

TOPODRONE DJI MAVIC 2 PRO L1/L2 PPK

USER MANUAL





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1. Drone preparation

1.1 First steps before work

DJI Mavic 2 Pro Topodrone PPK – is a ready-to-fly geodetic survey solution which is based on DJI Mavic 2 Pro drone. It is strongly recommended to learn DJI M2P manual first, you can find it on the official web-site: <u>https://www.dji.com/uk/mavic-2/info#downloads</u>

Correct preparation of the drone means following exact rules to ensure flight safety and the best orthophoto or 3D-model quality. Flight safety – is the main basis of all our solution.

- 1. <u>Checking.</u> All components of the drone must be in a condition: no damages, cracks or malfunctions. It is needed to carefully inspect blades, motormounts, motors, arms, gimbal, micro-sd cards, cables and connectors, especially if you had drone in a public use. Always check your DJI Mavic 2 Pro Topodrone PPK before large orders and far business trips.
- 2. <u>Charging.</u> You should charge all batteries of the drone, remote controller (RC) and mobile device up to 100%. Never use DJI Intelligent Battery which is charged lower than 90%, especially if battery has started its storage discharging. It can cause premature termination of the flight mission.
- 3. <u>Exploring.</u> Before move to the working area, explore locality in a on-line geo-services like <u>DJI GEO</u>, <u>AirMap</u>, and <u>PilotHub</u>, to provide yourself more knowledge about places and objects located nearby. It is not allowed to fly in No-Fly-Zones: airports, prisons, sports stadiums. Military bases, state institutions, objects of strategic importance (CHP, hydroelectric power plants, nuclear power plants, etc.) are particularly dangerous, but they are not marked at GEO-services. Electricity transmission lines, located at the place you need to capture, can cause radio and magnetic interference during the flight.



- 4. <u>Setting.</u> In the DJI Go 4¹ App set all parameters for comfort flying in a manual mode:
 - 1. Distance limit "turn off" value is recommended
 - 2. Maximum Flight Altitude -500 meters² value is recommended
 - 3. Return to home altitude 100 meters or higher value is recommended. Anyway it changes during the mission planning in the other apps.
 - 4. RC MODE settings changes axes of the sticks, value 2 is strongly recommended
 - 5. EXP tuning provides you control drone more accurate, 0.10 value is recommended
 - 6. RC signal lost action which drone would make if lost RC signal. Value "Return to home" is recommended
 - 7. Low battery warning set at the minimum, 20% value is recommended³

NOTICE 1. DJI Go 4 App is the basic application for DJI Drones. You could not set several parameters via other apps. It is recommended to make manual flights using DJI Go 4 App.

NOTICE 2. In some countries maximum allowed flight altitude for UAV is 120 meters. Setting 500 meters value in maximum flight altitude menu provide drone follow the terrain, flies higher than 120 meters from the altitude of home point, but not from the terrain.

NOTICE 3. If area of photographing is located far from you (more than 1 km), increase this value to 30% NOTICE 4. Camera settings described in paragraph 1.3 of this manual.



1.2 Compass calibration.

As the basic model, DJI Mavic 2 Pro Topodrone PPK needs the compass calibration (CC) each time you move to the new location. CC helps your drone to adapt to local magnetic field lines. During CC, accelerometer and compass makes two rotations in different axes. After that, drone makes adjustment between values of each sensors. To make correct CC follow next steps:

- 1. CC makes directly before flight at the open outdoor area. Making CC indoor is useless
- 2. Remove gimbal holder and unfold drone's arms.
- 3. Turn on the drone and RC, insert and plug the mobile device.
- 4. Make sure, there are no large metal constructions or magnetic fields in a 50 meters.
- 5. Enter drone into CC mode. At least there are two ways:
- a) In the DJI Go 4 app open MC Settings / Advanced settings / Sensors state / Compass / Calibrate compass / OK
- b) At the right side of RC, rapidly move the slider to S and T positions not less than 4 times.
- 6. Ensure that rear LEDs of the drone lights solid yellow.
- 7. Put RC in the left arm and take drone from the in your right arm. Hold drone from the top under the battery. Do not change the orientation of the drone!
- 8. Rotate drone to the left side (counter-clock wise) in 380 degrees (a bit more than 360 degrees). Stop when the rear LEDs will change color from solid yellow to solid green.
- 9. Change orientation of the drone, turning it in 90 degrees in a longitudinal axis.
- 10. Rotate drone to the left side (counter-clock wise) in 380 degrees (a bit more than 360 degrees). Stop when the rear LEDs will change color from solid green to blinking green.
- 11. If using 5a way entering CC mode, turn the Flight Mode slider to P (central position). This is especially important!
- 12. Compass calibration now is complete.

Before and after CC you can check the value of magnetic interference in the DJI Go 4 App - it should be at the green zone after CC. If the app

notice you compass calibration failed (rear LEDs blinks red rapidly) – recalibrate compass at another place nearby.

Notice 1: no magnetic or ferromagnetic objects on the body of pilot are allowed. For example: massive jewelry, metal inserts or magnets in the end of the iPad tablet etc. If you have some of these objects, even after successful CC, your drone will have "Compass Error" after taking off.

Notice 2: CC increase flight stability of the drone during the flight. But compass error can appear even after absolutely correct calibration. It usually caused by different external interferences such are metal objects, large antennas, electricity transmission lines (ETL)







1.3.Camera calibration and settings

Before the shooting process will be started, you should calibrate focus of your DJI Mavic 2 Pro PPK camera and set optimal image settings. It is recommended to use next order.

- 1. You should determine drone's working altitude. This value depends on many factors: scale of the final orthophoto map, properties of the lens, height of the obstacles, features of relief, etc. Usually, working altitude is from 60 to 12 meters.
- Set correct image ratio. Go to the image menu, tap the second tab. Use the Image Ratio 3:2 value, it allows to use all square of camera's matrix. Do not use 16:9 Ratio! Check another values of this menu – all defaults.



- 3. Lift off the drone to the working altitude and move gimbal to the 90 degrees (nadir). Ensure that focusing method now is in the AF value. Then tap to the center of the screen to let the camera focusing at the surface. After that change focusing method in the MF value manual focus scale will appear. Do not touch it! Now drone's camera is focused at the selected height value. It will not change in the future.
- 4. Now it's time to set the best camera settings. All parameters are at auto as default. In this case, drone will change image brightness, smoothness during the flight. But this way is bad for triangulation image processing: key points at different images will be different. To get the best image quality during the flight it is strongly recommended to set image params as follows:

ISO: from <u>100</u> to <u>200</u>. Upper values increase image noise, and decrease ortophoto map quality **Aperture:** from <u>2.8</u> to <u>4</u>. Upper values decrease stream of light, so images will be darker **Shutter:** from <u>1/1600</u> to <u>1/640</u>. Upper values increase image motion blur, lower ones does not allow the camera to get enough light, so images will be darker and more discolored.







1.4. IMU calibration and settings

IMU calibration needs very rarely. However some things can affect the sensor states: falls and bumps, temperature changes and long stand by time. Because of use the additional module upper the shell of DJI Mavic 2 PPK, the process of IMU calibration is

not the same as the default. To calibrate IMU you need to do next:

- 1. Set up the props to motors
- 2. Fold the arms like at photo
- 3. Prepare your table or another flat surface: the horizon should be aligned to the bubble level
- 4. Start the IMU calibration process and make steps 1-4 as they are.
- 5. At step 5 you shoul place the drone head over heels. Use the edge of table to make this step. Place your drone like at the photo below





- 6. When the step 5 is complete, rotate drone and place it normally
- 7. IMU calibration now is complete



1.5.GNSS settings

Appearance and description of elements:



Green LED. Indicate power supply module. Blue LED. Indicate quality of receive GNSS signal.

State	Description
No flash	PDOP>10
Slow blink	3 <pdop<10< td=""></pdop<10<>
Fast blink	2 <pdop<3< td=""></pdop<3<>
Solid blue	PDOP<2

Orange LED. Indicate recording data to a flash card. When recording in progress, LED rapidly blink. Each blink means that 4 kB data is recording.

Red LED. Indicate, if system have error. In case of error, check flash card. If change, or install/format microSD card not solved a problem, contact support.

Plug in microSD card. Dual frequency (L1/L2) antenna



2. GNSS DATA POST PROCESSING AND IMAGES GEOTAGGING

2.1 Data preparation

Remove SD card with images from a drone and copy photos to your computer. Divide a whole images dataset to separate flights and store photos from each mission in separate folders. For example, Flight 1, Flight 2 etc. NOTICE. *Do not delete any images*.

Remove SD card from GNSS receiver installed on the drone and copy ubx files to your computer to a folder ROVER (for example).

Download GNSS static logs from a base station and convert them to Rinex format. Copy Rinex files to a folder BASE (for example)

Mesure coordinates of ground control points (GCPs) and coordinates of the base station.

NOTICE. Coordinates of the base station should be in Latitude, Longitude, Ellipsoid high, WGS 84 coordinate system.

2.2 GNSS data post processing

Step 1. Run TOPOSETTER 2.0 application

TopoSetter 2.0			_ □
1. Path to the photos from t	he rover:	Logs:	<u>Open log file</u>
•			
2. Path to the ubx file from	the rover:		
3.Specify the path to the ba			
4. Base coordinates:			
Degree d°m's"			
Latitude -			
	degree		
Longitude -	degree		
Elevation (meters) -			
5. Base antenna height:	0.000 🚖 meters		
6. Rover antenna offset:			
Height -	0.00 🖨 meters		
Offset forward/backward -	0.00 🖨 meters		
Offset left/right -	0,00 🔹 meters		
7. Output folder:			
Processing steps:			
1. Z Data conversion			
2. GNSS data postproc	Start		
3. Images matching an	d geotegging		
Advanced settings	Stop		
in the ball ball and ballings	Stop		



Step 2. Select folder with photos

TopoSetter 2.0			- 🗆 X
1. Path to the photos from	the over	Logs:	Open log file
E:\TUTORIAL\FLIGHT 1 2. Path to the ubx file from		26.11.2019 13:50:16: Read metadata from photos 26.11.2019 13:50:26: Done! 26.11.2019 13:50:26: Found 397 photos	
2. Path to the ubx file from	the rover:		
3.Specify the path to the b			
4. Base coordinates:			
Degree d°m´s*			
Latitude -	degree		
Longitude -	degree		
Elevation (meters) -			
5. Base antenna height:	0,000 🛓 meters		
6. Rover antenna offset:			
Height -	0.00 🚖 meters		
Offset forward/backward -	0.00 🖨 meters		
Offset left/right -	0.00 🖨 meters		
7. Output folder:			
E:\TUTORIAL\FLIGHT 1\Output	· ···		
Processing steps:			
 Data conversion GNSS data postproc 	cersing		
3. Images matching an	Start		
Advanced settings	Stop		
		120-11-2013-13-34-01. FUERD 337 DR808	



Step 3. Select UBX file from a drone

🗮 TopoSetter 2.0			- 🗆 X
		Logs:	Open log file
1. Path to the photos from t	the rover:	26.11.2019 13:50:16: Read metadata from photos	
E:\TUTORIAL\FLIGHT 1		26.11.2019 13:50:26: Done! 26.11.2019 13:50:26: Found 397 photos	
2. Path to the ubx file from			
E:\TUTORIAL\ROVER\19-09-27	7\14-40-32.ubx	₽	
3. Specify the path to the ba	ase station data file:		
4. Base coordinates:			
Degree d°m′s*			
Latitude -	degree		
Longitude -	degree		
Elevation (meters) -			
5. Base antenna height:	0,000 🔹 meters		
6. Rover antenna offset:			
Height -	0.00 🚖 meters		
Offset forward/backward -	0.00 🖨 meters		
Offset left/right -	0,00 🗭 meters		
7. Output folder:			
E:\TUTORIAL\FLIGHT 1\Output			
Processing steps:			
1. 🗹 Data conversion			
2. 🗹 GNSS data postprod			
3. V Images matching an	nd geotegging		
Advanced settings	Stop		
_			



Step 4. Select Rinex or UBX file from a base station

1. Path to the photos from the rover: Exit UTORIAL/FLIGHT 1	🖆 TopoSetter 2.0	– 🗆 X
ENTUTORIALISELIGHT 1 2. Path to the ubx file from the rover: ENTUTORIALISEVEN190927144702x 3.Specify the path to the base station data file: ENTUTORIALISENT Cargere dmisi Lattude - degree Bevation (meters) - 5. Base antenna height: Offset forward/backward - 0.00 © meters 7. Output folder: ENTUTORIALISELIGHT I Notated Processing steps: 1. Data conversion 2. GINSS data postprocessing		Logs: Open log file
2. Path to the ubx file from the rover: ENTUTORIAL/ROVER/19-09-27/14-40-32 ubx 3. Specify the path to the base station data file: ENTUTORIAL/BASE/raw_20190927/1437.ubx 4. Base coordinates: Degree dm's' Lattude - degree Longtude - degree Elevation (meters) - 5. Base antenna height: 0.00 meters 6. Rover antenna offset: Height - 0.00 meters Offset forward/backward - 0.00 meters 7. Output folder: ENTUTORIAL/RUGHT No.teput Processing steps: 1. Data conversion 2. GNSS data postprocessing		26.11.2019 13:50:16: Read metadata from photos
ENTUTORIALNROVER1999-27/144032.ubx		26.11.2019 13:50:26: Found 397 photos
3.Specify the path to the base station data file: EXTUTORIALNBASE/vaw_201909271437.ubx 4.Base coordinates: Degree dm's' Lattude		
EXTUTORIAL/BASE/vaw_201909271437.ubx 4. Base coordinates: □ Degree d'm's* Latitude - Latitude - Longitude - degree Bevation (meters) - 5. Base antenna height: 0.00 € meters Offset forward/backward - 0.00 € meters Offset left/right - 0.00 € meters Offset left/right - 0.00 € meters		
4. Base coordinates: Degree Lattude - Lattude - Longitude - degree Bevation (meters) - 5. Base antenna height: 0.000 ⊕ meters 6. Rover antenna offset: Height - 0.00 ⊕ meters Offset forward/backward - 0.00 ⊕ meters Offset left/right - 0.00 ⊕ meters 7. Output folder: Processing steps: 1. < Data conversion 2. < GNSS data postprocessing		
Degree d'm's" Lattude - degree Longitude - degree Bevation (meters) -		
Latitude - degree Longitude - degree Elevation (meters)		
Longitude - Bevation (meters) - Elevation (meters) - 5. Base antenna height: 0.000 meters 6. Rover antenna offset: Height - 0.00 meters Offset forward/backward - 0.00 meters Offset left/right - 0.00 meters 0.00 meters Processing steps: 1. Data conversion 2. GNSS data postprocessing	Degree d°m's	
Bevation (meters) - 5. Base antenna height: 0.000 ★ meters 6. Rover antenna offset: Height - 0.00 ★ meters Offset forward/backward - 0.00 ★ meters Offset left/right - 0.00 ★ meters 7. Output folder: Processing steps: 1. ○ Data conversion 2. ○ GNSS data postprocessing Stat	Latitude - degree	
Bevation (meters) · 5. Base antenna height: 0.00 meters 6. Rover antenna offset: Height · 0.00 meters Offset forward/backward · 0.00 meters Offset left/right · 0.00 meters	Longitude - degree	
5. Base antenna height: 0.000 ♀ meters 6. Rover antenna offset: Height - 0.00 ♀ meters Offset forward/backward - 0.00 ♀ meters Offset left/right - 0.00 ♀ meters Offset left/right - 0.00 ♀ meters 7. Output folder: Processing steps: 1. ○ Data conversion 2. ○ GNSS data postprocessing		
6. Rover antenna offset: Height - 0.00		
Height - 0.00 ♀ meters Offset forward/backward - 0.00 ♀ meters Offset left/right - 0.00 ♀ meters 7. Output folder: ENTUTORIALNELIGHT NOutput Processing steps: 1. ☑ Data conversion Start	5. Base antenna height: 0.000 🚖 meters	
Offset forward/backward - 0,00	6. Rover antenna offset:	
Offset left/right - 0.00	Height - 0.00 🚖 meters	
Offset left/right - 0.00 meters 7. Output folder: ENTUTORIALNELIGHT 1NOutput Processing steps: 1. ✓ Data conversion Start	Offset forward/backward - 0.00 🗣 meters	
ENTUTORIAL\FLIGHT 1\Output Processing steps: 1. Data conversion 2. GNSS data postprocessing Start		
Processing steps: 1. Data conversion 2. GNSS data postprocessing Start	7. Output folder:	
1. ✓ Data conversion 2. ✓ GNSS data postprocessing	E:\TUTORIAL\FLIGHT 1\Output	
2. GNSS data postprocessing	Processing steps:	
Start	1. V Data conversion	
Start	2. GNSS data postprocessing	
	Start	
Advanced settings Stop	Advanced settings	
oup oup	July Stop	



Step 5. Impute coordinates of the base station in WGS 84. Define antenna offset for a drone.

TopoSetter 2.0			– 🗆 X
1. Path to the photos from the rover:		Logs:	Open log file
E:\TUTORIAL\FLIGHT 1		26.11.2019 13:50:16: Read metadata from photos 26.11.2019 13:50:26: Done!	
2. Path to the ubx file from the rover:		26.11.2019 13:50:26: Found 397 photos	
E:\TUTORIAL\ROVER\19-09-27\14-40-32.ubx			
3.Specify the path to the base station data file:			
E:\TUTORIAL\BASE\raw_201909271437.ubx			
4. Base coordinates:			
Degree d°m's*			
Latitude - 36.523717043 degree			
Longitude4.663284915 degree			
Elevation (meters) - 152.6403			
5. Base antenna height: 0.000 + meters			
6. Rover antenna offset:			
Height - 0,07 🖨 meters			
Offset forward/backward0.02 💭 meters			
Offset left/right - 0,00 🖨 meters			
7. Output folder:			
E:\TUTORIAL\FLIGHT 1\Output			
Processing steps:			
1. 🗹 Data conversion			
2. GNSS data postprocessing	Start		
3. Images matching and geotegging	əldil		
Advanced activities	Chan		
Advanced settings	Stop		
			0

NOTICE.

FOR DJI MAVIC 2 PRO PPK use the following parameters Height: 0.07 Offset forward/backward: -0.02 FOR DJI PHANTOM 4 PRO PPK use the following parameters Height: 0.17



Step 6. Setup data processing setting. Click advanced setting. Advanced setting will appear.

To embed precise coordinates to photos EXIF tags check Burn exif check box. This option may lead increasing of data processing time.

To save list of coordinates check Save text file check box. Select format of text file Pix4D or Metashape Click Save button.

TopoSetter 2.0							×
1 Dub to the choice from t			Logs:		Q	<u>)pen log file</u>	
1. Path to the photos from t E:\TUTORIAL\FLIGHT 1	the rover:		26.11.2019 13:50:16: Read meta 26.11.2019 13:50:26: Done! 26.11.2019 13:50:26: Found 202				
2. Path to the ubx file from			26.11.2019 13:50:26: Found 397	pnotos			
E:\TUTORIAL\ROVER\19-09-27	∿14-40-32.ubx						
3.Specify the path to the ba							
E:\TUTORIAL\BASE\raw_20190)9271437.ubx						
4. Base coordinates:							
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Longitude -	-4.663284915 degree	TopoSetter 2.0: Advance	d settings X				
Elevation (meters) -	152.6403	Display utility windows	GLONASS satellites				
5. Base antenna height:	0,000 🚔 meters	🗹 Burn exif Satellite m	ask angle: 15 🚖 degree				
6. Rover antenna offset:			text file:				
Height -	0.07 🚔 meters	•	PIX4D O Metashape				
Offset forward/backward -	-0.02 📥 meters		Save				
Offset left/right -	0.00 🚔 meters						
7. Output folder:							
E:\TUTORIAL\FLIGHT 1\Output	:						
Processing steps:							
1. 🗹 Data conversion							
2. GNSS data postproc	cessing						
3. Images matching an	d geotegging	Start					
Advanced settings		Stop					
							0

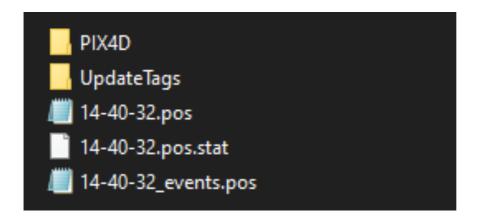
NOTICE. To look at data processing performing switch on Display utility window option.

Click Start button



After finishing of all steps of data processing (data conversion, GNSS data post processing, images matching and geotagging) all results will be stored in Output folder.

File Coordinates.txt is stored in PIX4D or Metashape folder Photos with updated EXIF tags are stored in UpdateTags folder Files with .pos extension are results of GNSS data postrpocessing



NOTICE. Coordinate system is WGS84.



Step 7. Checking processing results.

After processing accomplishing, the following buttons will appear.

TopoSetter 2.0	X
1 Date to the effect of the more	Logs: Open log file
Inposence 2.0 I. Path to the photos from the rover: E:\TUTORIAL\FLIGHT 1 Path to the ubx file from the rover: E:\TUTORIAL\ROVER\19-09-27\14-40-32.ubx Specify the path to the base station data file: E:\TUTORIAL\BASE vaw_201909271437.ubx	
Advanced settings Stop	< >
	6

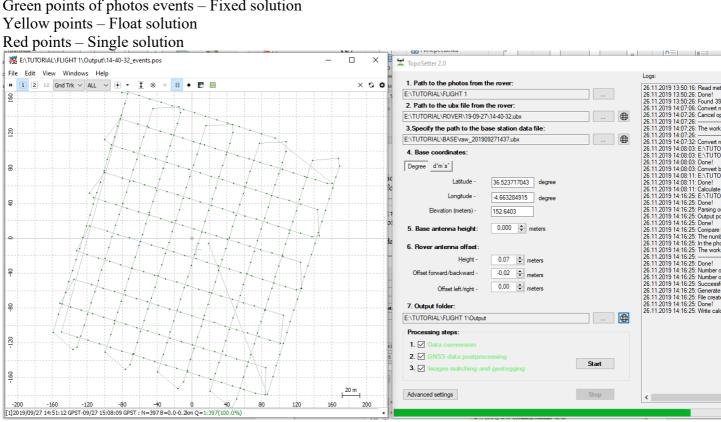
NOTICE.

Click buttons in front of Rover or Base fields to open GNSS observation files to check the quality of GNSS signal.

To check quality of GNSS data postprocessing click button

button in front of output results.





On the map you can see results of GNSS data postprocessing. Green points of photos events - Fixed solution

NOTICE.

If there are only red points on the map it means, that GNSS data from a drone and a base station were not collected at the same time.

If there are only yellow points (float solution) you should check coordinates of a base station or quality of the signal. To remove noisy GNSS signal try to increase satellite mask angle or exclude GLONASS satellite in Advanced setting menu.



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3. PHOTOGRAMMETRY PROCESSING IN PIX4D MAPPER SOFTWARE 3.1 Creating pix4d mapper project

Run PIX4D mapper application.

	rocess View Help			
Pitto				2
Home Hap View 22 rayCloud Volumes	Project Process	Pix4	Pixto D mapper	
Mosaic Editor	Projects Hel	p Demo Project		
Index Calculator		p Denie i reject		
Catulator	+ Hew Proj Follow the wizz project with you		Open Project Open an existing project.	
	PIX4D,p4 422 images Last modified: L	A STREAM OF A	QATAR.p4d 326 images Last modified: BC ноя 24 2019	
	test2.p4d		test1.p4d 130 images Last modified: Ср ноя 20 2019	
	News	Tips		
	NEWS	(')	Did you know How to generate the Point Cloud Classification?	
Cog Output				
opions (

Click New Project. Select a project folder location. Click next

🗾 New Pro	oject	×
This wizard Choose a n	l creates a new project. name, a directory location and a type for your new project.	
Name:	PIX4D	
Create In:	E:/TUTORIAL	Browse
Use As	Default Project Location	
Project T	ype	
New	Project	
O Proje	ect Merged from Existing Projects	
Help	< Back Next	> Cancel



Select images to be processed from output\UpdateTags folder. Click next

🧾 New Project					×
Select Images					
Enough images are selected: press Next to proceed	d.				
205 image(s) selected.	Add Images	Add Directories	Add Video	Remove Selected	Clear List
E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_038	6.JPG				~
E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_038	7.JPG				
E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_038	8.JPG				
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E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_040	7.JPG				
E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_040	8.JPG				
E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_040	9.JPG				
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E:/TUTORIAL/FLIGHT 1/Output/UpdateTags/DJI_041	2.JPG				¥
Help			< <u>B</u> ad	k <u>N</u> ext >	Cancel



Software will read precise coordinates of images and accuracy setting automatically. Click Next.

	olocation						
-	te System						
-		Geodetic System 1984	4; Coordinate System	: WGS 84			Edit
-	on and Orientation						
🕑 Geo	olocated Images: 2	203 out of 203		Clear	From EXIF	From File	۲o File
Geolocati	on Accuracy: 🔘	Standard 🔾 Low	Custom				
Selected (Camera Model						
•							- 10
90	′L1D-20c_10.3_5	472x3648 (0K8TG74	0120251) (RGB)				Edit
Enabled	lmage	Group	Latitude [degree]	Longitude [degree]	Altitude [m]	Accuracy Horz [m]	Ac V
\checkmark	DJI_0389.JPG	group1	36.52239990	-4.66220570	221.339	0.003	0.006
\checkmark	DJI_0390.JPG	group1	36.52251434	-4.66216040	221.160	0.003	0.006
	DJI 0391.JPG	group1	36.52263260	-4.66211557	221.198	0.003	0.006
	231_0331131 0			4 66207075	221.162	0.003	0.006
	DJI_0392.JPG	group1	36.52274323	-4.66207075			
\checkmark	-	group1 group1	36.52274323 36.52285767	-4.66207073	221.005	0.003	0.006
2	DJI_0392.JPG					0.003	0.006
9 9 9	– DJI_0392.JPG DJI_0393.JPG	group1	36.52285767	-4.66202545	221.005		
	DJI_0392.JPG DJI_0393.JPG DJI_0394.JPG	group1 group1	36.52285767 36.52297211	-4.66202545 -4.66197968	221.005 220.971	0.003	0.006

NOTICE. It is possible to upload coordinates from txt file. Click From File button and select coordinates.txt file

It is recommended to check camera settings. Cilck Edit button and check if Linear rolling shutter camera model is enabled in case if DJI MAVIC 2 PRO was used for survey.



Select output coordinate system and click Next.

🗾 New Project	×
Select Output Coordinate System	
Selected Coordinate System	
Datum: World Geodetic System 1984 Coordinate System: WGS 84 / UTM zone 30N	
Output/GCP Coordinate System	
Unit: m 💌	
O Arbitrary Coordinate System [m]	
Auto Detected: WGS 84 / UTM zone 30N	
O Known Coordinate System [m]	
Q Search Coordinate System	
Advanced Coordinate Options	
Help	< Back Next > Cancel



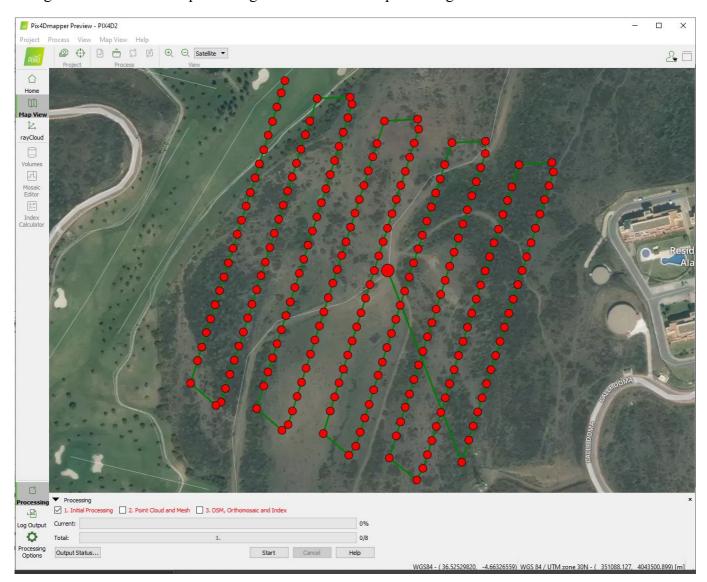
Select type of data processing options. Click Finish.

Standard	3D Models
3D Maps 3D Models Ag Multispectral Rapid 3D Maps - Rapid/Low Res 3D Models - Rapid/Low Res Ag Modified Camera - Rapid/Low Res Ag RGB - Rapid/Low Res Advanced	Generate a 3D Model from any set of overlapping images. Image Acquisition oblique flight terrestrial Outputs Quality/Reliability High
Ag Modified Camera Ag RGB Thermal Camera ThermoMAP Camera	Processing Speed Slow Fast Input Image Recommendations Any images with a high amount of overlap such as images taken from the ground or oblique aerial images (free flight).
	Outputs Generated 3D Mesh Point Cloud For the constant of th



3.2 Initial aerial triangulation

As soon as images with precise coordinates were loaded to the project, we can start initial aerial triangulation. Select initial processing checkbox and start processing.

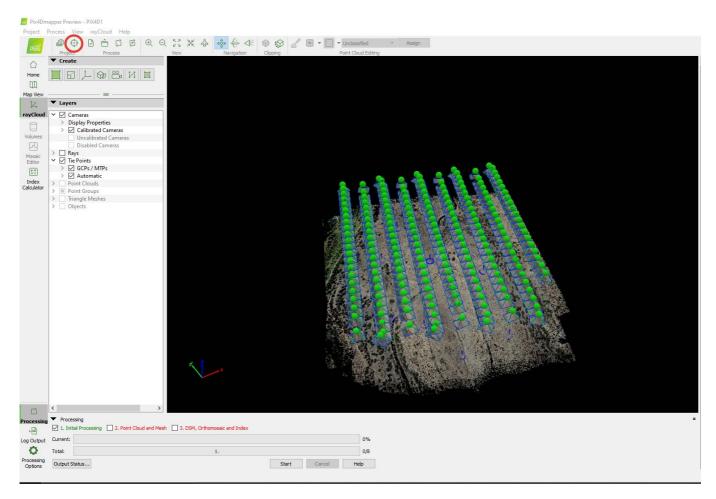




3.3. Camera calibration

In order to calibrate focal length of the camera you need at list one GCP.

Click GCP/MTP button.





Select coordinate system of ground control points and import GCPs. Click OK.

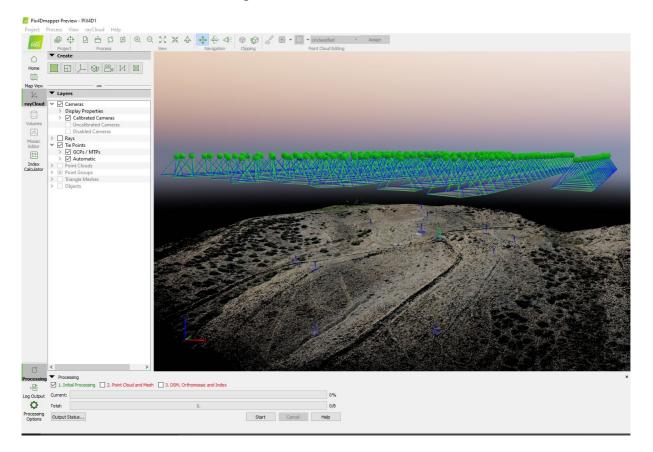
P/MTP	~~~~								Import GCPs
	Label	Туре	Latitude [degree]	Longitude [degree]	Altitude [m]	Accuracy Horz [m]	Accuracy Vert [m]	^	Export GCPs
O Ba	ase	3D GCP	36.52371704	-4.66328492	152.506	0.020	0.020		L
14 Po	oint 1	3D GCP	36.52372766	-4.66311001	148.133	0.020	0.020		
0 Po	oint 2	3D GCP	36.52377147	-4.66264965	153.482	0.020	0.020		Add Point
0 Po	oint 3	3D GCP	36.52340747	-4.66240828	153.772	0.020	0.020		Remove Point
0 Po	oint 4	3D GCP	36.52320690	-4.66257781	149.481	0.020	0.020		Remove Poin
0 Po	oint 5	3D GCP	36.52224430	-4.66288253	138.133	0.020	0.020	J	
P/MTP order t order t rking G	to take GCPs into a GCPs/MTPs after s	position of a GCP/MTP, account for georeferenc tep 1. Initial Processing (it needs to be marked on ing the project, at least 3 requires the user to run P ity Report or in the rayCle	GCPs need to be marke rocess > Reoptimize. oud Editor.	d. Use the Basic Editor eith		Import N	larks	Export Marks

Change GCPs type to Check point.

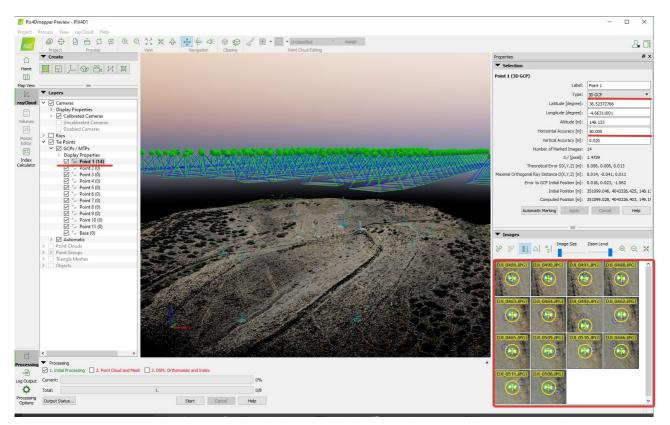
Label	_				-	-	A Import G
	Туре	Latitude [degree]	Longitude [degree]	Altitude [m]	Accuracy Horz [m]	Accuracy Vert [m]	Export G
Base	Check Point	36.52371704	-4.66328492	152.506			
4 Point 1	Check Point	36.52372766	-4.66311001	148.133			
Point 2	Check Point	36.52377147	-4.66264965	153.482			Add Po
Point 3	Check Point	36.52340747	-4.66240828	153.772			Remove
Point 4	Check Point	36.52320690	-4.66257781	149.481			remove i
Point 5	Check Point	36.52224430	-4.66288253	138.133			~
der to take GCPs in ing GCPs/MTPs afte	2 3D position of a GCP/MTP, to account for georeferen er step 1. Initial Processing y can be verified in the Qua	ting the project, at least 3 requires the user to run P	3 GCPs need to be marke Process > Reoptimize. loud Editor.	d. Use the Basic Editor either		Import Ma	arks Export Ma



All GCPs will be shown on the map.

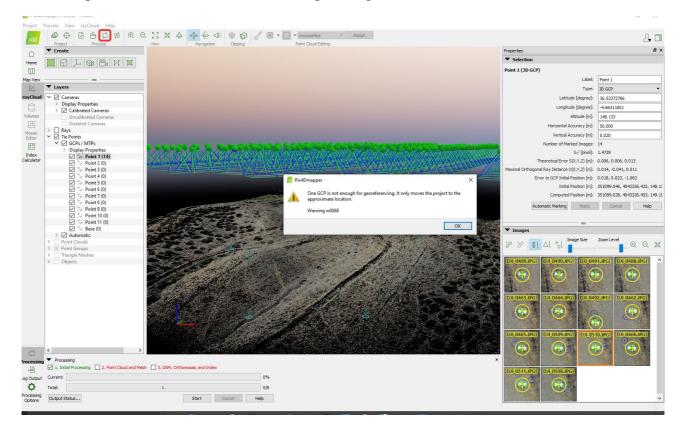


Select one GCP, define position of ground control point at each image, change type of GCP to 3D and setup horizontal accuracy to 50 meters.

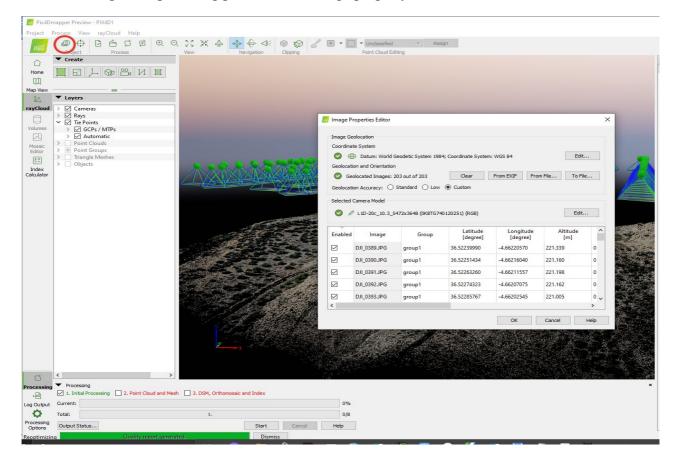




Click Reoptimize button. Click Ok on warning messages.



After finishing of reoptimizing process click Image property editor button.





Click Edit camera model buttons in Image Properties Editor window and in Edit Camera Model window

Coordinat	te System					-	EXIF ID:	L1D-20c 10.3 5472x3648 (0K)	3TG740120251)	
⊘ ∉	Datum: World	Geodetic System 1984	4; Coordinate System:	WGS 84	Edi	it		<pre> L1D-20c_10.3_5472x3648 </pre>		
Geolocati	on and Orientation	i i i i i i i i i i i i i i i i i i i							Remove	Edit New
🕑 Ger	olocated Images: 3	203 out of 203	Clear	From EXIF From	m File To F	ile				
eolocati	on Accuracy: 🔘	Standard 🔘 Low	Custom				Camera Model Bands			
elected (Camera Model						Bands: RGB			▼ Edit
0	L1D-20c_10.3_5	472x3648 (0K8TG74	0120251) (RGB)		Edi	t	Camera Model Paramete	ate from EXIF Load Optimized	Parameters	
nabled	lmage	Group	Latitude [degree]	Longitude [degree]	Altitude [m]	^			econstruction. Read the Help fo Shutter Model: Linear F	
	DJI_0389.JPG	group1	36.52239990	-4.66220570	221.339	0			r	
2	DJI 0390.JPG	group1	36.52251434	-4.66216040	221.160	0	 Image Width [pixel] 		Sensor Width [mm]:	12.825
3	DJI 0391.JPG	group1	36.52263260	-4.66211557	221.198	0	Image Height [pixe]]: 3648	Sensor Height [mm]:	8.55
3	DJI_0392.JPG	group1	36.52274323	-4.66207075	221.162	0	Focal Length [pixel]	: 4324.02	Pixel Size [µm]: Focal Length [mm]:	2.34375
3	DJI 0393.JPG	group1	36.52285767	-4.66202545	221.005	0,	Principal Point x [pix		Principal Point x [mm]:	6.42715
	01_0333.PG	group	50.52205101	-4.00202343	221.005	>	Principal Point y [pix	-	Principal Point y [mm]:	4.24875
				ОК	Cancel	Help	Camera Model with	Distortions: 5		
						Страница	Radial Distortion R1	-0.012488	Tangential Distortion T1:	-0.00176074
							Radial Distortion R2	. 0.033735	Tangential Distortion T2:	-0.000554806
							Radial Distortion R3	-0.0366009		

Click Load Optimiezed parameters. Copy Focal Length value for future work.

NOTICE. It is possible to use the calibrated value of focal length for the processing If you don't change focus settings for future flights.



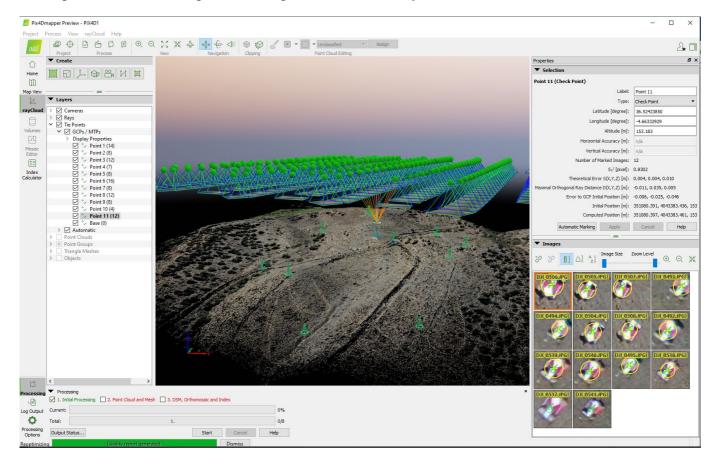
ait	Edit Camera Model				Х
	_	3_5472x3648 (0K8	*		
	Camera Model Name: 🖉 L1D-20c	_10.3_5472x3648	(0K8TG740120251)	ve to DB Cancel Edit	
	Camera Model Bands				
	Bands: RGB			▼ Edit	
	Camera Model Parameters				
	Clear Estimate from EXI	F Load Optimized	Parameters		
	Warning: Wrong parameters can ca	use failure in the re	construction. Read the Help for	more information.	
	Perspective Lens O Fi	isheye Lens	Shutter Model: Linear R	olling Shutter 🔹	
	O Image Width [pixel]:	5472	• Sensor Width [mm]:	12.825	
	Image Height [pixel]:	3648	Sensor Height [mm]:	8.55	
			Pixel Size [µm]:	2.34375	
	Focal Length [pixel]:	4320.34	Focal Length [mm]:	10.1258	
	Principal Point x [pixel]:	2743.49	Principal Point x [mm]:	6.43005	
	Principal Point y [pixel]:	1808.96	Principal Point y [mm]:	4.23974	
	Camera Model with Distortions:	5 🔻			
	Radial Distortion R1:	0.00102062	Tangential Distortion T1:	-0.00170976	
	Radial Distortion R2:	0.00651764	Tangential Distortion T2:	-0.000448533	
	Radial Distortion R3:	-0.0047835			
			ОК	Cancel Help	



3.4 Accuracy estimating

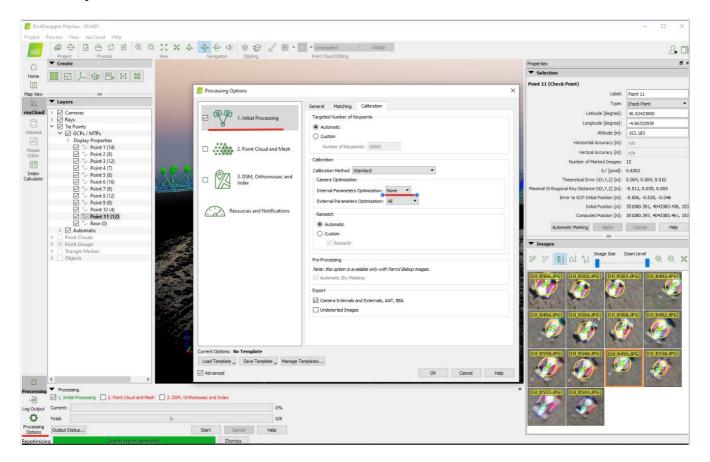
Load ground control points. Set up as check points.

Select position of all check points at images to check accuracy.





Go to Processing option. Select None for Internal Parameters Optimization. Click Ok. Click Reoptimize.





After finishing optimization process go to Process Menu, click Generate quality report.

Data processing report will be generated. Go to Geolocation Details to estimate accuracy of the project.

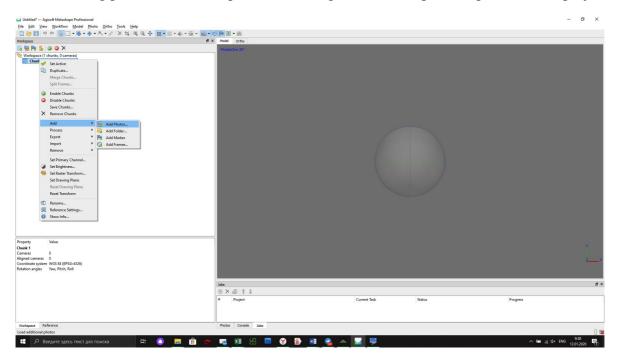
								💭 Online Su
	0.120 0.128	0.004	0.016			004		0.010
Sigma 0		0.004).004).001	0.005	0.010
eolo	ocation		taile					0
	nd Control	Points		out of 12 chec	k points have be	en labeled as inacou	irate.	0
Check Po	int Name	Accura	acy XY/Z [m]	Error X [m]	Error Y [n	n] Error Z [m]	Projection Error [pixel]	Verified/Marked
Point 1				-0.004	-0.031	-0.012	1.494	14/14
Point 2				-0.004	-0.046	-0.005	1.091	8/8
Point 3				0.011	-0.044	-0.003	0.706	12/12
Point 4				0.003	0.001	-0.025	0.777	7/7
Point 5				0.015	0.040	-0.040	0.791	8/8
Point 6				0.031	0.079	-0.010	0.485	16 / 16
Point 7				0.026	0.064	-0.037	1.135	8/8
Point 8				0.030	0.028	0.030	0.635	12 / 12
Point 9				0.020	0.019	-0.037	0.503	8/8
Point 10				0.020	-0.019	-0.084	0.916	4 / 4
Point 11				-0.006	-0.027	-0.046	0.808	12 / 12
Mean [m]				0.012876	0.005672	-0.024386		
Sigma [m]			0.013208	0.041314	0.028233		
DMS Erro	or [m]			0.018446	0.041701	0.037306		



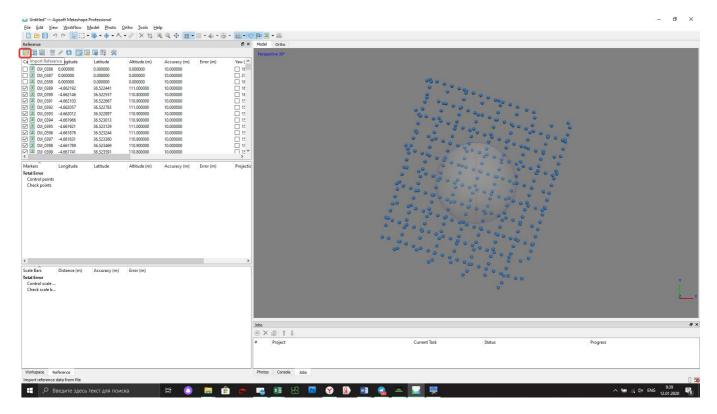
4. PHOTOGRAMMETRY PROCESSING IN AGISOFT METASHAPE SOFTWARE

4.1 Creating project, photos alignment

The following process should be performed in Agisoft Metashape. Add photos to the project



Import positions from file coordinates.txt. Go to Reference. Click Import button, select coordinates.txt file from folder with photos

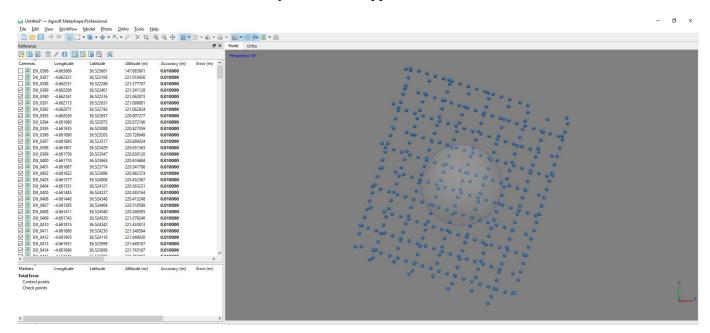




Select WGS 84 coordinate system, setup columns order 1,3,2,4, click Accuracy checkbox, select field 5, click OK

Coordinate System	1							
WGS 84 (EPSG::4	1326)							•
Rotation angles:			Yaw, Pitch, R	oll				-
Ignore labels			Threshold (m)	:	0.1	1		
Delimiter		Columns						
Tab		Label:	1 🗘 🖂 🗛	curacy		Rotation	ח ו	Accuracy
				-		-		-
		Longitude:			Yaw:	5	9	*
-		Latitude:	2 🗘 5	÷	Pitch:	6	9	-
O Space		Altitude:	4 🗘 5	-	Roll:	7	9	Å
Other:								
	ecutive delimiters					Enabled flag		
tart import at row: irst 20 lines previev	1 •	Longitude	Altitude	Location Acro		-		¢ All
tart import at row: irst 20 lines previev Label	1 🔹 v: Latitude	Longitude	Altitude	Location Acco		-		
tart import at row: irst 20 lines previev Label Name	1 🔹 v: Latitude Latitude	Longitude Longitude -4.663068715	Altitude	Location Accor Accuracy 0.010		-		
tart import at row: irst 20 lines previev Label Name	1 v: Latitude Latitude 36.523661137	Longitude -4.663068715	Altitude 147.68380052109	Accuracy 0.010		-		
tart import at row: irst 20 lines previev Label Name DJI_0386.JPG	1 • v: Latitude Latitude 36.523661137 36.5221056845317	Longitude -4.663068715	Altitude 147.68380052109 221.010430292536	Accuracy 0.010 0.010		-		
tart import at row: irst 20 lines previev Label Name DJI_0386.JPG DJI_0387.JPG	1 • v: Latitude Latitude 36.523661137 36.5221056845317 36.5222860844363	Longitude -4.663068715 -4.66232114533	Altitude 147.68380052109 221.010430292536 221.377707372442	Accuracy 0.010 0.010 0.010		-		
tart import at row: irst 20 lines previev Label DJI_0386.JPG DJI_0387.JPG DJI_0388.JPG DJI_0389.JPG DJI_0390.JPG DJI_0390.JPG	1 Latitude Latitude 36.523661137 36.5221056845317 36.5222860844363 36.52224010804326 36.5225160334709	Longitude -4.663068715 -4.66232114533 -4.66225057902 -4.66220581866 -4.66216066346	Altitude 147.68380052109 221.010430292536 221.377707372442 221.241127832579 221.062872597887	Accuracy 0.010 0.010 0.010 0.010 0.010 0.010		-		
tart import at row: irst 20 lines previev Label DJI_0386.JPG DJI_0387.JPG DJI_0388.JPG DJI_0389.JPG DJI_0390.JPG DJI_0391.JPG	1 Latitude Latitude 36.523661137 36.5221056845317 36.5222860844363 36.5224010804326 36.5225160334709 36.5226306035956	Longitude -4.663068715 -4.66232114533 -4.66225057902 -4.66220581866 -4.66216066346 -4.66211540151	Altitude 147.68380052109 221.010430292536 221.377707372442 221.241127832579 221.062872597887 221.099880851059	Accuracy 0.010 0.010 0.010 0.010 0.010 0.010 0.010		-		
tart import at row: irst 20 lines previev Label DJI_0386.JPG DJI_0387.JPG DJI_0388.JPG DJI_0389.JPG DJI_0390.JPG DJI_0391.JPG DJI_0392.JPG	1 ➡ Latitude Latitude 36.523661137 36.5221056845317 36.5222860844363 36.5224010804326 36.5225160334709 36.5226306035956 36.5227431767471	Longitude -4.663068715 -4.66232114533 -4.66225057902 -4.66220581866 -4.66216066346 -4.66211540151 -4.66207096454	Altitude 147.68380052109 221.010430292536 221.377707372442 221.241127832579 221.062872597887 221.099880851059 221.062823904092	Accuracy 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010		-		
tart import at row: irst 20 lines previev Label DJI_0386.JPG DJI_0387.JPG DJI_0388.JPG DJI_0389.JPG DJI_0390.JPG DJI_0391.JPG DJI_0392.JPG DJI_0393.JPG	1 ➡ Latitude Latitude 36.523661137 36.5221056845317 36.5222860844363 36.522860844363 36.5222610304709 36.5225160334709 36.5226306035956 36.5227431767471 36.5228566580435	Longitude -4.663068715 -4.66232114533 -4.66225057902 -4.66220581866 -4.66216066346 -4.66211540151 -4.66207096454 -4.6620256512539	Altitude 147.68380052109 221.010430292536 221.377707372442 221.241127832579 221.062872597887 221.099880851059 221.062823904092 220.907277145259	Accuracy 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010		-		
tart import at row: irst 20 lines preview Label DJI_0386.JPG DJI_0387.JPG DJI_0388.JPG DJI_0389.JPG DJI_0390.JPG DJI_0391.JPG DJI_0392.JPG	1 ➡ Latitude Latitude 36.523661137 36.5221056845317 36.5222860844363 36.522860844363 36.5222610304709 36.5225160334709 36.5226306035956 36.5227431767471 36.5228566580435 36.5228566580435 36.5229732876239	Longitude -4.663068715 -4.66232114533 -4.66225057902 -4.66220581866 -4.66216066346 -4.66211540151 -4.66207096454	Altitude 147.68380052109 221.010430292536 221.377707372442 221.241127832579 221.062872597887 221.099880851059 221.062823904092 220.907277145259 220.872190284877	Accuracy 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010		-		

Accurate X,Y,Z coordinates and accuracy values will appear in Reference window





.Go to Tools, click Camera calibration and input calibrated parameter for focal length 10.4777, select fixed F parameter

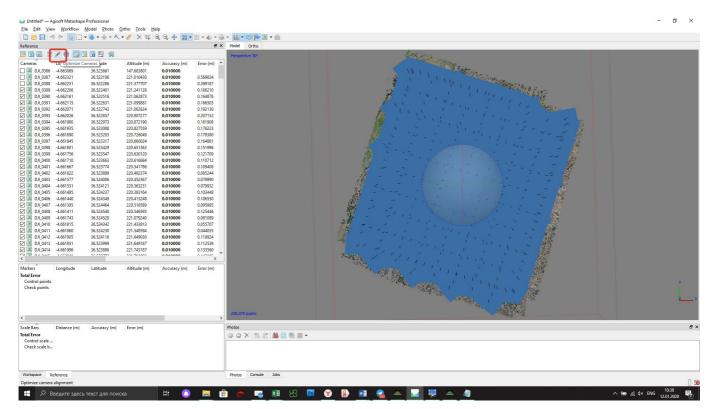
Camera Calibration		
🚌 L1D-20c (10.26mm)	Camera type:	Frame
¹⁰⁰ 397 images, 5472x364	Pixel size (mm):	0.00241071 x 0.00241071
	Focal length (mm):	10.4777
	Enable rolling shutter compensation	Film camera with fiducial marks
	Initial Adjusted Bands GPS/INS Offset	t
	Type: Auto	· E 🖪 🖩
	Auto	
		cx: 0
	f: 4346.30519	cy: 0
	k1: 0	p1: 0
	k2: 0	p2: 0
	k3: 0	b1: 0
	k4: 0	b2: 0
	Fixed parameters: None	Select
	Image-variant parameters: None	Select
🖬 Fixed	Parameters	×
		ength Date & time
Paramet		2019:09:27 16:50:54
Che	k all	2019:09:27 16:52:09
[∏f]	Cx, cy	2019:09:27 16:52:12
		2019:09:27 16:52:14
🗌 k1	p 1	2019:09:27 16:52:16
🗌 k2	p2	2019:09:27 16:52:18
□ k3	□ b1	2019:09:27 16:52:20
		2019:09:27 16:52:22
□ k4	□ b2	2019:09:27 16:52:24
		2019:09:27 16:52:26
c	OK Cancel	2019:09:27 16:52:28
	OK Cancel	

Go to Workflow and click Align Photos for aerial triangulations

🖬 Untitled* — A	Agisoft Metasha	pe Professional					- 0 ×
<u>Eile Edit Vie</u>	w Workflow	Model Photo					
i 🗋 😁 🔚 🖷	් 🗟 Add	Photos	- / × 4	④ ⊕ ∳ 88 •	· III • 📣 • 🖼		
Reference	🗟 Add	Folder			đ×	Model Ortho	
8 6 6 6	Alian	Photos				Perspective 30°	
Cameras	Engi	Dense Cloud	Altitude (m)	Accuracy (m)	Error (m) ^		
DJI_0386		I Mesh	147.683801	0.010000		98 0	
DJI_0387			221.010430	0.010000			
DJI 0388	Build	I <u>T</u> exture	221.377707	0.010000			
DJI_0388	Build	I Tiled Model	221.241128	0.010000			
DJI_0390		I DEM	221.062873	0.010000			
DJI_0391	- Build	Orthomosaic	221.099881	0.010000			
DJI_0392	-4	Chunks	221.062824	0.010000		8000 0 0000	
DJI_0393			220.907277 220.872190	0.010000			b
DJL_0395	ivierg	ge Chunks	220.872190	0.010000			.
DJL_0396	Batch	h Process	220.726049	0.010000			k.
DJI_0397	-4.661845	36.523317	220,660024	0.010000			
DJI_0398		36.523429	220.651363	0.010000			
DJI_0399	-4.661756	36.523547	220.630120	0.010000			
🗹 🖪 DJI_0400		36.523663	220.616684	0.010000			
DJI_0401		36.523774	220.541786	0.010000			
DJI_0402		36.523889	220.482374	0.010000		80 98 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
DJI_0403		36.524006	220.452367	0.010000			
DJI_0404		36.524121 36.524237	220.363231 220.383164	0.010000			
DJI_0406		36.524348	220,413248	0.010000			
DJL_0407		36.524464	220.518589	0.010000			
DJI_0408		36.524540	220.546595	0.010000			
DJI_0409	-4.661743	36.524520	221.079240	0.010000		0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
DJI_0410	-4.661815	36.524342	221.433813	0.010000			
🗹 🖪 DJI_0411		36.524230	221.548594	0.010000			
		36.524116	221.649030	0.010000			
DJI_0413	-4.661951	36.523999 36.523886	221.649187 221.743187	0.010000			
	-4.001990	30.323880	221.743107	0.010000	~		
<					>		
Markers	Longitude	Latitude	Altitude (m)	Accuracy (m)	Error (m)		
Total Error							
Control points							N N
Check points						0 0 00 0 0	
						• • • • •	z _ x
						•	
<					>		
Scale Bars	Distance (m)	Accuracy (m)	Error (m)			hotos	8 ×
Total Error							
Control scale							
Check scale b							
March and an						et al August 1 Mar	
Workspace R	Reference					Photos Console Jobs	
Align cameras	_						
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After finishing aerial triangulation go to Reference, click "Optimize Camera Alignment" and click on Fit additional corrections check box. Click OK



🥁 Optimize Camer	ra Alignment	×
General		
Fit f	Fit cx, cy	
Fit k1	Fit p1	
Fit k2	Fit p2	
Fit k3	Fit b1	
Fit k4	Fit b2	
Fit additional co	rrections	
Advanced		
Adaptive camer	a model fitting	
Estimate tie poir	-	
	OK Cancel	



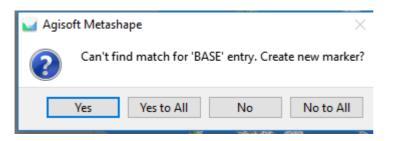
4.2 Accuracy estimating

After finishing aerial triangulation go to Reference, click "Import" and load GCP.txt file

Use the following settings and click OK

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	_	Model Photo			000 A CES	1				
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Reference					₽×	Mode	del Ortho		<i>#</i>	
	i 🖉 🗘 🔯	🗷 🐻 🖣 🔗				Perg	rspective 30°		1 th State Barrows	
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🔲 🔝 DJI_0386		36.523661	147.683801	0.010000					NI I	
🔲 🖪 DJI_0387		36.522106	221.010430	0.010000	0.164313				a v ' <u>V</u> L L	References .
🔲 🖪 DJI_0388		36.522286	221.377707	0.010000	0.062559		and the second se	2	i	and a start
🗹 🚨 DJI_0389		36.522401	221.241128	0.010000	0.060017		Market Ma		×	U. Cartage
🗹 🖪 DJI_0390		36.522516	221.062873	0.010000	0.043913					
DJI_0391		36.522631	221.099881	0.010000	0.033234		Coordinate System			the tensor
DJI_0392		36.522743	221.062824	0.010000	0.045026		WGS 84 (EPSG::4326)		-	1 1 1
DJI_0393		36.522857 36.522973	220.907277 220.872190	0.010000 0.010000	0.037136 0.042318					Carlos I I
☑ ☑ DJI_0394 ☑ ☑ DJI_0395		36.523088	220.872190	0.010000	0.042318		Rotation angles:	Yaw, Pitch, Roll	•	
☑ ☑ DII_0395		36.523088	220.827559	0.010000	0.034353		Ignore labels	Threshold (m):	0.1	1 1 1
☑ IDI_0390		36.523317	220.660024	0.010000	0.041734					
DJI_0398		36,523429	220.651363	0.010000	0.046186		Delmiter	Columns		1 1-1
DJI_0399		36.523547	220.630120	0.010000	0.056818		⊖ Tab	Label: 1 🗢 🗌 Accurac	y Rotation Accuracy	
DJI_0400		36,523663	220.616684	0.010000	0.048853		Semicolon			· · · · ·
🗹 🖪 DJI_0401		36.523774	220.541786	0.010000	0.036907		O Comma	Longitude: 2 🗢 5	≎ Yaw: 5 ≎ 9 ≎	
DJI_0402		36.523889	220.482374	0.010000	0.031036		-	Latitude: 3 🗘 5	₽itch: 6	l 🔪 🤇 🕹 🖓
🗹 🖪 DJI_0403		36.524006	220.452367	0.010000	0.035799		 Space 	Altitude: 4 🗘 5	≎ Roll: 7 ≎ 9 ≎	1 / - · · · · · · · · · · · · · · · · · ·
🗹 🔝 DJI_0404		36.524121	220.363231	0.010000	0.036229		O Other:	Altitude: 4 S		
🗹 🔝 DJI_0405		36.524237	220.383164	0.010000	0.047895		Combine consecutive delimiters		Enabled flag: 10 🗘	
🗹 🖪 DJI_0406		36.524348	220.413248	0.010000	0.039974					· · · - 🎊
🗹 🖪 DJI_0407		36.524464	220.518589	0.010000	0.056265		Start import at row: 2 🜩		Items: All 🔻	$T^* \sim T = M$
🗹 🚨 DJI_0408		36.524540	220.546595	0.010000	0.107954		First 20 lines preview:			
DJI_0409		36.524520	221.079240	0.010000	0.047091			Laterala Alexada	•	
DJI_0410		36.524342	221.433813	0.010000	0.024034		Label Longitude	Latitude Altitude	Â	
DJI_0411		36.524230	221.548594	0.010000	0.024499		name longitude Point 1 -4.663110006	latitude elevation 36.52372766 148.1333512		
☑ ☑ DJI_0412 ☑ ☑ DJI_0413		36.524116	221.649030	0.010000	0.014767		Point 1 -4.663110006 Point 2 -4.662649647	36.52377147 153.4818		
☑ DJI_0413 ☑ DJI_0414		36.523999 36.523886	221.649187 221.743187	0.010000 0.010000	0.022033		Point 2 -4.662408277	36.52340747 153.7719672		
	-4.001990	30.523880	221./4518/	0.010000	A A3AAAAA Y		Point 4 -4.662577812	36.5232069 149.4809714		
<					>		Point 5 -4.662882529	36.5222443 138.1332341		
Markers	Longitude	Latitude	Altitude (m)	Accuracy (m)	Error (m)		Point 6 -4.663660449	36.52234384 123.8944143		
Total Error							Point 7 -4.663964677	36.52287468 140.5192487		
Control points	s						Point 8 -4.664343952	36.52318291 132.7402509		
Check points							Point 9 -4.663987151	36.5241323 144.5694333		
							Point 10 -4.663459245	36.5244935 157.8480623	~	
							Point 11 -4.663329295	36.5242385 153.1832755		and the second sec
								OK Cancel		
<				_		200	Joro porks			
٢.					>					

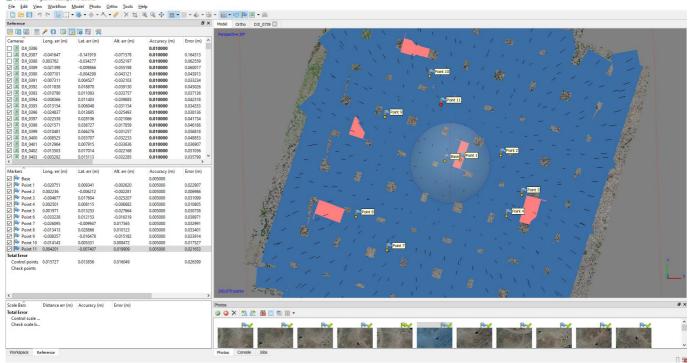
Click «Yes to All» button. GCPs will be shown at Model window.



Select locations of each GCP on photos and look at accuracy report



- 0 ×

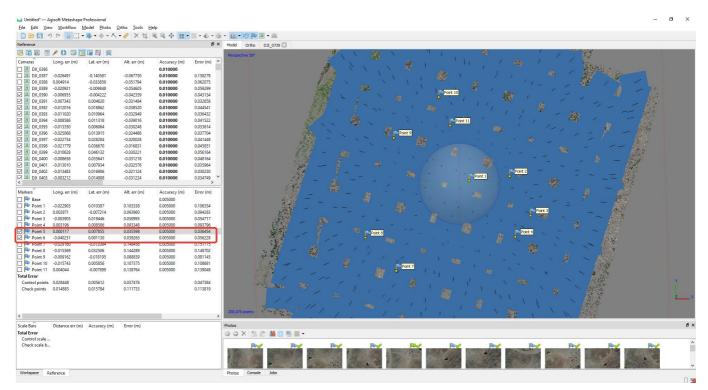


Markers	Long. err (m)	Lat. err (m)	Alt. err (m)	Accuracy (m)	Error (m)
🗹 Þ Base				0.005000	
🗹 🏴 Point 1	-0.020751	0.009341	-0.002620	0.005000	0.022907
🗹 Þ Point 2	0.002236	-0.006212	-0.002281	0.005000	0.006986
🗹 🏴 Point 3	-0.004677	0.017604	-0.025207	0.005000	0.031099
🗹 🏴 Point 4	0.002501	0.008115	-0.006682	0.005000	0.010805
🗹 🏴 Point 5	0.001971	0.013253	-0.027664	0.005000	0.030738
🗹 Þ Point 6	-0.033238	0.012153	-0.016319	0.005000	0.038971
🗹 Þ Point 7	-0.026095	-0.009947	0.017565	0.005000	0.032991
🗹 Þ Point 8	-0.013413	0.028866	0.010123	0.005000	0.033401
🗹 Þ Point 9	-0.008357	-0.016478	-0.015182	0.005000	0.023914
🗹 Þ Point 10	-0.014143	0.005331	0.008472	0.005000	0.017327
🗹 Þ Point 11	0.004201	-0.007407	0.019909	0.005000	0.021653
Total Error					
Control points	0.015727	0.013856	0.016049		0.026399
Check points					



4.3. Camera calibration

To calibrate camera focal length, load images, import accurate coordinates of photos, perform phots alignment (don't fix F parameter) and import GCPs. Define position of markers on each photo. Select 2-3 markers



Click Optimize camera Alignment, use the following settings and click OK

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	v Workflow M					
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ference					8 ×	Model Ortho DII_0739 🖸
	P 🕄 🗔 📃	18 🗳 %				Perspective 30°
DJI_0386	Long. err (m)	Lat. err (m)	Alt. err (m)	Accuracy (m)	Error (m) ^	and the second sec
	-0.026491	-0.140581	-0.067730	0.010000	0.158278	
	0.004914	-0.033859	-0.051794	0.010000	0.062075	🖬 Optimize Camera Alignment X 1
DJI_0389	-0.020921	-0.009848	-0.054605	0.010000	0.059299	
DJI_0390	-0.006955	-0.004222	-0.042359	0.010000	0.043134	General General General
DJI_0391	-0.007343	0.004620	-0.031484	0.010000	0.032658	Ø Ritf Ø Ritax, av
	-0.012016	0.018862	-0.038520	0.010000	0.044541	
DJI_0393	-0.011020	0.010964	-0.032949	0.010000	0.036432	
DJI_0394	-0.008586	0.011318	-0.039016	0.010000	0.041522	Period Press
DJI_0395	-0.013350	0.006064	-0.030248	0.010000	0.033614	
DJI_0396	-0.025068	0.013915	-0.024486	0.010000	0.037704	
DJI_0397	-0.022734	0.028284	-0.020028	0.010000	0.041448	The additional corrections
DJI_0398	-0.021779	0.036670	-0.016831	0.010000	0.045851	Advanced
DJI_0399	-0.010628	0.046132	-0.030221	0.010000	0.056164	
DJI_0400	-0.008658	0.035641 0.007934	-0.031218 -0.032576	0.010000	0.048164	Adaptive camera model fitting
DJI_0401	-0.013010	0.007934	-0.032576	0.010000	0.035964	Estimate le point covariance
DJI 0403		0.014908	-0.031224	0.010000	0.034749	
1001 0405	-0.003212	0.014300	-0.031224	0.010000	>	OK Cancel
arkers	Long. err (m)	Lat. err (m)	Alt. err (m)	Accuracy (m)	Error (m)	
P Base				0.005000		
Point 1	-0.022903	0.010387	0.103338	0.005000	0.106354	
Point 2	0.002971	-0.007214	0.093960	0.005000	0.094283	
Point 3	-0.003905	0.019446	0.050995	0.005000	0.054717	
Point 4 Point 5	0.003196	0.008586	0.093348	0.005000	0.093796	
Point 5 Point 6	0.000117 -0.040231	0.007855 0.001130	0.035598 0.039265	0.005000	0.036454 0.056228	Point 6
Point 7	-0.029160	-0.012084	0.039265	0.005000	0.030228	
Point 8	-0.015369	0.032506	0.144289	0.005000	0.148702	
Point 9	-0.009162	-0.018195	0.088839	0.005000	0.091145	
Point 10	-0.015743	0.005856	0.107375	0.005000	0.108681	
Point 11		-0.007899	0.138764	0.005000	0.139048	
tal Error						
Control points		0.005612	0.037476		0.047384	
Check points	0.014883	0.015784	0.111733		0.113819	
						200,00 ports 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2
					>	
ale Bars	Distance err (m)	Accuracy (m)	Error (m)			Photos
tal Error						② ○ × 為. 於 勤 回 團 課 ▼
Control scale						
Check scale b						
Vorkspace R	eference					Photos Console Jobs



After finishing aerial triangulation, go to Tools, click Camera calibration. Select adjusted and Save button.

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eference	2 85 III III				D' X	Model Ortho DJI_0739		19	iller.	x	Ч., 8	6	11-11-11-11-11-11-11-11-11-11-11-11-11-	a'	_	-
Imperation Im	Image: Constraint of the second sec	Lat. err (m) -0.140283 -0.03470 -0.009461 -0.003461 -0.003464 0.019339 0.011930 0.011930 0.001652 0.001840 0.00652 0.001820 0.011840 0.006532 0.001820 0.011840 0.006532 0.001820 0.011758 0.03728 0.045749 0.036139 0.045749 0.036139 0.045749 0.045749 0.036139 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.045749 0.04574 0.04574 0.04574 0.04574 0.036139 0.04574 0.0457 0.0457 0.0457 0.0457 0.0457 0.045 0.0457 0.045 0.0457 0.045 0.0457 0.045 0	AR: err (m) -0.066733 -0.05348 -0.05348 -0.037700 -0.03247 -0.032547 -0.032847 -0.032847 -0.032847 -0.038547 -0.019827 -0.0198	Accuracy (m) 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000 0.010000	Error (m) 0.157607 0.065792 0.035912 0.0431707 0.043903 0.035112 0.0431125 0.041125 0.041145 0.041484 0.045673 0.044484 0.045673 0.045564 0.030384 v v	Fergenzine 30*	Focal length (mm):	3	PS/INS Offset	ame 00241071 26 Film camera with fid Film camera with fid 0.0194963 12 0.00039566 12 0.0039566	N N N I I I					
Iarkers The Base The Point 1 Point 2 Point 2 Point 2 Point 3 Point 4 Point 5 Point 6 Point 6 Point 8 Point 9 Point 1 Point 11 Stal Error Control points Check points		Lat. err (m) 0.010099 -0.007261 0.019413 0.008365 0.010356 0.003583 -0.014250 0.035468 -0.018374 0.006065 -0.007862 0.008387 0.015525	Alt. err (m) 0.034887 0.030623 -0.011290 0.027014 -0.003440 0.003543 0.071740 0.003553 0.077740 0.046590 0.046590 0.046590 0.04977110	Accuracy (m) 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000 0.005000	Error (m) 0.042379 0.022032 0.022897 0.028702 0.01739 0.033382 0.078207 0.068740 0.02632 0.057687 0.057667 0.025021 0.051635	< ,	k4: 0 Carmera fabbel DJI_0386 B DJI_0386 B DJI_0387 B DJI_0393 B DJI_0393 B DJI_0393 B DJI_0393 B DJI_0392 B DJI_0393 B DJI_0393 B DJI_0393 B DJI_0394 B DJI_0395 B DJI_0395	Resolution 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648 5472x3648		2: 0	Date 8; time 2019;09:27 16:55:4 2019;09:27 16:55:49 2019;09:27 16:55:19 2019;09:27 16:55:14 2019;09:27 16:55:14 2019;09:27 16:55:16 2019;09:27 16:55:16 2019;09:27 16:55:26 2019;09:27 16:55:28 2019;09:27 16:55:28					Y
cale Bars otal Error Control scale Check scale b	Distance err (m)	Accuracy (m)	Error (m)		>		• # •	OK	Cancel	President						e

Select Info Camera Calibration format and save file.

🖂 Сохранение					×
$\leftarrow \rightarrow \checkmark \uparrow \square \ll Da$	ata (D:) > _PROJECT > SPAIN > ATYGES > IM.	AGES → Output → Metash	ape v	🖸 Поиск: Metashape	م
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sync ^	Имя	Дата изменения	Тип	Размер	
_{Ог} Скриншоты	📄 calibration.txt	12.01.2020 10:13	Текстовый докум	1 КБ	
💻 Этот компьютер	coordinates.txt	12.01.2020 9:25	Текстовый докум	29 КБ	
🚆 Видео					
🔮 Документы					
🖊 Загрузки					
📰 Изображения					
🍌 Музыка					
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Имя файла: calib	pration.txt				~
Тип файла: Inpho	o Camera Calibration (*.txt)				~
 Скрыть папки 				Сохранить	Отмена .::



Open txt file and copy focal length value

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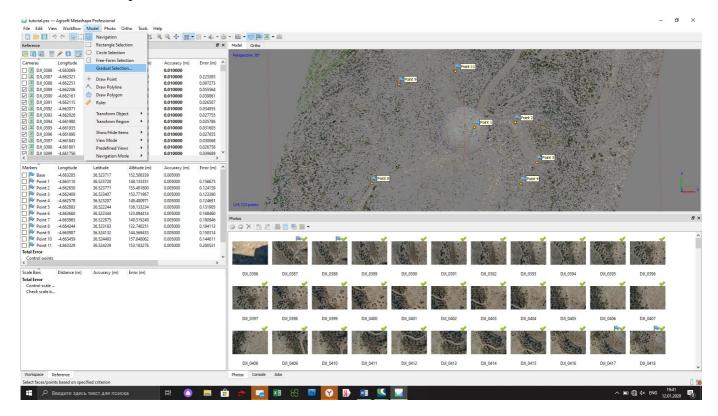
\$CAMERA \$TYPE : L1D-20c_(10.26mm) \$DATE : 11:09:31 12/01/2020 \$BRAND : Custom \$KIND : CCDFrame \$CCD_INTERIOR_ORIENTATION : 412.893 -0 2580.68 0.000000000 -414.547 1817.54 \$CCD_COLUMNS : 5472 \$CCD ROWS : 3648 \$PIXEL_REFERENCE : CenterTopLeft \$FOCAL_LENGTH : 10.4717 \$PRINCIPAL_POINT_PPA : 0.000000 0.000000 \$DISTORTION_TYPE : Polynomial \$RADIAL_COEFFS : 8.19425e-08 -2.12222e-06 0 -1.53934e-05 -7.31114e-10 0 0 0 \$DECENTRE_COEFFS : -0.00140953 2.44127e-05 0 0 \$GPS_ANTENNA_OFFSET : 0.000000 0.000000 0.00000 \$CAMERA_MOUNT_ROTATION : 0.000000

NOTICE. It is possible to use the calibrated value of focal length for the processing If you don't change focus settings for future flights.



4.4. Aerial triangulation accuracy improvement. Tie points filtering

In order to increase an accuracy of your model, we would suggest to filter tie points using Gradual Selection tool. Open Model menu, click Gradual Selection.



Select Gradual selection and input 0.35 value

🖌 Gradu		×
Criterion:	Reprojection error	•
Level:	0.35	
1	•	
3.5		0.0
	OK Cancel	
	Criterion: Level:	3.5



Go to Edit menu and delete selected points

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C ^e Redo	Ctrl				đ×	Model Ortho		Mart Martin	- 46 TT - W.S.	The Party Party and	100-10-2011	A PARA PARTIE		A Martin Contractor	12 12 12 12 12 12 12 12	
	ielection	1 %	1000 0	Lis serv		Perspective 30°										
Grow S	election	sigma	Alt. sigma	Accuracy (m)	Error (m) ^			the states and	1. 1 × 3		Point	11	. States	AT ALLA A POPULA	A DAY	
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D)1 0399 (0.002408	0.002136	0.000949	0.010000	> 0.039089		a alter -	A COLOR	Contraction of the			TO REAL PROPERTY	Poir	13 X X X	a series	
sî l		the states	All states	A	Franker) A		a manufacture of the	The little		Ren Trans				the second	Safe Barrie	14
Base	Long. sigma	Lat. sigma	Alt. sigma	Accuracy (m)	Error (m) ^		13. Salar			1 And the second			Strange Star	140000		
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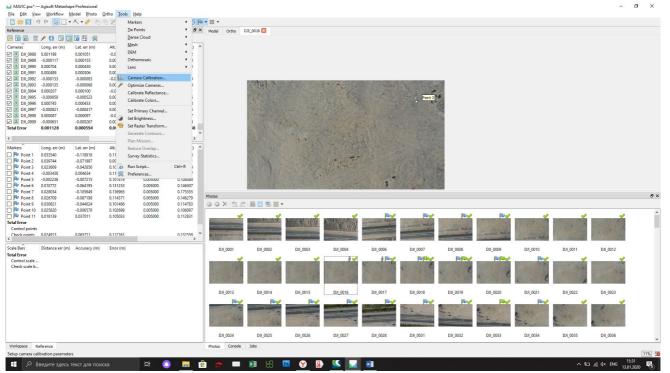
Check accuracy and repeat described above steps until Reprojection error reach 0.65-0.35 value.



4.5. Removing rolling shutter distortion

If photos acquisition was made with a low shutter speed or high flight speed we would suggest to remove rolling shutter distortion.

Open Tools, Camera Calibration



Enable rolling shutter compensation. Reoptimize cameras. Check accuracy.

d Camera Calibration							-	⊐ ×
🚗 L1D-20c (10.26mm)	Camera type:			Fram	e			-
¹⁰⁰ 309 images, 5472x3648	Pixel size (mm):			0.003	241071		x 0.00241071	
	Focal length (mm):			10.50	006		-	
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	DJI 0003	5472x3648	L1D-20c		10.26		2019:11:05 14:41.	
	DJI_0004	5472x3648	L1D-20c		10.26		2019:11:05 14:41.	0.037
	IDJI_0006	5472x3648	L1D-20c		10.26	1	2019:11:05 14:41.	0.015
	🗵 DJI_0007	5472x3648	L1D-20c		10.26		2019:11:05 14:41.	0.033
	DJI_0008	5472x3648	L1D-20c		10.26	1	2019:11:05 14:41.	0.038
	EII_0009	5472x3648	L1D-20c		10.26	1	2019:11:05 14:41.	0.021
	🗵 DJI_0010	5472x3648	L1D-20c		10.26	1	2019:11:05 14:41.	0.023
	🗵 DJI_0011	5472x3648	L1D-20c		10.26	1	2019:11:05 14:41.	0.031
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