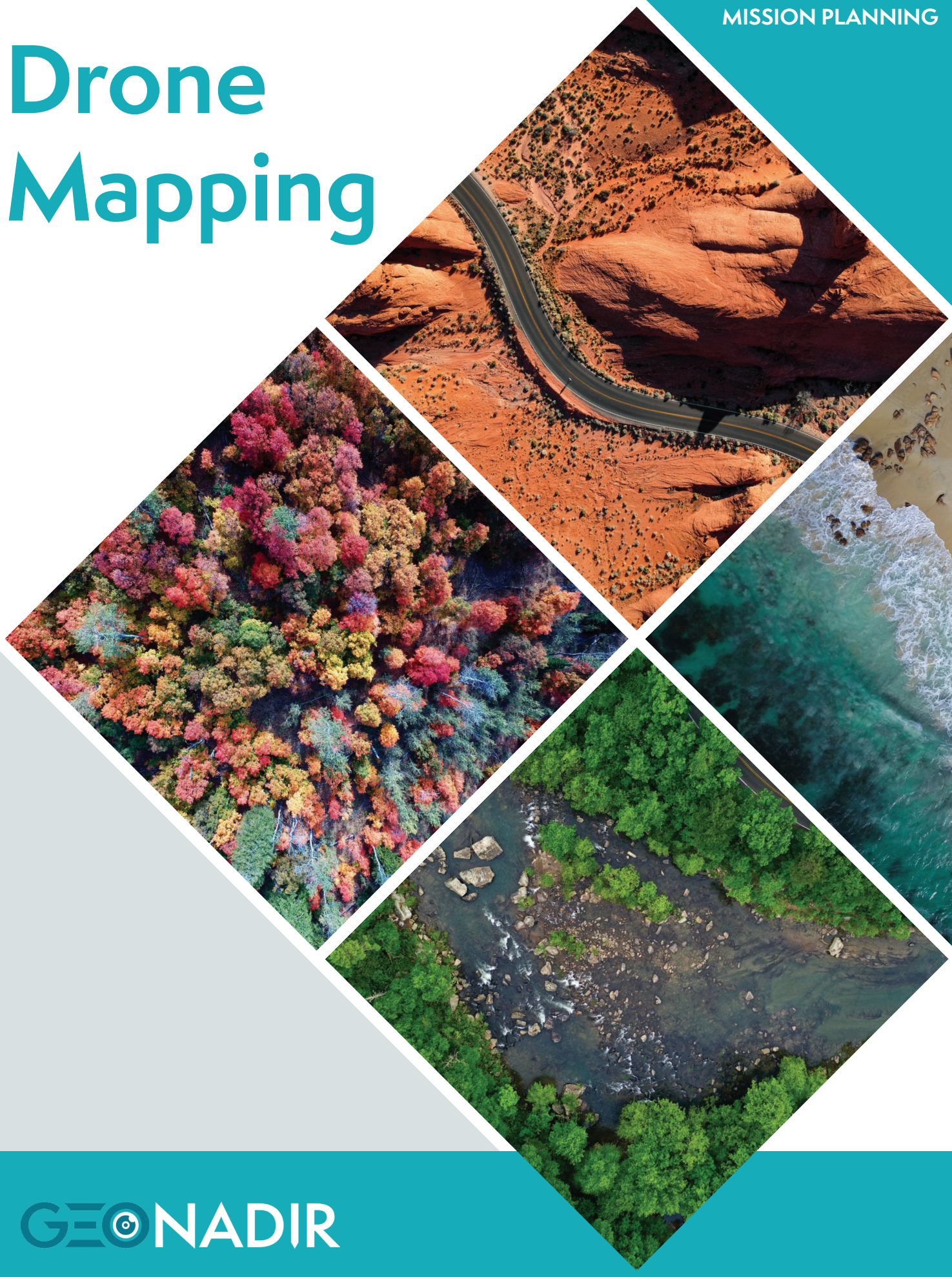
AN INTRODUCTORY GUIDE TO

# Drone Mapping

PART 1
MISSION PLANNING



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# Contents



Photo by Abdhulla Yashau, Unsplash

## Foreword

– By Dr Karen Joyce

As you embark on your drone mapping journey, it's important to remember one thing: time spent in mission planning is time saved in data analysis.

Prior planning really does make a difference if you want to capture analysis-ready data.

I've written this e-book to help you guide you in that mission planning phase, so you can benefit from my years of 'experimenting' and making mistakes in this space!

01

# TOP 10 TIPS FOR DRONE MAPPING

Not all data is good data. It takes time and effort to make sure we capture our data in ways that are conducive to how we wish to process them, and will allow us to extract real information.

In the fitness industry, we have a saying – you can't out-exercise a bad diet. In other words, exercise is never enough unless you get the nutrition right in the first place. I like to apply this to drone data capture – you can't out-process bad data! So the key is to capture 'good' data in the first place and you'll save yourself a lot of headaches in the processing stage.

I can also honestly say that in the past eight years of ongoing learning about how to capture 'good' drone data, I've also captured my fair share of 'bad' stuff :). This obviously can become expensive! But the upside of this is that you don't need to make the same mistakes, because I've generously made them for you...

If you read no further in this e-book, at least check out my top 10 tips for capturing 'good' drone mapping data.

## 01

**Safety first.** Make sure that you follow your local regulations and do the appropriate safety checks with your equipment.

## 02

**Choose a good mission planning app.** This will depend on the type of drone you are flying, and the device you would like to use for planning. I like using (a) Drone Deploy as I can plan on desktop, iOS, or Android (b) DJI GS Pro, but this is only on iOS unfortunately; or (c) Pix4D Capture – this one's good as there are some non-DJI options as well, and can be used on iOS or Android. Learn more in Section 4.

## 03

**Plan to cover an area larger than you actually need.** When we orthomosaic images together, the edges of the composite can be a little dodgy. So don't let your important features be right on the edge of your coverage.

## 04

**Fly at least three parallel lines in a single grid** (not a cross grid). Multiple flight lines is important to get the full coverage of your area with sidelap (overlap between flightlines). I know that some people prefer cross grid, but I've always found that not only does it double the amount of flight time required to cover an area (i.e. less total area covered), the final orthomosaic product doesn't work out so well.

## 05

**Choose your altitude carefully.** There is a tendency for people to want to fly higher and cover larger areas, but there is no point in doing this if it is no longer possible to detect your feature of interest. You should first determine the size of the smallest feature you need to detect, and then use that to decide the resolution of the required imagery and then calculate the altitude required to achieve that pixel size. Learn more in Section 2.

## 06

**Be generous with overlap and sidelap.** The software used to orthomosaic (stitch together) your images and create 3D models requires high levels of overlap to match photos together. The center of every photo is also the least distorted component, so the high overlap allows the algorithms to favour these areas. While it is a little environment dependent, I recommend using 80% overlap and 80% sidelap to start with as it is easy to remember!

## 07

**Keep your drone camera at nadir.** Make sure that your camera is set to point directly down! Unless of course you want a map of the horizon.

## 08

**Timing matters.** I recommend capturing data around the middle of the day in terrestrial environments to minimise shadow. However, if you have any water in your area at all, stay away from the middle of the day! Otherwise, you will end up with a nasty reflection of the sun right in the middle of the best part of your photo. I therefore recommend around 10am or 2pm if there is water. This will depend on location and how many daylight hours you have – the earlier in the morning or later in the afternoon the better, but there will come a time when the light is inadequate, so keep an eye on that. Learn more in Section 3.

## 09

**Use a fast SD card, and change between flights.** The microSD cards are inexpensive, so keep a good stash of them. That way if you happen to lose your drone, you don't lose and entire days' worth of data.

## 10

**Know how to cancel the mission in-flight!** There are many reasons why you may want to call the drone home early. Check your app, device, and drone for how to do this safely.

02

# WHAT HEIGHT SHOULD I FLY?

Although this is a frequently asked question, it's the wrong question to ask. What is more important is to understand the size of the feature/s that you are trying to map.

It may come as no surprise that as you increase the altitude of your drone, you are able to photograph larger areas. But the trade-off is that in doing so, you lose the amount of detail you can see in each image. There is absolutely no point in covering a large area if you can no longer identify your feature of interest!

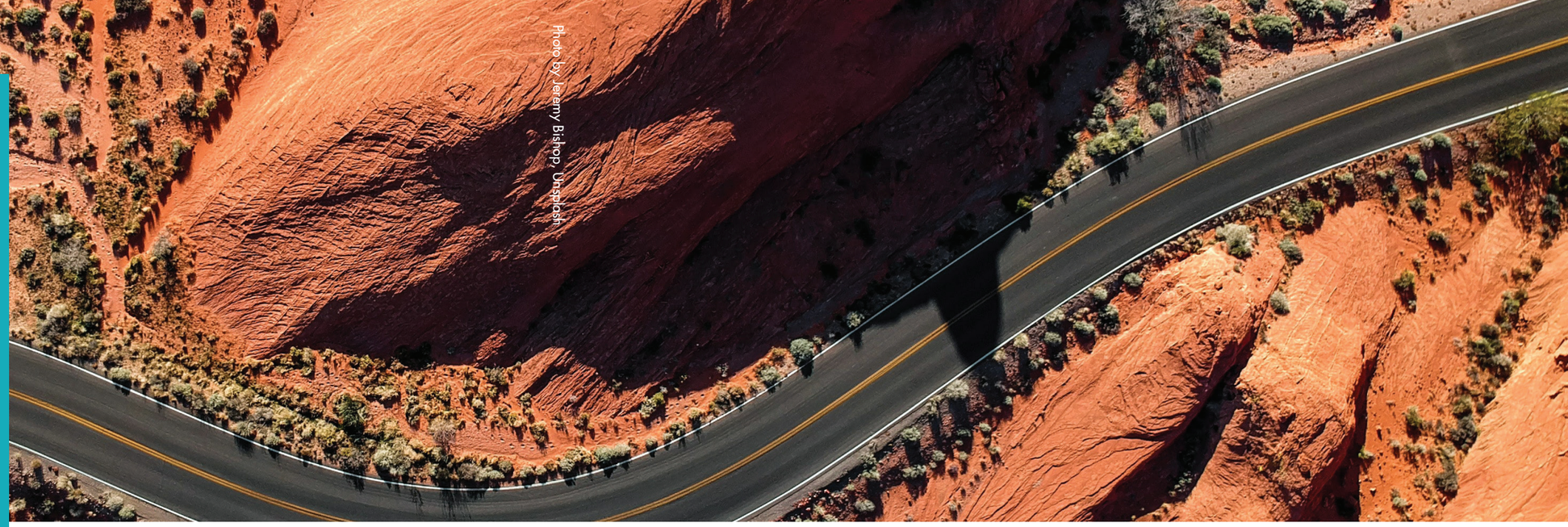


Photo by Jeremy Bishop, Unsplash

## How to calculate the optimal flying height

To figure out the optimal flying height for any particular application, follow these steps:

1. Determine the size of the smallest feature that you wish to identify (e.g. a particular weed of minimum size 20cm).

2. Take the number that you determined in (1) and divide by 10... this is roughly the minimum pixel size that you will need in your imagery. In the example of the 20cm weed, you need a 2cm pixel size.

3. Do a google search to find your drone camera specifications.

4. From the specifications, determine the camera field of view (FOV), which is the angular measurement of the sensor. For example, a fisheye lens has a 180deg FOV. The Phantom 4 Pro FOV is 84deg, and the Mavic 2 Pro is 77deg.

5. From the specs, determine the size of the pixel array. The Phantom 4 Pro and Mavic 2 Pro both have 5472 × 3648 arrays.

6. Revisit your high school trigonometry class and use TAN to figure out the required flying height based on your drone camera specifications and the pixel size requirement. Refer to this video to follow the calculation. I'm pretty sure that this is the only application for which I ever used trigonometry since I left school!

## Wait, there's a shortcut...

If it all sounds too hard to do steps 3-6, and math isn't your strong point, you might be pleased to learn the shortcut. You can use a drone mapping mission planning app, and as you experimentally change your planned flying height, it will estimate the resultant pixel size. For example, if I plan a mission in DroneDeploy based on using a Phantom 4 Pro, I can see that at 66m altitude, I can expect to achieve a 2cm pixel size, while I can fly at 90m altitude with the Mavic 2 Pro. If you're going to use this method, double-check that it is basing the calculation on the correct drone. You can find the planning camera in the advanced settings section of DroneDeploy.

Be aware that the flying altitude you set will be relative to the take-off location unless you are using an app with a terrain-following feature where the altitude is relative to the ground above which you are flying. This means that the effective resolution of your imagery will actually vary throughout your region of interest – unless it's a flat region.

## Remember to check local drone flying regulations

As always, please check your local regulations to ensure that you are not exceeding the maximum flying height. In Australia, that's 400 feet or 120 metres, though that ceiling height may be lower if you are within the approach or departure path of an airport.

# 03

# WHAT'S THE BEST TIME FOR DRONE MAPPING?

One of the things that I love about working with drones is the ability to be flexible about when and where I fly to capture data. I've worked with satellite data for over two decades and it can be really restrictive when data are only acquired at a set time of day, and only when the satellite passes over a specific location.

The orbit of many satellites is designed such that the satellite can capture data in the morning, aligned with the statistically determined probability of lower cloud cover. But what if that time of day isn't optimal for some other aspect of the environment of interest? Or what if it happens to be raining or cloudy on the day of capture? That means that we can miss our window of opportunity to capture imagery for our application.

## So what's the solution?

Having flexibility with drones means we can manipulate the Venn diagram to find the optimal time of image capture. We look for times where the optimal weather conditions, environmental conditions, and our own availability align – or at least present the least compromise. For more detail, check out this paper: Joyce K, Duce S, Leahy S, Leon J and Maier S (2019) Principles and practice of acquiring drone-based image data in marine environments. Marine and Freshwater Research, 70(7): 952-963. If you don't have access to this journal, email GeoNadir on hello@geonadir.com and we'll get you a copy of the paper.

Photo by Spencer Watson, Unsplash





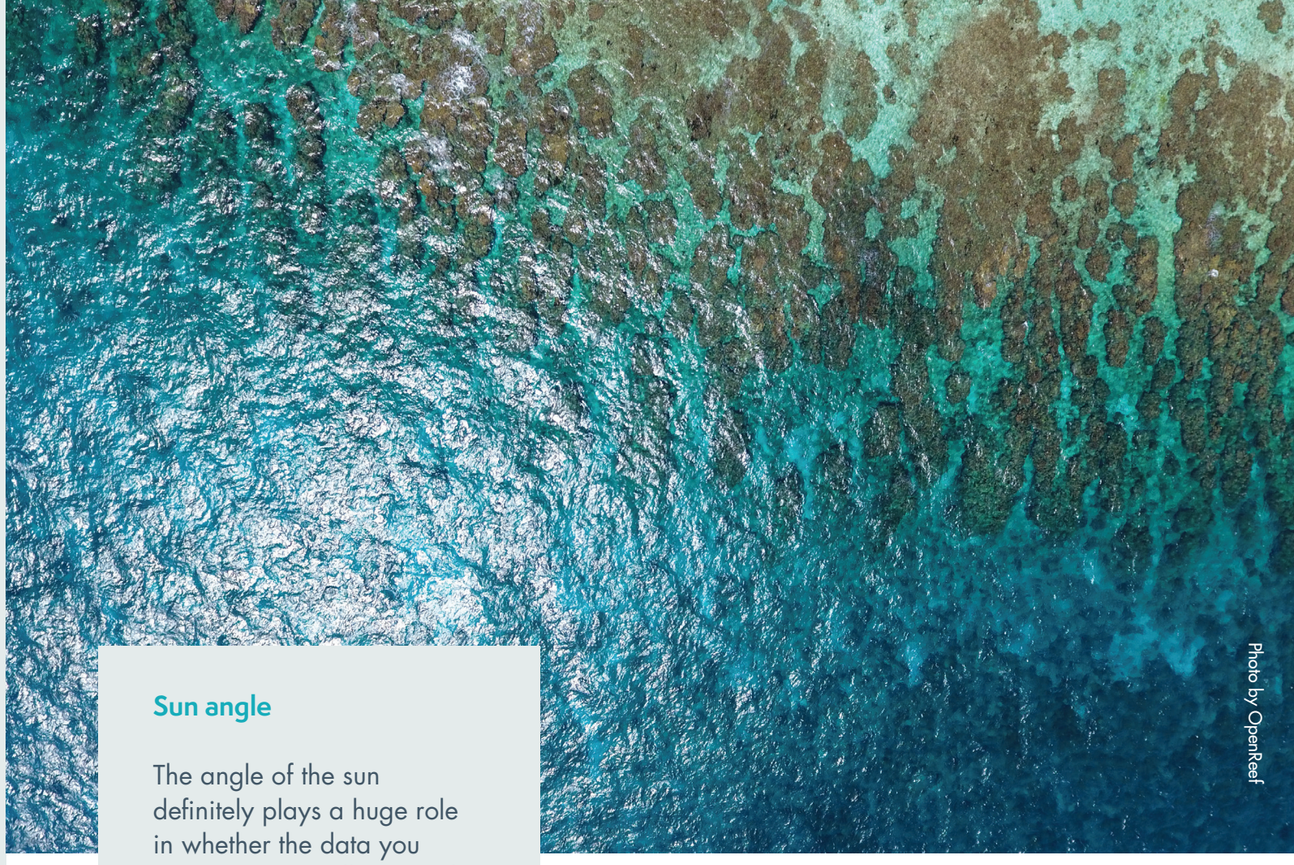


Photo by OpenReef

## Sun angle

The angle of the sun definitely plays a huge role in whether the data you capture are excellent or sub-par for a number of reasons. The sun needs to be high enough in the sky to provide sufficient light for quality photography, but the actual time of day corresponding to 'sufficient light' will be location and season-dependent. Low sun angles also create shadows from tall objects (trees, buildings, boulders), so it's best to capture data close to midday in terrestrial environments to avoid these shadows (unless you want to use them to calculate object height!). Conversely, the middle of the day is terrible if you have water in your scene as the sunlight will mean that it's very difficult to see below the surface of the water.

## Clouds

While clouds are less likely to obscure features in drone imagery than with satellite data (drones generally fly below the clouds), shadows and varying light intensities due to clouds impact the quality of mapping data (see this image by Daniel Nugroho, on the GeoNadir Platform). Where possible choose a completely sunny day, or alternatively one with uniform, thick cloud cover for more stable lighting.

Photo by OpenReef

## Wind

All drones have an upper limit in terms of their ability to operate effectively in wind, but this will most likely be far higher than the wind levels that are tolerable for mapping. Because the process of stitching together individual photos relies on software being able to identify matching features in adjacent images, problems arise when those features are moving. So grasses, leaves, branches, etc. blowing in the wind are not so good. In marine or aquatic environments, surface ripples or white caps on water bodies are also not good. Unless you want to study water movement of course!

## Seasons

Perhaps you are interested in a particular plant and it's easily distinguishable from the surrounding vegetation at a certain time of year when it flowers, for example. Or maybe it stays green for longer during a dry season. It's important to understand the ecosystem to determine the best time of year you capture your data to achieve success. You can distinguish the native grasses from the invasive buffelgrass in this image as the native grasses are much greener.

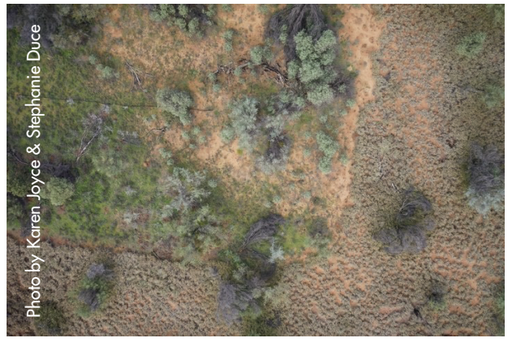


Photo by Karen Joyce & Stephanie Duce

## Tides

If you are working in a coastal or marine environment, chances are you are conscious of the tides in your location. As water obscures submerged features, we want to fly on those days/times when the tide is as low as possible. If you look over the side of your boat and can't see the bottom, then don't expect a drone to magically be able to do so. The image on this page is pretty cool as you can see how water depth affects our ability to see the corals. It's very low tide and in the bottom half of the image, the water depth would be less than 30cm. Of course, it was a spectacularly calm afternoon as well!

## The Goldilocks Zone

Finding the time that's 'just right' for you and your application can definitely be a challenge. You can probably see that aligning all of these factors might seem nearly impossible, depending on the environment you are mapping. But the idyllic days do exist, we just need to be flexible and ready to get our batteries charged in time!

With experience, you'll get to understand your own level of compromise on 'perfection' as well. But remember that it's better to put time into capturing analysis-ready data in the first place, than trying to out-process bad data.

Photo by Karen Joyce & Stephanie Duce


# 04

# SELECTING A MISSION PLANNING APP

Yes, apps can make our lives easier, but do we really need so many of them?! Let's check out some of the free (or freemium) options in the mission planning phase of drone mapping, what they're used for, and some of the pros and cons of each. This will hopefully help you narrow down the most appropriate app/s for you to use for your specific needs.

There are two main categories in my app-stack for drone mapping. There are apps that control the drone itself, then there are apps that provide a peripheral but equally important service. The latter help me ensure that I am operating safely and legally. So let's start with the peripheral apps, as they are the first that I consult as I develop a drone mapping mission.




## Peripheral drone mapping apps

There are a plethora of apps available to help us make good decisions about when and where we fly. Here are some to consider:

### Safety and regulations

Note that the following apps only provide guidelines and it is still the pilot's responsibility to check with local authorities and regulations. They have however been verified in Australia by CASA.

OpenSky – Available via a browser, iOS, and Android, and no apparent limitations outside of Australia. The interface is simple to use, a map legend is available to describe the category of each restriction, and the detailed information for a 'clicked' location is thorough though simple. There is an option to change the type of pilot (e.g. recreational, commercial excluded, or REOC holder), as well as to set the planned flight date and time. National park warnings are included.

AirMap – Available via a browser, iOS, and Android, though outside of Australia it's recommended only to use the browser version. There is limited functionality or customisation available without creating an account, and it doesn't appear to cover marine/national park boundaries as part of the restrictions. There is also limited information related to the restrictions that apply in any of the annotated areas, except to show that they exist. For example, in the approach and departure paths of an airstrip but outside of the three nautical mile radius, it notes that there is a restriction but the details of the restriction itself is unclear.

OK2Fly – As a web browser only option, and only available over Australia, this is really only just OK. It provides the option to change between the pilot type (e.g. recreational, commercial excluded, or REOC holder) and contains information about the airspace as well as that about marine/national parks etc. Unfortunately, I've never been able to find a legend for all the colours and patterns that are depicted on the map (huge cartographic no-no!), so getting an overview at first glance isn't so easy without clicking on specific locations.

Epicollect5 – This app doesn't really have anything to do with drone mapping, but that doesn't stop me using it for that purpose! It's a free app where you can create your own forms for data collection. I've used it to create my on-site drone safety checklist, and also to capture other on-site metadata related to the mission.

## Weather

UAV Forecast – I love this app for curating all relevant weather information on an hourly basis in a simple interface (rain, sunrise/sunset, temperature, wind speed, gusts, wind direction, visible satellites, cloud cover). The free version gives 24hr forecasts though you can upgrade to the paid option to get a seven-day forecast.

WillyWeather – This is a really comprehensive weather app that provides similar information to that contained in UAV Forecast, however has the added bonus of including tides which is really important for my marine and coastal drone missions. I also like the graphical representation of the information and the forecast is available for up to one week in advance.

Vaavud – I use this app to give me the wind speed when I'm out in the field. It was designed for surfers, but I find it useful for droning! It only measures the wind speed and direction at the location of my phone though, and obviously, this may not be the same as what the drone will experience at altitude. The app is free, though you do need to purchase the attachment for your phone/tablet. With more experience, it becomes easier to estimate the wind speed without using this tool, but it's definitely great for beginners.

Photo by Stephanie Duce

## Drone mapping mission planning apps

These are apps that allow users to set an autonomous grid flight plan for the purpose of creating an orthomosaic and 3D model in photogrammetry software.

Pix4D Capture – works on iOS and Android and for a range of different drones in the DJI, Parrot, and Yuneec ranges. I also like that it works on my phone – some of the other apps need tablets, but I wish it had a desktop app.

DJI GS Pro – iOS only and needs at least a 7" screen. Aside from that, this is my favourite for user-friendliness for DJI drones. It also allows the drone to fly backwards thus always keeping photos in the same orientation, which is super helpful for cutting out sunlight on water bodies. There are some paid options in this app though I have never investigated them, and I always use the Free version.

DroneDeploy – iOS, Android, and desktop, and also works on my small phone. DJI models only. I really like the ability to plan on my desktop. The paid version of this app also processes your data into an orthomosaic and 3D model, though to be honest I prefer to do this level of processing myself. I just use the Free version.

Mission Planner – Windows desktop app only, but this is the most comprehensive mission planner I've ever used. In fact, it does way more than just mission planning and is a 'full-featured ground control station'. It's also open source and supported by the community BUT it is limited to drones on ArduPilot open source software (e.g. Pixhawk). I used to use it on my 3DR drones and custom builds but alas it's not compatible with my DJIs.

QGroundControl – Runs on Windows, Mac, Linux, iOS, and Android so is the most flexible app available, but as with Mission Planner it is limited to drones running ArduPilot open source software. It is also full-featured and provides many more options for pilots to plan and monitor flights than just creating a survey grid.

Autel Explorer – iOS, Android and also works on my phone. This one is only for the Autel series of drones but I really like it! The best thing about it is that it integrates the basic flight app with the mapping component, so you don't have to use a separate app (by contrast if you have a DJI drone you will need to use the DJI basic app (e.g. DJI Go 4, and then one of the mission planner apps separately). I also like that it has some of the airport restrictions marked, however those markings are incomplete so I wouldn't recommend relying on them without checking for more comprehensive information in one of the apps in the first section above.

I know that there are many other apps out there and I have only focused on the free ones or those with a free component that's sufficient for the tasks I undertake when mapping.


# 05

# CATCHING YOUR DRONE

With their super fast spinning propellers easily able to slice and dice, sometimes I think that drones remind me of flying Edward Scissor hands! So why on earth would I want to have that anywhere close enough to my body to catch?

The truth is that sometimes catching the drone is actually sometimes safer than the alternative. In my case, if I'm working off the back of a small boat for example, there's often very little clear space for the drone to land. It's always wet, and there's usually a lot of other equipment around. The boat is also not stationary, so the drone is likely to even crash into the side of the boat and potentially spin out of control and cause further damage.

So when I weigh up the risks, catching it is a better option – as long as I take certain precautions!

## Here are my top tips for a safe catch:

The longer the 'legs' on your drone, the better. The handle like legs on the Phantom 4 work really well.

Have two people – one controlling the drone, the other catching. I know some people can control and catch for themselves, but I find that my hands are too small to hold the controller safely in one hand. Hopefully your catcher has long arms!

Have the drone operator standing (never sit – you can get out of the way faster if standing) directly behind the catcher so that you have the same perspective.

Practice the technique and the communication required with your droning partner in a safe and stress free location, preferably on land, rather than when it's mission critical.

Make sure that you have ample battery remaining so you don't feel stressed or forced to make a swift landing.

Try to have the sun behind you, or at least off to the side rather than in the catcher's eyes as they look up.

Wear protective gloves. Watch this drone blender video and see how easily the drone blender sliced through those carrots? I have some pretty basic kevlar ones (e.g. like this) and I think they cost me about $15. My colleague Dr Tim Hawthorne uses gardening gloves but I never liked those so much as they were bulky and made me feel a bit clumsy.

Wear glasses. Again with the drone blender – did you see the cherry tomatoes?

Take off your hat so the prop wash doesn't blow it away.

Slowly bring the drone down to the catcher's hands. The catcher should then loosely grip the legs rather than grabbing it, or little dronie will rev up and get upset! The catcher should keep their arms extended until the motors come to a complete stop.

Sure, these tips may seem like common sense, but I have seen drone injuries and they're not pretty. So hopefully this helps you to continue or even start your drone operations safely and confidently.

06

# MINIMALIST MAPPING

'With a vision to create the most detailed map of the planet ever possible using crowd-sourced drone imagery (see GeoNadir), I can hardly miss an opportunity to map a bit of Queensland's coastline as I travel. I like to do a tech detox while on holidays, so it's important to me that I can do the mapping as quickly and easily as possible so it doesn't feel like I'm working when I should be holidaying. For that reason, I've kept simplicity and ease of use in mind as I write this.'

Photo by Vitaly Vlasov from Pexels

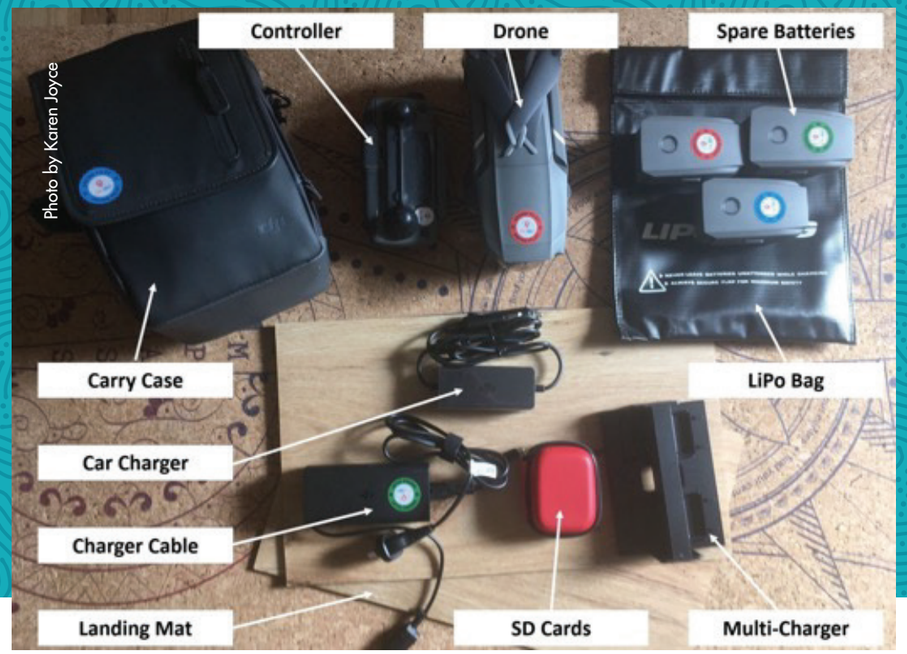
## Finding a good drone mapping site

When locating a good drone mapping site here are my top three considerations that help me to choose where I fly:

1. Large areas of open space. This is important as I don't want to (and am not allowed to) fly over the top of people.

2. Not in a National Park or too close to an airport. I prefer to fly legally and avoid spending time getting permits.

3. I typically choose a beautiful part of the world! I take this opportunity to to appreciate mother earth for all that she provides.




## What I take with me

Here's my key basics that I pack when mapping for fun:

- **My Mavic 2 Pro.** I prefer my Phantom 4 Pro for mapping to be honest, but the Mavic is way more compact so it's really convenient. This includes the controller, spare props etc. Whatever fits into the little carry bag, no fancy pelican case or anything.

- **Spare batteries.** I usually travel with four batteries.

- **LiPo battery bag.** Keeps my spare batteries protected and hopefully contains a fire if they were to explode (!!!)

- **A landing mat.** Nothing fancy, I have three laminate flooring mats that I use. Super portable and they were just off cuts from a house build so didn't cost me anything. I have used a kitchen chopping board on previous trips if that's the best I could find! It's really important though, as the mat protects the drone from dust and sand kicking up into the motors.

- **Charger cable** including the car charger (though I confess I've never actually used the car charger!)

- **Multi-charger.** This lets me charge all four batteries sequentially without having to swap them over manually.

- **Spare SD cards.** I change the SD card after every flight just in case I happen to lose the drone, I haven't lost the previous flights' data! This is particularly important if I don't have the opportunity to download and back up the data as I go.

## What I don't take with me

As I mentioned above, I'm always aiming for convenience and compact travel if flying for fun.

However, the following list are additional items that I would typically pack when on a work drone mapping mission.

- **Ground control points**. I sacrifice the positional accuracy of my mapping.
- **Additional GNSS (GPS, GLONASS, RTK).** As above, I'll make do with what co-ordinates come off the drone
- **iPad.** I prefer mapping with a larger screen when mapping for work.
- **Other in-situ survey tools.** Often on work trips I may take transect tapes, quadrats, etc. for putting in place calibration and validation.
- **Redundancy.** Aside from some small things like spare propellers and SD cards that don't take up much space. This is in stark contrast to my last field trip for example where we had three Phantoms and a Mavic as well as two spare iPads, as well as their cases and accessories – just in case. When you're in a remote area and the drone is mission critical, we don't take chances!
- **Pelican case or heavy-duty tub.** On a work trip my equipment can get knocked about a bit moving between boats etc so I usually pack it all in waterproof tubs or cases for extra protection.

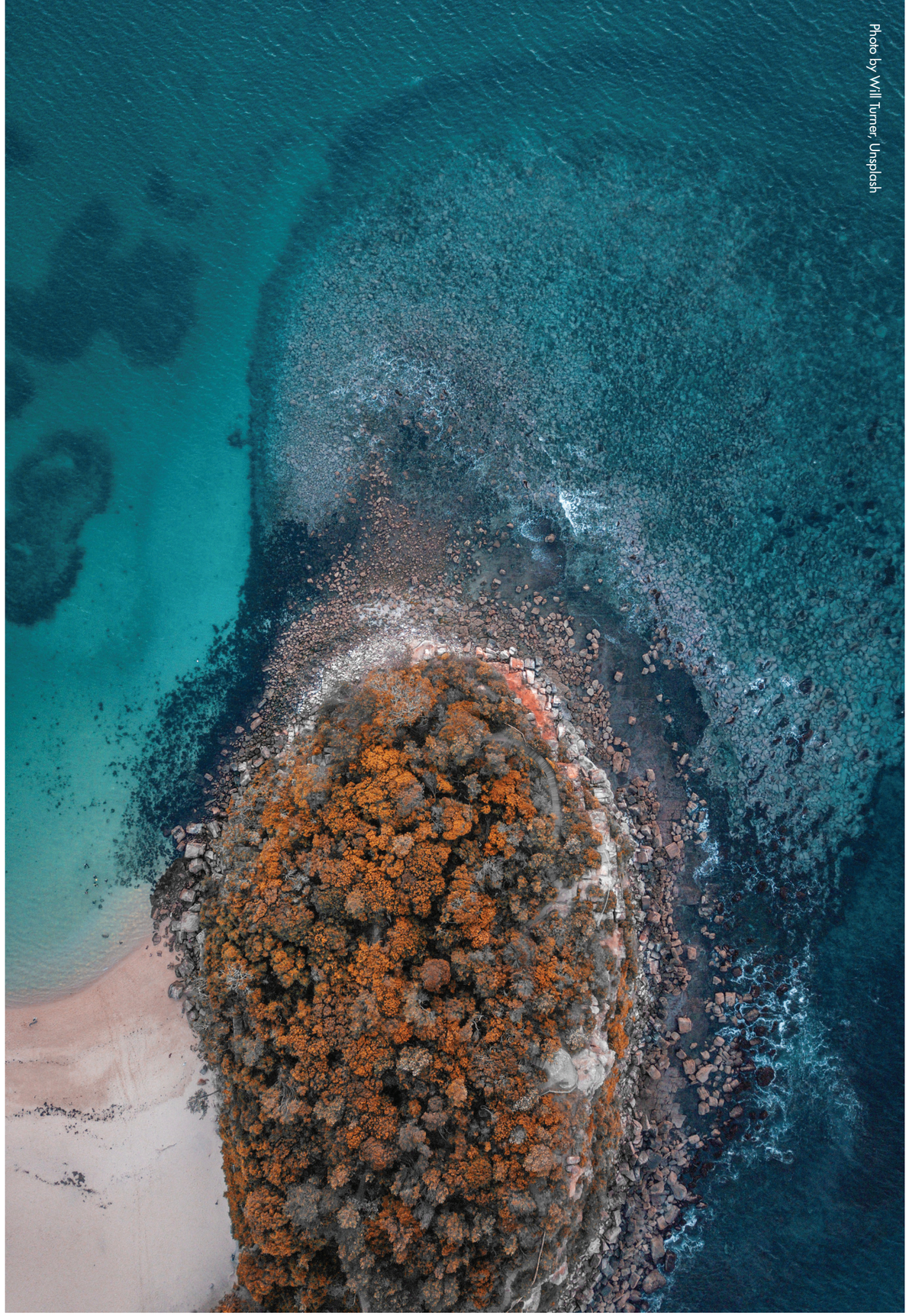


Photo by Will Turner, Unsplash

## Other things to make my life easy

Probably one of the biggest things that I've realised I need to do when drone mapping in remote locations is to cache the background imagery in the drone mapping apps while still in wifi range. It's really hard to plan a mapping mission with no basemap!

To cache the imagery, all you need to do is to go into your chosen mission planning app (e.g. DJI GS Pro, Pix4D Capture, or DroneDeploy), and zoom and pan around the area where you think that you might fly. Even better if you put in a draft mission while you're at it. Wait until the imagery tiles load properly and then you'll be good to go once you're out of wifi range. You can always double check that you've done this properly by putting your device into airplane mode and re-opening the app.

## Mapping data back-up

I have to admit that I'm quite obsessive about data back ups. I typically transfer the data from the SD cards to my laptop as soon as possible, and then upload it directly to GeoNadir via my phone hotspot. This means that my data is safely stored in two locations before I format the SD card for re-use.

07

# GROUND CONTROL AND DRONE MAPPING


## What is 'ground control'?

No, we're not calling Major Tom... Ground control points (GCPs) are points or features on the surface of the earth (or even underwater) with a known location. We want these points to be identifiable in corresponding drone or satellite imagery so that we can align our datasets to the 'correct' location on a map.

## Where do we find good GCPs?

On land, you may be able to find survey markers that have been placed specifically for surveyors to use for ground control. However, these are often too small to be found in satellite or drone imagery, so we need to identify other features in the environment and use GPS to record their location. The size of the feature will depend on the scale of the imagery being used – for example road intersections work well with Landsat data, while paint markings on a road are better suited to drone imagery.

Sometimes it's not possible to find reasonable ground control so we need to create our own. Aeropoints are designed for this purpose when using drones and even have an in-built GPS – you can read more about using these as GCPs here.


## But what about marine environments?

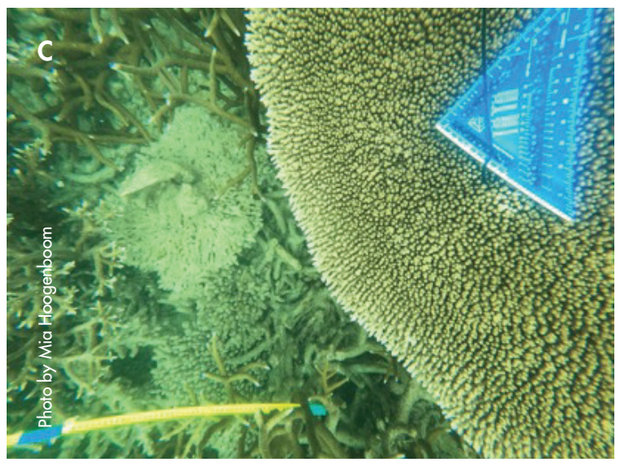
Of course there's nothing to stop us using Aeropoints on an island, however most of the time I'm actually interested in the underwater habitats. The laminated cards that Dr Javier Leon, University of the Sunshine Coast uses are a good option here (A). We use dive weights to hold these down underwater. The patterns on the cards are also recognised within the Agisoft Metashape photogrammety software, which helps georeference the images and resultant orthomosaics.

My personal favourite is the wonderful fluorescent sun hat, pioneered as a GCP by Dr Stephanie Duce from James Cook University. I love the multi-purpose use here (B). They are also super easy to see in our drone imagery and come in a variety of fashion colours! At low tide we use the RTK GPS to precisely measure the hat location for those that are deployed in areas easily accessible by walking on the reef flat.

## What if it isn't possible to keep an RTK GPS dry?

This is actually the reality of most of the work that I do. So most of the time we do not have precise or accurate location data... gasp! Often we can co-register our drone data to available satellite imagery, but sometimes the latter is far too coarse so we just have to make do with what we have.

We can still co-register the drone imagery to suitable in-situ data such as this underwater image mosaic captured along a transect line below for example. A number of corals are easily identifiable, as is the transect tape (within the full resolution imagery), and some metallic setsquares we have placed at the start and end of the transect (C). We use a hand held GPS in a waterproof bag to get their approximate location too.



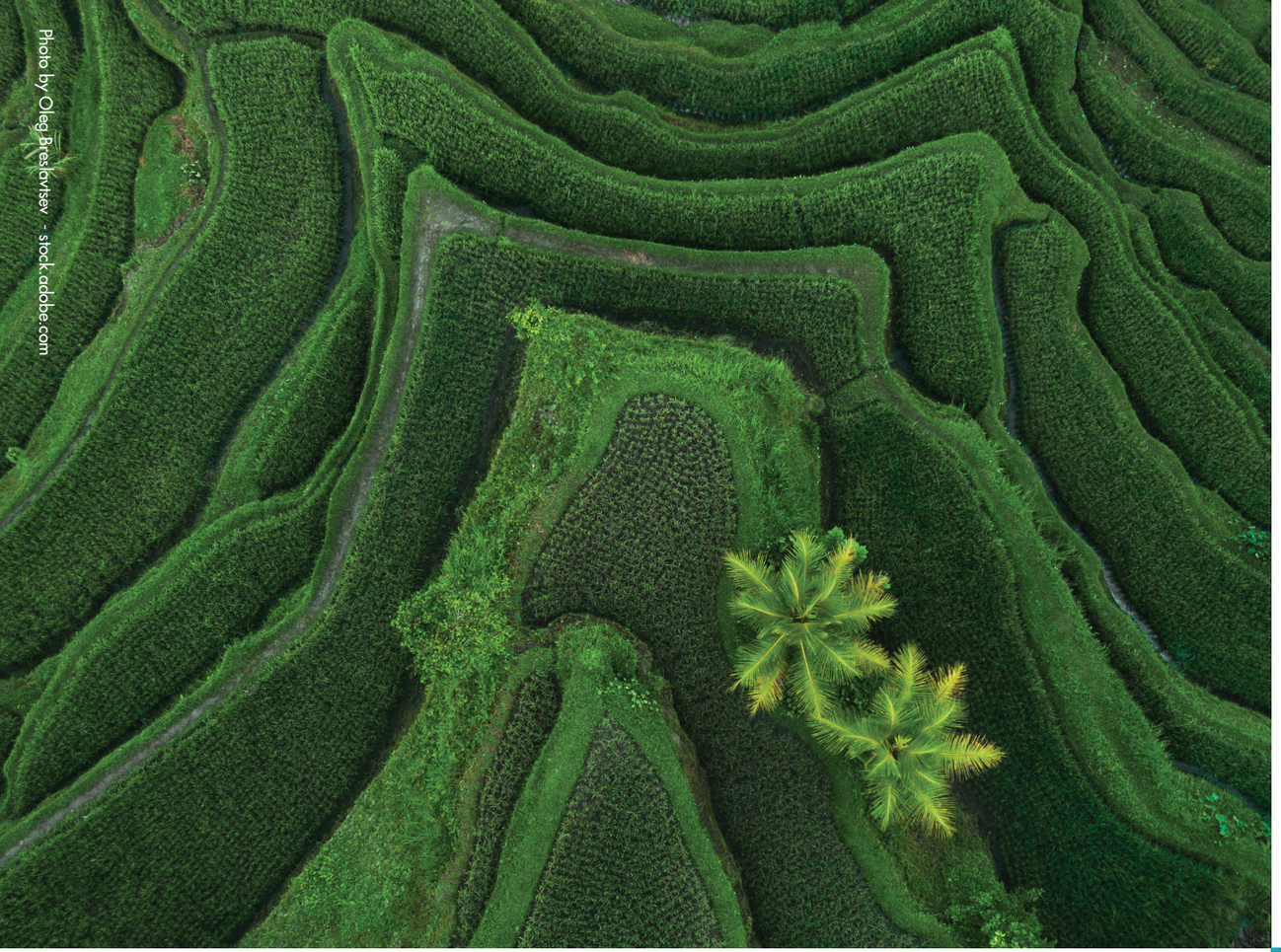


Photo by Oleg Breslavtsev - stock.adobe.com

## Why do we need ground control when drones have GPS anyway?

The drones we use do have GPS, and there are some drones now that also have an RTK GPS. But as with all GPS there is a margin of error. It also represents the location of the drone at the time of image capture, which may not be the same as the on-ground projection of the data due to the aircraft roll and pitch as well as any off-nadir camera angle. So the location of tagged imagery isn't necessarily as accurate as we might like.

## Final word

The purists might feel debilitated by the level of precision and accuracy I deal with in marine environments. However, I'm a firm believer that something is better than nothing and even if it's not possible to get ground (or sea) control, there's plenty of good that I can still extract from my data.

While GPS is the term that most people use to describe the device that provides positional information, the correct term is GNSS – or Global Navigation Satellite System. In Australia this is actually comprised of the Russian GLONASS satellites as well as the US GPS satellites.





## Here's my 'final word'...

Hopefully reading through this ebook has given you some valuable insights into how you can capture analysis ready data with your drone. There are many things to consider, but it's absolutely worth spending the time in prior preparation to prevent poor performance! The best thing that I can recommend now is to get out and give it a go. You have the foundation for making good mission planning choices now, and like a good wine, you will improve with time.

When you've captured your data, be sure to upload it to GeoNadir, helping to co-create our planet's most detailed map ever possible. Your data in combination with many other datasets around the world can help us solve our environment's greatest challenges.

Stay tuned to learn more from upcoming books in the series!

Part 1 – Mission Planning
Part 2 – Data Pre-Processing (coming soon)
Part 3 – Mapping and Analytics (coming soon)

**Happy flying!**

# About Karen Joyce

**Co-Founder, Chief Scientist & Data Feminist @ GeoNadir**

I am a biographer for Mother Earth, using satellites and drones as my scientific illustrators.

I share my experiences drawn from more than 20 years as a geospatial scientist in academia, military, industry, and small business to help people discover science beyond lab coats and test tubes. But I have an ulterior motive. I am passionate about how we can use drones and geospatial technology to watch over our environment and its changes. So the more people I can inspire to join me, the faster we can put plans in place to help keep our environment healthy into the future.

Connect with Dr Karen Joyce on:

# How can I get involved in GeoNadir?

GeoNadir hosts drone images from around the world to help save some of the world's most at-risk ecosystems, and we'd love your help.

Next time you're out flying your drone, simply take an extra battery and fly a mapping mission too. Follow our step-by-step process here.

Upload your images onto your free GeoNadir account, a great place to manage and store all your drone images. Oh, did we mention that your account is FREE and you can upload as many images as you like

**It's really that easy!**





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# About GeoNadir

At GeoNadir we are creating the most detailed map of the planet ever possible using crowdsourced drone data.

We process and manage these data on our cloud-based platform, making the central repository available to users around the world under FAIR data principles (findable, accessible, interoperable, reusable).

In return for freely hosting and providing basic data processing services to drone pilots, our revenue model focuses on providing automated knowledge as a service to government and corporate organisations.

With our vast data inputs to drive machine learning, we will be able to report on environmental assets, natural capital accounting, and ecosystem change at a local level while baselining globally.

www.geonadir.com

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