# Mapping habitats or monitoring with drone technology.

**Guidance hand notes**

This document is to be used as a guide only. It is the drone operators' responsibility to adhere to all local laws and to ensure the safety of themselves and the general public.

All the hardware and software mentioned are because of the author's familiarity with it, rather than any endorsement. There are many different products out there - it is up to you to choose the correct one for you! Any prices mentioned were correct as of March 2020.

**Before you purchase a drone for data collection**

Please consider what you are trying to achieve with the drone data? Did you choose to use a drone for the right reasons? Does an alternative source of information exist that may be easier to acquire and process. It may be cheaper and easier to use free satellite imagery.

The main reasons why drones are used are because:

- they can deliver imagery with very fine (cm) spatial resolution,
- compared to satellites and manned aircraft surveys, you have much better control over the timing of the survey: you can fly below clouds and once you are in location, a drone survey can be carried out very quickly.
- with larger drones, you may have the flexibility to change sensors depending on your monitoring needs

**Planning your drone-based survey**:

**The success of your flight campaign and quality of survey data is dependent on the pre-campaign planning.**

**Area to be surveyed**

A first step is to establish the size of the area you are planning to survey and the spatial resolution you are aiming for. This combined with your sensor-drone specifications and number of available battery sets will determine how many days the survey will take. The spatial resolution is determined by the height at which you fly the drone and to a lesser extent the flight speed. This in turn determines the total area covered per unit of time. NOTE: the maximum altitude that you can fly in the UK (and many other countries) is 400ft or 120m above ground level. The flying time available within a day, is determined by the number of charged battery sets available, average wind speed and the altitude of the terrain.

Depending upon the legal national requirements, you may also need to:

- Acquire the landowner's permission.
- Locate roads and other public byways and establish how close they are to your survey area – you may have to keep a minimum distance from them.
- Establish if the general public has access – if so you may need warning signs and/or other 'qualified' people to help with crowd control.
- Establish if you will have line-of-sight from where you are flying – this can be difficult if flying over a wooded area or areas of extreme topography for example.
- Establish if there are restricted areas close by (e.g. military base, airports). In the UK we use the Altitude Angel Drone Safety Map (https://www.dronesafetymap.com/) (Figures 1 & 2).

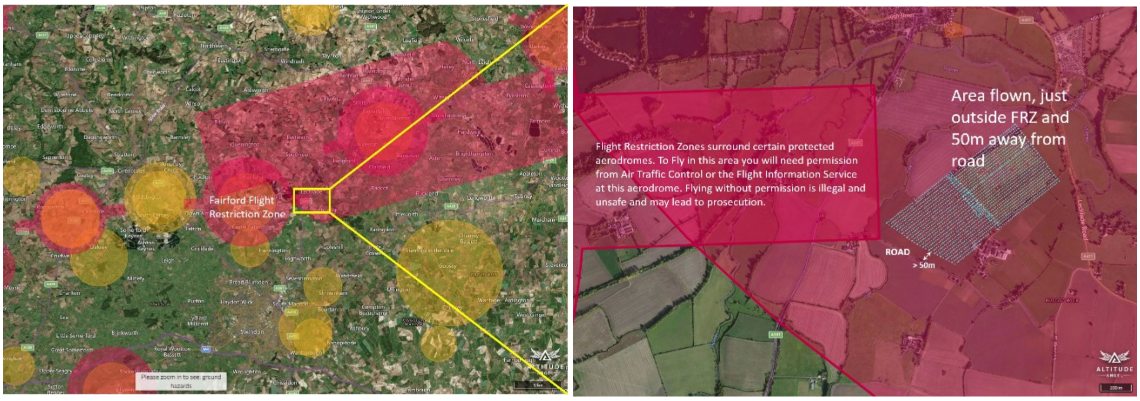



Figure 1. Drone safety map – area flown outside FRZ of Fairford but within CTR of Brize Norton, so ATC need informing about drone flights.

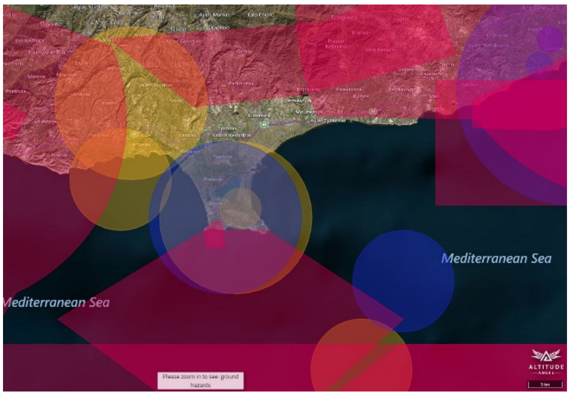



Figure 2. Drone safety map around Akrotiri

**Ground Control Points (GCPs).**

Using GCPs will greatly improve locational accuracy of your drone map. In other words, including GCPs help ensure that the latitude and longitude of any point on your map corresponds accurately with actual real world coordinates. See https://www.dronedeploy.com/blog/what-are-ground-control-points-gcps/ for a guide on how to use. However, an assessment needs to be made as to whether the time taken to accurately locate them is worth the extra spatial precision achieved – If you are locating the corners of a plot of trees for example, do you really need an absolution location within 10cm or is 1m adequate?

**Calibration targets.**

If you are using hyper or multispectral cameras on your drone, then calibration targets are recommended for atmospheric correction and conversion into reflectance. This will enable comparisons over time, and between sites https://arcticdrones.org/2017/05/22/additional-information-on-pre-post-flight-calibration-targets/.

A set of white, grey and black reference panels or sheets are usually recommended, however from experience for vegetation surveys we just use the grey and black as the white saturates the sensors. This is due to vegetation having a reflectance in the NIR of around 50% - approximately the same as a grey target. If you were flying over a bright material such as sand, you would probably use the white and grey panels. We use a sail material called Odyssey from Kayospruce which has a very matt finish, stuck onto an 80 x 80cm frame. In rapidly changing illumination conditions, ideally a target needs to be in every frame taken. However, practically this is not possible, so if to achieve your mapping or monitoring objectives you require imagery that is consistent across space and time seek out days with stable illumination conditions (e.g. clear sky or lightly overcast with high clouds).

**Designing the flight campaign and flying the drone**:

Structure from Motion (SfM) software is used to stitch the individual drone images together to form phot-mosaics and Digital Surface Models (DSM). For SfM to work you will need an overlap between each photo, both along track and between tracks. This needs flight control software to automatically control the flight path, the flight speed and the shutter interval of the drone. Depending upon your drone setup, this flight control software can be an app on a tablet. On a base-map in the software you just draw a polygon around the area to be surveyed, and add such parameters such a flight height and amount of overlap. The flight control software will then plan out a flight path in the form of a grid. For 3D point cloud generation and DSM's you will want 80% overlap in each direction.

**Flight Control Software**

An example of free flight control software is Pix4Dcapture (Figure 3) which works well for flat terrain, and allows a map to be cached for use when out of mobile signal.

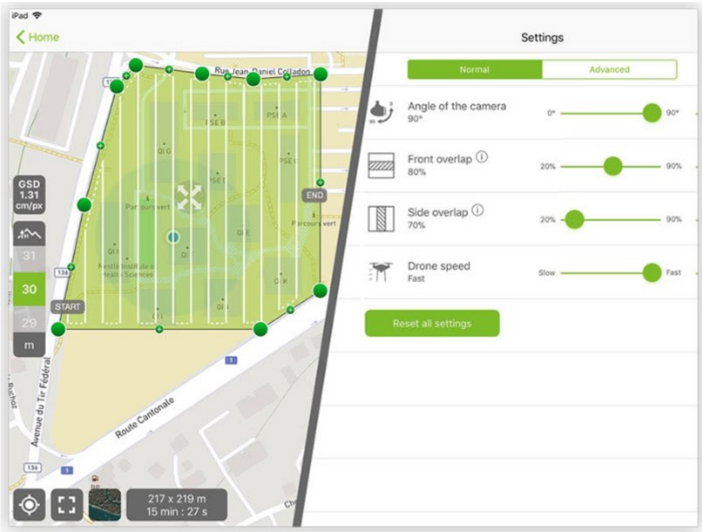



Figure 3. Pix4Dcapture

**Terrain following Flight Control Software**

If the area you intend to survey contains extreme topography we would recommend you use flight control software that allows the drone to change altitude according to the terrain. This will allow the drone to fly at a constant height above the ground (Figure 4) giving a constant ground resolution (and won't fly into the mountain side!!). One such software is Drones Made Easy, Map Pilot @ ~£58. This also allows flight plans to be saved ahead of time. This is useful if the area to be flown does not have any cell reception, and to also save time (and tablet battery) whilst out in the field.

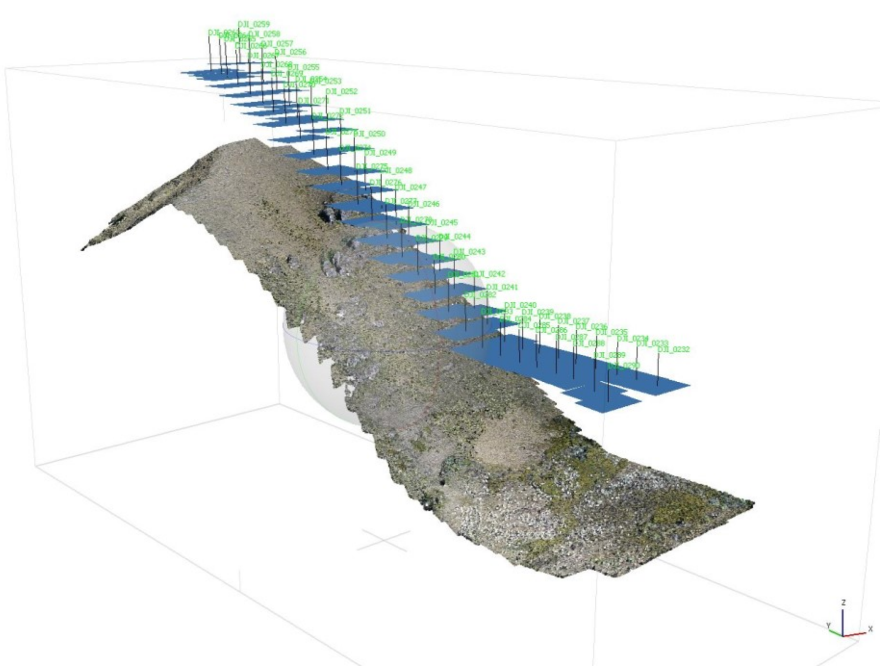


Figure 4. Terrain following flight control software - each blue square is an image taken by the drone at a set altitude above the ground

**Hardware**

Drone:

Your choice of drone and sensor will depend on your objectives and your budget. There are many reviews on the internet. We have included the ones we use:

Drone – DJI Mavic 2 Pro

Pros : RGB large sensor so good signal to noise ratio. Easy to carry as it folds up. Most Flight control software will work with most DJI drones.

Cons: RGB sensor. DJI (Chinese) so military might be suspicious of it.

Drone – DJI Matrice 600

Pros : Can carry up to 5.9kg payload so you can put your own sensors on it eg hyperspectral, thermal

Cons : Is very large and heavy (it's case is 80x80x80 cm, and 32kg when fully loaded)

**Other essentials:**

**Spare batteries** or battery sets. Each set gives around 20 mins mission flying time. Return to home when 30% battery left. We have 8 batteries for the Mavic (~£130 each!) and 4 sets (of 6 batteries) for the Matrice.

2 examples giving the areas we might fly with the MAVIC 2 Pro using 1 battery:

- 40m alt, 80% overlap front and side, speed 4.5m$^{-2}$, for 20 mins flying time an area **180x180**m could be flown to give a pixel size of ~1cm for the orthomosaic and ~ 1cm for the DSM.
- 120m alt, 80% overlap front and side, speed 4.5m$^{-2}$, for 20 mins flying time an area **450x450**m could be flown to give a pixel size of ~3cm for the orthomosaic and ~ 6cm for the DSM.

**Hub charger** to charge several batteries at once.

**Ipad or Tablet** – The flight control software can be operated on either Android or iOS (sometimes both) so can be used on tablets or phones. However, phones are fine for playing around but for mission planning I would suggest you need a larger screen to see the detail.

**Hood** for iPad/tablet (Figure 5) on Drone Remote Controller – as you will not be able to read the tablet even in modest sunlight. This is essential as a lot of critical flying information is displayed on the flight control app such as location of the drone and how much battery is remaining. https://tuff-luv.com/3-in-1-blackout-periscope-hood-for-drone-remote-controller-apple-ipad-air-1-2-new-ipad-9-7-dji-controller-inspire-phantom-plus-others.html

Figure 5 Hood for tablet

**Power supply for ancillaries**

If you are flying multiple missions within a day, then there is a fair chance the iPad and or Remote Controller will run out of battery power, so make sure you take a power bank to recharge them.

**Take-Off/Landing Mats**

These are useful for keeping any wisps of vegetation (grass stems etc) from impeding the rotors when taking off and landing, they also inform the general public where you are landing.

If you are flying where the public is likely to be walking about then you may need some way of separating the landing and take-off zones using cones or poles and tape.

If you can't find a suitable spot to take off and land from due to the vegetation being too long or the terrain not being flat then you may need a table with adjustable legs as your landing zone.

**Problems - too cloudy/windy/shadows/birds of prey**

Always check the local weather forecast beforehand

You should know what the operating parameters of your drone are *eg*. for the Mavic 2 Pro the advised max wind speed is 10 m/s. So take an anemometer into the field. However, be aware that the wind at altitude is generally higher than at ground level or you may be sheltered by the terrain.

Wind can also cause processing problems if it moves the vegetation around, as this will mean from one image to the next the pattern of the vegetation will have changed. As SfM relies on pixel patterns being recognised in neighbouring images, if the scene is changing as it is being blown about, anomalies can be introduced into the final products.

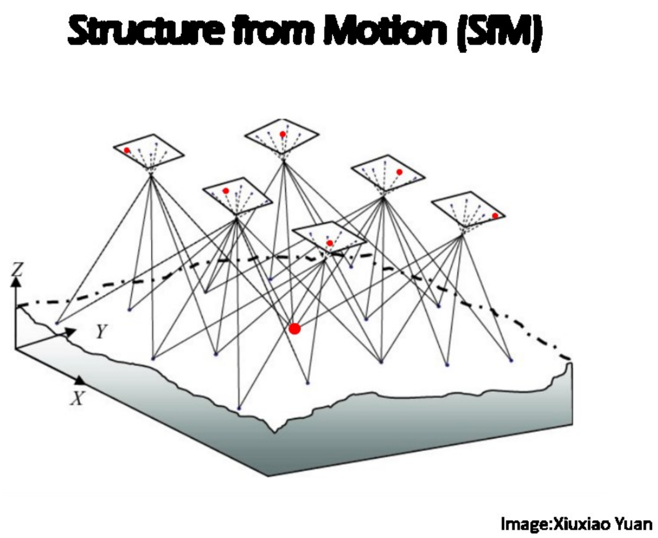
Some flight control software (*eg*. DJI flight app Go 4) will tell you if it is too windy, or you may see the drone veering off the expected path on grid shown on the app. If you notice this happening you should manually take over and using the remote controller lower the altitude of the drone to where the wind velocity is less and fly back towards the landing area. If you think wind may be a problem, if possible make sure you are standing downwind from the survey area, as then if the wind gets too strong the drone will be blown back towards you, not further away.

Be aware of large birds of prey – the only thing you can do is keep an eye out and stop the flight if necessary.

For surveying purposes you should not fly your drone through clouds (fog) or rain, as any water between the drone and the ground will attenuate the signal. Many drones also are not waterproof.

**Processing:**

To stitch all the images together Structure from Motion (SfM) software is used. SfM uses photogrammetry to form 3D point clouds from the overlapped imagery, from which orthomosaic and digital surface models (DSM) can be constructed (fig 6). The orthomosaic can then be manipulated as you would any satellite imagery.



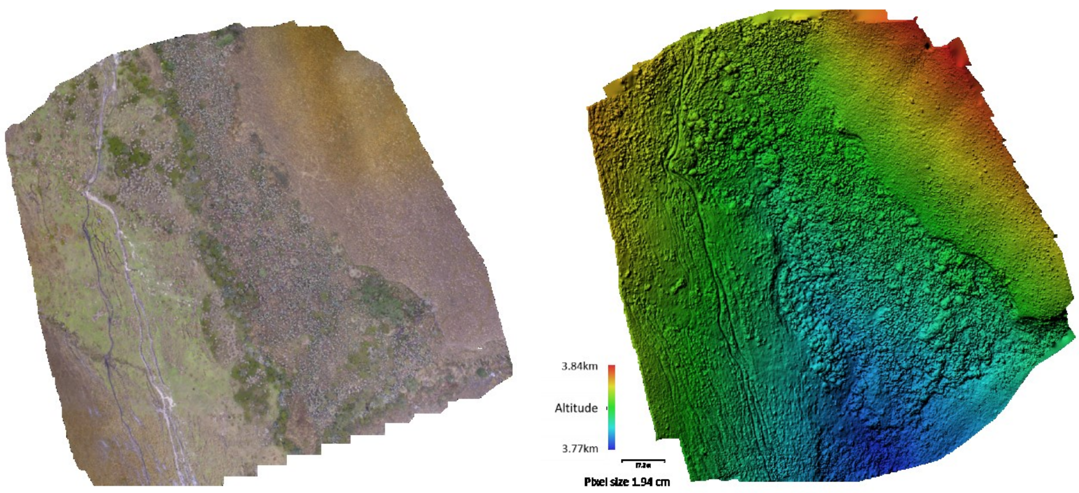




Fig 6. Orthomosaic and DSM constructed from 91 aerial images using SfM

We use Agisoft Metashape to construct the orthomosaic and DSM. The process consists of 3 main steps:

1. Alignment: feature points across images are matched into tie points, and for each image the position of the camera is estimated. These camera positions are required for the 3D surface reconstruction.

2. Generation of Surface: Based on the estimated camera positions and using dense stereo matching of the images a dense point cloud is constructed.

3. Orthomosaic creation: The individual images are projected according to their internal and external orientation data onto either the DEM or mesh surface.

See https://www.agisoft.com/pdf/metashape-pro_1_6_en.pdf for details.

There are two main choices when it comes to processing your imagery. If you are planning to carry out a lot of image processing and would also like to have more control over the processing parameters, then you should consider use SfM software installed locally on your own computing system. However, if you are only surveying a few times a year, it may make more sense to use one of the cloud processing options available.

To run the software yourself, you will need a high end PC with a dedicated graphics card – an example is shown below:

**Example of PC setup.**
Agisoft Metashape Pro Edition $3499
High end PC (>64GB RAM, CPU: Octa-core or hexa-core Intel Core i7 CPU GPU: Nvidia GeForce GTX 980 Ti) ~ £4000 ( see https://www.agisoft.com/downloads/system-requirements/)

There are also open source alternatives such as OpenDroneMap ($57) https://www.opendronemap.org/ For a list of software see https://all3dp.com/1/best-photogrammetry-software/

Cloud processing packages include:
Pix4D mapper $216 Month
DroneDeploy $299 Month
MapsMadeEasy PAYG

(There are many more companies out there and the list is continually growing.)

**Additional costs**
Liability Insurance – depending upon your fleet and how many operators you have, it might make financial sense to not have an annual policy, but to insure on a daily basis. Plenty of insurance firms do this now (eg Coverdrone).

Time for maintenance – depending upon the drone manufacturers recommendations you should thoroughly inspect the drone for loose screws and worn parts etc. You also need to keep up-to-date with firmware upgrades (always test your drone after any upgrades).

Batteries – be aware that the batteries are a ‘wearing part’ and so will need replacing depending upon use and storage.