Monocle Flight Guidelines V1

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Project goal: Acquire multispectral images to assess water quality. By taking the images of the water surrounding measurement buoys, they can compare the images with accurate measurements.

Purpose: Collect drone data which allows the derivation of water quality parameters. This is done by avoiding reflections and choosing well defined camera parameters.

Solution: Photos are always taken away from the sun with a slightly tilted gimbal (15° off from nadir) and spectral reference panel will be captured regularly for calibration.

Application: Monocle Flight Planner

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Table of Contents

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1. Introduction

This flight manual explains how to acquire drone data over water surfaces step by step with DJI drones. Deriving quantitative information over water with drones requires careful flight mission planning and a proper camera set-up. This because water bodies are dark objects with low reflectance and can act as a mirror.

The manual list the soft- and hardware requirements, introduces the MONOCLE flight planner and explains the set-up of two different flight scenario's: hovering and mapping. Adequate camera settings are specified and finally data upload towards the FTP server is explained. This makes data accessible for further data processing.

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2. Requirements

Hardware

- Drone platform: DJI series
- High Speed SD card min. 64 GB (as raw data are required)

Software:

- iOS operating system
- Drone pilot app: GS Pro https://www.dji.com/be/ground-station-pro
- FTP client (e.g. winscp, https://winscp.net/eng/download.php)

Spectral reference panel with albedo of 12%

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3. Monocle Flight Planner

Link: https://sm-projects-monocle.azurewebsites.net

App Structure

The **MONOCLE Flight planner** is an online tool which supports drone pilots in defining the correct parameters to set-up a flight plan for data acquisition over water. During data acquisition, the drone pilot has to avoid reflection at the water surface as much as possible. This can be done by looking away from the sun with the camera under a slightly tilted angle of about 15°. To avoid any triangulation calculations in the field, depending on the location of the sun, this tool is a useful guide.

The two parameters which are derived with this tool are the heading of the camera and the Lat and Lon location of the drone with respect to a point of interest (POI).

The app consists of two sections:

1. The first section aids in calculating the angle of the sun on a certain location at a certain time.
2. The second section aids in translating the coordinates of buoys to make sure the pilot can capture the buoys in the center of the image with a tilted camera (15° from nadir).

Sun Angle

The first section aids in calculating the angle of the sun on a certain location at a certain time. You provide approximate coordinates for the location of the flight and the table will show you the position of the sun throughout the day.

The angle of the sun is the angle of the sun relative to true north:

- 0°: sun is in the north
- 90°: sun is in the east
- ±180°: sun is in the south
- -90°: sun is in the west

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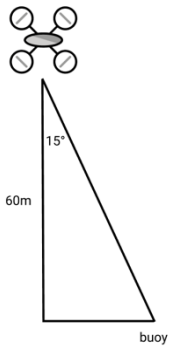
The angle for flight is the angle the drone should use. This is basically the angle of the sun, rotated by 180°. This way the drone is always facing away from the sun. This angle can be transferred directly into GS Pro as the heading of the drone.

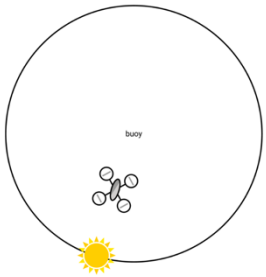
Time: the application is taking account always the local time zone

Coordinate Shifter

The second section aids in translating the coordinates of buoys to make sure the pilot can capture the buoys in the centre of the image with a tilted camera (15° from nadir).

The images below explain how it works. With a tilted camera, the coordinates of the drone are slightly shifted compared to the coordinates of the buoy. In which direction depends on the location of the sun.





It is very crucial that the drone look away from the sun, therefore the camera is not automatically in direction with the flight lines.

Monocle flight planner allows you to add multiple locations that have to be converted.

Comment sections: can be used to indicate which buoy the coordinates represent.

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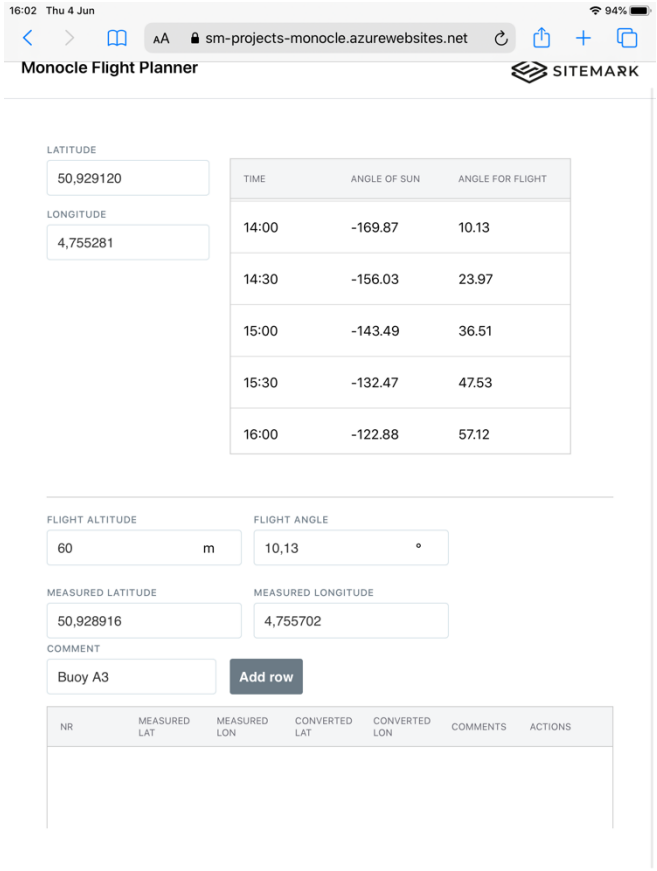
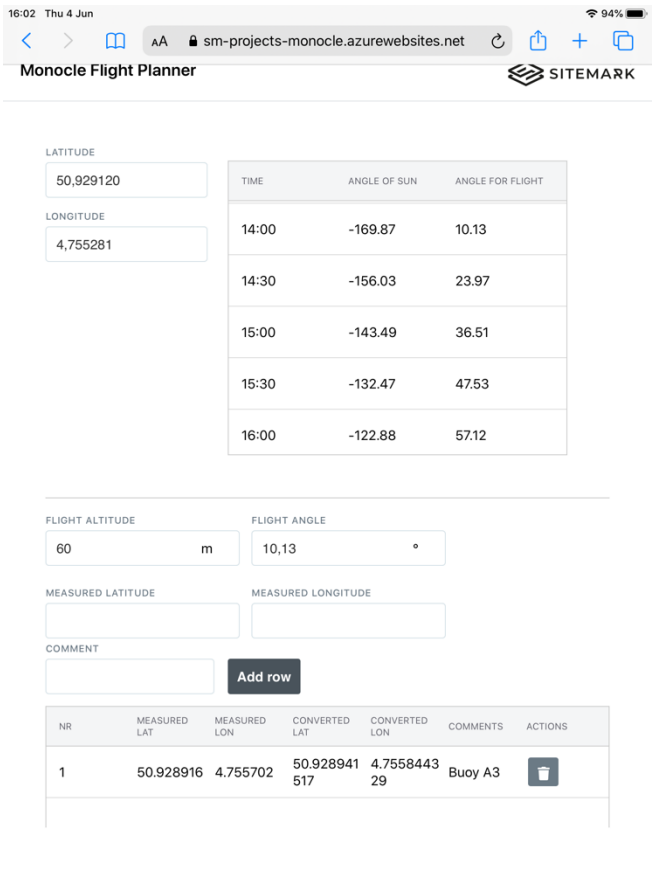
The screenshots below demonstrate a simple example:

Let's assume we want to fly at 14:00, then we use the 10° flight angle from the table in the first section. We'll be flying at an altitude of 60 m. You then fill in the coordinates of the different buoys and they'll appear in the table below. Those coordinates can then be used in GS Pro.





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4. Flying scenarios

Scenario A: Hover & Capture in 12 steps

- Predefined ground point locations (one or multiple). The drone has to hover over each ground control point and take at least 5 pictures. (taking into account orientation of camera, height, ….)

Scenario B: Mapping X steps

Flight: Speed: approx.4 m/s; return to home speed & towards waypoint_1 speed: not too fast (max 6 m/s)

Height: by default 60 m

We foresee two flight scenario's for data acquisition over water. The first one is **hovering scenario**, when data is collected over (a) fixed location(s), e.g. monitoring buoy(s). This hovering can monitor highly dynamic flotations at the water surface. Secondly, a **mapping scenario** is tackled. This is interesting for collecting data over a wider region and mosaicking the results.

There are a couple of general assumption for the two scenarios:

- The take-off and landing of the drone occur at the same spot.
- A spectral reference panel of 12% is location near the take-off and landing site, with known coordinates. Capture one image with the drone, while lifting the drone at chest height. This image will contain the coordinates of the reference panel.
- At the beginning and end of each flight, once the drone is at his flying height, he has to hover over these panels and take at least 5 pictures.
- Always fly with the back of the drone towards the sun. To adequately define the heading, you can make use of the MONOCLE flight planner (see section … for a detailed description) **https://sm-projects-monocle.azurewebsites.net**

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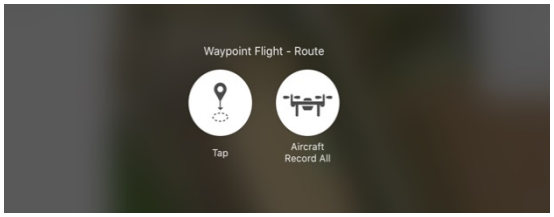
Scenario A: Hover & Capture in 12 steps

Step 1: Prepare the GSpro app

Step 2: Open the Monocle flight app in a different window

Step 3: Select New Mission type – WayPoint Route + Aircraft Record All

To create tackle the Hover & Capture scenario using GS Pro, a waypoint route mission can be used.



Step 4: Place spectral reflectance panel (12%) nearby take-off location

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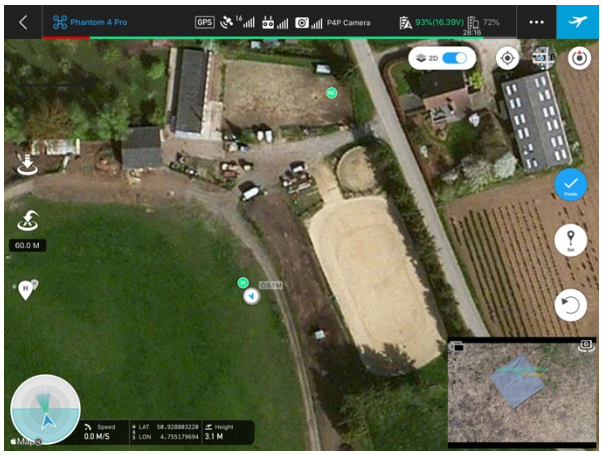
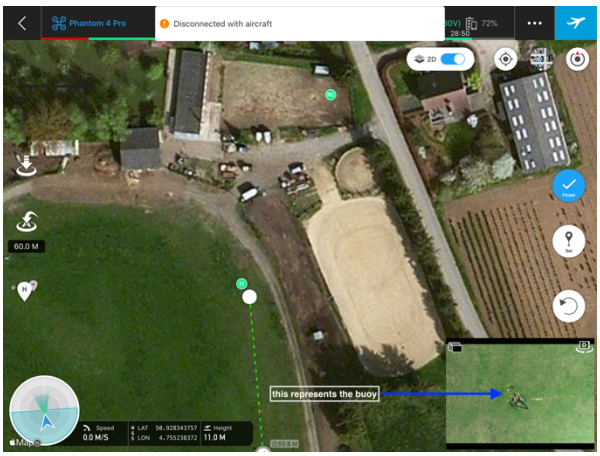
Step 5: Perform the Coordinate Reconnaissance flight

Manually fly over the reflectance panel and over all buoys, centering the points with the camera in nadir to register the coordinates.

The drone has to hover over each ground control point and take at least 5 pictures.

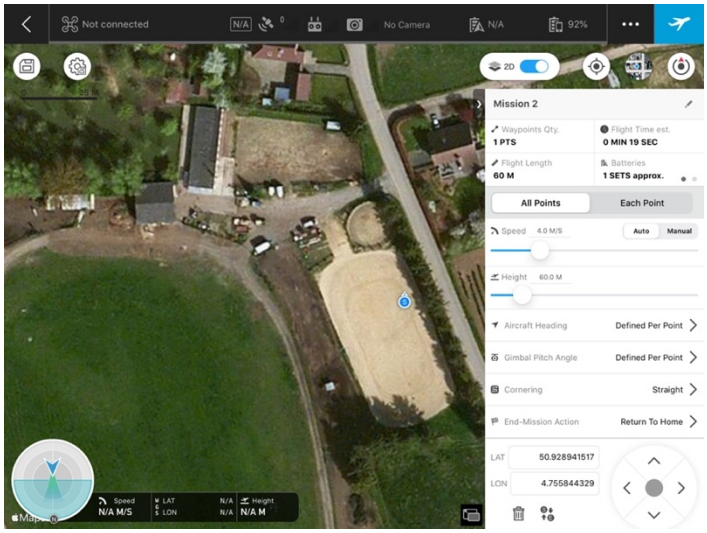
In case you know the coordinates upfront you can skip it and add the coordinates of buoys by tapping.





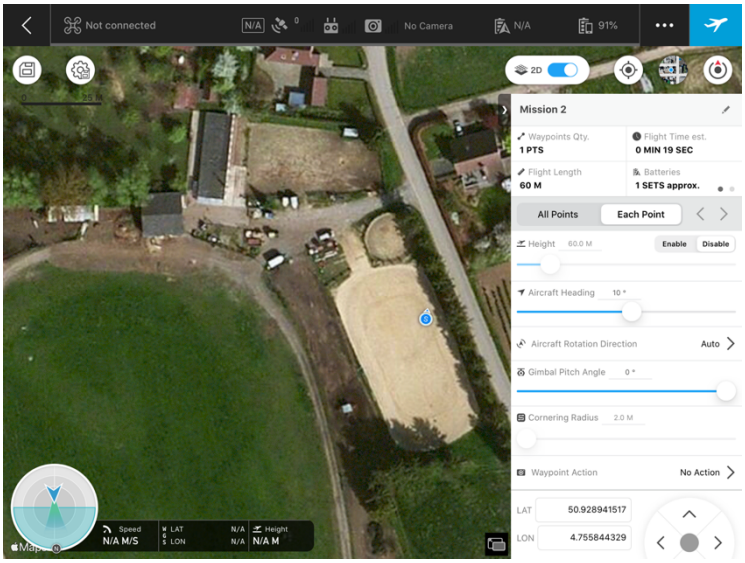
Once the points are added, the following mission level settings **(All Points section in GS Pro)** should be used:

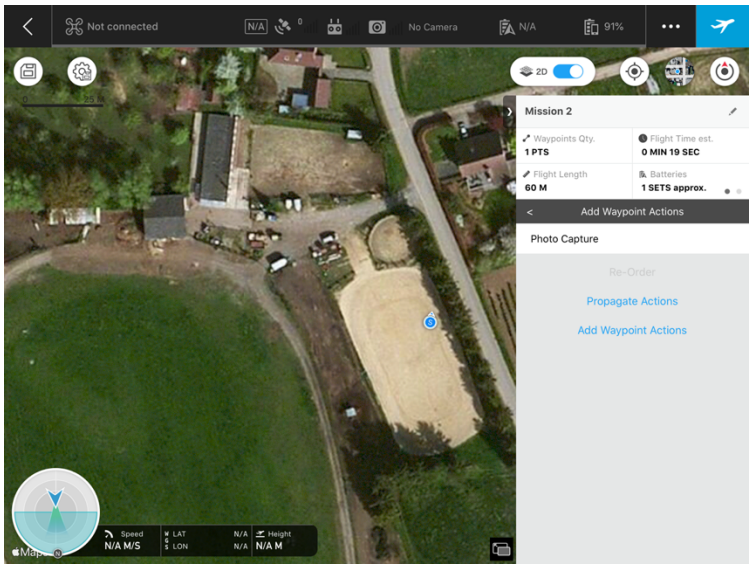
- Aircraft Heading: Defined Per Point
- Gimbal Pitch Angle: Defined Per Point
- Cornering: Straight



Then the following mission level settings **(Each Point section in GS Pro)** should be used:

- **Aircraft Heading:** the Angle for Flight as indicated by the Monocle Flight Planner tool
- **Gimbal Pitch Angle:** **-75°** to make sure it's **15° tilted from nadir**
- **Height:** **DISABLE**





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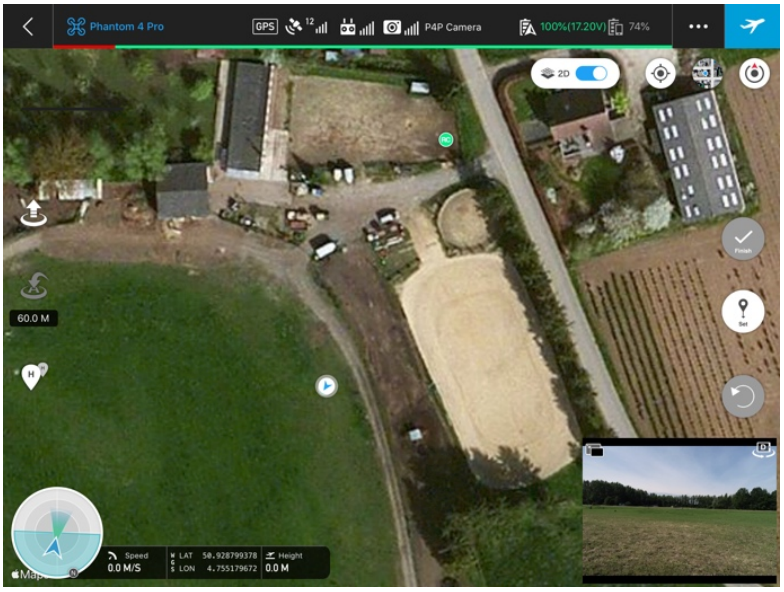
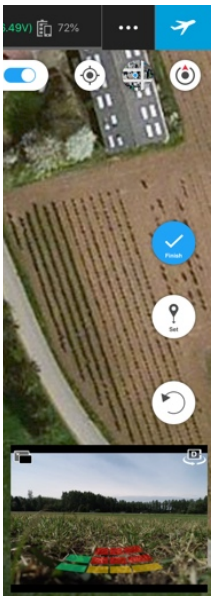
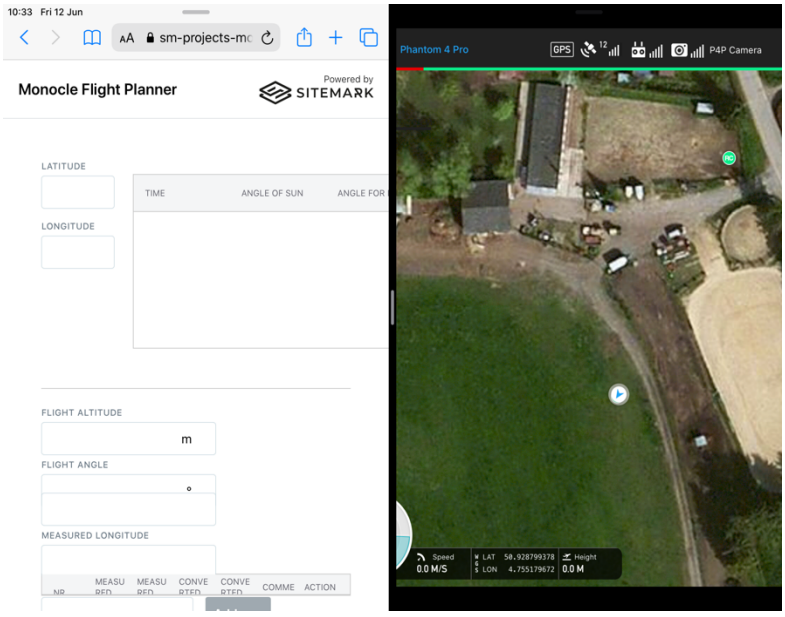


Once you set all point click on finish

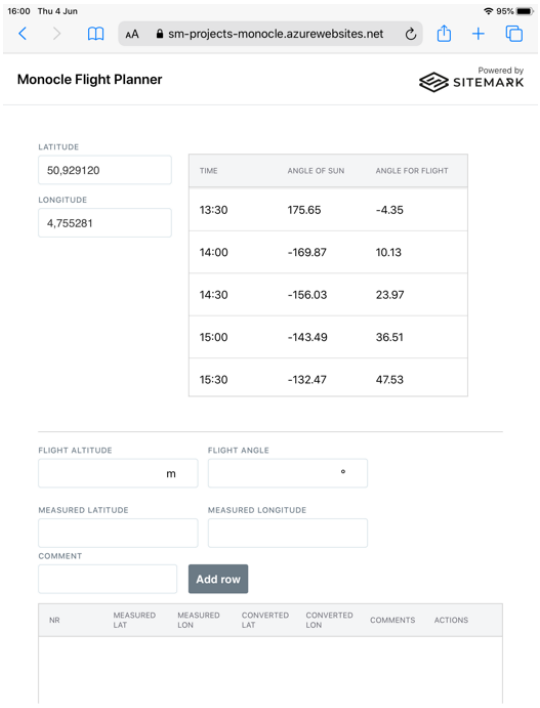


Step 8: Copy one of the captured coordinates to the first section of the app to calculate the sun and the flight angle

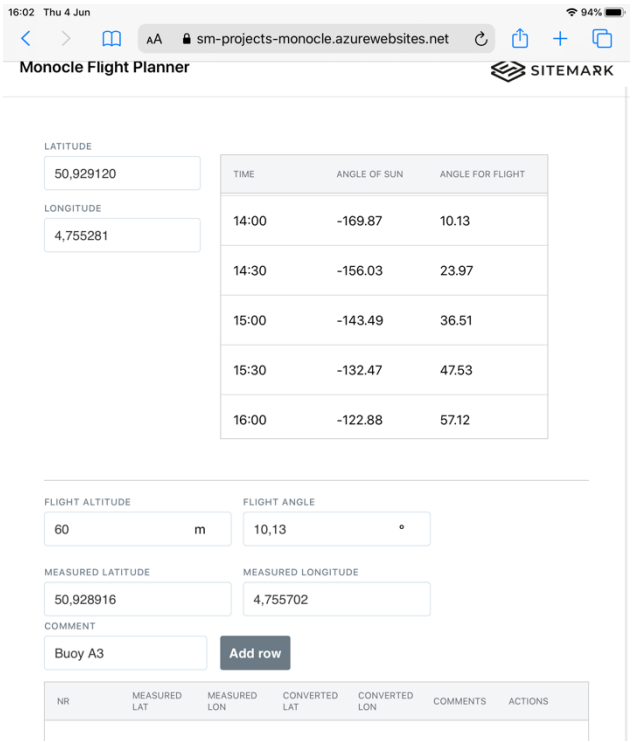


- You don't have to recalculate this angle for every point, just make sure to take the middle time of the flight.
- Place the Monocle Flight Planner tool side by side with the photos app to easily type over the coordinates

Select the time of the flight



Step 9: Take over the flight angle to the second section to start taking over the buoy coordinates.



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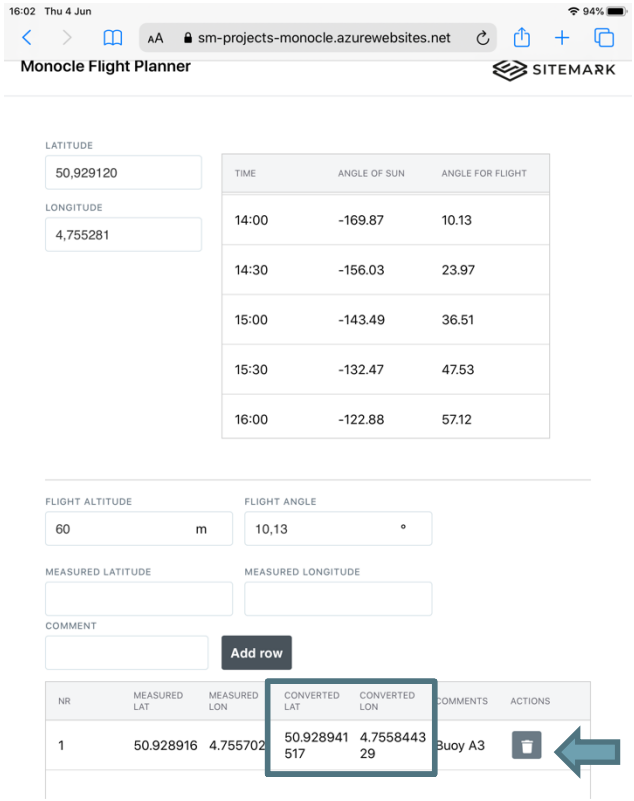
Step 10: Take over the coordinates of the reflectance panel and the buoys into the coordinate convertor



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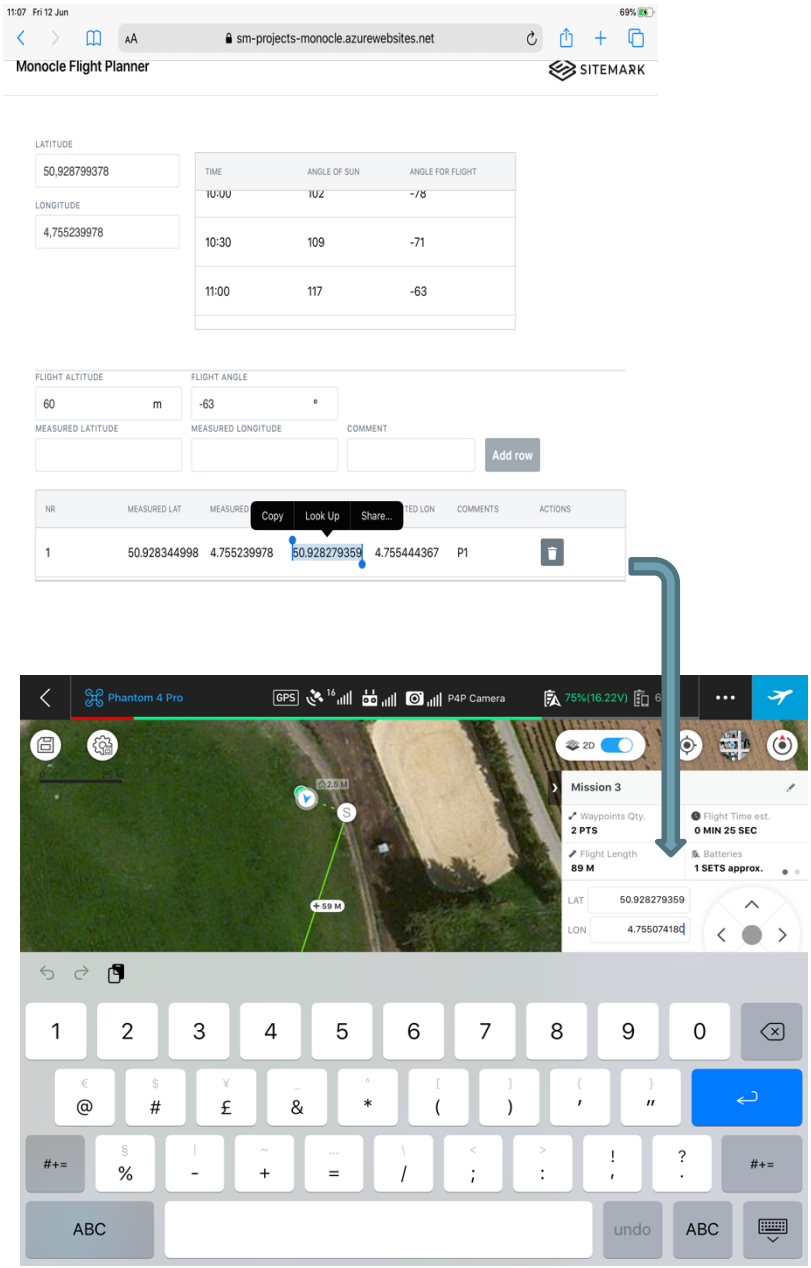
Step 11: Take the results back to GS Pro and update the coordinates (under each point)



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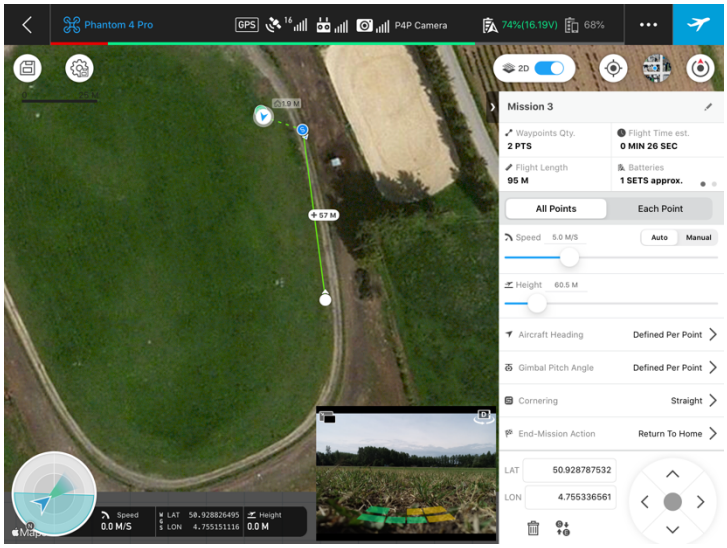
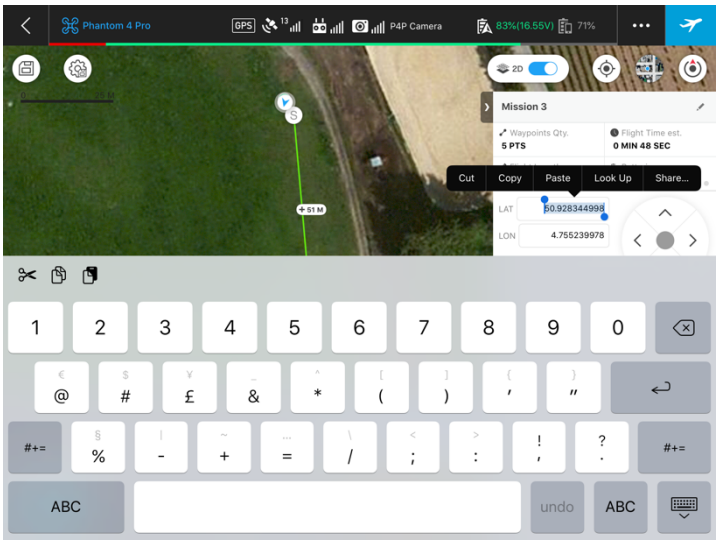
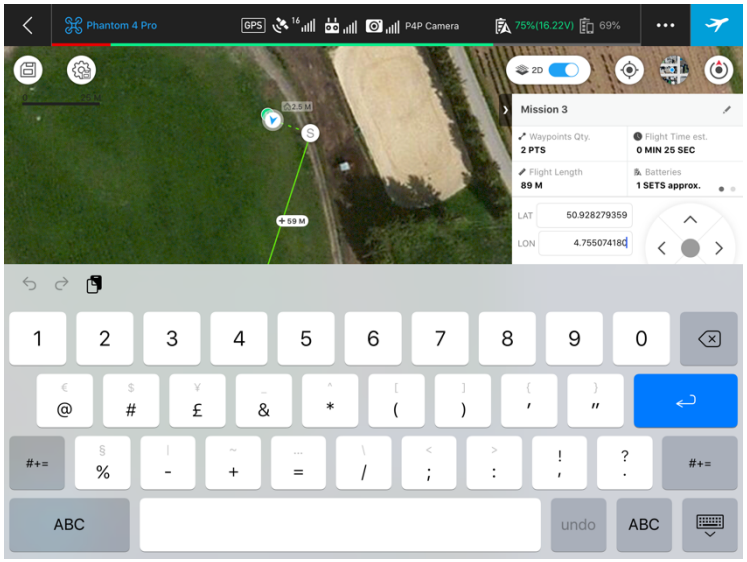
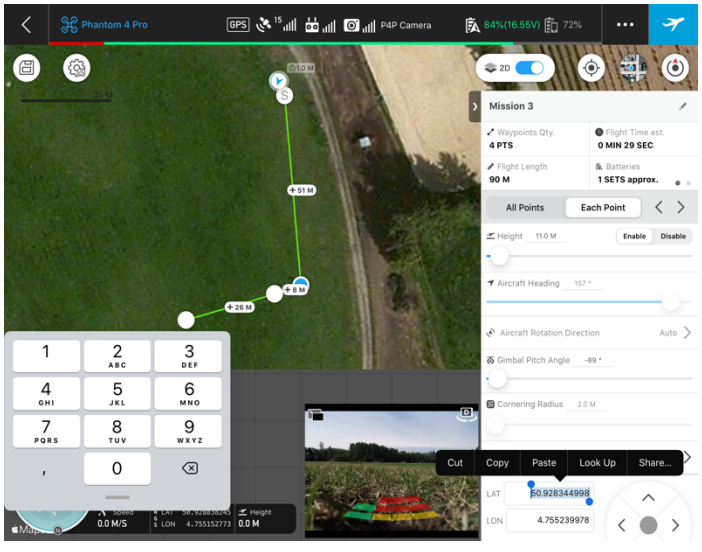
Click on Each Point



Copy & Paste the coordinates







Once all the converted coordinates are entered you can start flying. To do so, set up the camera as guided.

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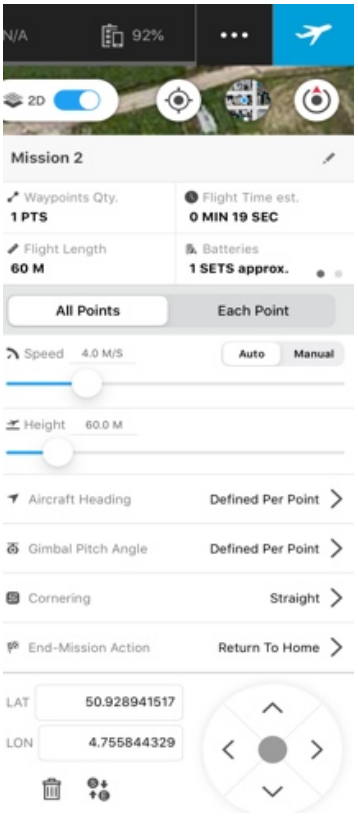
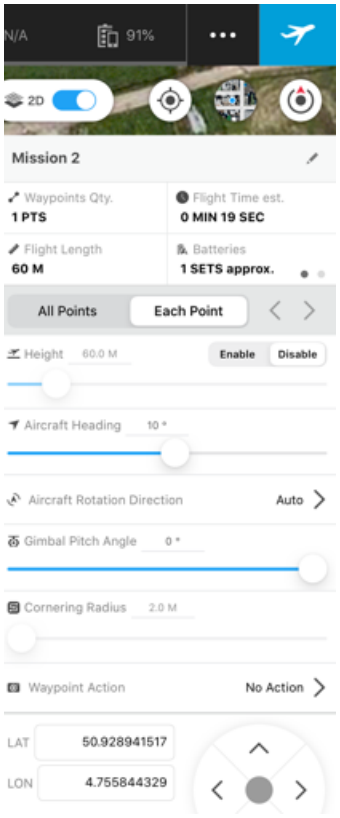
Step 12: Flying parameters in GSPro

Select the parameters as below:





All points

Speed 4.0 m/s

Height 60.0 M

Aircraft Heading – Defined per point

Gimbal Pitch Angle - Defined per point

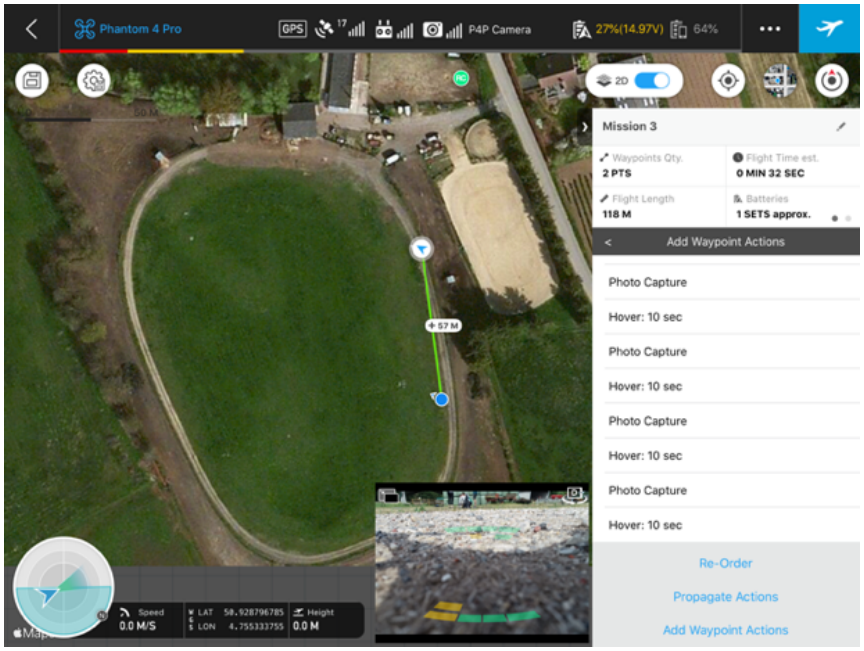
Cornering -Straight

Each point

Aircraft Heading- 10 degrees

Gimbal pitch Angle- 0 degress

Add waypoint actions (for 6 photos we need to 5x times propagate the action, only by that the drone will take 5 consecutive photos)



Add Waypoint Actions

Create a Photo Capture 5xtimes and under always propagate an action: Hover 10sec

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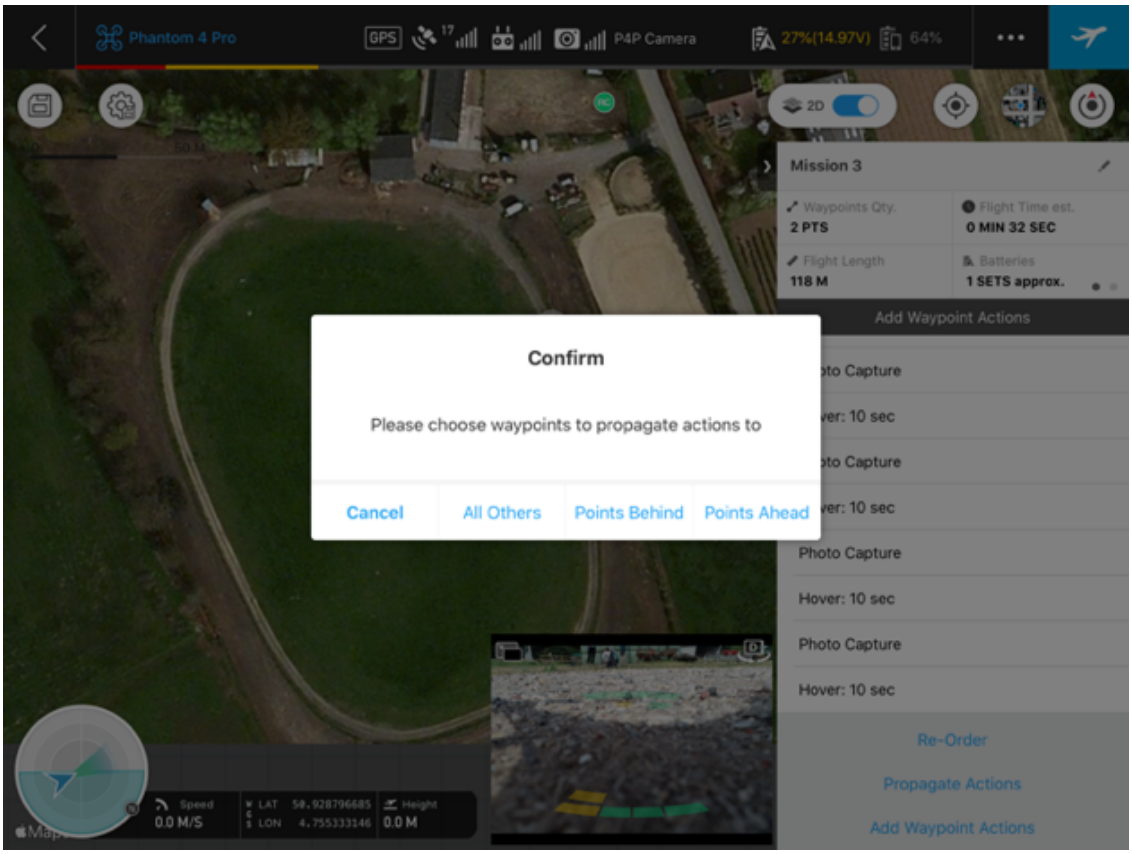
Choose to propagate actions to – **ALL OTHERS**



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Scenario B: Mapping Flight

Mapping scenario:

- Bounding box, with GCP's Included is given → Drone monitors the area
- Overlap requirements: minimum of 80% for RGB camera
- When battery is getting empty → drone lands in time.
- RGB camera at 15° tov nadir, also during flight (in case of only RGB)

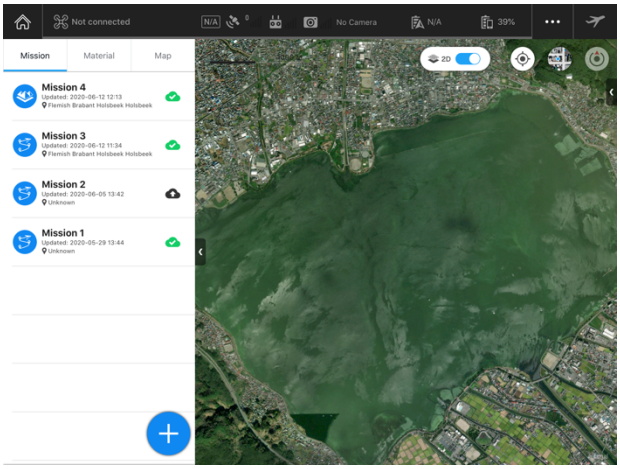
Step 1: Prepare the GSpro app

Step 2: Open the Monocle flight app in a different window

Step 3: Select New Mission type – 3DMap Area + Tap or Aircraft

Step 4: import kml

Go to the mission section – Material – Start Import – upload the kml via the default link



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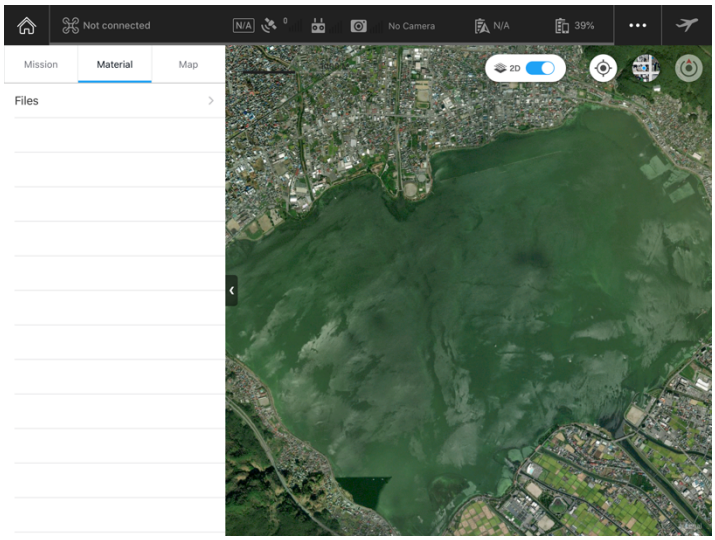
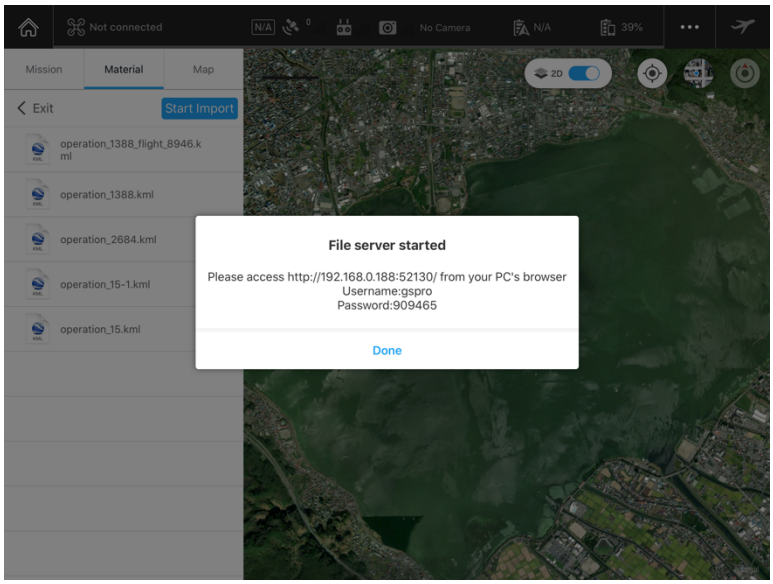
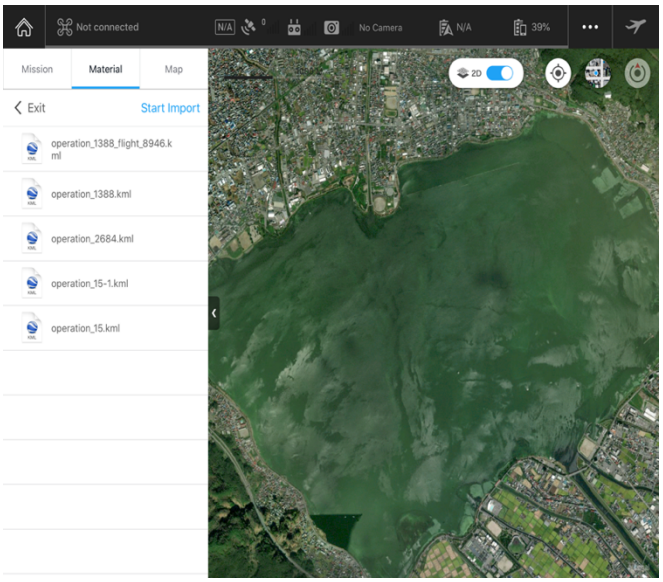
Click on **Material**



Click on **Start Import**





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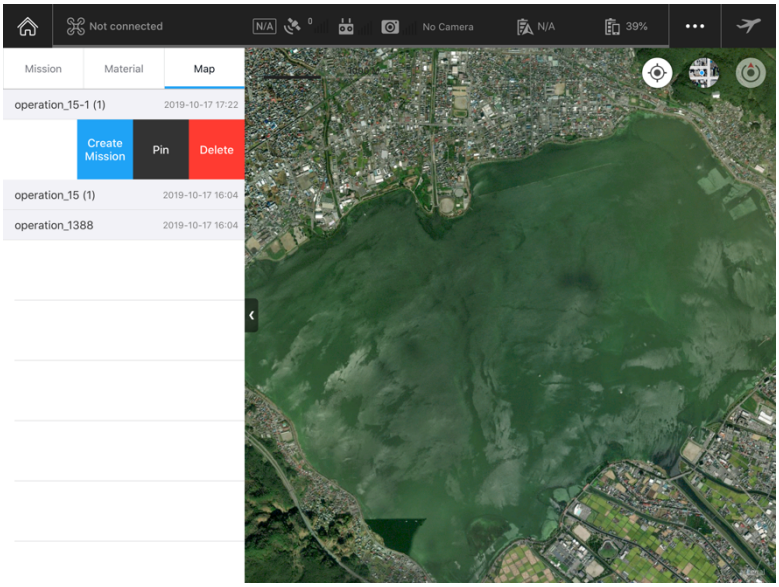
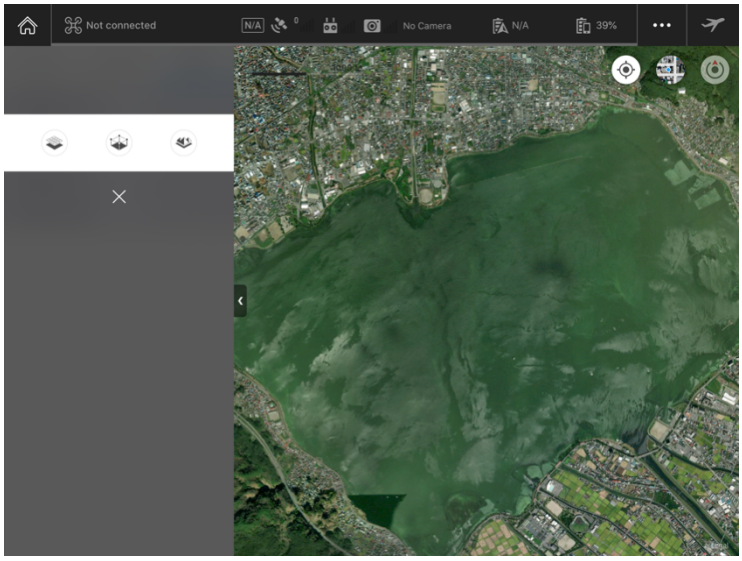
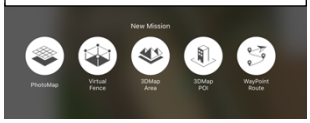
Slide to the left to **Create a mission**



You will receive the three options. Select the 3D map area



Options in GSPro



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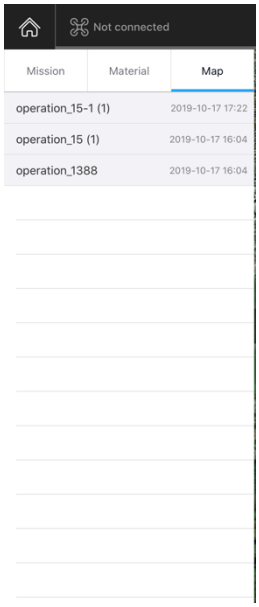
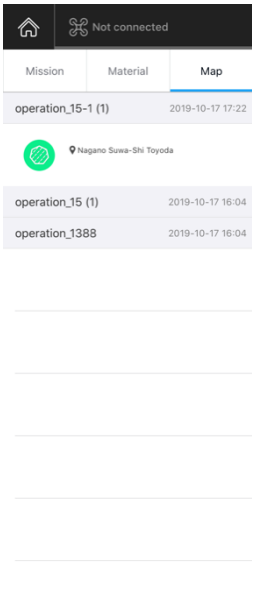
Or if you don't have a kml you can select **Map – and choose the place**





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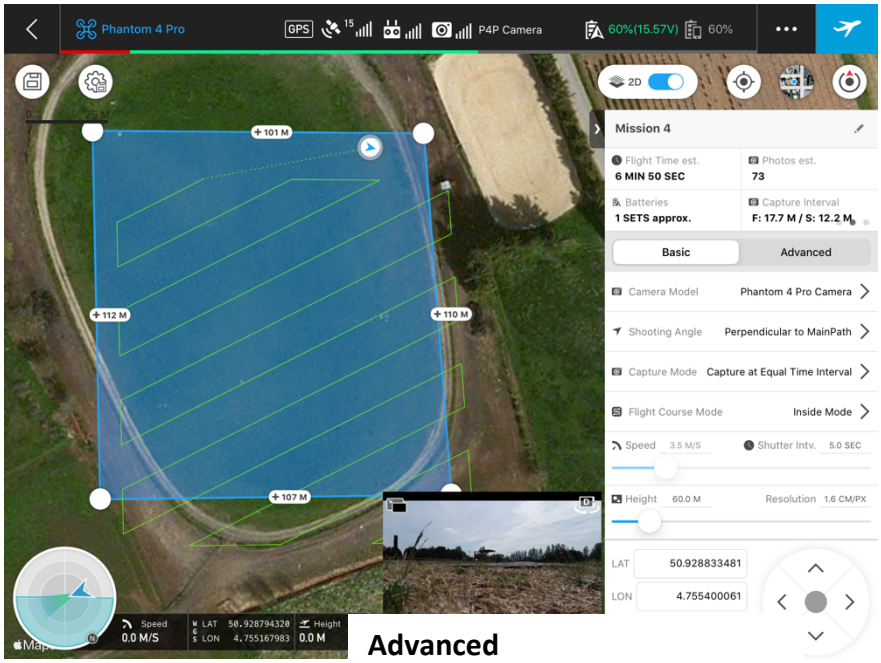
Step 5: Set up the Basic and Advanced

Basic

Camera Model: choose your RGB camera from the list
Shooting Angle: Perpendicular to MainPath
Capture Mode: Capture at Equal Time Interval
Flight course Mode: Inside mode
Speed: 3,5 M/S
Height: 60.0 M
Resolution: 1,6 CM/PX



Advanced

Overlap: 80% 80%

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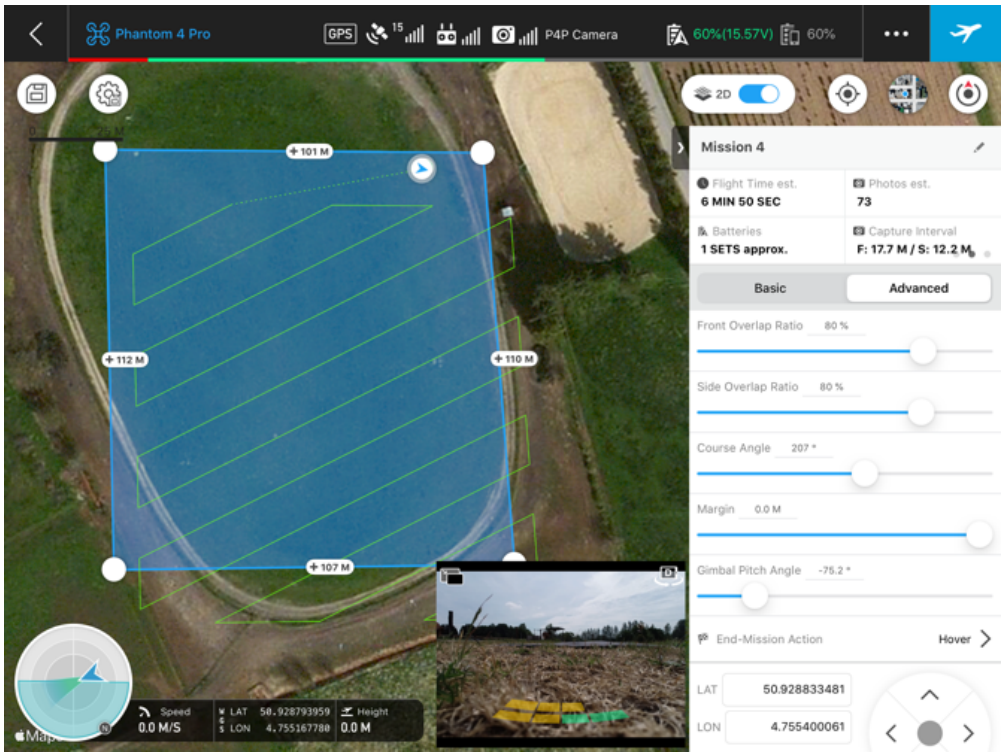
Flight Angle

For the calculation of the flight angle in the mapping scenario you should do the following: if the flight angle coming from our tool is between -180 and 90, you should add 270. If it's between 90 and 180, you should subtract 90.
Two examples:

Example A: In our example the flight angle was -63, which is between -180 and 90. Adding 270 gives 207.
Example B: If the angle for example was 104, it's between 90 and 180. Subtracting 90 gives 14.



Example A

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5.Camera settings

Flying RGB camera – summary

a. Camera settings:

- " F-stop fixed" (4.5)
- White balance: fixed: sunny or cloudy
- Focus on infinity
- Light Measuring mode (partial metering or centre-weighted average metering)
- JPG on max resolution
- Shutter mode = s (shutter speed priority)
- Shutter iso = auto
- Shutter time = 1/2000 (sun) or 1/1000 (clouded)
- Always zoomed out
- Type of image: **RAW**

b. Drone settings:

- Side overlap: 80%
- Front overlap: 80%

- If the weather conditions are stable, it's fine to just capture the reflection panel at the beginning and ending of each flight. Otherwise, you should capture it between every buoy

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GSPro settings (explanation)

- Camera Settings

: Tap to set the ISO, Shutter Speed, F-number and Exposure Value of the camera, Capture Mode, Image Size, Image Format and White Balance, AF Assistant, MF Assistant and Grid.

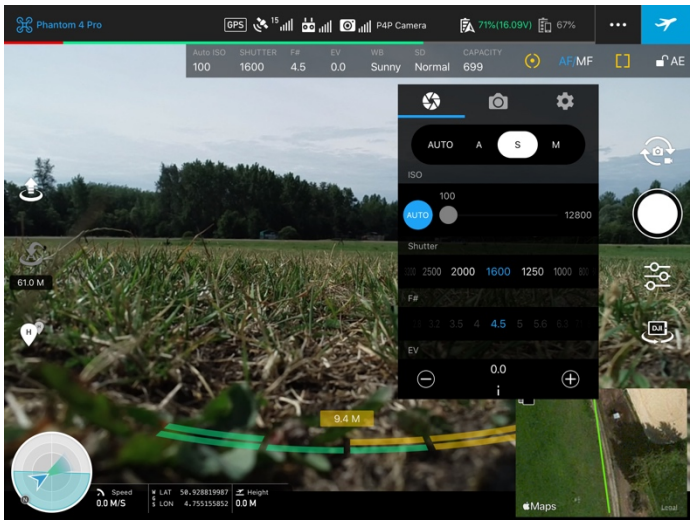
- Map

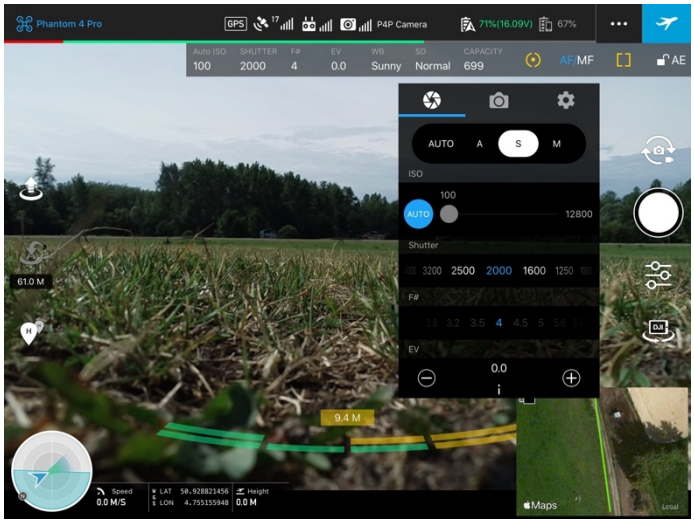
Tap the map to return to the Map View. Tap the icon in the left top corner to minimize the map.

Set up the parameters as below:

Shutter mode = **S** (shutter speed priority) **F-stop fixed** = (4.5)

Shutter time = 1/2000 (sun) or 1/1000 (clouded)





Select Image size: 3:2 / Image Format: RAW

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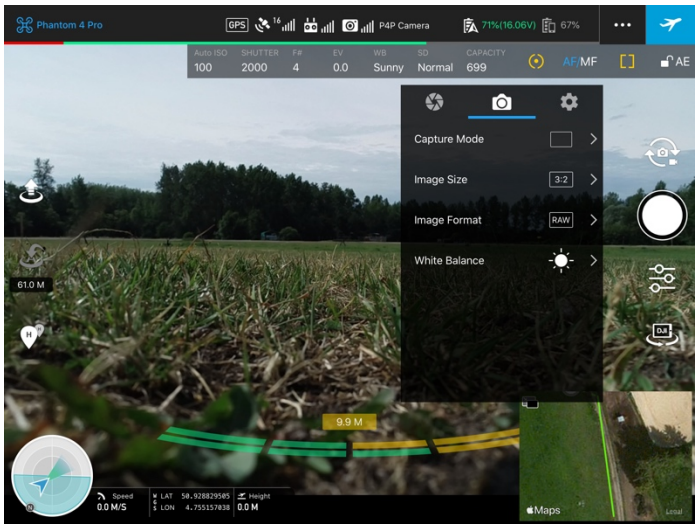
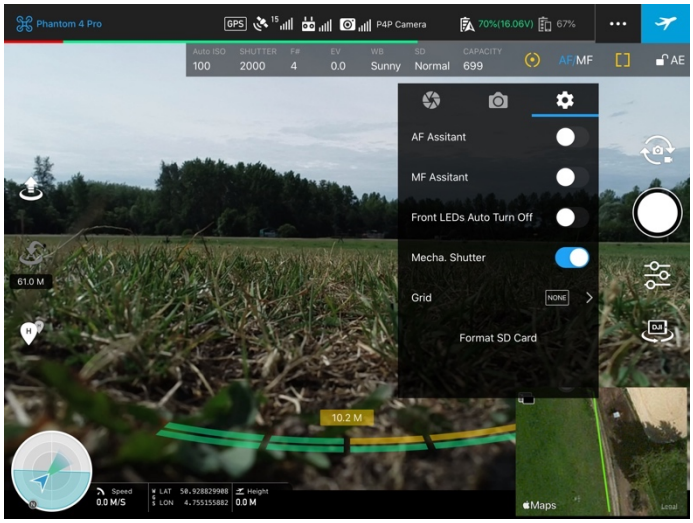


Mechanical Shutter – ON

Grid → you can choose a grid in order to center the buoys for example while looking at the camera - it will give you a squares for better detail



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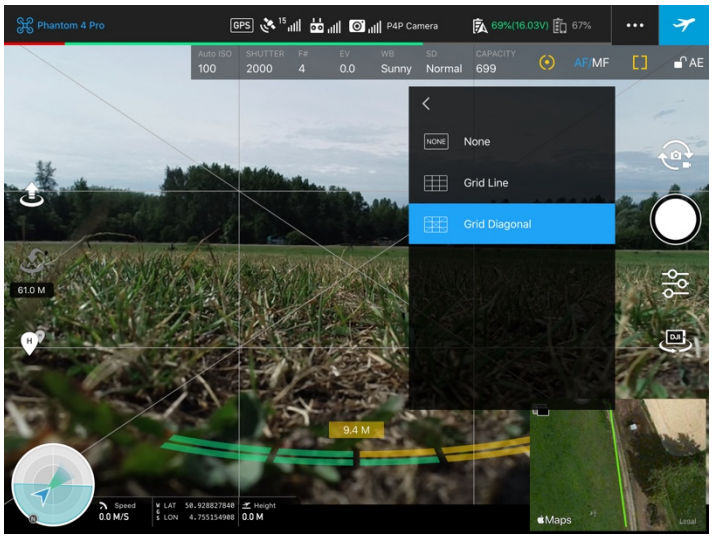
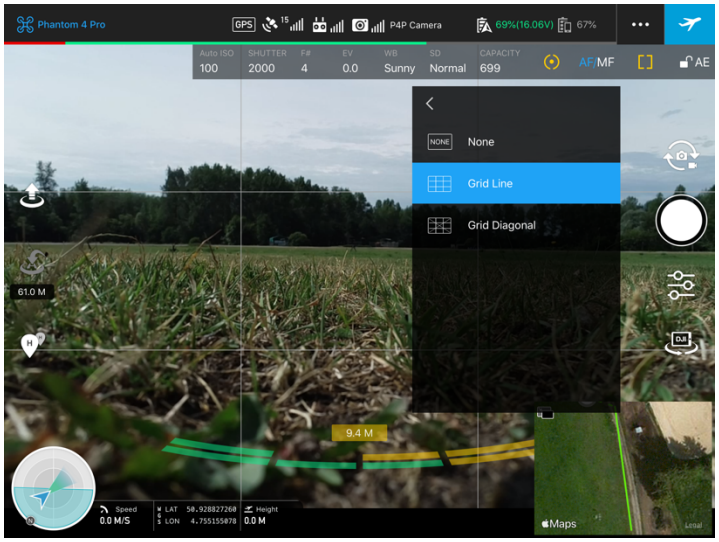
Grid Diagonal



Grid Line



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6. Data upload

Once the drone data is collected, it can be uploaded to an FTP server for further processing. You can use an FTP client (such as winscp) to reach the FTP server.

FTP credentials –

Send a request to remotesensing@vito.be and ask for access to MONOCLE FTP server.

When logging in using these credentials, the user is redirected to the root of the FTP server. The root of the FTP server is indicated below as "/".

Data structure on FTP server

The operator is responsible for creating the following directory structure.

/<mission_ID>/PHA4RGB/remoteInputData/*.DNG (for RAW)

or

/<mission_ID>/PHA4RGB/remoteInputData/*.JPG (for JPEG)

<mission_ID> is defined as follow: <YYYYMMDD>_<location>_F<nn>

e.g.: 20190705_LakeBalaton_F01

With:

- YYYYMMDD: date of the mission. E.g.: 20190705 being July 5th 2019
- Location tag: eg: LakeBalaton
- nn: 2-digit sequence number of the flight, incrementing in case of multiple flights on the same date, starting at 01

The image files need to be copied from the Phantom 4 Pro SD card without modification.

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