

Mapping and Aerial Image Processing Software

USER MANUAL

Version 2.7.0



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1. ABOUT

3Dsurvey is a mapping and aerial image processing software solution. It lets you build professional 3D models from 2D images and geospatial data, captured using drones or other vessels and devices. 3Dsurvey offers photogrammetric processing (building geometry, geo-referencing, dense reconstruction) as well as 3D modelling and analysis of both 3Dsurvey-generated photogrammetric point clouds and third-party-source data (las, LiDAR, CAD, etc). Create your own orthophotos (DOF), digital surface models (DSM) or calculate volumes and manage stockpiles in a fast and easy manner. An integrated reports wizard will help you put all that work together in a compact and presentable way.

This manual will help you get the most out of 3D survey to achieve high-accuracy, survey-grade results in a professional and high-tech approach. Naturally, being a team of surveying professionals, we made sure that 3D survey also supports data acquired with classical measuring methods and devices.

For more information about pricing and license options, terms of use and support please visit www.3Dsurvey.si.

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2. SYSTEM REQUIREMENTS

3Dsurvey runs on Windows 64-bit operating system. Processing runs on CPU, graphical interface runs on GPU. For best performance and speed make sure you have enough RAM (16GB+). See below for further specification requirements.

Minimum system requirements:

- Windows 7, 8, 10; 64 bit
- I5/i7
- 16 GB RAM
- Nvidia GTX760
- SSD 128 GB + HDD 500 GB

Recommended system requirements:

- Windows 10; 64 bit
- i7: https://ark.intel.com/products/88967/Intel-Core-i7-6700HQ-Processor-6M-Cache-up-to-3_50-GHz
- 16 32 GB RAM
- Nvidia GTX960 or better
- SSD 256 GB + HDD 1 TB

Advanced Professional Use (large datasets, full-frame cameras)

- Windows 10; 64 bit
- i9: https://ark.intel.com/products/123613/Intel-Core-i9-7900X-X-series-Processor-13_75M-Cache-up-to-4_30-GHz
- 64 128 GB RAM
- Nvidia GTX960 or better
- SSD 512 GB + HDD 1 TB



Recommended operating system settings:

- a) Using notebook PC: Power plan should be set to high performance
- b) In case of additional graphics card: Dedicate the use of graphics card to 3Dsurvey.

Right click on 3Dsurvey shortcut -> Run with graphics processors -> Change default graphics processor... When card's control panel pops up, go to Manage 3D settings -> Program settings. Check if 3Dsurvey is on the list of selected Program to customise. If not, click Add button and find 3Dsurvey. Click Add Selected Program and close Control panel.



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3. 3DSURVEY GUI (GRAPHICAL USER INTERFACE) WALKTHROUGH

3.1 Welcome screen

Opening 3D survey brings us to a welcome screen with a couple of options to start our project; *New project*, *Open* an existing project, or select from *recent projects* list. Other buttons remain disabled as no data is loaded in the app.



Graphical user interface of 3Dsurvey consists of four fundamental sections with tools, advanced options, guidelines and information for data processing:

- Toolbar is the upper left part that provides us with all main options
- Working Panel is located on the right side containing seven tabs, each giving us basic and advanced tab related tools. Tabs unlock as we move through processing to point cloud, modelling, Orthophoto, etc. Some menus, as well as some functions are locked due to either lack of data or because we tried to skip some of the processes.
- Live Command Window is located on the lower left part, providing us with live results of running functions: coordinates of marker's position, computed distances, etc.

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Viewer is the central board for viewing images, and all of 2D or 3D data.

3.2 Toolbar and Working Panel

All accessory functions and processes are located in the Toolbar and Working panel sections.

Tool bar: Load
Project Save
New project Save as
Open Orthophoto
Recent project Calculate new

Save Load
Save as Save
Generate report Save as
General project report Options

Measurements report Application settings

Exit Help

ImagesUser manualLoad imagesOnline tutorialsDataContract support

Load control points License

Save control points Check for updates
Save control points as About 3Dsurvey

Export camera parameters Working panel:
Export camera calibration Images

Export undistorted images
Telemetry Image name
Import DXF X [m]
Export DXF Y [m]
Point Cloud Z [m]

Load Error 3D [m]
Save Projections
Save as Error [px]

DSM Total number of images
Calculate new Selected number of images



Registered number of images Create textured object List of ground control targets Polygon selection **GCP** Point picking X [m] Profile calculation Y [m] Calculate profile Z [m] Measurements Error [m] Delete all **Bundle Adjustment** 2D distance Orientation 3D distance Orientate with GCP data Slope Orientate with telemetry ∆ height data Text size Reset orientation Classification DSM Reconstruction CAD Delete Fdit tool Show arid Selection tool Wire only Draw lines tool Height map Draw circles tool Point snapping Snapper settings Drape DOF Use element snappers Select Deselect Use point picker snapping Clear Measurements display 2D distance Delete selection Delete others 3D distance Clear Slope Flatten ΔHeight List of layers Manipulate points Element properties Set height to Point cloud Increase height to Delete Average height Merge Undo Redo Point render size Calculate volume View options Calculate contour lines Height map Point snapping DOF



Remove selected

Select

Recalculate DOF

Cut Merae

Calculate area

Profile

Vertical exaggeration

Text size
X axis
Y axis

Profile title

Remove selected

Profile points

Profile lines

Anchor points

Reset view

Reconnect

Delete

Export DXF

Export PDF

Contour lines

Show height

Delete selected

Export DXF

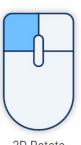
Export PDF

Volume

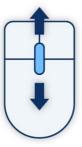
3.3 Viewer and Live Command Window

Main Viewer screen and Live Command line provide and interactive graphical and numerical interfaces for you to control and work with models, results, pick points, monitor coordinates as you explore your 2D or 3D material. The easiest way to handle models in 3Dsurvey is using a mouse and its four operations. Left mouse click is, just like any other app, used for selecting (starting polygon selection). When selecting polygon, use left mouse button to determine its points and right mouse click to finish your selection. To rotate models, click and hold left mouse button. To zoom in or out use the scroll wheel. If you need to shift the selected angle of view at selected zoom, click scroller and use it like pan function. When viewing Orthophotos or Profiles use scroller to zoom and pan.









Scroll Wheel to Zoom in or Out



Pan Function



Confirming Closing selection

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4. WORK FLOW

4.1 Introduction

Type of accessible data differs from project to project as should work flow. Two most popular use cases:

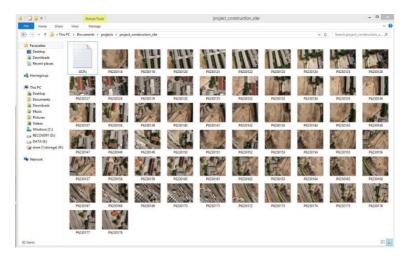
- Drone flight & Mission Planner + 3Dsurvey Processing + 3Dsurvey Modelling and Analysis
 Capture your own images (along with EXIF, GNSS, GPS RTK, etc. data for geo-referencing) and import them to 3Dsurvey for photogrammetric processing. Set parameters for bundle adjustment, orientation (geo-referencing) and reconstruction. The result will be a metric, geo-referenced, realistically coloured 3D point cloud that serves as a basis for all further calculation, modelling and analysis. <u>Learn more about project preparation</u> or jump to Processing Aerotriangulation, Geo-referencing and Reconstruction
- 2. 3Dsurvey Modelling and Analysis
 Just finished with Processing? Importing third-party data, such as las point clouds, photogrammetric point clouds from other sources, LiDAR, etc. without having your own data for photogrammetric processing? No problem. This part lets you build, manipulate and customize point clouds, DSMs, DEMs, orthophotos, calculate volumes and profiles, contour lines, generate reports and export data in various formats for further CAD or any other use. Go to Modelling & Analysis

4.2 Preparation

Prepare your project folder on your disk and copy your images of selected project from SD card into the folder. If your UAV supports telemetry, use that data. Depending on your UAV model, telemetry data are ascribed to images, or recorded into *.csv file. The .csv file must also be added alongside images and



consists of further data: enabled, index, longitude, latitude, altitude, date, time, yaw, pitch, roll, x Sigma, y Sigma, z Sigma, p Sigma, blur, and file name. Organization of data must be known but is to be specified as you wish. See below an example of generic telemetry file (use this option if your UAV type is not listed). It is recommended you save your ground control point coordinates (GCPs) .txt file into the same folder as your image files. GCP file should be organized in the following way: point name, x coordinate, y coordinate, z coordinate – space delimited.



Example of GCP coordinate file:

2000	461826.497	101890.277	299.055
2002	461890.872	101944.218	306.204
2003	461912.476	101975.102	298.454
2004	461918.598	102038.315	298.804
2005	461924.782	102083.948	298.882
2006	461889.252	102029.085	297.492
2007	461862.244	101990.371	294.797
2008	461863.334	102042.424	294.880
2009	461828.060	102028.207	300.632
2010	461796.036	101953.868	299.634

Example of csv telemetry file:



1	Enabled:Index:Longitude:Latitude:Altitude:Date Time:Yaw:Pitch:Roll:xSigma:ySigma:zSigma:gSigma:Blur:FileName
2	1:0001:13.9583636602449.45.8337773528361:271.2905.12.2015
	11:14:39.874;146.75;3.31;1.62;0.00731778655059028;0.00550990901579003;0.0127800625976558;0.0157206870078887;0.0045;F\\S.12.2015\\120m_70\\DCIM\\100M\SDCF\\DSC00001.JPG
3	1;0002;13.9584470721282;45.8336518897466;271.253;05.12.2015
	$11:14:40.674;162.75;3.37;1.68;0.00731368580129062;0.0054972720507539;0.0127718440328717;0.0157108242940974;0.00565;\\F:\colored by the contraction of the contractio$
4	1;0003;13.9584784645431;45.8335148563475;271.744;05.12.2015
	$11:14:41.474;177.56;3.31;1.62;0.00730547739713155;0.00549181208709839;0.0127569588852516;0.0156929920665245;0.00392;F\cdot \\ \{5.12.2015\ \\ 120m_70\ \\ DCIM\ \\ 100mSDCF\ \\ DSC00003.JPG\ \\ DSC000$
5	1;0004;13.9584659361907;45.8333702699896;272.749;05.12.2015
	11:14:42.314;188.4;3.31;1.74;0.00702281994643178;0.00547722557505166;0.0123923363414652;0.015260733927305;0.00532;F:\\$.12.2015\120m_70\DCIM\100MSDCF\DSC00004JPG
6	1;0005;13.9584281045896;45.8332299296499;274.225;05.12.2015
	11:14:43.154;192.07;3.31;1.74;0.00479061582680139;0.00540462764674866;0.00847230783199005;0.011132834320154;0.00585;F:\5.12.2015\120m_70\DCIM\100MSDCF\DSC00005.JPG
7	1;0006;13.958391200951;45.8331052934532;275.878;05.12.2015
	11:14:43.914;190.53;3.31;1.80;0.00478539444560216;0.0054018515344278;0.00847289796940811;0.0111296900226376;0.00417;F:\S.12.2015\120m_70\DCIM\100MSDCF\DSC00006.JPG
8	1;0007;13.958362663814;45.8329738996776;277.428;05.12.2015
	11:14:44.714;185.58;3.37;1.74;0.00477912125813941;0.00539444158370447;0.00846108740056501;0.0111144050672989;0.00617;F\\$.12.2015\120m70\DCIM\100MSDCF\DSC00007.JPG
9	1;0008;13.958354030887;45.8328480387836;278.474;05.12.2015
	11:14:45.474;179.71;3.37;1.62;0.004773887304912;0.00538794951720968;0.0084504437753292;0.0111009008643443;0.00556;F;\\$.12.2015\120m_70\DCIM\100MSDCF\DSC00008.JPG

Example of .csv generic telemetry log file:

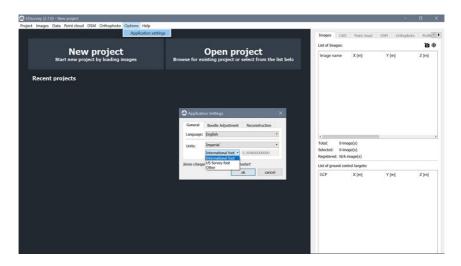
Standard log file for telemetry import:

File type: *.csv Delimiter: semicolon [;]

mage name/ID		Longitude		Latitude		Altitude		Yaw		Pitch		Roll
DSC01762.JPG	;	34.841698	;	119.183754	;	230	;	146.75	;	3.31	;	1.62
DSC01763.JPG	;	34.841301	;	119.183754	;	229	;	162.75	;	3.37	;	1.68
D5C01764.JPG	:	34.840881	;	119.183762	:	230	;	177.56	;	3.31	;	1.62
DSC01765.JPG	;	34.840485	;	119.183754	;	230	;	188.4	;	3.31	;	1.74
DSC01766.JPG	;	34.840088	;	119.183762	;	229	;	192.07	;	3.31	;	1.74
D5C01767.JPG	;	34.839672	;	119.183754	;	230	;	190.53	;	3.31	;	1.80
DSC01768.JPG	;	34.839275	;	119.183762	;	229	;	185.58	:	3.37	:	1.74
DSC01769JPG	;	34.838879	;	119.183762	;	230	;	179.71	;	3.37	;	1.62
DSC01770.JPG	;	34.838463	;	119.183762	;	230	;	172.85	;	3.31	;	1.68
DSC01771.JPG	;	34.838066	;	119.183762	;	229	;	166.39	;	3.31	1	1.74
DSC01772JPG	;	34.83765	;	119.183762	;	230	;	161.6	;	3.31	;	1.85
DSC01773.JPG	;	34.837254	;	119.183769	;	229	;	159.01	;	3,37	;	1.85
DSC01774.JPG	;	34.836838	;	119.183769	;	230	;	157.79	;	3.42	;	1.85
DSC01775.JPG	;	34.836437	;	119.183769	;	229	;	157.45	;	3.37	;	1.85
DSC01776JPG	;	34.83604	;	119.183769	;	230	;	157.43	;	3.37	;	1.85
DSC01777.JPG	;	34.835625	;	119.183769	;	230	;	157.88	;	3.37	;	1.85
DSC01778.JPG	;	34.835228	;	119.183777	;	230	;	157.48	;	3.37	;	1.85
DSC01779.JPG	;	34.834812	:	119.183769	;	230	;	156.64	;	3.37	;	1.85
DSC01780.JPG	;	34.834415	;	119.183769	;	229	;	155.85	;	3.37	;	1.85
DSC01781JPG	;	34.834019	;	119.183777	;	230	;	154.99	;	3.37	;	1.85
D5C01782.JPG	;	34.833618	;	119.183777	:	230	;	155.07	;	3.37	;	1.80

Start **3Dsurvey** and set language. Click **Options** -> **Application settings** and select language and units- You have to restart application to assign applied changes.





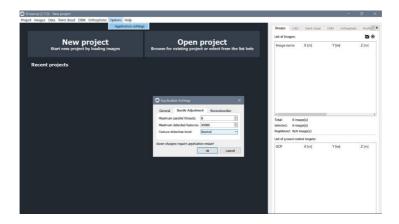
When imperial units are selected, you can further assign weather you want **International foot** or **US survey foot**. You can select **Other.** On the right, where by default is set 1.0000000000000, type value of 1 unit in meters.

Next, click **Bundle Adjustment**. There you can assign:

- Number of Maximum parallel threads depends on your computer CPU type.
 For default value 3Dsurvey checks number of available threads and directs them all. Decreasing threads is an option when RAM is insufficient to avoid plausible comp crash. It is imperative to keep sufficient level of RAM and processor. For example: if you have a good i7 processor with 4 cores 8 threads and just 8GB of RAM we would advise you to lower the threads number to 4. This will avoid memory leaks during the processing.
- Number of Maximum detected features, default number is 40.000;
 Features correspond to so called tie points on each image further used for "sawing" them to strings and strings to block.

Feature detection level defines robustness of the matching step. Level of detection is inversely proportional to reliability and smoothness of detected points – features. Level of detection is also proportional to time of computation. Levels rise from *Normal*, *High* to *Ultra*.





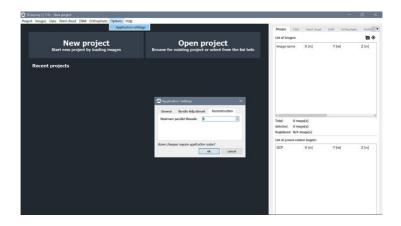
Click **Reconstruction** to set **Number of maximum parallel threads**, where default value is 8. When all preferred values are assigned, click Ok to assign selected measures.

To save the changes for Language and Units you have to restart application to assign applied changes.

Changes of Bundle adjustment and Reconstruction settings are confirmed with selecting OK button - You don't need to restart application.

Note, that, if selected language is other than English, furtherly named command buttons and functionalities will be translated to selected language and will therefore defer from presented screenshots.





4.3 Processing – Aerotriangulation, Geo-referencing and Reconstruction

This part of 3Dsurvey empowers you to import your own dataset(s) containing images and geospatial data to generate metric, geo-referenced point clouds that serve as a basis for further modelling and analysis. When using unmanned or manned aircraft for the resulting data are overlapping aerial images along with image positions (exif gps, rTK, PPK, etc.) and/or GCPs to further improve geospatial orientation of the model. Therefore, it is advised to utilise flight mission planning software/app compatible with your UAV (pixhawk, GS Pro DJI, etc.). Flight path needs to be planned as to achieve image overlap that is paramount to successful matching and alignment of the images. Recommended overlap is 70% or more (For terrain with higher terrain difference increase it up to 80%).

Another important parameter of mission planning is <u>setting the right flaying</u> <u>height</u>. Its value depends on desired ground pixel size, resolution of used camera, and terrain characteristics. If your platform supports telemetry data, this is where it comes into play. Use it. To further improve geo-locating and



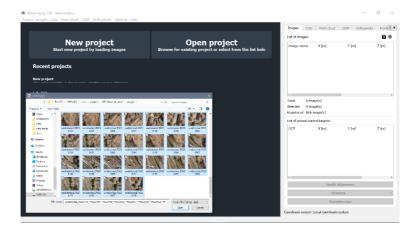
referencing your project/model it is recommended to use ground control points. They need to be distributed across the surveyed site properly as to provide adequate spatial reference (minimum 3 GCPs, recommended 9 GCPs per every 500m x 500m area/segment). GCPs can be measured manually using GNSS devices (or any other device with GPS/GNSS capabilities) and can be in the form of natural/manmade features (building corners, rocks, manholes, shafts, etc.) or in the form of ground control targets. You can find the video description for all the procedure in the following video:

https://www.youtube.com/watch?v=oDBGeafcbE4

To recap: Place GCPs \rightarrow Plan flight mission + UAV flight (capture images and positions) \rightarrow Import to 3D survey.

4.3.1 LOAD IMAGES

Start 3D survey, select **New project** button in *Viewer* and select project images in your folder. Same can be done through *Toolbar's* **Images** - > **Load images**.

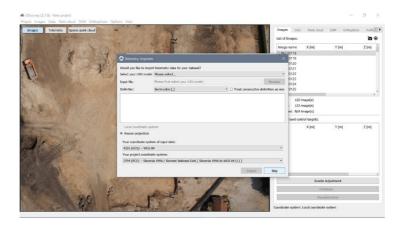




When images are loaded, *Telemetry importer* window pops up. For DJI drones, Yuneec drones and all other drones who are writing GPS position of the images during the flight use EXIF data.

For drones with the separate log file use one of following options:

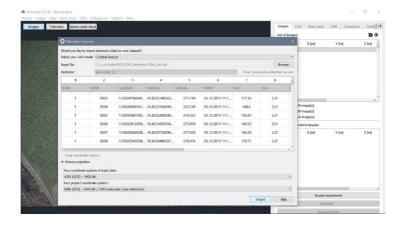
- C-astral Bramor -> *.csv
- MaVinci Sirius Pro -> *.csvExif data (DJI Phantom 4, Inspire 1, eBee, Falcon 8,..)
- Other -> *.csv



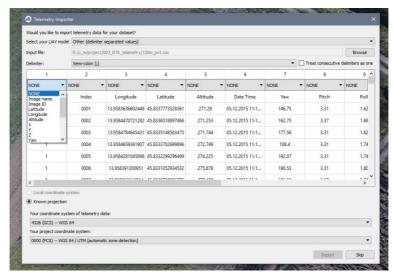
4.3.1.1 Telemetry

Telemetry data is attribute data to your images. They hold information about external orientation of images in the moment of exposure (their position). As the next process is matching and stitching the images together, adding telemetry data at this stage significantly speeds up the process of Bundle Adjustment/Image Alignment.





In case you are not using DJI drones the most universal is "Other" option. First you must set the data delimiter. Click where Semi-column [;] is displayed and select delimiter sign. Now you must assign attributes of your log file to each column. Click on a tab on top of each column, where none is displayed. Scroll the list and click on desired attribute, to assign each column to specified attribute.



See below for example of how log file should look like.



Standard log file for telemetry import:

File type: *.csv Delimiter: semicolon [;]

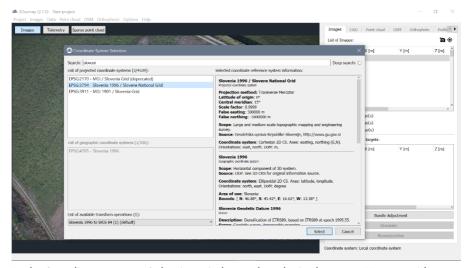
mage name/ID		Longitude		Latitude		Altitude		Yaw		Pitch		Roll
DSC01762.JPG	;	34.841698	;	119.183754	;	230	;	146.75	;	3.31	;	1.62
DSC01763.JPG	;	34.841301	;	119.183754	;	229	;	162.75	;	3.37	;	1.68
D5C01764.JPG	:	34.840881	:	119.183762	:	230	;	177.56	;	3.31	;	1.62
DSC01765.JPG	;	34.840485	1	119.183754	;	230	:	188.4	;	3.31	;	1.74
DSC01766.JPG	;	34.840088	;	119.183762	;	229	;	192.07	;	3.31	;	1.74
DSC01767.JPG	;	34.839672	1	119.183754	:	230	;	190.53	;	3.31	;	1.80
DSC01768.JPG	:	34.839275	;	119.183762	;	229	;	185.58	:	3.37	1	1.74
DSC01769.JPG	;	34.838879	;	119.183762	;	230	;	179.71	;	3.37	;	1.62
DSC01770.JPG	;	34.838463	:	119.183762	:	230	;	172.85	;	3.31	;	1.68
DSC01771.JPG	:	34.838066	1	119.183762	;	229	;	166.39	;	3.31	1	1.74
DSC01772.JPG	;	34.83765	;	119.183762	;	230	;	161.6	;	3.31	;	1.85
DSC01773.JPG	:	34.837254	;	119.183769	:	229	;	159.01	;	3.37	;	1.85
DSC01774.JPG	:	34.836838	1	119.183769	;	230	1	157.79		3.42	1	1.85
DSC01775.JPG	:	34.836437	:	119.183769	:	229	;	157.45	;	3.37	;	1.85
DSC01776JPG	:	34.83604	:	119.183769	:	230	:	157.43	;	3.37	;	1.85
DSC01777.JPG	:	34.835625	1	119.183769	:	230	;	157.88	:	3.37	1	1.85
DSC01778JPG	:	34.835228		119.183777	:	230	:	157.48	;	3.37	:	1.85
DSC01779.JPG	:	34.834812	1	119.183769	:	230	;	156.64	-	3.37	1	1.85
DSC01780.JPG		34.834415	-	119.183769	:	229	:	155.85	:	3.37	:	1.85
DSC01781.JPG	:	34.834019	1	119.183777	:	230	:	154.99	:	3.37	-	1.85
D5C01782.JPG	;	34.833618	;	119.183777	;	230	;	155.07	;	3.37	;	1.80

Further chose coordinate systems. In most of the projects the "Your coordinate system of telemetry data" is WGS 84 – and this is also the default value in 3Dsurvey. In case your drone is writing the telemetry data in any other coordinate system feel free to change it.

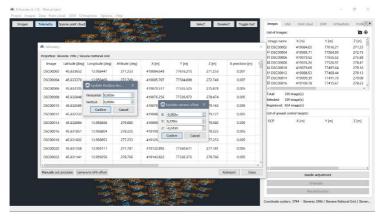
Second, select **project coordinate system**, the system you want your data to be computed in. Please be aware to select the ---right project coordinate system, because afterwards you cannot change it! History of last selected systems are seen in the pop up menu or click more to select desired one.







In the Coordinate system Selection window, select desired system. You can either write its name, or name of the country into search window or scroll down the list to find desired one. Click desired system and click **Select.** If you would like to know more about items in Selection window go to chapter <u>4.3.1.2</u>. When desired system is selected click OK.



Telemetry window pops up, presenting imported data and its transformation to project coordinate system with their accuracy. You can **manually set precision** and determine **Camera to GCP offset.** If you imported wrong log file, click **Reimport**, to reimport telemetry data or/and close. Camera positions are



displayed in the *Viewer* after the data has been imported and processed. In the upper left side of the *Viewer* you will see three buttons, *Images*, *Telemetry* and **Sparse point cloud** to observe data in preferred mode. By these stage, Sparce point cloud isn't available. When in *telemetry* mode, three buttons appear in the upper right side.

Third button *toggle text* is for *display* of image names. By default all imported images are selected – number of selected images from available is shown in the working panel. Use *Deselect* button to exclude any number of images from bundle adjustment. Use the *left mouse button* to *draw* polygon surrounding desired cameras. *Close polygon* and confirm selection with the *right mouse button*. Deselected images will change colour from blue to grey and on the list of images in working panel, deselected images will be unhooked. If you wish to include some of the deselected ones, click **Select** button to reselect them, or hook them on the list of images. That has intrinsic value in two cases:

- When a data set of more than 1000 mages is being processed probably more effective way would be to process them by parts;
- You can easily deselect images which are not important for your project and would just increase the processing time for the project – panoramic images, images during the drone lift to the exact height,...

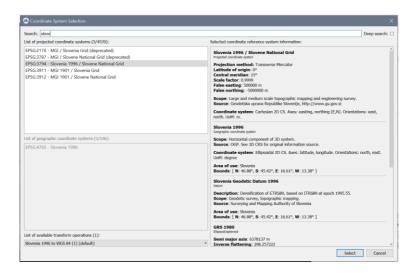
4.3.1.2 Advanced explanation about coordinate systems

When importing image telemetry data or ground control points, you need to select data coordinate system and project coordinate system. When you are assigning preferred project coordinate system, as described in <u>4.3.1.1</u> you may be interested in data displayed along selected coordinate systems.

In the upper left window, **list of available projected coordinate systems** appears. You can either scroll down the list or type name of the country or coordinate system in search menu. In the right window, observe **information** about **selected**



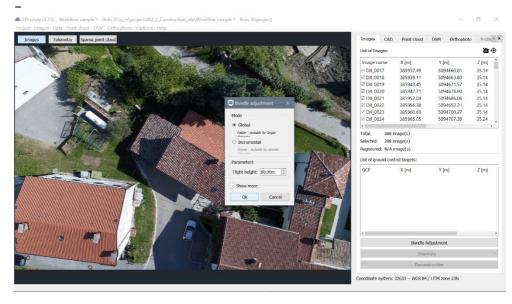
coordinate system. Bottom left window presents a list of geographic coordinate systems found due to search menu. List of available transformation operations that refer to selected system appears below. In the right window you can inspect coordinate system metadata. In case of several systems for one country, it might be handy to select the right one.



4.3.2 BUNDLE ADJUSTMENT

Above **Bundle Adjustment** button **number of all images** is presented as a **number of used images**. Press **Bundle Adjustment** to calculate parameters of camera orientations.





You need to select the Mode of adjustment:

- Global is faster method suitable for larger datasets use it for default setting. In case you will not be satisfied with the number of matched images repeate the Bundle Adjustment calculation with Incremental approach.
- *Incremental* is slower but more stable suitable for project where image texture or overlap isn't the best: High vegetation, bad overlap between images, blurry images... We advise you to use incremental approach for data sets up to 500 images (because of the processing time...)

Next, you need to select your flying height – use the same value as you set into the planning software (for example: DJI GS PRO, Mission planner, Microdrone Cockpit,...). If you are flying at different heights: 60m high with first battery, and 80m with the second battery, and you wish to compute entire dataset in one take, you have to select the higher value, meaning 80m.



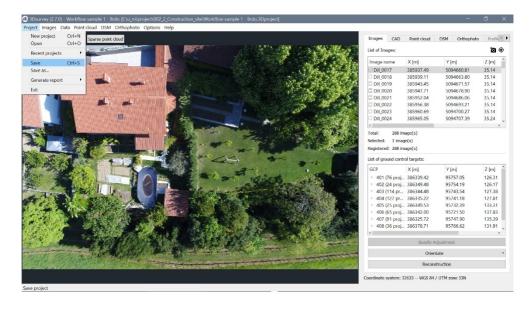
If you have camera calibration parameters, click more and load camera parameters. Such data significantly improves the speed of the process of bundle adjustment and should be imported if available. For most popular drones (DJI Phantom 4, 4 PRO, Mavic,..) the predefined parameters are already integrated in the software and you don't need to import it additionally. In case you are using other cameras, we advise you to calibrate your camera on your fist project and use those parameters for future projects. Check out chapter: 4.3.4.3 Export camera calibration for detailed instructions.

Click **OK** to start Bundle adjustment. The processing time could be between a couple of minutes and up to several hours. It depends on the number of images and your CPU specifications (number of cores,...)

Note: Try to save your project after every operation (Bundle Adjustment, Orientation and Reconstruction). It can be done through *Toolbar Project > Save project*.

All images must be imported from a single folder to be processed as one project. Some of the drones start to write images in a second folder after 1000 created images and start once again with the image name 001.jpg (Phantom 4 Pro). In this case rename the images in second folder and copy all in one folder.





4.3.2.1 Bundle Adjustment Troubleshooting

If bundle adjusted set of images is beneath your expectations, here are some guidance, that might help.

In case, that matches were found on only half of the selected images (probably due to insufficient overlap, bad texture on images, high vegetation, images of water areas that are blurry) you may get better results by:

- recomputed Bundle Adjustment using *Incremental* mode. If results aren't better, proceed;
- go to 3Dproject folder, and inside the folder with images manually delete folder named "Features". Then increase Number of maximum detected features to 80.000 in 3Dsurvey -> Options. Results should be better.
- 3. If the results are still insufficient: repeat the step 2. and increase also Feature detection level from Normal too High or Ultra.



After computation, set all changed parameters back to default, because made changes increase processing time and are unnecessary for standard datasets.

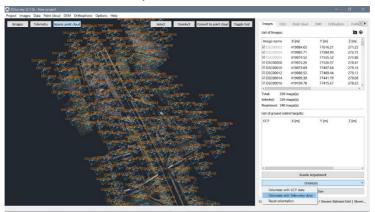
Default values of *Number of maximum detection features* is 40.000. *Feature detection level* is, by default set to *Normal*.

4.3.3 ORIENTATION (GEO-REFERENCING)

To geo-reference a project, proceed with **Orientation**. Three options are available depending on your data type.

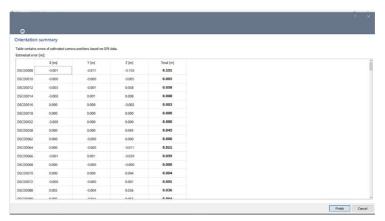
4.3.3.1 Orientate with telemetry data

In case of available and imported telemetry data, you can orientate images using just telemetry recordings, although it is recommended to use GCPs to achieve better accuracy.



To proceed, click **Orientate with telemetry data** and follow the pop-up wizard. First you inspect location of images in assigned coordinate system. Some rows might be seen in grey colour as image's telemetry has error. To proceed, click **Next**.

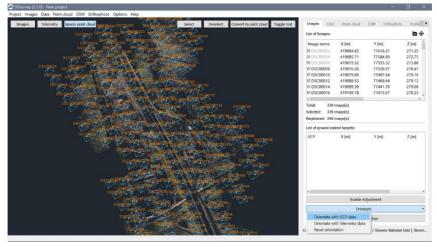




Orientation summary window presents residuals of adjusted camera positions on all three axis and its spatial value. Click **Finish** to complete orientation. If some images have errors in telemetry, they appear as unregistered in the **List of images** in **Working panel**.

4.3.3.2 Orientate with GCP

In most cases, especially when telemetry data cannot be measured, or it isn't accurate enough (most UAVs caries GPS antenna with 1.5m accuracy), block of images is orientated using ground control points (GCPs). Position of GCPs are measured using GNSS services or by total stations.



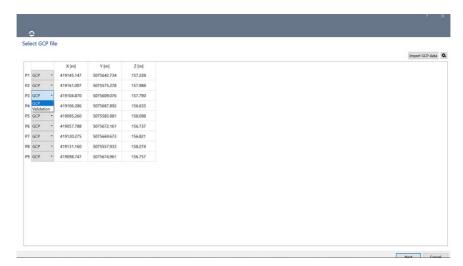


To proceed, click *Orientate with GCP* and follow the Orientation pop-up wizard: First, **select** *ground control points* (*.txt) file and click *next*. Continue by defining the purpose of GCP. Click on a tab after points name and select whether it is ground control (GCP) or validation point:

- GCP its reference coordinates are used in the orientation adjustment,
- Validation point excluded from orientation adjustment and used for quality assessment at the end of the process.

Further select GCP's coordinate system and also project coordinate system in which computed results and data will be transformed. Usually the GCP coordinate system is the same as project coordinate system which was defined after importing the images with telemetry.

In case you select the wrong coordinate system by importing the images into project, be reminded that you cannot change project coordinate system in this step. If you would like to correct this you need to start from the beginning (New project,...) or use the second option – select: Local coordinate system. Further information about coordinate systems can be found in chapter 4.3.1.2.

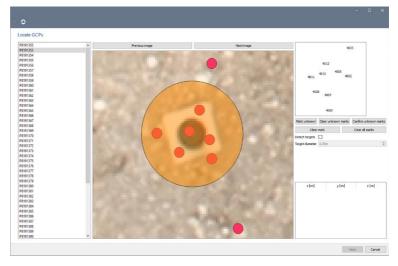






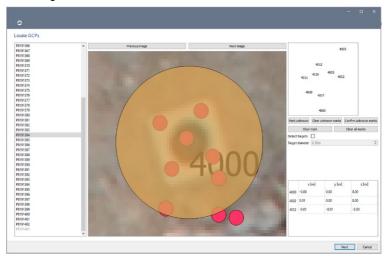
4.3.3.2.1 Automatic Orientation

On the left of the pop-up window, **select image** with GCP. Use mouse scroller to zoom in or out. For automatic orientation a minimum of 3 GCPs need to be manually marked. **Mark** GCP with a **right mouse click**. Marked position is coloured in orange and ascribed a "?" as its name is not defined.





Continue by **selecting additional two** GCPs from other segments of your project area. When you select the third ground control point the automatic recognition for all other GCPs will start. Three marked GCPs remain orange coloured while automatically found GCPs are now coloured green and the names of all GCPs are identified.



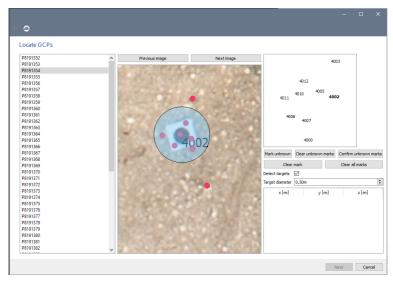
If you mismark the position of the ground control point, click *Clear all marks* button and reselect. Otherwise, click *Confirm unknown marks*. A useful tool for checking the appropriation of GCPs are their *residuals*. If displacements of selected points are high, you should check if you forgot to survey one of them (their position is missing in the file). Described method of <u>Automatic orientation</u> as furtherly described <u>Troubleshooting with orientation</u> in chapter <u>4.3.3.2.3</u> can be watched on web.

4.3.3.2.2 Semiautomatic orientation

Use GCP Map and select first the name of the ground control point on GCP map with **left mouse click** (for example 2009) and **mark** its position **on image** with **left mouse click**. Marked position is coloured blue, and its id appears.

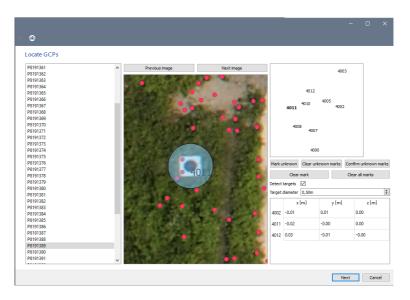


If you mismark the position, click *Clear mark* button and reselect. *Clear all marks* button clears all selected markers.

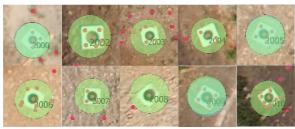


Select two more GCPs with a left mouse click (same as above). When you select the third ground control point the automatic recognition for all other GCPs will start. GCP are now coloured green and the names of all GCPs identified.





In the lower right corner appears the **residuals** of marked points. Residuals should be within 1m. Check if the automatic positions are calculated correctly GCPs need to be coloured green. If not, correct them with manual selection. First, select the name of GCP on GCP map, then show the exact position of GCP map on an image. Use left mouse click.



In case you are using **3Dsurcvey GCP targets** (black dot on white plate) be sure to select the "Detect targets" and set the correct diameter for the black dot. The default value for diameter is 0,27m (standard 3Dsurvey target). In case you are using some detail points for orientation as **manholes**, **road marks**, **building corners**... deselect "Detect targets" click **next** to **continue with orientation**.



In the next step, we can see automatic recognition of ground control points (in case of 3D survey targets). If the GCP is not recognised on a specific image, it is eliminated and coloured red. If you want to include this GCP into orientation, just double click the image and the red overlay will disappear. Several images can be marked or unmarked by ticking them in their upper left corner, where unticked square appears. Use Ctrl + a shortcut to select all target windows at once. You can also correct/realign the automatic measurement - left mouse click and move the centre of GCP to the green cross. Same approach can be used to correct the positions of GCPs that have been automatically detected but not measured perfectly because of the bad conditions during data acquisition.



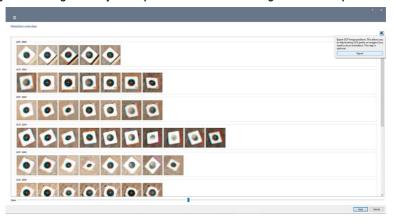
Faster approach for centring target is provided by the right mouse click. Put the mouse in the centre of the target and right mouse click for centration. Use mouse wheel or slide bar below to zoom in or out, which works for all target windows to realign easier.

If you using the same dataset in numerous computations/projects it can be useful to **export GCP image positions** of centred targets. Click **tooth wheel button** in the upper right corner and click **export**. In case if you calculate the

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same project again next time you don't need to select and correct the GCP targets once again but just import the saved file and go to next step.

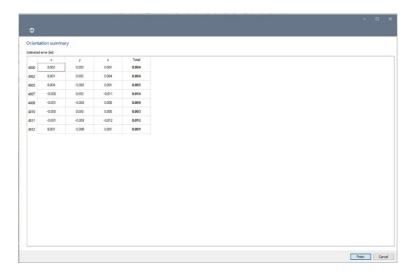


Click next, to observe orientation's accuracy.

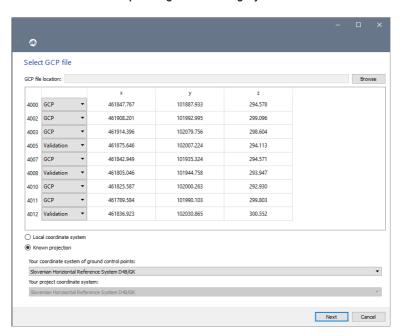
Orientation summary displays GCP errors – a sum of photogrammetric measurements and total station /GPS measurements. **Check GCPs accuracy** by **observing** their **residuals**. If residuals show high displacements of certain GCPs, go and recheck them. Click **back** button on the upper left corner and repeat the marking process. Click **Finish** when satisfied.

Save project.



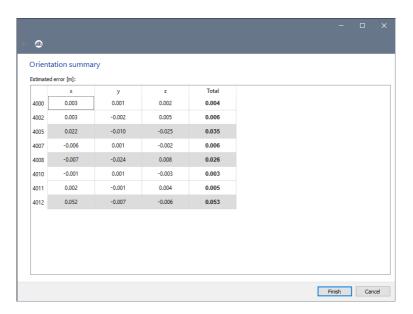


To check for independent accuracy quality, GCPs can be marked as Validation points that provide independent values to compare against GCP values. Points defined as Validation points get coloured grey.





Approach the orientation automatically or semi-automatically, as previously described.



In the *orientation summary*, you can observe adjusted accuracy presented with residuals. As four points are used as control points, orientation is computed based only on selected GCPs. As described above, residuals need to be low. Impact of their size can be observed on residuals of control points. In case of high values markings need to be corrected.

If no GCPs are used, your results will be similar to those presented on page 17.

4.3.3.2.3 Troubleshooting with orientation

In case if automatically selected point markers mismatch - residuals show large coordinate differences, that exceed 1m limitation for presentable final centring, as presented below - you should click *clear all marks* and proceed semiautomatic orientation, as described above. Keep in mind that selected points need to be observed - have observed coordinates written in *.txt. If at



the beginning of the orientation, at least one of selected markers is declared as control point, residuals will show misplacements. Described proceeding can be seen on web.



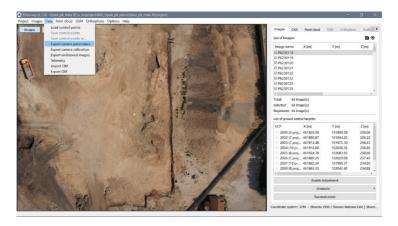
If you would like to continue with the standard work flow, go to chapter 4.3.5 and continue with the reconstruction. If you desire to see advance options, continue with chapter 4.3.4

4.3.4 ADVANCE FUNCTIONALITIES

4.3.4.1 Export camera parameters and undistorted images

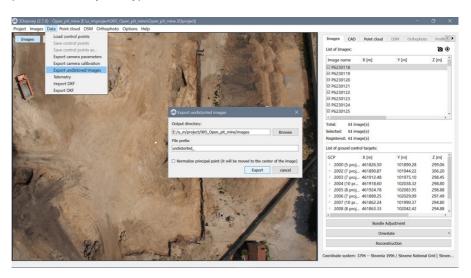
If you would like to import results of Bundle Adjustment in any other photogrammetric software, you need to export camera parameters and undistorted images. Click **Data**, chose **export camera parameters**. Type preferred name of exported document or chose predetermined one and confirm.





4.3.4.2 Export undistorted images

Click **Data** and chose **export undistorted images**. In the popup window assign path of directory and type in its name.



4.3.4.3 Export camera calibration

For proper photogrammetric use, it is necessary to have camera calibration data. Even when non-photogrammetric camera is being used, we can still provide reliable calibration details that can provide better results in further



projects. Knowing such parameters can fasten computation by 30% and tightens accuracy. For purpose of calibration ideal case has to be surveyed:

- Squarish area (~ 200 x 300m),
- at least 10 randomly scattered GCPs
- dataset should hold 100 300 images.

Calculate Bundle adjustment and Orientation based on GCP points and Export camera calibration. When using cameras (other than Phantom 4, 4 PRO, Mavic, ...) it is highly recommended to calibrate camera on your first project. Data must then be exported and reused in further projects. Every so often (minimal every 2 years), it is recommended to resurvey ideal case and export parameters as they might change in time.

Click **Data**, choose **export camera calibration**. You can choose preferred name and confirm.

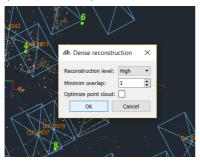


4.3.4 RECONSTRUCTION

When you are finished with orientation wizard the main window will appear. Next step is Reconstruction of dense point cloud. On image you can find the default



values for Reconstruction step which offers you the most effective calculation (time VS results).



Click OK to start reconstruction.

Continuing each reconstruction parameter is described for more information. **Reconstruction level** – there are 4 levels of reconstruction:

- Low,
- Medium,
- High,
- Extreme.

Minimal overlap - how many overlapping images to include in the point cloud reconstruction? The higher the overlap the higher the reliability of reconstructed point position. Minimum possible overleap is 2 (edges of surveyed area), the rate of its maximum depends on the set of images. **Default number is 3** and fits 99% of situations.

Optimise point cloud – in case of areas with good texture (open pit mines, garbage damps, rural areas, high vegetation areas...) there is no need to use the Optimize point cloud option – it would just increase the processing time. In case of areas with bad texture, such as asphalt areas, roads, vast parking grounds it is reasonable to use optimization option. Be aware that the use of optimisation:

- doubles the amount of time necessary for computation.
- is extremely RAM consuming process. It could happen pretty fast that you won't own sufficient level of RAM.

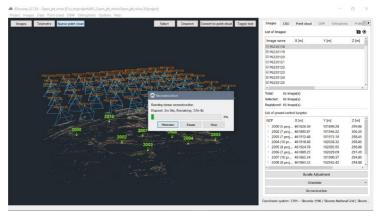


 Is recommended when you process data is set at up to 500 images per project.

Areas with good texture are ideal for computation without the use of optimization:

- set up by default
- two times faster than with optimization
- works also for big data sets. Up to 5000 images

As the reconstruction is in progress, the *Point cloud* tab unlocks in *Working panel*. In the *Viewer*, the progress bar displays the stage of completed processing. The predicted processing time is realistic after 7% of the process is computed.

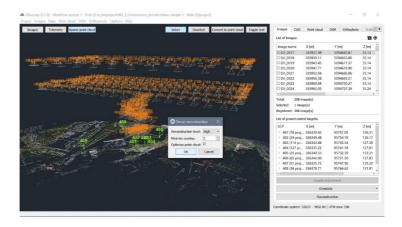


4.3.5.1 Reconstruction advances

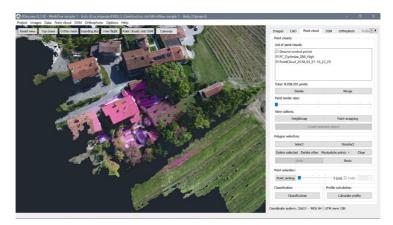
As described in 4.3.1 desired images can be chosen to reconstruct point cloud from. When all images are being orientated, point cloud can be reconstructed from only one selected image. Although you chose only one image, app runs reconstruction with all of overlapping images, with same detail of surface. Select preferred images and run reconstruction. You can use select or deselect button or manually deselect images from the image list. Further assign desired level of reconstruction, number of overlapping images and possibility of optimization.



This function allows you to process the dense reconstruction for one project in two pairs (1st half and 2nd half) or calculate the dense reconstruction with a different level – for example: centered area with Extreme level, less important area on High or Medium level.



To see the effect, we selected point cloud (coloured purple) reconstructed from one selected image with its overlapping images selected amongst point cloud reconstructed from entire batch of images. Although selected image was from the first row of images, about 700.000 points were reconstructed.





5. Modelling & Analysis

This part of 3D survey empowers you to:

- Continue from Processing and perform further modelling and analysis on reconstructed point cloud
- 2) Start your project here by loading third-party data (point clouds from other sources, LiDAR, las, dxf, etc.) and perform modelling and analysis.

As your data set is now externally orientated/geo-referenced – linked to surveyed area in chosen coordinate system and correctly scaled, further computation and modelling can take place. Here you can generate DSMs, DEMs, Orthophotos, measure anything in 2D or 3D, calculate volumes, generate reports, perform stockpile measurements, calculate profile lines, cross-sections, contour lines, export results to any CAD or GIS software.

5.1 POINT CLOUD MANIPULATION

The calculated point cloud will appear in Point Cloud tab. To manipulate the point cloud: use **left mouse click** to rate point cloud, **scroll** to zoom in or out, click and hold the **mouse scroller** to pan the model.

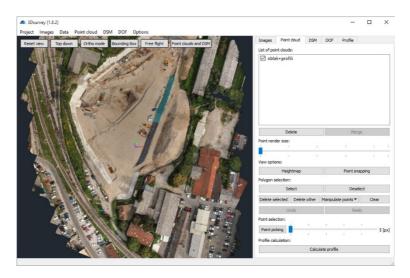






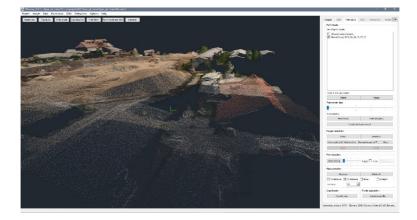
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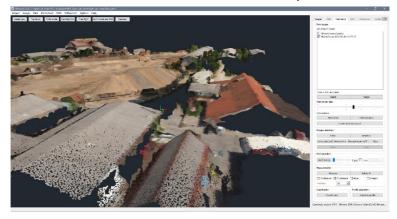
Point Cloud includes points from surface, buildings, vegetation and other objects. To generate a digital Orthophoto those obstructions need to be eliminated (select and delete) as to get a clear digital terrain model that serves as a basis for Orthophoto generation.

5.1.1 POINT RENDERING



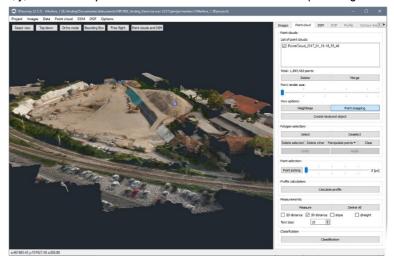


Use the **Point render size bar** to increase or decrease the points of Point Cloud.



5.1.2 POINT SNAPPING

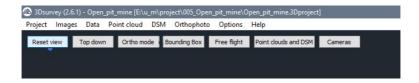
Use the **Point snapping** tool to inspect the 3D coordinates of the point cloud. The x, y, z values are presented in the live command window (lower right corner).



5.1.3 3Dsurvey VIEWER

Use Reset view to set the default view.



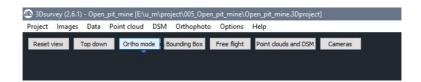


If you would like to view PC or DSM from nadir projection, click

Top down button. Model can now be rotated only around z-axis. The button is on as long as you do not switch it OFF.



If you would like to view the point cloud in orthogonal projection, you need to click **Ortho mode** button. Enabling the function results in the button colouring blue. To rotate around all axes, disable the Orto mode by selecting the function one more time.



If you would like to capture short movies from your 3D model with an external software, you can use **Free flight** function and smoothly fly around 3D model and objects. Use: **left mouse click + keyboard**. **A** to move left, **D** to move right, **W** to move forward, **S** to move backward, **F** to zoom in, **R** to zoom out, **V** to zoom in centre. **Scroll** to set vertical angle of view. To speed up the flaying press +, to reduce speed press -.





IF you wish to see PC and DSM at the same time, click **Point cloud & DSM** button. You can use this function in Point Cloud tab or DSM tab. This is a useful tool when you are working with Point Picking function.



Bounding Box - It is a useful tool for two reasons.

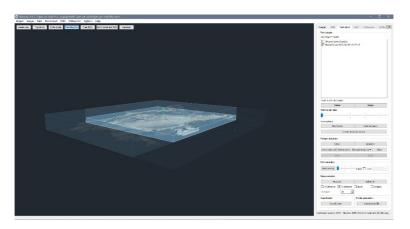
First, move sections freely left, right, up or down and the tool lets you easily inspect the data inside the box whilst ignoring everything outside your box selection.

Second, sliding 2 opposite Bounding Box panes together gives you a 3D profile of the surface model. To move through the 3D model press CTRL and left-click on the Bounding Box pane and you will be able to slide it in any direction and explore all the sections on the fly. Turning on the Height map displays the height differences even more clearly.

Use Bounding box in either point cloud tab or DSM tab.

It is possible to inspect the differences between several point clouds or surfaces, of course. For example, loading two-point clouds from the same area but measured at a different time and using Bounding Box will clearly show the difference. Apply different colours to surfaces for even more impressive results.







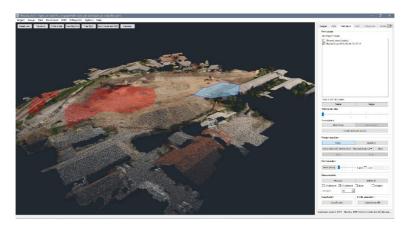
If you wish to see positions of cameras above the point cloud – reconstructed terrain, click **Cameras**.

5.1.4 POINT SELECTION

Click **Select** button and draw polygon around surveyed area using **left mouse click**. Finish the selection with **right mouse click**. Selected points will be coloured.

Use the Deselection function to ignore interested points from selection. Left mouse click to select, with right mouse click to finish selection. Use ESC on keyboard to cancel selection or click clear button.





5.1.5 DELETING POINTS

To delete points you need to select them first.



Delete selected points either by clicking **Delete selected** button or use delete button on keyboard.

Use *Delete other* function to delete everything that is not selected.

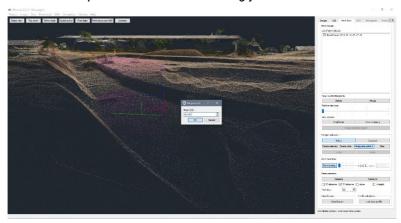
Use **Undo** or **Redo** function in case you change your mind.



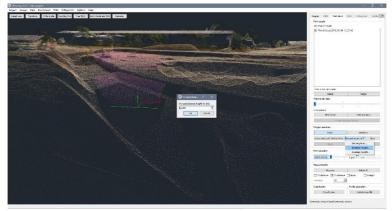
5.1.6 MANIPULATE POINTS

Popup *Manipulate points* enables you to set height, increase height or compute average height of selected area.

Select desired area and click **set height**. **Type** desired new **height** and click **OK**. The selected points are moved accordingly.

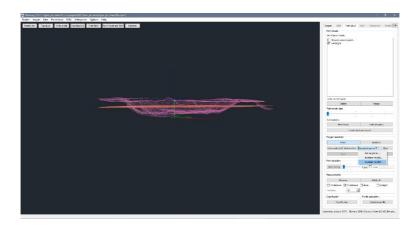


In case you would like to lower or raise the selected points use increase height function and type the desired value. For example, if you would like to lower the selected points for 0.5 meters type -0.5 m. If you would like to raise the selected point to specific value, type for example 1.5m and click OK.





You can also compute the average height of selected points. Firstly, select the area of interest, go to Manipulate points and click Average height.



5.1.7 CALCULATING PROFILE

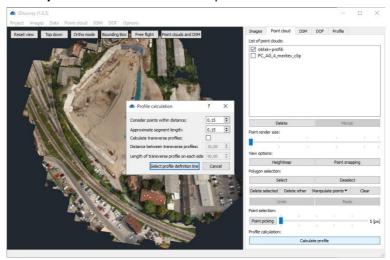
It is often required, especially on construction sites, to present profiles. Open Point cloud tab and click *Calculate profile*. Set the parameters in the pop-up:

- Consider point within distance <u>0.15</u> by default distance of buffer zone for snapping longitudinal profile to PC,
- Approximate segment length <u>0.15</u> by default approximate stationary distance of longitudinal profile,
- Calculate transverse profiles <u>disabled</u> by default to set computation of transverse profiles,
- Distance between transverse profiles <u>10</u> by default stationary distance on longitudinal profile to compute transverse profiles,
- Length of transverse profile on each side <u>10</u> by default width of either flank of transverse profile.

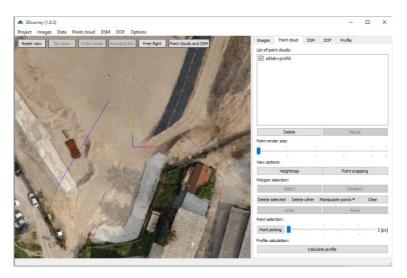


5.1.7.1 Longitudinal profile

To compute longitudinal profile, *Calculate transverse profiles* must be *disabled*. Click *Select profile definition line* to define profile.

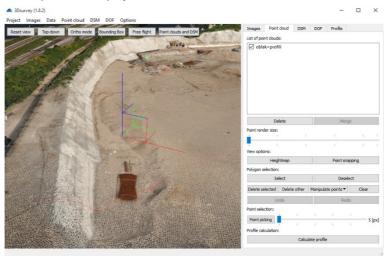


Left clicking the mouse, **draw polygon**, that defines longitudinal profile, ending it with a right mouse click.

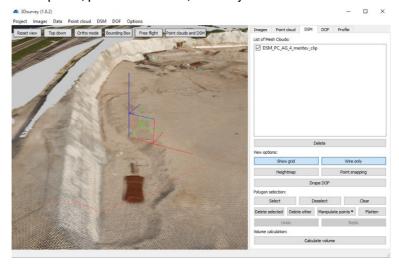




Calculated profile is displayed on the Point cloud in both 2D and 3D.



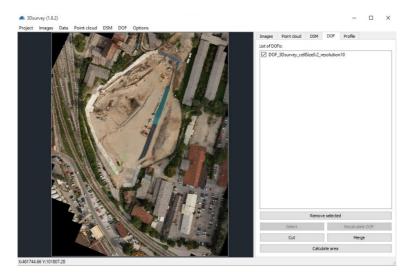
Calculated profile, presented on DSM, Wire only



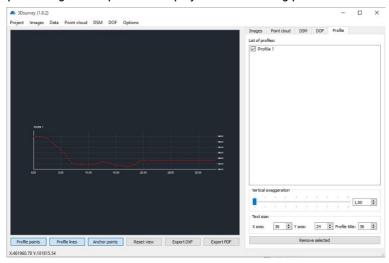
You can observe defined profile presented on DOF, and open Profile

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Computed longitudinal profile is displayed in the working panel.



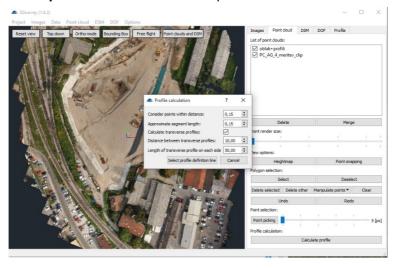
Save project.

5.1.7.2 Transverse profiles

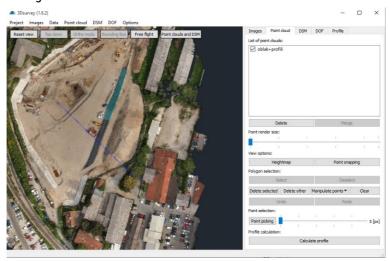
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To compute transverse profile, *Calculate transverse profiles* must be *enabled*. Click *Select profile definition line* to define profile.

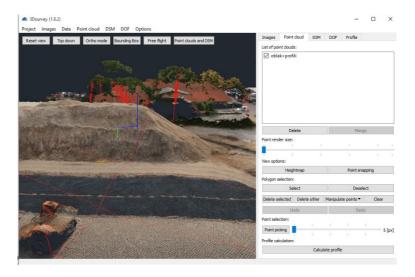


Left clicking the mouse, **draw polygon**, that defines longitudinal profile, ending it with a right mouse click.

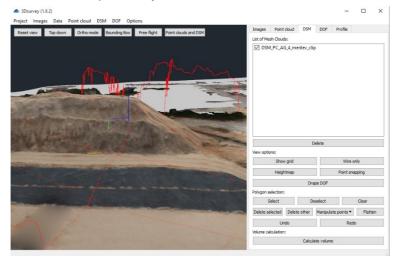


After right click, transversal profiles are drawn on top of longitudinal profile. As we used raw point cloud without removing obstructions, transverse profiles include objects and tree canopies.



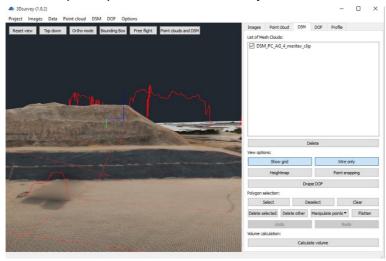


The same profile presented on top of DTM shows the shape of deleted objects on which transverse profiles lay on.

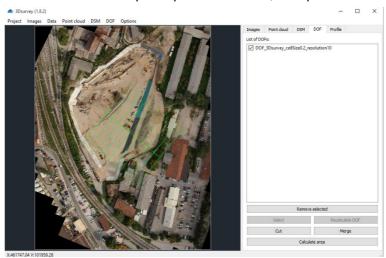




Calculated profile, presented on DTM, Wire only.

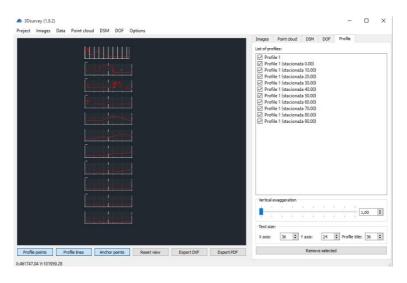


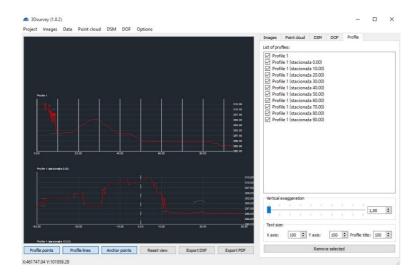
You can observe defined profile presented on DOF, and open Profile.



Transverse profiles are displayed below longitudinal profile, as displayed on the list in the **Working panel**. If you wish to view desired profile, you can zoom to it or click it on the list.







Using point clouds of two temporal measurements of construction site, you can observe reshaping of terrain, as presented below. Transverse profile shows two profile points, which present two measurements.

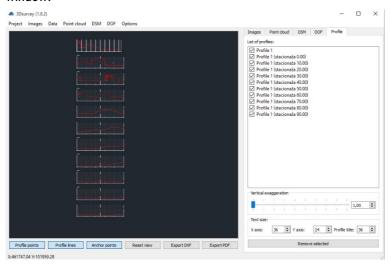
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5.1.7.3 Profile manipulation

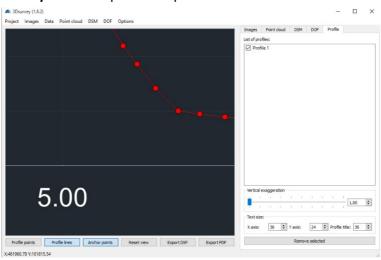
Profile manipulation buttons/tools are displayed on the bottom of the profile window.





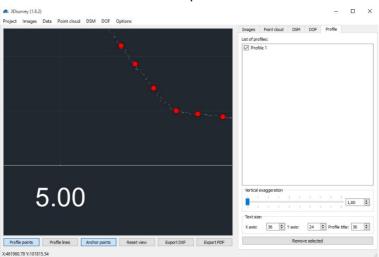
5.1.7.3.1 Profile points

Profile points show point cloud points detected in buffer zone.



5.1.7.3.2 Profile lines

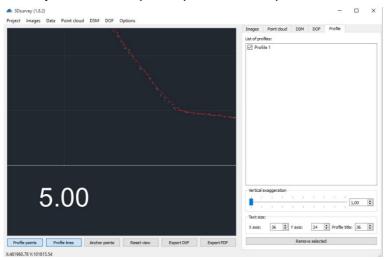
Profile lines show lines that define profile.





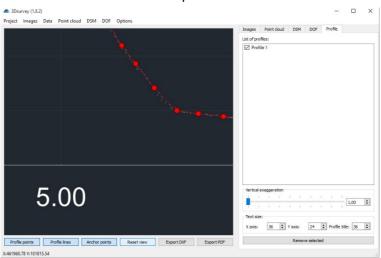
5.1.7.3.3 Anchor points

Anchor points show interpolated point that define profile line.



5.1.7.3.4 Reset view

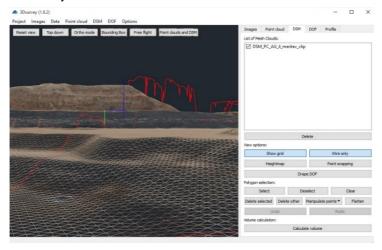
Reset view returns the view to all profiles.





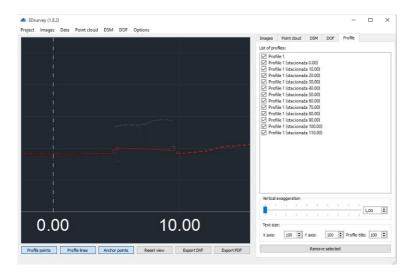
5.1.7.3.5 Reconnect

Reconnect, reconnects profile line between two selected anchor points. When you have a bump or undeleted object on top of the terrain, or if you would like to reshape it. Here we have transversal profile computed across construction machinery.

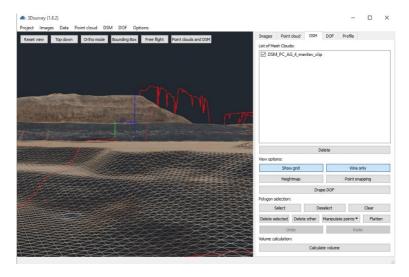


To shape it to preferable curve or level, zoom to transversal profile and click two external points that present the desired shape. Click *Reconnect* button and the transversal profile will be reshaped. As you see, points that define transverse profile remain present as profile points - the new shape is displayed below them.





Present new shape of transversal profile on top of wire only model. New shape is now suitable to shape of the DTM.



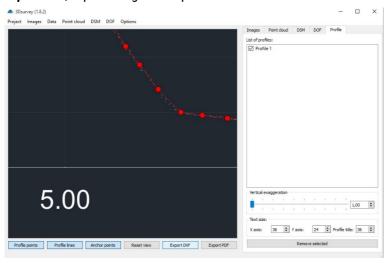


5.1.7.3.6 Delete

Delete deletes selected anchor point and automatically reconnects neighbouring points.

5.1.7.3.7 Export DXF

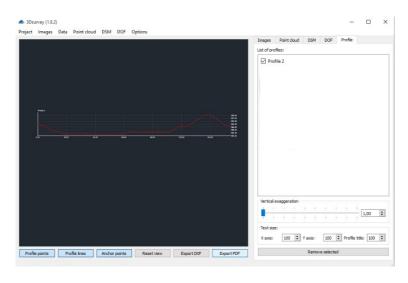
Export DXF, exports longitudinal profile to desired dxf file.



5.1.7.3.8 Export PDF

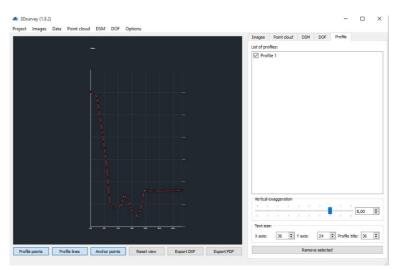
Export PDF, exports what you see in the window to pdf file.





5.1.7.3.9 Vertical exaggeration

Vertical exaggeration slide bar allows you to extend vertical scale of profile.





5.1.7.3.10 Text size

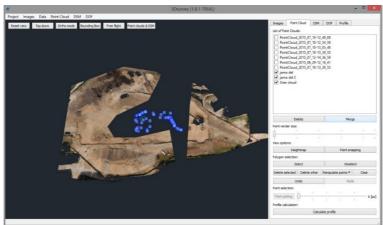
Profile title, allows you to change scale of profile title.

- Y Axis, allows you to change scale on longitudinal axis.
- X Axis, allows you to change scale on vertical axis.



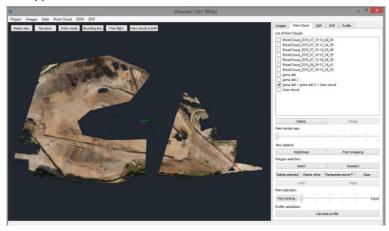
5.1.8 POINT CLOUD MERGE

If you have different point clouds you can merge them to a new point cloud. Both point clouds need to be selected. Click *Merge* button to merge them into one.



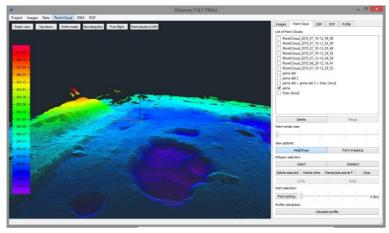


New PC appears



5.1.9 HEIGHT MAP

When processing Point clouds or DSMs, data can be viewed in hypsometric scale. When viewing desired data, click on *Height map* button to display digital elevation model with accompanying scale and colour legend.





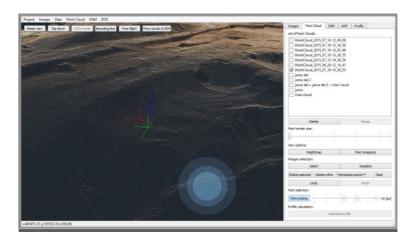
5.1.10 DELETE

Tick point cloud data that you would like to delete from application and click **delete** button.

5.1.11 POINT PICKING

Point picking is a function for point selection in order to compute point. Click **Point picking** button and **slide bar** to set circle radius. Set marker to desired position. **Left mouse click** creates a new point. Its position is computed based on neighbouring points (those covered with the marker circle).

Picture shows three samples of circle radius and their appearance on PC.



5.1.12 SAVING POINT CLOUDS

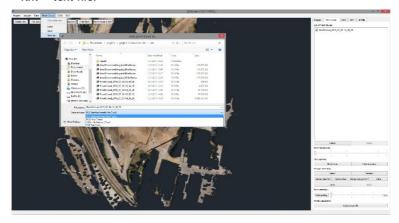
Save project. You can export PC to – Select from dropdown list **Point cloud** -> **Save as**:

- *.ply default Stanford mesh file
- *.koo file of coordinates,

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- *.las laser format file,
- *.txt text file.

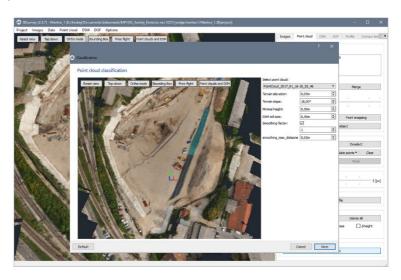


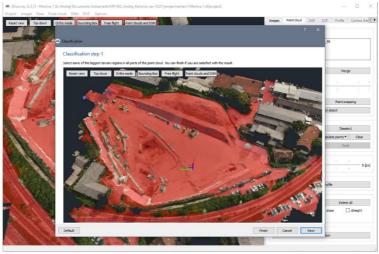
5.1.13 CLASSIFICATION

Click *Classification* button to classify terrain points. In the pop up window, you can adjust:

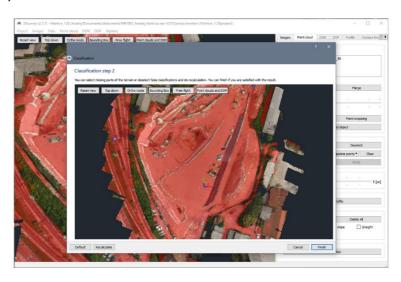
- terrain elevation -maximal sudden elevation change in terrain
- terrain slope -maximal angle between horizon and slope in degrees,
- minimal height minimal height of objects to be deleted,
- DSM cell size cell size of previously computed DSM,
- smoothing factor proportionate to smoothness of classified terrain
- smoothing maximum size maximal size of influential area.

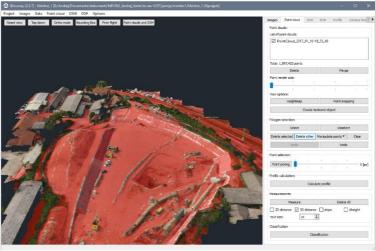




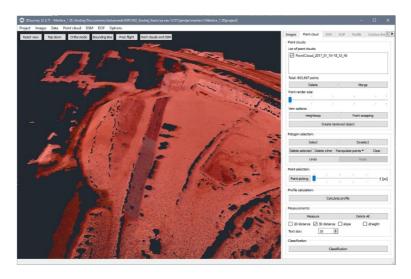








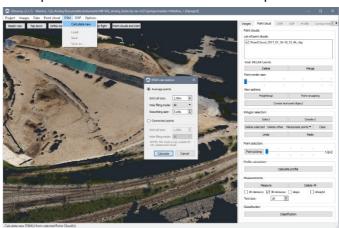




5.2 Digital surface model (DSM) manipulation

5.2.1 CALCULATE DIGITAL SURFACE MODEL

Select from dropdown list **DSM** -> **Calculate new** and set parameters.



For Orthophoto production the default parameters are:

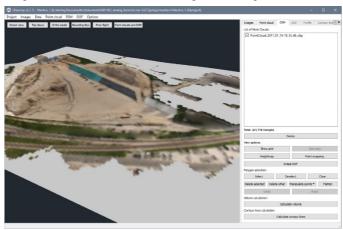


Grid cell size: 1.0m

Hole filling mode: All

• Smoothing size: 3 cells

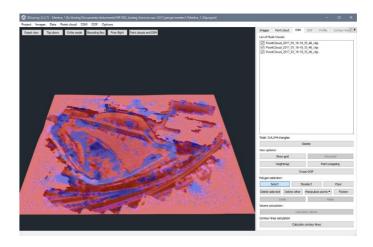
The lowest grid cell to be set is 20 cm and gives the highest detail.



Comparison of three DSMs shows that higher **smoothing size** gives smoothest surface. Selected models present the effect of three *smoothing sizes*:

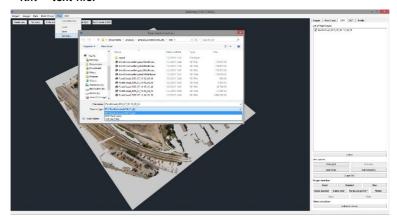
- 10 cells (red) the smoothest
- 5 cells (purple) semi-smooth
- 1 cells (blue) the least smooth.





You can export computed DSMs to – Select from dropdown list **Point cloud** -> **Save as**:

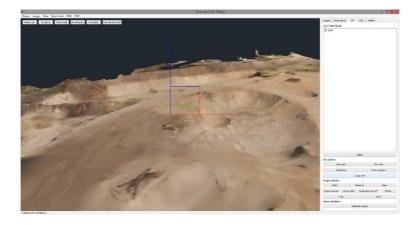
- *.ply default Stanford mesh file
- *.koo file of coordinates,
- *.txt text file.



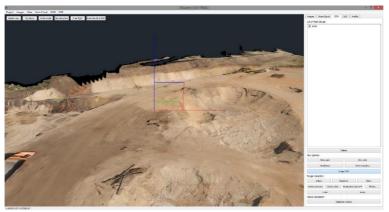
5.2.2 DRAPING DIGITAL ORTHOPHOTO

For better visualization and spatial presentation, DOF can be plastered on top of DSM. Open DOF tab, **select desired model** and click **Drape DOF**.





Desired DOF is displayed with a shape of DSM.



5.2.3 SHOW GRID

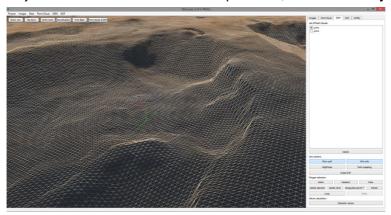
If you want to see wire surface of undraped DSM, click **Show grid** button.





5.2.4 WIRE ONLY

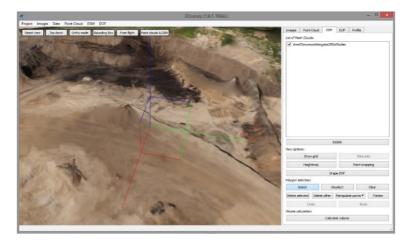
If you want to see wire of undraped DSM, click Wire only button.



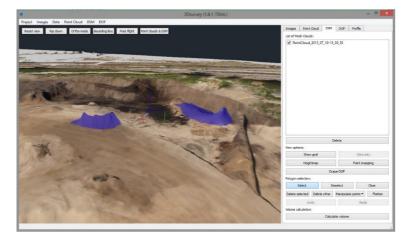
5.2.5 FLATTEN

Check for any objects that you would like to filter out of the model.



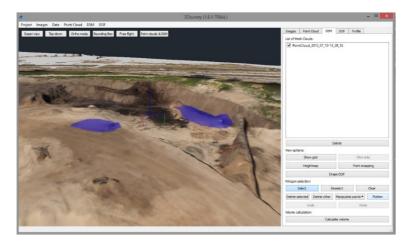


First **select** recognised masses extended to surrounding area with preferable height. To eliminate masses use function *Flatten*.



After Flatten:





5.2.6 VOLUME CALCULATION

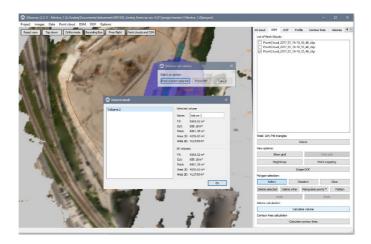
a) Volume calculation based on one surface: Calculate volume of material for single measurement - appropriate for the calculation of dredged material.

How?

Calculate or **load point cloud** of selected area -> Click **DSM** -> **Calculate New** and set DSM calculation parameters as shown in the image below.

Click **Select** button and select area for Volume calculation with left mouse click. To finish selection, click right mouse click. To calculate the volume on the selected area, click **Calculate volume**. Click **From current selection** to calculate volume of selected area. You can also choose **From DXF**. An *Import DXF file* window appears. Select path and import desired *.dxf file.



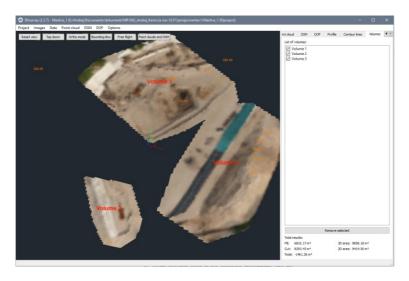


When *Calculate volume* is in process, the lower surface will be first generated based on points closer to the edges of selections! Displayed results present values for both current volume selection and a total sum of all volumes, consisting of:

- Fill volume of needed mass to fill holes beneath mean surface.
- Cut volume of mass above mean surface
- Total sum of filled and cut volume
- Are 3D three-dimensional area of selected surface
- Area 2D horizontal area of selected surface

Select **Volume** from the *Working panel* to observe all calculated volumes. Areas of volume calculation are presented as cuts from **draped DSM**, each with its own title. If **Contour lines** are visible, their cuts are also presented. You can **select**, deselect and **remove selected** volumes.

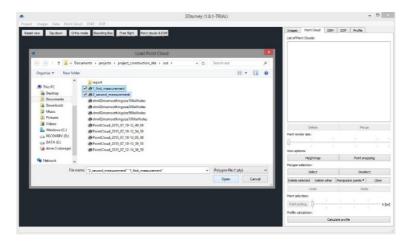




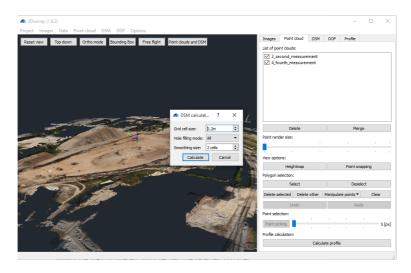
b) Volume calculation based on two consecutive measurements: Ideal for monitoring on construction site. Measure the volume difference between two consecutive measurements.

How?

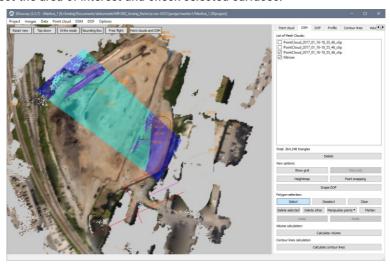
Calculate or **load two point clouds** the area you would like to calculate -> Click **DSM** -> **Calculate New** and set DSM calculation parameters as shown on the image below.





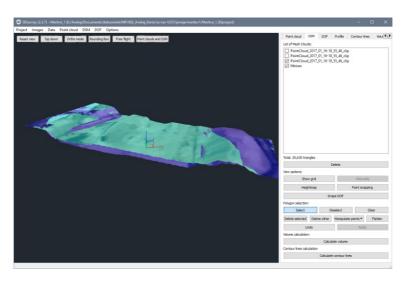


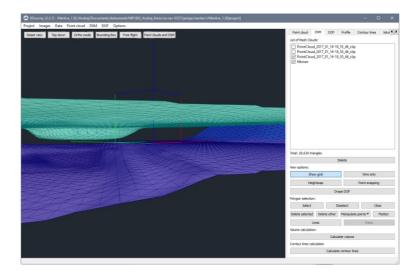
Select the area of interest and check selected surfaces.



Use **Delete other** button to selecte surfaces one above the other.

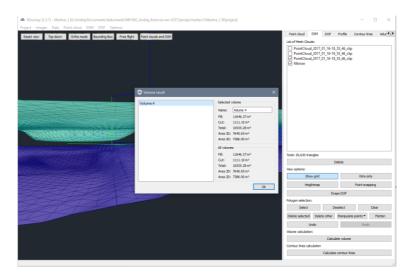






Click Calculate volume button and save results.





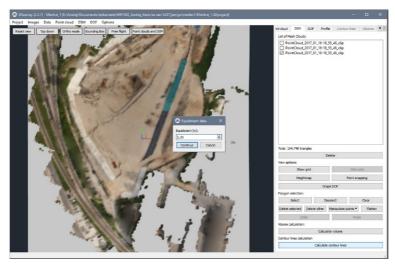
Presented results contain:

- Fill volume of added masses
- Cut volume of removed masses
- Total sum of filled and cut volume
- Area 3D three-dimensional area of selected surfaces
- Area 2D horizontal area of selected surfaces.

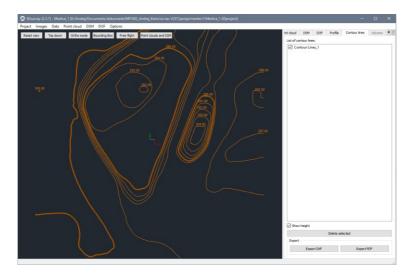
5.2.7 CALCULATE CONTOUR LINES

Click button *Calculate Contour lines*. Select desired equidistance in a pop-up window.





Calculated contour lines are displayed on the DSM. To export, go to *Contour lines* tab in *Working panel*.



Contour lines' height can be displayed by checking **Show height** box. To **export** contour lines, choose between *.**DXF** and *.**PDF** data types. A new window, titled Save contour lines as DXF or Save contour lines as PDF, pops up. Enter desired file name and click **save**. New window with exported file path pops up.





5.2.8 DELETE

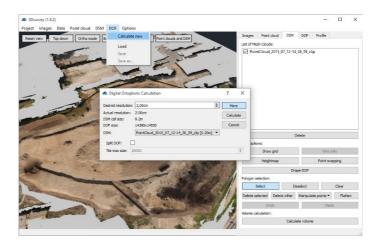
Tick DSM data, you would like to delete from application and click *delete* button.

5.3 Digital Orthophoto

5.3.1 DIGITAL ORTHOPHOTO CALCULATION

Select from dropdown list **DOF** -> **Calculate new**.

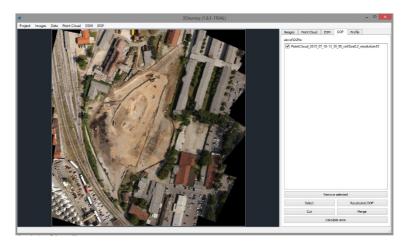




Set parameters in a *Digital Orthophoto Calculation* pop-up. First, set *Desired resolution*. As entered value may not be possible to compute, *Actual resolution* is presented below to inform you about the closest available result. It is an outcome of entered desired resolution and DSM cell size based on selected *DSM*. Click *more* to check the *split DOF* box. Default *Tile maximum size* is set to 20.000, meaning DOF will be split if it exceeds 20.000 pixels. When set, click *Calculate*.

Resolution parameter depends on flight height and size of grid cells. For example: If we set resolution parameter on 50 and use DSM grid size 1.00m this mean 50 pixels on 1.00 meter -> end result pixel size will be 1 cm (Orthophoto with resolution of 1 centimetre).

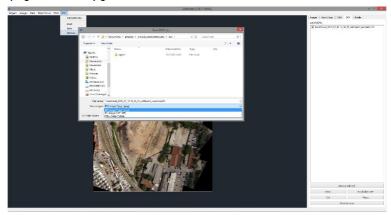




Save project. You can export computed DOF to - Select from dropdown list **DOF**

-> Save as:

- *.jpg *.jpeg + *.jgw
- *.tif *.tiff + *.tfw
- *.png + *.pgw



In addition to image file is appointed **text file** (*.jgw, *.tfw or *.pgw) that contains DOF geolocation and pixel size.



5.3.2 DIGITAL ORTHOPHOTO CORRECTIONS

To calculate digital Orthophoto follow steps from 1 to 11 (page 2-21). If you are not satisfied with results you can use correction tools to improve them. Because of low flight altitude, often artefacts on roofs of the houses will appear. You can easily correct them with Recalculation DOF tool.

Note: Simply loading your Orthophoto into 3D survey is not enough for Recalculate DOF function. To be able to recalculate, one needs to go through the whole process for DOF calculation.

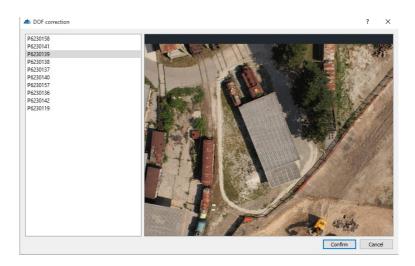
How?

When your Orthophoto is calculated, select the areas you would like to recalculate. Use **Select** button and select preferred images.

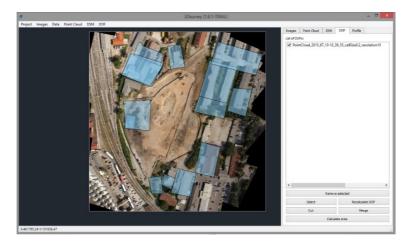


Wizard for image selection, with images of selected area will appear – **select** the **image** you would like to use for recalculation and click **Confirm**.





In case of additional artefacts repeat the same process to select all the areas. When you are finished with selecting click *Recalculate DOF* button.





Results:

Before





5.3.3 DOF CUT

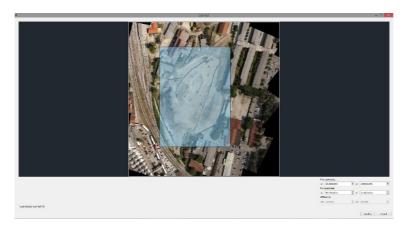
You can also cut certain area out of the DOF and save it as another DOF. Click **Cut**.



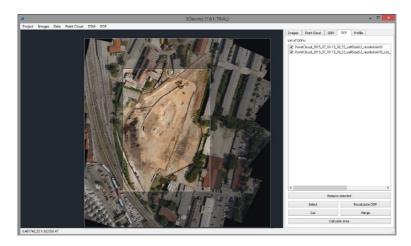
Select desired area. Left mouse click to start drawing rectangle and drag mouse to select rectangle over desired area. You can observe



coordinate values in left bottom corner and coordinate range of selected rectangle.



When area of interest is selected, click confirm to calculate DOF cut.



5.3.4 MERGE DOF

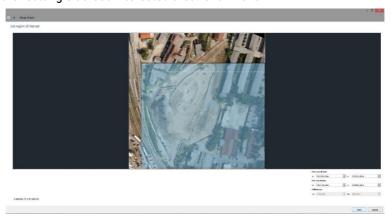
Merge DOF is a function that merges two DOFs that don't need to overlap or even converge.



Load or select desired DOFs and click Merge.



In a pop-up window, **select** area you want to merge. Left click on one end and set the rectangle across interested area. Click **Next**.

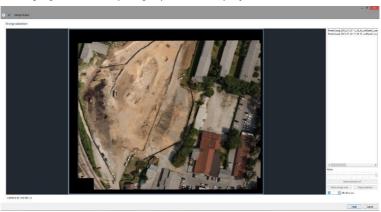


When you click on desired part on the right side, it pops on area of a new DOF. Another click shows what actually is on new DOF. You can select specific area of DOF part to be merged. Click *Paste selected DOF* button to paste part on new DOF. Clicking next DOF part on your list gives you an option to set its transparency by adjusting **Alpha**. **Select** desired area on the second part adjusting alpha shows merging boundaries. *Blending size* allows you to smooth edges between overlapping parts. When all parts are pasted, **click Finish**.





When merging ends, new (merged) DOF is displayed.

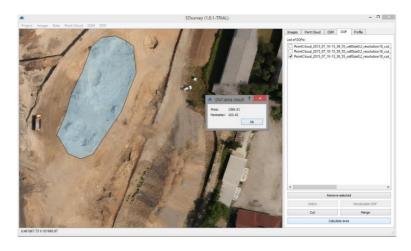


5.3.5 CALCULATE AREA

Click *Calculate area* button to compute area on DOF. Select area with polygon using left mouse click to determine points and right one to close it. DOF Area result, will popup:

- Area planimetric area of selected region,
- Perimeter circumference of selected region or length of polygon





5.3.6 DELETE

Tick DOF data, you would like to delete from application and click **delete button**.

5.4 CAD FUNCTIONALITIES

There comes a need, when you wish to draw on your point cloud. Draw objects entities that could further be used in Computer aided design (CAD) programs. In working panel tab CAD. At the top is a working panel tool bar, with edit tool, selecting tool, draw line tool and draw circle tool. You can check all layers in the layer list on working panel. Each layer has its attributes (whether it's selected, visible or locked), name, colour and line weight.

5.4.1 PREPARING LAYERS

As all CAD applications tent to use layers, it is useful, if you first make new layers, assign their colour and line width. Click + to make new layer. To change name, double click it. Pres enter to confirm. Double click on colour square, to change the colour.



Change line weight by double clicking on number. Type new weight. Those layers that are visible, have a scheme in the second row, as oppose to nonvisible ones. At the time, only one layer can be selected, in the second row is visible, as oppose to all the others. Third row shows whether layer is **locked** or **unlocked**. To change any of layers attributes, click on unwanted scheme in desired row of layer.



5.4.2 SELECT TOOL

Use **select** tool to select multiple drawn CAD objects. By selecting from left to right, you can select different points.

- when you draw selection from right to left, all objects, of which parts were inside selection are selected;
- when you draw selection from **left to right**, you will select only those objects, of which all parts are being selected.

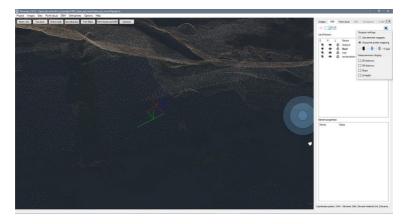
5.4.3 DRAW LINE

To draw set the desired layer and select **draw line** tool . Second, click on **snapper settings** to select type of snapping and **measurements display**. If you want to snap

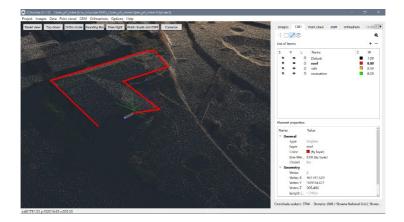


directly on point cloud point, select **Use element snapper**. This option supports also snapping on endpoints and midpoints on existing lines.

2nd option is to draw the line by creating new points – this option is useful in case you don't have a certain point cloud point to draw on – in this case **Use point picker snapping** and select desired radius of **point picker** to define the average height (at least one point of the point cloud needs to be in the blue circle) of the new point which will be created in the centre of the mouse cross.

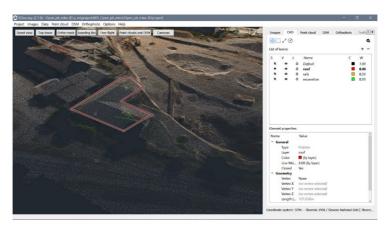


Start drawing lines, using *left mouse click*. If you misclicked use *backspace*, to delete last point. Abort drawing at any point with **escape** button. End drawing polygon of lines using *right mouse click*.



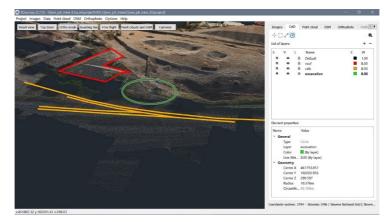


If you want to end drawing polygon on already drawn point, select to **use element snapper** an approach desired point with your cursor. As snapper is active, already drawn element/elements will mark. Click at desired point with left mouse click and continue to draw. You can change **snapper settings** while drawing CAD objects.



5.4.4 DRAW CIRCLE

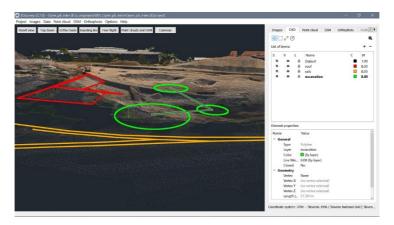
To draw a circle, select **draw circle** tool and desired layer. Left click circles base point, drag mouse to assign diameter, confirm with left mouse click. Use right *mouse click* as well as escape button to abort drawing.



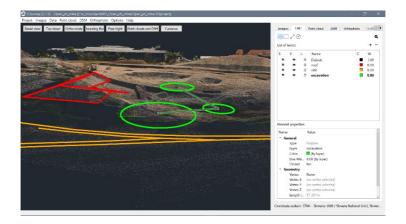


5.4.5 EDIT TOOL

To edit drowning, select **edit** tool — or use ESC button on keyboard and get close to desired objects. When marked, select it with *left mouse* click. You can move, redraw or delete selected points or objects.



All data of selected object is displayed in **Element properties** window of **working panel**. There you can change its **colour**, **line type** or **layer** by clicking on desired attribute and change it from available possibilities.



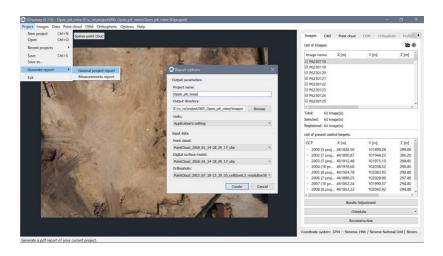


6. REPORTS

Generating a general project report and/or measurements report, is basically in a few clicks and the report is done. General report contains information about imported/processed images, geo-referencing, camera positions, flight characteristics, calculated accuracy, GCP positions, orthophotos, DSMs, error summary. With measurements report you get the ability to include all your calculated data, profile lines details, volume and stockpile measurements, and contour lines.

6.1 General report

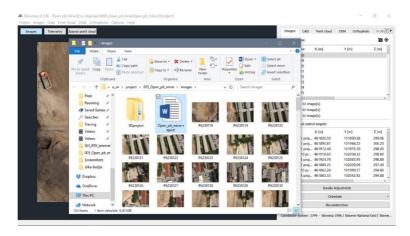
To create a general report, click **Project** - > **Generate report** - > **General report**.



Enter the document's name and select the data you want included in the report. If not, 3Dsurvey automatically selects top listed data from all working panel tabs.



After the report is generated, the folder with report file path pops up for you to verify the information. It is created in *.docx file which makes it easily customizable. Simply save it as pdf in your text editor if needed.



Here is a quick overview of a general project report.

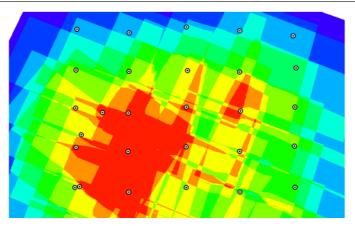
Project:	Me	eritve_1			
Date of capturing images	: 20	14-08-19			
Camera model		Resolution	Focal length	Sensor size	Pixel size
OLYMPUS IMAGING CORE	P. E-P2	4032 × 3024	17mm	17.3 × 13.0 mm	4.291µm
Orthophoto size:	203m x 3	258m	Pixel resolution:	0.022m	





Survey Data

Number of images:	52	Number of registered	51
		images:	
Flying altitude:	90.7m	Number of key points	3265
		per images / average:	
Ground resolution:	0.0220m	Georeferencing:	Yes



Ground Control Points

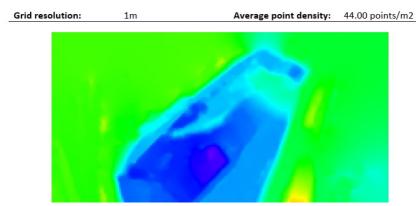






		Coordinates			Error	s [m]		Number of
Point ID	x	Y	Z	х	Υ	Z	3D	projections
4000	461847.767	101887.933	294.578	0.002	0.002	-0.001	0.004	7
4002	461908.201	101992.995	299.096	0.002	-0.001	0.010	0.010	6
4003	461914.396	102079.756	298.604	-	-	-	-	0
4005	461875.646	102007.224	294.113	0.004	0.002	0.002	0.005	8
4007	461842.949	101935.324	294.571	-0.007	0.004	-0.002	0.008	7
4008	461805.046	101944.758	293.947	0.002	-0.006	-0.002	0.007	9
4010	461825.587	102000.263	292.930	-0.005	0.001	-0.000	0.005	11
4011	461789.584	101990.103	299.803	-0.000	0.001	-0.002	0.002	8
4012	461836.923	102030.865	300.552	0.004	-0.003	-0.001	0.005	7

Digital Elevation Model



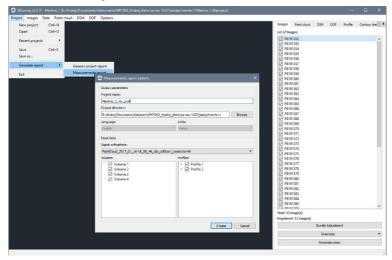
Processing Parameters

Bundle adjustment statistics	
Images	52
Registered images	51
Number of ground control	9
points	
3D tie points	39678
DN4C''	0.616437



6.2 Measurements report

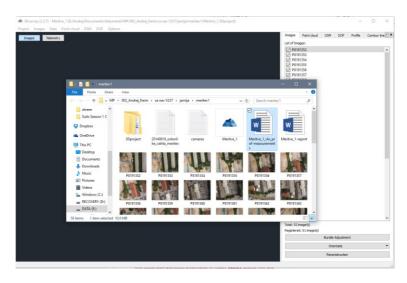
To create Measurements report, click **Project - > Generate report - > Measurements report**.



Enter the document's name and select the data you want to have included in the report. If not, 3D survey automatically selects top listed data from all working panel tabs.

After the report is generated, the folder with report file path pops up for you to verify the information. It is created in *.docx file which makes it easily customizable. Simply save it as pdf in your text editor if needed.





Here is a quick overview of a measurements report.

Volume

Name:	Volume 1		
Fill:	6660.52 m³	2D area:	4117.00 m ²
Cut:	659.18 m ³	3D area:	4356.65 m ²
Highest point:	304.29 m	Lowest point:	294.57 m









Profile line with transverse lines





Profile names:	Profile 1, Profile 2			
Lowest point:	293.763 m	Length of profile:	97.799 m	
Highest point:	305.154 m	XZ scale:	1:1	

Longitudal profiles - 2D break point coordinates	X	Y
T1 (Profile 1)	461886.625	101875.562
T2 (Profile 1)	461853.000	101942.453
T3 (Profile 1)	461842.062	101962.609
T1 (Profile 2)	461886.625	101875.562
T2 (Profile 2)	461853.000	101942.453
T3 (Profile 2)	461842.062	101962.609

Transverse profiles - 2D break point coordinates	Start X	Start Y	End X	End Y
Profile 1 (distance 0.00)	461841.969	101853.102	461931.281	101898.023
Profile 1 (distance 10.00)	461837.469	101862.039	461926.781	101906.961
Profile 2 (distance 10.00)	461837.469	101862.039	461926.781	101906.961
Profile 1 (distance 20.00)	461832.969	101870.969	461922.281	101915.891
Profile 1 (distance 30.00)	461828.500	101879.906	461917.812	101924.828
Profile 2 (distance 30.00)	461828.500	101879.906	461917.812	101924.828
Profile 1 (distance 40.00)	461824.000	101888.836	461913.312	101933.758
Profile 1 (distance 60.00)	461815.000	101906.703	461904.312	101951.625

