Mission Planning Guide

Introduction

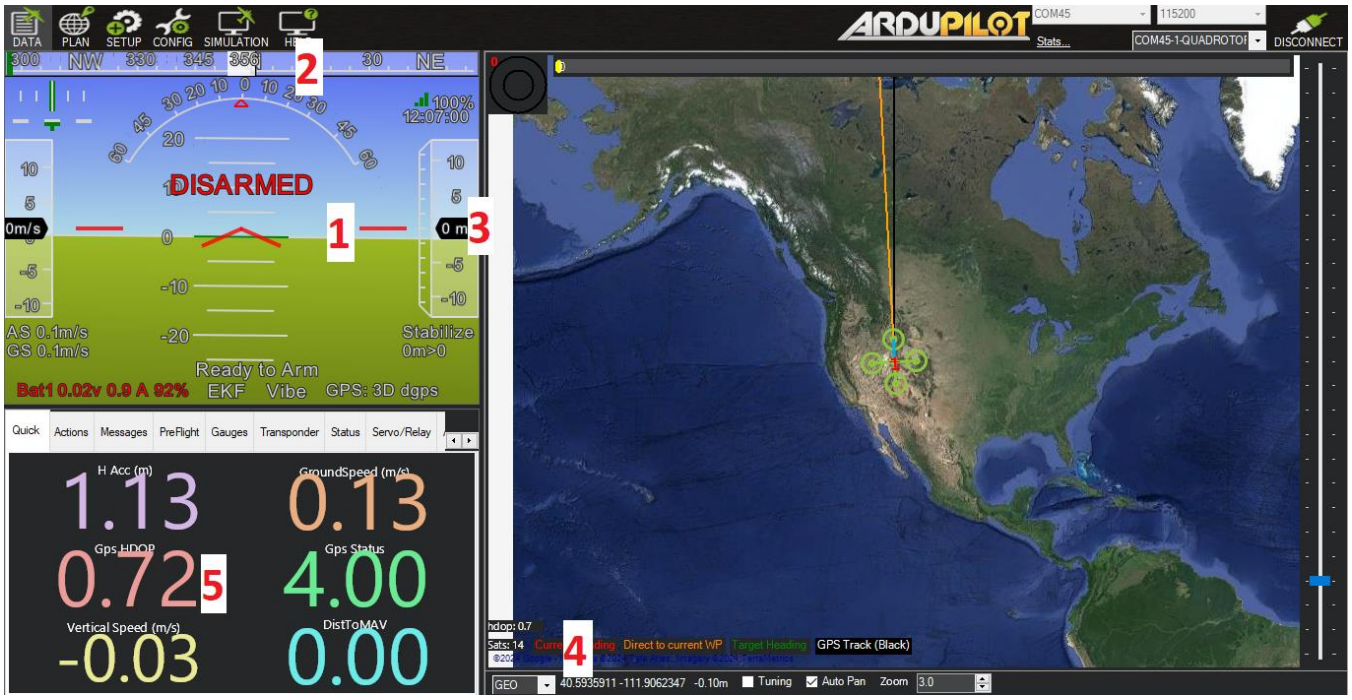
This document will go over the requirements for preparing for and setting up a preplanned and automatically executed mission using the Mission Planner software. Additionally, this document will include some information about the possible methods of reliably terminating or pausing a mission should the need arise. The information that follows is intended for Kairos Multirotor fitted with a complete set of 3D positioning hardware (Barometer, GPS, Compass). Additionally, some aspects of the mission setup outlined in this document rely upon a standardized set of parameters that designate how payloads are interfaced with.

This document is broken into 6 sections

1. Pre-Mission Checklist; Sensor Checklist
2. Fetching maps
3. Understanding Automated Missions
4. Automated Payload Dropping
5. Safety Systems and methods for unplanned Termination of Mission

1 – Pre-Mission Checklist; Sensor Checklist

A brief verification of sensor readings before an automated mission is executed. It is not intended to replace diagnostic tests that fully verify the behavior of the drone. Instead, this checklist will inform the user of the aircraft's readiness to perform a mission quickly and immediately before mission execution.



1. ☐ Attitude displayed on mission planner is steady, level with horizon
2. ☐ Compass reading is stable, matches orientation of aircraft front
3. ☐ Altitude reading is stable in-between -3m & 3m
4. ☐ Sat Count >= 9 Sats
5. ☐ HDOP reading <= 1.0

2 - Fetching maps

In order to plan a mission an image of a geographic area must be available. Mission planner will use this map and command points to create a customized flight mission for the UAS.

Obtaining map data

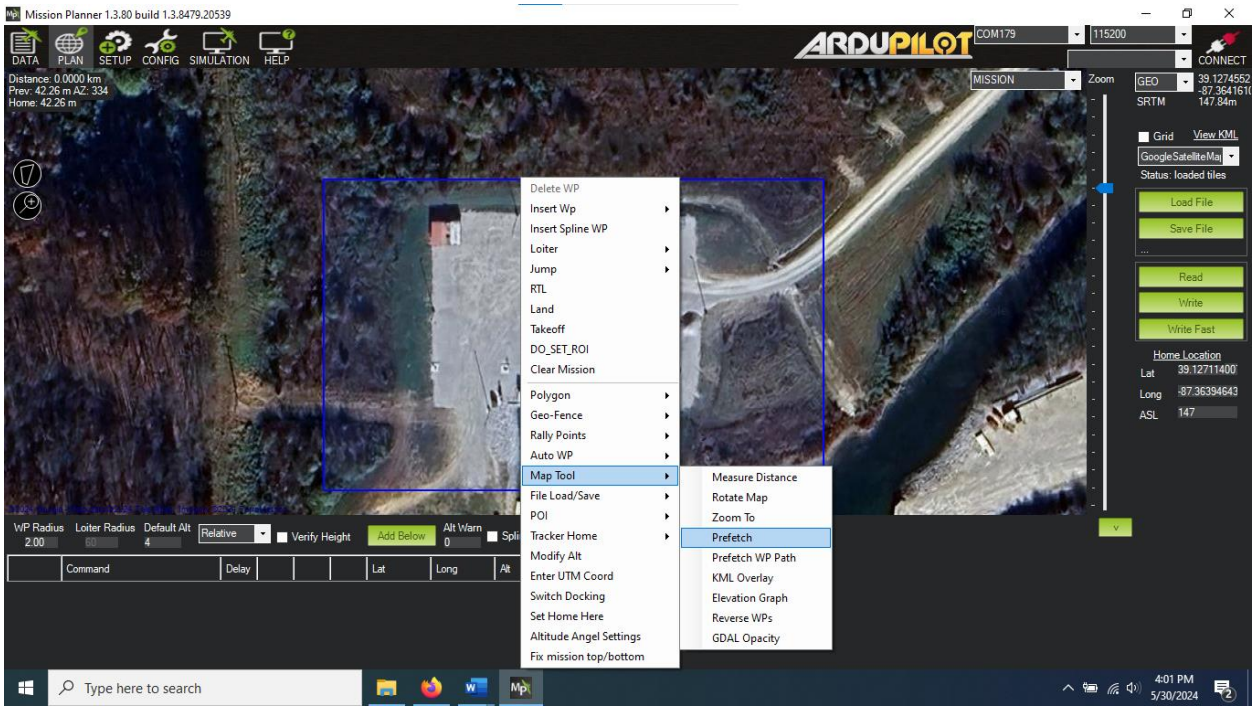
Mission planner will need data retrieved from the internet in some fashion (connected to the internet directly or hotspot) in order to grab a geographic image from google maps. Once this is retrieved planning can begin as long as the computer being used can maintain a data connection. For best practice it should be assumed that no data will be available in which case learning to pre-save map data is advised. Fetching map data will allow a certain area at a certain zoom of a map will be available for use and stored in the memory of the computer.

How to prefetch

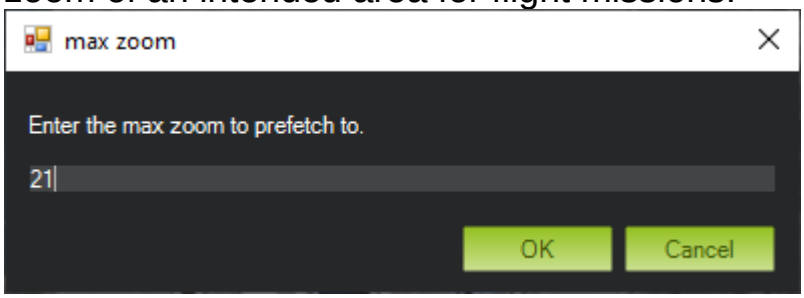
1. Open up Mission Planner application and at the top hit plan.

2. Find the desired area of interest and adjust the window zoom.

3. Hold the Alt key on the computer down and drag a box around the desired area.
4. Right click on the screen and scroll down to **Map tool** then select **Prefetch**.



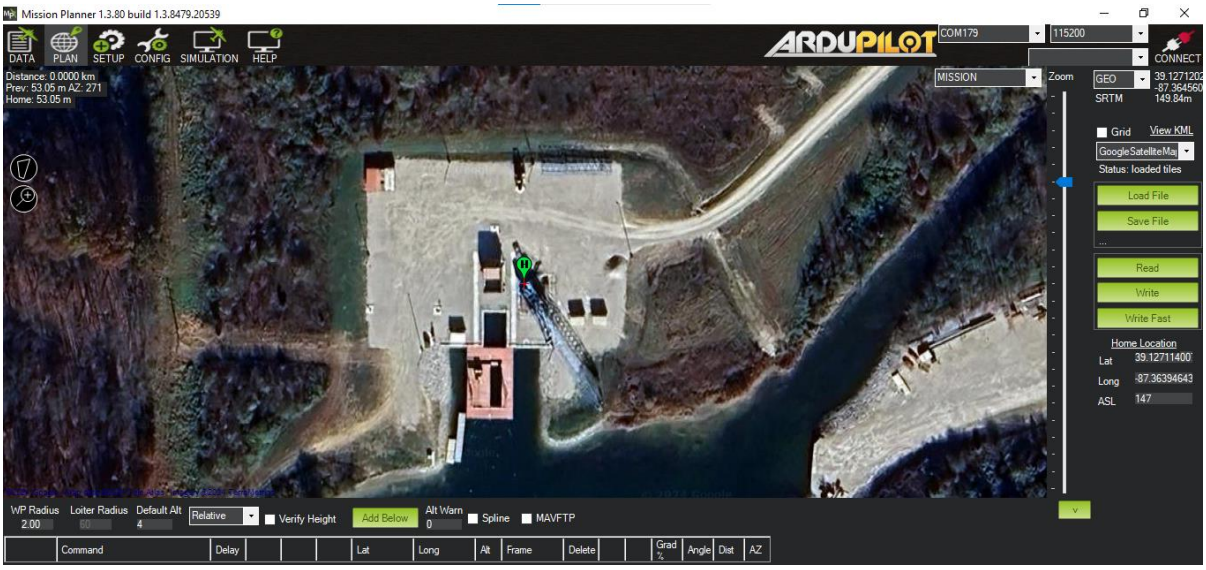
5. In the window prefetch to 21 and hit ok. This should provide adequate zoom of an intended area for flight missions.



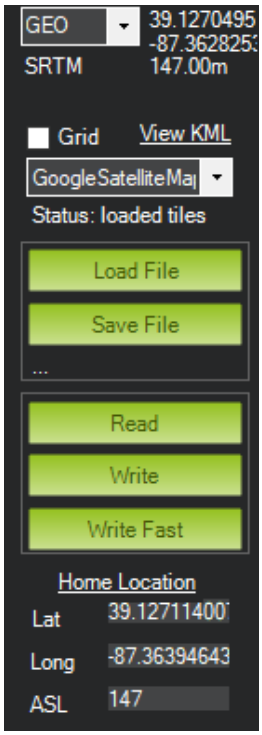
6. The computer should download the area in the form of images into the map cache saved on the computer. This area should load in the intended zoom when no internet is available.

3 - Understanding Automated Missions

This section will cover the general information regarding using Mission Planners mission creation interface. Also, general information about the ways in which the mission will be executed by the aircraft will also be covered.



Above is the Mission Creation screen, found within the "**Plan**" tab in the top left corner of Mission Planner.



Uploading of Automated Missions

Load file: Load a previously saved mission file, which includes all information an aircraft requires to execute the mission.

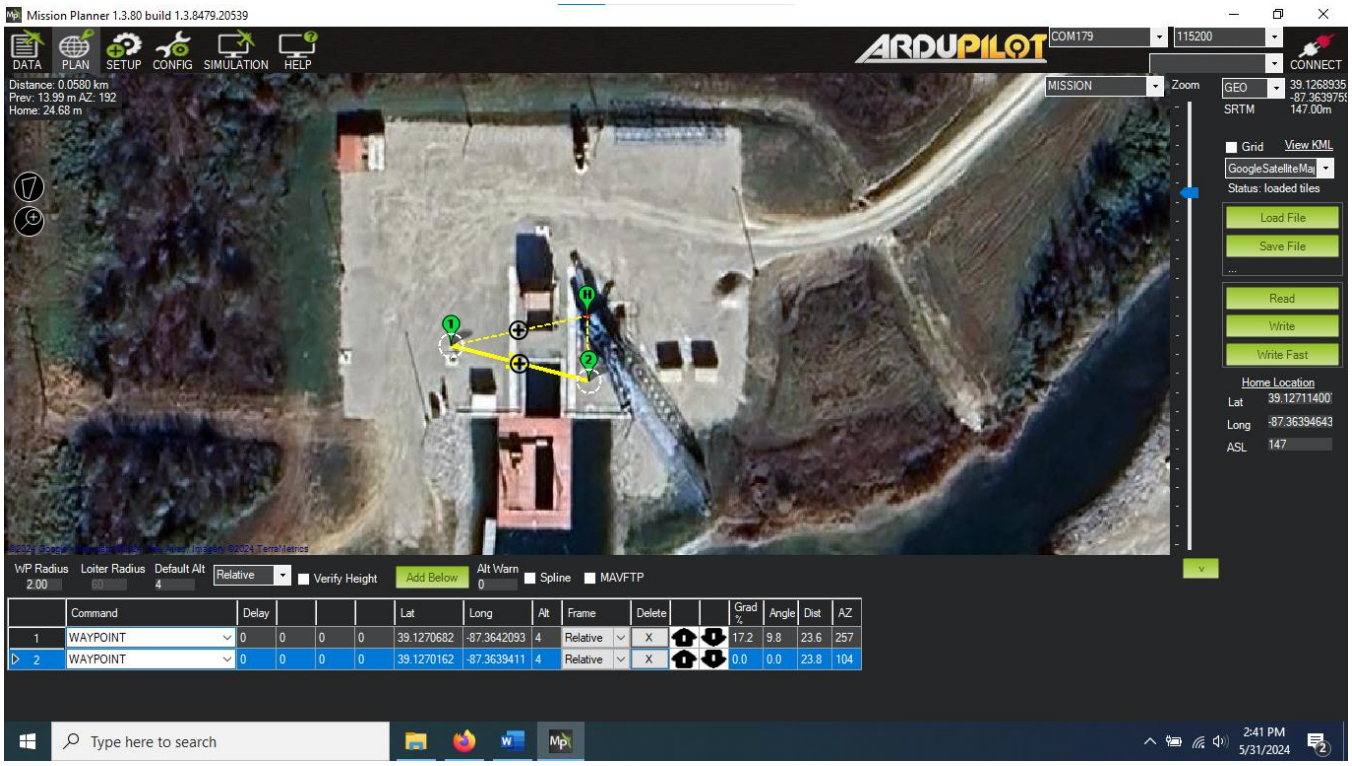
Save file: A file is saved on the computer that stores all the information relevant to the execution of the mission currently viewed in the Mission Planning menu.

Read: Retrieve the Automated mission that is stored (and ready to be executed) on the aircraft that Mission Planner is connected to.

Write: Uploads the Automated mission that is displayed on the Mission Planner software to the Aircraft.

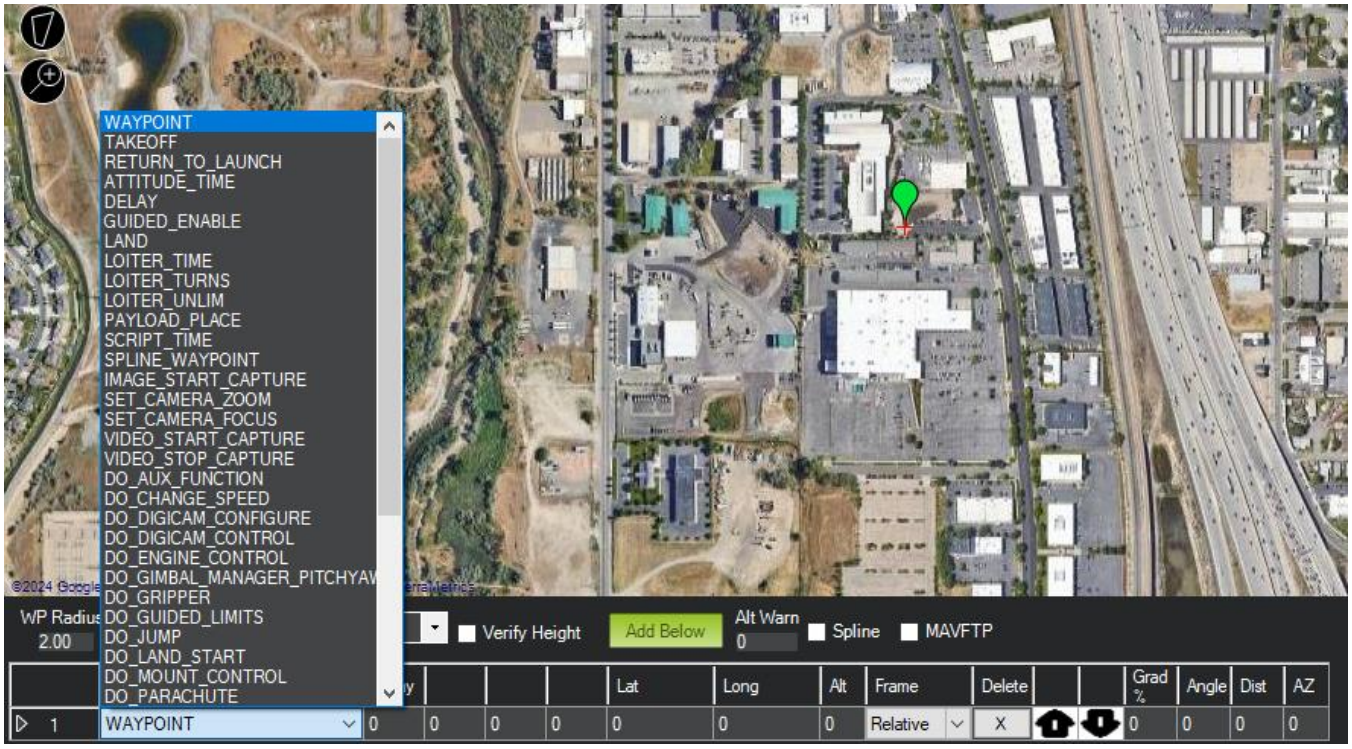
Write Fast: Do Not Use. This uploads the mission without double checking of uploaded information, reducing the reliability of the mission upload.

Warning



Shown above is a mission that has had 2 total Generic Mission items added to it using the **Add Below** button. Notice that the current “Lat” and “Long” fields could contain any value. The default location automatically filled in is at a lat, long of 0,0 somewhere off the West coast of Africa.

The Lat Long fields of location dependent mission items should always be double checked for sanity.



Mission Actions

As is shown in the drop-down menu that has been expanded in the above screenshot, there are many possible mission actions. Descriptions of each can be found at this link: https:///ardupilot.org/copter/docs/mission-command-list.html

What is Frame?

This drop-down menu selects the reference frame for altitude values.

Relative: Altitude value provided by user is relative to the altitude of the aircraft when takeoff is initiated. **Users are encouraged to utilize Relative Altitude.**

Absolute: Altitude value is relative to sea level altitude; use of Absolute Altitude is not encouraged.

Terrain: if the altitude of the terrain within the operating environment is provided to the aircraft, the altitude of the aircraft can be set relative to the terrain the aircraft is directly above, using Terrain mode is not currently supported.

Mission Item Ordering

Missions uploaded to an aircraft are executed staring from line item #1 in order until the last mission item is completed. In this case, Mission item #1 would execute, complete, and then the aircraft would execute mission item #2

Tips for mission item creation:

1. If possible, it is best to **create location-based mission items by clicking directly on the map** (not all missions items rely on location). A waypoint mission item will be created at the location of the mouse click. This removes the need to type in the fields of Lat and Long.
2. **Height Alt field shown is in meters, NOT feet.** Example- An entry of 20 in the Alt field (20 meters) is more than high enough to clear a 2-story building. Large values (40+) will prevent the operator from accurately observing the behavior of the aircraft.
3. Location based mission items appear at their respective Lat long positions on the map displayed in the planning screen of mission planner. Verify that mission items are located where expected.

Universal Mission Setup Steps

There are several standard mission items that come at the start and end of nearly every mission currently run by Kairos multirotor.

In general, this includes:

1. Takeoff Command
2. Waypoint Command
3. Land Command

Note that these three mission items are all location-based mission items. Always perform a sanity check of the latitude and longitude values displayed before uploading/executing a mission. It is advised that missions start with a takeoff command and end with a land command, though other methods of mission execution are also possible.

Above is a general outline of a barebones mission executed by the Kairos Multirotor.

Description of expected behavior

- Vertical takeoff (nominally no horizontal deviation) to an altitude of 20 meters.
- Translates horizontally to the Latitude and Longitude position described in mission item #2 at an altitude of 20 meters.
- Translate horizontally above the latitude and longitude position described in mission item #3.
- Once above the landing position, the aircraft will begin to descend slowly until it detects it has touched down, where the motors will stop spinning.

4 - Payload Dropping

As a safety factor, the dropping of a payload requires multiple mission items in the correct sequence.

WP Radius 2.00 | Loiter Radius 60 | Default Alt 4 | Relative | Verify Height | Add Below | Alt Warn 0 | Spline | MAVFTP

	Command	Secon (or -1)	Hour UTC	Minute UTC	Secon UTC				Frame	Delete			Grad %	Angle	Dist	AZ
1	TAKEOFF	0	0	0	0	0	0	4	Relative	X			0	0	0	0
2	WAYPOINT	0	0	0	0	39.127295	-87.3640028	4	Relative	X			16.2	9.2	25.0	80
3	DO_SET_SERVO	7	2000	0	0	0	0	0	Relative	X			0	0	0	0
4	DELAY	1	0	0	0	0	0	0	Relative	X			0	0	0	0
5	DO_SET_SERVO	5	2000	0	0	0	0	0	Relative	X			0	0	0	0
6	DELAY	1	0	0	0	0	0	0	Relative	X			0	0	0	0
7	DO_SET_SERVO	5	1000	0	0	0	0	0	Relative	X			0	0	0	0
8	RETURN_TO_LAUNCH	5	1000	0	0	0	0	0	Relative	X			0	0	0	0

Mission Item #1-Launch: Aircraft vertically takes off from current position

Mission Item #2-Waypoint: Aircraft translates to the location and altitude where the drop of the payload will occur.

Mission Item #3: Set Servo 7 = 2000: This "arms" the payload dropping mechanism.

Mission Item #4: Delay: No Behaviors for specified time period.

Mission Item #5: Set Servo 5 = 2000: (IF payload is armed) This Drops Front Payload.

Mission Item #6: Another delay command to allow the drop to fully execute.

Mission Item #7: Set Servo 5 =1000: (If payload is armed) This resets the front payload to its stowed, inactive state.

Mission Item #8: RTL: Return to location of takeoff, land the aircraft.

	Set Value = 1000	Set Value = 2000
Set Servo 5	Reset Rear Payload	Fire Rear Payload
Set Servo 6	Reset Front Payload	Fire Front Payload
Set Servo 7	Disarm Payloads	Arm Payloads

Notes:

1. The Waypoint immediately before the payload dropping mission items is the location of the payload deployment.
2. The resetting of payloads after firing expedites future use of the aircraft.
3. Users should mimic these series of mission items for reliable autonomous use of the payload system onboard the Sturnus.

5 - Safety Systems and Methods for Mission Termination

There are several checks integrated into even the most basic non-automated operation of Kairos aircraft. This includes automated preflight checks, operator based pre-flight checks, and a basic operator understanding of the normal and non-normal aircraft behavior. This document, however will focus on safety systems specifically catered to the safe operation and execution of automated missions. While many of these are optional, the operator must carefully consider the operational environment when selecting how many and which safety systems must be integrated to ensure the safe execution of an automated mission.

Warder Warden System-Complete Control of Mission Execution

The Kairos Warder Warden system's intended purpose is to enable an operator to have full confidence in the operation state of the aircraft. In practice the Warder/Warden system allows the operator of an aircraft to take the aircraft out of the sky at a moment's notice. The pilot can issue the command to disrupt power to the motors. This means for any unforeseen behavior or unexpected variables can be responded to rapidly.

Warden

Pilot's safety device. Must send heartbeat and run command in order to operate and run the UAS.

Warder

UAS safety device. Must receive heartbeat from warden and run command. Safety loopback is required during startup.

Using the Warden/Warder

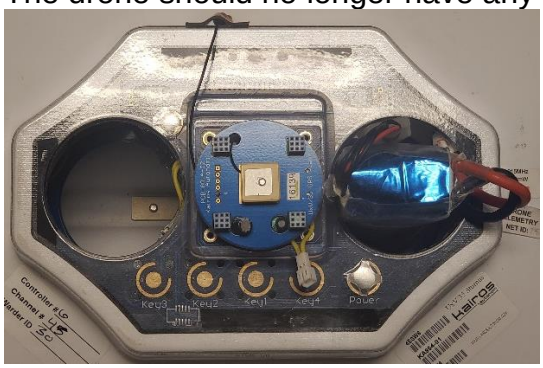
1. Turn on warden using the power switch located on the top left of the battery pack.

2. Push and hold the smaller button located on the lower part of the battery pack until the run mode is shown.

3. Power on the drone.
4. Remove the safety loop back. The drone should still have power to the motors.

5. To Estop the UAS, press and hold the large button on the Warden until the CMD line says Estop.

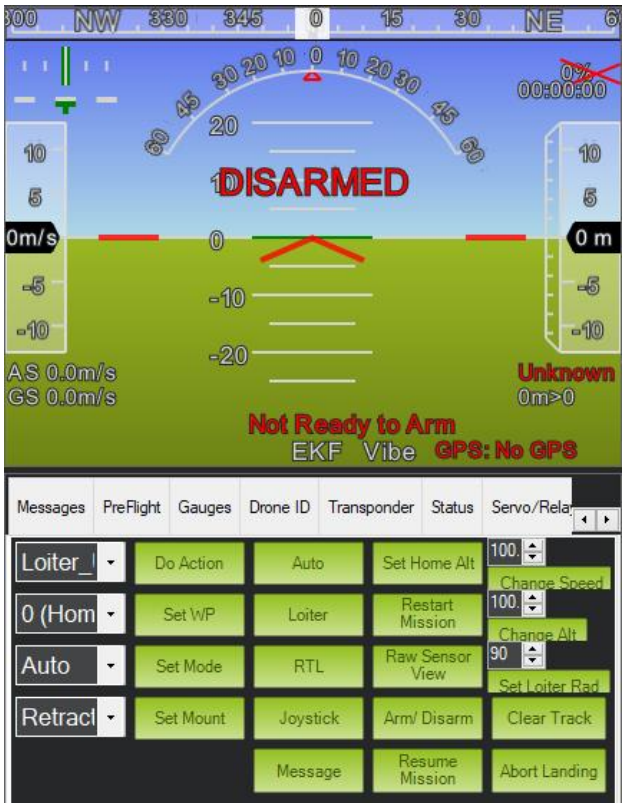
6. The drone should no longer have any power.



7. To turn on the UAS and arm for use, plug the safety loop back in and put the Warden in the run CMD mode.

Remote Mavlink Connection-Live connection with Mission Planner

There are various options for maintaining a remote connection between the mission planner software and the aircraft. In general, these mimic the behavior of a USB connection directly between the aircraft and the mission planner software. The possible options enabled by this remote connection regarding safety are outline below.



Do Action: To the left of the Do Action green button is a drop down menu. Within, you will find the following most commonly used optinos.

1. **Loiter_Unlim** – This action instructs the aircraft to pause mission execution and hold its position in 3D space, Pausing the aircraft. The aircraft will not resume any behaviors until instructed by an input device.

2. **Return to Launch** – The aircraft will cease the execution of a mission items and will immediately traverse horizontally over the location where takeoff occurred. It will then descend slowly until it lands and cuts power to the motors. If the aircraft does not have a GPS Fix, then the drone will attempt to land at its current location and cut power to the motors.

Auto: This green button will set the flight mode to Auto (Autonomous). If the aircraft has already been armed, the execution on any uploaded mission will immediately begin after the auto button is pressed.

Loiter: This button instructs the aircraft to switch to the Loiter flight mode. Devoid of any operator input to a hand controller, an aircraft set to the loiter flight mode will hold its position in 3D space indefinitely until instructed otherwise.

RTL: This button executes the same behavior as Do -> Return to launch.

Arm/Disarm: This button begins or ceases the spinning of the motors of the aircraft. There are no checks in regards to the execution of this command, whether on the ground or while in flight. **This button can be used as a last resort to take the aircraft out of the sky if needed.**

Version History

Name	Date/Version	Description	Reason
Dom P	6/20/2024 V1.0.0	Document Created	
Dom P	6/25/2025 V1.1.0	Mission – Sensor checklist added	
Nick R	7/1/2025	Revisions for Clarity	