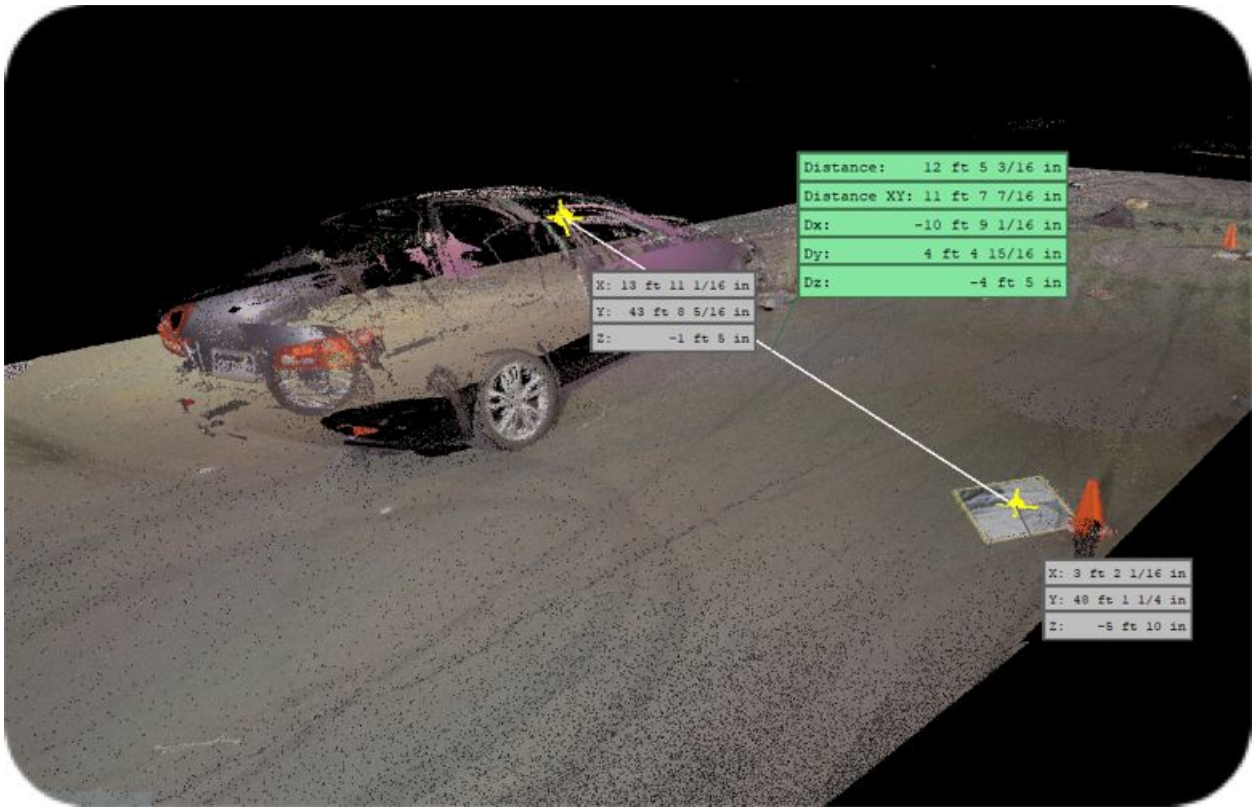
Pix4D Pic-Point sample GCP4 - GCP5

SkyBrowse Pic-Point sample GCP4 - GCP5



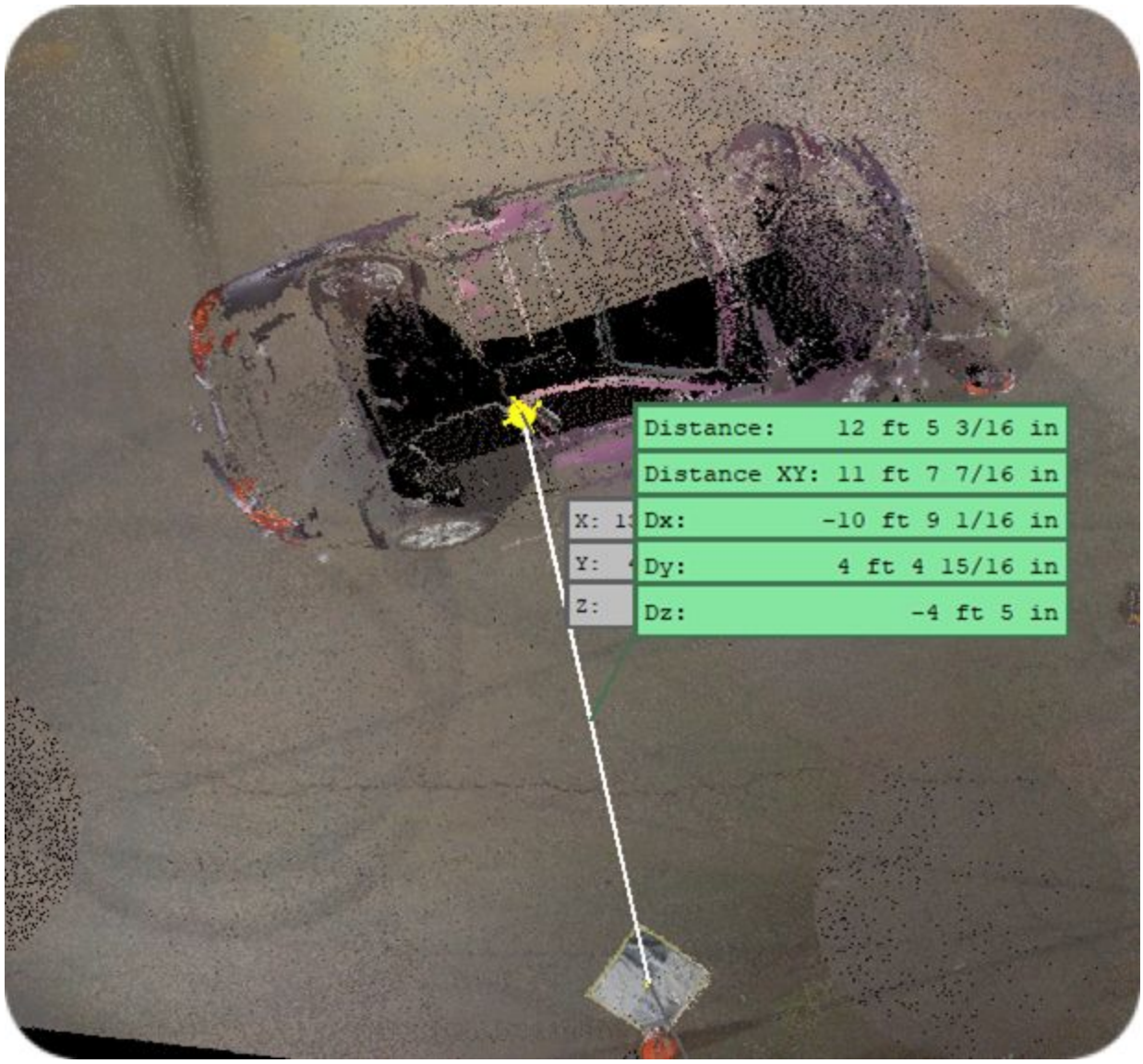
Leica BLK360 Pic-Point / Complex angular measurements.

Dual perspective from point clouds (View 1)



Leica BLK360 Pic-Point / Complex angular measurements.

Dual perspective from point clouds (View 2)

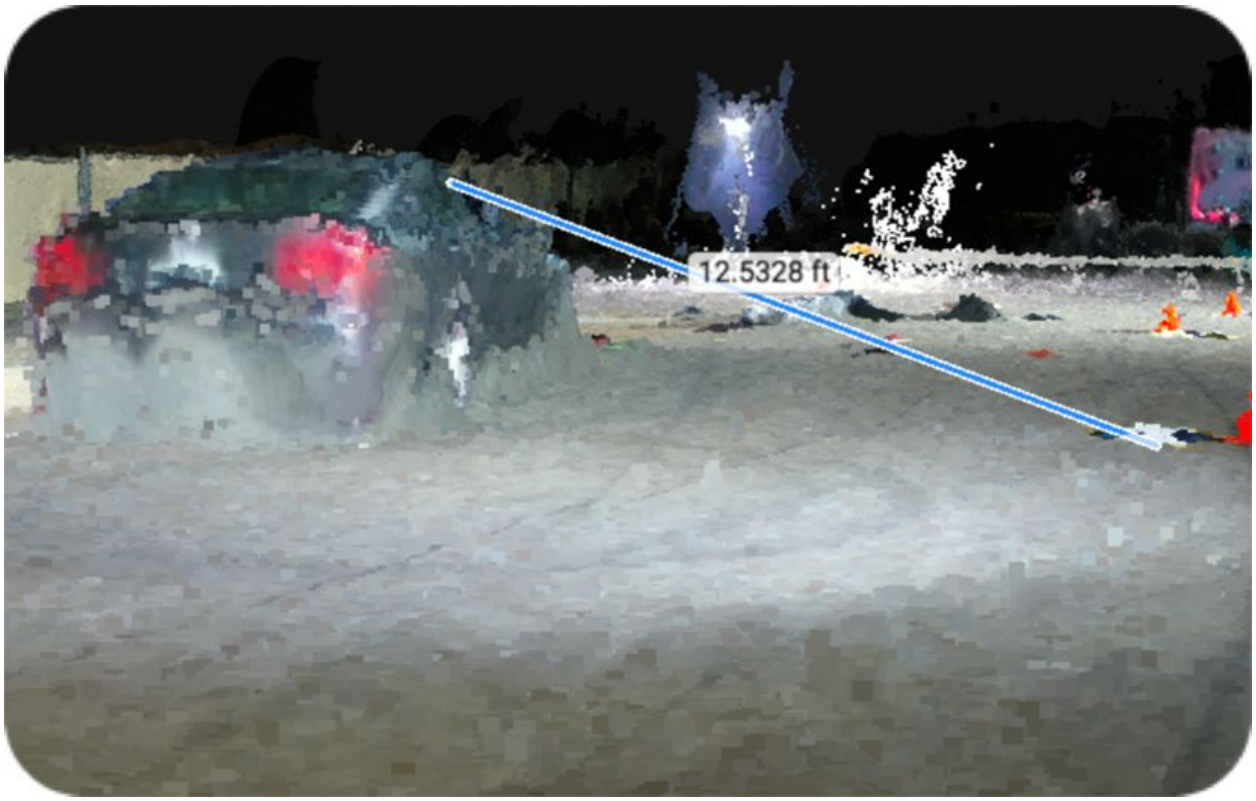


Leica BLK3D Pic-Point / Complex angular measurement.

Because the BLK3D is not point cloud based we can only view it in one perspective for this example.

Pix4D Pic-Point

Complex angular measurements dual perspective (View 1)

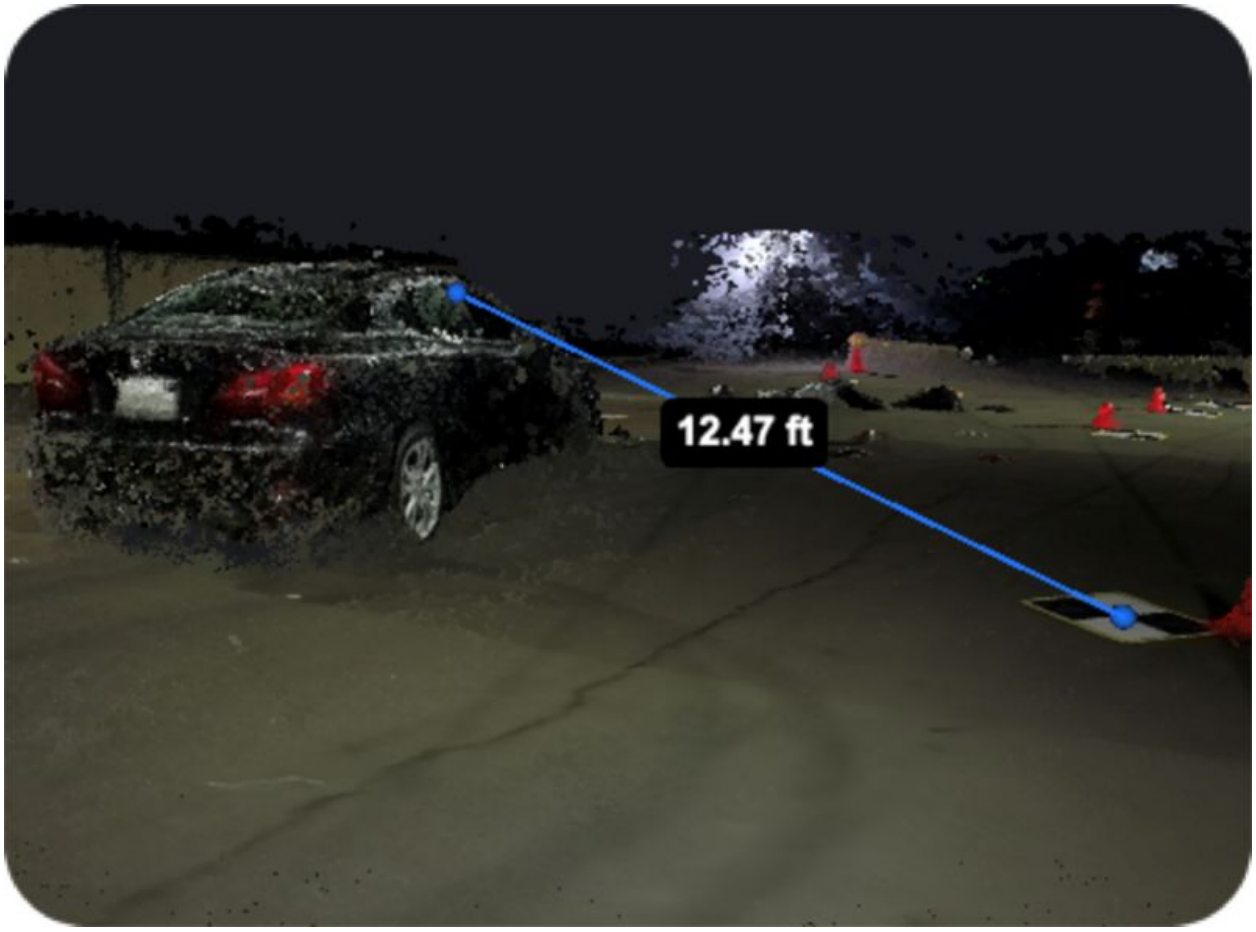


Pix4D Pic-Point

Complex angular measurements dual perspective (View 2)

SkyBrowse Pic-Point

Complex angular measurements dual perspectives (View 1)

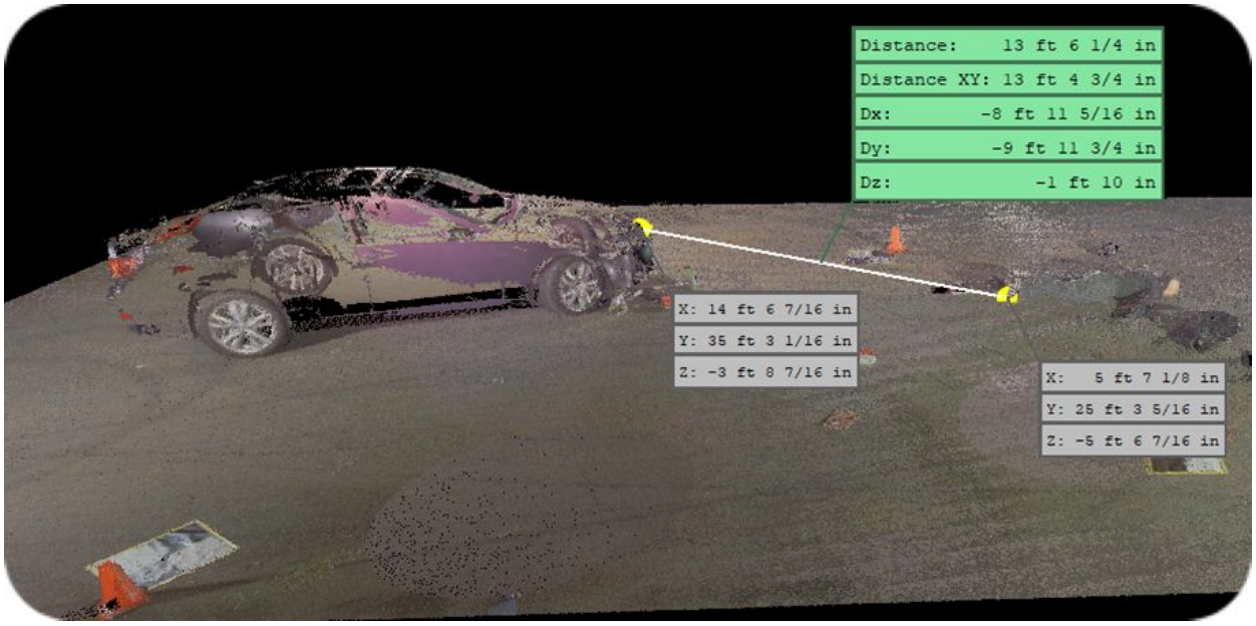


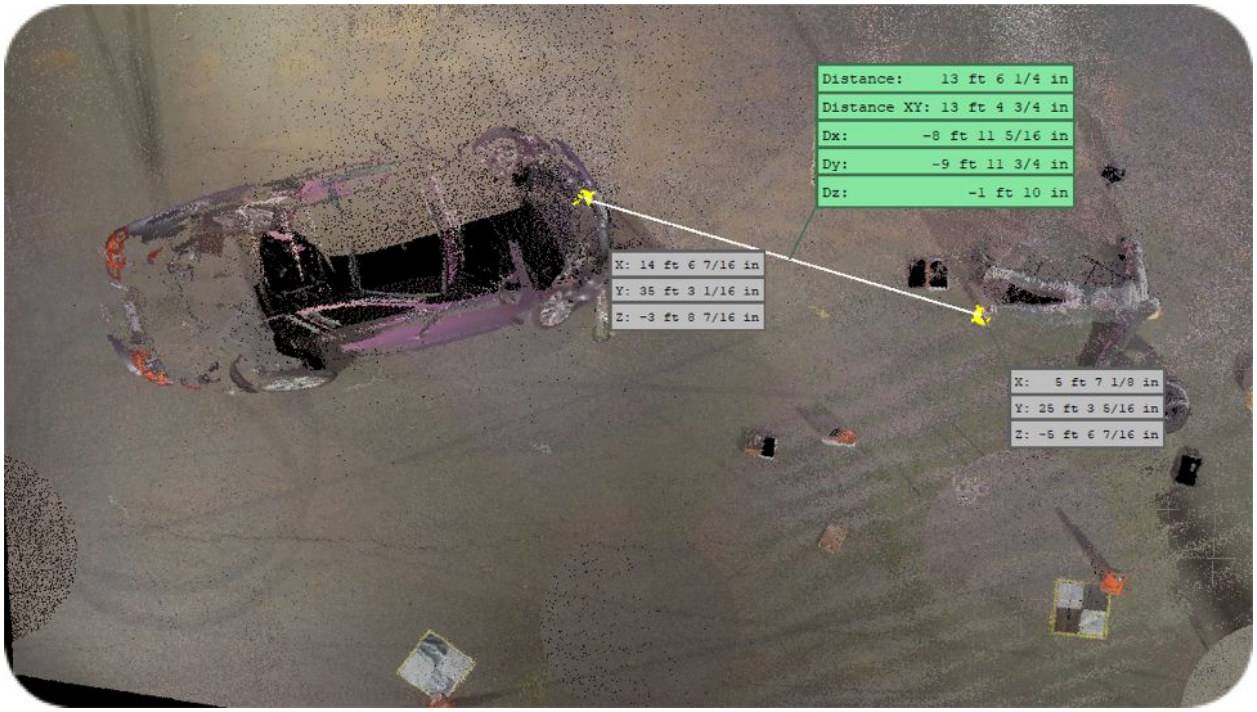
SkyBrowse Pic-Point

Complex angular measurements dual perspectives (View 2)

Leica BLK360 Pic-Point / Complex angular measurements continued

Front of car to foot of victim dual perspective





Leica BLK3D Pic-Point / Complex angular measurement

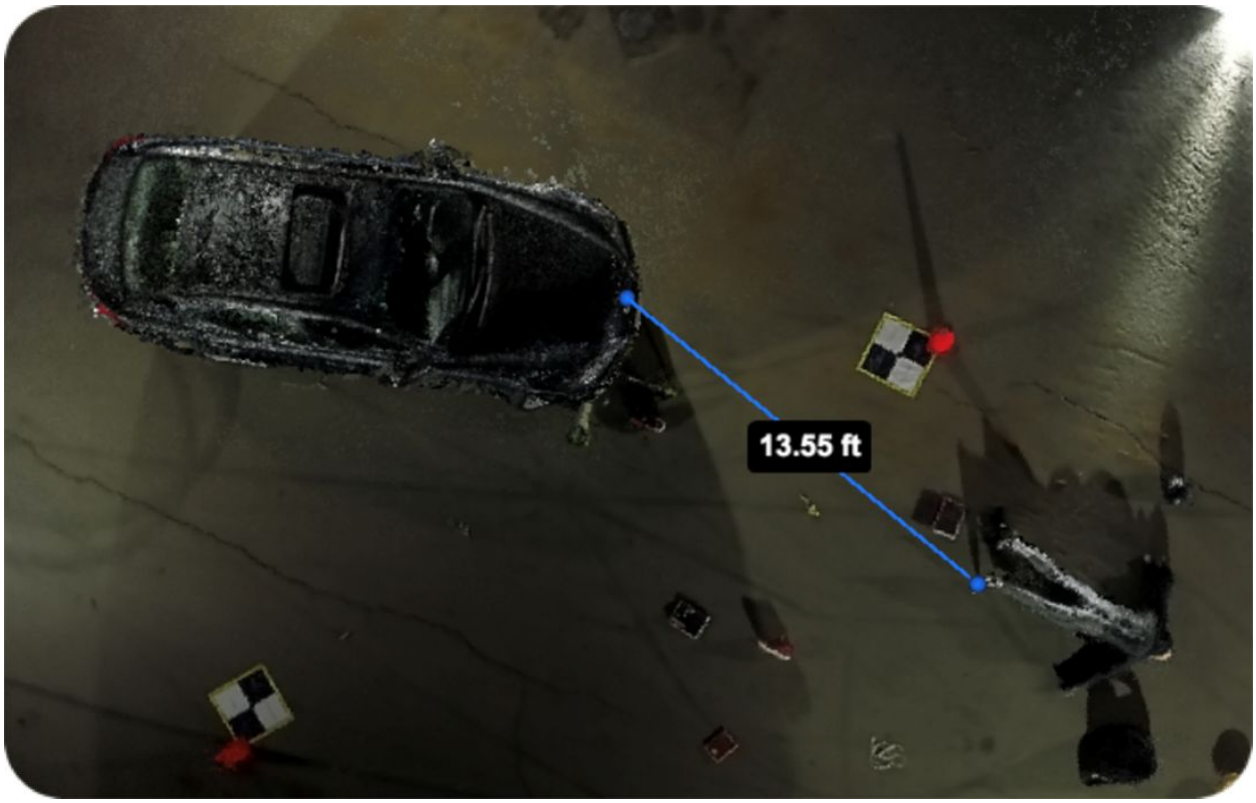
Because the BLK3D is not point cloud based we can only view it in one perspective for this example.

Pix4D Pic-Point / Complex angular measurements continued

Front of car to foot of victim dual perspective

SkyBrowse Pic-Point / Complex angular measurements continued

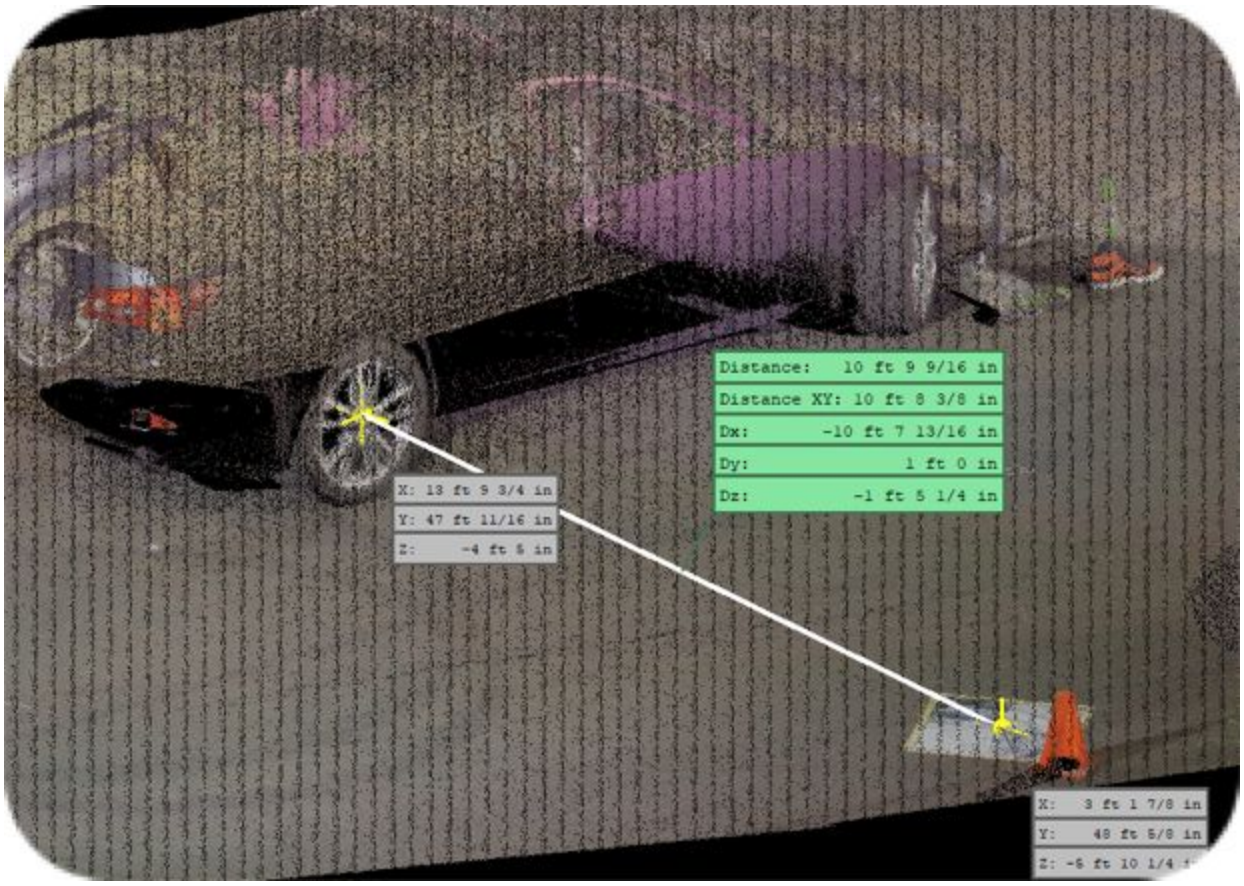
Front of car to foot of victim dual perspective



Leica BLK360 Pic-Point / The Cyclone Register360

3 distance measurements as shown to combine two angles and a horizontal point to point

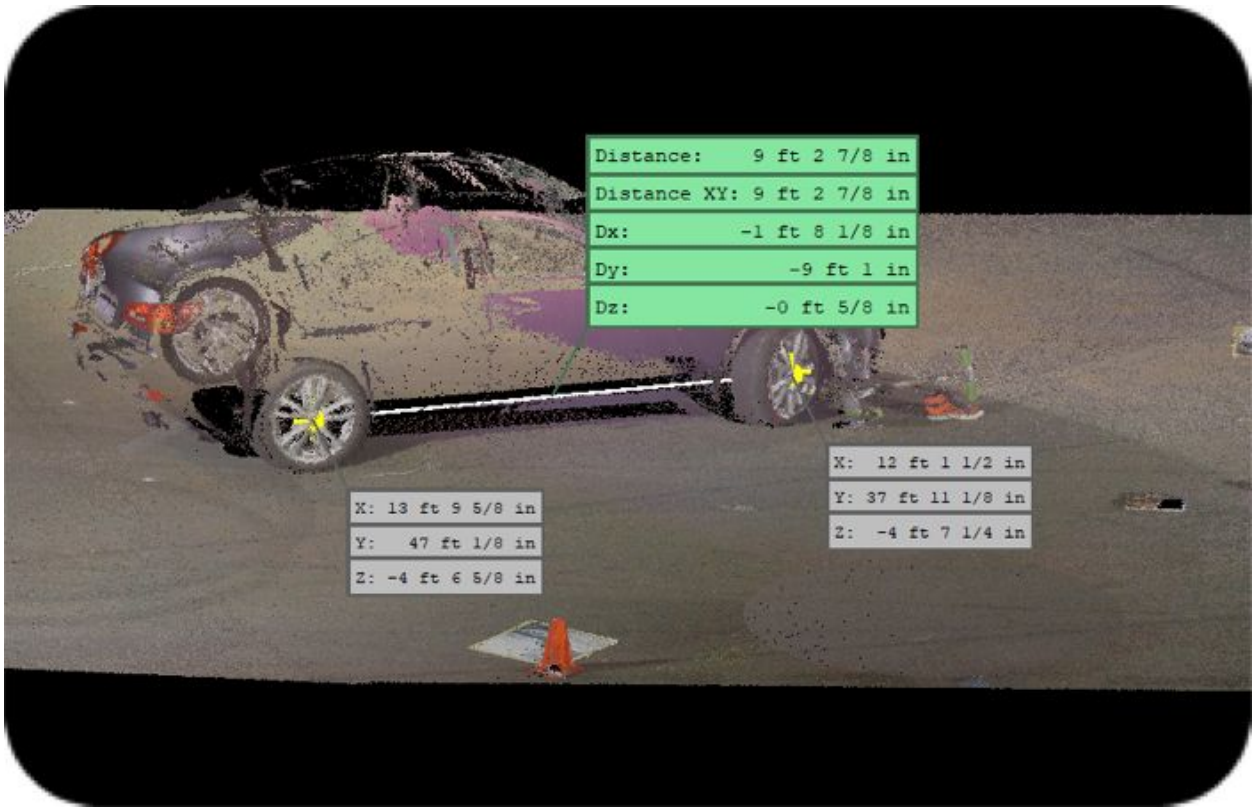
Distance 1 (Back Wheel to GCP4)



Leica BLK360 Pic-Point / The Cyclone Register360

3 distance measurements as shown to combine two angles and a horizontal point to point

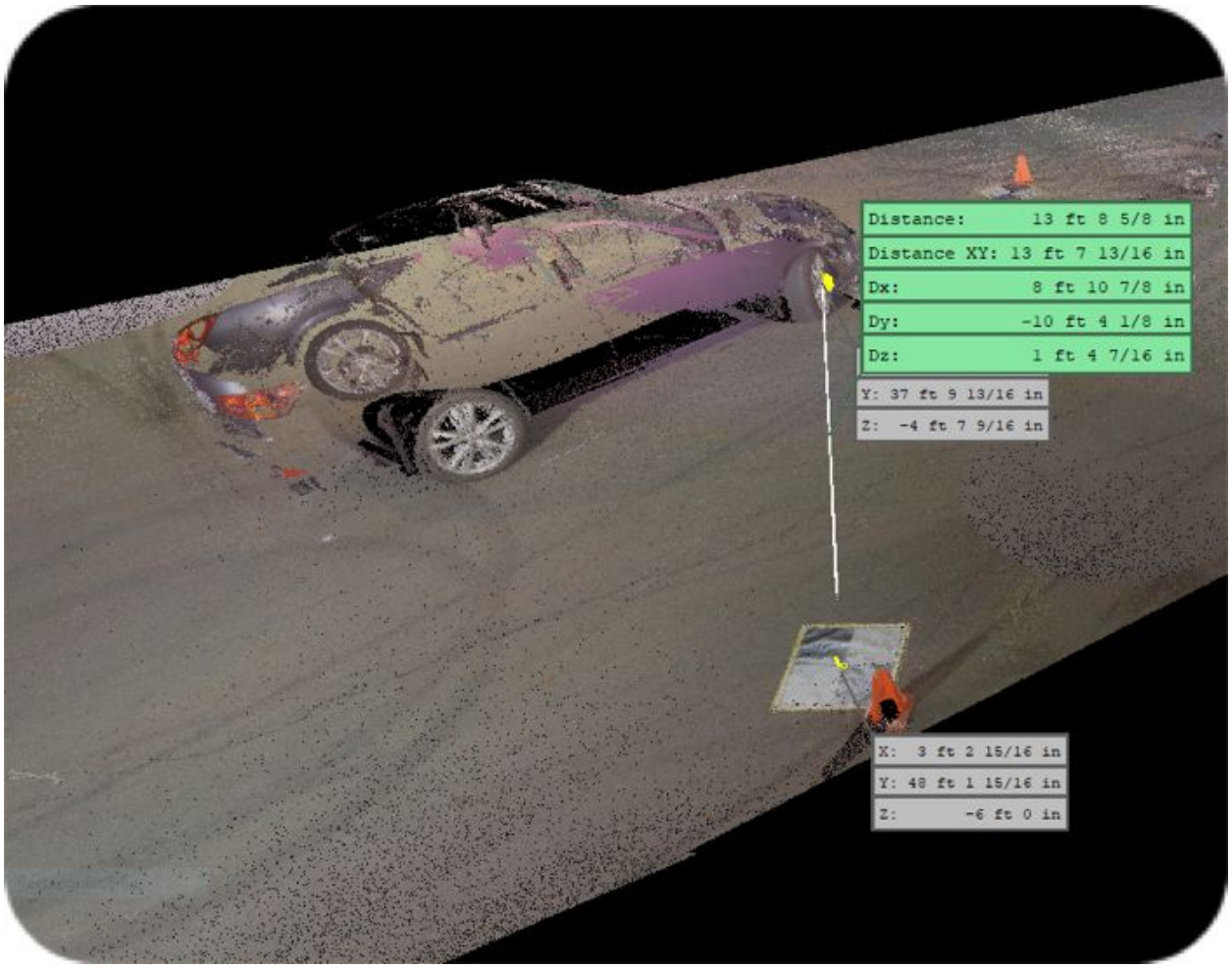
Distance 2 (Back Wheel to Front Wheel)



Leica BLK360 Pic-Point / The Cyclone Register360

3 distance measurements as shown to combine two angles and a horizontal point to point

Distance 3 (Front Wheel to GCP4)

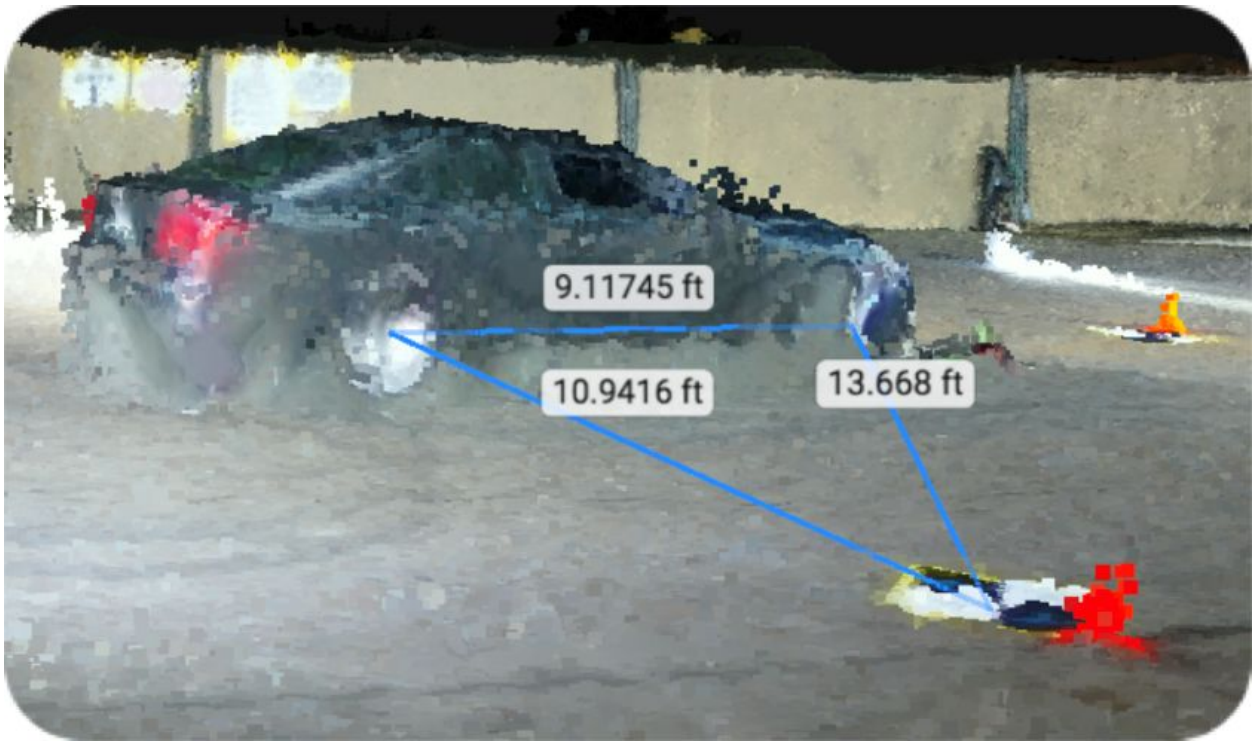


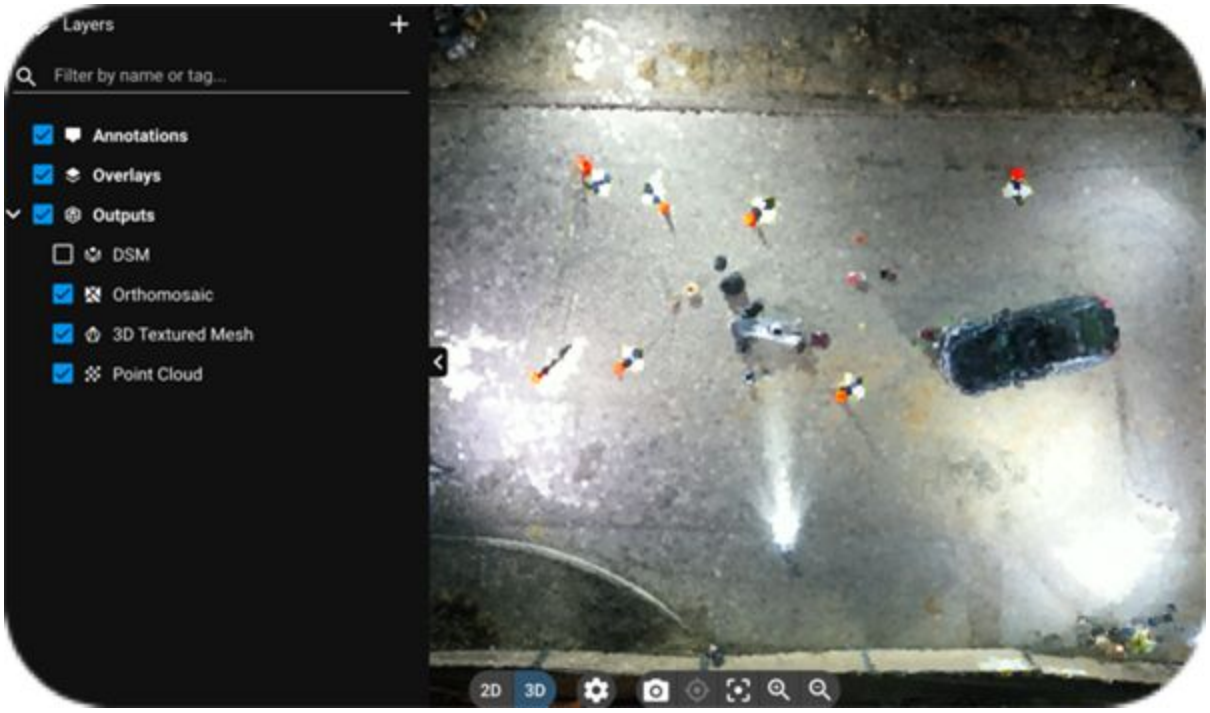
Leica BLK3D Pic-Point

3 distance measurements as shown to combine two angles and a horizontal point to point.

Pix4D Pic-Point

3 distance measurements as shown to combine two angles and a horizontal point to point.





SkyBrowse Pic-Point / 3 distance measurements as shown to combine two angles and a horizontal point to point.