Mission Planning with Terrain Following Waypoints
30 August 2024

Introduction
Terrain Following is the term used for when a drone modifies its altitude to keep a defined distance above the ground while following a flight path. In Ardupilot there are two available ways to utilize this behavior. The method documented in this guide is currently the only option for Kairos flight controllers at this time.

Method 1:

Utilizing terrain data cached (saved locally for offline) with prefetched maps. Mission Planner (GCS) will automatically adjust Waypoint altitudes to keep the drone at a defined altitude above ground level (AGL). Between waypoints, the drone will raise or lower its altitude gradually to match the next waypoints requested altitude.

Method 2 (Not currently supported):

The Flight Controller received terrain data from the GCS and saves it on the drone. As the drone flies, it references the terrain data to adjust its altitude automatically while it travels to the next waypoint.

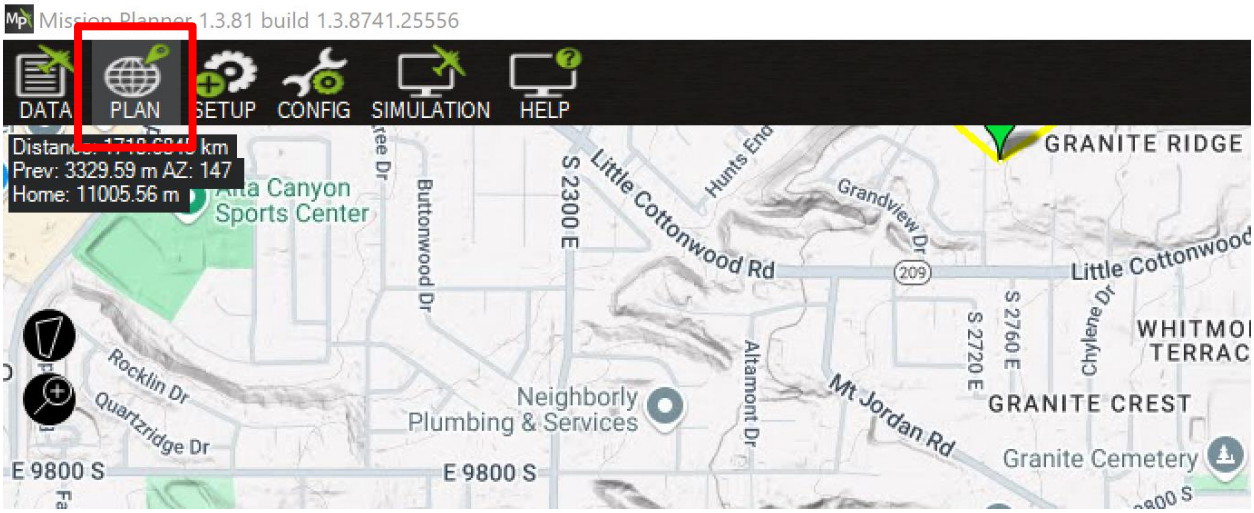
Method 1 Guide:

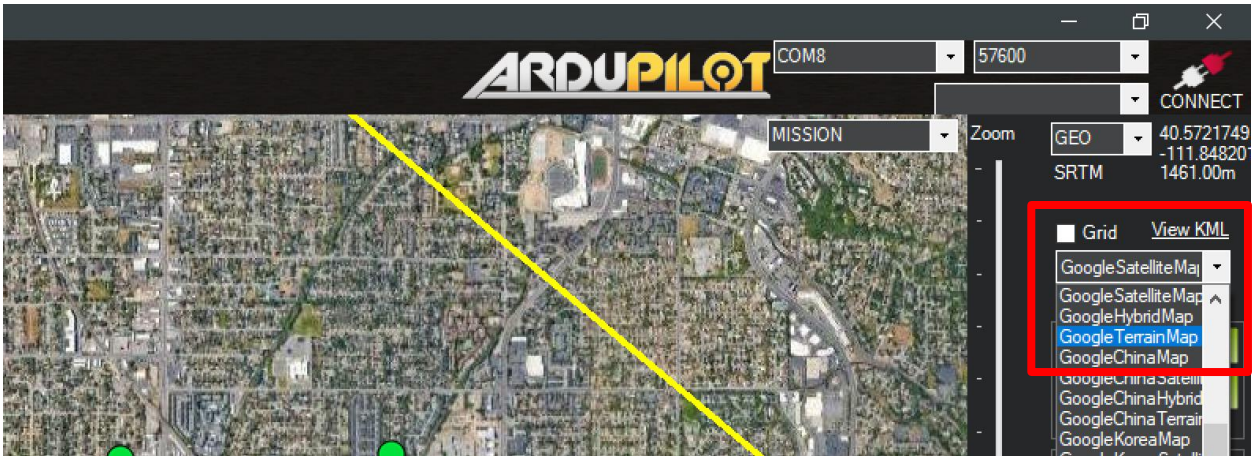
Key Notes:

- The accuracy of terrain following in method 1 is entirely dependent on the number of waypoints used. A higher number of waypoints will improve the terrain following.
- Default Alt (In Mission Planner Planning) is the altitude above the launch location the drone will fly to. It is recommended to set this to the desired value (ex. 10 meters) and then not change it.
- Utilizing terrain maps while planning will assist with determining where waypoints are needed based on changes in terrain along the flight path.
- Method 1 will work in offline mode as long as maps for the location are prefetched on the GCS. Kairos provided a guide for prefetching maps in the Mission Planning Guide.

Step 1:

Switch to the *Plan* window and change base maps if desired





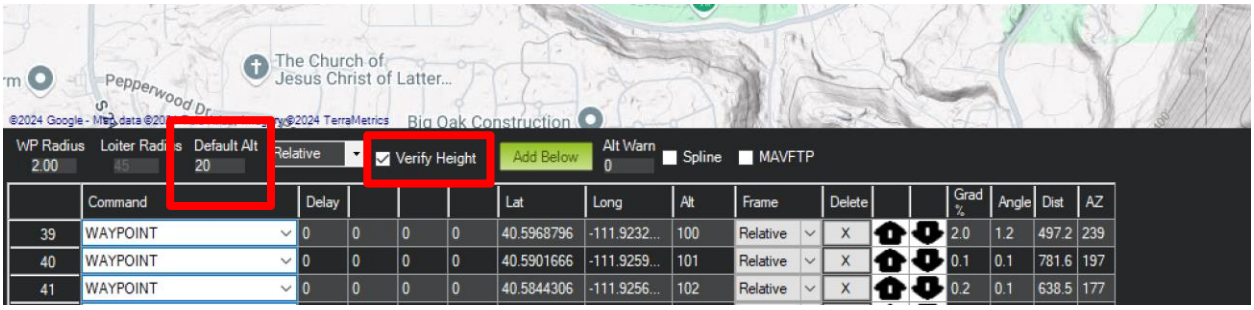
By default, Mission Planner will utilize GoogleSatelliteMap. Switching to GoogleTerrainMap may assist with better visualization of Terrain.

*Note that you will have to prefetch maps for both if you need to switch between them in offline mode.

Step 2:

Determine what altitude you want the drone to fly at and set the *Default Alt*. value. The *Verify Height* option will also be turned on here.

For example, if you want the drone to fly at 20 meters above the ground you would set *Default Alt*. to 20.



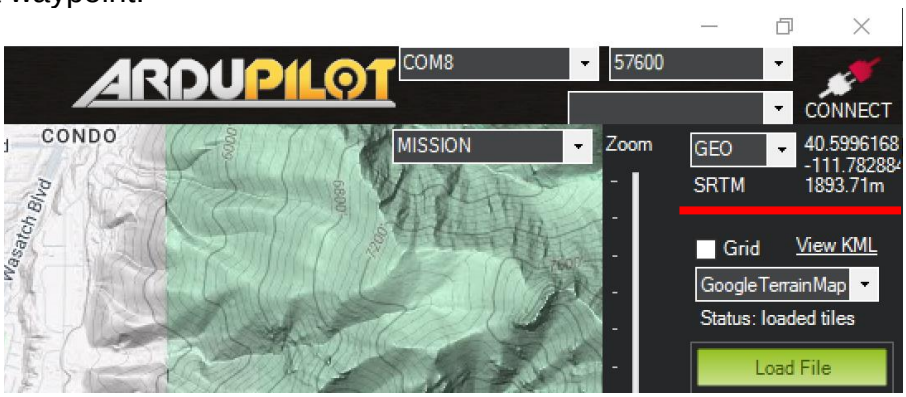
Set the *Default Alt* and turn on *Verify Height*

Step 3:

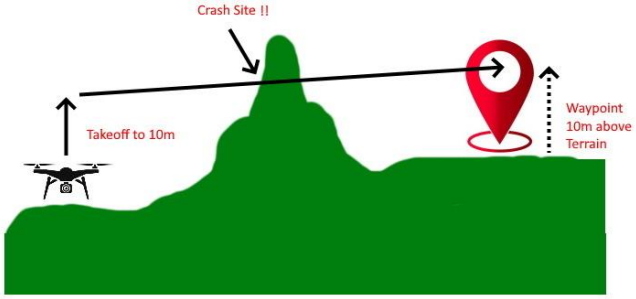
Begin adding waypoints.

Enter waypoints the same way you would with normal mission planning. The main difference will be making sure that there are sufficient waypoints over hills and into valleys to ensure the drone stays at the correct altitude above ground.

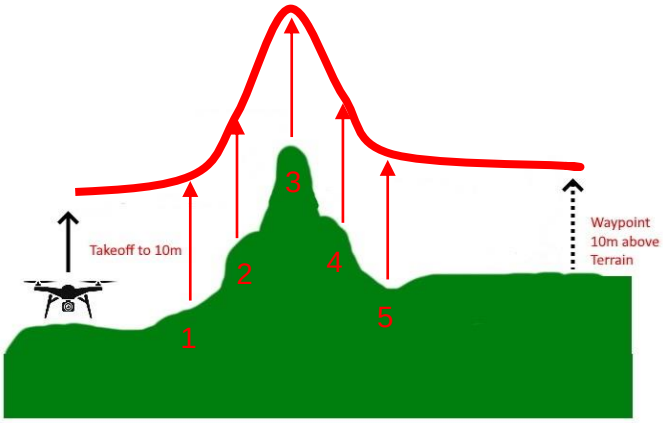
It is useful to monitor the *SRTM* value in the top right which is the estimated elevation at that waypoint. You will see this value change as you move the cursor around and when you select a waypoint.



One example is if a hill is between waypoints. In the diagram below, there are insufficient waypoints along the flight path and the drone will impact the ground.



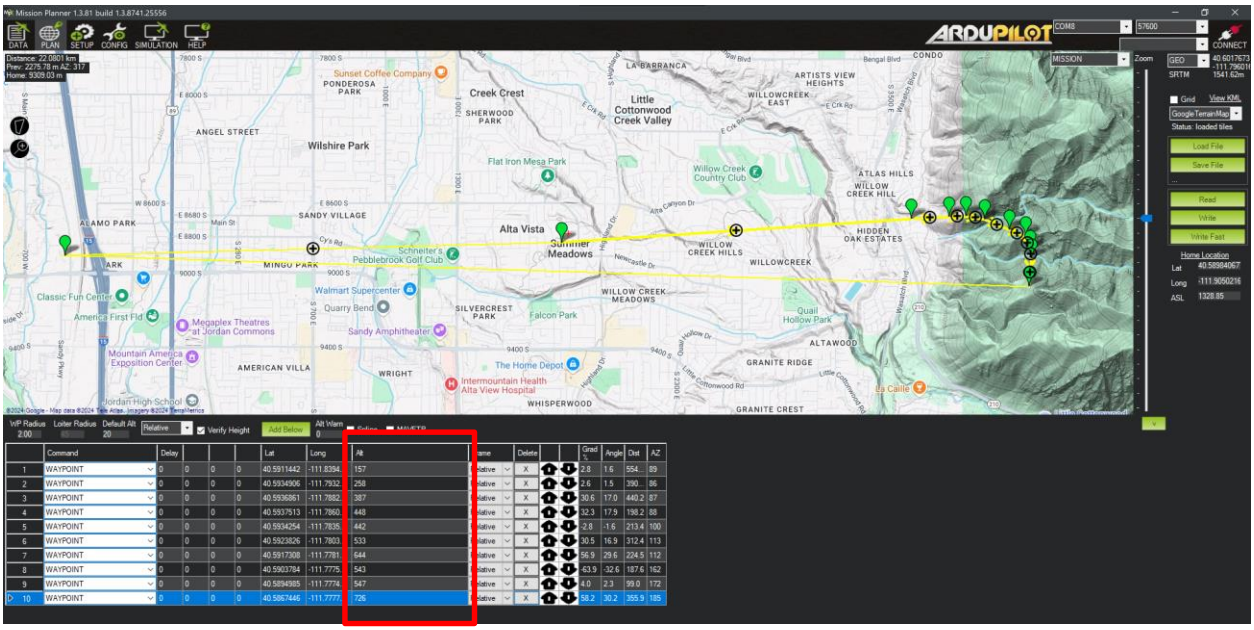
Solve this by adding waypoints specifically around the ground feature to increase the drone's altitude at that point.



Follow the same process if you want the drone to follow ground terrain into a valley. If ground terrain drop down between waypoints, the drone will fly at a constant altitude to the next waypoint and not drop into valley.

Step 4:

Verify altitude changes across waypoints.



As you plot waypoints across a terrain feature, you will see the *Alt* value for the waypoint change based on its change in elevation from the launch location (home). The *Alt* value may go negative if a waypoint is plotted in a location lower than the launch location.

In the example above, the drone will keep an altitude of 20 meters above the elevation measured at that waypoint location.

Step 5:

Edit waypoint altitudes as needed. Altitudes can be edited after being created if needed. The drone operation will however need to calculate the altitude manually to get the desired result.

Ex: *Default Alt.* is set to 20 meters and Mission Planner calculated the *Alt* value for a waypoint at 50 meters. If you want the drone to drop down at that waypoint to 10 meters AGL, you would set the *Alt* value to 40 meters (50 – 10). Do not lower the *Alt* value by more than the *Default Alt* value or the drone will crash into the ground.

Ex: *Default Alt.* is set to 10 meters and Mission Planner calculated the *Alt* value for a waypoint at 30 meters. If you want the drone to increase altitude to 40 meters AGL at that waypoint, you would subtract the *Default Alt.* (10) from the desired altitude (40) and add that to the waypoints *Alt* value ((40 – 10) + 30 = 60 meters).

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Version History

Date and Signature	Revisions	Reasons for Revision
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