

Using Tower App with 3DR Solo UAS

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There are two apps that communicate with the 3DR Solo: Solo and Tower. Both are from 3DR. Both use WiFi to communicate from your Android phone/tablet. Only one can be on at a time. Connect use the tablet wifi. For SoloLink_3FA587, password jerrysolo, forget other wifi.

- Solo app: For controlling manually, controlling a GoPro Hero 4 or some other cameras, but for just flying you can just use the remote controller. See the Solo app guide in the appendix.
- Tower app: Designed for planning a mission for 3D image capture or mapping. We'll focus on mapping needs – basically capturing vertical aerial photography.

This guide will provide a basic look at Tower for capturing aerial photography, choosing options that work well with the MicaSense Rededge multispectral camera. To learn more about Tower, there's not much in the way of a manual, but users have created YouTube videos, which you can find via Google or YouTube searches. Here are some I've found useful:

- Tower mission planning video (50 minutes): <https://youtu.be/qFH6PvmbC38>
- Video of spline survey method, including whole flight: <https://youtu.be/L48Kgu01As4>
We'll use a spline survey method.

Essentials of the Tower App

The two most frequently used views in Tower are:

- **Vehicle Data**, where you'll link to the aircraft, check its status and fly the mission; and
- **Editor**, where you'll create mission plans.

You can create mission plans on-site or elsewhere, and it's obviously easier to work not out in the bright sun so you can see the screen.

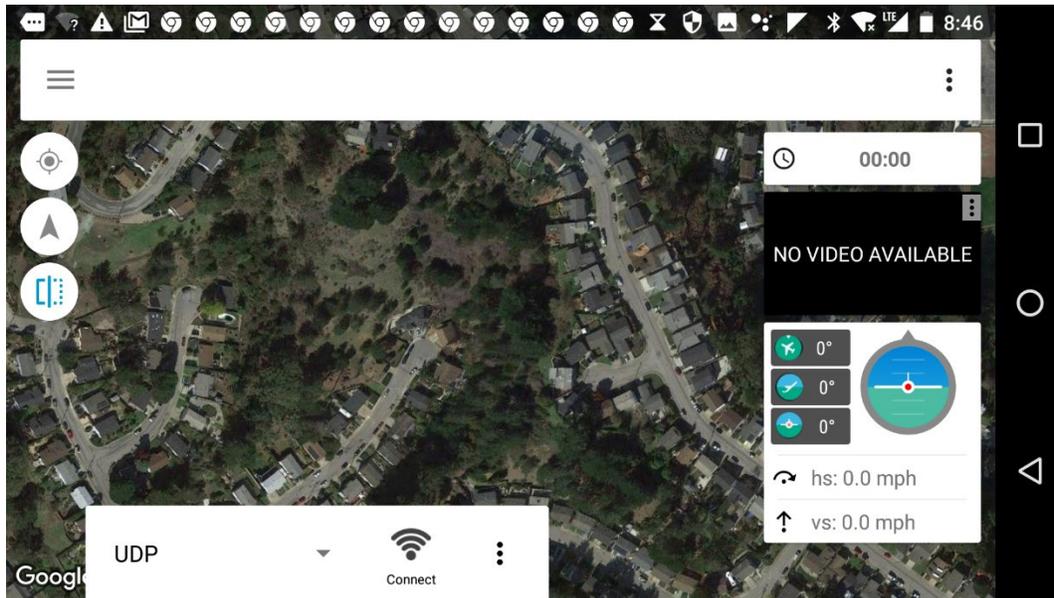
Mapping with the RedEdge Sensor

Mapping with the MicaSense RedEdge sensor mounted on the Solo platform requires a combined use of communicating with the Solo with Tower to create and run missions and communicating with the RedEdge to set up imaging. You'll want to use two mobile devices, probably a smart phone to set up the camera and a tablet to run Tower. Tower runs only in Android, so that may determine your choice.

This guide is only about running missions with Tower and doesn't cover the RedEdge. Refer to the RedEdge Mapping Guide for a combination guide:

<https://geoq.sfsu.edu/sites/default/files/RedEdgeMapping.pdf>

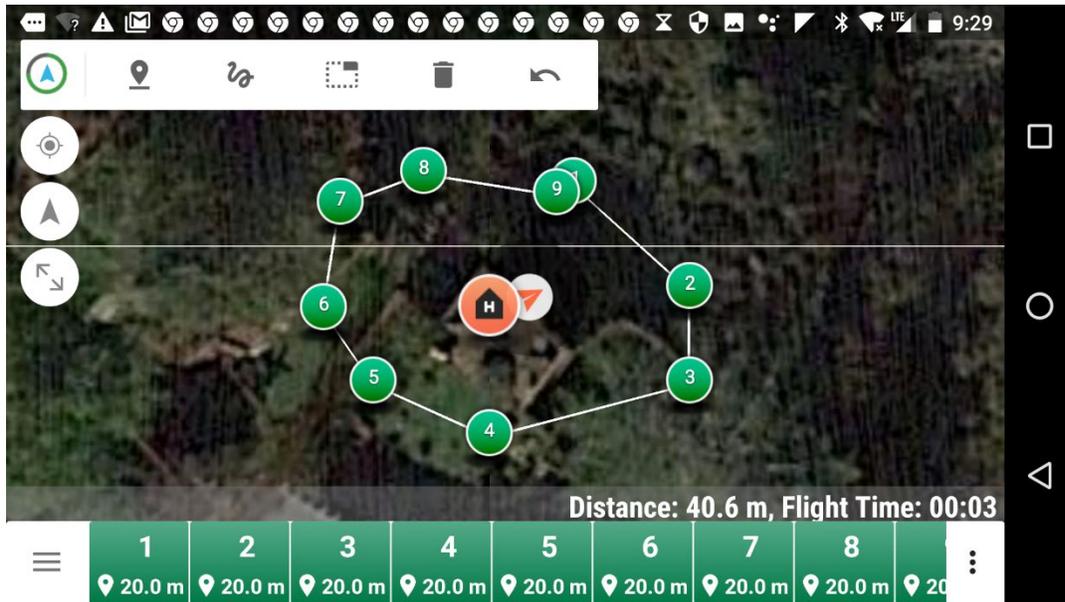
Vehicle Data View



Connecting, arming, and controls in flight.

| | |
|--|--|
| | <p>Connect mode, connect, settings. To connect using Wifi, use UDP setting.</p> |
| | <p>Readings and menu, including to upload and download mission.</p> |
| | <p>Arm (to start props) and Dronie. To execute the mission after arming, slide the bar.</p> |
| | <p>During flight, return home, land in place, pause, run Auto mission (do this after initial launch), follow me, settings.</p> |
| | <p>Aircraft attitude</p> |

Editor View



Controlling the display

| | |
|--|--------------------------------------|
| | Zoom to GPS |
| | Zoom to aircraft |
| | Zoom to mission |
| | Toggle display of feature properties |

Creating and editing waypoints

| | |
|--|--|
| | |
| | Create Waypoint, Spline Waypoint, Circle, Land, Region of Interest, Structure Scanner |
| | Draw a line or poly to create multiple waypoints: Waypoints, Spline Waypoints, Survey, Spline Survey |
| | Select all |
| | Deleted selected or entire mission |
| | Undo |

Editing waypoints

Select waypoint to get to choices of type of waypoint or event:

- Waypoint types can be simple or more complex, like a point the aircraft moves around at a set radius.
- Events may be associated with a point or just a change of settings like speed.
- For a survey, start with a Change Speed setting and create a Survey or Spline Survey to create a set of waypoints.
- Save a survey by exporting to file. Useful when trying find your study site on a cached basemap image.



| Waypoints | Definition | Properties to modify |
|--------------------------|--|--|
| Waypoint | Waypoint connected from last and to next waypoint with a straight path | Altitude, Delay (before next waypoint) |
| Spline Waypoint | Waypoint connected with spline curves around bends | Altitude, Delay |
| Circle | Center waypoint with circle at radius | Altitude, Radius, N turns |
| Region of Interest (ROI) | Point at the focus of a survey. Copter points toward or aims camera. | Altitude |
| Structure Scanner | Map a building | Radius, Start altitude, Steps |
| Events | | |
| Change Speed | From after the last waypoint, change the speed | Speed |
| Takeoff | From wherever the aircraft is (so isn't recorded as a point) to a specified altitude | Altitude, Pitch |
| Land | Land at current location. You must manually exit Auto mode to disarm motors | |
| Return to Launch | Return to location the aircraft was armed | |
| Camera Trigger | Trigger the camera at regular distance intervals | Length |
| EPM Gripper | Release the payload | |
| Set Yaw | Set condition to reach a certain target angle | Target angle |
| Set Servo | Move a servo to a PWM value | Channel, PWM |
| Do Jump | Jump to a particular waypoint | Waypoint, Repeat count |
| Reset ROI | Reset the ROI lock | |

Creating a grid (survey) mission with an intervalometer-controlled camera

If we set our camera, like the Canon S95, to take pictures every 2 s, we can either (a) set the drone speed to a slow enough speed to take pictures while moving, or (b) include delays. Using the table below for the Canon S95, at 50 m AGL, our longitudinal spacing of photographs for 75% overlap is about 12 m. Moving at 6 m/s, we'd thus get pictures at about the right spacing. So we could make that setting, and hope the photos are steady enough.

| | 35mm equiv | FOV° | Heights AGL | | | | | |
|--------------------------------|--------------|------|-------------|------|------|------|-------|-------|
| | focal length | | 30 | 40 | 50 | 60 | 80 | 120 |
| Canon S90 or S95 default (min) | 28 | | | | | | | |
| scene width | | 64 | 37.5 | 50.0 | 62.5 | 75.0 | 100.0 | 150.0 |
| scene length | | 50 | 28.1 | 37.5 | 46.9 | 56.3 | 75.0 | 112.5 |
| longitudinal spacing 75% | | | 7.0 | 9.4 | 11.7 | 14.1 | 18.8 | 28.1 |
| lateral spacing 75% | | | 9.4 | 12.5 | 15.6 | 18.8 | 25.0 | 37.5 |

Here's the process:

1. Create a single waypoint (anywhere), then select it and change it from a waypoint to a Change Speed event, setting it to 6.0 m/s.
2. Using the multipoint button with either Survey or Spline Survey, draw a polygon with your finger around the area you want to survey. A grid pattern will be created. 20
3. Select that survey, and make any changes to its parameters, such as Flight Altitude, Overlap, and Sidelap. Note that changes in these parameters will change the shape of the grid in order to support those settings.
4. Export the survey to a file, giving it a useful name. Note that if you later import the survey from the file, it will return with waypoints.

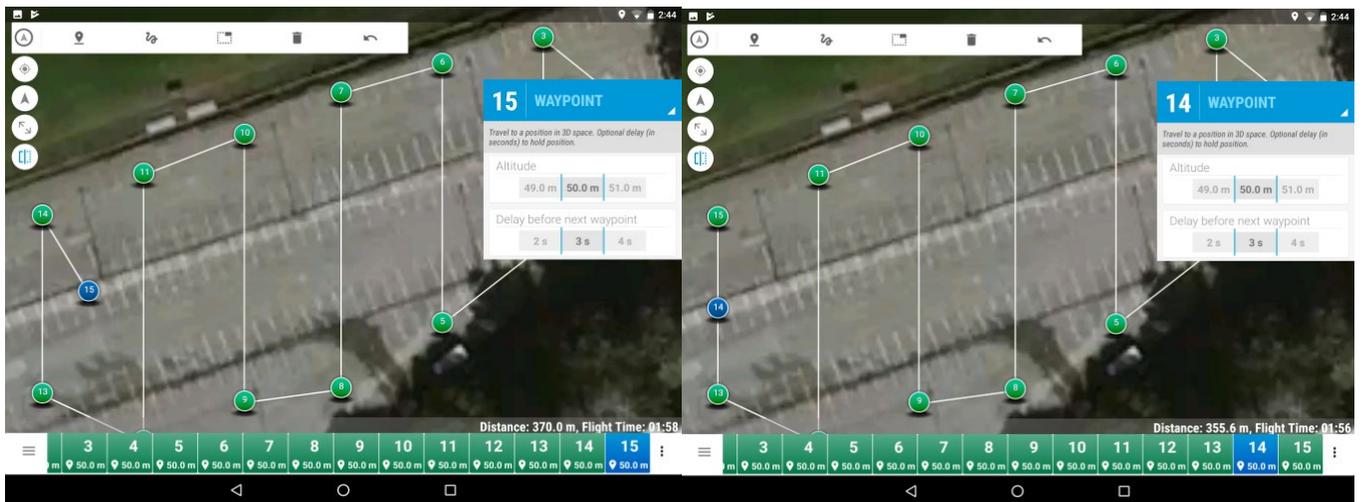
To add delays

In order to add delays to the above survey, we'll probably need to add intermediate waypoints, and add delays to all waypoints. It's easiest to do this in that order. So after we've completed step 4 above,

5. Delete the entire mission, and then load it back to get all of the waypoints individually.

6. Successively add intervening waypoints at about $\frac{3}{4}$ of the spacing of the path spacing (4:3 aspect ratio). Click where you want each to go, not worrying about the fact that the order will be wrong.

7. Get the waypoints in the right order. For each, from the list at the bottom, select the waypoint (turns blue), and then move it where it should go, between two waypoints. Note that the numbering changes.



8. Finally, select all of these waypoints, and deselect any non-waypoints like events, then apply a 3-s delay before next waypoint. This should ensure that all waypoints have steady shots, with a 2-s interval. It will however require a fair amount of culling the photos to remove unnecessary ones.



9. Don't forget to save: export the mission.

Mission

1. Power up the Solo and controller to get it finding GPS and establish a connection.
2. In **Editor** mode, either create a new mission (see above) or import a saved mission. It's a lot easier to create a mission where you have some shade so you can read the screen. You don't have to be at the site to create it, but you do need to be there to run it, and your first waypoint should be accessible from the home point where you power up the aircraft. You should also confirm that there are no obstructions in the path of the mission.
3. Everything else is in **Vehicle Data** mode, so go there.
4. Make sure you're connected via WiFi to the aircraft. You may need to select it in your tablet settings; jerrysolo might be the password. Note that when you connect, it will display a message that it's not connected to the internet, which of course it isn't. That's ok.
5. When connected, you should see



the home position where the aircraft first powered up, and



the current location of the aircraft, as well as the location of your tablet (blue dot).



You'll also see the current aircraft attitude which you can turn on or off



with the icon.

↻ hs: 0.0 m/s

↑ vs: -0.0 m/s

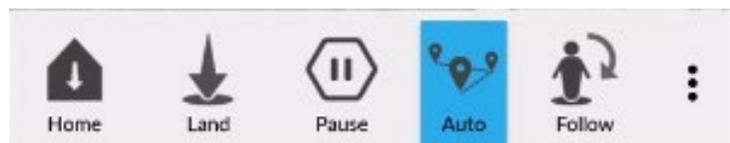
6. Upload the mission to Solo using the menu dots in the upper right. It will prompt you "Do you want to append a Takeoff and RTL to your mission?" which you might want to Ok. You should hear a message "Waypoints saved to drone" though sometimes text-to-speech doesn't work.
7. The mission will be ready to arm and run. You'll see an "Arm" icon on the screen next to the



"Dronie" icon.

When you arm it, a slider will appear confirming this choice.

- During the flight, you'll see a new set of icons that provide access to return home, land in place, pause, auto, and follow. When ready, click Auto to go through the waypoints. Pause either here or on the controller to pause the flight, which can then resume. Turn off Auto to go to manual. Either the FLY or the PAUSE button on the controller takes over manual control.



Note: Review the Fail-safe Procedures before all flights.

Caching Basemaps for Offline Use

In order to see basemaps like satellite imagery when offline, you need to be able to cache image basemaps. This requires using an online map data service that allows for caching. In Tower at least, the standard Google map service doesn't support this, but Mapbox does. In order to do this, the following method works at least currently:

1. Create a Mapbox custom map with a satellite image and streets style, and get the map id and access token:
 - a. Get a free Mapbox account if you don't have one already.
 - b. Download the Mapbox Studio Classic on your laptop, and build a map with just a satellite and streets style. There may be a way to use their more current app, but this produces the map id and access token that is needed in Tower and described in https://youtu.be/0BSD_7a5O9g which is about creating offline maps in Tower using Mapbox. The map id is your Mapbox user name followed by a dot and an 8-character (actually 4 bytes in hexadecimal) code.
 - c. As suggested in the YouTube video, the best way to get the very long access token is to copy it in Mapbox Studio Classic and email it to yourself to bring up on your tablet.

Map id: spedunkler.5d037977

Access token:

pk.eyJ1Ijoic3BIZHVua2xlcilsmEiOiJjajRrMWM4eXAwZWFWMnduM3EzZnBndnRoln0.x7Clfm6qN-w-S7OFc2SWtg#8/39.162/-121.907

2. Also following the YouTube video, go to settings in Tower, then User Interface, then Map Provider Preferences, and set Mapbox as Map Tile Provider. Then in Tile Provider Preferences, check "Enable offline map layer" and "Add Download Map to menu" and enter the map id in Mapbox Id and the long Mapbox Access Token.
3. Then once you have the area of interest displayed, you can pull down the 3-dot menu and download the map while online. The map downloaded will cover the whole area shown at all finer resolutions.
4. When offline, this should result in being able to still see the basemap downloaded *in the Editor screen only*, but it may not immediately appear. Try zooming in and out.

It's a good idea to export a mission for each cached site area to a file, even if you're going to create a new one in the field. It can sometimes be hard to find your site and cached basemaps when offline at the site. When you import an exported mission from file, the map zooms to the area of the mission. You can then edit it with the cached basemap visible.

Fail-Safe procedures to review before flying.

It can be nerve-wracking during a mission when something goes wrong. You need to know what to do without having to look it up. So it can be critically important to review some emergency procedures in advance to know what to do, and to know what the normal response of the Solo will be to any failures in the guidance system. This information is all covered in the Solo manual. *Important: make sure your antennas are pointed correctly; you'll have no control if you lose this.*

What happens when Solo loses GPS position?

If GPS position drops beneath a reliable threshold during flight, Solo will automatically switch to Fly:Manual mode. This mode does not provide the flight-stabilizing GPS functionality, and will drift with the wind, but you can control Solo visually. Visual flight should be practiced, and it helps to know that the tail lights are red *and that the antennas are correctly set*.

What happens when Solo loses controller connection?

- Displays "Controller signal lost" and Solo initiates Return Home.
- If signal is recovered, displays "Signal recovered" and standard manual control (includes GPS) can be regained with FLY button. Note that this is not Fly:Manual (no GPS), which you can force it into by programming the A button to do this. *To return to normal FLY mode, press either FLY, Pause, or RTH.*

What happens when battery failsafe triggers?

- At 10% battery, Solo initiates Return Home. Warnings at 25% and 15%.

What is the responsibility of the pilot when the above happen?

- First, if the pilot in command (PIC) is not at the controls, that pilot should take control.

What are all the options for return to home and how are they set/used?

- RETURN HOME button
- If the Solo loses controller connection and it's in normal FLY mode, it should return home.
- See the Cone Zone discussion (p. 32) defining where it can safely move while returning home
- (Or to land at current location, press and hold the FLY button.)



What are the characteristics of solos flight modes?

- Standard flight : manual with GPS lock to maintain position. Control with joysticks.
- Fly:Manual : a version of standard flight without GPS lock. Control with joysticks, but note that the aircraft will drift with the wind and momentum. Requires constant adjustment to maintain (right stick) position and (left stick) orientation. Should be set to Preset A. Can be overridden by pressing FLY, Pause, or RETURN HOME.
- Guided : programmed by app (Tower, Solo). Can be overridden

What if the Tower app crashes mid-flight?

- Since the mission is stored in the Solo, which continues to fly it, you can download it, so:
 - Start up Tower again and you may see the mission running again. If not, make sure you're connected and download the mission from the aircraft.

What to do if you need to abort the mission (about to hit a tree or other hazard appears)?

- *Note that the aircraft joystick controls do not respond while in a mission, except when about to land.*
- PAUSE : Stops the mission, allowing you take over manual control to move the aircraft to a safe position. If safe, you can then use Tower controls to continue the mission or return home to start over.
- RETURN HOME : Stops the mission and returns home.



Control buttons:

- FLY : The Fly button lets you control Solo's main flight functions: starting motors, takeoff, land, and activating GPS flight. You can land in place by holding the FLY button.
- RETURN HOME : *If* initial GPS position established in power-up, will return to that location.



- PAUSE : will hover in place, including interrupting Return Home. As with RETURN HOME, it depends on GPS however, so will have no effect if GPS signal is lost.
- A : *Assuming you're an experienced pilot*, should be programmed to go to **FLY:Manual** mode, *which does not use GPS for stabilization and will drift in the wind*. On the 3DRPilots Forum, this is recommended by some, but not by others who note that if the GPS signal is lost the aircraft will automatically go to FLY:Manual mode and forcing this could create problems for inexperienced pilots. *Your connection via antenna becomes critical if you're in FLY:Manual mode since it's not using GPS*. One purpose of this setting is to practice flying in this mode, which you will probably need someday. Note that in this mode, similar to standard, the throttle stick corresponds to altitude. You must Enable Advanced Flight Modes in Advanced Settings in the Solo app to be able to assign this or other advanced modes to the preset.
- B : *Also assuming you're an experienced pilot*, should be programmed to go to **Stabilize** mode. In Stabilize mode, the throttle stick controls power and acceleration directly. Should be practiced, but presumably could work to overcome situations where the altitude is not detected by the aircraft.

See the *Fly manual conundrum* thread at 3DRpilots.com:

<https://3drpilots.com/threads/fly-manual-conundrum.11189/>

Selecting a camera in the Tower App

For the grid survey method to derive longitudinal and lateral spacing for a chosen overlap %, you'll need to choose a camera. Theoretically, you can create your own camera model by entering xml code in a folder on the mobile device, but that can be difficult to achieve unless you have a rooted device. So what we've done is selected a similar camera.

We'll be using a close approximation to the Canon S95 in the Camera choice: Canon S90. The key information is the 35-mm equivalent focal length and a standard 4:3 aspect ratio.

$$\text{FOV}^\circ \text{ width} = \text{DEGREES}(2 * \text{ATAN}(35 / (2 * f)))$$

$$\text{FOV}^\circ \text{ height} = \text{DEGREES}(2 * \text{ATAN}(26.25 / (2 * f)))$$

where f = focal length (35 mm equivalent).

$$\text{Scene width or height} = 2 * \text{TAN}(\text{RADIANS}(\text{FOV}/2)) * H$$

where H = camera height AGL

| | focal length | 35mm equiv | FOV° | heights (m) | | | | | |
|------------------------------|--------------|------------|------|-------------|------|------|-------|-------|-------|
| | | | | 30 | 40 | 50 | 60 | 80 | 120 |
| Canon S90 or S95 default (m) | 6 | 28 | | | | | | | |
| scene width | | | 64 | 37.5 | 50.0 | 62.5 | 75.0 | 100.0 | 150.0 |
| scene length | | | 50 | 28.1 | 37.5 | 46.9 | 56.3 | 75.0 | 112.5 |
| longitudinal spacing 75% | | | | 7.0 | 9.4 | 11.7 | 14.1 | 18.8 | 28.1 |
| lateral spacing 75% | | | | 9.4 | 12.5 | 15.6 | 18.8 | 25.0 | 37.5 |
| Canon SX260 | 4.5 | 25 | | | | | | | |
| scene width | | | 70 | 42.0 | 56.0 | 70.0 | 84.0 | 112.0 | 168.0 |
| scene length | | | 55 | 31.5 | 42.0 | 52.5 | 63.0 | 84.0 | 126.0 |
| longitudinal spacing 75% | | | | 7.9 | 10.5 | 13.1 | 15.8 | 21.0 | 31.5 |
| lateral spacing 75% | | | | 10.5 | 14.0 | 17.5 | 21.0 | 28.0 | 42.0 |
| DJI Spark | ? | 25 | | | | | | | |
| scene width | | specs: | 82 | 52.2 | 69.5 | 86.9 | 104.3 | 139.1 | 208.6 |
| scene length | | | 62 | 35.7 | 47.6 | 59.5 | 71.4 | 95.2 | 142.8 |
| longitudinal spacing 75% | | | | 8.9 | 11.9 | 14.9 | 17.8 | 23.8 | 35.7 |
| lateral spacing 75% | | | | 13.0 | 17.4 | 21.7 | 26.1 | 34.8 | 52.2 |