DroneDeploy

Making Great Maps:

The Complete Guide to Professional Mapping with DroneDeploy

By Adam Carp

Forward

Welcome to ‘Making Great Maps: The Complete Guide to Professional Mapping with DroneDeploy’.

This guide is designed to be the ‘one place’ where you can find the majority of your questions about mapping with DroneDeploy answered. It can either be read from start to finish, giving you a wide baseline knowledge of connected topics or, you can pick out individual sections to read case-by-case as you need them. You can skip a lot of real-life trial and error by reading this document in detail.

Here is a summary of the journey we’ll take you on:

We start this e-book by describing the basic processes behind Map Engine. Understanding the basics behind structure-from-motion photogrammetry processing allows you to create datasets that are tailored towards success. Next, we’ll walk you through each of the most important flight modes and describe their use cases and the best techniques to keep in mind when using them. Once you’ve chosen your flight mode, refining those settings using the ‘Advanced’ panel can be important to assure a quality result, so we’ll describe all of the parameters available in that section as well.

The physical aspects of the subject, such as elevation change, homogeneity, and reflectivity, will often require further adjustments to your flight plan. We’ll describe those common complications and how you can further refine your plan to best avoid a negative impact from these complications. The final pieces to factor in when designing a flight plan are your resolution and accuracy goals. This includes all of the considerations needed to successfully map using Ground Control Points.

At that point, you’ll be set to complete the design of your flight plan. We’ll then describe suggested workflows and checklists for pre-flight preparation and on-site flying. This ensures that you can avoid hiccups in the field that might impact the efficient use of your time.

To ensure that your hard work pays off, we’ll explain how to correctly process your data in the right modes. Finally, we’ll then give you the tools and knowledge you’ll need in order to quality check your completed map and to continue building on your photogrammetry and mapping knowledge for the future.

As always - Happy Mapping!

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Introduction

Capturing, processing, and analyzing accurate drone data can be as easy as a few taps on your mobile device. Our mission is to make mapping easy and accessible, even for projects with a tough list of requirements and a difficult subject.

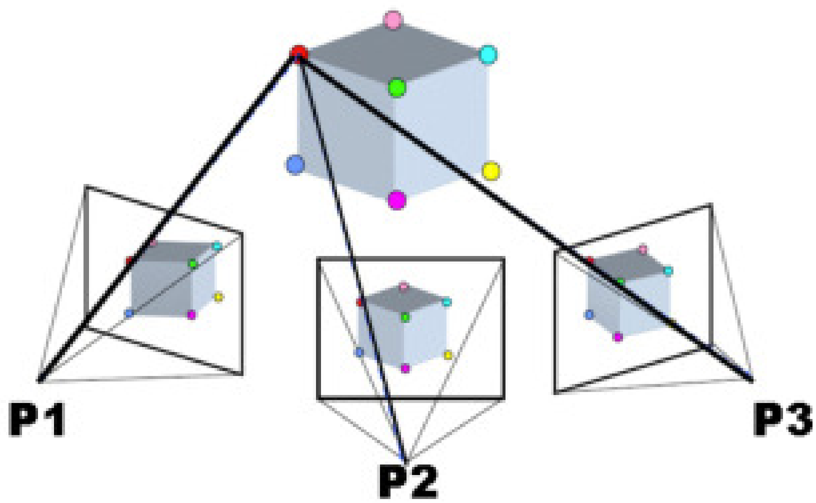
01

Understand How Structure-from-Motion Photogrammetry Works

It is important to first understand the basic concept behind drone photogrammetry. DroneDeploy's Map Engine is our in-house photogrammetry processing pipeline. It stitches your image sets into complete maps and models using a process called 'structure-from-motion'. But how?

This process is similar to how we see with our eyes. Our two eyes give us two different perspectives of the same scene. Over many years, our brain learns the distance between our eyes, and how that corresponds to the distance to an object is based on seeing the same object with both eyes. Similarly, our photogrammetry pipeline works by matching visually distinctive 'key-points' that have been captured in multiple photos taken from different locations. Each photo is like having another 'eye-in-the-sky' viewing the scene, and that allows us to create a 3D reconstruction from photos.

Entire image sets are aligned into maps based upon similar features found in multiple photos. The best maps have at least 8 images per single location.



Identifying and matching tiepoints across three photos

What Does Photogrammetry with DroneDeploy Truly Come Down To?

The more matched, distinct objects across multiple photos we can find, the more accurate the map becomes. These matches we find are called 'key-points'. In the example above, you can see one key-points that have been matched between three photos. Using DroneDeploy for flight ensures you take enough photos to gather as many key-points needed to make a clear map.

Now that you know the basic concept behind the process of photogrammetry, let's learn about all of the tools at your disposal.

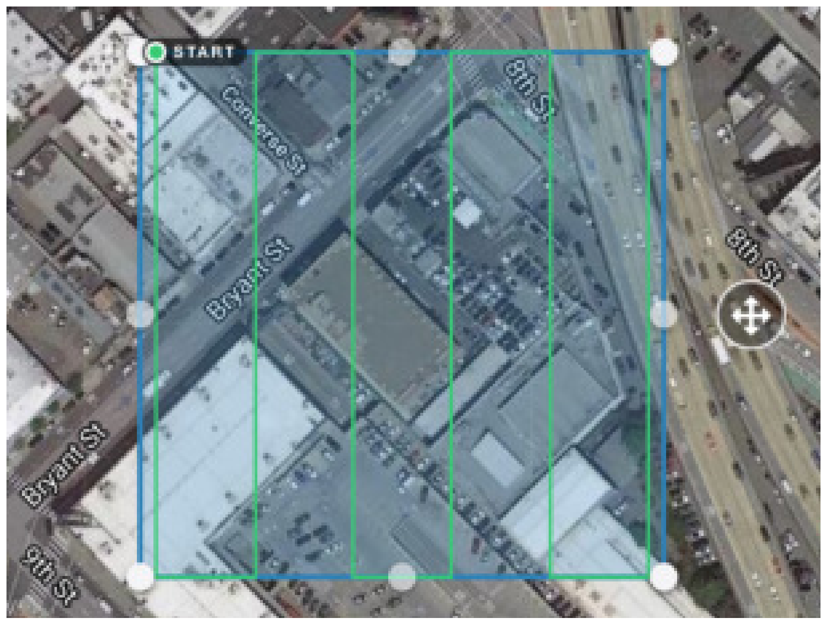
02

Choose the Correct Flight Planning Modes

Using the right flight planning modes is the first concrete step you can take to put yourself on the path of making a successful map. The different flight modes that you can use to capture and process imagery in DroneDeploy each produce output that has different strengths and weaknesses.

Non-Structures Mode Flight

When you start off with a brand new flight template in DroneDeploy, Structures mode will be off. When Structures mode is off, your drone will capture a lawnmower pattern (back and forth) capturing rows of nadir imagery (images taken from an overhead view with your drone's camera pointing straight down at the ground). This mode can efficiently cover a large area.

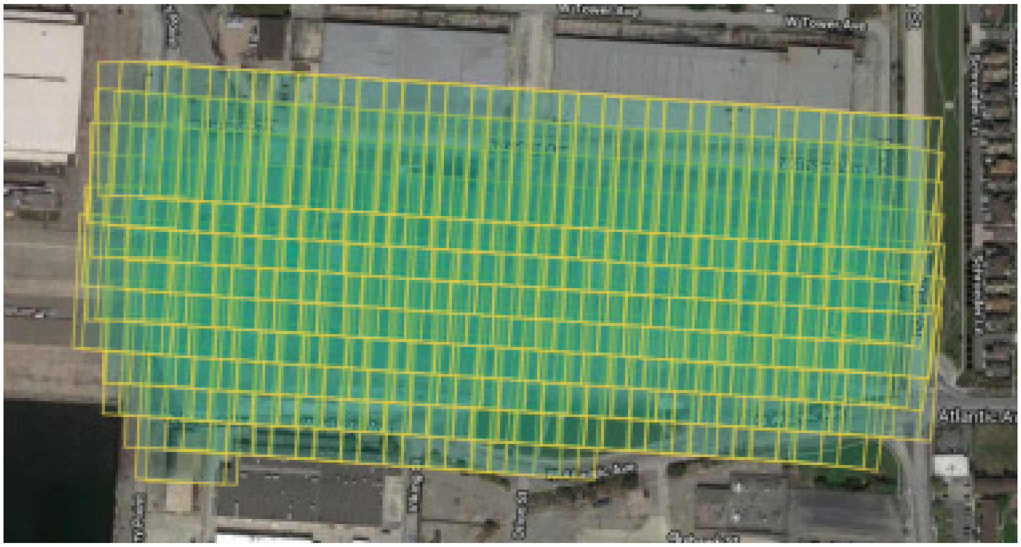


Non-Structures mode flight pattern. The drone follows the green lines.

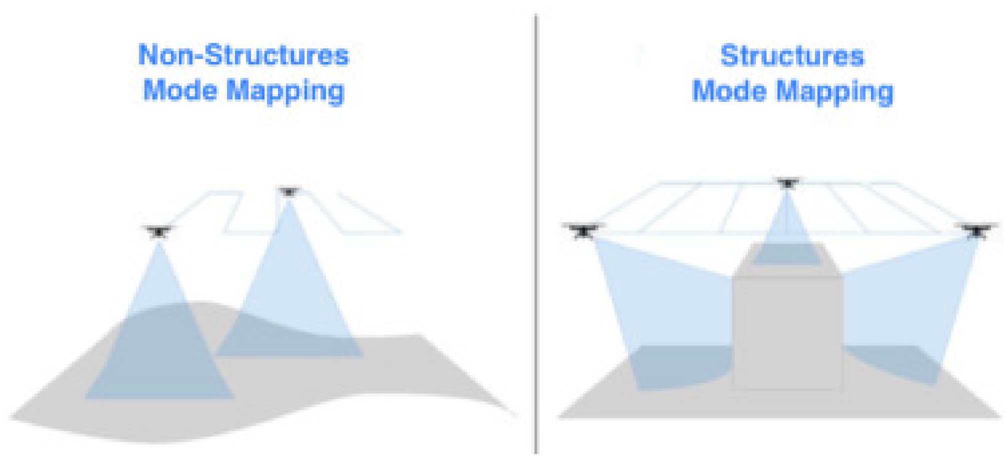
Non-Structures mode flights are best suited for big tracks of land such as agricultural fields or site surveys. Non-Structures mode datasets are well-optimized for homogeneous scenes (where every image looks very similar to the next), especially for agricultural fields.

While processing data captured in Non-Structures mode will also produce 3D data products (point clouds and 3D models), it's best suited for accurate 2D layers and elevation profiles. Non-Structures mode is best used for when you'd like to efficiently cover a larger area without a relatively high image count or without using a lot of batteries. Also, make sure the scene doesn't have any drastic elevation changes (cliffs/buildings) or overhanging features (caves/arches).

Within this section and later sections, we'll go into more detail on how you can properly address sites that require 3D models, for which a Non-Structures mode flight will not suffice.



Structures Mode

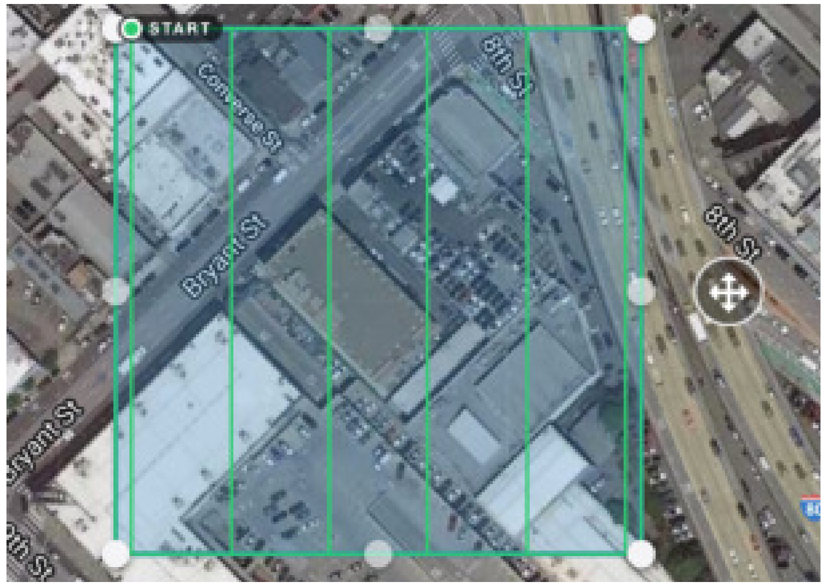


Structures mode can be toggled on the left side of your flight planning dashboard. It is optimized to reconstruct buildings, statues, objects, and other objects in 3-dimensions. If you are looking for a compelling 3D model, we would recommend starting with "Structures" mode.

In addition to the base set of nadir images (just like Non-Structures mode), Structures mode also captures 'oblique images' (angled to capture the sides of buildings or objects) from the perimeter of your mission plan, facing towards the center of your subject. It does this while carefully not including the horizon in the shots.

“The best obliques are taken at a lower altitute and at a bit of a horizontal distance”

You can see the green waypoint lines around the perimeter in the second photo on this page.



Notice the green waypoints around the perimeter of the flight. Structures mode captures side angles of your subject, compared to Non-Structures mode, which is just the lawnmower pattern.

The best obliques are usually taken at a lower altitude and at a bit of a horizontal distance from your subject. Shooting too close to a building results in an extreme angle taken of the vertical wall of that building.

As the photo angle becomes steeper and steeper, fewer and fewer pixels are describing the same sized wall area, which decreases the model’s quality and can even cause meltiness or holes to form in the end-result.

Here’s an example of a shot that is too close to effectively help with the vertical wall reconstruction:

When trying to reconstruct the close vertical wall of this brick building, this image is taken too high up and too close.

If you shoot from farther away from the building and/or drop altitude, the side of the building is seen more clearly. This results in more pixels describing the same area now, which allows us to stitch the model with greater detail. Here's an example:

To ensure that all 360 degrees of your Structures images provide well-angled coverage of vertical walls, it is important to properly frame your subject within the orbit of your Structures flight.

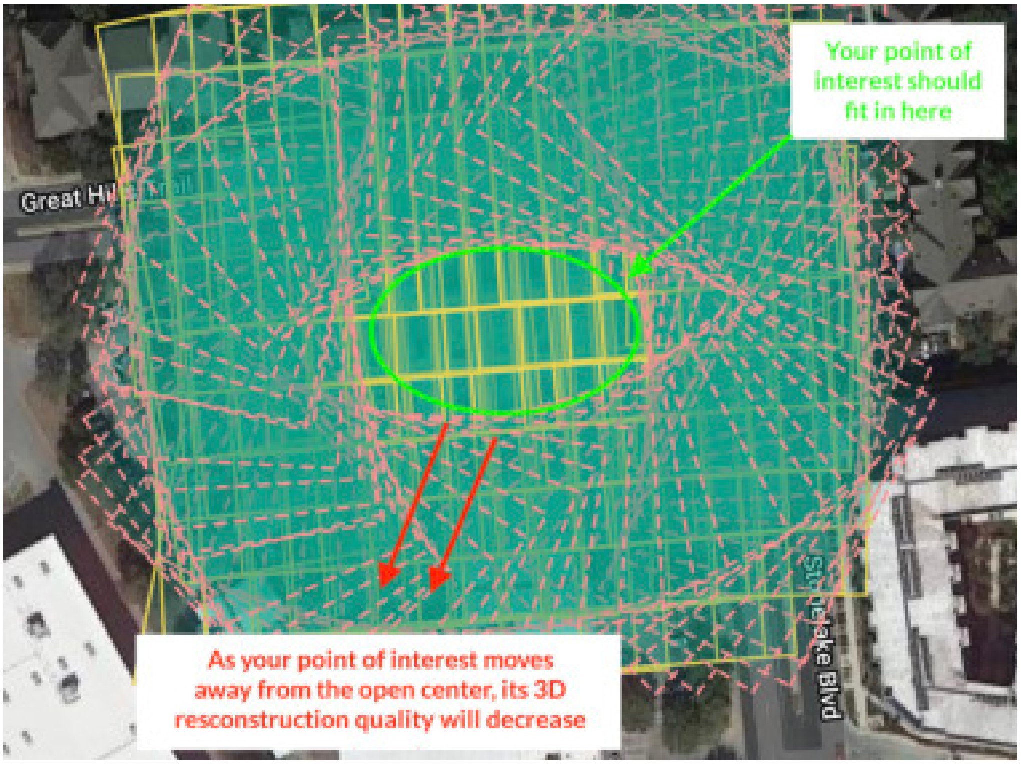
POI - Point of Interest

An important concept regarding Structures mode is 'Points of Interest', or 'POI's'. POI's are where the flight pattern and camera will need to focus on in 360 degrees to deliver a high-quality result. Almost any structure that you'd like accurately modeled is a POI, for example, a large stockpile.

You might identify multiple points of interest in a single area, such as two buildings on opposite sides of the site. For quality 3D results with multiple POI's within a single map, usually, combining multiple Structures mode flights is required. More detail on that can be found below.

Why is it recommended to combine multiple POIs in a single map? This is because Structures rotates 360 degrees around a singular POI.

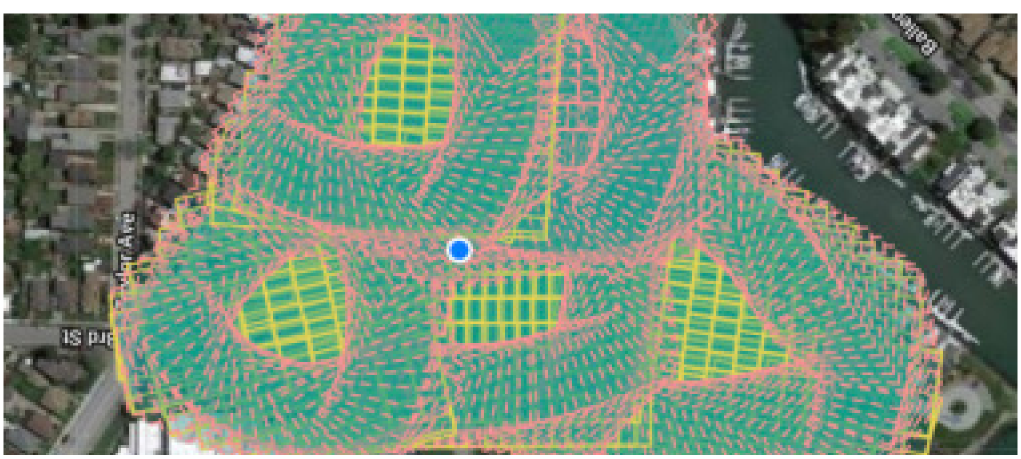
In order to achieve the required 360 degrees of even coverage, with solid vertical reconstruction, the POI needs to be centered within the oblique orbit of photos, as seen below:

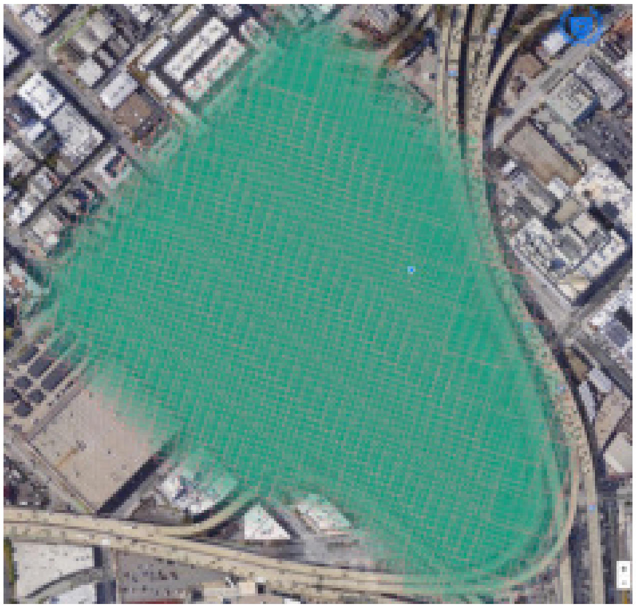


If your primary structure (POI) doesn't mostly fit into a circle of obliques, or if you have multiple POI's that don't quite fit within a single orbit, it is likely that the obliques will not capture adequate vertical data of those objects, and they may not be reconstructed accurately. The 3D result will usually be better than a Non-Structures mode flight would be, but it won't produce the best data possible.

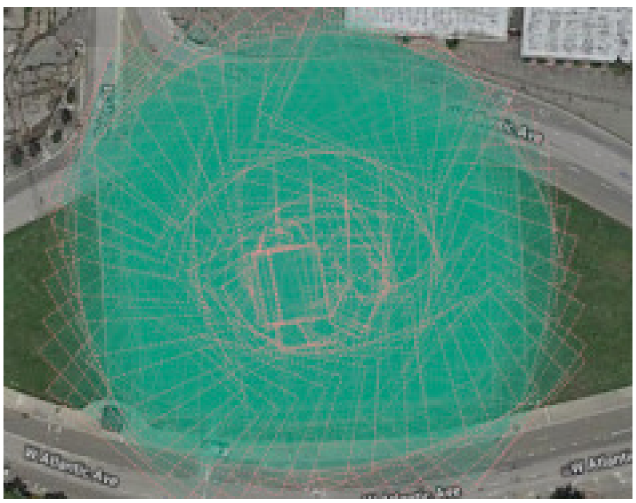
So, what if you're mapping an area with multiple points of interest, such as a city block with a handful of high-rises? To remedy this, you can combine multiple Structures mode flights to be processed into a single map by uploading the images together. If possible, it is best to take off from the same location. Minimizing your takeoff location and mapping altitude differences can help keep the altitude data in your images consistent.

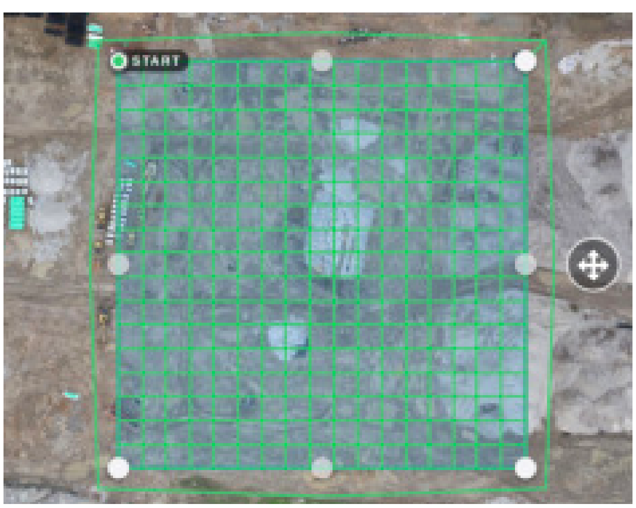
Set up each Structures flight to rotate around each important POI, and make sure that each flight fully overlaps with the other flights. Here's an example:





A blanket of obliques provides a wide range of 3D coverage over a large area.





Crosshatch Mode

Another fantastic option for a situation with multiple POI's is to use the crosshatch pattern from the Auto Flights Modes app. Crosshatch doubles the number of images that the lawnmower, Non Structures mode style flights captures by intersecting each of those rows with a perpendicular pass.

Because the image count is doubled, overlap is not typically a large concern when using the Crosshatch mode. Crosshatch mode only takes oblique, or angled images. This increases the quality of the 3D reconstruction of a large area with more than one point of interest because this pattern does not center around a particular point of interest but still does provide a diversity of views over this large area.

House & Roof, Precision 3D Model app

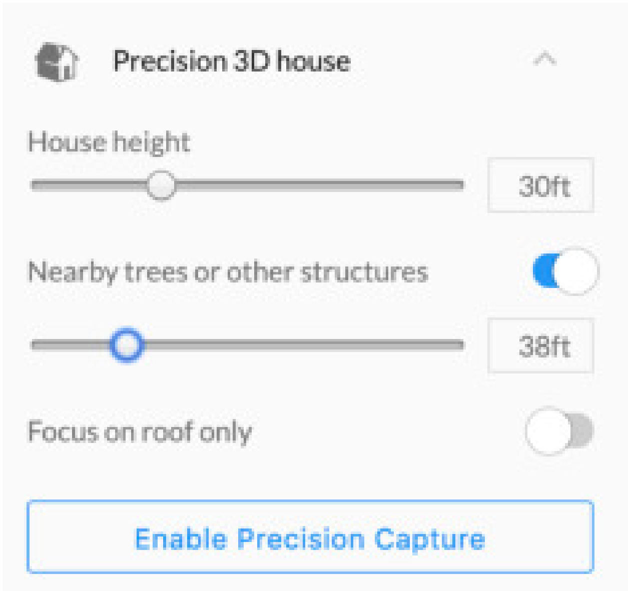
What if you want the ultimate single POI 3D reconstruction that DroneDeploy can provide, or if you need a detailed residential Roof Report? Look no farther than the House & Roof, Precision 3D model app, available on our App Market!

The top section of the House & Roof app is a crosshatch pattern, exactly the same as described in the previous section. This provides a dense and wide baseline of views for the general area, which is excellent for 3D modeling.

Not only does the Precision 3D app have the crosshatch pattern, but it also orbits twice around your subject, each at a different altitude. This is an extra orbit compared to a Structures mode flight.

This makes the House & Roof app essentially a single POI version of the Crosshatch mode or a higher-detail version of the Structures mode.

It also has easy-to-use controls that automatically set mapping altitude according to the altitude of your point of interest and of obstacles in the area. This helps to ensure that overlap is almost never a concern with this flight mode.



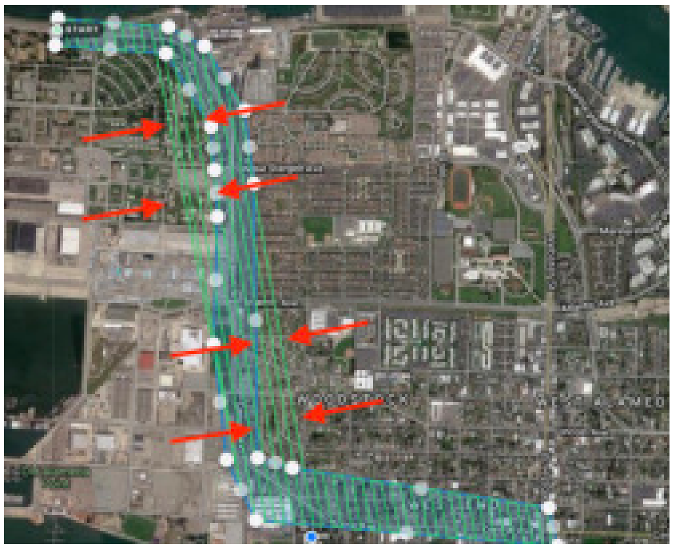
What is the disadvantage of the Precision app? Simply, time, SD card space, and batteries. It takes a longer time in the air to cover the same area compared to Structures mode flights. This effect becomes increasingly prevalent as the mapped area gets bigger, which is why the primary intention of this app is to map a single structure and not city blocks.

Linear Flight Plan

You may find yourself mapping a roadway, oil pipeline, train tracks, or other linear infrastructure that is long and narrow.

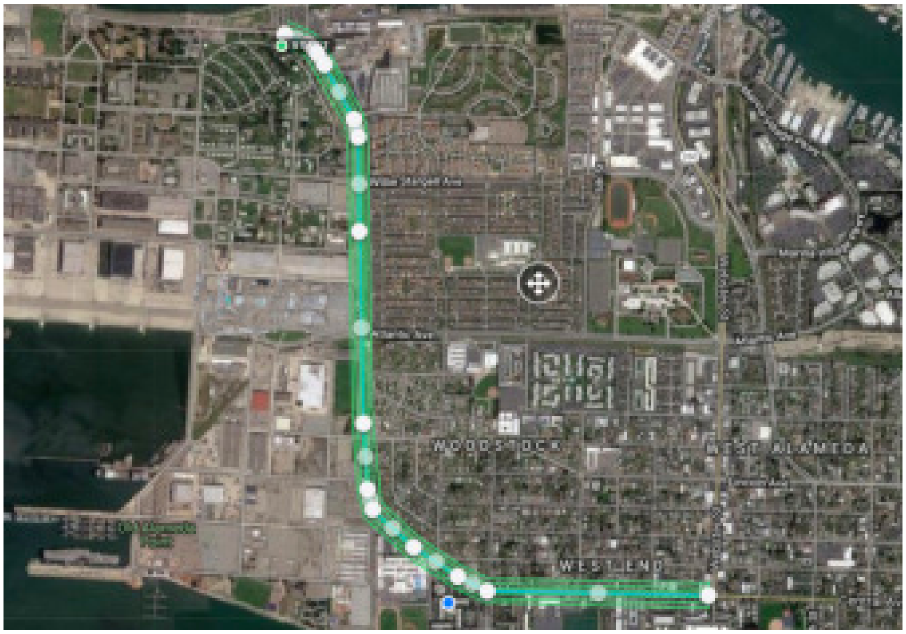
It is possible to map such a subject successfully using the regular Non-Structures mode flight planner, but you're more likely to run into overlap and coverage issues. Oftentimes, if you use the Non-Structures mode flight like this, the edges of the linear plan will have really spotty, uneven coverage - often 'stairstepping' up and down.

Additionally, if the long and narrow subject curves even moderately, depending on the flight direction, there might be passes that take the drone outside of the boundary you've created, which creates inefficiencies in flight and processing. Here's an example:

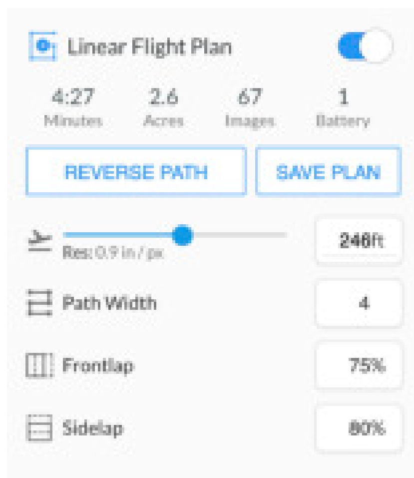


To solve these issues, Business and Enterprise subscribers have access to the Linear Flight app, available on our app market. The Linear Flight app takes only nadir photos, similar to Non-Structures mode. This means that linear is well-optimized to produce high-quality 2D outputs, and its 3D outputs vary depending on the subject.

Here is the same road, except now it is planned with Linear. Notice that no there are no wasteful passes, unlike above:



The easiest way to plan a Linear flight is to turn on the Linear application on a brand new flight template. Press 'Yes' to accept waypoint modification, and then 'Save Plan' to activate the app.



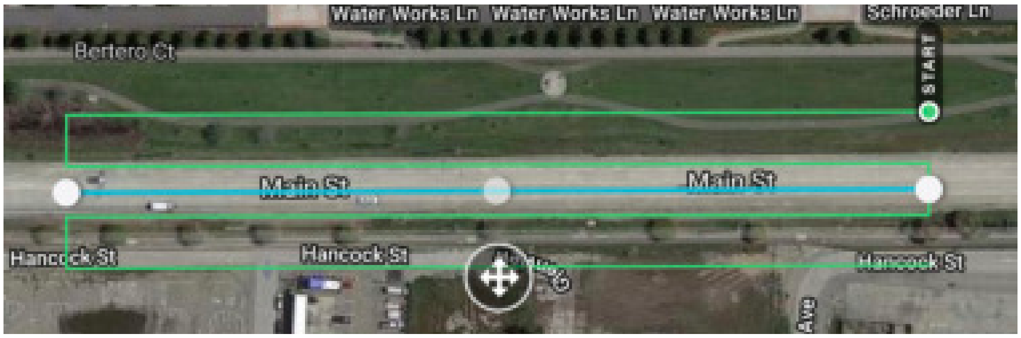
After that, you'll start out with a partial box consisting of two green flight paths surrounding the blue line guiding them. Move and adjust the blue line so that it follows the middle of your linear subject.

We've directed the flight to the right line, but only two passes may not provide a wide enough coverage of the sides of the road.

Especially if you don't map at a high altitude, there's a reasonable chance that the default 2-passes will not be wide enough to capture all of the data for your scene, or won't have a sufficient number of images for good reconstruction. Therefore, it may be important to increase the width of the flight by increasing the 'Path Width' beyond '2'. In general, it's usually better to slightly over-capture than under-capture.

It is really important to note that processing, exporting, and handling linear datasets is more difficult than data from more typically-shaped flight plans. Subpar coverage of an area on a linear map is more likely to cause a processing problem compared to a more standard map. Please be sure to set altitude, overlap, and path width as conservatively as possible.

See below for the result of doubling the path width to '4'. With this adjustment, compared to the initial 2 passes, we are now more confident that every inch of the road will be captured in several images - giving us a little extra breathing room:

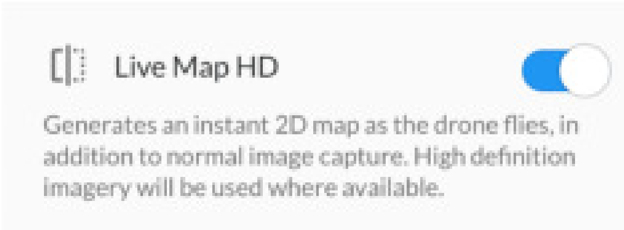


When you're satisfied with your Linear plan, please be sure to press 'SAVE PLAN' on the app.

Live Map HD

Have you ever flown and wished that you could receive a processed map in real-time as you fly? Gaining instant insight into the situation on the ground as your feet are on that very same ground is powerful. Luckily, with Live Map HD, this all is a reality.

As your drone flies, you can expect to see the drone 'paint' the orthomosaic as it flies on your screen. It can be pretty fun to watch!



Live Map uses the live first-person-view (FPV) video to stitch the map in-real time. This is in contrast to the full-resolution images from the SD card stitched together using Map Engine for regular maps.
This means that the Live Map is lower resolution compared to your full maps, and does not have 3D data (point clouds, 3D models, and elevation data). It's designed to be used for 2D measurements and scouting with moderate precision.

The default flight settings will work well for the Live Map. We also recommend avoiding areas that vary more than 75ft (25m) in elevation. Areas with small hills and buildings shouldn't be a problem, but buildings or terrain taller than 5 stories (50ft or 15m) may cause stitching artifacts in the Live Map.

Because Live Map uses the live data feed from the drone, losing connection to the drone will cause gaps or stitching errors in the Live Map, or the map may fail or stitch incompletely. Connectivity between the drone and the RC is the main consideration to take into account when diagnosing Live Map issues.

Depending on your subscription, you may have access to Thermal Live Map and Live Plant Health map, which works similarly to the regular Live Map.

Manual Shots Using Dronedeploy's Manual Mode

After your automated flight completes taking its photos, if there are nooks, crannies, and small complicated objects that would be difficult to clearly point out in at least 5 photos, please switch to DroneDeploy's manual mode to provide greater image coverage of these areas. Further into the article, we'll help you easily identify these areas.

Attempting to overlap your manual shots similarly to how DroneDeploy overlaps the automated shots is a recipe for success! You will usually only need to do this in a few areas.

Please be sure to not include the horizon line in your manual shots, and try to keep the altitude of the manual shots to within 100 feet of your autonomous shots.

Combining Images From Different Flight Modes

Think of each flight mode as a color on your easel. Depending on your purpose, you can use each color alone or you can combine them into new colors. You can also combine image sets taken from different flight modes into well-balanced maps, such as adding a Structures mode flight within a Non-Structures mode flight.

Please make sure that each image section fully overlaps the surrounding sections, and there are limitations to combining images with a very large altitude difference: image sets with more than 100 feet of altitude difference between other image sets may cause image stitching issues.

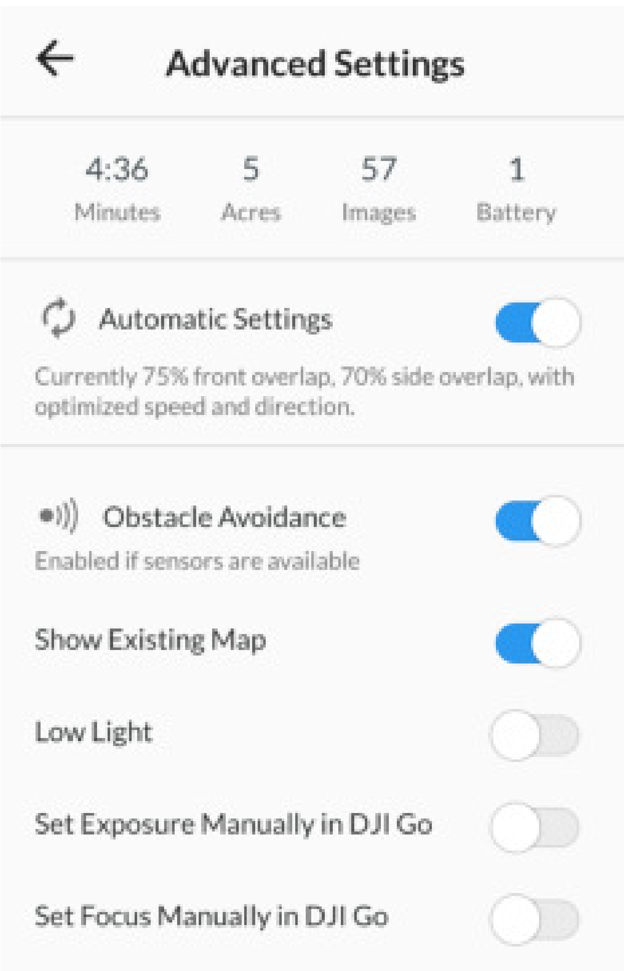
After you've chosen the flight mode(s) you'll use for your flight, now it is time to refine your parameters a little further.

03

The 'Advanced' Panel

On the 'Advanced' Panel, you'll find more settings you can adjust to fine-tune your flight after you've chosen your flight mode.

Automatic settings by default will be turned on. This optimizes overlap, speed, and direction of the drone, and will work for most scenes that don't have factors making them especially hard to map. Those factors are outlined in future chapters. If your subject has any of them, it is likely that you should turn off Automatic Settings.



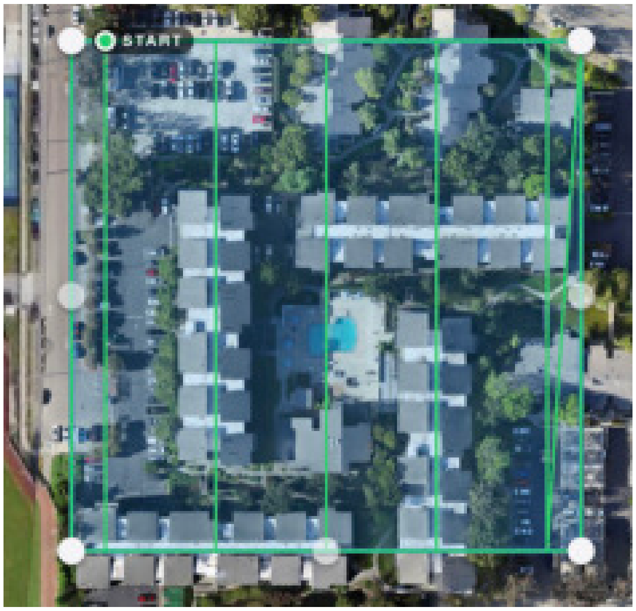
Below Automatic Settings, available to toggle on and off are:

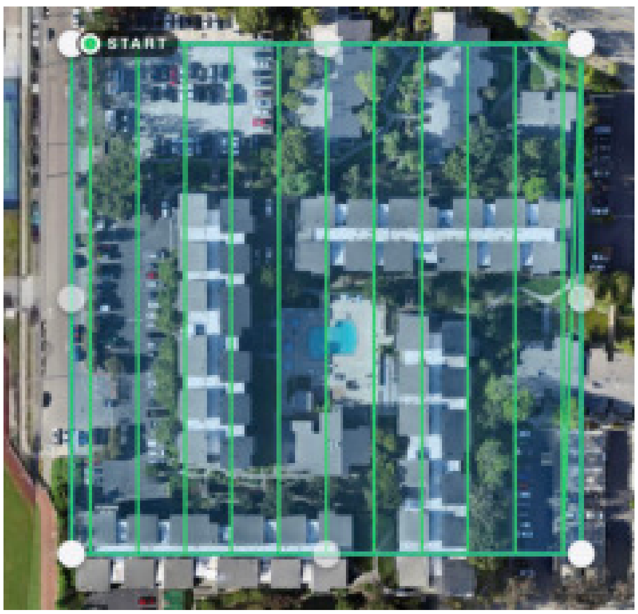
Obstacle Avoidance: We generally recommend keeping it on, as it can help your drone avoid a crash. Remember that Obstacle Avoidance is imperfect and cannot be relied on to prevent all crashes. Obstacle Avoidance can sometimes cause the drone to hover when flying directly into the sun (confusing the sun as an object) or if the lenses are dirty. Turning Obstacle Avoidance off may enable the drone to fly faster, and thus capture larger areas on a single flight plan. Please always manually fly to check the height of obstacles in the area you plan on flying to be sure that your drone will avoid them.

Show Existing Map: Planning on an up-to-date base layer is easier than planning on an old one. 'Show Existing Map' places previous drone maps in the same area on the 'Fly' tab for you to plan the next flight over.

Low Light: Increases camera ISO to 400, which makes the camera more sensitive to light, but can slightly increase graininess or noise in the images. This is recommended to be used when you're mapping in low lighting conditions and the required shutter speeds are too slow to capture sharp data.

Manual Exposure and Focus: If the automatic camera (exposure, shutter speed, and ISO) settings are producing poor-quality imagery, you can toggle these switches on, and manually adjust those parameters in the DJI Go app.



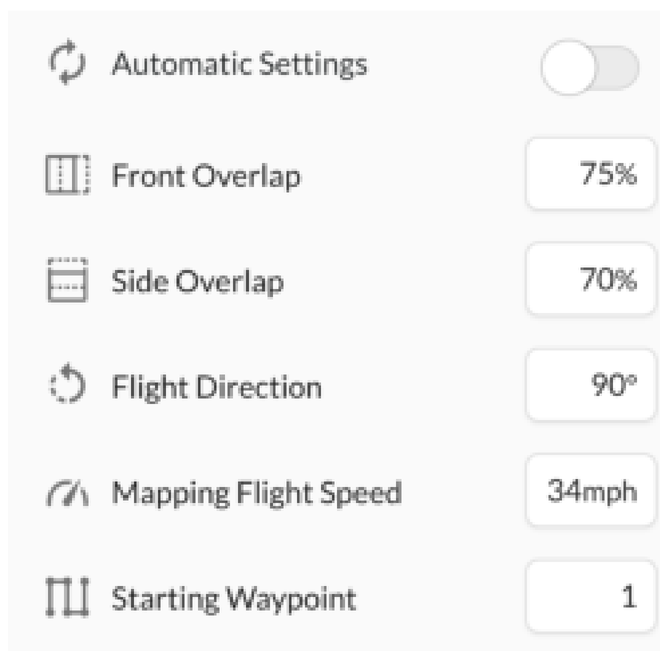


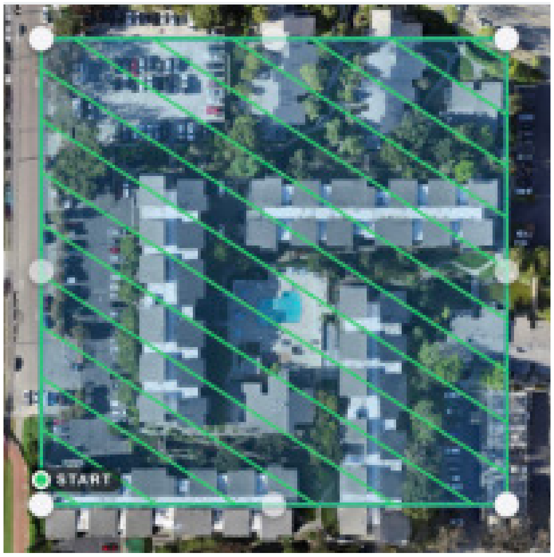
If you turn off Automatic Settings, you can then adjust the parameters:

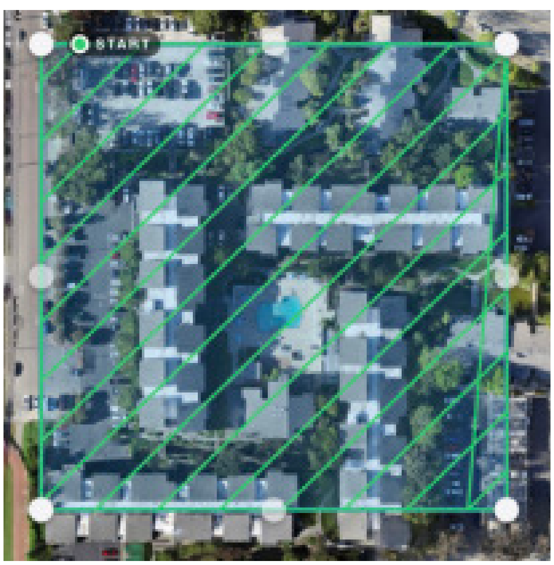
Front Overlap: The percent amount that each photo will overlap with the previous and next photo from top to bottom, as the drone moves throughout each pass. Increasing front overlap means that more photos will be taken one-after-the-other within the same space. The drone will fly slower with a higher front lap.

Side Overlap: The percent amount that each photo will overlap with the previous and next photo from on each side as the drone moves between passes. Increasing side overlap increases the number of passes that the drone will fly over the same area.

With few exceptions, mapping with higher overlap will increase the quality of your final result compared to mapping with lower overlap. This applies until you reach about 90% - 95% overlap. At that point, the benefits of increasing overlap diminish rapidly. Below, you can see the difference between a flight plan with 65% side lap and 85% side lap:







Overlap is a Very Important Setting

Overlap and altitude are two parameters that will most directly control the quality of your output after you've chosen the correct flight mode. In the next chapter, we will discuss when to increase your overlap, and in a later chapter will go in further detail about altitude selection.

Typically, if you'd like to have a 100% fully-stitched dataset, as you decrease your mapping altitude from 300 - 400 feet, for every 50 - 100 feet of altitude loss, your overlap must be increased in intervals of 5% to compensate for the greater difficulty there is in stitching lower-altitude images.

Flight Direction: The orientation of the passes that the drone will take. We recommend adjusting this if you are finding that the drone is hovering repeatedly in the same spot. We also recommend adjusting the flight direction parallel to rowed objects such as solar panels or row-crops.

Mapping Flight Speed: This is the maximum speed that the drone can fly at while it is taking pictures. It won't necessarily map at this speed - it will most likely map much slower than the selected default. We recommend only slowing down the speed of the drone if the photos have unavoidable motion blur due to low light, or if the drone cannot handle image capture requests quickly enough. Pro-tip: if you're finding this issue, try purchasing a faster SD card.

Starting Waypoint: When you move the 'Starting Waypoint' slider, it adjusts the location at which the drone will start taking photos. If your flight plan was a 16-waypoint plan, and you moved the starting waypoint to waypoint 10, the drone would fly to the 10th waypoint to start mapping, and only fly 7 waypoints in total.

Make Available Offline: On the mobile device you plan on mapping with, toggle 'Make Available 'Offline' to save the plan locally to your device, as well as saving the satellite base-map to your device to let you see the background without internet connectivity. Before going offline, ensure that the DroneDeploy app is open and logged in. You may want to turn off automatic updates for your device to avoid the app automatically quitting due to updates during your car ride to the field. Please note that apps from the App Market are online only. After using the flight plan offline, toggle 'Make Available Offline' off to remove the flight plan and satellite images from your device.

04

Consider How Your Subject Can Complicate Things And How You Can Respond

Now that you know which flight tools and parameters you can use to capture your subject, it is time to think about what aspects of that subject may present a risk factor for your successful map. We'll explain how you can mitigate their negative effects with the flight tools and parameters we've just learned about in the previous two chapters.

Each factor listed below makes stitching the model more difficult. Some of them should be responded to differently than others. But as a good rule of thumb, except when noted, when you run into any one of these issues, typically you'll want to increase your overlap by at least 5-10% and make sure you're increasing your altitude.

Why Do I Increase Overlap And Altitude To Compensate For Most Of These Complications?

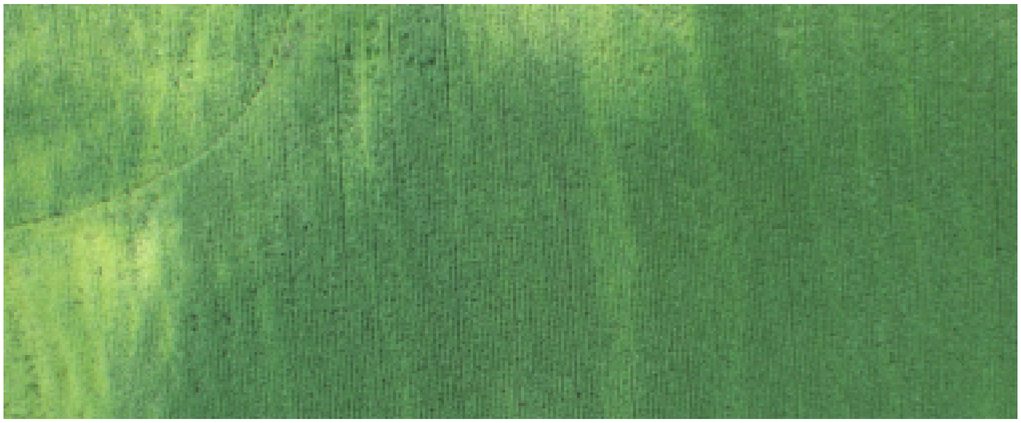
Increase overlap - Increasing your front and side overlap increases the number of photos per point, which means that Map Engine can double-check its work across more images, increasing our stitching confidence, and thus, increasing accuracy.

Fly as high as possible - The higher you fly, the larger your field of view is. The larger your field of view is, the more 'features' Map Engine might be able to find per-photo. This also increases how many tiepoints can be found, which increases stitching confidence and accuracy.

A Homogenous Subject

The homogeneity of your subject is one of the biggest factors determining the number of tiepoints we can identify. A homogenous subject is a subject that looks very similar throughout each photo. It is hard to pick out distinct locations. Late-stage row-crops, forests, deserts, metal roofs, and water are all examples of homogenous subjects.

To illustrate this, imagine in your hand you have two unique photographs of the same part of a field, such as the image below. You are asked to point out the same exact same plant between two photos. This would be very hard for you to do because there are very few obvious reference points to start from and everything in the picture looks like everything else. This is the same problem that Map Engine can run into.



Most of this image looks the same. It's 'homogenous'. It's difficult to find tiepoints here.

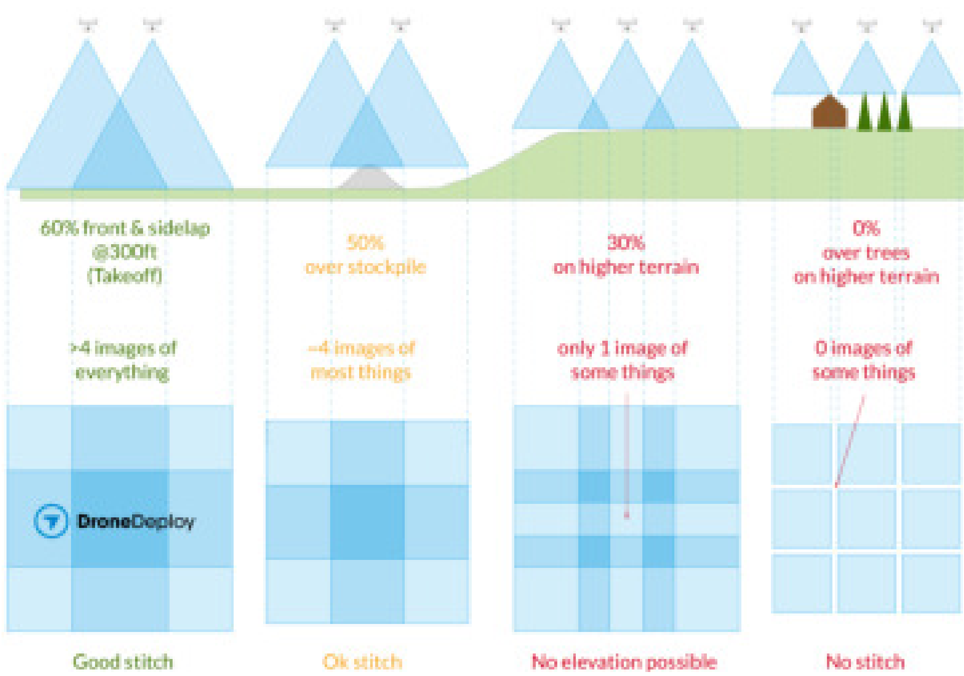
Map Engine has a much easier time successfully stitching together a 'featured' map when compared to a 'homogenous' one. If you use the default template settings on a homogenous subject, there is a chance that the map won't stitch successfully. Homogenous scenes cause the Map Engine to find fewer tiepoints than in highly-featured scenes or causes confusion between the same tiepoint being considered in multiple locations.

When you are mapping a subject with a lot of vegetation, please fly with increased overlap and fly as high as possible. Increasing your overlap by at least 10% is ideal, but even more may be necessary.

Elevation Change

A large elevation change in your map or a large difference between the height of objects in your map can require adjustments to your flight plan. Elevation change includes tall structures and terrain shifts.

If your overlap values remain constant, as you decrease your effective altitude over the ground, the density of your image coverage reduces, as seen below:



"If the terrain of your map changes by more than ~20%, you may need to consider increasing overlap and increasing your altitude as much as possible to compensate for the reduced coverage of the high area."

This essentially means that as your ground moves closer and closer to the drone, the likelihood that there will be enough images to stitch a model successfully goes down as well.

A 20% elevation increase within your map usually is not enough to negatively affect coverage enough to make a difference. This is true as long as the map is not already near the fringes of successfully processing.

To illustrate this, if you flew at 300 feet, and there was a 50-foot elevation shift in the area, the section that was 50 feet higher than the rest will likely turn out fine. Similarly, if you flew at 100 feet, a 20-foot elevation increase would probably not require adjusting your flight settings for that 20 foot higher section specifically.

If the terrain of your map changes by more than ~20%, you may need to consider increasing overlap and increasing your altitude as much as possible to compensate for the reduced coverage of the high area. If the elevation shift is quite large, you may need to carry out the flight using multiple, different flight templates, in order to keep the distance from the ground to the drone consistent.

Optimize your Overlap Across Elevation Changes

You can use the Overlap Optimizer app to help calculate the proper overlap needed given the altitude you plan on mapping from, and the altitude of your highest obstacle.

To identify the altitude of your highest obstacle, we recommend manually flying to the height of that obstacle using DroneDeploy's Manual Mode.

Intricate/Fine Structures

Oftentimes, you may be interested in reconstructing objects that are small, thin, and with fine details. This includes subjects like scaffolding, rebar, external stairs, statues, or a crane. Successfully modeling these objects can be paradoxical because you must fly low in order to achieve the resolution needed to clearly see them in the first place, but flying low reduces the likelihood of a successful stitch.

This usually means that you'll need to fly low (<120 feet) with very high overlap, such as 80-90%. This gives you the resolution to see the details for these small objects, and the overlap to compensate for the likelihood of stitching problems due to low altitude.

You may want to consider if you need oblique (angled) shots in order to provide enough vertical and side data for a model. The Precision House 3D app, crosshatch, and manual flight modes can help produce those kinds of datasets.

Points of Interest and Difficult-to-See Angles

This topic was covered in the Structures Mode 'Flight Planning' section, but it is so important it is worth bringing up again.

Some objects, such as a very simple stockpile, will be adequately modeled from a basic Non-Structures mode flight. However, many objects will turn out melty and inaccurate if they aren't identified as a POI that needs a wide range of side angled shots, or obliques, in order to be accurately processed.

Even if you add a flight that completely centers around a single object, for some areas, the autonomous flight will not capture sufficient data. For example, if you were mapping two tall silos that were very close to each other, it is likely that it will be impossible to autonomously capture imagery that sufficiently covers the section of the silos that face each other. Another example might be an alleyway that is in between two buildings, such as what you see below:

Please take the time to identify each of these areas in the area you are mapping, then taking a number of manual shots of these areas to supplement the autonomous ones.

Mapping Rule of Thumb

If you can't clearly see what you'd like modeled in at least 7+ of the original images, it is unlikely that it will be modeled well.

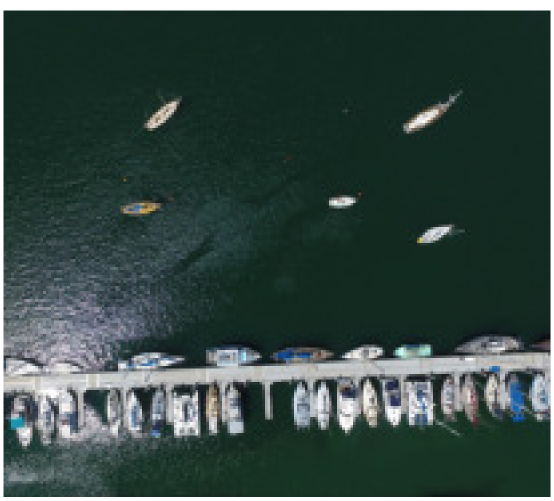
The Shape of the Flight Plan Area

A simple polygon is the best type of shape for flight planning. The more uniform the flight plan is, the more uniform and accurate the model is likely to be.

Longer, more narrow linear maps or maps with sharp-angled hooks, straights, or peninsulas are more likely to run into coverage issues because there won't be more than 8 images of the areas at the tips of the points.

Additionally, it is important to always slightly overfly. This means to fly a slightly bigger area than you know is necessary to ensure there's sufficient overlap at the edges of the plans.

Oftentimes, the data captured right along the border of the flight template is insufficient compared to the rest of the flight plan. You should expect that near the border or edge of your flight plan, there may be some warping or misalignment, so if the section you care particularly about is near the edge of the polygon, please expand the boundary so that it is at least 100 feet from the edge of the plan. These problems can be somewhat compensated for with overlap and altitude adjustments, but the best practice would be to expand and simplify the flight plan to cover the larger area evenly.



Reflectivity and Lighting Conditions

We started this article by describing how Map Engine works. For example, we identify a roof section in photo 1, and the roof again in photo 2, and then build a model with the information we can deduce about the roof from multiple angles.

But what if the roof looks different in every single photo? This can happen if it is made out of highly reflective material. If the sun is powerful enough to cause a strong reflection, an object will have a different reflection in each location the drone takes a new photo, which makes it very difficult to match parts of the object to itself.

In addition to the object looking 'different' in each photo, sometimes, a reflection has such a high intensity of light that it covers any appreciable information about the object itself as well.

This effect is most commonly seen in the water, metal roofs, and solar panels.

To mitigate the effects of a highly reflective surface, we recommend flying on an overcast day (or at least when the sun is low), experimenting with camera filters, increasing overlap, and flying as high as possible.

The sun affects drone mapping in more ways than causing reflectivity. Flying your drone when the light is flat but still present will help contribute to the most even and accurate map possible. Objects are evenly exposed and shadows aren't significantly large.

It is still possible to receive great results if mapping while the sun is more intense, but it may be slightly more difficult than a more even-tempered day.

Mapping in dusk-like or dark conditions often causes there to be motion blur and insufficient contrast between objects on the ground. Poor weather conditions such as fog or condensation can also contribute to model difficulties. In these scenarios, you'll need to pay extra attention to your camera settings and the quality of your photos as you fly. You may want to enable 'Low Light' or manual camera settings.

Moving Objects

A moving object captured in your dataset will cause some degree of inaccuracy. This is because the information Map Engine receives shows one single object in multiple places which then has to be placed into one single snapshot of a moment, which is physically impossible. Moving objects not only change position but can also change shape, causing them to be even more difficult to model.

Map Engine does attempt to detect when an object is moving and to process it in a single place, but it doesn't always work. Here is an example of two horses, both of which were moving while this subject was mapped. One horse was well-modeled, while the other is inaccurately reconstructed.

Bodies of water, vegetation rustling in the wind, driving vehicles, and people walking are the most commonly found moving objects in maps that will reduce the accuracy of your map.

05

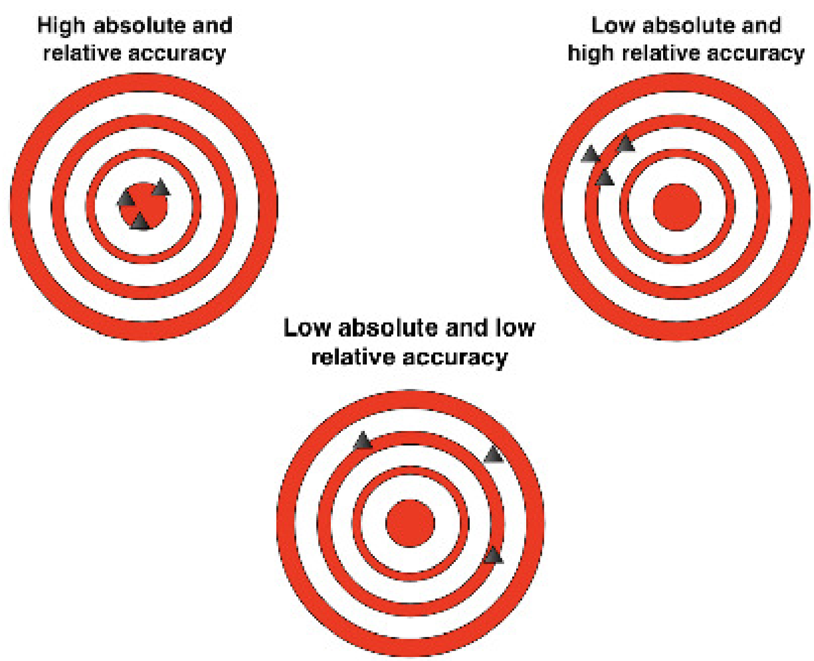
Tie In Your Accuracy and Resolution Goals

You've now thought about the flight planning tools at your disposal and the difficulties that your subject may cause. You've adjusted your flight parameters to compensate for potential risk factors that your subject may present. It is finally time to add in other specific project requirements or goals you or your clients may have, such as relative accuracy, global accuracy, and resolution.

Accuracy

You might have a client or manager say 'I would like this map to be accurate to 5cm'. But what does that actually mean in real terms?

There are two main ways to describe accuracy: relative accuracy, and global accuracy. It is important to know which type of accuracy is important for your use case so that your final result satisfies your project goals.

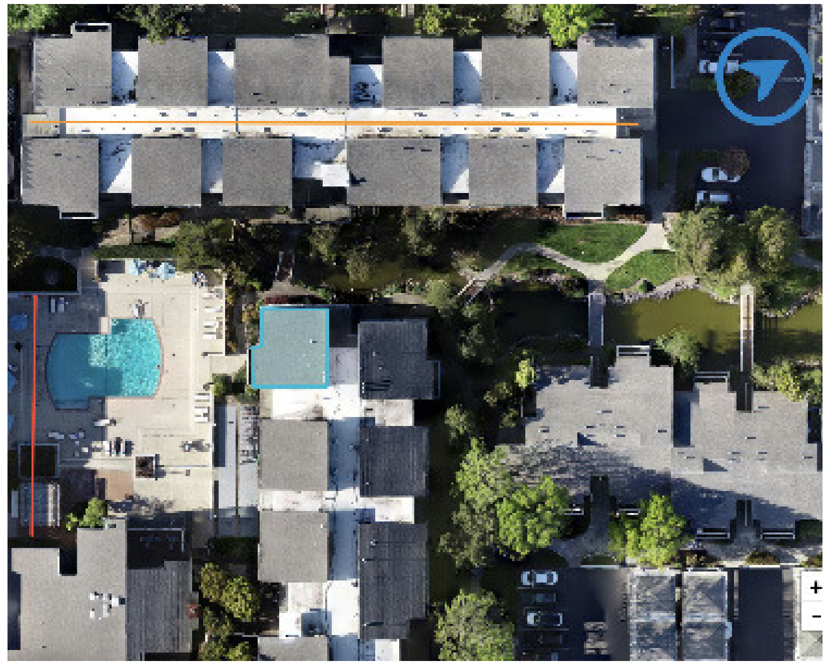


Relative Accuracy

Relative accuracy describes how accurately the objects within the map are placed compared to other objects in the same map area. For relative accuracy, it does not matter how well the drone data lines up on the Google base layer. The degree of relative accuracy describes how accurate are the measurements within the map are to real life.

It is common to require high relative accuracy for measuring the length, area, and volume of objects, in construction site management, crop scouting, and creating marketing material.

“High relative accuracy can be achieved without Ground Control Points (GCPs) by flying low with high overlap and strong oblique coverage if necessary.”



You could have high relative accuracy even if your map was placed on the completely wrong side of the world because the measurements within the map would still be correct, but the geographic coordinates would be incorrect.

High relative accuracy can be achieved without Ground Control Points (GCPs) by flying low with high overlap and strong oblique coverage if necessary. With proper GCP technique, relative accuracy will often improve a little bit, but primarily, relative accuracy is a function of the quality of the image set and your drone’s GPS accuracy.

Absolute Accuracy

Absolute accuracy describes how accurately placed your map is in the world compared to where it truly should be placed. High absolute accuracy means that if you were to pick a location on your drone map, and you were to send someone out into the real world to that same geographic coordinate, they would be standing at the same location in the real world as you picked on the drone map.

It is common to desire high absolute accuracy for land title surveys, as-built surveys, environmental documentation, and overlaying geo-referenced site plans.

The accuracy of the location annotation depends on the absolute accuracy of the map.

High relative accuracy is often a byproduct of high absolute accuracy because it is difficult to accurately place something in the world correctly if its dimensions are incorrect.

High absolute accuracy can be achieved by properly using GCPs (Ground Control Points), PPK (Post-Processed Kinematic), or RTK (Real-Time Kinematic) GPS devices.

When you have instructions to achieve a certain accuracy, we would recommend making sure it is specified precisely the type of accuracy needed.

How to Increase your Accuracy without using GCPs, RTK, or PPK

You can achieve a map with high relative accuracy without adding GCPs, PPK, or RTK. Successfully designing a flight plan for high relative accuracy is dependent on three main factors:

1. High-Quality Images: Sharp images are paramount for a non-GCP map to be highly accurate. If an image has blur that goes across a couple of pixels, the accuracy of the entire map may be halved because half of the pixels are getting smeared before we process anything. Mapping in good light conditions and knowing when and how to adjust your camera settings are important for this.

2. High Overlap: We've described in this article how more images of the same location increases how confident we are about an object's size, shape, and location. Increasing your overlap will generally increase how relatively accurate the map will be because we are checking our work across many images. Very rarely, if there is a lot of movement in your map, high overlap can have a negative effect on accuracy, because each photo will show something new and different, instead of confirming what is staying the same.

3. Fly Low: Assuming risk factors such as a homogenous subject or elevation change have been factored in, and therefore no part of the model is at risk for not aligning with the rest of the model at all, and that overlap is properly set, the lower you fly, the more accurate your map will be. When you fly at 100 feet instead of 400 feet, the images at 100 feet will describe a smaller area compared to the 400 feet image set but will do so with the exact same number of pixels. This means that each feature at 100 feet is captured using more pixels compared to the 400 feet data, and therefore has greater detail. You also have more images and thus more GPS samples. This allows for the Law of Large Numbers to have better convergence.

High Precision Mapping

If you've flown low with high overlap and good image quality and the relative or absolute accuracy of your maps is not high enough, using GCPs, RTK, PPK can roughly increase your absolute accuracy by a factor of 10 compared to a regular flight. If you add GCPs to your map, you should record your on-the-ground GCP coordinates by using a high-precision GNSS receiver that is accurate to the centimeter level.

You Don't Need GCPs	You Do Need GCPs
You do not necessarily need GCPs if only relative accuracy is important. Drone mapping projects that only require high relative accuracy include: • Measuring length, area, and volume of objects • Construction Site Management • Crop Scouting • Creating Marketing Material	If absolute accuracy is important then you will need to use GCPs on your map. Drone mapping projects that require high absolute accuracy include: • Land Title Surveys • As-Built Surveys • Environmental Documentation • Overlaying Geo-Referenced Site Plans

GCPs vs Checkpoints?

Ground Control Points and checkpoints are both marked points on the ground that have a known geographic location. For both, you'll submit tags, which will precisely define the center of these markers.

GCPs make your map accurate, while checkpoints allow you to assess how accurate it is. Checkpoints and GCPs are captured and tagged exactly the same, except for how they are labeled in the CSV file before uploading them.

GCPs are used as points to 'snap' the map to correct locations during processing. They increase absolute accuracy, but you can't use their locations to measure accuracy, because they are algorithmically forced to be near where their coordinate data says they should go.

Checkpoints aren't forced to go in any location. Checkpoints are allowed to move freely during the processing of the map. Because we know exactly where they should be, and exactly where they end up, checkpoints are the only true way to measure the resulting absolute accuracy of a map.

The balance of checkpoints and GCPs you choose will affect how accurate your map is and how quantifiably confident you can be about the accuracy of your map. The more GCPs you use, the more accurate your map is likely to be, but if you have few checkpoints to verify this, it'd be hard to definitively say how accurate the map is. Using a ratio of 2 GCPs for every 1 checkpoint is a common starting point, with 20 checkpoints being the ASPRS recommendation for getting a 95% confidence interval on the results.

We find that Ground Control Point placement is often overlooked. Poor GCP placement can cause datasets to be more inaccurate with GCPs than without them! Think of GCPs as having a substantial amount of weight in the accuracy of the map - this weight, if concentrated in sections of the map without enough counterweight, can actually cause the map to sag down, tilt, bowl, or even flip.

You should place the GCPs such that if you were to divide out smaller, evenly-sized sections of the map, they would each roughly have the same number of GCPs. We recommend planning out the GCP placement before arriving at the site.

On GCP placement/numbers and map size:

We are often asked how many GCPs are required per acre. Interestingly, one seldom-considered factor in this equation is the altitude at which you're flying. You can think of GCPs as 'nails' and each image as a link in a chain. Having a GCP in an image 'nails' that link to the correct place in space. The more links in the chain between images, the more play there is in the system (the more the chain will be able to move). Similarly, if we had a GCP in every image, they would all be nailed down, whereas if there are many images between two GCPs, there's more opportunity for sub-pixel errors in the stitching process to accumulate. We understand that you can't feasibly put a GCP in every image, so we recommend 1 GCP for every 60 images.

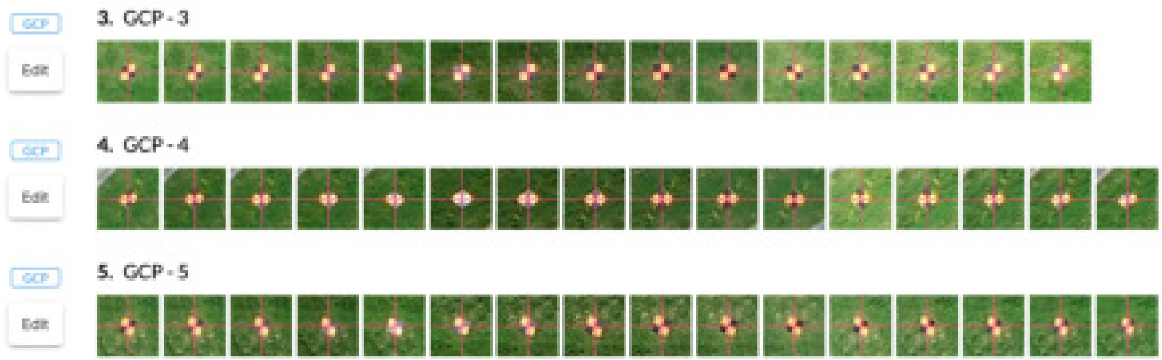
GCP Placement Rules

- GCPs are evenly distributed throughout the map area
- Minimum of 4 GCPs per map, but 6+ is preferable.
- Roughly 1 GCP for every 60 images (larger maps may scale this down)
- At least 50 feet from the border of the map and from any other GCP
- Use clear markers with a defined center
- Cover the full elevation range of your subject to increase accuracy

Here is an example of a good distribution of checkpoints and GCPs for an 800 image map. The 13 red stars are GCPs, and the 12 yellow circles are checkpoints. Notice the evenness and symmetry of the locations of the GCPs and checkpoints. There is not an area that is missing coverage from either the GCPs nor checkpoints. They aren't clumped together. With this number of GCPs, as long as they're tagged correctly, our accuracy will be increased substantially over a non-GCP version, and we'll be able to verify that this is the case across the entire map area by checking the checkpoint accuracies. In a future section, we will help you interpret this data correctly.

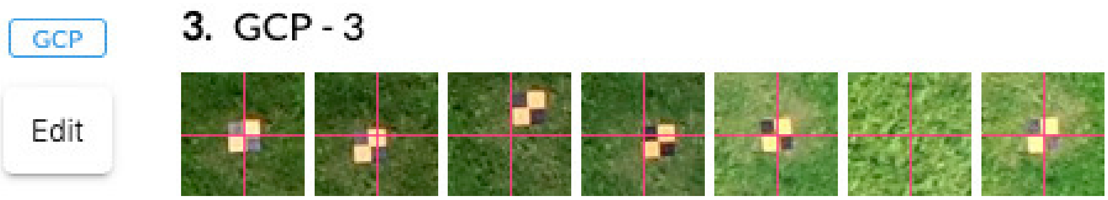
The accuracy of the location annotation depends on the absolute accuracy of the map.

Tagging your GCPs accurately is just as important. Taking the time to precisely click the middle of the target and to verify that there are no stray, erroneous tags that are off-center or of a different GCP is the final ingredient leading you towards the next level of accuracy. Please tag at least 6 views per GCP.



Notice how each GCPs' tags are centered and look similarly exposed and focused.

Here is an example of poor tagging. 4 out of the 6 tags are off-center. This will create a large degree of inaccuracy for at least the area around the GCP, if not, the entire map.



Notice how each GCPs' tags are off-center compared to the first image

You can also increase global and relative accuracy by using a drone with RTK or PPK. When you fly a normal drone without RTK or PPK technology, its GPS accuracy will be similar to your smartphone - typically within a few feet, which is not very good for high-precision mapping, and is the reason why non-GCP maps have similar accuracy limitations.

PPK and RTK systems mean that the drone can record its own location very accurately, which means that the information we're receiving to build our model is more accurate. Oftentimes, the relative and global accuracy of PPK and RTK maps is good enough such that no GCPs are needed to increase accuracy, this can be a time-saver and simplify the workflow.

There are still reasons to use some GCPs if you're RTK mapping, for example, only checkpoints are able to verify that the drone data is accurate.

"PPK and RTK systems mean that the drone can record its own location very accurately"

Interpret Your Accuracy Report Data Correctly

You now know the difference between relative and absolute accuracy and if they're important to your project goals. You know how regular flight techniques, GCPs, and checkpoints can impact absolute and relative accuracy. Now, to conclude our section about accuracy, we're going to explain the accuracy report data. What does it mean, and what can you infer from it?

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
1	0.7441	-0.1772	-0.2498
2	0.4458	0.4803	0.8071
3	-0.4134	-1.0313	0.1102
4	-0.4724	-1.7992	0.2362

When you map (1) without GCPs, (2) with only GCPs, (3) with checkpoints, the accuracy data you receive in each of these three scenarios is a different and unique metric. So, if you want to tie this data back to those relative or absolute accuracy goals, it is important to know what data you are actually receiving in the report and what you can and can't deduce from it.

The glossary in the Accuracy Report for your maps contain these specific definitions. Here is a summary of how you can use your Accuracy Report data

Map Type	Data Type Received	How can it be used?
No GCPs or checkpoints used	The camera location XYZ root means squared error (RMSE) is the average image location error. It's saying 'How close were the drone images' geotags to the locations where we found the images needed to be in order to make a model that makes sense?'. This is more of an indication of the accuracy of a particular processing step of the Map Engine, and less an indication for the accuracy of the entire map.	**The camera location XYZ RMSE cannot be used to determine relative or absolute accuracy.** **It can sometimes give you a general estimation for the relative accuracy of your map.** For example, if your camera location RMSE was less than a few meters, it's likely your map has solid relative accuracy - but not a guarantee. If your camera location RMSE is above 10 meters, we would recommend taking a closer look at the map. It, however, still could possibly be accurate.
Just GCPs used	The ground control point (GCP) XYZ root mean squared error (RMSE) is the average GCP location error in the XYZ axis across all the processed GCPs. It's saying 'How close was the GCP location as measured by your precision GPS device compared to the corrected GCP location that is calculated during map processing?' This is more of an indication of the accuracy of a particular processing step of the Map Engine, and less an indication for the accuracy of the entire map.	**The GCP XYZ RMSE cannot be used to determine relative or absolute accuracy.** These values are calculated using a weighted mathematical estimation, because we 'force' the GCPs to go very close to their CSV coordinate locations. When we 'force' the GCPs to move into a particular location in order to help rectify the rest of the map, the RMSE values become algorithmically based, instead of based on the accuracy of the map.

...Continued

Map Type	Data Type Received	How can it be used?
Checkpoints used (with or without GCPs)	The checkpoint XYZ root means squared error (RMSE) is the average checkpoint location error in the XYZ axis. It's saying 'What is the difference between the checkpoint location as measured by your precision GPS device and the correction checkpoint location that is calculated during map processing.'	**Checkpoint location error is a measure of the absolute accuracy of your map.** This metric seems similar to the GCP XYZ RMSE. The difference between the two is that checkpoints aren't weighted. They aren't 'forced' to go anywhere. That way, they 'naturally' move completely with the rest of the map. Remember that the location error for a checkpoint only describes the locational accuracy of that single point. It doesn't actually describe the locational accuracy of the entire map, because it is normal to have different accuracy in different parts of the map. So, the more checkpoints you use over a wider area of your map, the better the estimation they'll provide for absolute accuracy.

So, how can you check for relative accuracy? You might have noticed that in the above chart, none of the data points are a true representation of relative accuracy, although if the absolute locations of the checkpoints are accurate, to a degree, the distances between them will also be accurate.

Remember that relative accuracy describes how accurate measurements within the map. So, if we know the dimensions of some objects on the ground, we can use 'ground-truth' comparisons to establish a relative accuracy estimation.

For example, when you're capturing your drone data, you might take a tape measure and take down the dimensions of clearly defined, static objects distributed throughout your map, such as the objects circled below:

Then, measure those exact same locations on the completed drone map, and be sure to be as precise as possible. The average percentage difference between the actual and the reported measurements can give you a good idea of relative accuracy. Here is some sample data:

Feature	Ground Measurement	Drone Map Measurement	% Difference
White sidewalk section	7.25 meters	7.50 meters	3.4%
Reflective parking lot strip	6.65 meters	6.74 meters	1.3%
Bridge	6.30 meters	6.18	1.9%

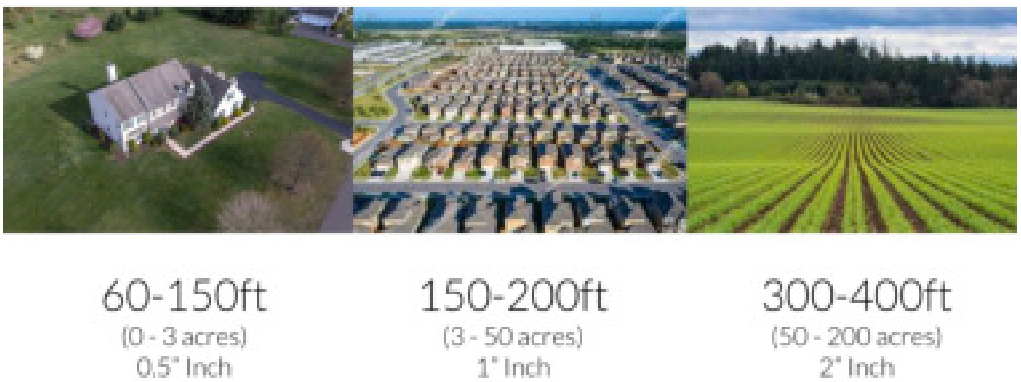
The average of the three percent differences is 2.2%. Therefore, the area of the map that these objects cover is likely to have a near 97.8% relative accuracy, and that would be a good starting point for the accuracy of the measurements you make in this area of the map. Just like checkpoints, bigger diversity objects measured over a wider area of your map will help estimate accuracy better.

Resolution

As you change mapping elevation, what changes is the size of the ground area in which each pixel covers. This is called the Ground Sampling Distance (GSD), and this is usually the metric someone is looking for when they say something along the lines of 'I would like the resolution to be 2cm'; they usually mean 2cm **per pixel.**

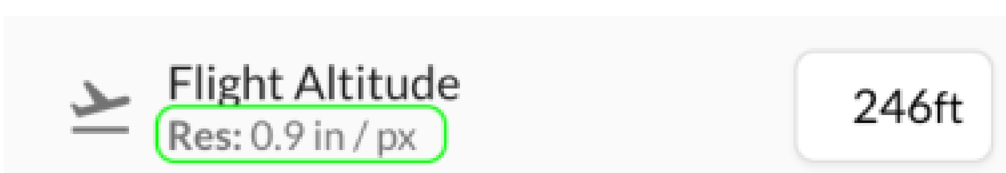
The lower you fly, the smaller your GSD will be, which means that each pixel, when mapped on the ground, will cover a smaller area. This means the map will be clearer and less pixelated than the maps you fly at a higher altitude. Remember to compensate with overlap increases as you decrease your mapping altitute.

Selecting Appropriate Altitude



Each image from the same camera is a fixed number of pixels in size. If that camera is close to an object, then many of those pixels will be of that object. If the camera is far away from the same object (and at the same zoom level), then there will be fewer pixels of that object. This is the principal behind GSD. As the drone is closer to the ground, each image will capture a smaller section of the ground, but it will have many more pixels for the same surface area of the ground compared to an image captured from a higher altitude. This increases the accuracy of the map.

As you change the altitude in your flight template, the expected resolution of your map will also change. Remember that until your drone is connected to the DroneDeploy app, we won't be able to know which camera (or lens) you are using, and so we will be estimating this based on the most popular drone used for mapping - the Phantom 4 Pro.



As you reduce your altitude in flight planning, you'll also see an increase in the estimated resolution.

06

Create A Flight Plan

If you've made it this far, you know that there are a lot of factors to consider when designing a top-notch drone flight plan. Depending on your subject and goals, there may be factors that produce opposing advice or seem to be in conflict with each other. There may be a few factors that push you to fly low and others that encourage you to fly high. But, now you know what flight planning tools you have at your disposal to create a balance between all of these forces.

You can balance these forces, such as desired accuracy, homogeneity, or the intricacies of your subject by first, compromise. For example, if you have reasons to both fly high and fly low, somewhere in the middle will likely be the best choice.

Secondly, balance these forces by compensating. You can counteract a shortcoming that one setting causes by changing another. In the same example as before, if you chose a moderate altitude when a higher one would be more ideal, you could react to that further by increasing overlap.

Lastly, redundancy and experimentation really pay off. While you're still mastering drone mapping, create alternative flight plans using different techniques and settings and try processing different versions of your subject.

For example, you might process one map with manual shots added and one without - see if the difference is enough to matter to you. You might also compare a Structures flight vs. a Precision 3D app flight of the same exact subject. Or, try to process one version in Structures mode, and one in Terrain mode.

The more maps you create using a wide range of settings, the faster you'll learn how each decision you make in the planning phase affects the final map.

07

Bring Your 'A' Game To The Field!

Using the officially supported mobile devices and drones are important for safety and performance reasons. Before every product release, we make sure to test every drone, camera, and lens combination listed in our supported drones list.

Be warned that unlisted devices are not frequently tested by our team, and we are unable to guarantee support for those platforms.

A few of the most commonly used drones on DroneDeploy.

It's also important to have a consistent routine for each mission you fly. Here is a list of some common workflows that will give you the best chance of having hundreds of successful flights. This is not the 'be-all-end-all' list, but a great starting point to make sure you're doing your due diligence:

1. Check the iTunes Store or the Google Play store for updates to DroneDeploy. We recommend turning on automatic updates.

2. Use DJI Go or DJI Assistant to upgrade to the latest firmware for your drone and remote controller, and make sure your aircraft is fully calibrated (especially the compass). Uncalibrated hardware and out-of-date firmware are the two most common issues that prevent people from flying or causes unexpected behavior.

3. Inspect your drone for damage before going out in the field to ensure that it's ready and safe to fly.

4. Fully charge your remote controller, mobile device, and drone batteries.

5. Format your SD card before going out to fly to make sure you have sufficient space. Always have a spare SD card on hand in case the card in the drone gets corrupted (or in case you leave the drone's SD card in your computer!)

6. Bring 2 USB cables for your mobile device, just in case one malfunctions.

7. Bringing additional propellers for your drone can help ensure you can keep flying even if propellers get damaged during your flight.

8. Utilize websites like weather.com to ensure that the area you will be flying in has good weather.

9. Scope the site out using Google Earth, and Google Streetview ahead of time to get more familiar with the site.

10. To ensure that the area you will be flying is cleared for drone use DJI Fly Safe.

11. Familiarize yourself with applicable local, state, and federal regulations.

Choose your home point and the location of your controller strategically. You should always maintain a line of sight with the drone, and you want to promote the strongest signal between your drone and your controller as possible. You also don't want to have significant altitude changes in your starting location between battery changes.

To do this, if possible, take off from a high point of the map, as well-centered within the area as well, and do not plan a flight that has a larger radius than the signal range of your drone. Avoid taking off next to sources of interference, such as physical barriers like big buildings, hills, and trees, and electromagnetic interference sources such as power lines, reinforced concrete, and large metal objects.

You must check the altitude of the notable obstacles within the entire area that your drone will fly. To do this, use Manual Mode in DroneDeploy to manually fly until the horizon is above all nearby obstacles to ensure your drone will fly over them with a comfortable buffer. Obstacle Avoidance can help avoid obstacles but it is not perfect.

As you fly, always be in command of your aircraft, fly within line-of-sight, and always be ready to take over manual control of a drone if something arises.

Check your Image Quality as you Fly

DroneDeploy does attempt to make your camera capture imagery at its absolute best quality. However, ultimately image quality is governed by so many factors that it is useful to check the quality of the individual photos captured as the drone is performing the flight. Check that your subject is evenly exposed and in focus. The easiest way to do this is to tap the FPV thumbnail so that you can view the FPV full-screen.

You can toggle the "Set Exposure/Focus Manually in DJI Go" setting under the 'Advanced' tab while planning your flight toggles to adjust your exposure and focus manually in the DJI Go App. You may need to restart the flight after adjusting your camera settings if the automatic settings are not producing great results.

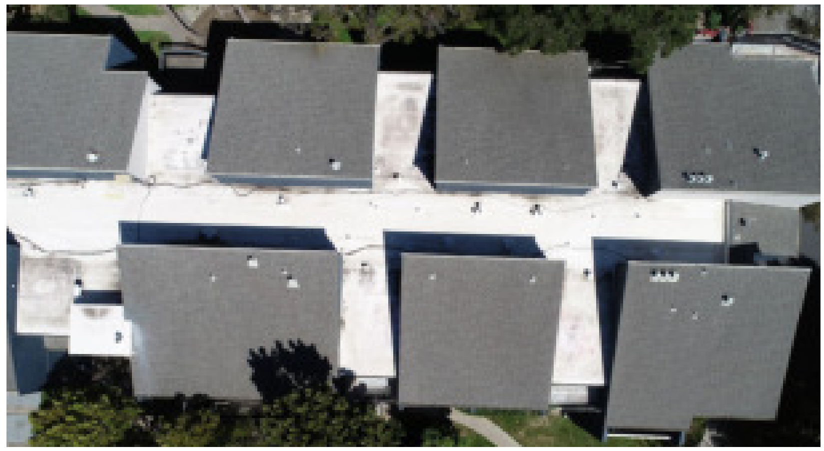
08

Process Quality Data in the Correct Mode

As soon as possible, we recommend inspecting your images on a desktop or laptop computer. If your images have problems, the sooner you find out, the sooner you can refly or reassess.

Your images should be evenly exposed and sharp. You should be able to zoom in on them a fair bit before they get soft.

Notice how you can see the details in the roof when zoomed in, even though the picture is from fairly high up. Both the white sections and the grey sections are properly exposed, which is also important.



In order to use the Map Engine, your data must meet the following requirements:

1. All images should be in JPG format

2. All images must have latitude, longitude, and altitude in the GPS EXIF data

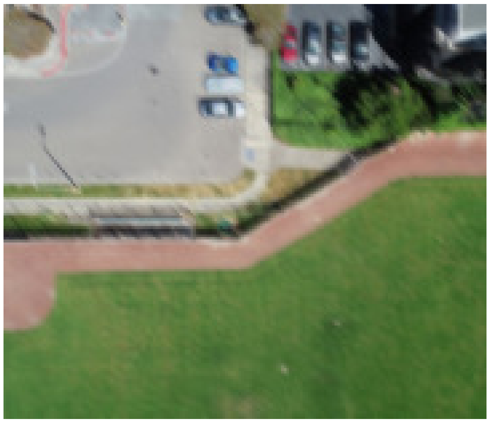
3. All images should be facing the area of interest

4. All images should have significant overlap (more than 70% side and front overlap)

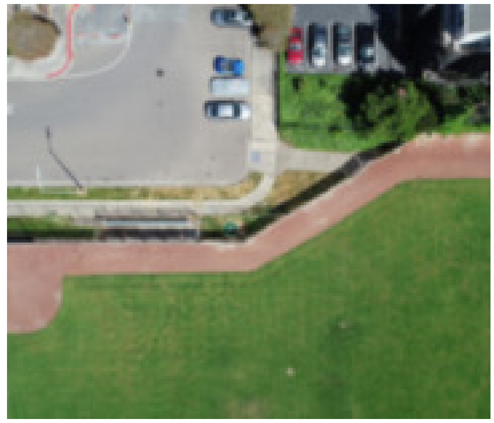
5. At least 30 images for reliable map processing.

Here are some common image problems to watch out for. These will all cause Map Engine to find fewer tie points, and will decrease the quality of your model. Remember, outputs (maps) can only be as good as the inputs (images).

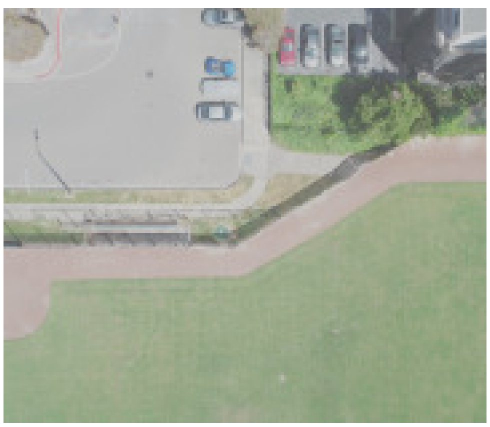
Motion blur, usually caused by a slow shutter speed or low lighting conditions:



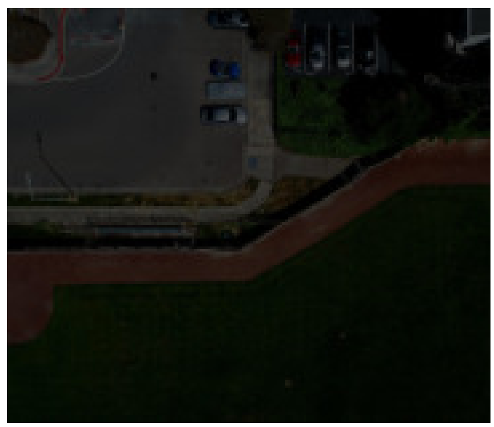
Soft or out of focus, usually caused by incorrect aperture setting:



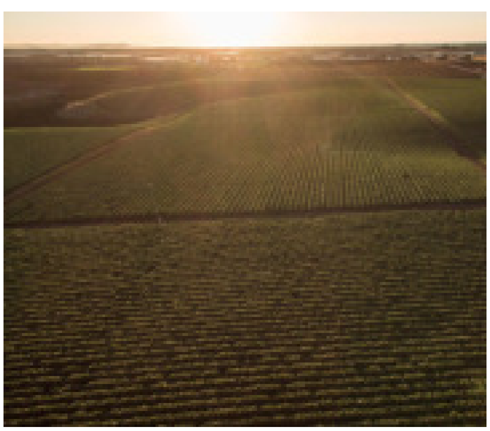
Overexposed, usually caused by slow shutter speed, high ISO or too large of an aperture:

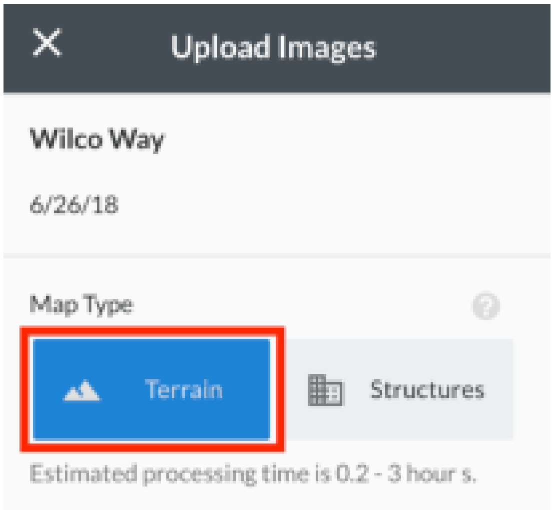


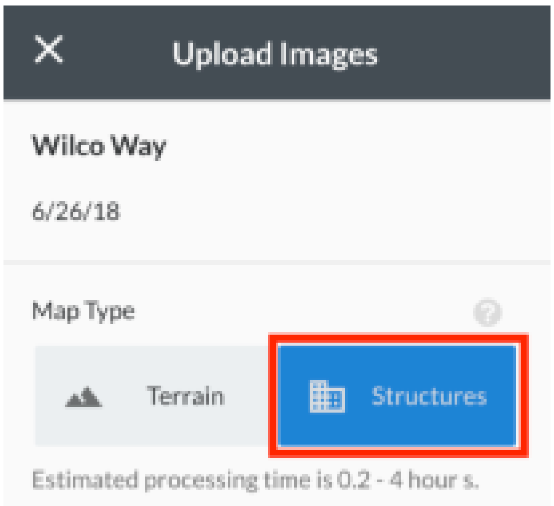
Underexposed, usually caused by fast shutter speed, low ISO or too small of an aperture:



Horizon included, caused by too high of a camera angle:







Processing Modes

We have 2 main processing modes that you can choose to process your data in. The first is the Terrain mode, and the second is Structures mode.

Non-structures mode flights typically receive Terrain Mode processing, and Structures mode flights typically receive Structures mode processing, but there are reasons that you may choose to process your data differently. It can often be crucial that you process in the right mode for your subject and project goals. Note that Terrain mode still generates 3D data products like Point Clouds, 3D Models, and Elevation Layers.

You can choose which mode to process in as you upload your data.

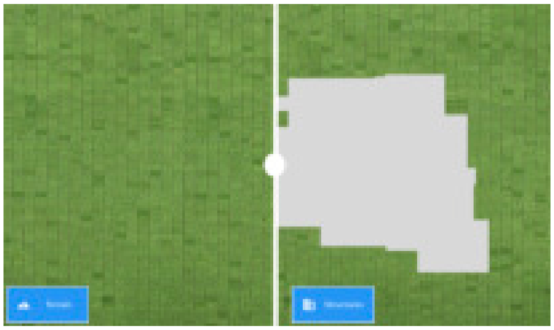
Terrain mode is optimized to:

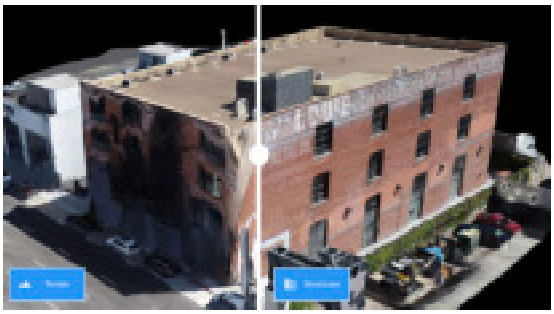
- Reconstruct large tracts of land such as agricultural fields or site survey accurately in 2D
- Reconstruct 3D surfaces that do NOT contain overhangs or vertically stacked points.
- Process datasets up to 10,000 images.
- Process nadir-only datasets.
- Provide a gridded raw point cloud that is 4x less dense than the Structures mode point cloud.
- Fill in holes more aggressively in Structures mode.

Structures mode is optimized to:

- Reconstruct 3D objects as accurately as possible.
- Process oblique imagery along with nadir shots.
- Process image sets of up to 1,000 images. If your dataset is a little bigger than that, you can still try to process it.
- Provide a point cloud that is 4x more dense as the Terrain point cloud, with data in overhanging regions preserved, and the points filtered less aggressively.

You can bend the rules strategically if the results you receive the first time around aren't what you would have hoped for.



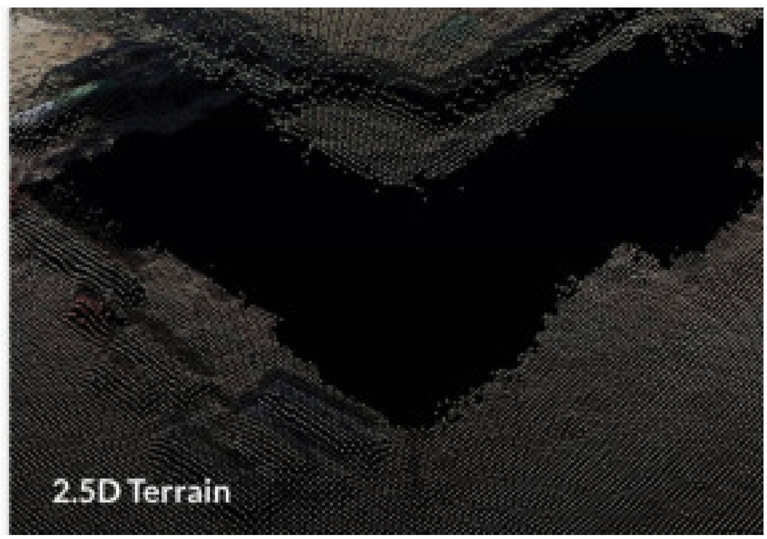


For example, if you have Non-Structures-style data (nadir only), but you were hoping for a better 3D result than what you received when you process the data in Terrain mode, you could reupload the data and process in Structures mode to try for a better result. The dataset is not designed for Enhanced Structures, but experimentation can lead to positive results sometimes!

Likewise, if you had Structures style data (including some obliques) that had coverage issues and had a few holes, you can certainly try to reupload the dataset in Terrain mode. You would see a reduction in 3D quality, but it may fill the holes more effectively.

Any dataset that includes obliques up to 1,000 images needs to be processed in Structures mode if you do hope for those obliques to be used effectively in processing to help the 3D model.

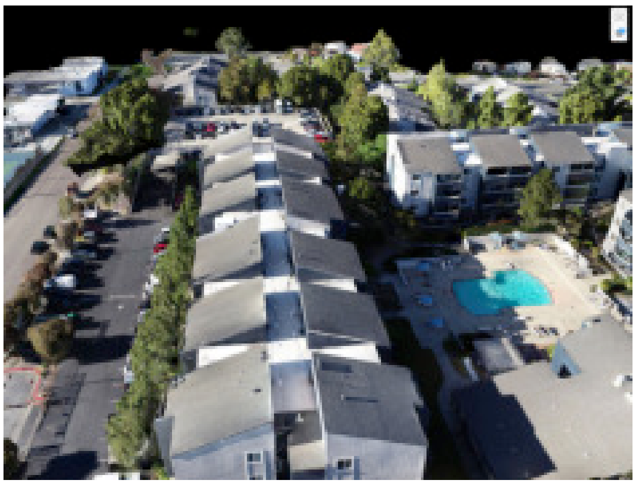
The processing time of your map varies highly depending on the size and quality of the dataset.



09 Quality Check Your Data and Map

Once your map completes processing, there are steps you can take each and every time to help you understand how accurate your data is and the reasons behind its accuracy. These steps are the basic troubleshooting steps that DroneDeploy support uses when you reach out with a question regarding the quality of your map.

The first step that we recommend taking is a sanity check using your eyes. We have a lot of tools and data points that can help you determine or infer the accuracy of your map but don't discount the power of your own pattern recognition.



Switch between the 2D and 3D views. In the 3D view, move around and double-check that everything looks similar to how it looks in real life. Where you start to see reconstruction problems, you are more likely to run into measurement inaccuracies. If part of the map is processed incorrectly, you are very likely to catch it over this step.

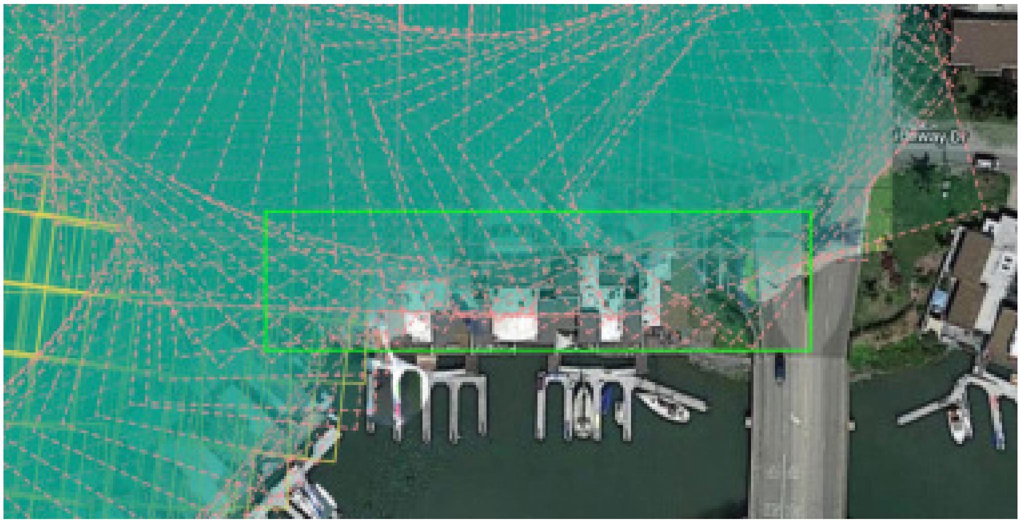
In the 2D view, check the alignment of the map against the base layer. Remember that without GCPs, your map may be at least a few meters off of its precise location because drone GPS data is not very accurate. Do also keep in mind that the Google base layer can be imperfect as well.

In this example, the top two circled areas are very well-aligned with the base layer. There is probably solid absolute accuracy in those sections. The lower circled area shows some warping near the bottom because this is near the edge of the map, where the image coverage is light. This warping indicates that this area is not accurately reconstructed, and so we would recommend avoiding trusting measurements in areas like this.

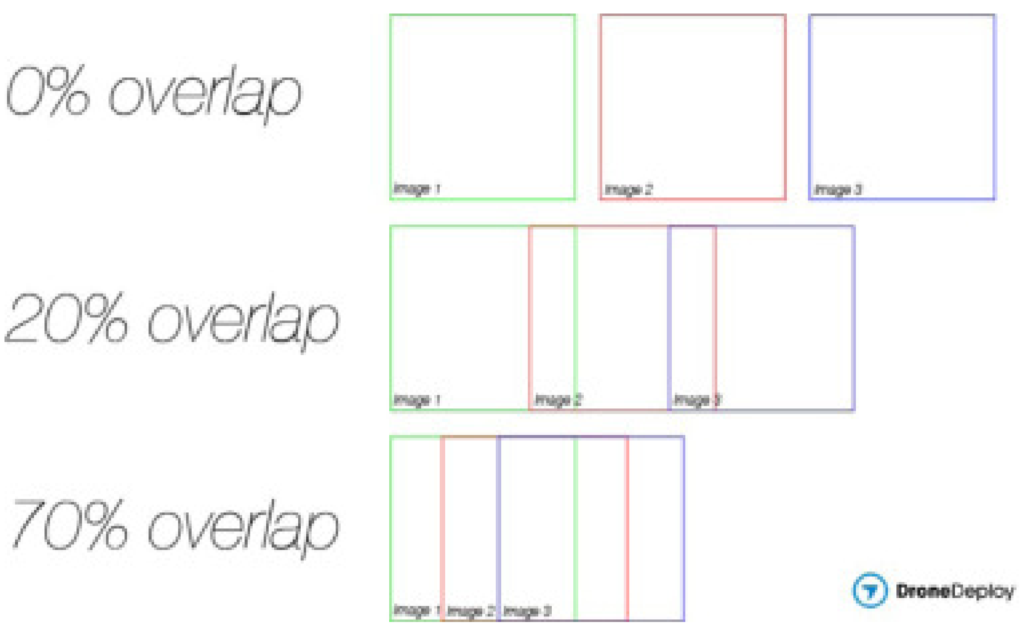
Now that you've inspected the map and understand its strong and weak points, relating those strengths and weaknesses to your image set will really begin to shape your understanding of photogrammetry and your ability to strategically plan your flights for beautiful results.

The second step we recommend taking is to turn on the image projections. Each and every time you process a map, we recommend going to the 'Media' section of your map and turning them on.

Consider the above picture. Why did that section turn out misaligned? Because the flight plan boundary was near the area marked in green below, and oftentimes, there is insufficient image coverage around the edges of the map, especially around a corner.

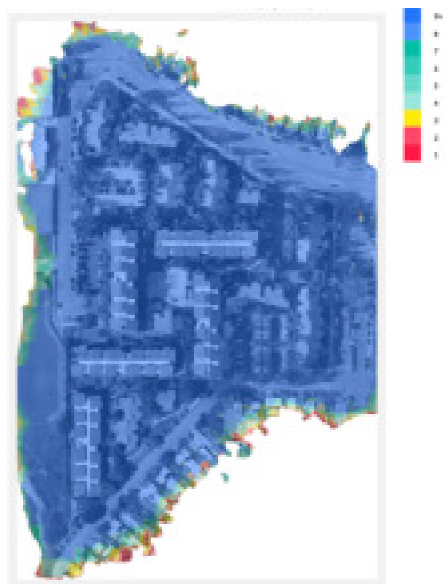


Oftentimes, poorly reconstructed areas have poor image coverage, and so if an area did not turn out as well as you would have hoped for, check to see if there is a continuous, dense block of photos directly over the problem area is a great step to take. Preferably, image projections might remind you of a thick blanket.



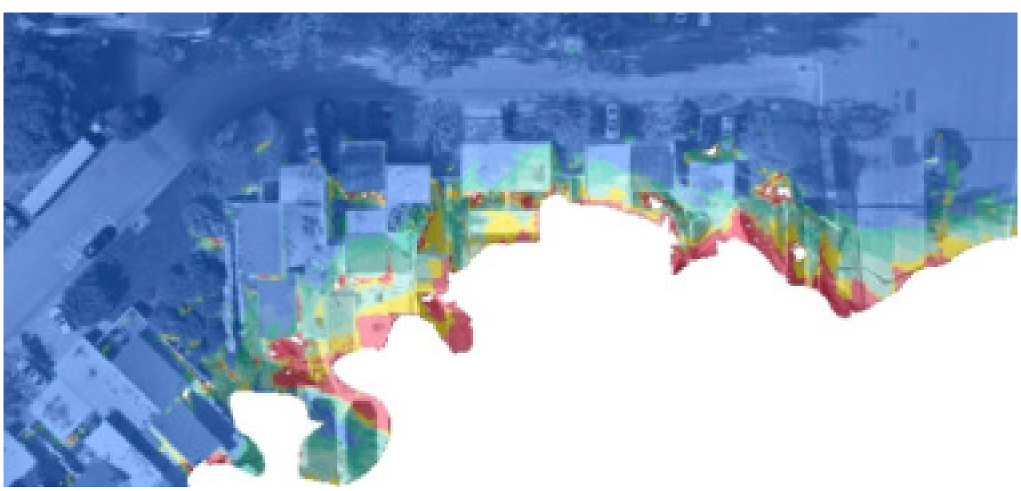
Your image set should not be slightly overlapping, disjointed, or scattered. You can see how this single bridge of ~20% overlapped images in thick homogeneous vegetation is might not provide enough data to construct a model.

Not only can you directly see the placement of the images in the user interface, but you can also inspect a heat map that shows the number of images per pixel.



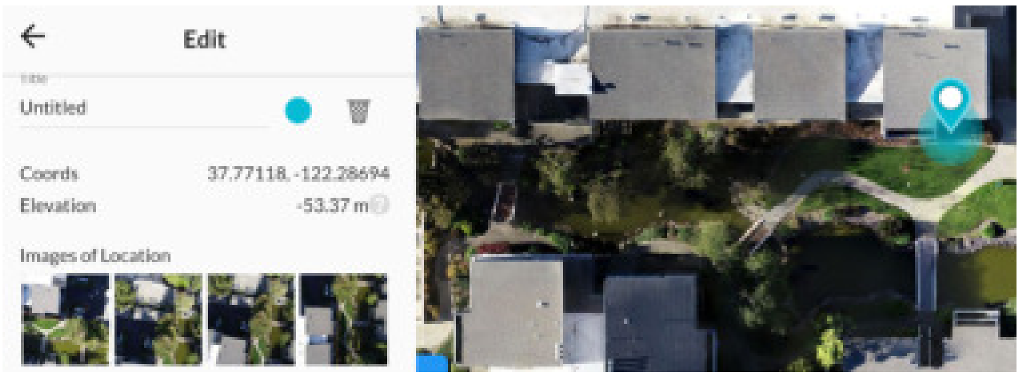
Areas in blue have good coverage, areas in green have medium coverage, and yellow and red areas have poor coverage. This can very quickly help you diagnose coverage issues such as holes or warping.

You can see how the poorly-reconstructed area also has little to no images per pixel:

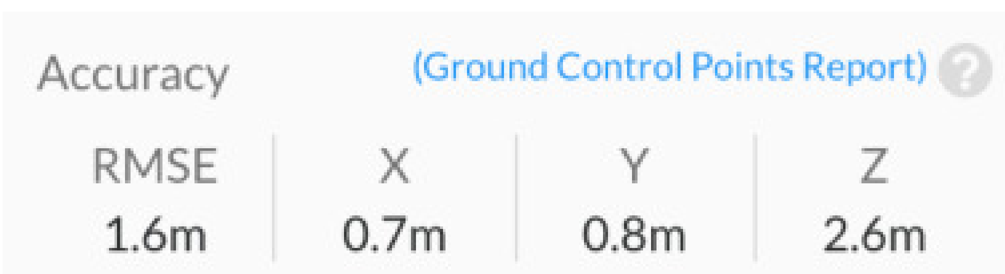


However, it is very possible to have what visually looks like dense coverage of your subject but is in fact not. It is a classic ‘quality vs. quantity’ situation. Going back to our ‘Flight Planning’ section, if there are not enough oblique images that cover the sides of your objects, 10+ images covering each pixel in that area, then there will not be enough data for an accurate reconstruction.

If a building looks melty or poorly reconstructed, drop a location pin on it and move it around. Inspect the images that cover it. If you can’t very clearly point out what you would an accurate model look like in at least 5 photos, it is likely that better coverage is needed.



Next, take a look at the accuracy numbers for the report. The “Tie in your Accuracy and Resolution Goals” outlines what you can extrapolate from the RMSE accuracy data of your map, depending on your usage of GCPs and checkpoints, and how these numbers are calculated.



Remember that most of the time, this data can only be used as a signal. You can think of the RMSE accuracy number loosely as a risk factor. The lower the number, the more likely that your map is accurate.

It is difficult to pick a particular RMSE value that you should begin to be concerned with. The best way to decide your threshold for RMSE accuracy is to look at the accuracy of similar maps you’ve processed in the past. If you were happy with the accuracy of those maps, the average of their corresponding RMSE values might represent a ‘green zone’ for you. If you were unhappy with the accuracy of maps in the past, those RMSE values might be a ‘red zone’, which may trigger you investigating the map more closely.

If you used GCPs or checkpoints, it is important to check out the accuracy report. Most GCP maps should have RMSE errors below a 1 meter. If your accuracy is worse than that, inspect the accuracy of each individual GCP and checkpoint.

Look for GCPs and checkpoints with outlier accuracy values. Oftentimes, if your GCP maps' overall accuracy is poor, there are outlier GCPs that have considerably worse accuracy than the others.

Those outlier GCPs are often mistagged, so please go back to your GCP tagging link to inspect their tags. You may want to retag your problem GCPs and reprocess. There also may be something wrong with the coordinate data or the image coverage of the GCP. If the GCP or checkpoint cannot be improved to a level closer to its peers, consider throwing it out of processing, as long as it is not in an essential part of the map.

With these final 'Quality Check' steps, you finally can be qualitatively and quantitatively sure that you've successfully mapped, and can repeatedly do so throughout a wide variety of conditions.

Happy Mapping!

10

Recipe Book for Common Project Goals

To end our guide, we're providing you with easy, bullet-pointed recipes for the basic direction to take when mapping for a specific project goal.

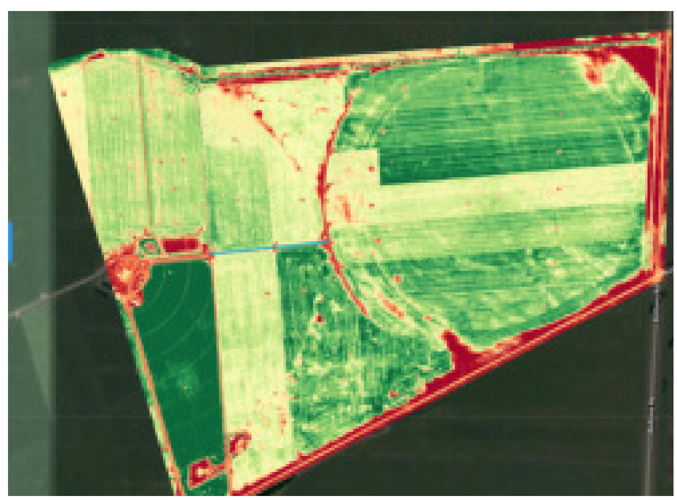
Important Considerations For 2D Layers:

1. Fly as high as possible to increase the percentage chance of successful stitching.

2. Take nadir shots for the highest possible accuracy.

3. Use a Non-Structures mode flight.

4. Maintain a drone-to-ground elevation change of no more than 50-100 feet.



Important Plant Health Map Considerations:

1. Increase overlap due to homogeneity.

2. Fly as high as possible in Non-Structures mode.

3. High resolution and accuracy are usually not needed.

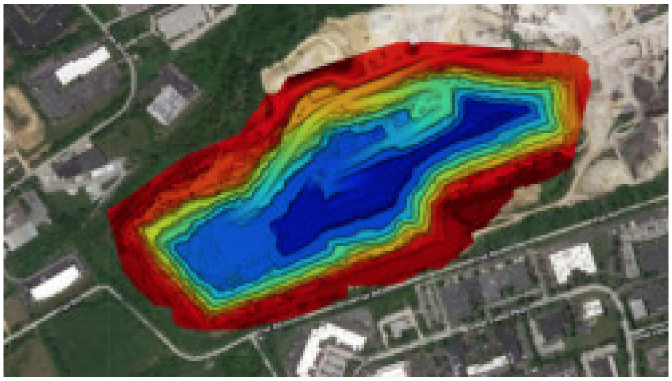
Important 3D model considerations:

1. Structures mode, or Precision 3D app to ensure orbits for side coverage.

2. Fly low for greater detail.

3. Extremely high overlap because of low altitude.

4. Structures requiring the highest 3D quality possible should be centered as a point of interest in a Structures mode or Precision 3D flight.



Most important Elevation layer considerations:

1. All 2D layer considerations listed in the first recipe apply here.

2. Sometimes more coverage of different angles and elevations is needed compared to just a 2D layer.

3. Flying lower increases elevation accuracy, but at the expense of the percentage chance of stitching success.

4. If you fly low you need to then increase the overlap to compensate.

DroneDeploy