Web ODM Report

2023-07-19

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Version: 2

Contents

Introduction

Web-ODM is an open-source software used for processing and analyzing aerial imagery captured by drones. It has a wide range of applications, including mapping, surveying, land management, and environmental monitoring. The purpose of this report is to go over the usefulness of Web-ODM by testing multiple sets of data. The report conducts an analysis of key factors including the installation type, machine specifications, and utilized datasets. The report will also highlight the software's limitations and potential for improvement, discussing important factors such as speed, accuracy, and reliability.

In addition, in the report we will also compare Web-ODM to DJI Terra, which is the software currently being used for creating 2D and 3D maps. The comparison will cover aspects such as features, efficiency, accuracy, and cost-effectiveness. This will give a comprehensive understanding of the strengths and weaknesses of each software and help choose the most suitable software for their particular needs and budget.

Background

Features	Web ODM	DJI Terra
Software Type	Open Source	Commercial
Operating System	Windows and all Unix based Systems	Windows
Photogrammetry	Yes	Yes
Aerial Triangulation	Yes	Yes
Point Cloud Densification	Yes	Yes
3d Model Generation	Yes	Yes
Real Time mapping	No	Yes
Flight planning tools	No	Yes (Only DJI drones)
Quality Report	Yes	Yes
Hardware compatibility	Compatible with Various Drones	Compatible with Various Drones (Works best with DJI drones)
Pricing	Free	Subscription

Software Features

Settings

WebODM offers 13 different processing presets, each applying specific settings to datasets to generate diverse outputs. The datasets include:

1. Custom: Allows users to precisely modify settings according to their preferences.
2. Default: Generates a point cloud, Orthophoto, and Digital Surface Model (DSM).
3. High Resolution: Provides a high-resolution output, albeit with longer processing times.
4. Fast Orthophoto: Focuses on producing only the orthophoto for quicker processing.
5. Field: Enhances quality for datasets related to field applications.
6. DSM + DTM: Creates both a Digital Terrain Model (DTM) and a Digital Surface Model (DSM).
7. Forest: Generates a higher number of points to better represent forested areas.
8. Points of Interest: Enhances mesh representation for improved handling of man-made structures.
9. Buildings Ultra Quality: Offers the best mesh representation for dealing with buildings.
10. Buildings: Provides improved mesh representation for better handling of buildings.
11. 3D Model: Produces an improved mesh for the 3D model.
12. Volume Analysis: Enhances DTM and DSM for accurate volume calculations.
13. Multispectral: Includes parameters tailored for processing multispectral images.

For the datasets analyzed in this report, the default preset was utilized (unless stated otherwise) as it offers the most balanced combination of settings, incorporating all the necessary outputs required for our analysis. The default preset ensures that we obtain a comprehensive range of outputs while maintaining a good balance between processing time and output quality, making it an ideal choice for our specific needs.

Data

Test Machine #	CPU	GPU	RAM	Storage
Test Machine 1 (The Office PC)	Intel(R) Core(TM) i7-8565U @ 1.80GHz	Nvidia GeForce Mx250	16 GB	477 GB
Test Machine 2 (Personal Laptop)	Intel Core i5 10600K @ 4.10GHz	Nvidia GeForce GTX 1080	64 GB	1000 GB

Machine Specifications

Process Time & Image Quality

Test Machine 1

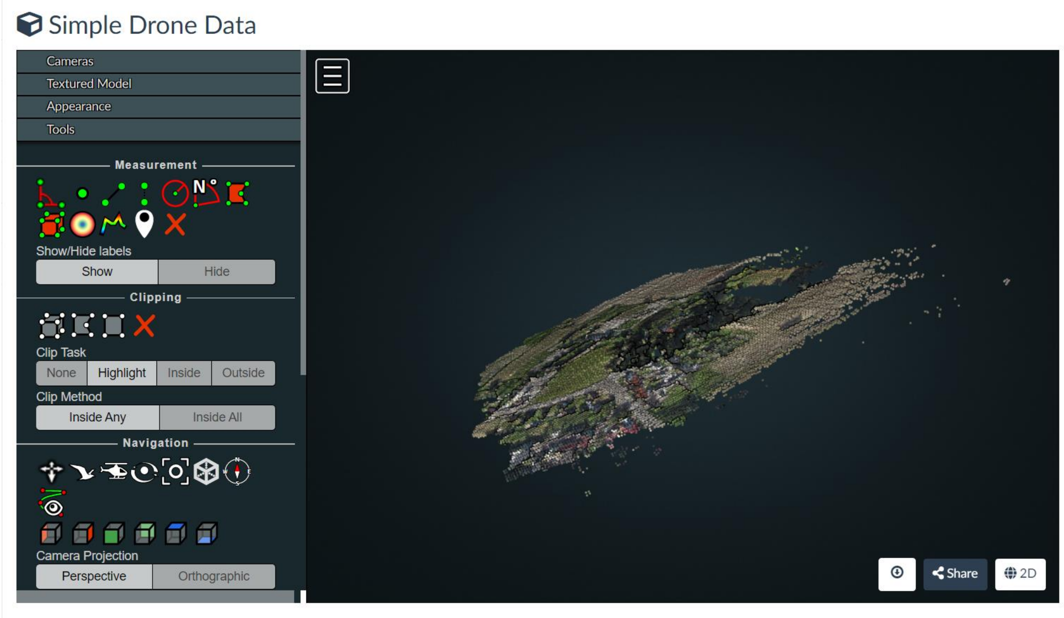
Using the Docker Installation of WebODM
Note the Docker installation was limited to 8GB of RAM

Sample Name	# of images	Resolution	Time(hh:mm:ss)	Completed processing
Test Sample (From ODM GitHub)	46	5k	00:33:53	Yes
Broadway Avenue - 5/28/2023 (DJI_202305281436_009_stalbans)	137	5k	01:53:44	No

Data Sets Processed by Docker installation of WebODM.

Test Sample
46 images, 3k resolution, completed in 00:33:53

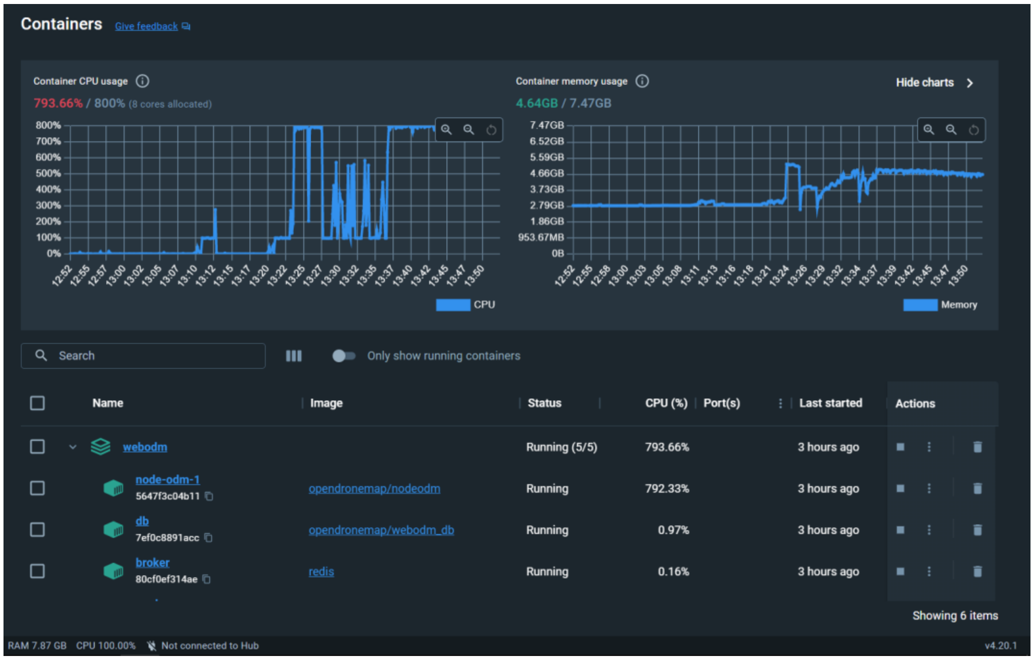
2d map of Test Sample



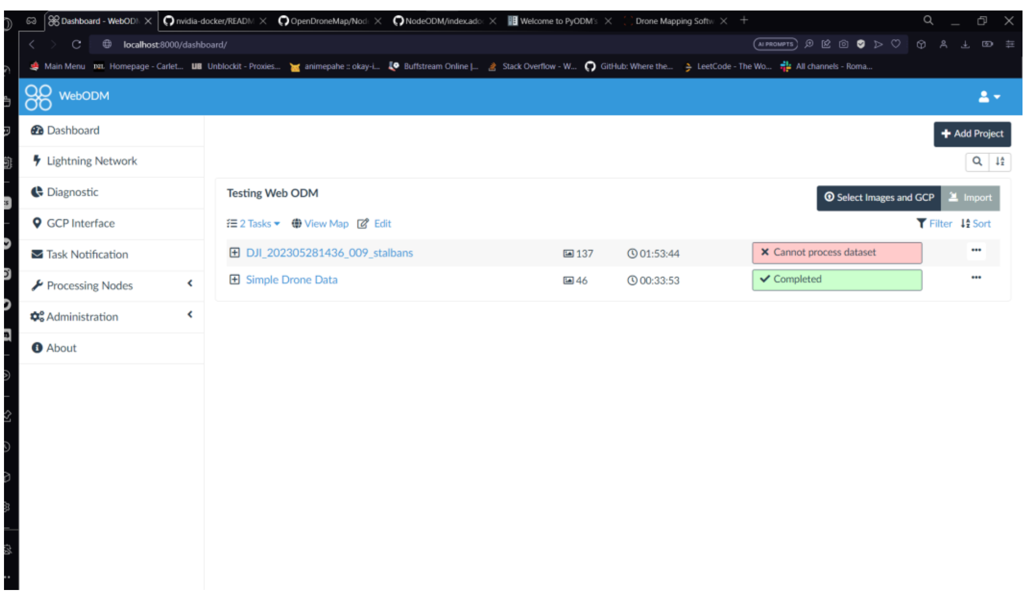
3d map of Test Sample

Sample Image from GitHub

Broadway Avenue - 5/28/2023
137 images, 3k resolution, Crashed at 01:53:22



Docker Process screen Before crash



Crash screen on WebODM

worker | INFO TaskNotification: Task Failedworker | [2023-06-07 19:17:19,780: INFO/ForkPoolWorker-68]

worker.tasks.process_task[add31e64-7599-4fe4-a9cd-d351f198fa20]: TaskNotification: Task Failed

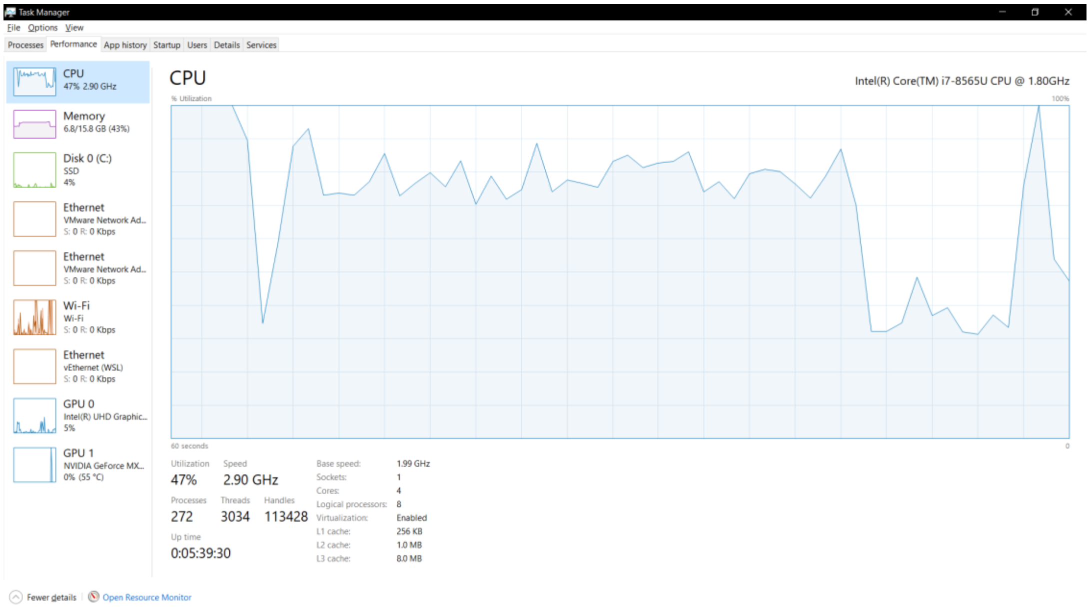
Errors thrown by WebODM

Using WebODM application

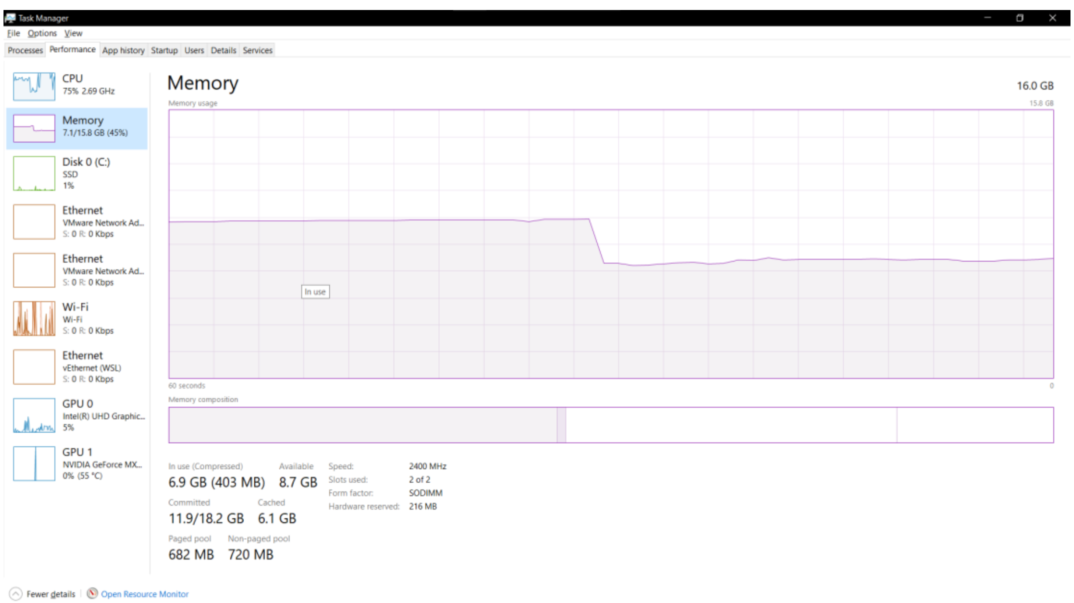
Sample Name	# of images	Resolution	Time(hh:mm:ss)	Completed processing
New Visible Light Reconstruction Mission Day 1 - 5/18/2023 (DJI_202305181543_002_Mapping1)	68	5k	00:32:33	Yes
Stalbans Mission 2 - 5/28/2023 (DJI_202305281436_009_stalbans)	137	5k	1:06:24	Yes
New Visible Light Reconstruction Mission - 5/19/2023 (DJI_202305191303_005_Tauvette1 - 165 ft)	350	5k	2:50:14	Yes

Data Sets Processed by installation of WebODM application

New Visible Light Reconstruction Mission Day 1 - 5/18/2023
68 images, 3k resolution, Completed at 00:32:33



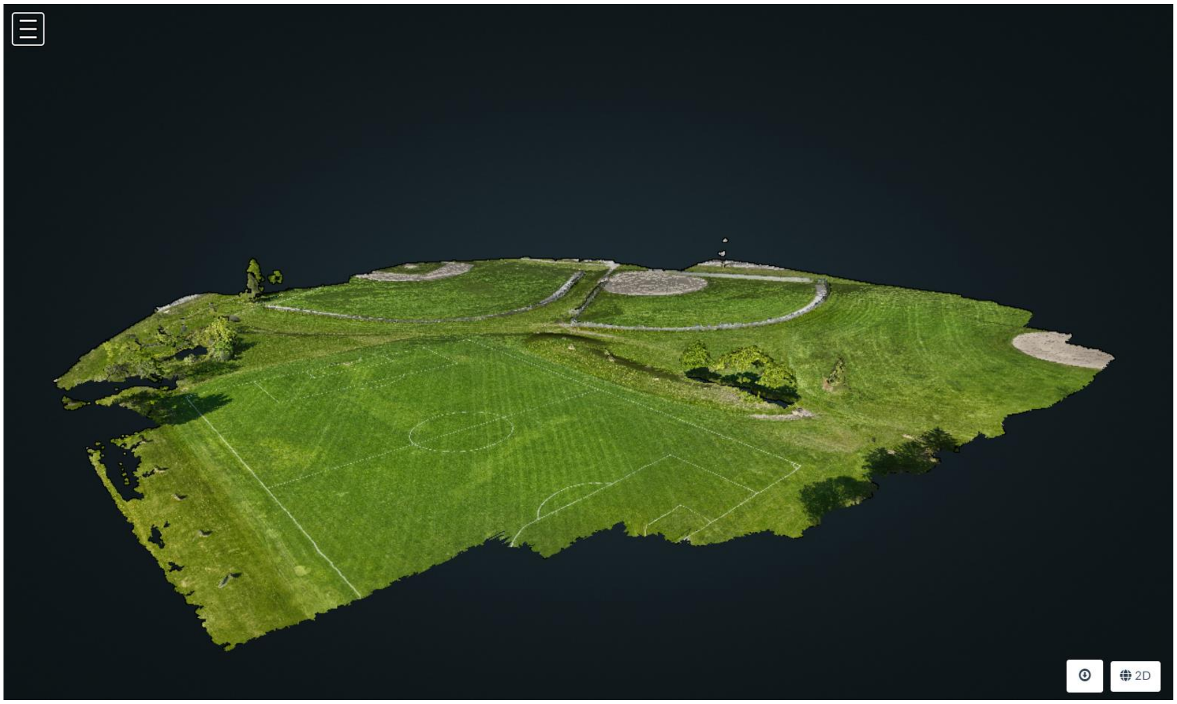
CPU Usage at 50% completion



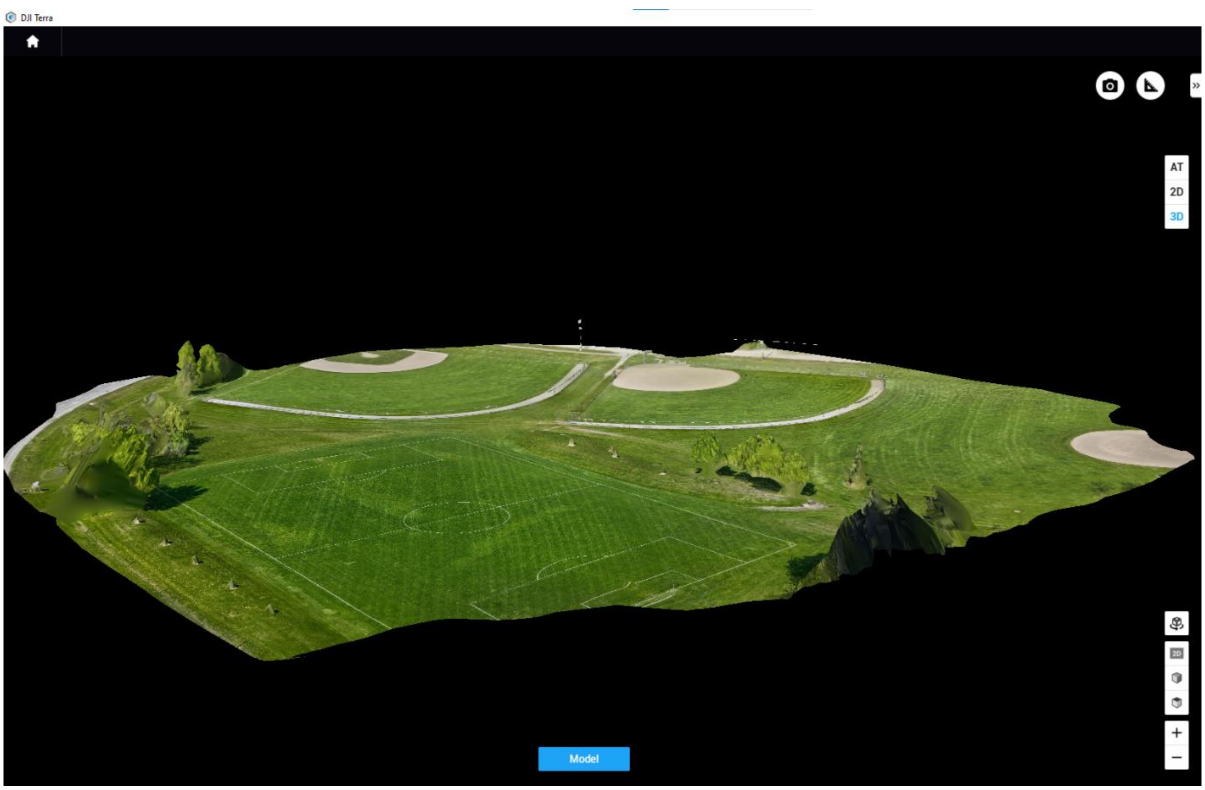
Memory Usage at 50% completion

2d map of the field from Web ODM

2d map of the field from Terra

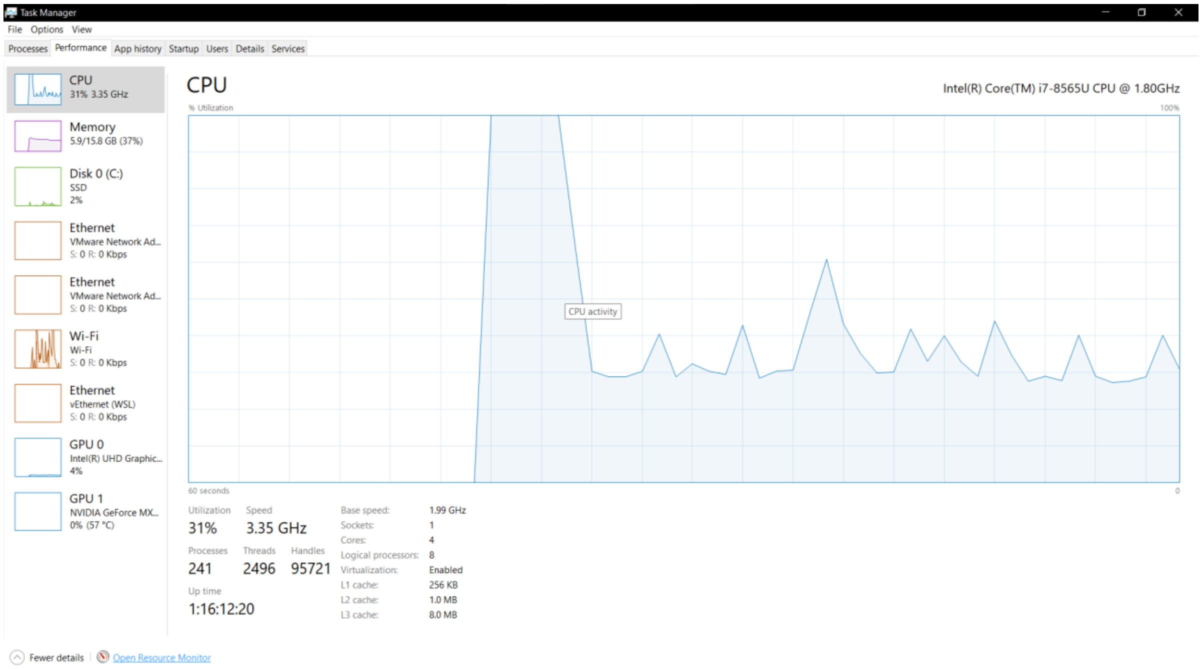


3d map of the field from Web ODM

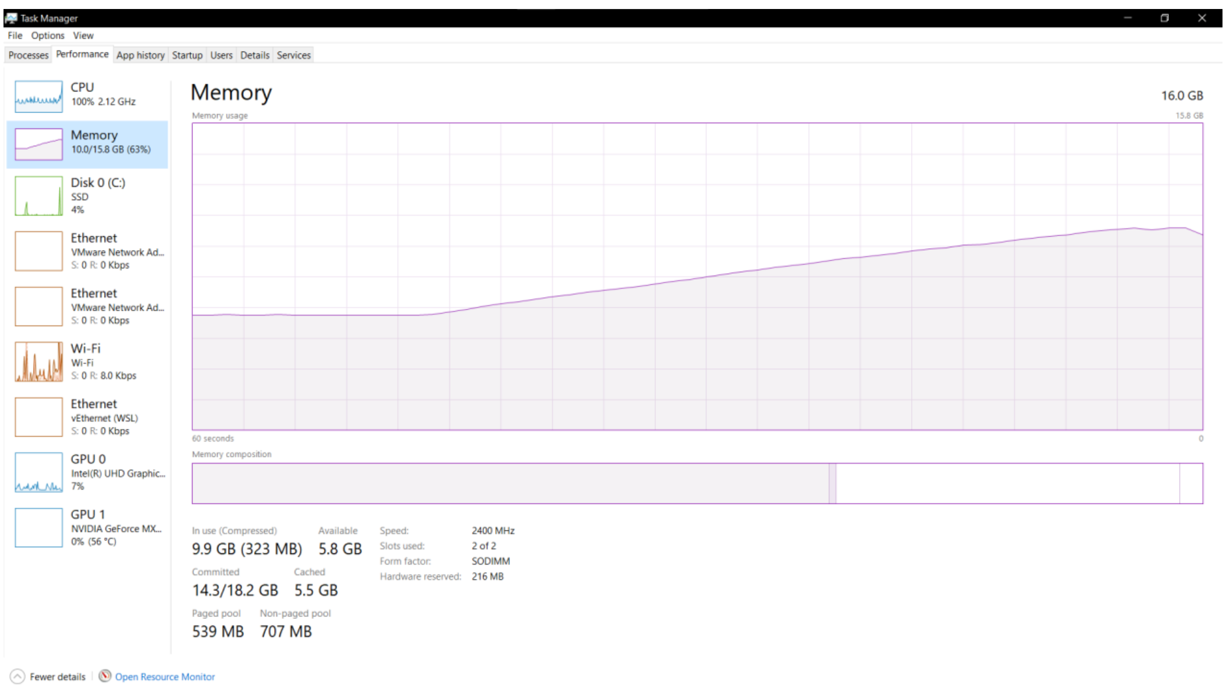


3d map of the field from Terra

Stalbans Mission 2 - 5/28/2023
350 images, 3k resolution, Completed at 2:50:14



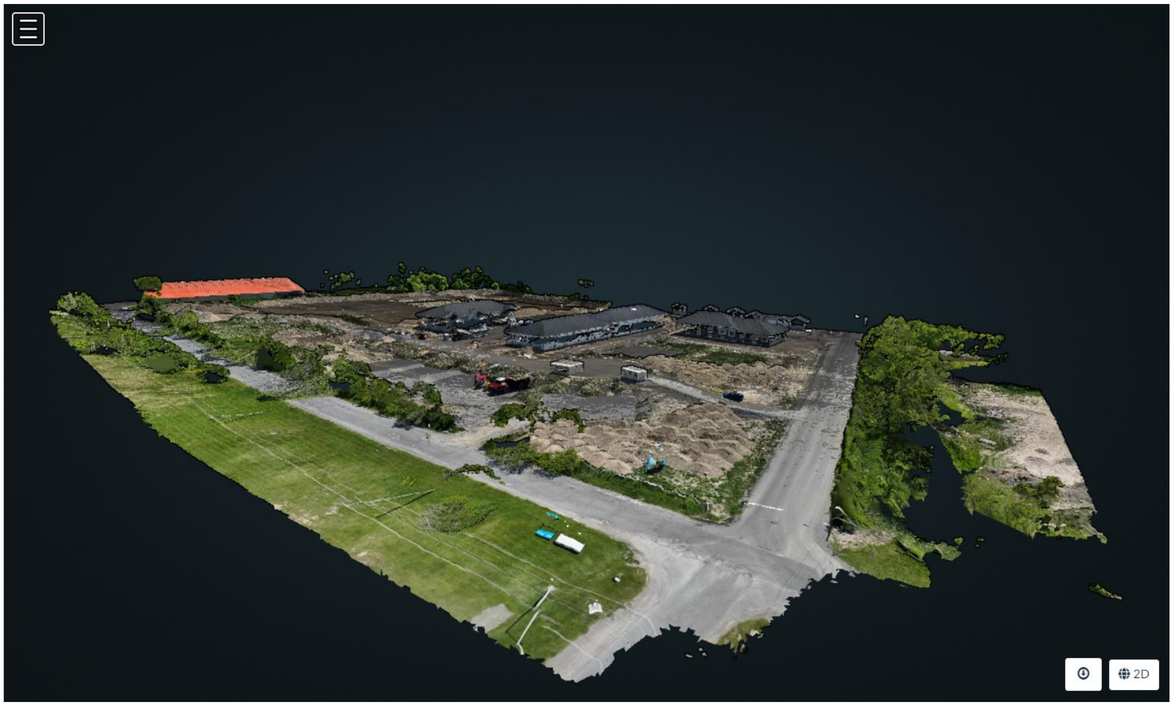
CPU Usage at 50% completion



Memory Usage at 50% completion

2d map of site from Web ODM

2d map of site from Terra



3d map of site from Web ODM

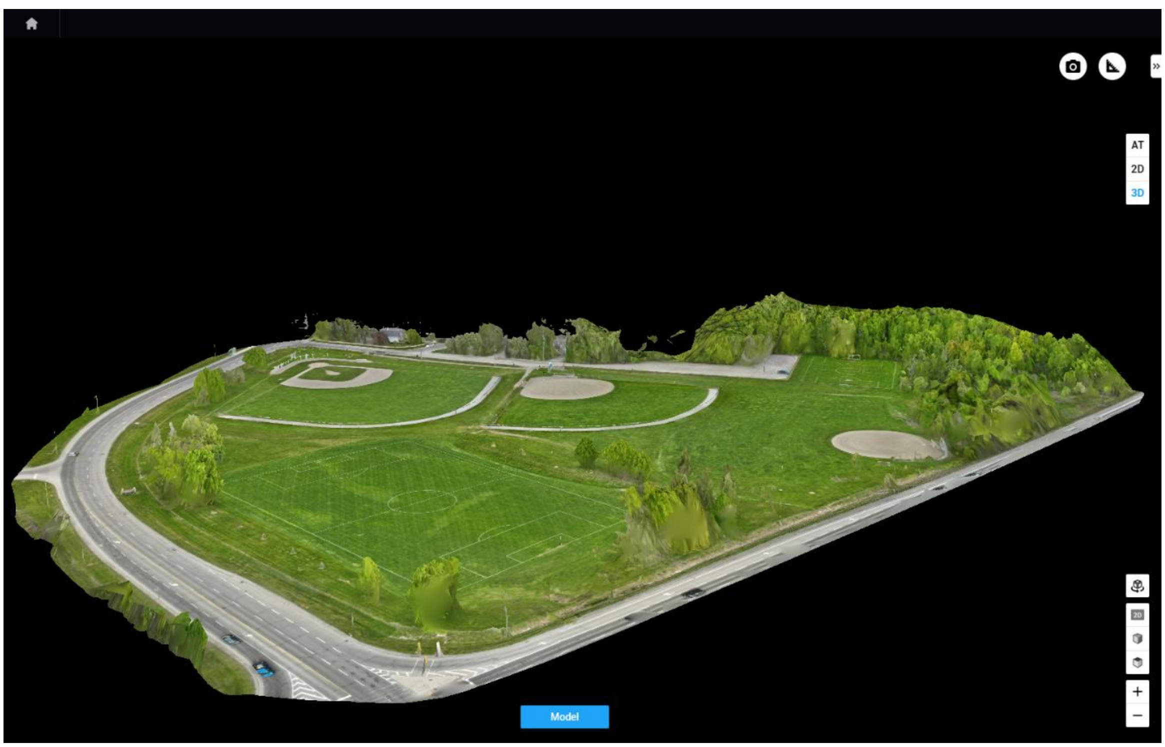
3d map of site from Terra

New Visible Light Reconstruction Mission - 5/18/2023
68 images, 3k resolution, Completed at 00:32:33

2d map of the field from Web ODM

2d map of the field from Terra

3d map of the field from Web ODM



3d map of the field from Terra

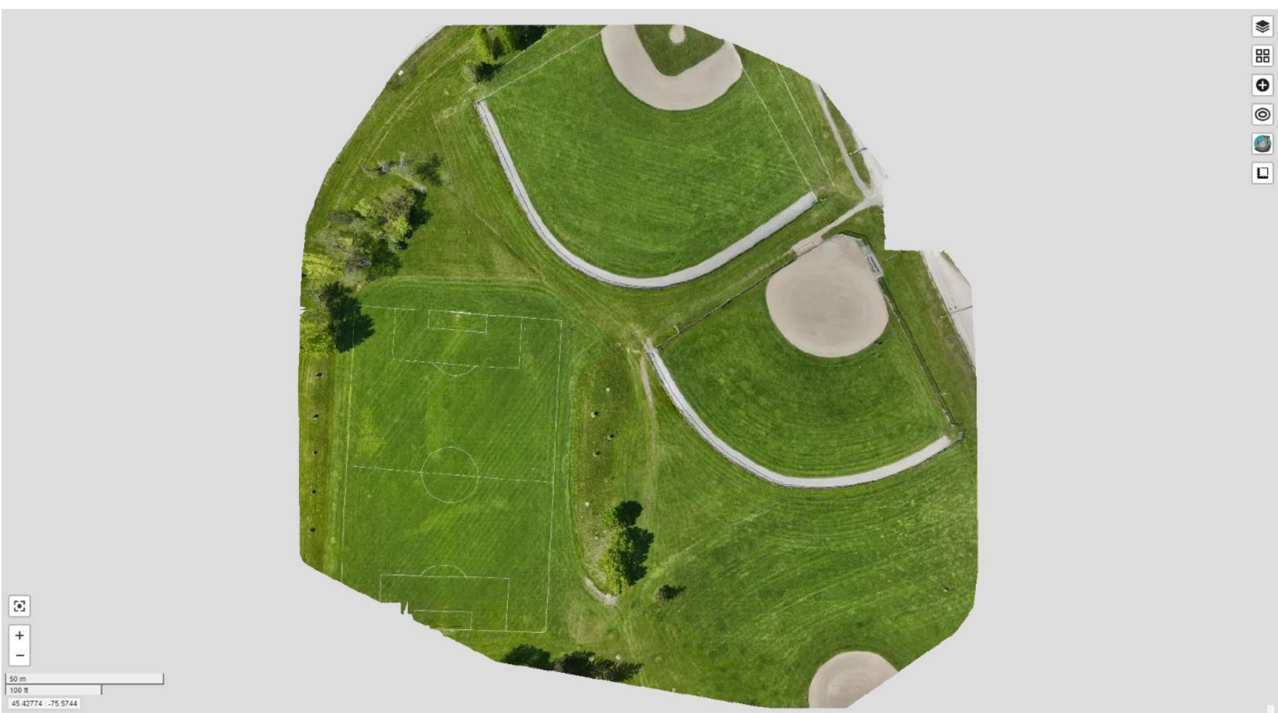
Test Machine 2

Using WebODM application

Sample Name	# of images	Resolution	Time(hh:mm:ss)	Completed processing
New Visible Light Reconstruction Mission Day 1 - 5/18/2023 (DJI_202305181543_002_Mapping1)	68	5k	00:14:14	Yes
Stalbans Mission 2 - 5/28/2023 (DJI_202305281436_009_stalbans)	137	5k	01:24:41	Yes
New Visible Light Reconstruction Mission - 5/19/2023 (DJI_202305191303_005_Tauvette1 - 165 ft)	350	5k	67:01:55	No

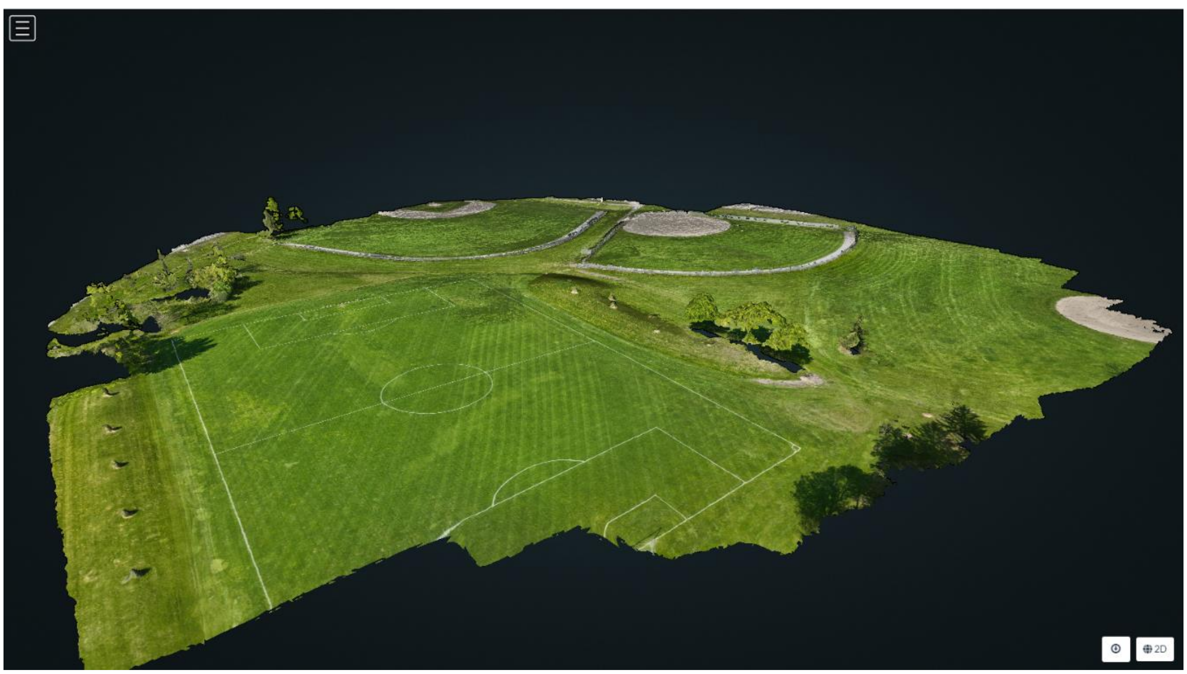
Data Sets Processed by installation of WebODM application

New Visible Light Reconstruction Mission Day 1 - 5/18/2023
68 images, 3k resolution, Completed at 00:14:14

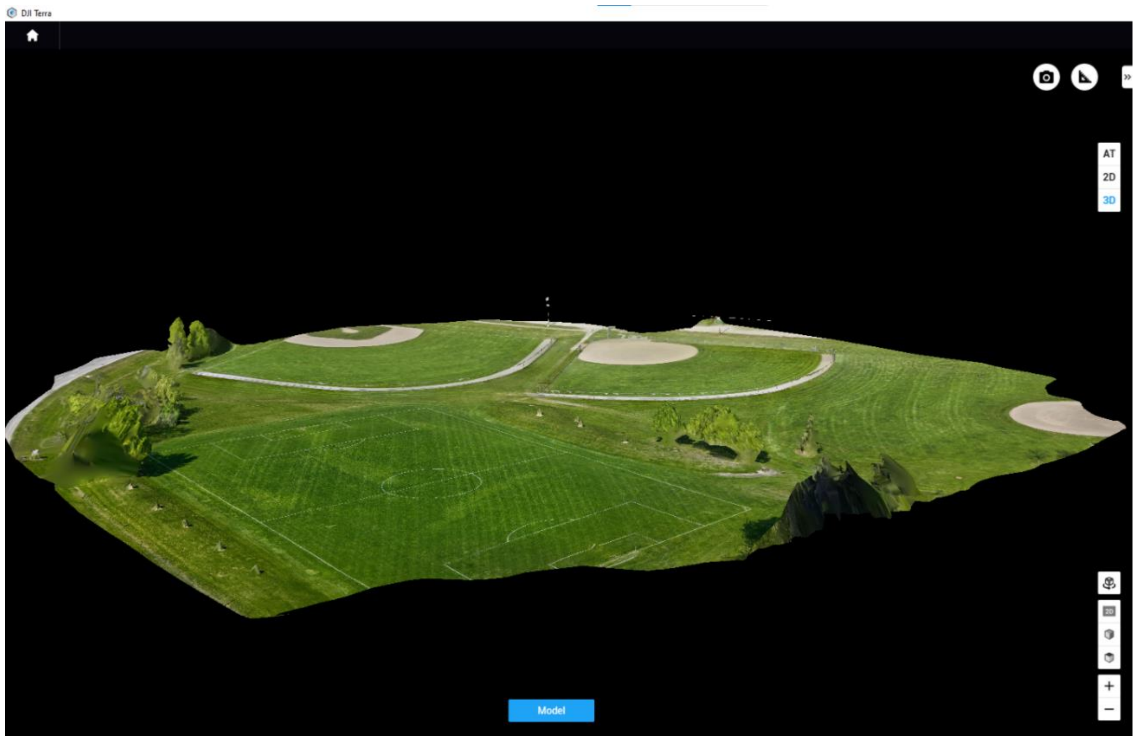


2d map of the field from Web ODM

2d map of the field from Terra

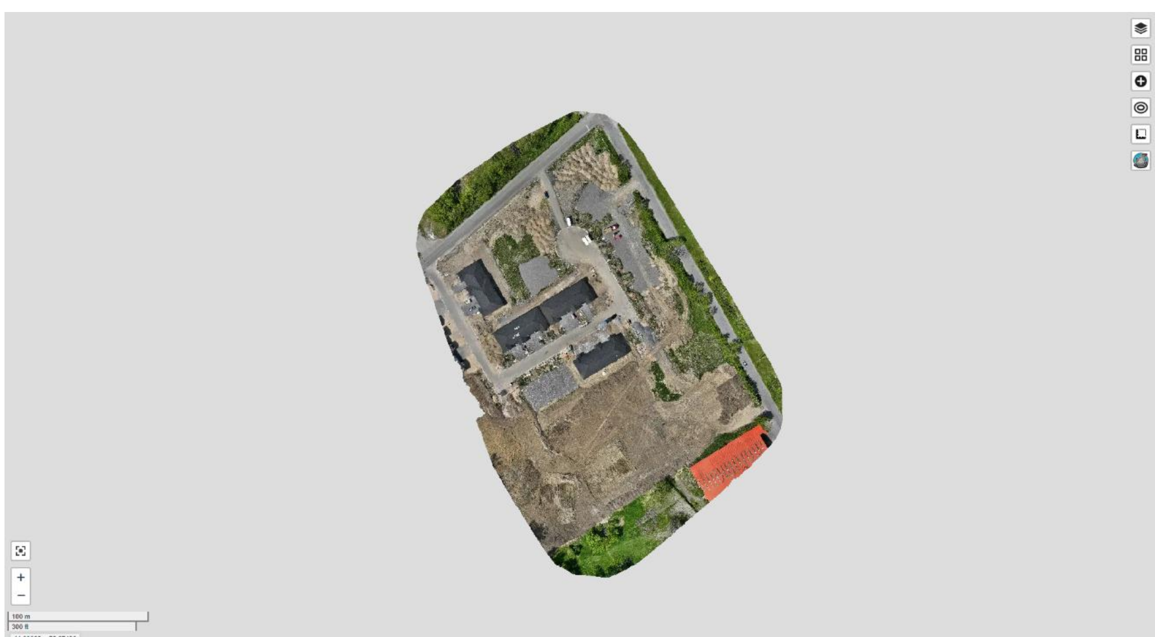


3d map of the field from Web ODM



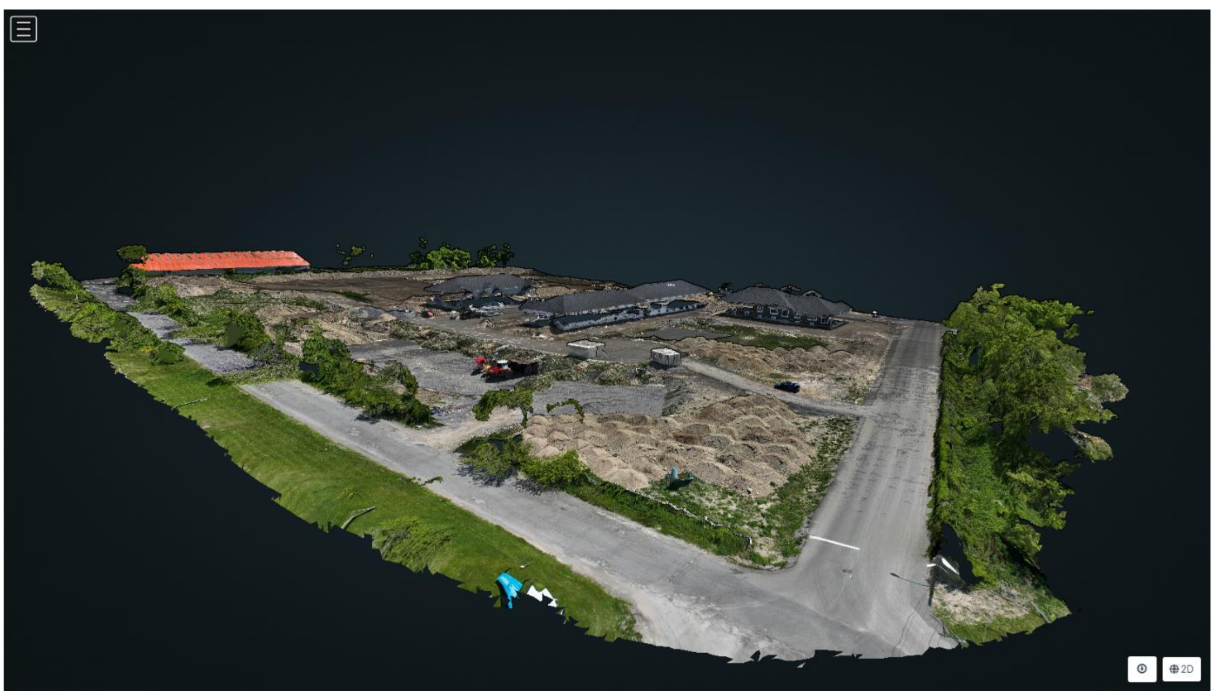
3d map of the field from Terra

Stalbans Mission 2 - 5/28/2023
137 images, 3k resolution, Completed at 01:24:41



2d map of site from Web ODM

2d map of site from Terra



3d map of site from Web ODM

3d map of site from Terra

New Visible Light Reconstruction Mission - 5/19/2023
350 images, 3k resolution, Canceled at 67:01:55

This process was cancelled as it was taking too long.

This process was ran 2 more times where they exceeded the 80 hours mark for processing.

On the final attempt the settings were changed to allow it to process better quality and it still did not complete.

Test Machine	Software	Sample Name	# of images	Resolution	Time	Completed
Test Machine 1	Web ODM Docker installation	Test Sample	46	5k	00:33:53	Yes
		Stalbans mission 2 - 5/28/2023	137	5k	01:53:44	No
	Web ODM direct installation	New Visible Light Reconstruction Mission Day 1 - 5/18/2023	68	5k	00:32:33	Yes
		Stalbans mission 2- 5/28/2023	137	5k	1:06:24	Yes
		New Visible Light Reconstruction Mission - 5/19/2023	350	5k	2:50:14	Yes
Test Machine 2	Web ODM direct installation	New Visible Light Reconstruction Mission Day 1 - 5/18/2023	68	5k	00:14:14	Yes
		Stalbans mission 2- 5/28/2023	137	5k	01:24:41	Yes
		New Visible Light Reconstruction Mission - 5/19/2023	350	5k	67:00:55 T2-71:58:32 T3-114:00:00	No
	DJI Terra	New Visible Light Reconstruction Mission Day 1 - 5/18/2023	68	5k	00:07:41	Yes
		Stalbans mission 2- 5/28/2023	137	5k	00:17:05	Yes
		New Visible Light Reconstruction Mission - 5/19/2023	350	5k	00:18:27	Yes

All Datasets

The WebODM direct installation was reattempted two more times using the dataset in which it initially failed. Modified settings were applied during these to improve processing performance. However, both attempts, labelled as T2 and T3 in the table, also resulted in failures.

GSD analysis

Ground Sampling distance (GSD) refers to the distance between two consecutive pixels measured on the ground. The bigger the value the lower the spatial resolution of the image is, and the less visible details will be.

Program	Map	GSD (cm)
New Visible Light Reconstruction Mission Day 1 - 5/18/2023	WebODM	2.7
	DJI Terra	2.1
Stalbans mission 2- 5/28/2023	WebODM	4.5
	DJI Terra	1.8
New Visible Light Reconstruction Mission - 5/19/2023	WebODM	3.5
	DJI Terra	1.8

Calculated GSD values

Based on the data collected, it is evident that DJI Terra outperforms WebODM in terms of accuracy. This is supported by the fact that the Ground Sampling Distance (GSD) values obtained from WebODM are consistently larger than those from DJI Terra. Consequently, this disparity in GSD values accounts for the noticeable decline in the quality of 3D models produced by WebODM when compared to the superior quality of 3D models generated by DJI Terra.

Georeferencing RMSE Analysis

Georeferencing RMSE (root mean square) is a measure of how accurately a reconstructed image's position matches its actual location on the Earth's surface as determined by GPS data. It calculates the root mean square error between the estimated position of the image and its real-world GPS position, providing a single value that represents the overall accuracy. A lower Georeferencing RMSE indicates a more precise estimation, while a higher value suggests a larger deviation between the reconstructed position and the true GPS location of the image.

Program	Map	RMSE (m)
New Visible Light Reconstruction Mission Day 1 - 5/18/2023	WebODM	0.64
	DJI Terra	0.64
Stalbans mission 2- 5/28/2023	WebODM	0.48
	DJI Terra	0.54
New Visible Light Reconstruction Mission - 5/19/2023	WebODM	0.64
	DJI Terra	0.8

Calculated Georeferencing RMSE

Based on the collected data, both algorithms exhibit comparable performance in terms of Georeferencing RMSE, with WebODM showing a slight advantage over DJI Terra. It is important to note that RMSE values fall within the range considered good, typically below 5 meters. However, the significance of this accuracy varies depending on individual user requirements and the intended purpose of the map. While a more precise RMSE calculation can be achieved using ground control points (GCPs) with exact coordinates, the absence of GCP points in the datasets used prevents GCP analysis. It's worth mentioning that setting up GCPs correctly is essential, as any inaccuracies in their placement can introduce errors in the georeferencing process.

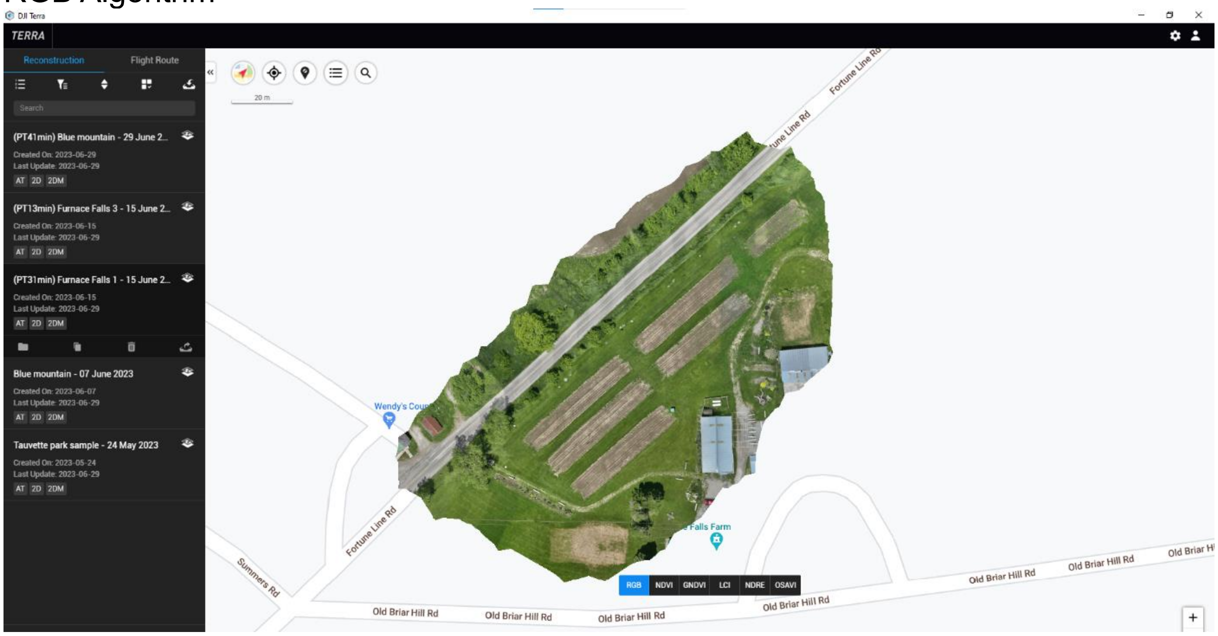
Multispectral Algorithms

All of the following tests were done on Test Machine 2.

	DJI Terra	Web ODM
Available Algorithms	○ RGB ○ NDVI ○ GNDVI ○ LCI ○ NDRE ○ OSAVI	○ NDVI ○ NDYI ○ NDRE ○ NDWI ○ NDVI(Blue) ○ ENDVI ○ vNDVI ○ VARI ○ MPRI ○ EXG ○ TGI ○ BAI ○ GLI ○ GNDVI ○ GRVI ○ SAVI ○ MNLI ○ MSR ○ RDVI ○ TDVI ○ OSAVI ○ LAI ○ EVI ○ ARVI

All available algorithms for Multispectral analysis

RGB Algorithm

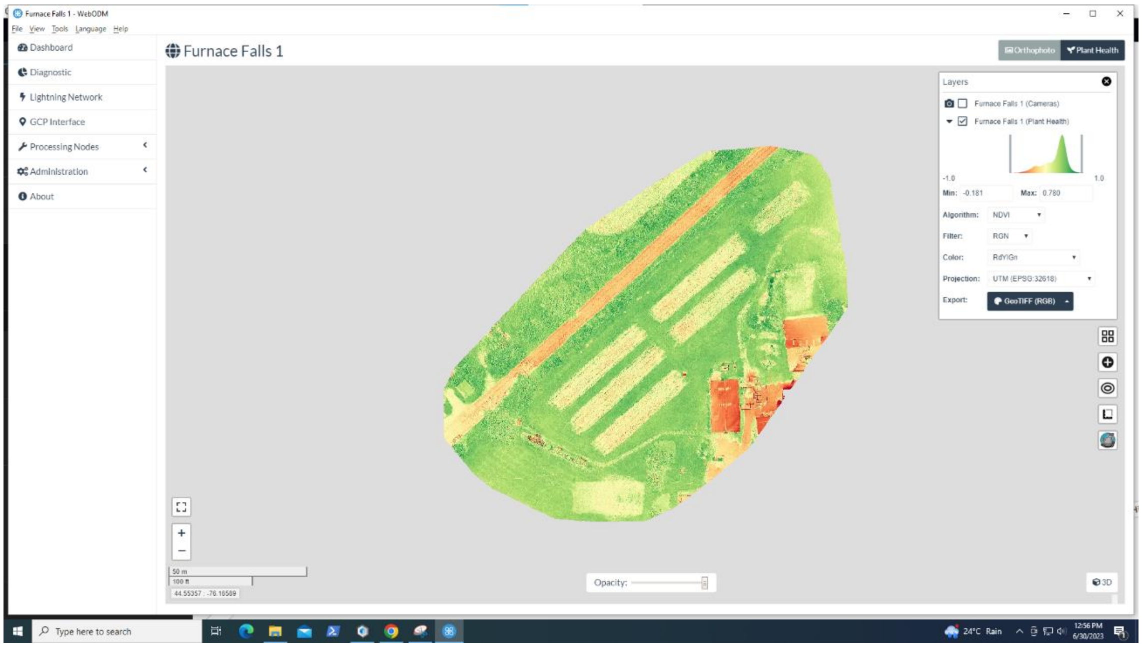


Terra RGB algorithm

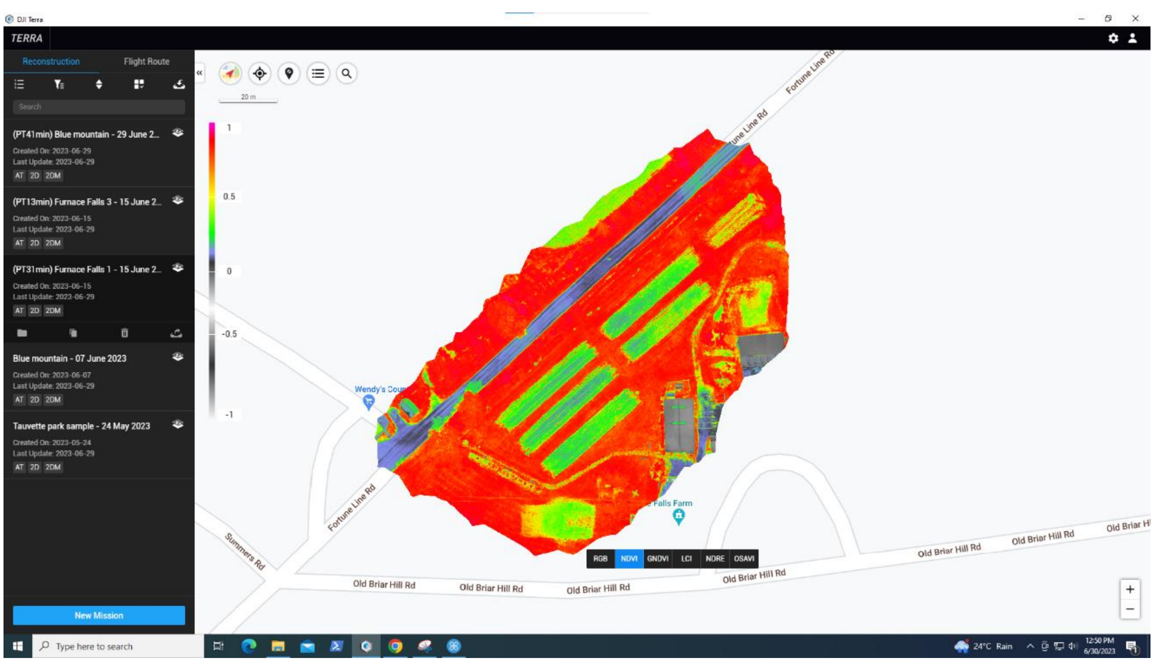
This is the unprocessed base RGB image, serving as the reference for the subsequent algorithms. The identical dataset was utilized consistently across all subsequent algorithms for accurate and fair comparisons.

NDVI

Normalized difference vegetation index (NDVI) is used for quantifying health and density of vegetation using infrared sensor data. The algorithm is mainly used to calculate the health of the vegetation on a scale of -1 to 1, where -1 on the index corresponding to dead plant or an inanimate object and 1 corresponds to healthy plants.



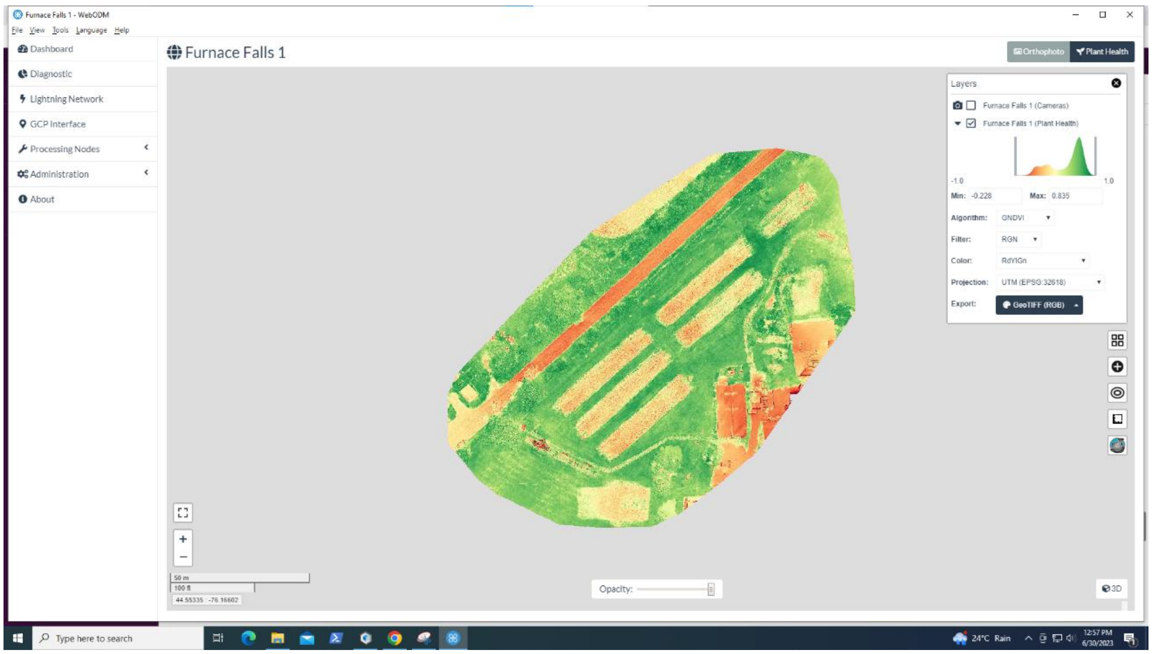
WebODM NDVI algorithm



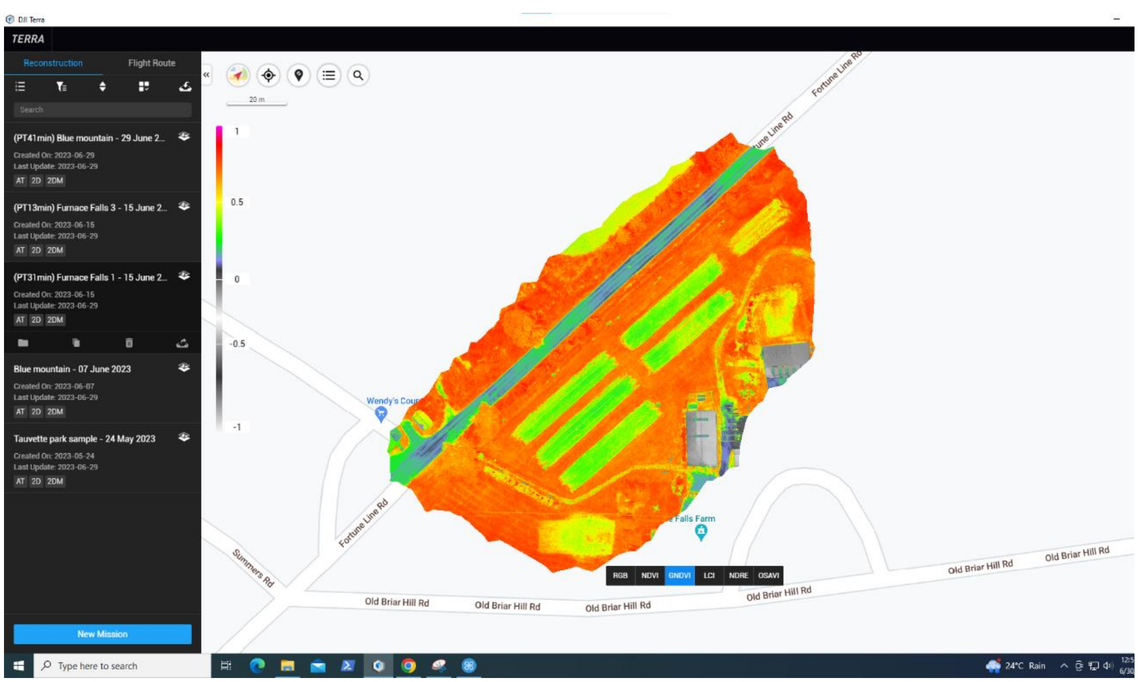
Terra NDVI algorithm

GNDVI

Green normalized difference vegetation index (GNDVI) is also used for quantifying health and density of vegetation, but it is more sensitive to chlorophyl and has a higher saturation point than NDVI. GNDVI is typically used with crops that have more dense canopies or in later stages in devlopment. This algorithm uses the same scale as NDVI.



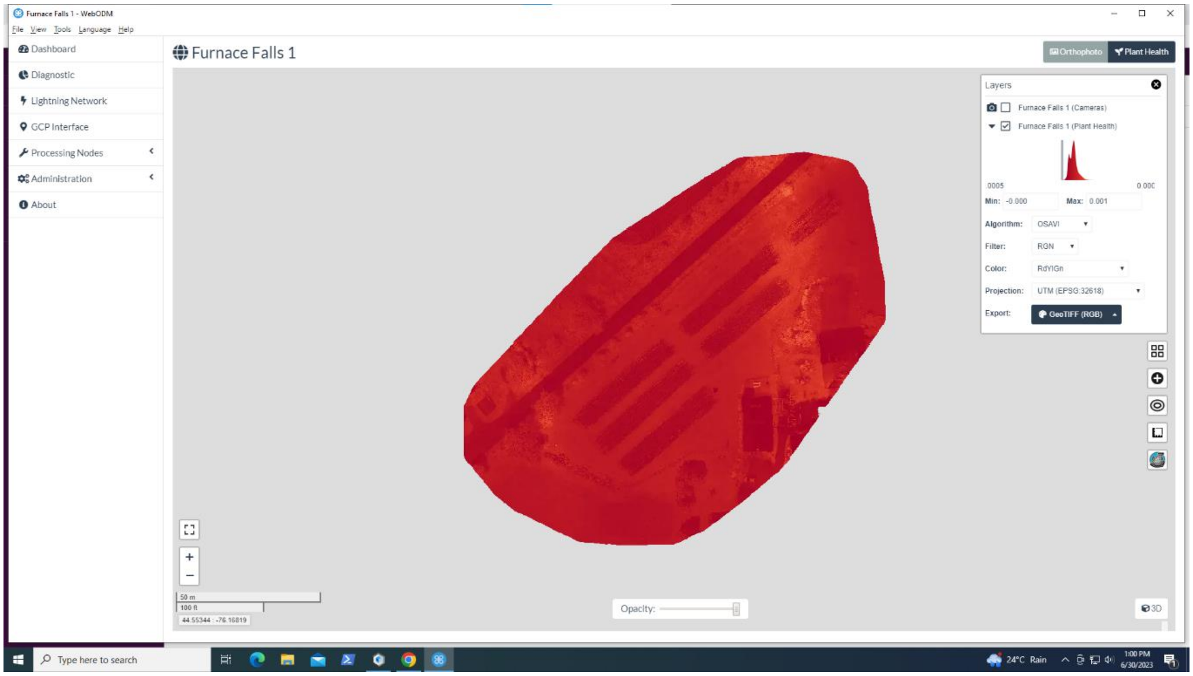
WebODM GNDVI algorithm



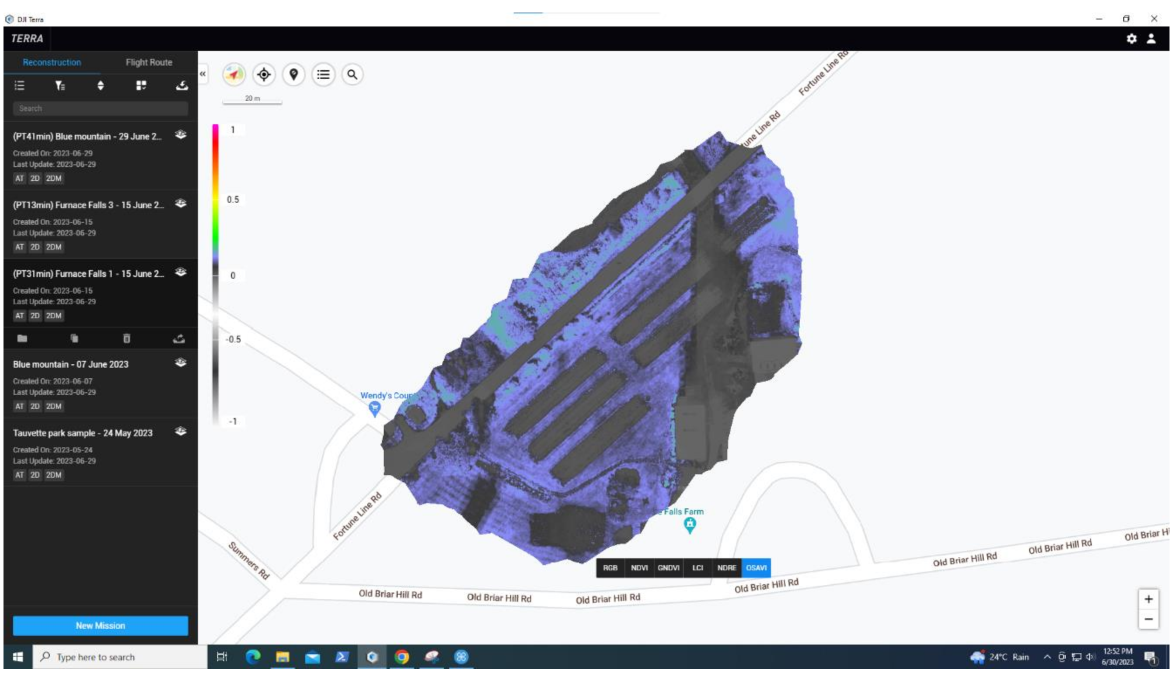
Terra GNDVI algorithm

OSAVI

Optimized Soil Adjusted Vegetation Index (OSAVI) is used to measure soil moisture levels and the health of the soil as well as measure the health of the vegetation. OSAVI considers the canopy level when looking at the soil as well as variation in the soil background.



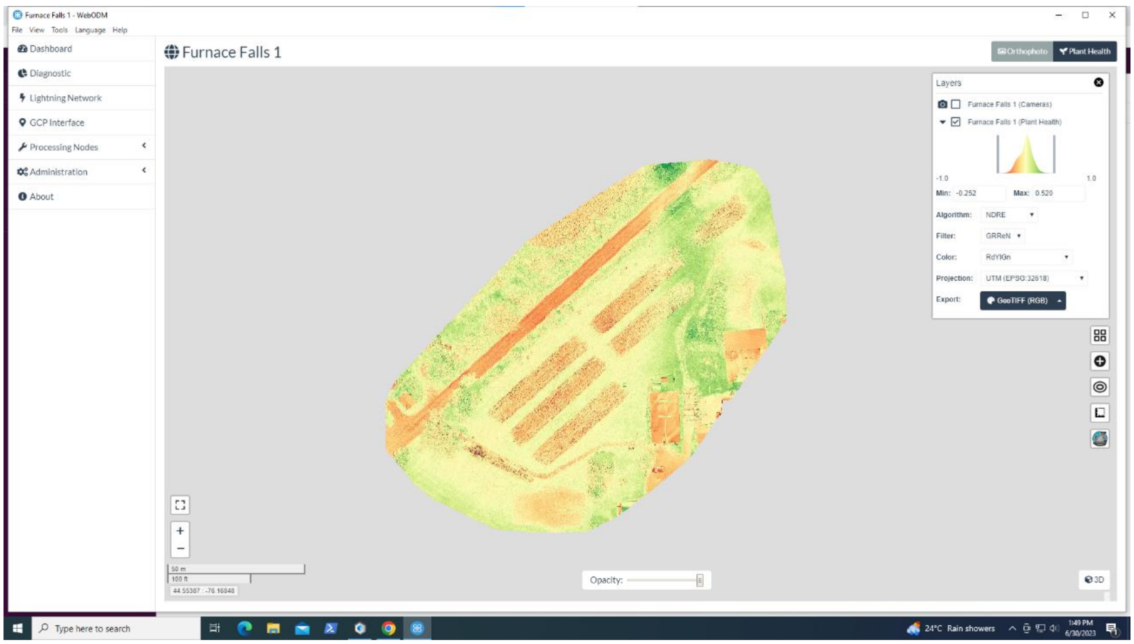
WebODM OSAVI algorithm



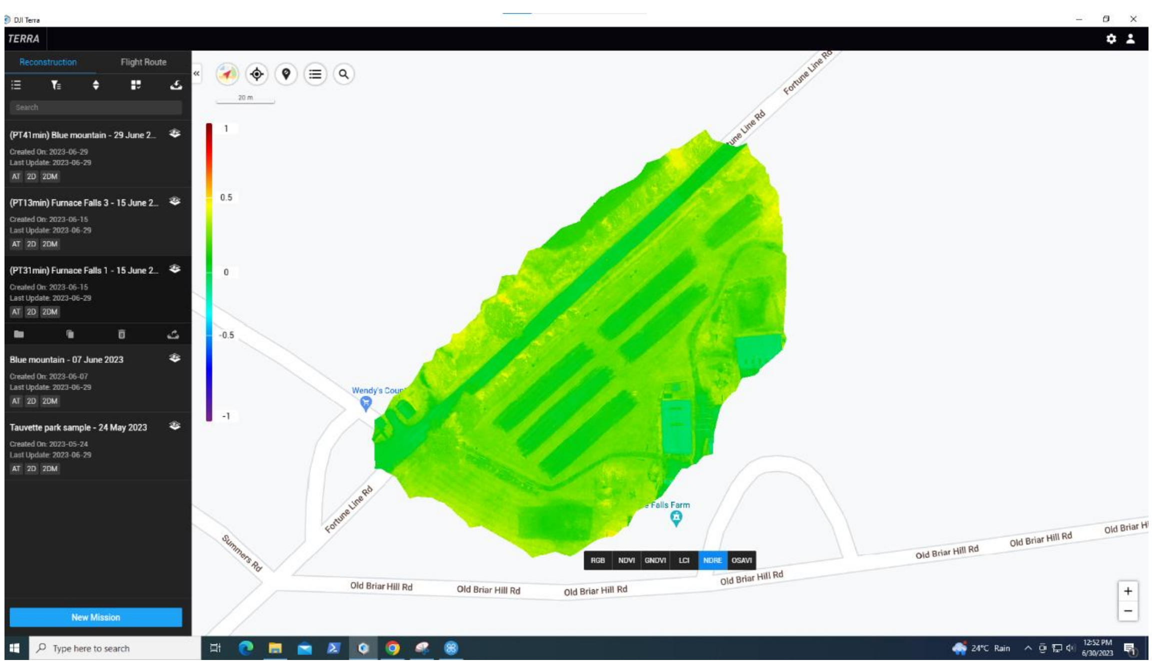
Terra OSAVI algorithm

NDRE

Normalized Difference Red Edge Index (NDRE) is used primarily for measuring the chlorophyll contents in plants to determine if a plant is growing healthily. NDRE can indicate multiple problems like sick plants, plants infested with pests, nutrient deficiencies, or damaged plants. NDRE does not tell you what the problem is but there is only one problem. NDRE is primarily used in later stages of plant growth.



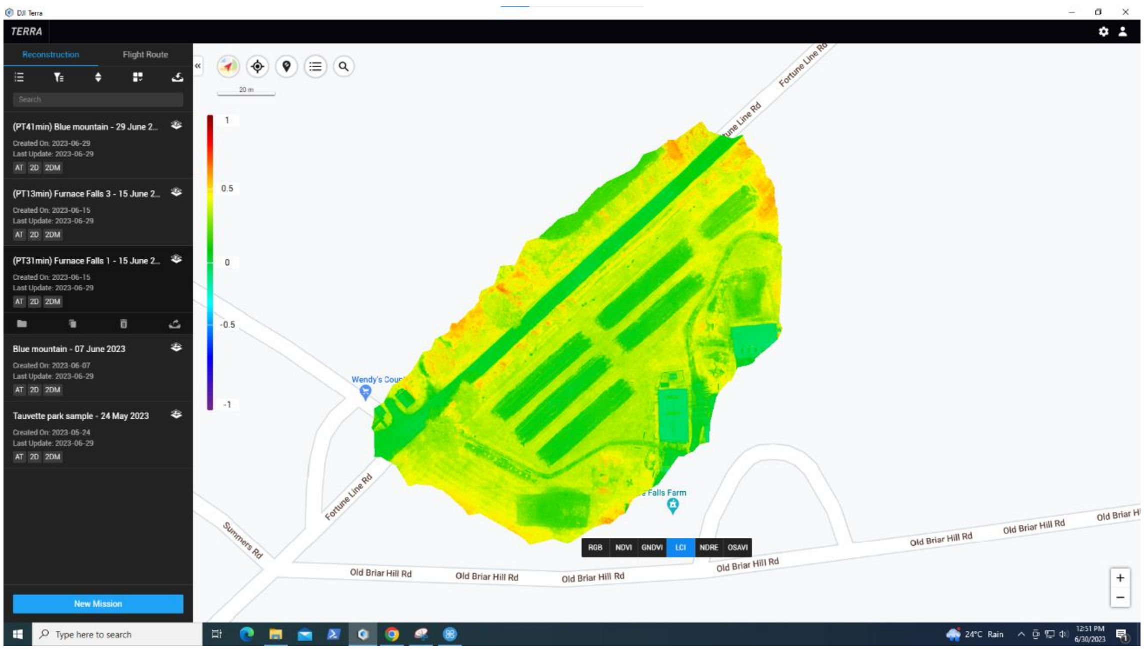
ODM NDRE algorithm



Terra NDRE algorithm

LCI

Leaf Chlorophyll Index (LCI) is used to calculate the total amount of chlorophyl in plants. This a one of the more accurate algorithms and is often used in nutrient management throughout different seasons. It also has other applications such as yield prediction and variable rate application (VRA) which is the automated application of nutrients. Calculated on a scale of -1 to 1.



Terra LCI algorithm

WebODM does not have the LCI algorithm.

Overall, both DJI Terra and WebODM demonstrate comparable multispectral algorithms, as they exhibit the same range of values on their respective scales. The graph on WebODM aligns with the scale in DJI Terra, indicating consistent and values for the respective locations.

Additional WebODM Algorithms

WebODM has several more algorithms that are used for various other niche purposes. There are also algorithms present in WebODM that do not account for the infrared spectrum so when giving WebODM a dataset that has infrared data it will produce an incorrect output.

Additional Algorithms that account for Infrared light

- NDWI
  - Normalized Difference Water Index (NDWI) is used to highlight open water against soil and vegetation. It is also used to effectively measure the moisture content on a scale of -1 to 1 where -1 is considered a drought and 1 is a water surface.
- NDVI (Blue)
  - Normalized difference vegetation index Blue (NDVI Blue) also referred to as NDVI Blue Green performs the same tasks as the base NDVI algorithm but uses the blue and green bands of light to isolate the red band.

- ENDVI
    - Enhanced normalized vegetation index (ENDVI)is the enhanced version of NDVI that considers the blue and green bands for the calculation. Though it is derived from the NDVI calculation it is more similar to the GNDVI output. Like GNDVI it is more accurate when the crops are much denser
- BAI
    - Burn area Index (BAI) is primarily used to highlight land burned in wildfires by emphasizing the charcoal signals.
- MNLI
    - Modified Non-Linear Index (MNLI) primarily used by satellite images to differentiate vegetation and soil while accounting for atmospheric conditions.
- RDVI
    - Renormalized Difference Vegetation index (RDVI) is used to highlight the areas of healthy vegetation in an area.
- TDVI
    - Transformed Difference Vegetation index (TDVI) highlights the vegetation in urban environments.
- ARVI
    - Atmospherically Resistant Vegetation Index (ARVI) used primarily in regions with high atmospheric aerosol content.
- SAVI
    - Soil Adjusted Vegetation Index (SAVI) is used in the same situations as NDVI but tries to remove the effect of soil areas.
- MSR
    - Modified Simple Ratio (MSR) is used to highlight vegetation while accounting for soil, water, and ice.
- LAI
    - Leaf area index (LAI) is used to estimate the foliage area and predict crop yields.
- EVI
    - Enhanced Vegetation Index (EVI) is primarily used in situations where NDVI is saturated to better correct soil signals.
- GRVI
    - Green ratio Vegetation Index (GRVI) is used to calculate photosynthesis rates in forests.

Additional Algorithms that don’t account for Infrared light

- VARI
    - Visual Atmospheric Resistance Index (VARI) used to highlight areas of vegetation while mitigating illumination.
- NDYI
    - Normalized difference yellowness index (NDYI) used to highlight vegetation that is yellow, primarily used to estimate the yield of Canola.
- MPRI
    - Modified Photochemical Index (MPRI) is used to see the effect of heat and drought on crops.
- ExG
    - Excess Green Index (ExG) is primarily used to emphasize the greenness of leafy crops.
- TGI

- ○ Triangular Greenness Index (TGI) is used in the same situation as ExG but performs better in agricultural applications.
- GLI
  - ○ Green Leaf Index (GLI) is used to highlight green leaves as well as stems.
- vNDVI
  - ○ Visible Normalized difference vegetation index (vNDVI) is primarily used to highlight any fruits generally used for citrus, grapes, and sugarcane.

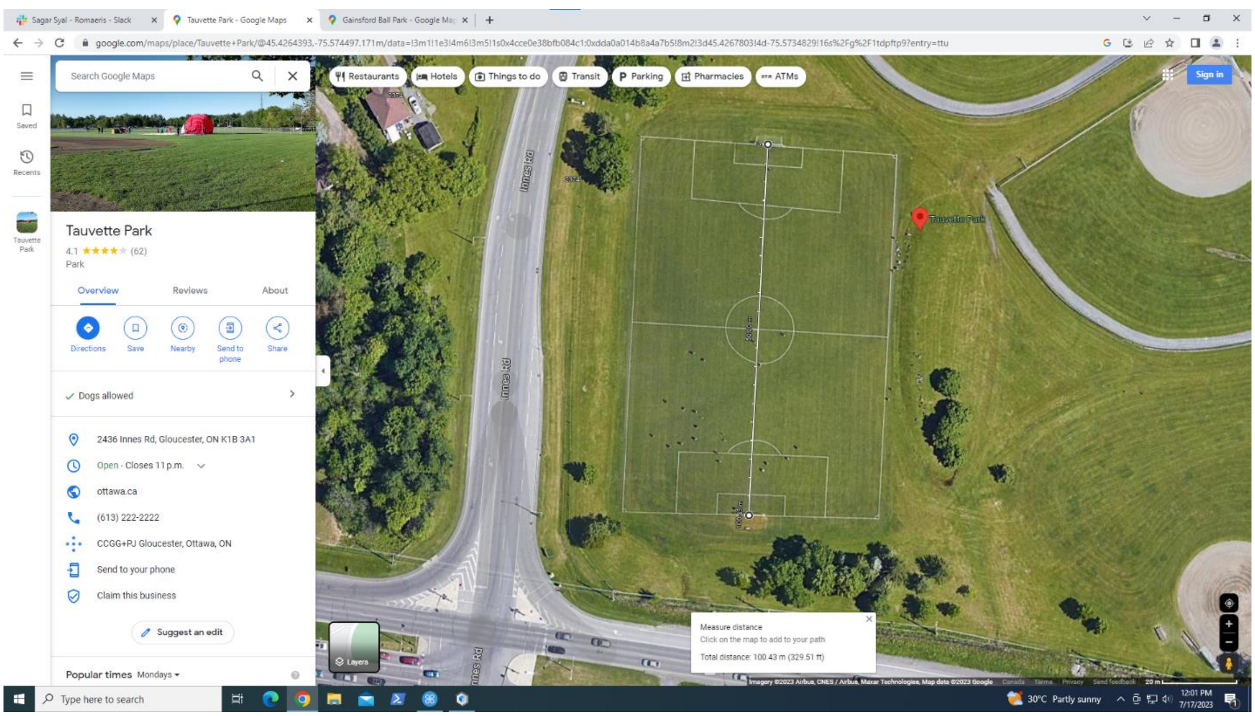
Measurement Analysis

In this section, Google Maps serves as our reference or control dataset.

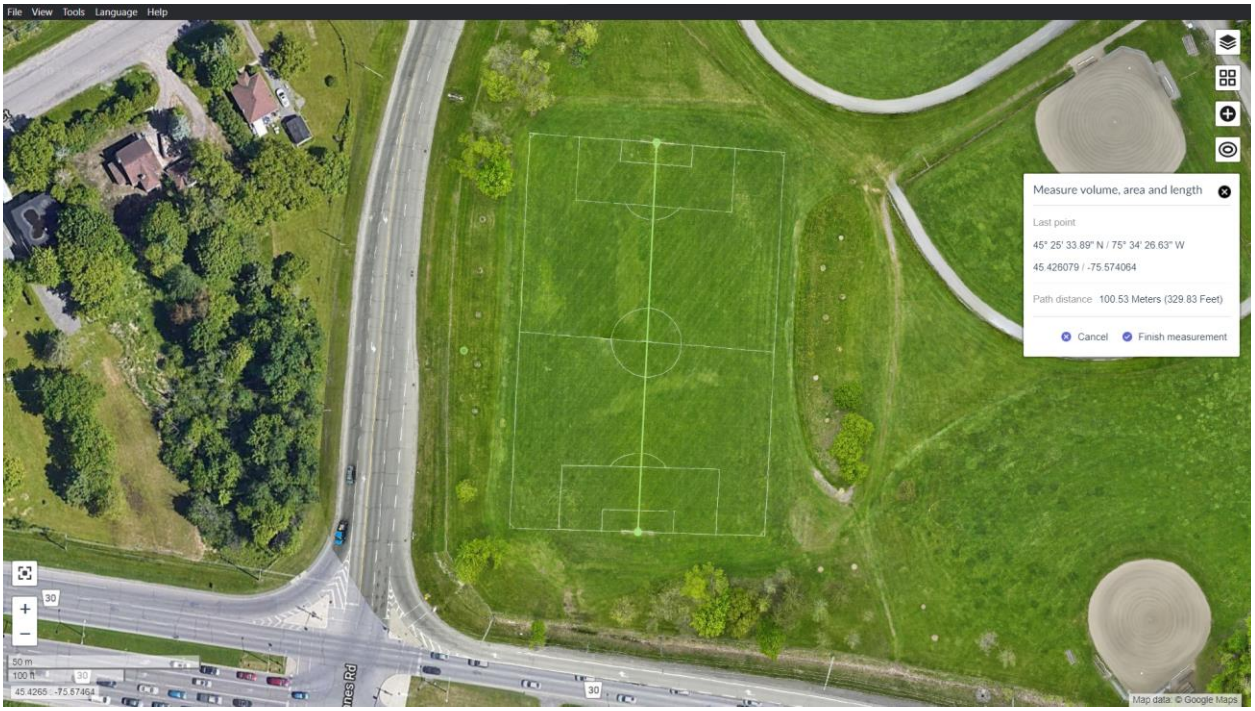
Distance

Program	Distance (m)	percent difference (%)
Google Maps	100.43	-
Web ODM	100.53	0.09
DJI Terra	100.5	0.06

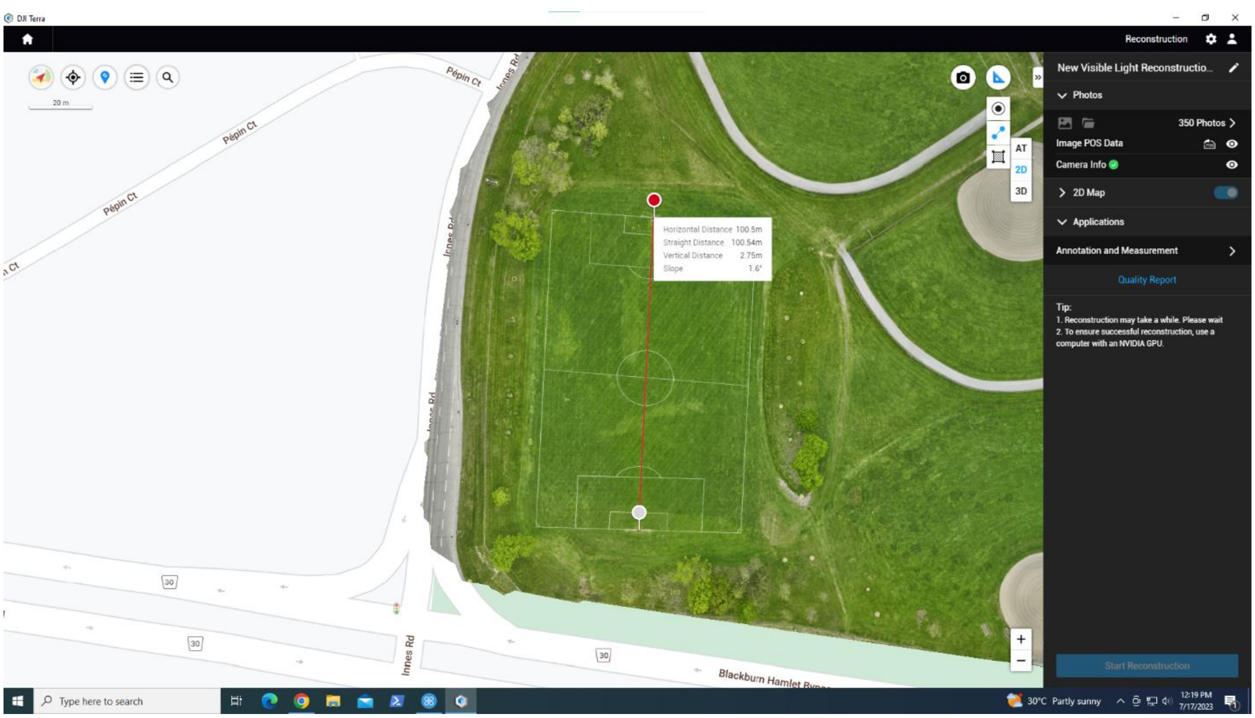
Distance Soccer Field



Distance Soccer Field from Google Maps

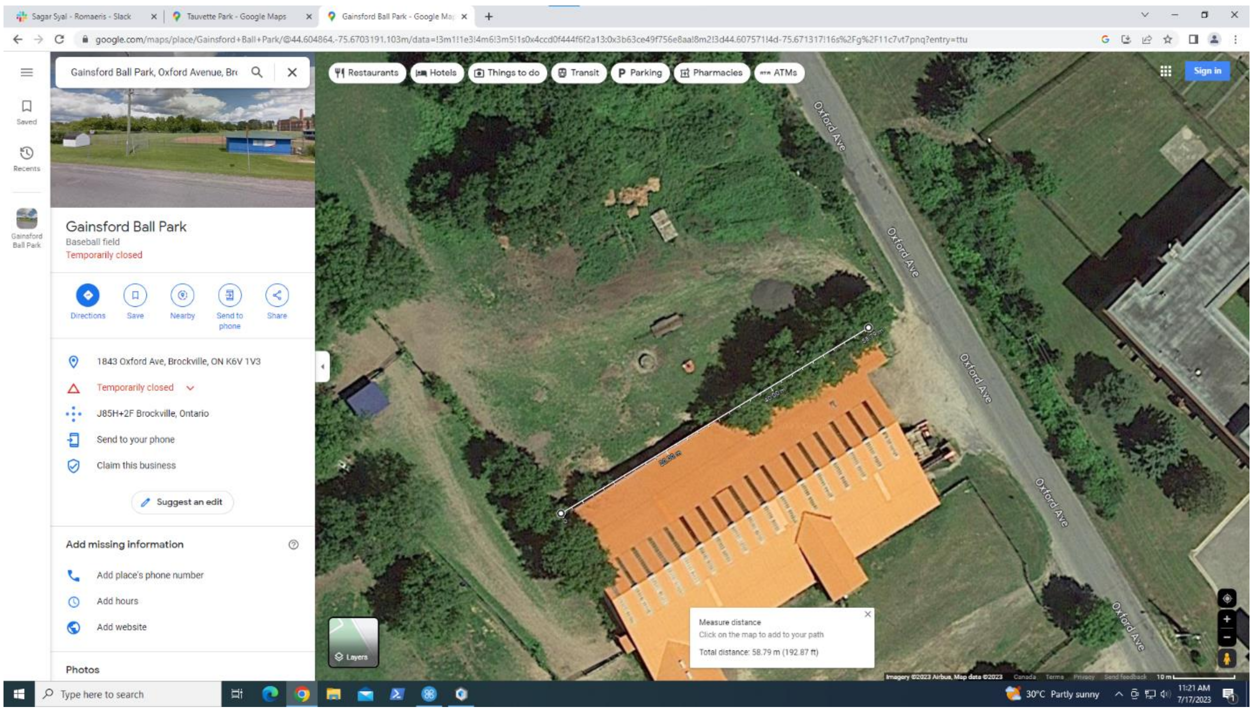


Distance Soccer Field from Web ODM

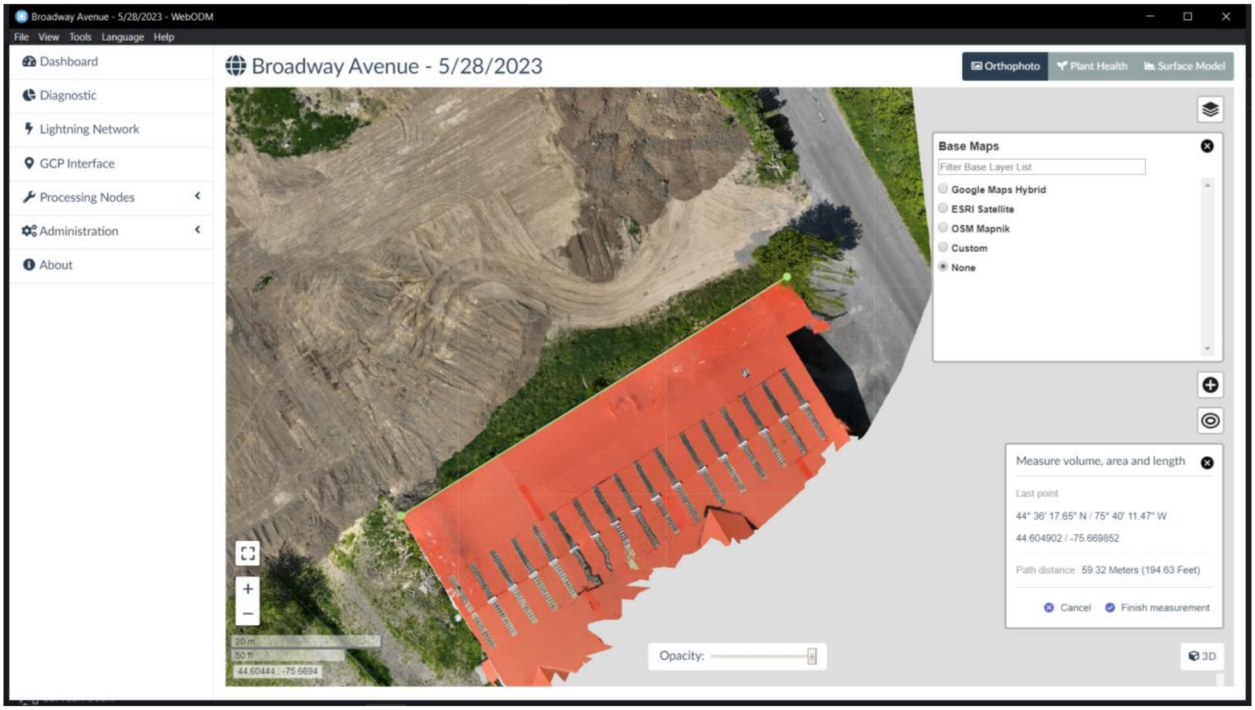


Distance Soccer Field from DJI terra

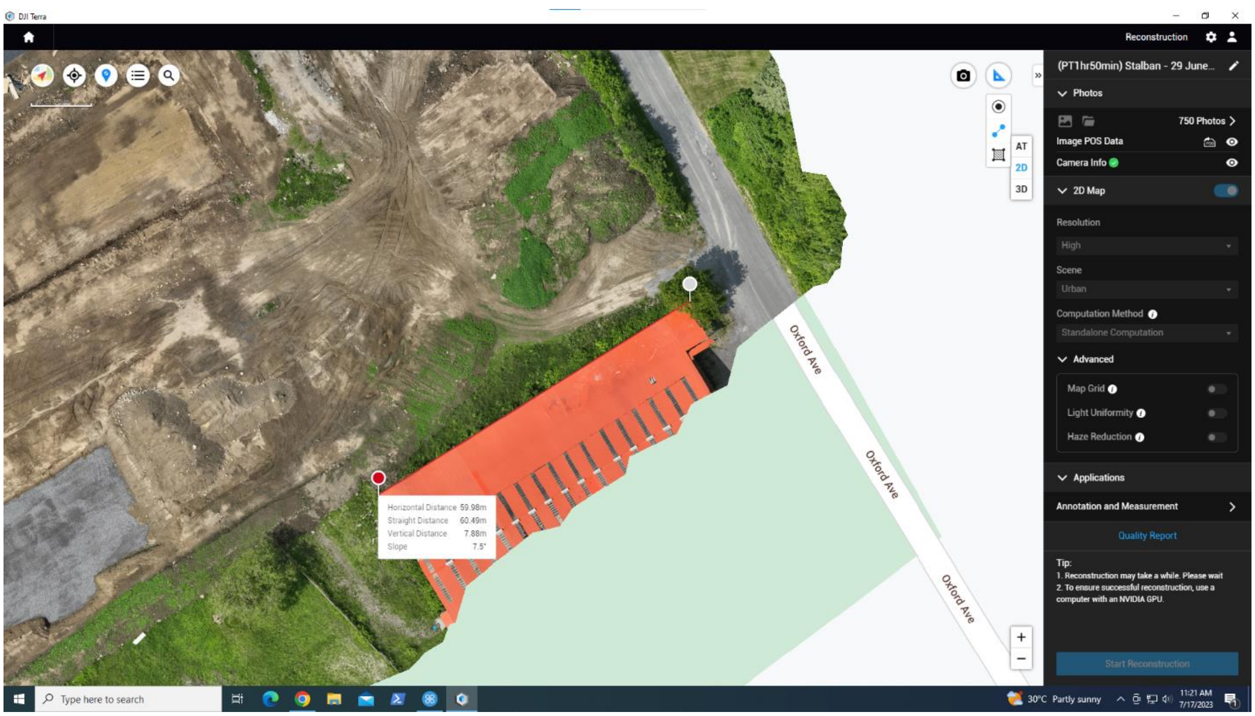
Program	Distance (m)	percent difference (%)
Google Maps	58.79	-
Web ODM	59.98	1.98
DJI Terra	59.32	0.90



Distance of Building from Google Maps



Distance of Building from WebODM

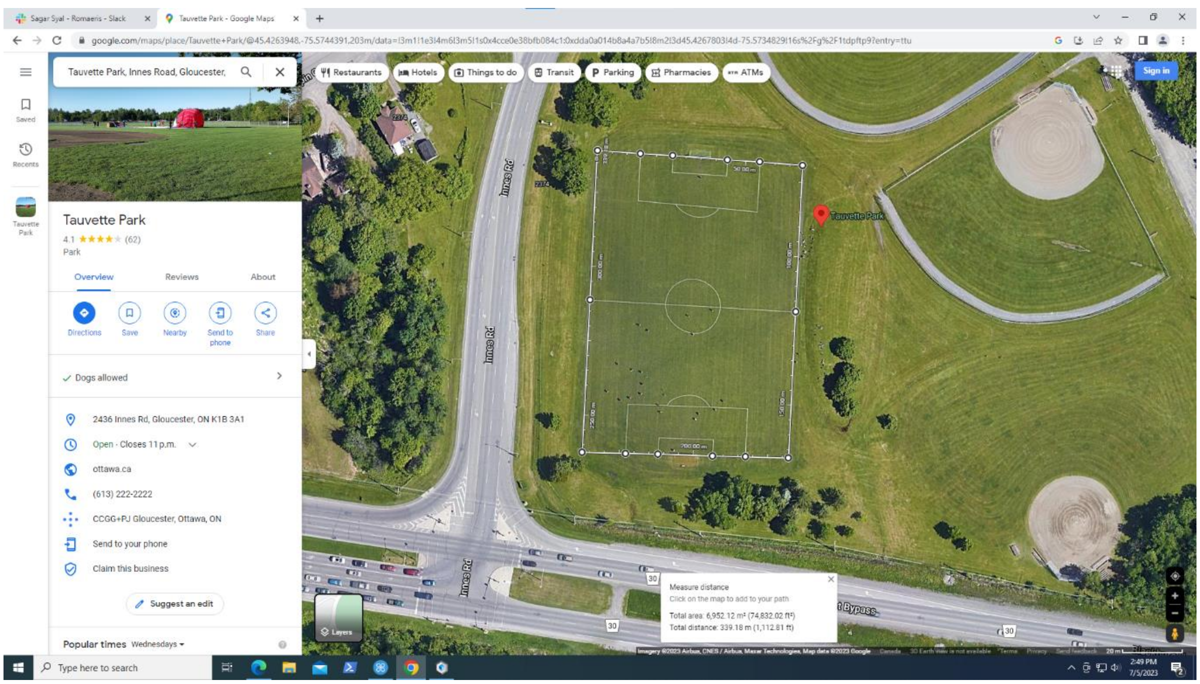


Distance of Building from DJI terra

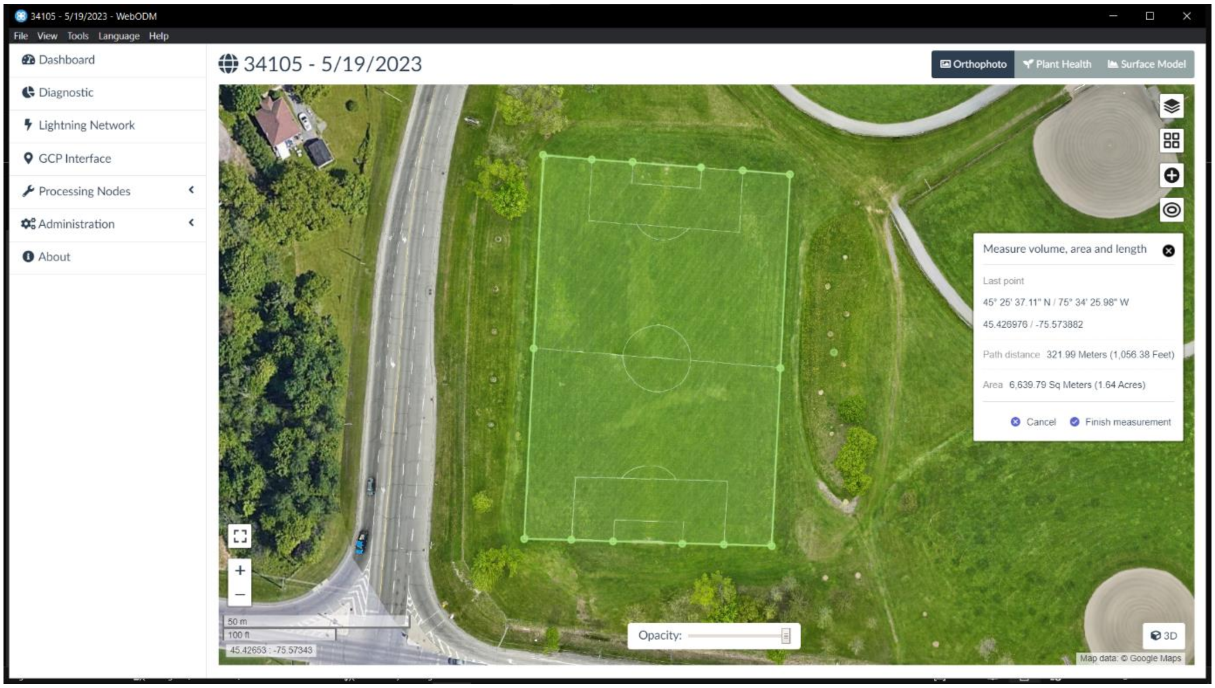
Perimeter

Program	Perimeter (m)	percent difference (%)
Google Maps	339.18	-
Web ODM	321.99	5.04
DJI Terra	333.87	1.54

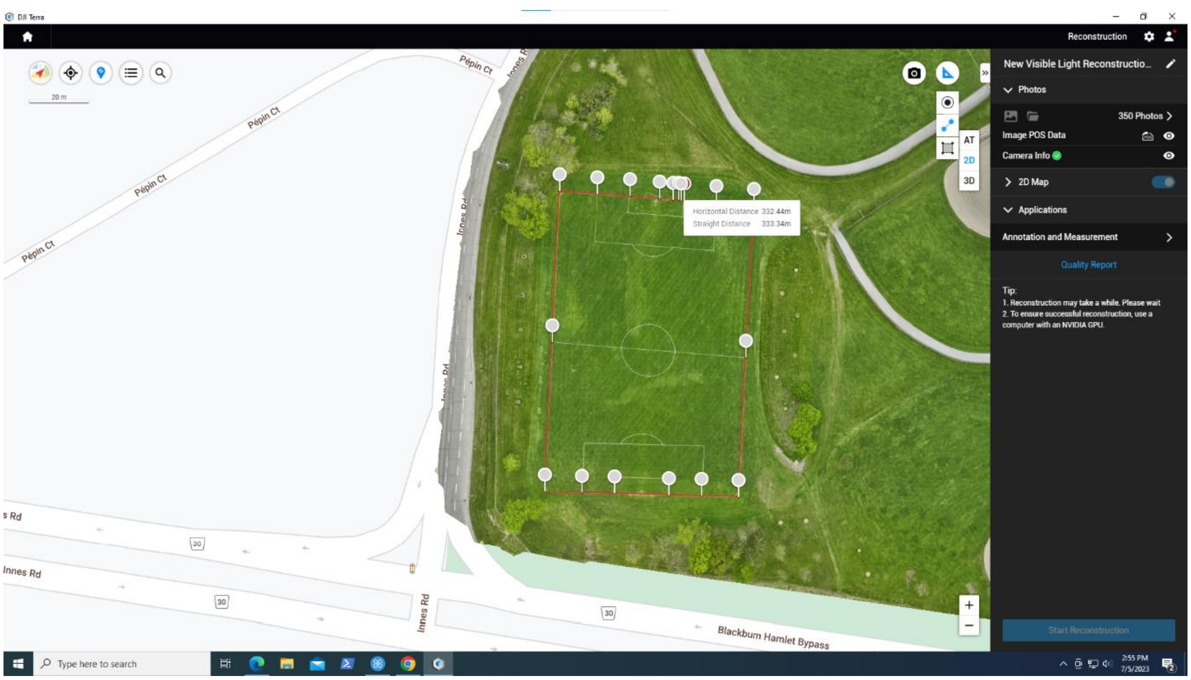
Perimeter Soccer Field



Perimeter & Area Soccer Field from Google maps



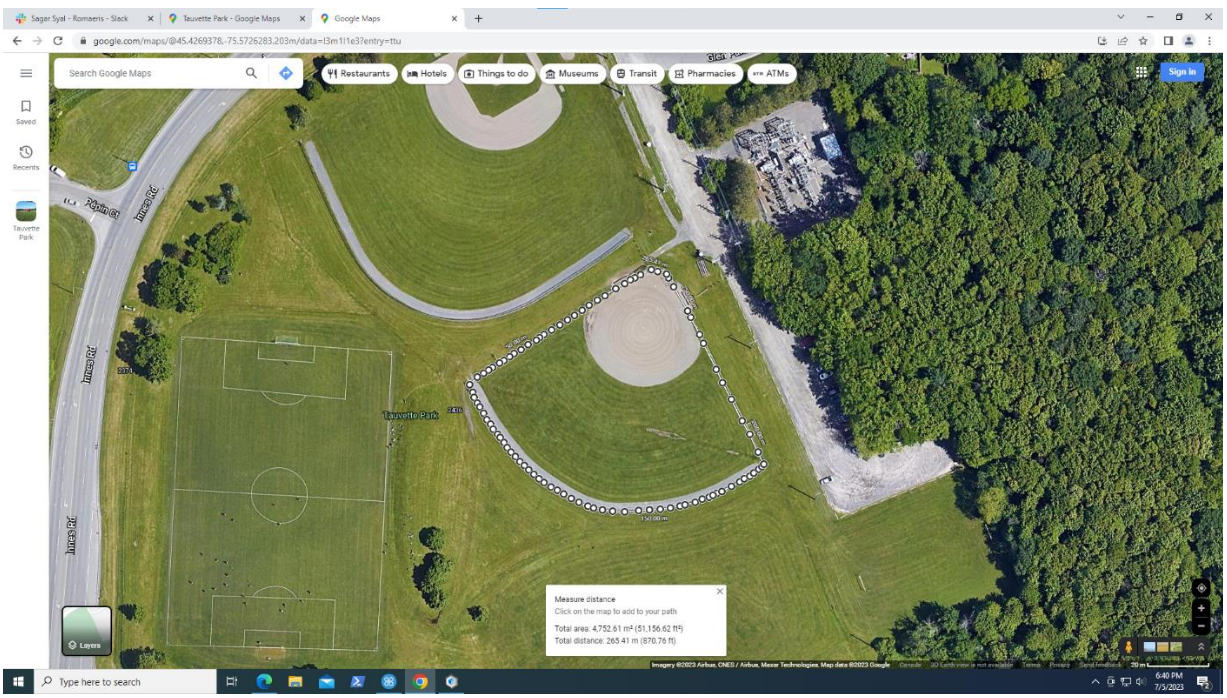
Perimeter & Area Soccer Field from WebODM



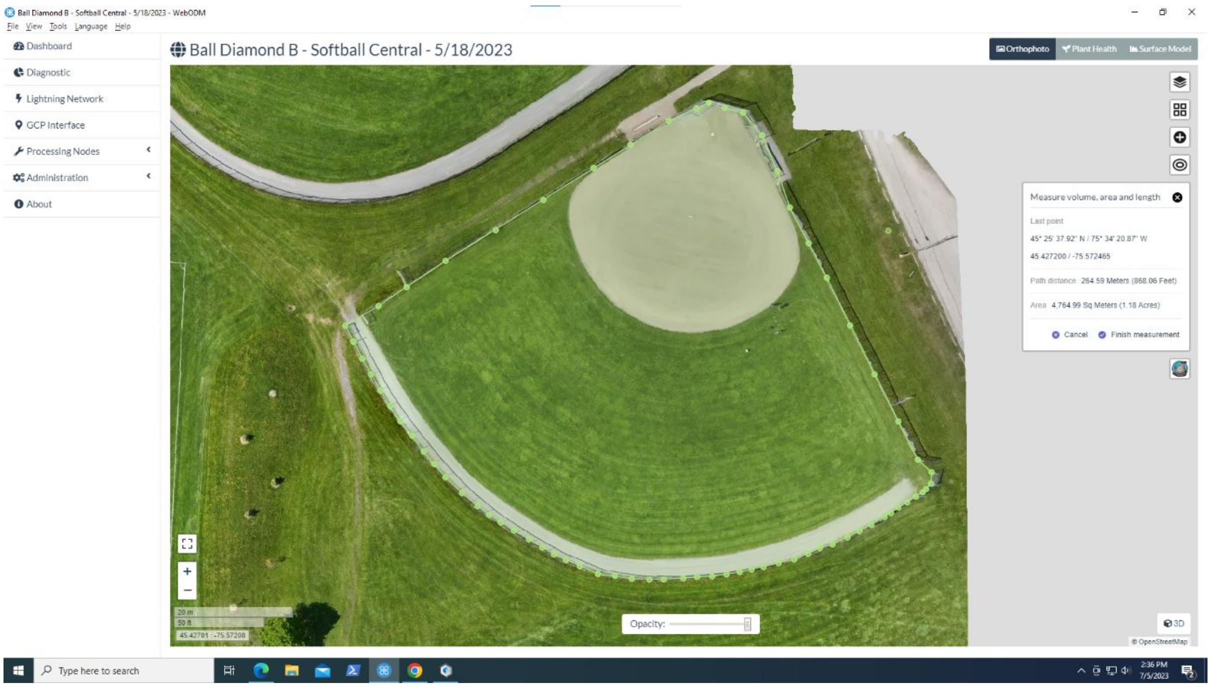
Perimeter Soccer Field from DJI terra

Program	Perimeter (m)	percent difference (%)
Google Maps	265.41	-
Web ODM	264.59	0.30
DJI Terra	265.87	0.17

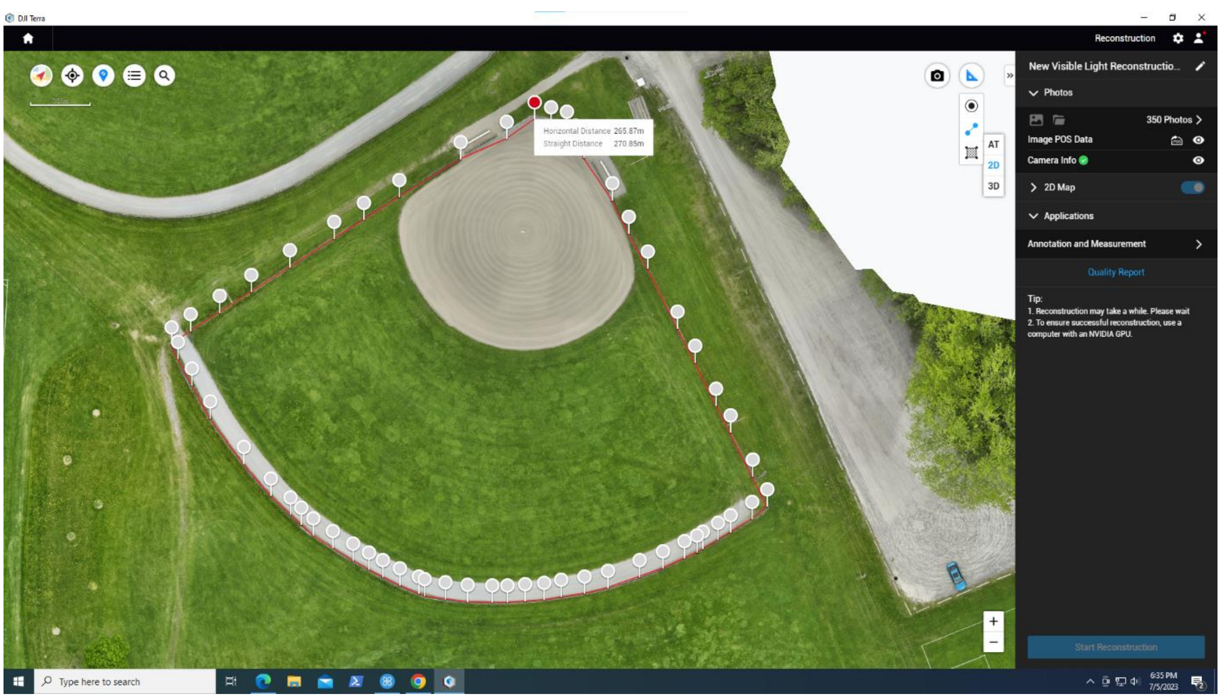
Perimeter Baseball Diamond



Perimeter & Area Baseball Diamond Google maps



Perimeter & Area Baseball Diamond from WebODM



Perimeter Diamond from DJI Terra

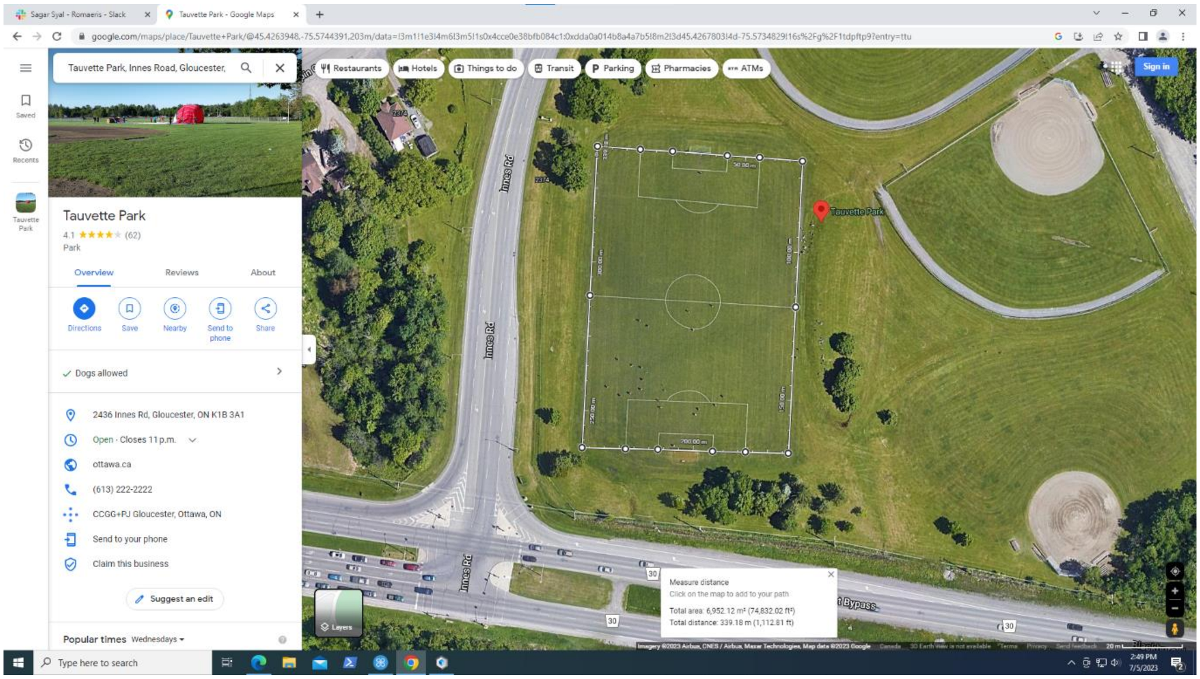
Area

Program	Dataset	Total Area Covered (m^2)
Web ODM	New Visible Light Reconstruction Mission Day 1 – 5/18/2023 (DJI_202305181543_002_Mapping1)	15426
	Stalbans Mission 2 – 5/28/2023 (DJI_202305281436_009_stalbans)	52463
DJI Terra	New Visible Light Reconstruction Mission Day 1 – 5/18/2023 (DJI_202305181543_002_Mapping1)	26671
	Stalbans Mission 2 – 5/28/2023 (DJI_202305281436_009_stalbans)	45710

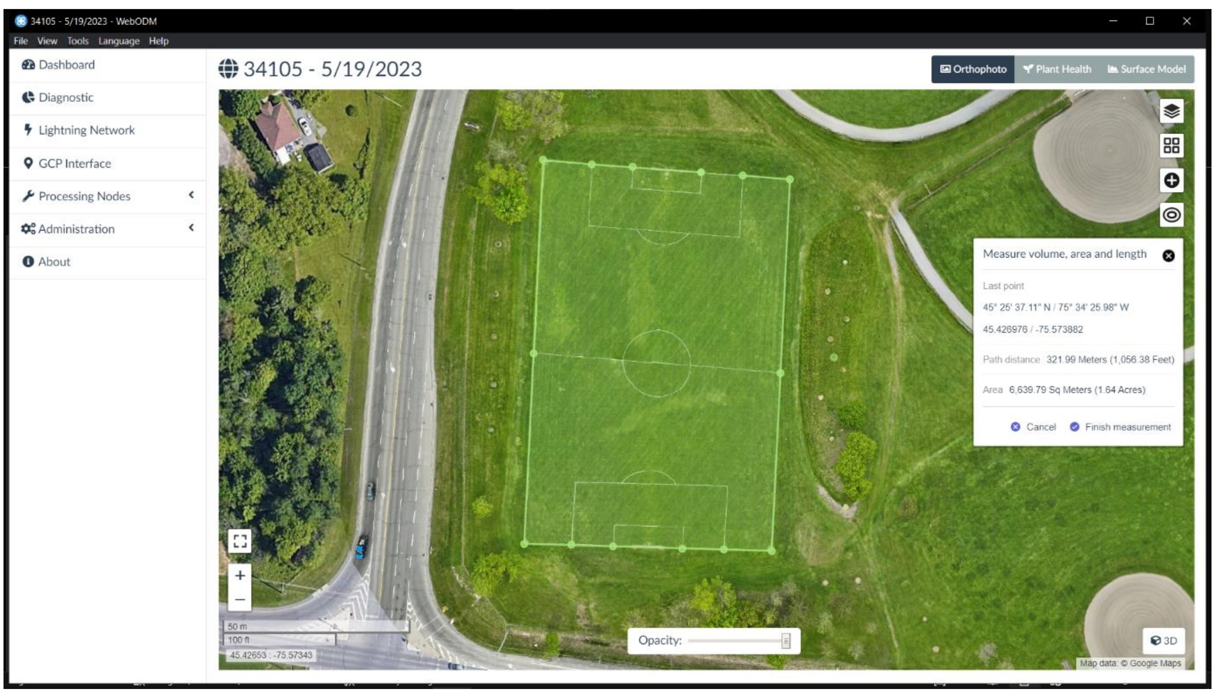
Total Area of Images

Program	Area (m^2)	percent difference (%)
Google Maps	6999.11	-
Web ODM	6639.79	5.13
DJI Terra	6656.44	4.89

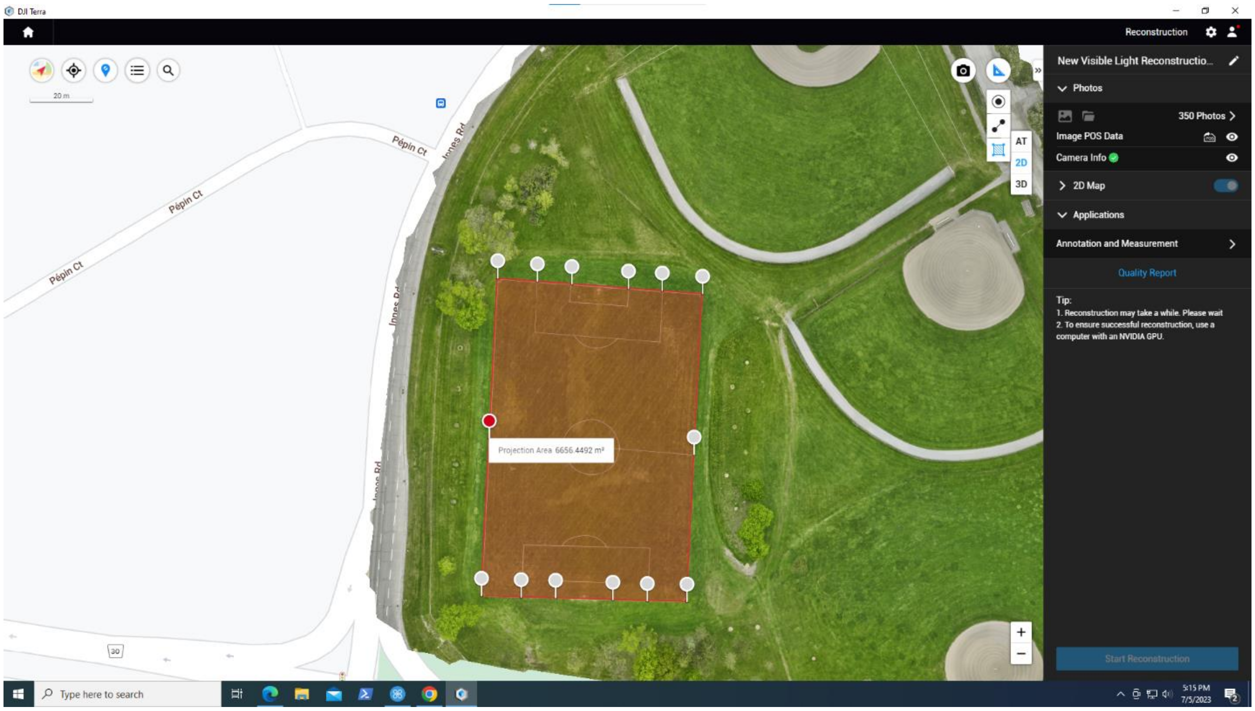
Soccer field area



Perimeter & Area Soccer Field from Google maps



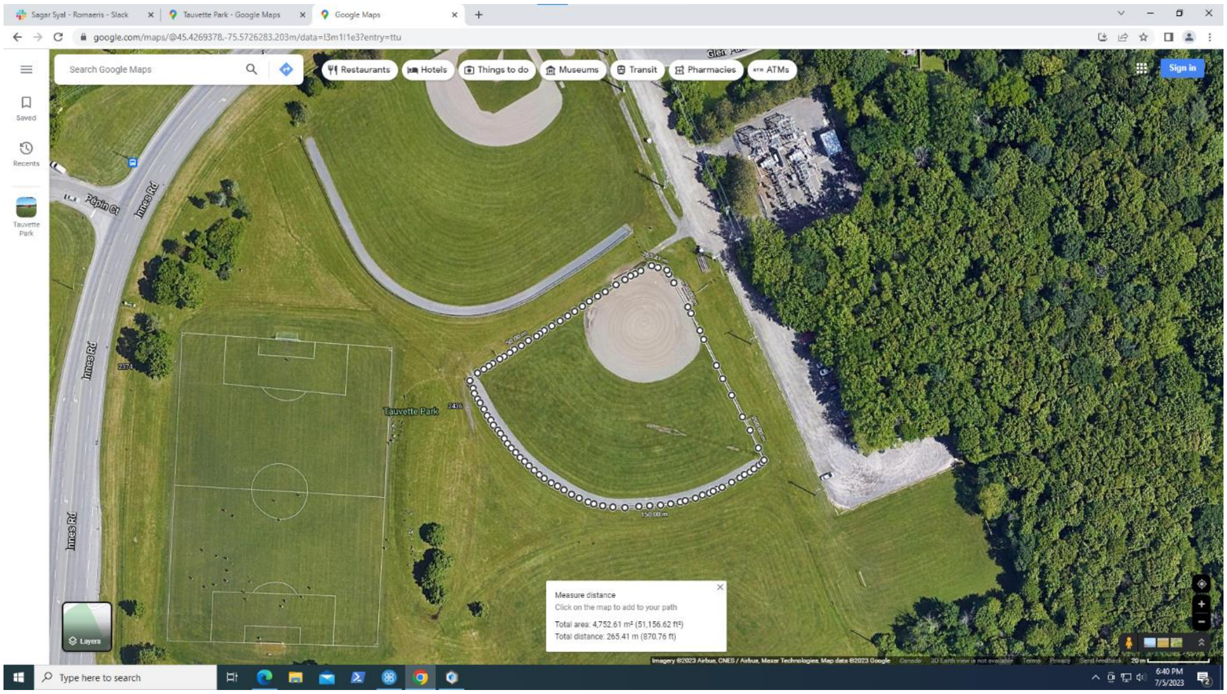
Perimeter & Area Soccer Field from WebODM



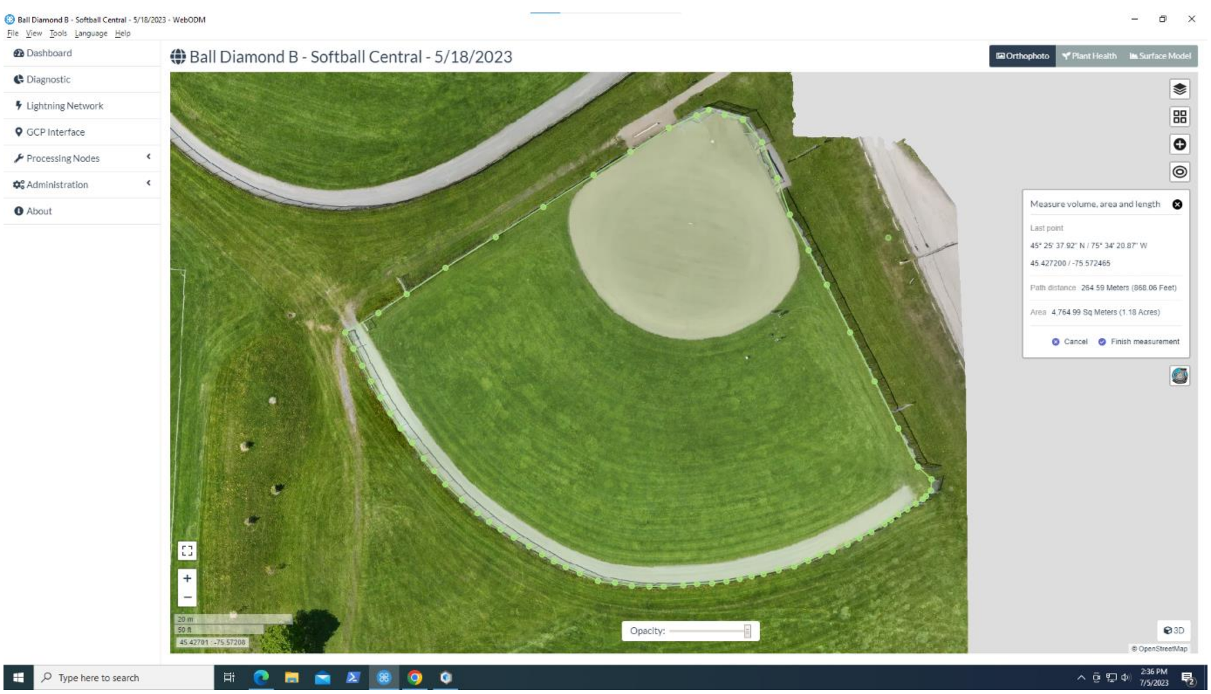
Area Soccer Field from DJI Terra

Program	Area (m^2)	percent difference (%)
Google Maps	4730.61	-
Web ODM	4764.99	7.2
DJI Terra	4847.09	7.09

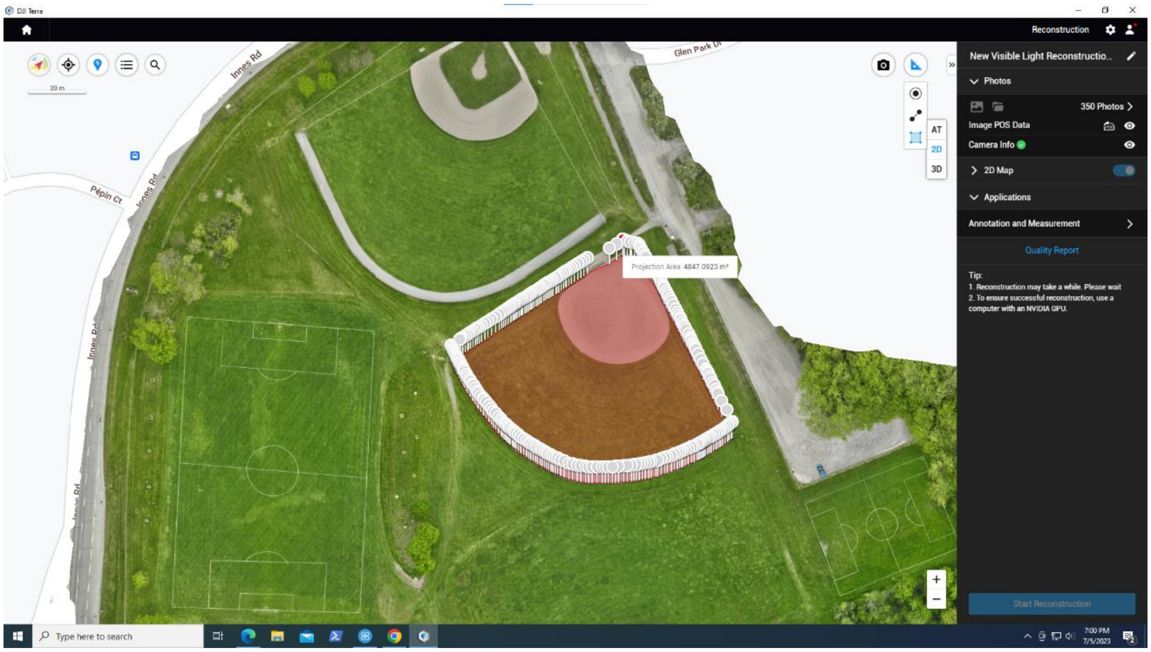
Baseball Diamond area



Perimeter & Area Baseball Diamond Google maps



Perimeter & Area Baseball Diamond from WebODM

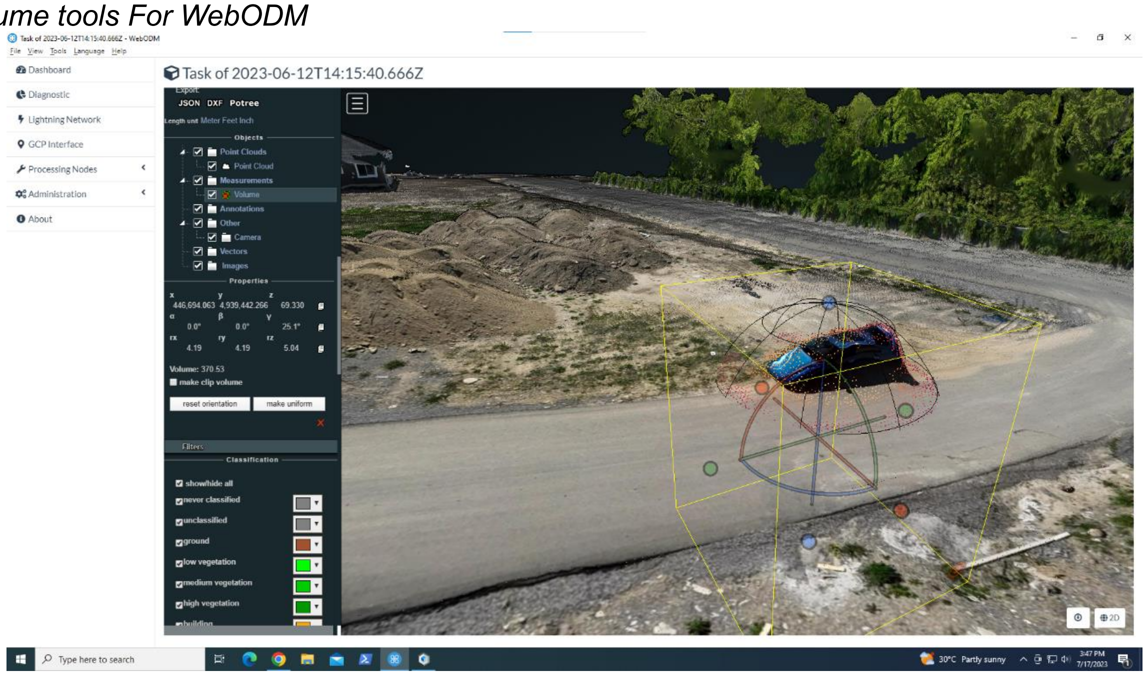


Area Baseball Diamond from DJI Terra

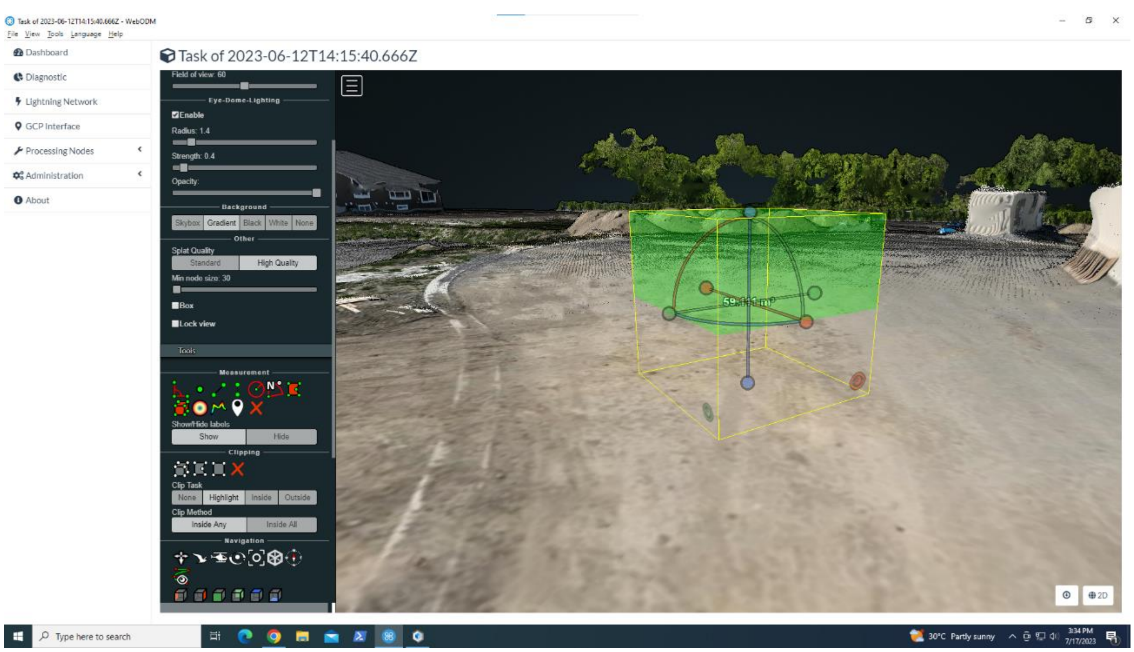
Volume

In DJI Terra, you have the flexibility to place a minimum of three points or more around the object you are trying to measure. The software will then utilize these points to calculate the volume from the highest point of the object to the base plane. This feature allows for accurate and efficient volume measurements. WebODM offers two tools for volume calculation: one based on a rectangular shape and the other on a spherical shape. While these tools can be useful for some applications, they have limitations when it comes to calculating the volume of complex shapes accurately.

Volume tools For WebODM

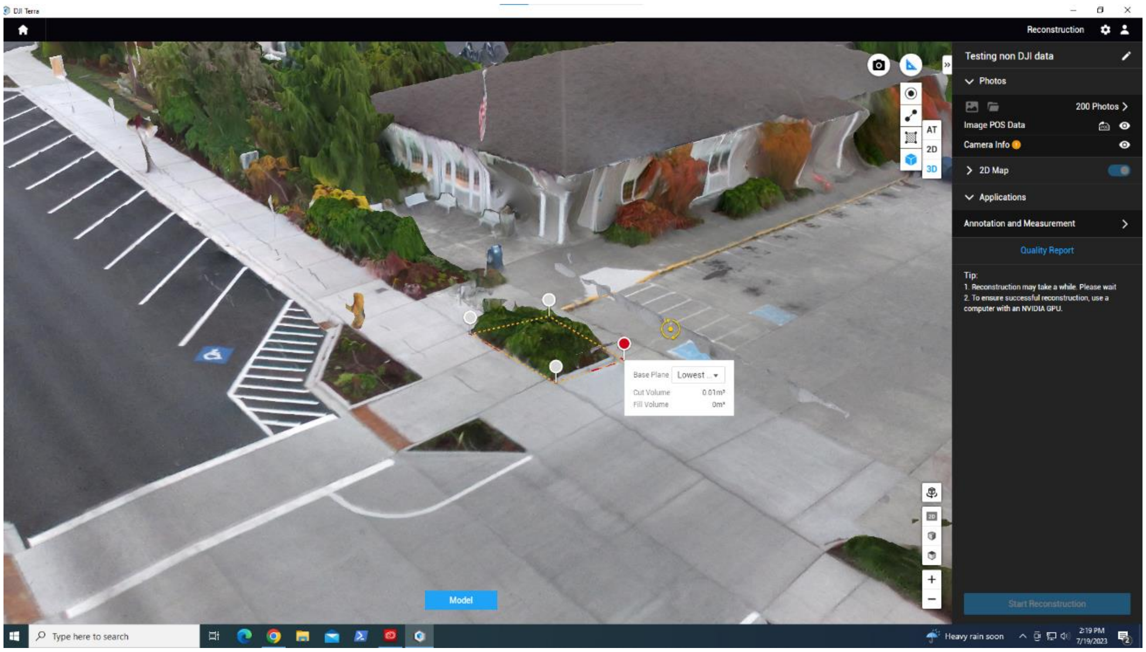


Spherical Volume tool from WebODM



Rectangular Volume tool from WebODM

Volume tool For DJI Terra



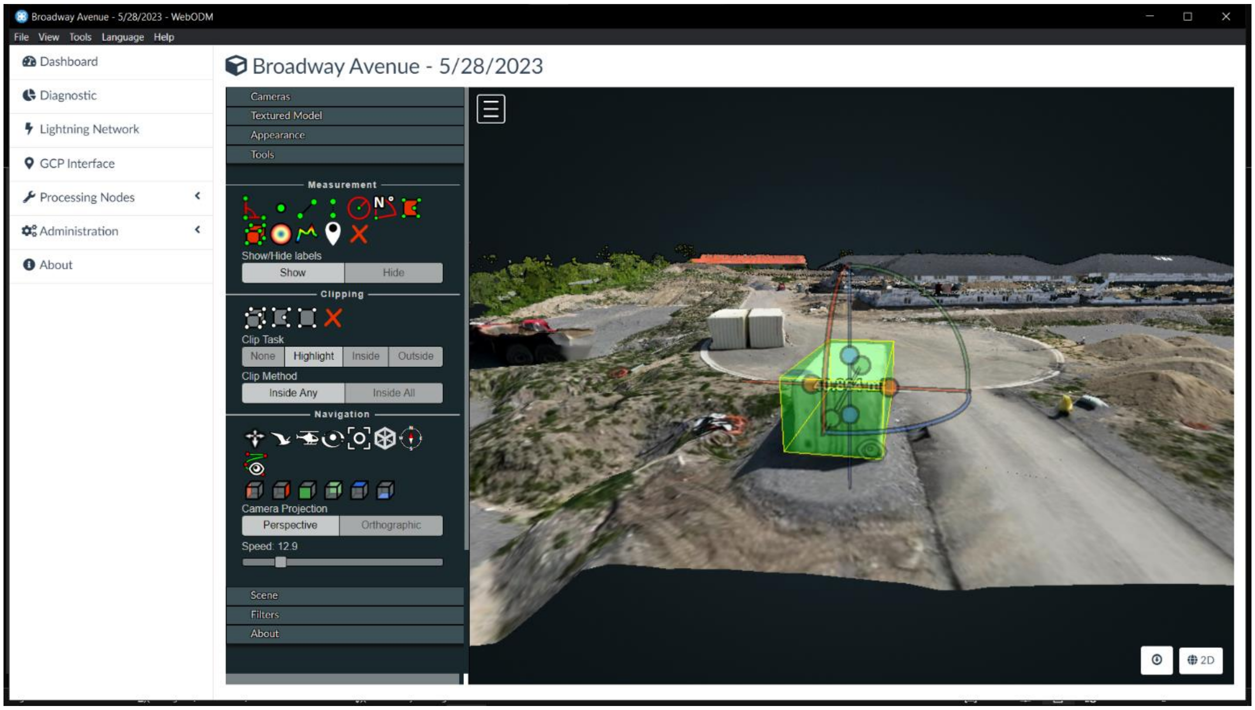
Volume tool from DJI terra

Volumetric analysis

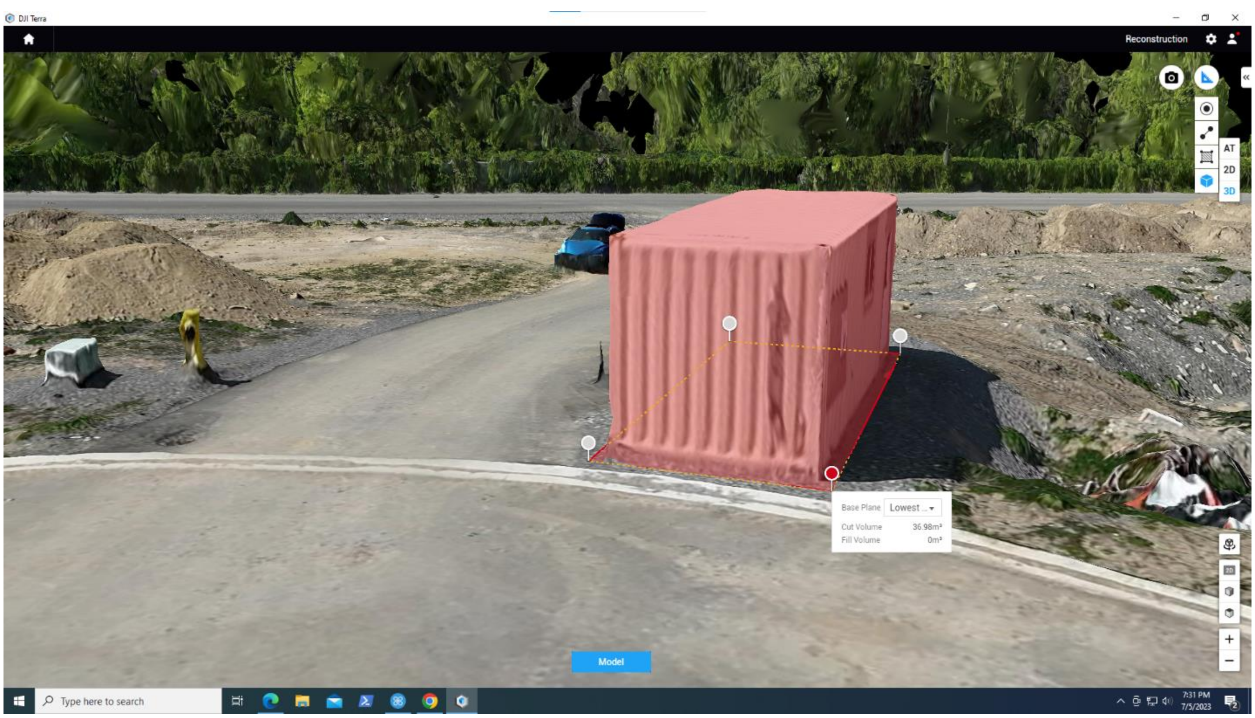
For the Shipping crate the exact model was found online, and volume was taken from there.

Program	Volume (m^3)	percent change (%)
Control	37.34	-
Web ODM	40.84	9.37
DJI Terra	36.81	1.41

Volume of shipping crate



Volume Shipping Crate from WebODM

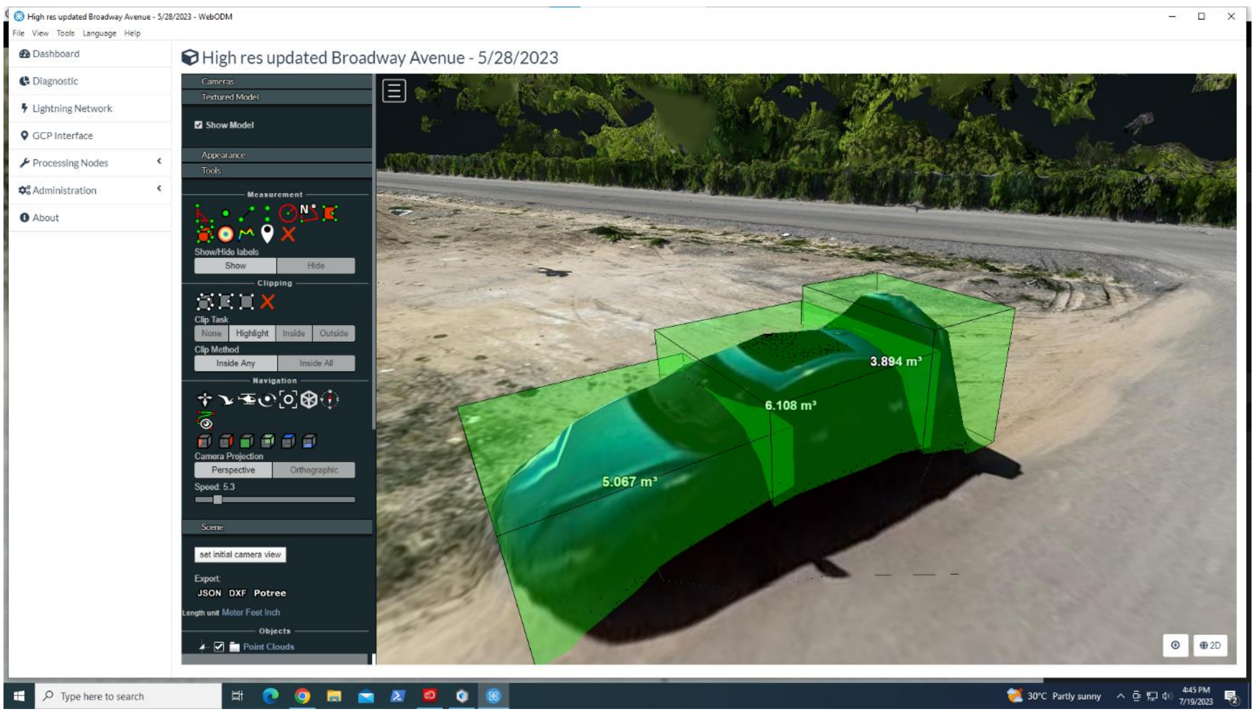


Volume Shipping Crate from DJI Terra

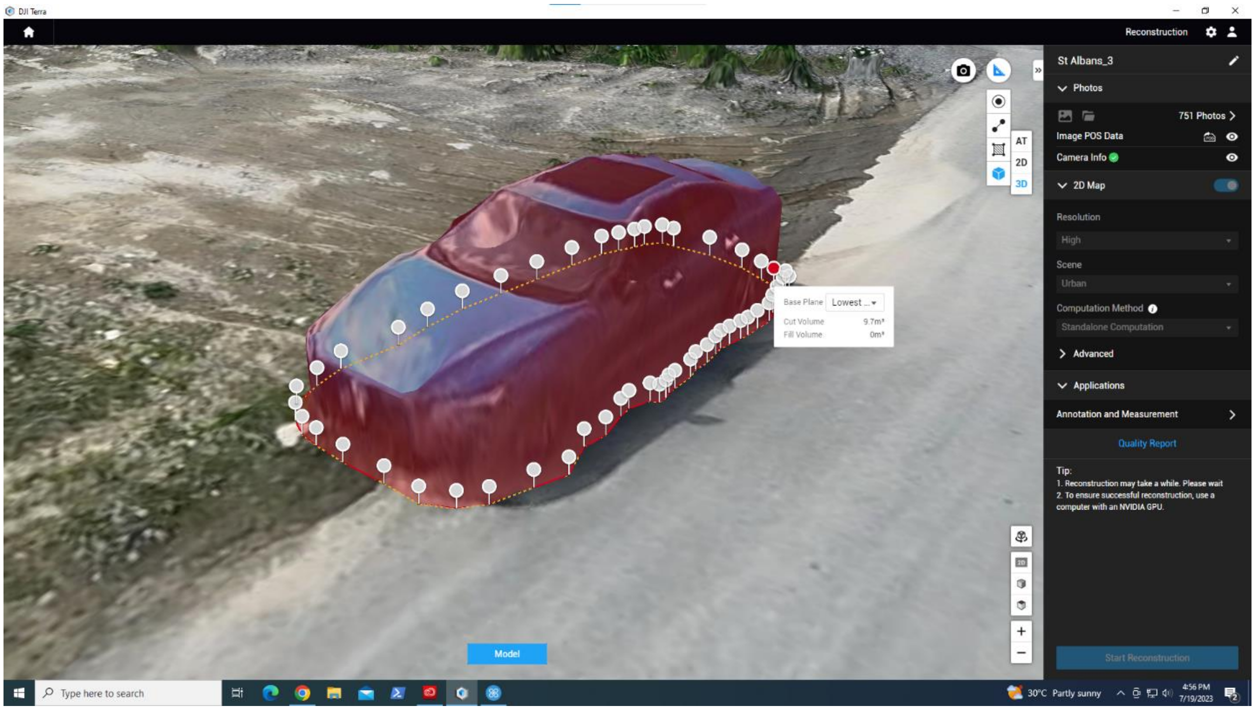
For the car, the precise model was provided, and the volume was determined by calculating it based on its dimensions and treating it as <u>a rectangular shape(this will include the free space present).</u>

Program	Volume (m^3)	percent difference (%)
Control	12.60	-
Web ODM	15.06	19.5
DJI Terra	9.70	23.01

Volume of Car



WebODM Volume of Car

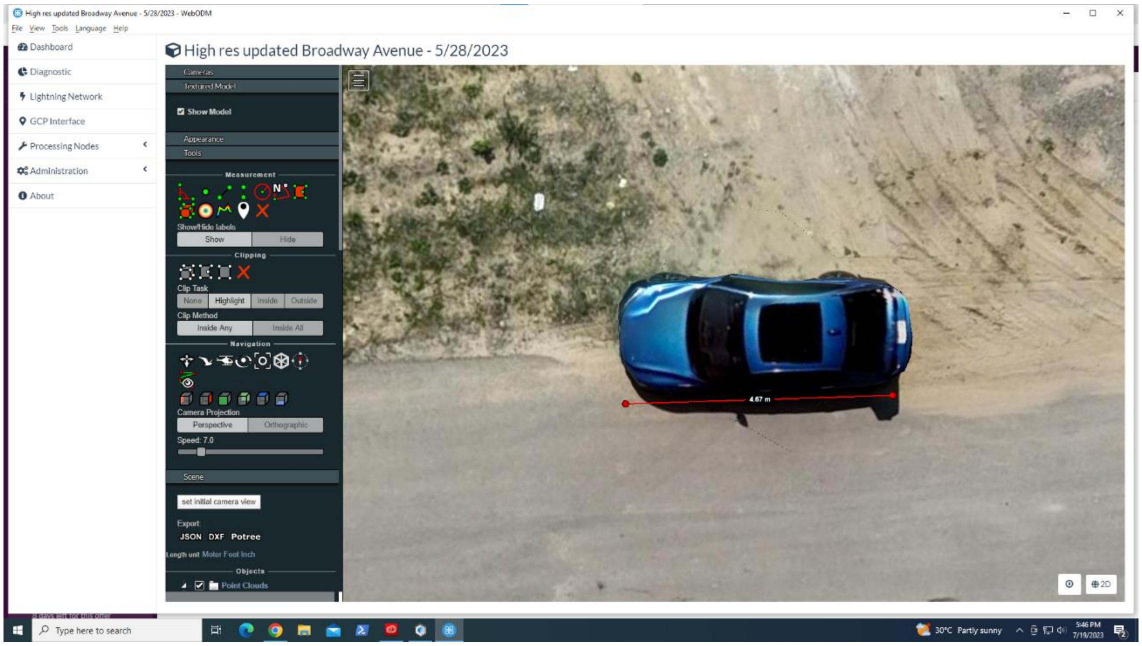


DJI Terra Volume of Car

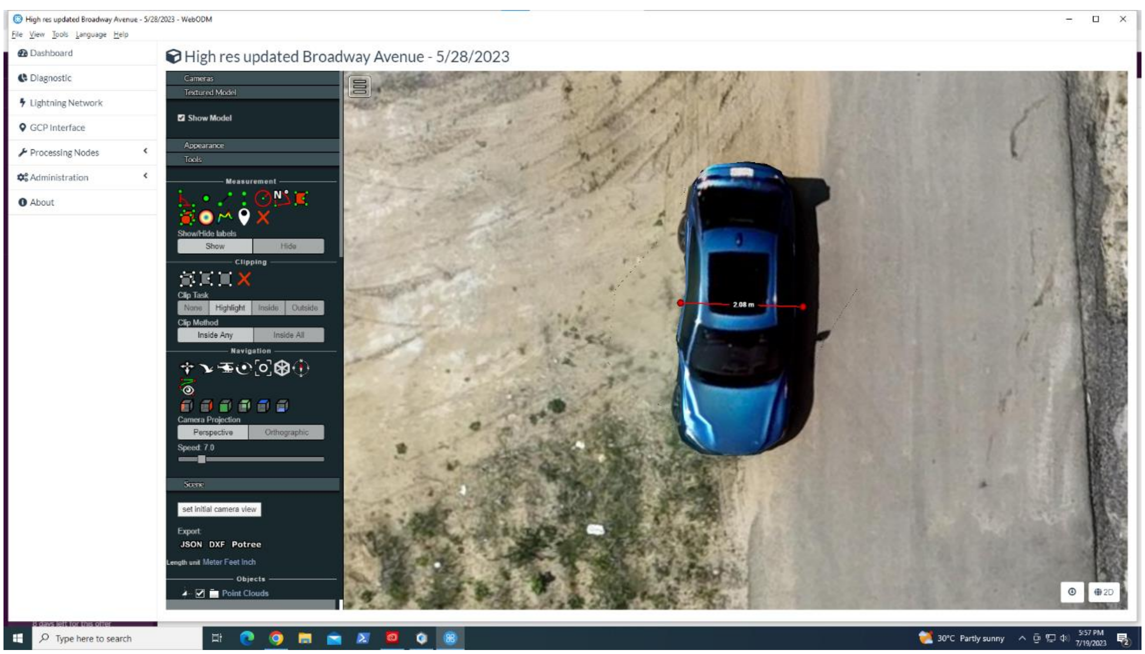
The presence of free space within the control dataset and WebODM, but its absence within DJI Terra, results in skewed volume calculations and percentage errors. To achieve a more accurate representation of the volume in relation to the control data, the dimensions of the car were individually measured and subsequently used to calculate the volume.

Program	Length(m)	Width(m)	Height(m)	Volume(m^3)	Percentage difference (%)
Control	4.76	1.85	1.43	12.60	-
WebODM	4.67	2.08	1.39	13.57	7.1
DJI terra	4.77	1.84	1.41	12.37	1.8

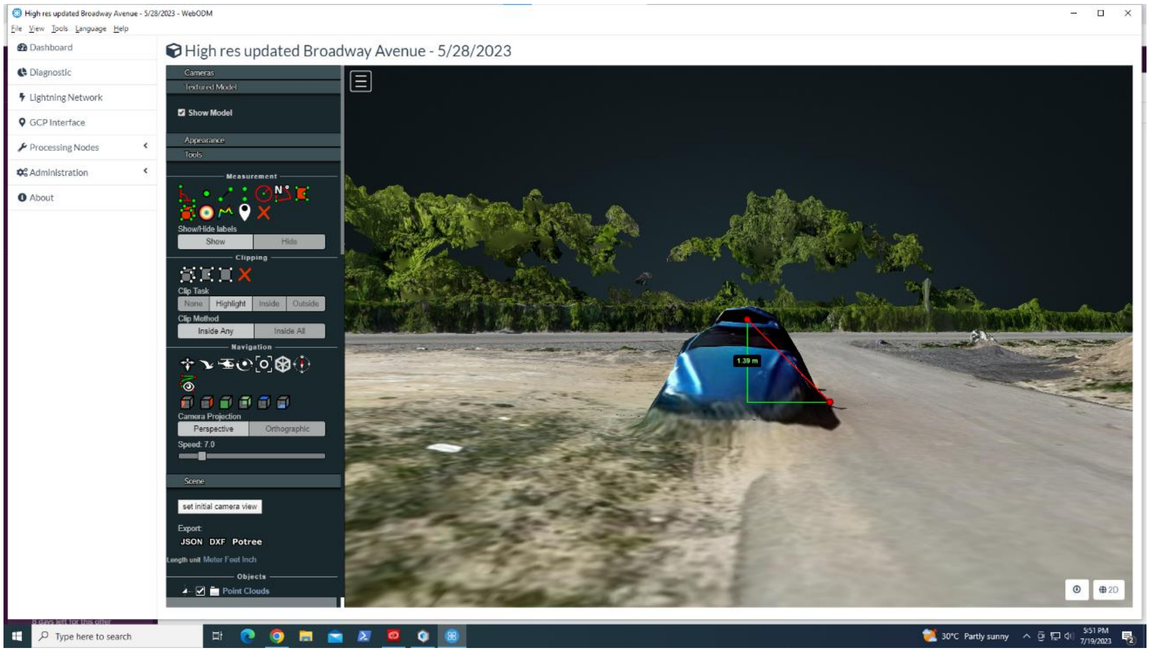
Dimensions & calculated Volume



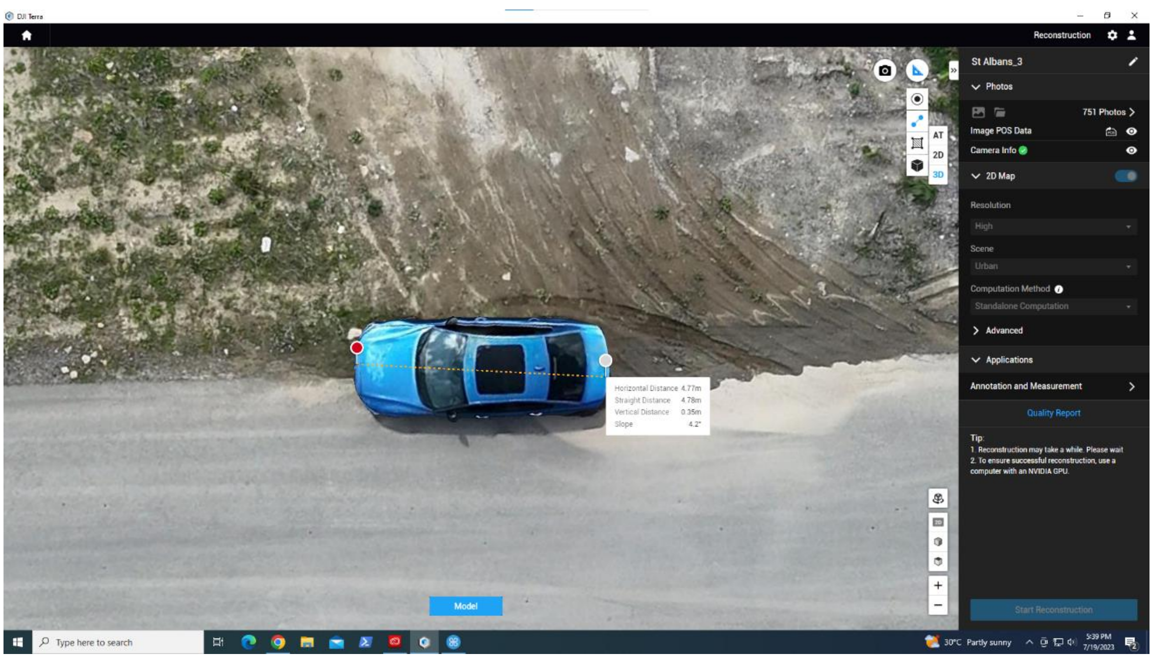
Length of Car from WebODM



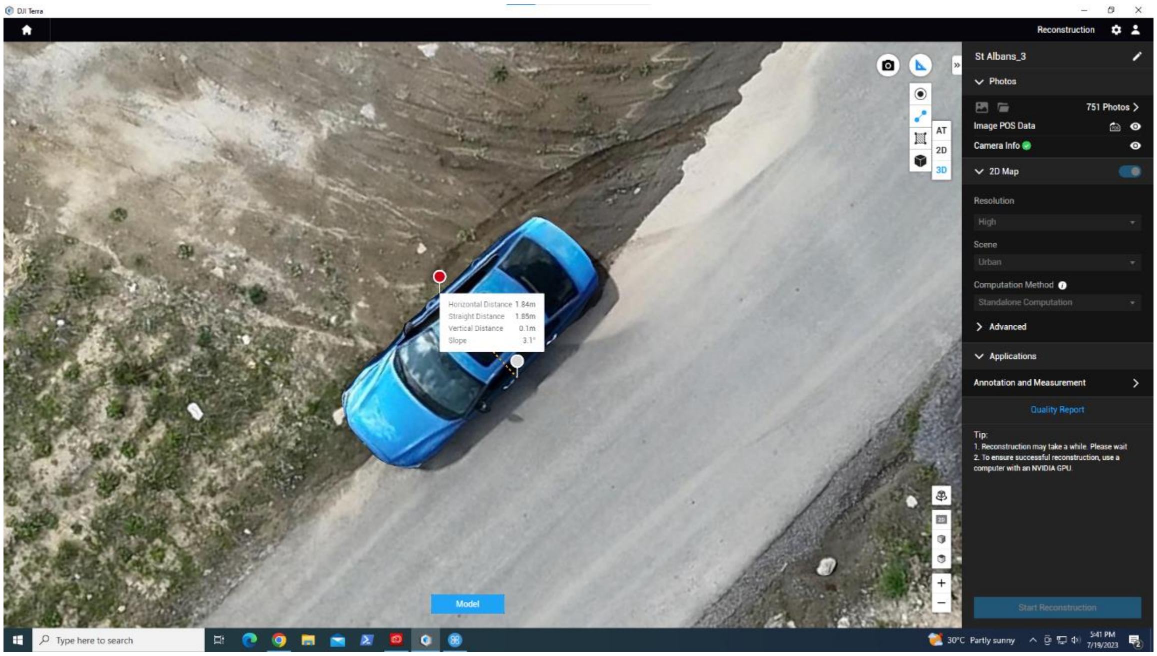
Width of Car from WebODM



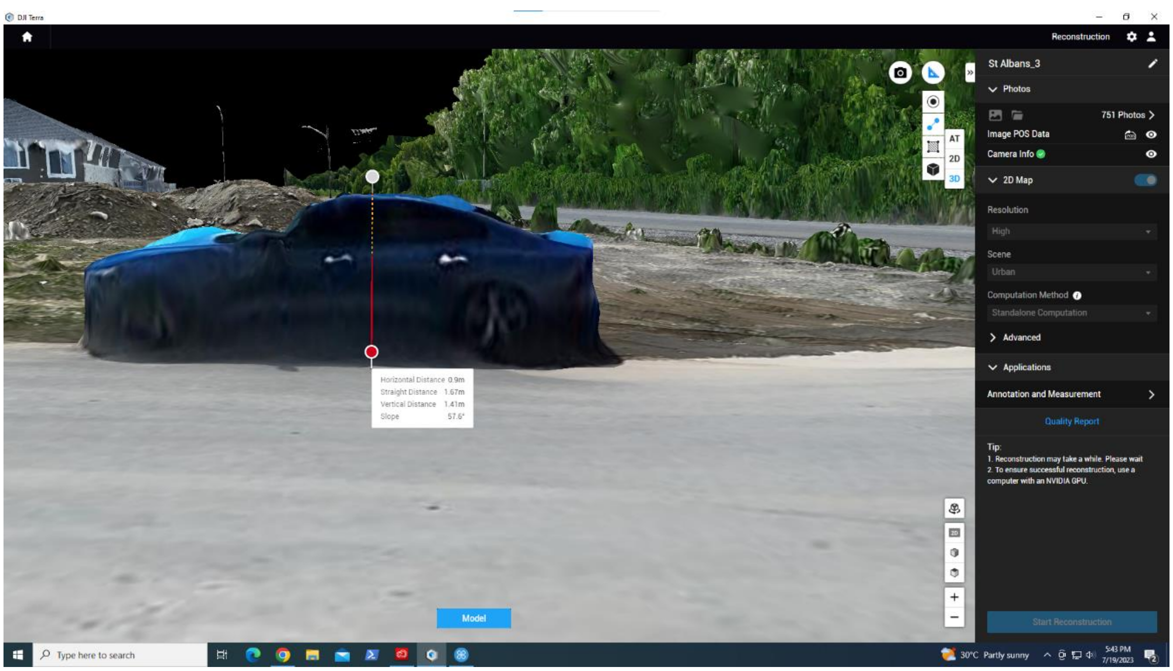
Height of Car from WebODM



Length of Car DJI terra



Width of Car DJI terra



Height of Car DJI terra

Conclusion

In conclusion, this report presents a comprehensive comparison between the mapping software DJI Terra and WebODM, with the aim of determining if WebODM is a viable alternative to DJI Terra. The analysis covered several critical factors, including processing time, 2D image quality, 3D model quality, multispectral data comparison, and measurement analysis. Overall, DJI Terra is the superior software. It demonstrated significantly faster processing times on the same machine, while WebODM struggled to complete the same datasets efficiently even when the settings were modified to help. Furthermore, WebODM’s 2D and 3D models exhibited poorer quality, supported by the higher Ground Sampling Distance (GSD) values obtained from WebODM. Both softwares performed admirably in terms of Georeferencing RMSE, boasting extremely low error values, indicating precise georeferencing capabilities. Concerning multispectral algorithms, the two software were comparable, with similar ranges of values present in the pictures. However, WebODM's extensive array of algorithms, although numerous, seemed niche and provided little practical benefit. Additionally, WebODM encountered challenges interpreting certain datasets when infrared data was included. The measurement analysis further emphasized DJI Terra's superiority, as it exhibited greater accuracy with measurements much closer to real/control values. This was demonstrated by DJI Terra's significantly lower percentile difference compared to WebODM. In summary, DJI Terra outperformed WebODM in various key aspects, including processing speed, 2D/3D model quality, multispectral data analysis, and measurement accuracy. As a result, DJI Terra stands as the ideal mapping software.