Rover (ROV)

Avionics Instructions

Department of Defense
DoDSTEM
Science · Technology · Engineering · Mathematics

SOUTHERN ILLINOIS UNIVERSITY
EDWARDSVILLE

UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

Raspberry Pi and Navio2 Configuration

Materials Needed:

- Avionics Kit
- Power Supply
- Putty – Installation Instructions Attached
- Internet Connection

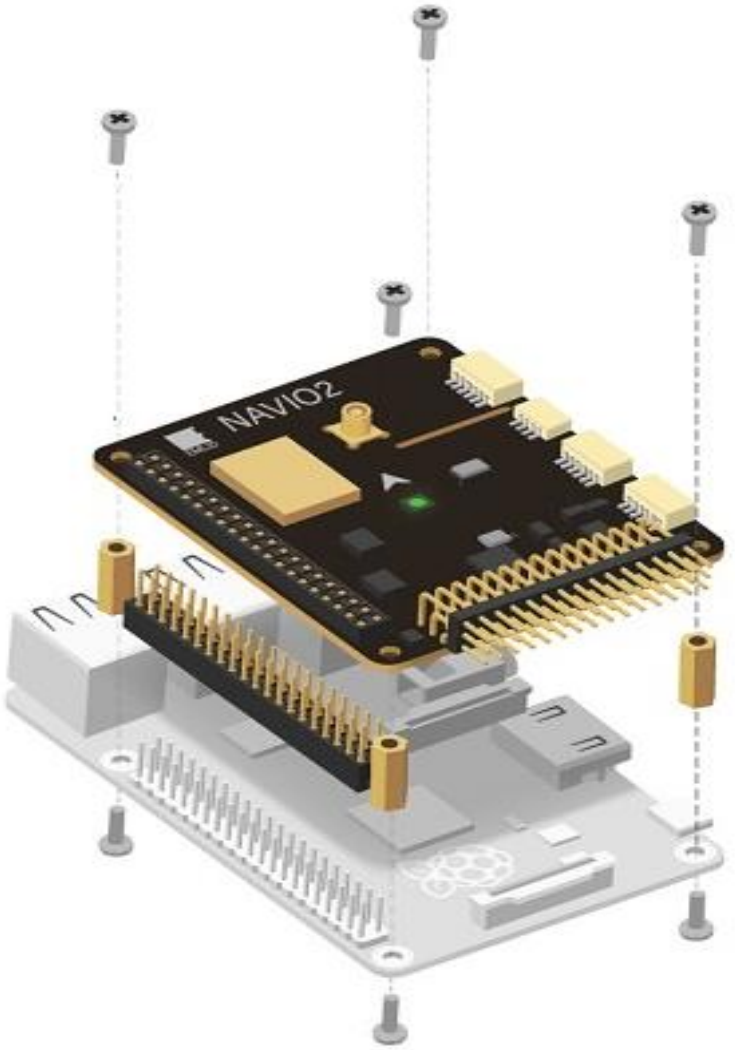
Step 0 Physical Assembly

0.1 Install Spacers to the top of the Raspberry Pi

0.2 Connect extension header to Raspberry Pi GPIO Port

0.3 Attach NAVIO2 To Extension Header

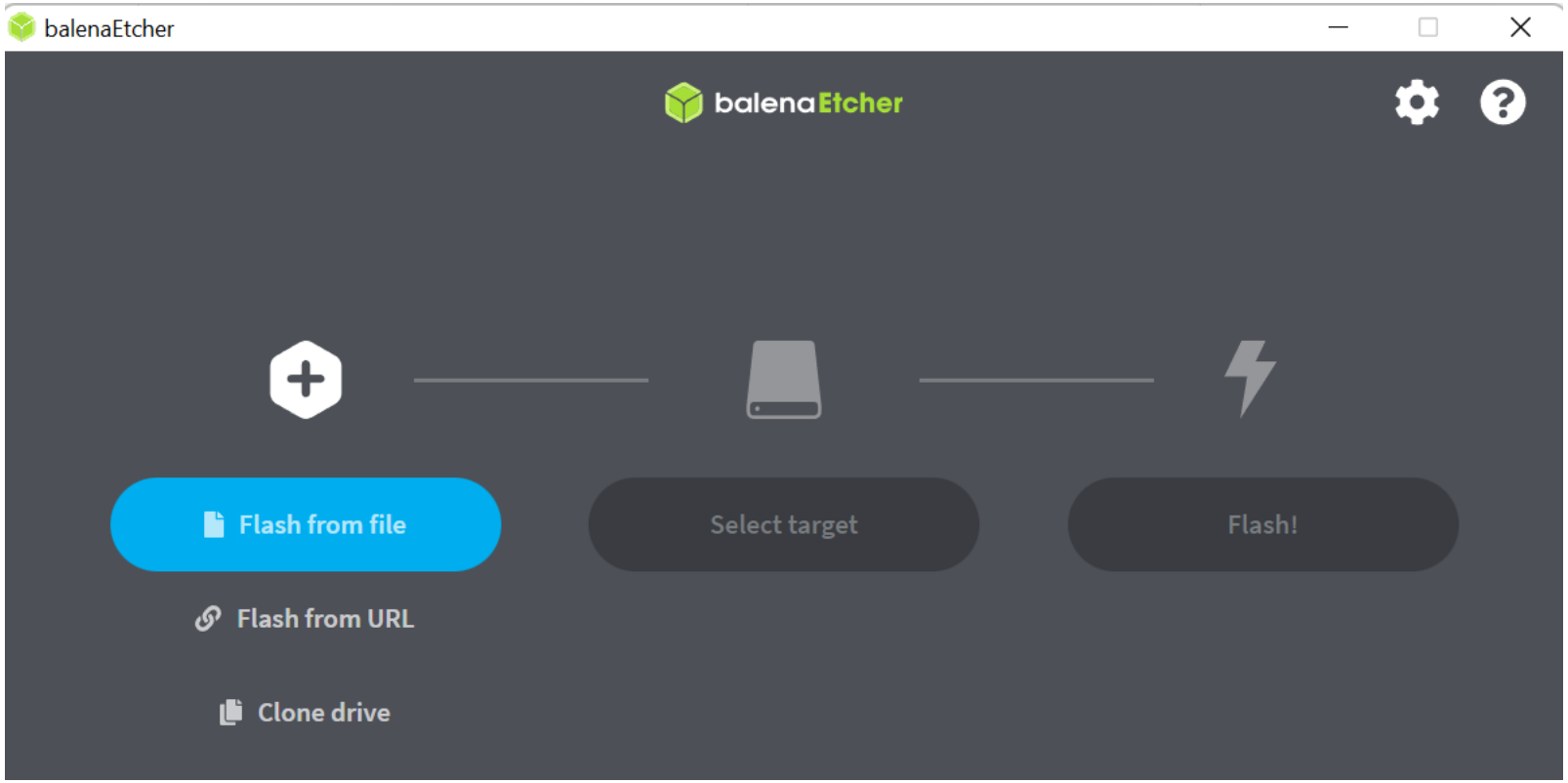
0.4 Install Screws to spacers



Step 1 Download Essential Software – Balena Etcher

1.1

- Balena Etcher is an open-source utility used to write system images to storage media such as a Flash Drive or SD Card. We will use this to place the operating system of our Raspberry Pi, called Raspbian, onto an SD card that can be inserted into the Pi.



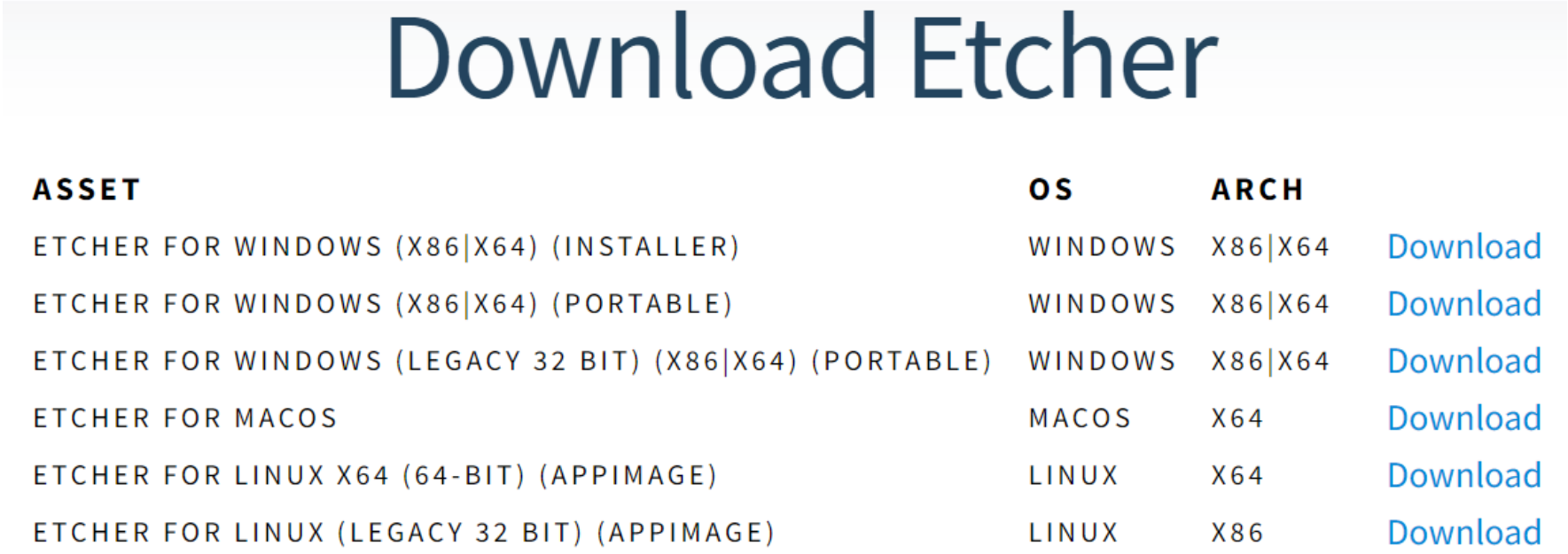
Step 1 Download Essential Software – Balena Etcher (Cont.)

1.2

- Navigate to the Install Page for Etcher
  https://www.balena.io/etcher

1.3

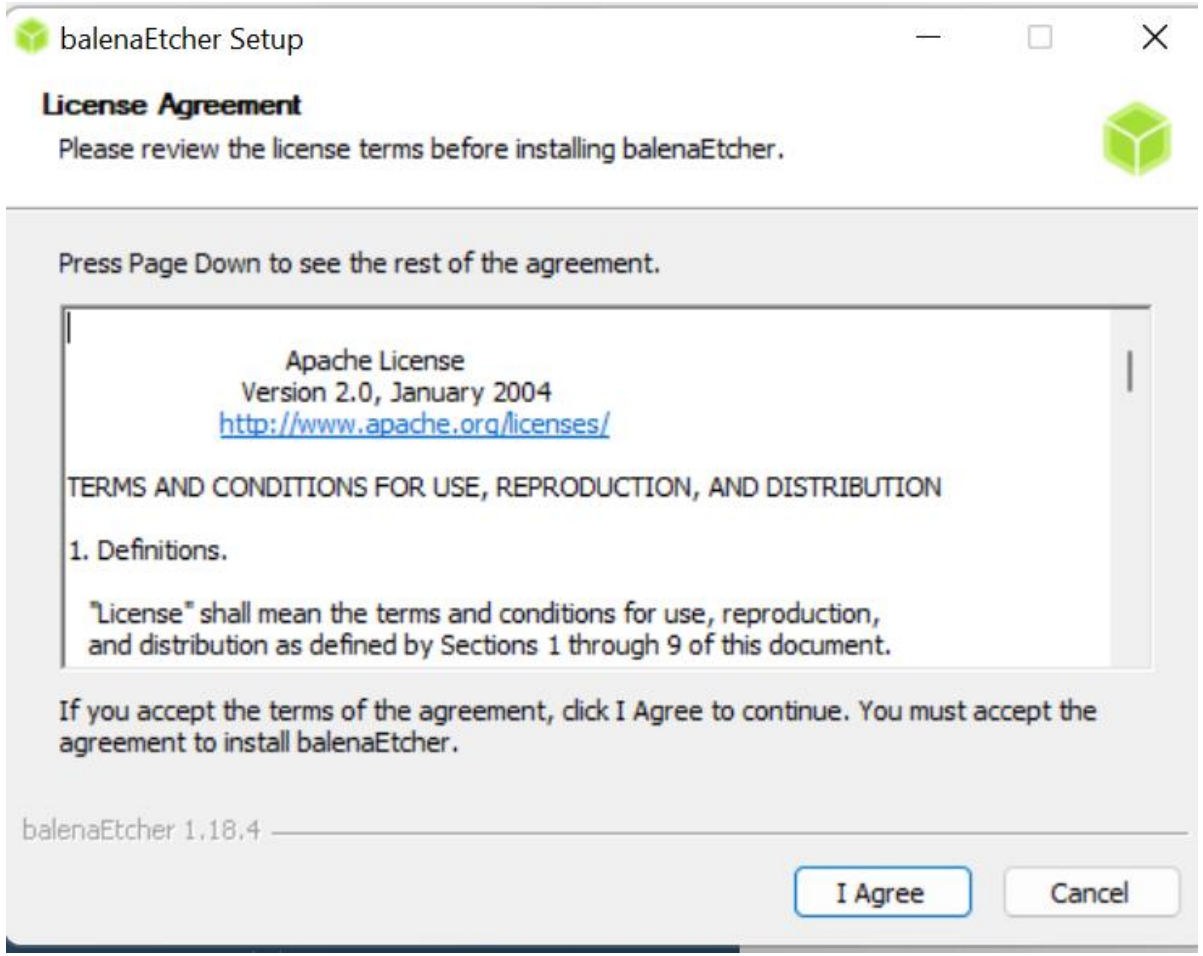
- Select the Version for your Operating System



Step 1 Download Essential Software – Balena Etcher (Cont.)

1.4

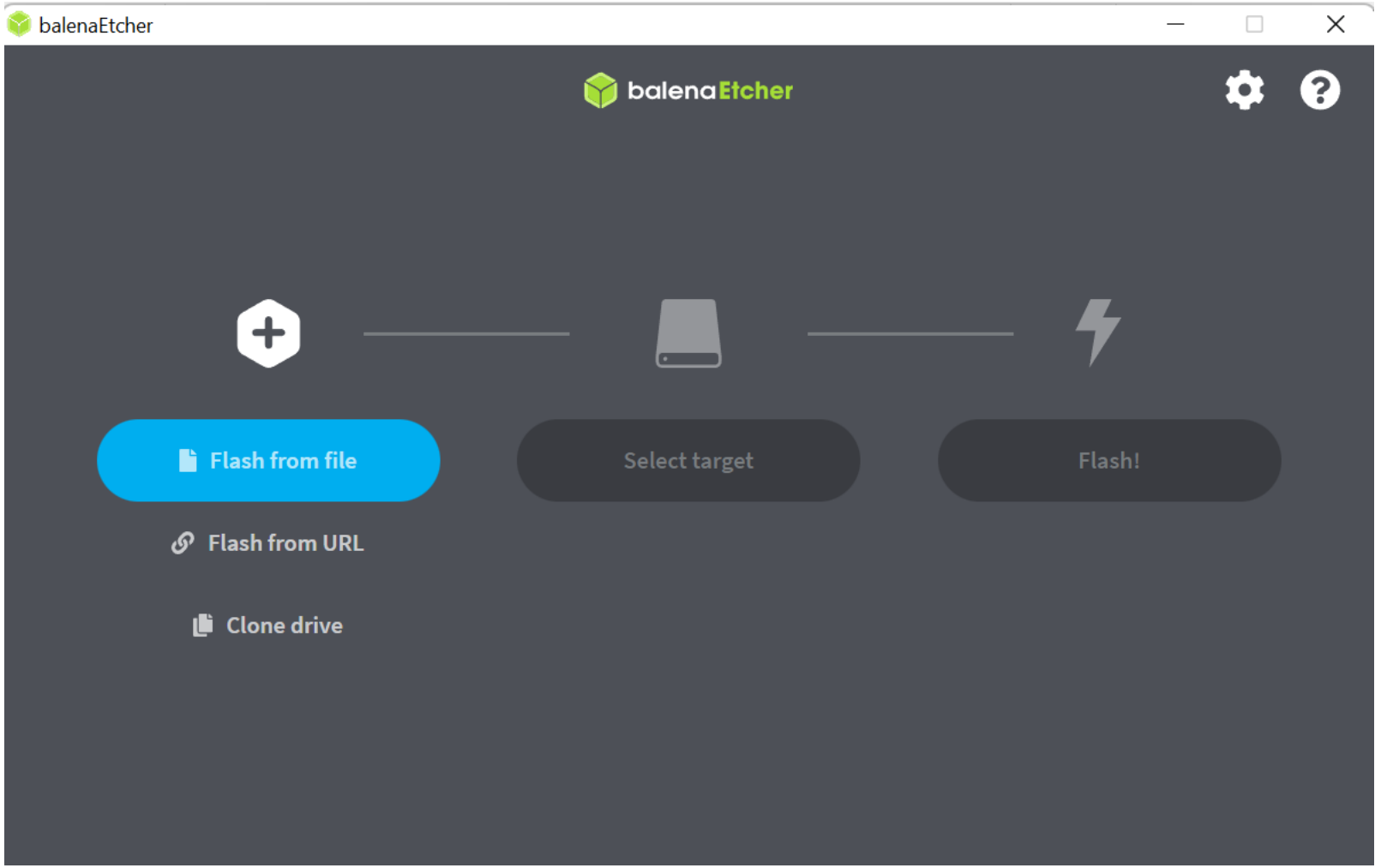
- Read the Terms of Agreement and select Agree



Step 1 Download Essential Software – Balena Etcher (Cont.)

1.5

- Wait for the download to finish, afterwards it will open up the Etcher Software

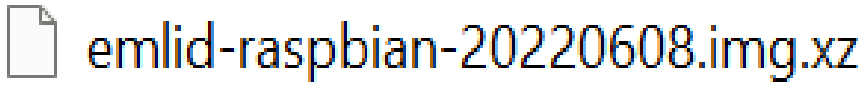


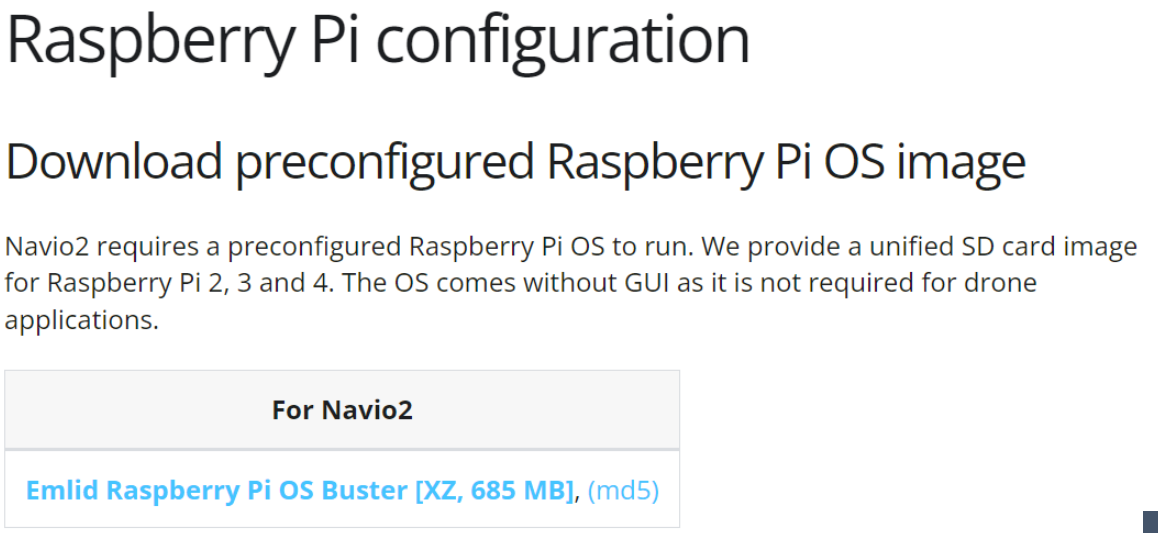
Step 2 Download Essential Software – Navio2 OS

2.1 With Balena, we now need a copy of the operating system we plane to use. Thankfully, the developers of the Navio2 have created a pre-configured operating system. All we need to do is download it and write the image to the SD card.

2.2 Download OS Here: https://docs.emlid.com/navio2/configuring-raspberry-pi

Note: This is a larger file so it may take several minutes to download
After it is finished, you should have a ".img.xz" file in your download folder. This is your image.

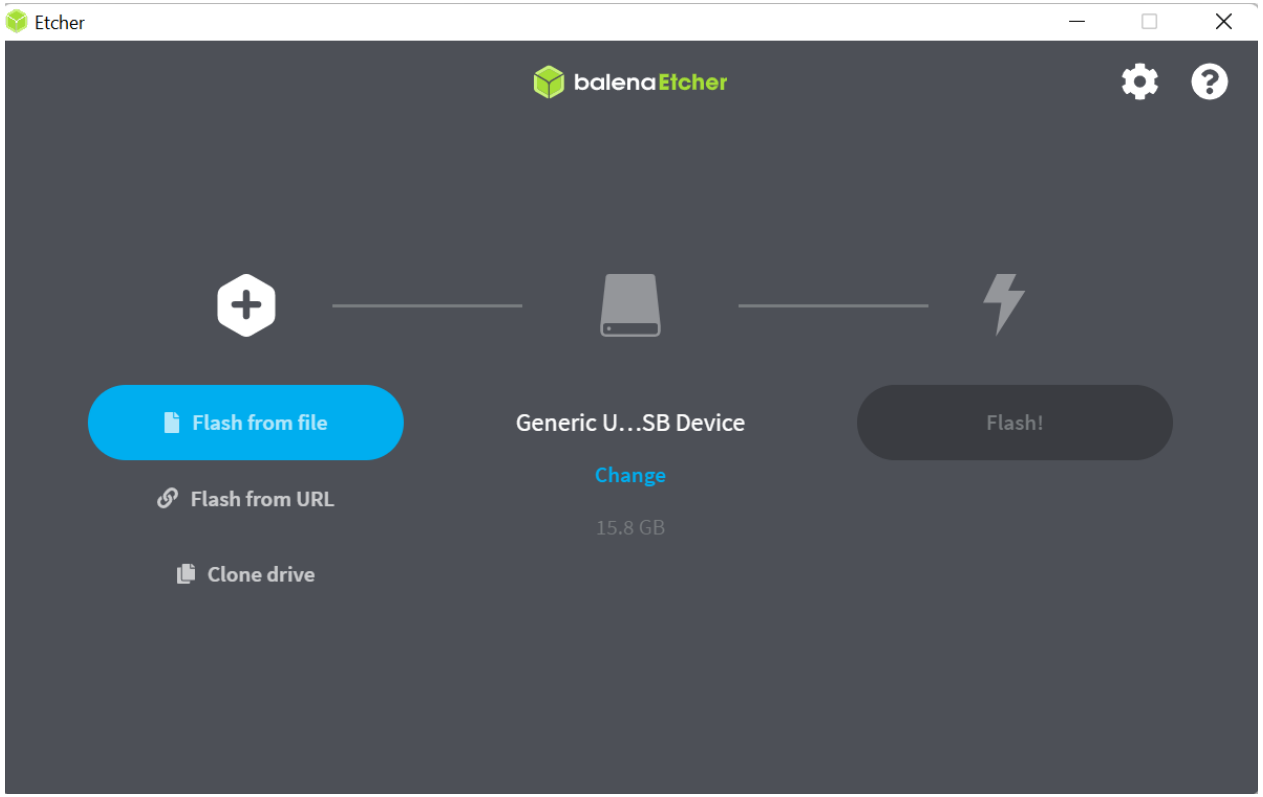




Step 3 Flashing the Operating System to a SD Card

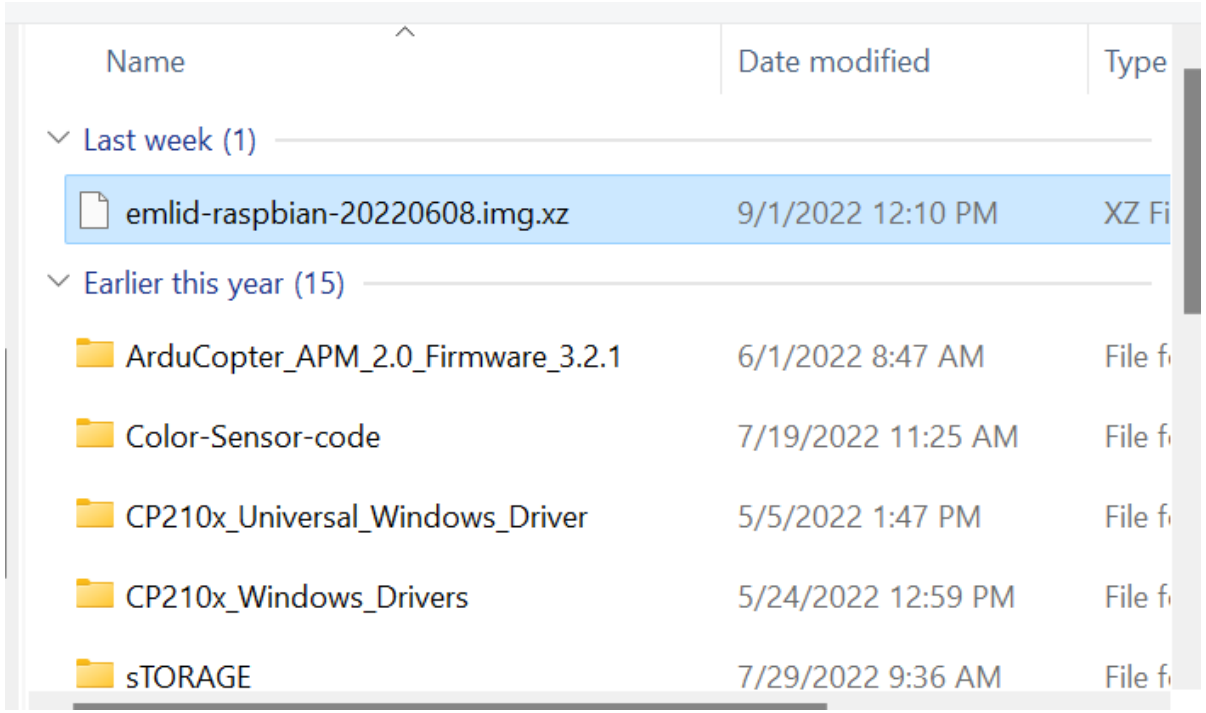
3.1 Now that we have both the writing software and the image, we can flash our SD card using the downloaded image. Flashing refers to the process of writing the contents of an image file to an SD file.

3.2 Open Balena Etcher if not already open, plug in SD Card to Computer



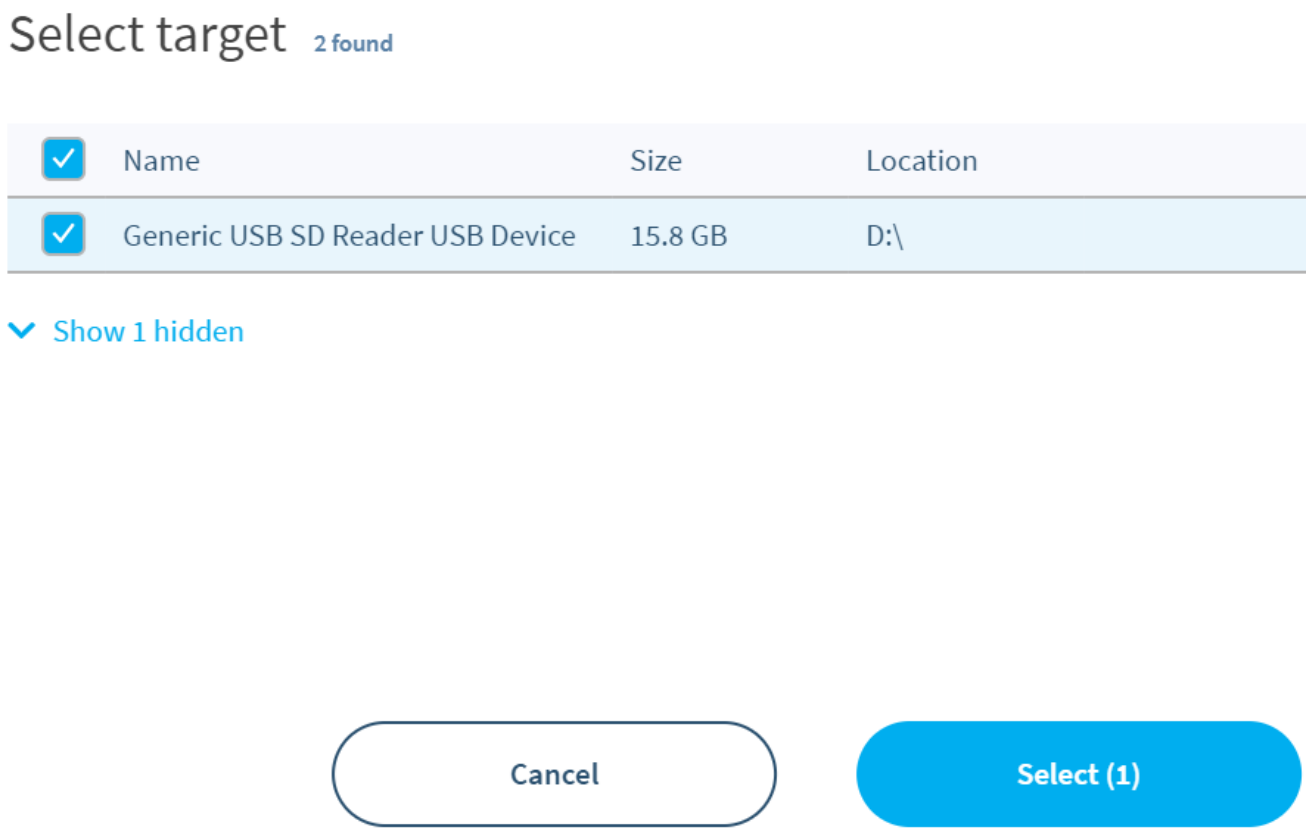
Step 3 Flashing the Operating System to a SD Card (Cont.)

3.3 Select the Navio2 Image that you downloaded in Step 2



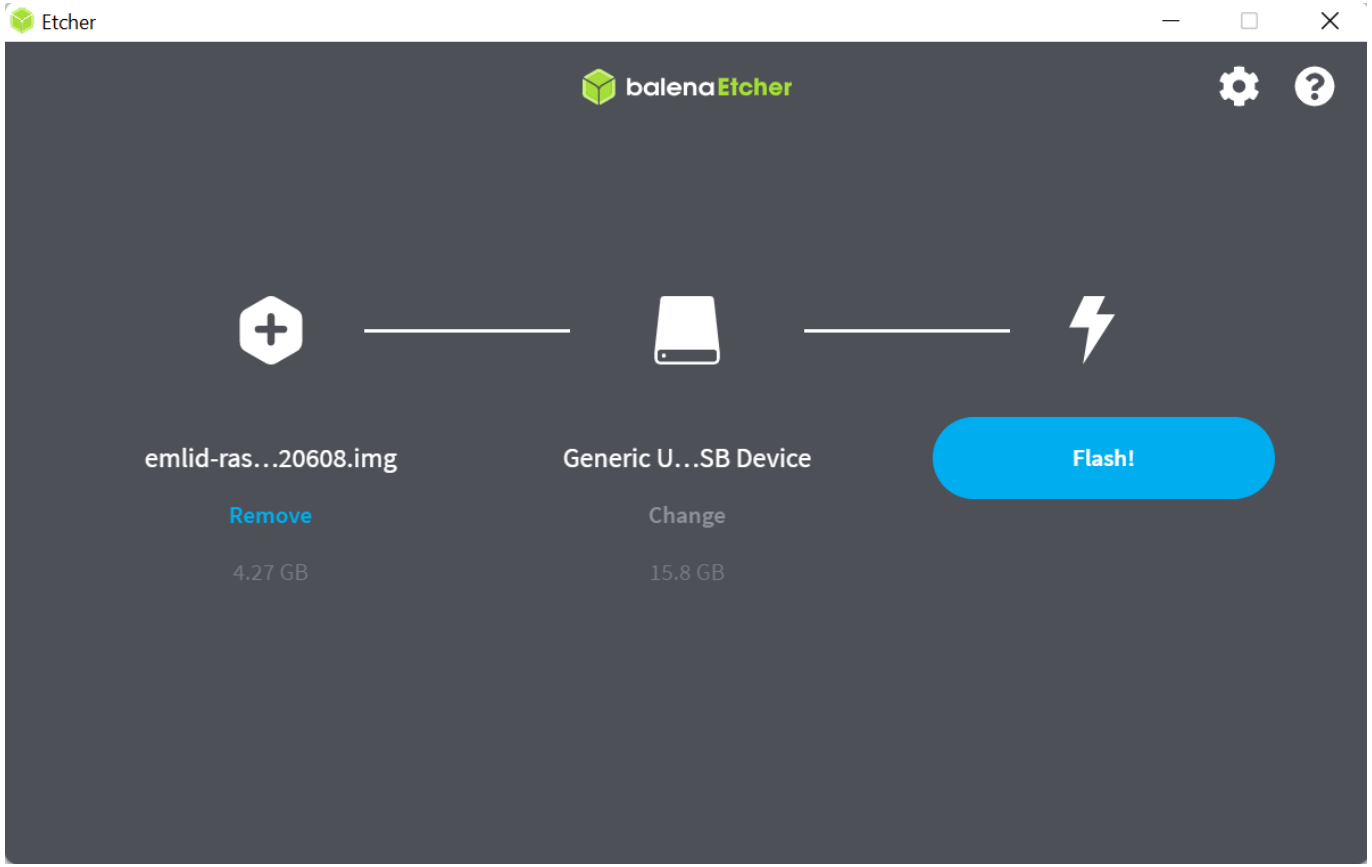
Step 3 Flashing the Operating System to a SD Card (Cont.)

3.4 Select the SD Card you wish to flash



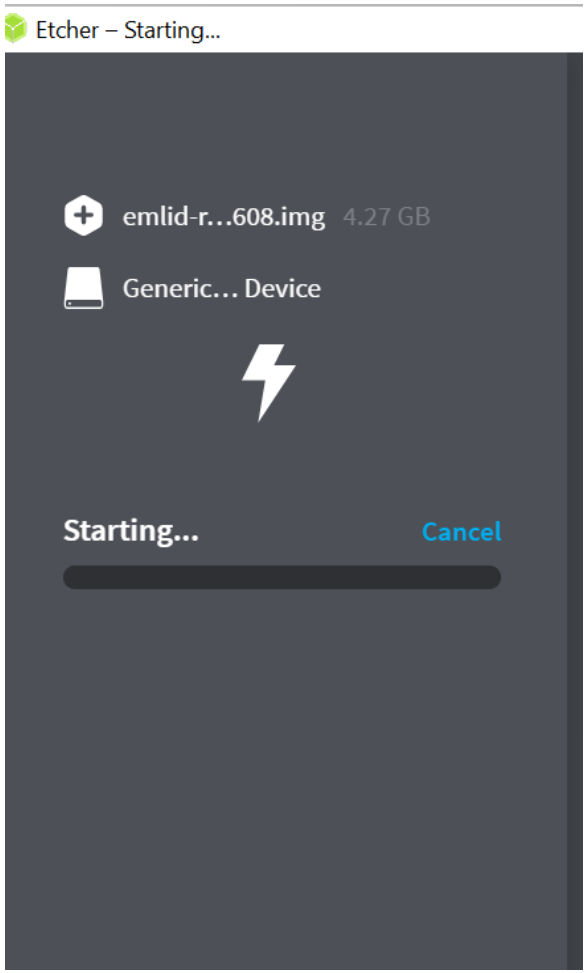
Step 3 Flashing the Operating System to a SD Card (Cont.)

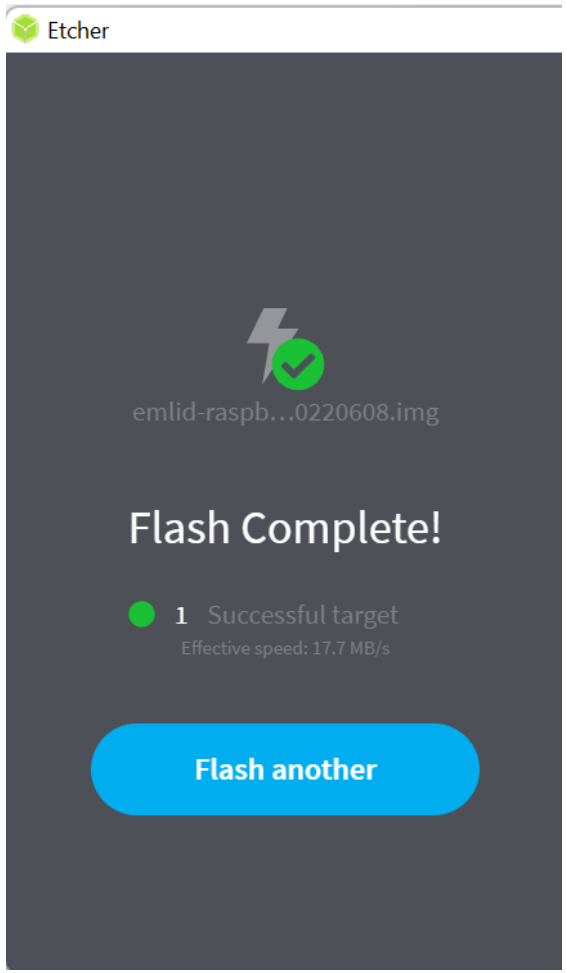
3.5 Begin Flashings by selecting the Flash Button



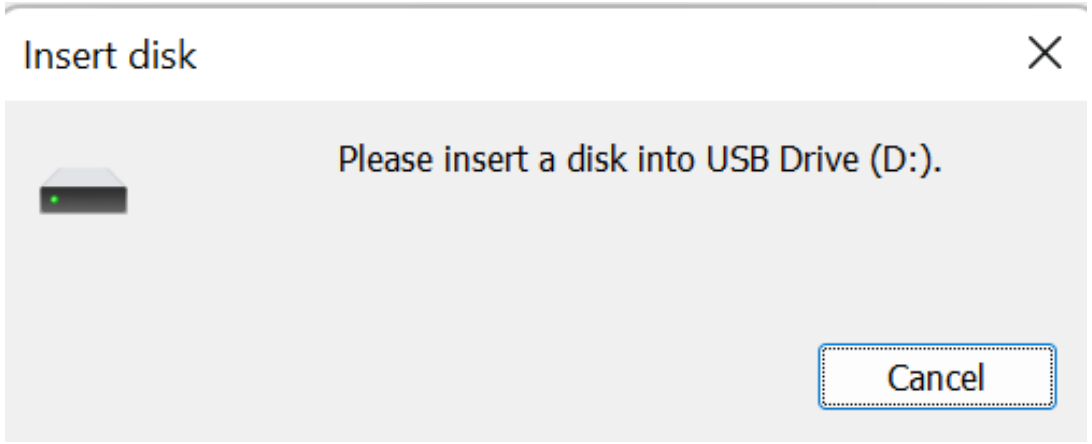
Step 3 Flashing the Operating System to a SD Card (Cont.)

3.6 Wait for Flashing to Finish





A pop up will appear saying to please insert a disk into USB Drive, do not do anything with these windows. They appear naturally during the flashing process and will disappear.



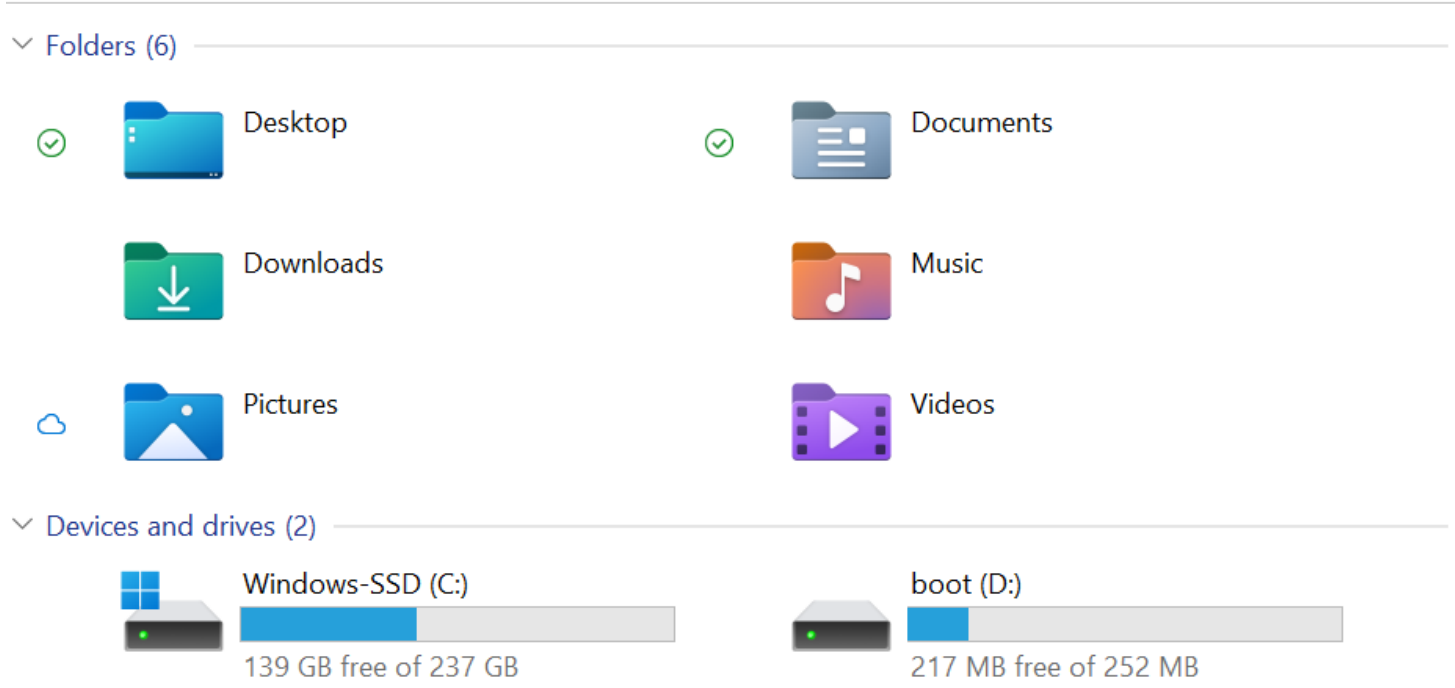
Step 4 Wi-Fi Configuration

4.1 Now that we have our image created, we need to configure our internet connection so that the Raspberry Pi will connect to your network on boot-up. This makes extracting data and setting up the Raspberry pi easier as you can then do it from your computer rather than using a second monitor and keyboard connected to the Raspberry Pi.

Step 4 Wi-Fi Configuration (Cont.)

4.2 With your SD card still connected to your computer, open up your file viewer and navigate to your available devices and drives.

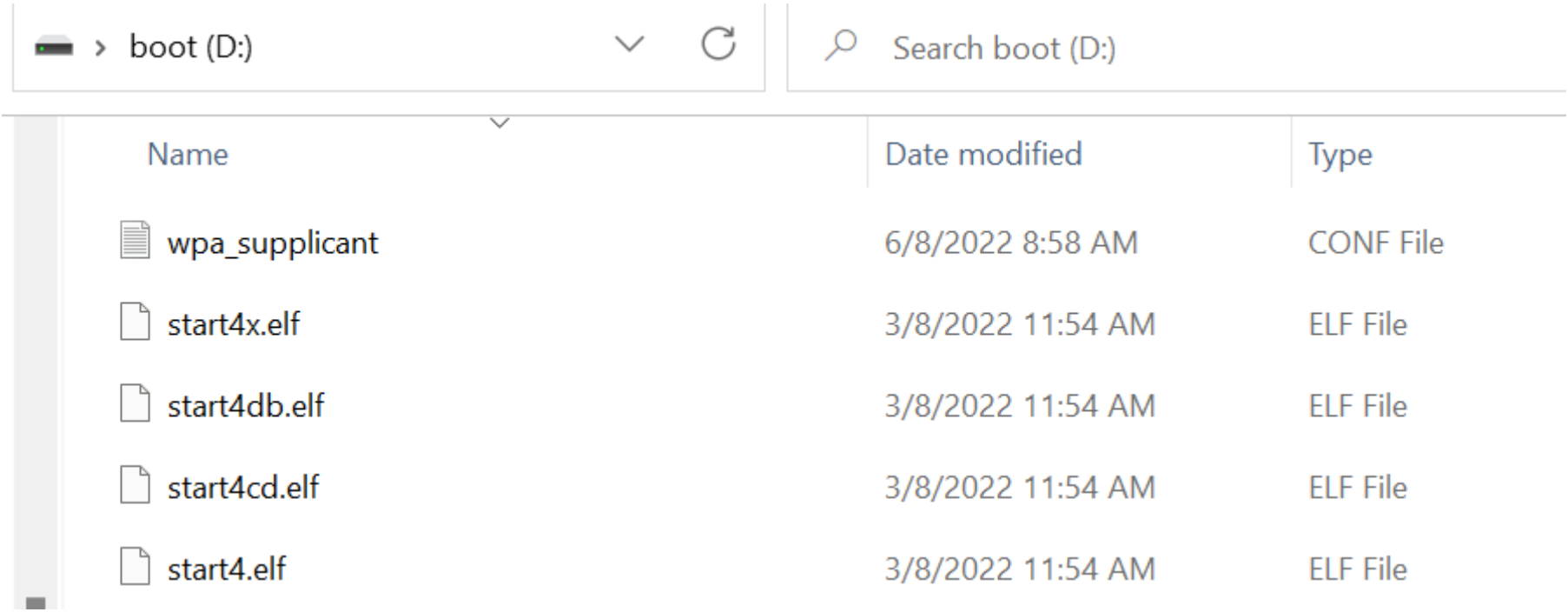
4.3 Open the Boot Driver



Step 4 Wi-Fi Configuration (Cont.)

4.4

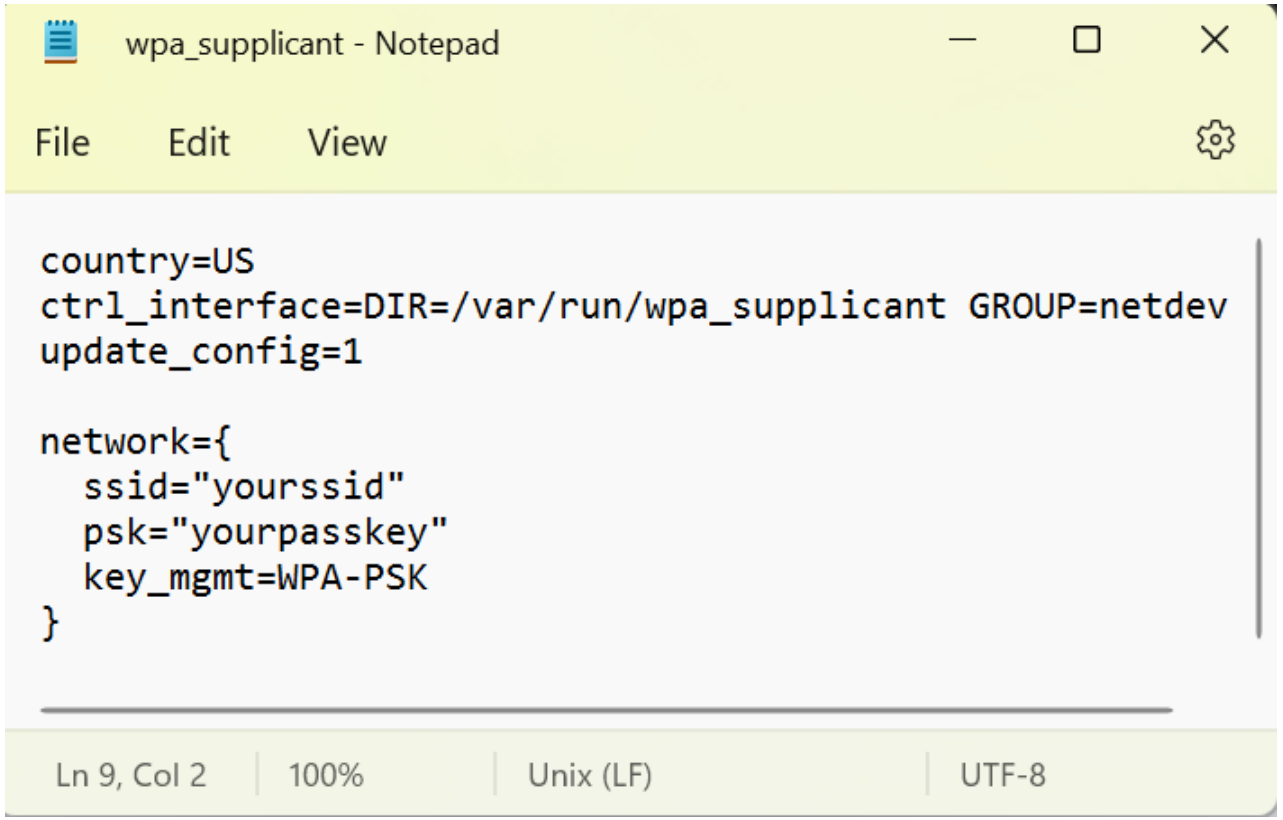
- Navigate to the Boot Drive and open the WPA_supplicant file using a text editor such as Notepad



Step 4 Wi-Fi Configuration (Cont.)

4.5 Your file should match the provided example.

Place your Wi-Fi name and password INSIDE the quotation marks, do not get rid of the quotation marks.



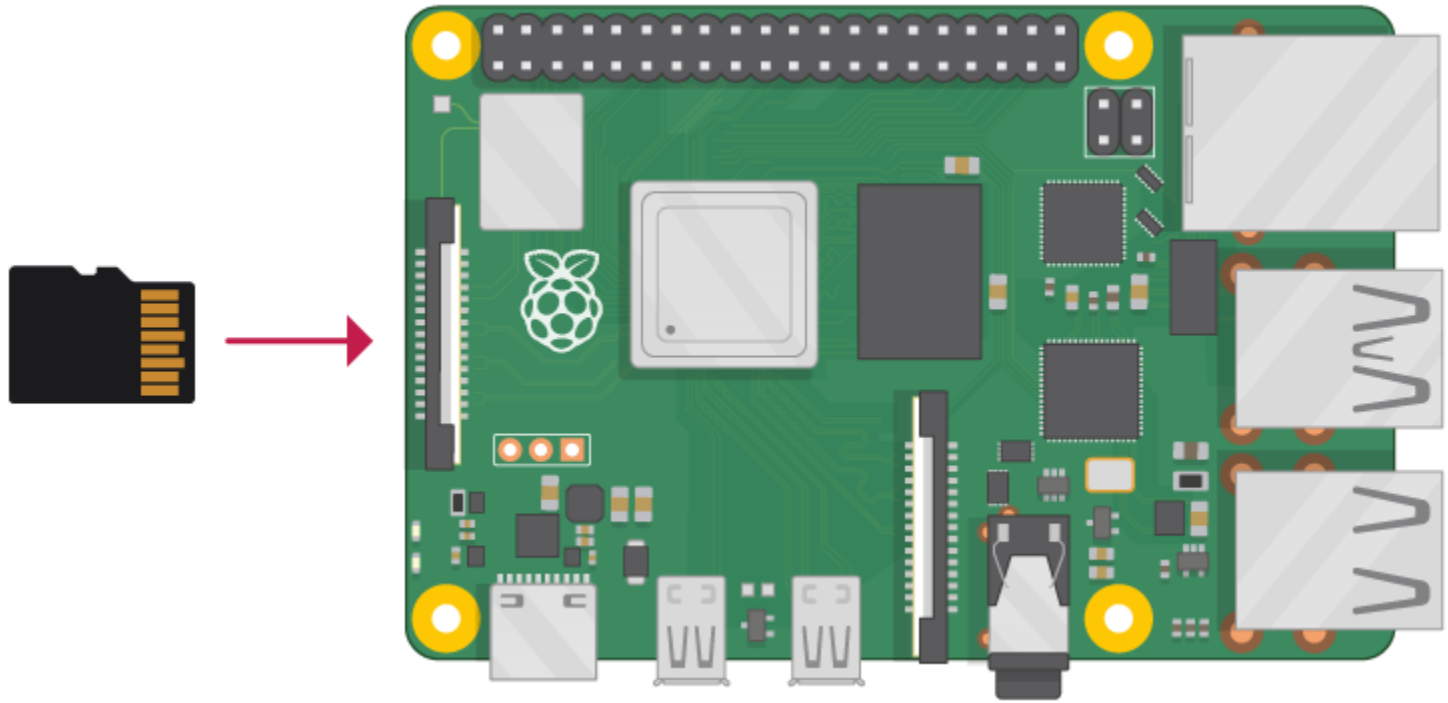
4.6 Save and close the file.

Eject the SD Card from the Computer

Step 5 Ardupilot Configurations

5.1 This will walk through on setting up the software side of the Navio2 before connecting to mission planner

5.2 First, install the SD Card into the Raspberry Pi on the underside of the device and connect Power to the Navio2 using the provided USB-C power supply.



Step 5 Ardupilot Configurations (Cont.)

5.3 In order to configure the software configurations, we need to be able to connect to the Raspberry Pi. You can do this by simply connecting a Monitor and Keyboard to it, but we are looking at being able to make these changes remotely using internet access.

5.4 Install Putty Here: https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html

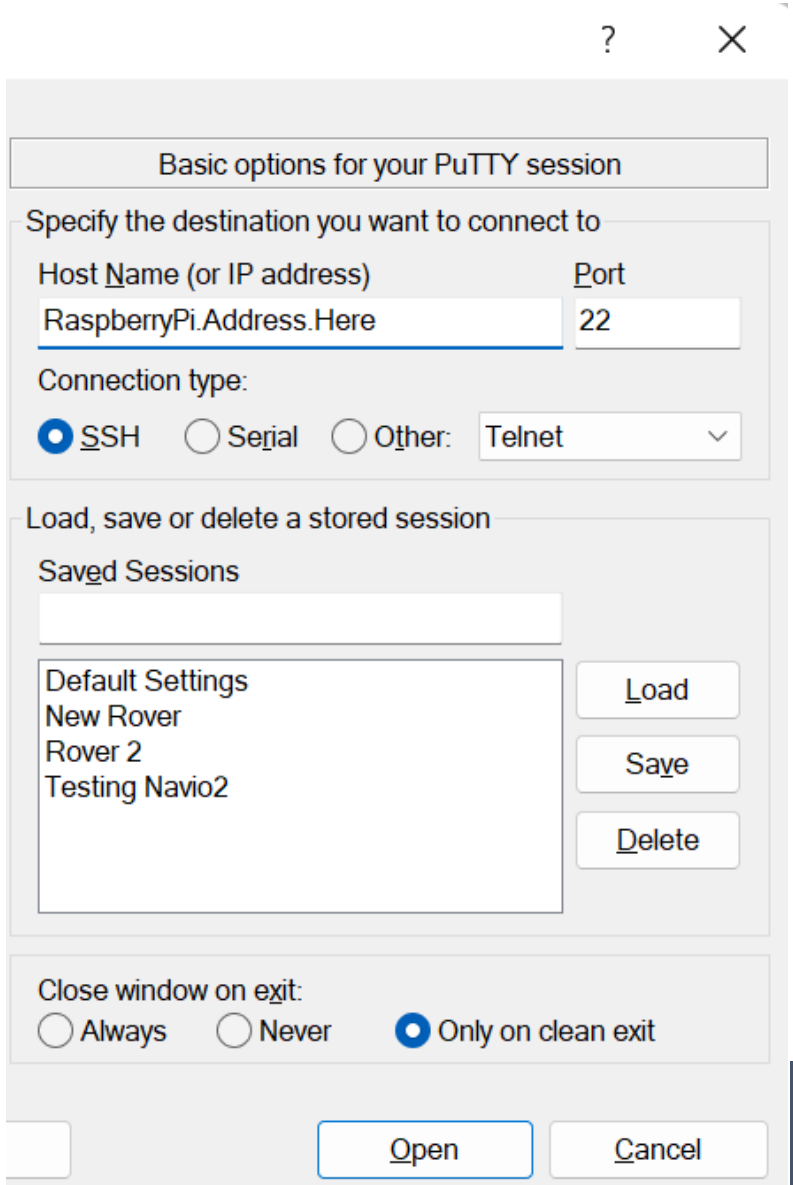
Scroll down to the “Package Files” section and select the installer that fits your system.

Step 5 Ardupilot Configurations (Cont.)

5.5 Once you have the software installed, you need to know the IP address of your Raspberry Pi. You can do this by either looking at the devices connected to your router, , by manually finding the IP address by connecting a Monitor/Keyboard to the Raspberry Pi and using the command “hostname –I”

Or, if you only have one Navio2 powered on, you can enter the default hostname “navio”

The hostname is for if you are unable to find the IP address of the Navio2, it allows you to connect to the device based on a pre-written name that represents the device.



Step 5 Ardupilot Configurations (Cont.)

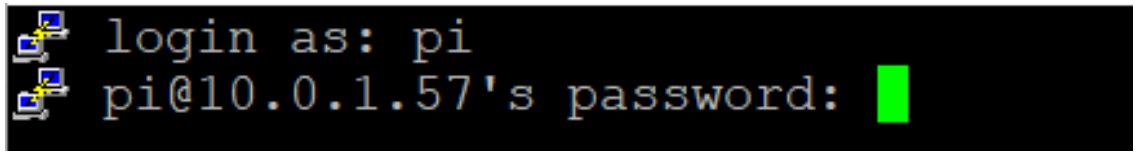
5.6 Enter the IP Address/Hostname into the “Host Name” tab of Putty, then click Open.

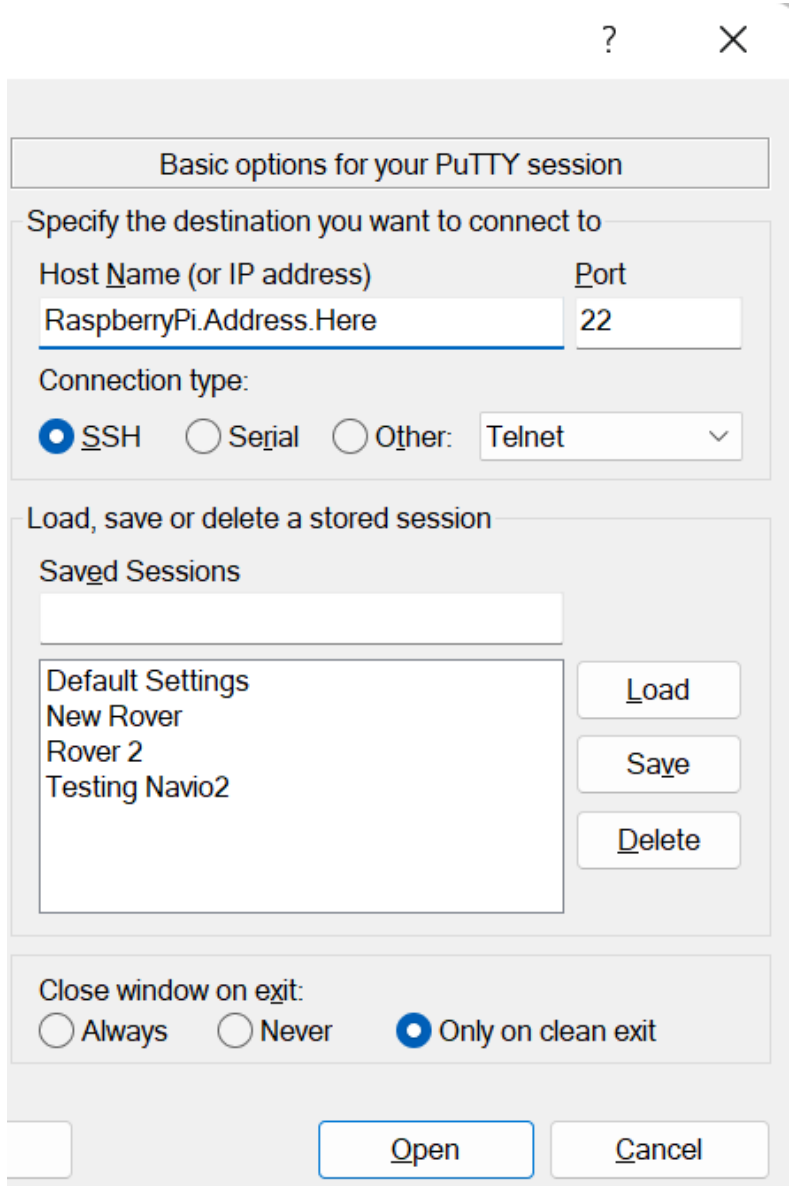
You will be prompted to enter the Username and Password of the Raspberry Pi.

Username: pi

Password: raspberry

When typing in the password, you will notice nothing appears. This is normal. Simply hit enter after inputting the password and if done correctly you will login.





Step 5 Ardupilot Configurations (Cont.)

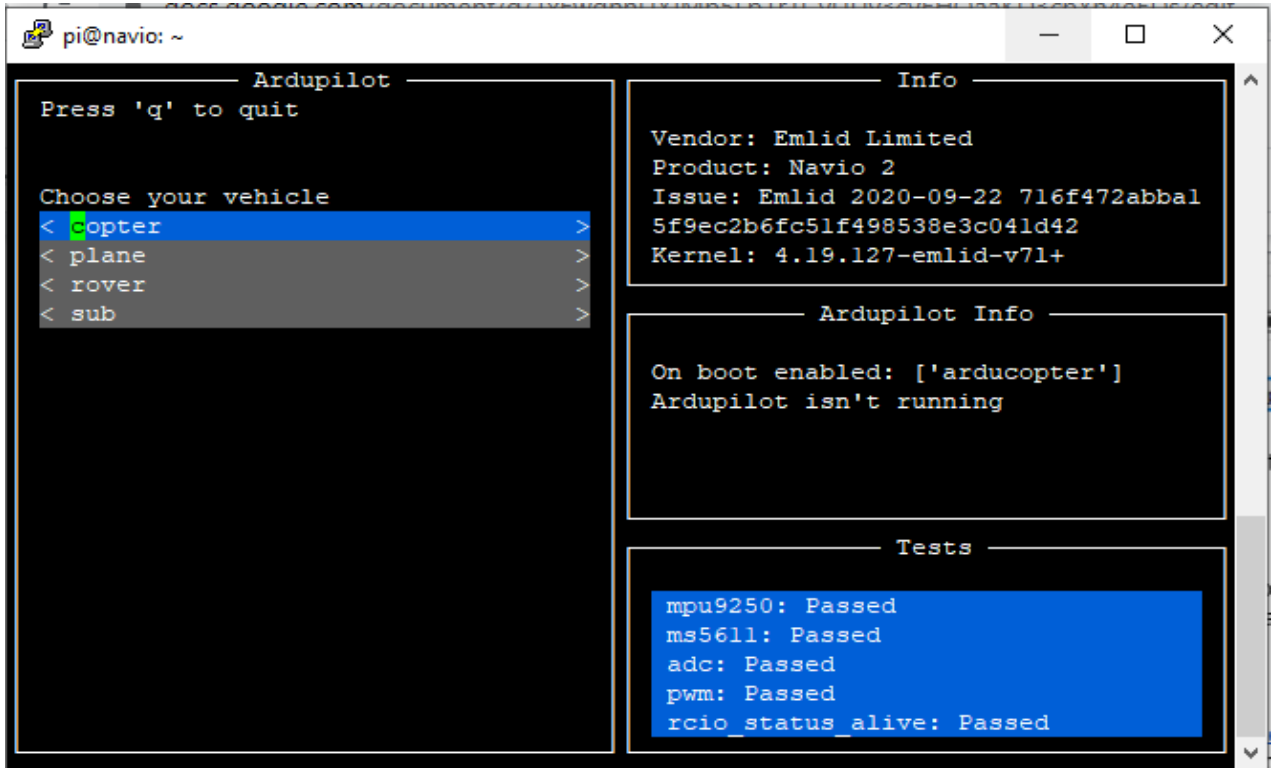
5.7 Once you are connected to the Raspberry Pi

Enter the command “sudo emlidtool ardupilot”

This will take you into the Ardupilot setup tool

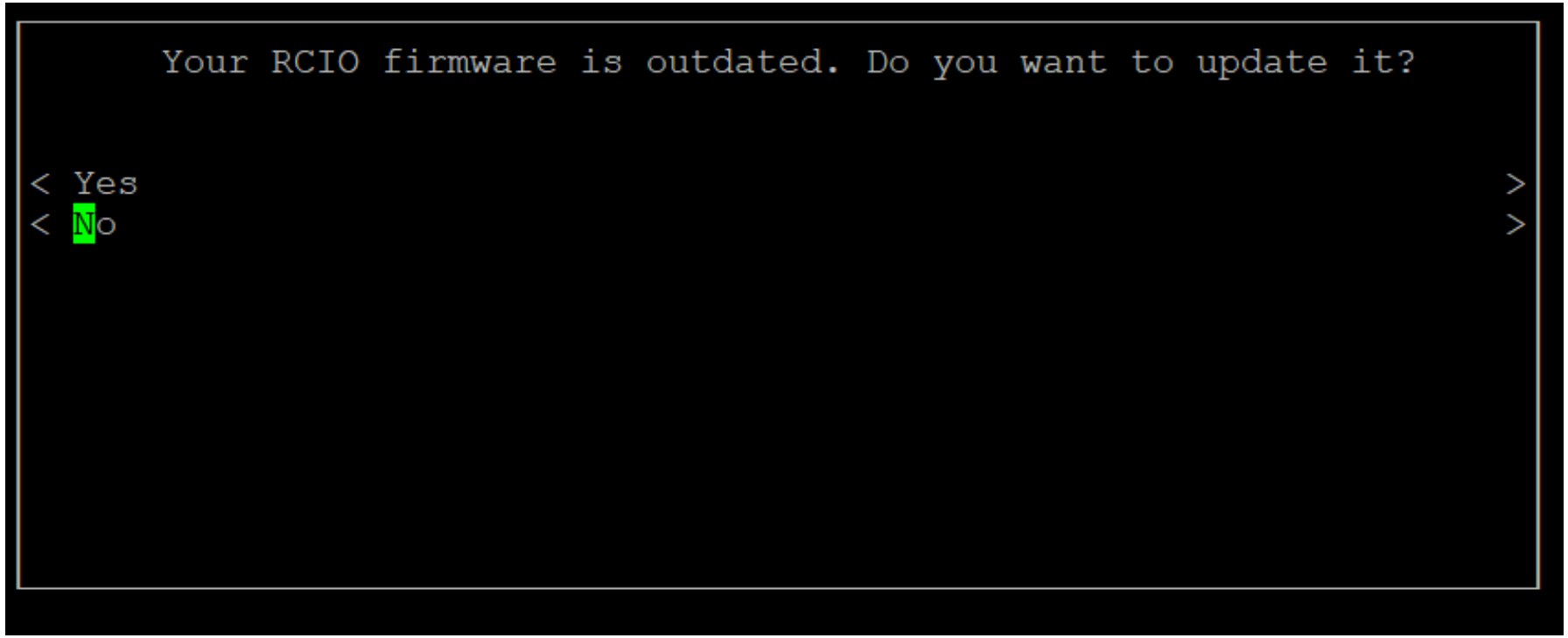
```
pi@navio:~ $ sudo emlidtool ardupilot
```

5.8 This window will appear



Step 5 Ardupilot Configurations (Cont.)

5.8 You might also see this pop-up, select “No” and hit Enter using the keyboard.



Step 5 Ardupilot Configurations (Cont.)

5.9 Now you will select the vehicle you are using along with version, an enable on boot. For the Rover, the following parameters to select:

Ardupilot: **rover**, select the Ardurover configuration

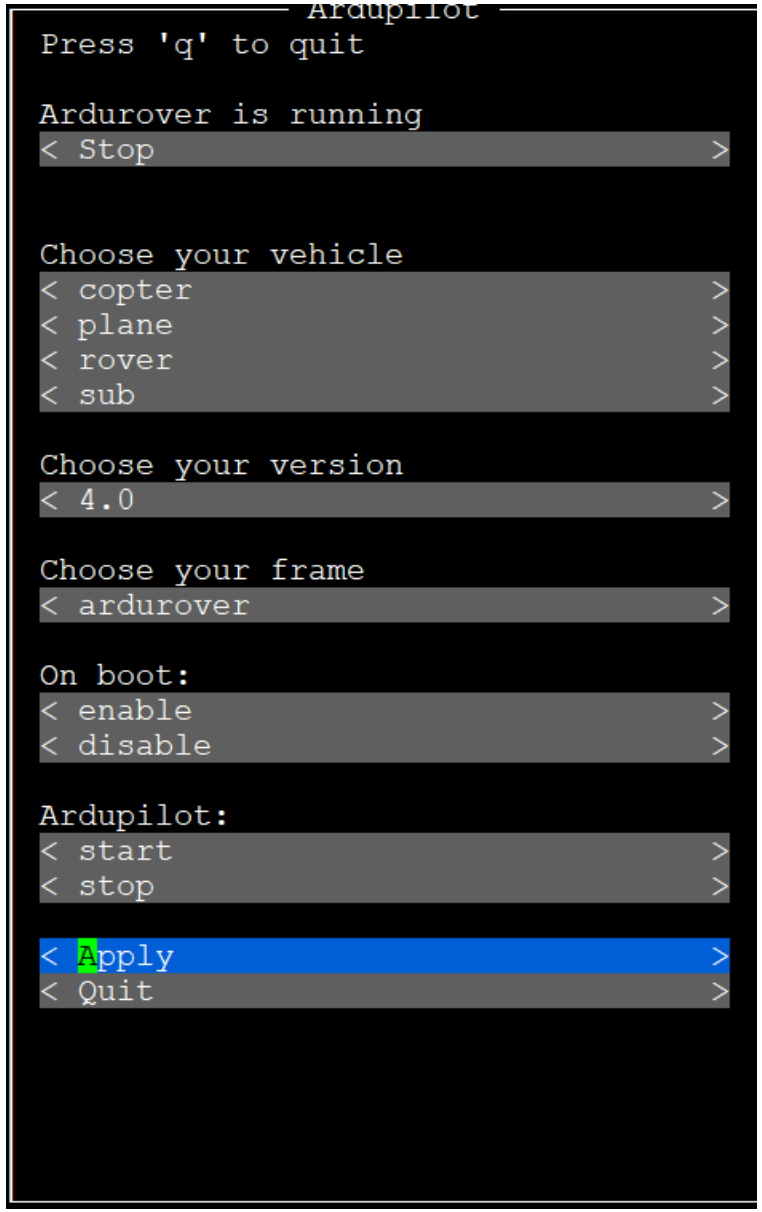
Version: **4.0**, There should only be one option here, but this is the version of Ardurover you wish to use

Frame: **Ardurover**,

On Boot: **Enable**, this will have Ardupilot start when power is applied

Ardupilot: **Start**, this will start the Ardupilot program now rather than waiting for power reboot

5.10 Select Apply and then press “q” to quit or hit “Quit”

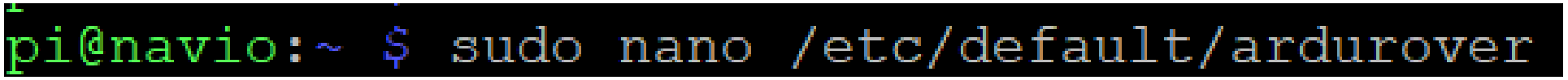


Step 6 Telemetry Configurations

6.1 Now that we have the Ardupilot setup, we can configure the Telemetry settings for our flight controller to operate with our radios to enable ground station communication.

6.2 To adjust the settings, enter the command “sudo nano /etc/default/ardurover”

This will open the configuration file for just the Ardurover configuration



Step 6 Telemetry Configurations (Cont.)

6.3 Here we will change the telemetry settings for the Navio2 to change the baud-rate to match the baud-rate used for our telemetry radios. To do this, we are changing Serial 0 of the Navio2 from using UDP connection method to the telemetry UART port.

6.4 Change the text from left original to the right new

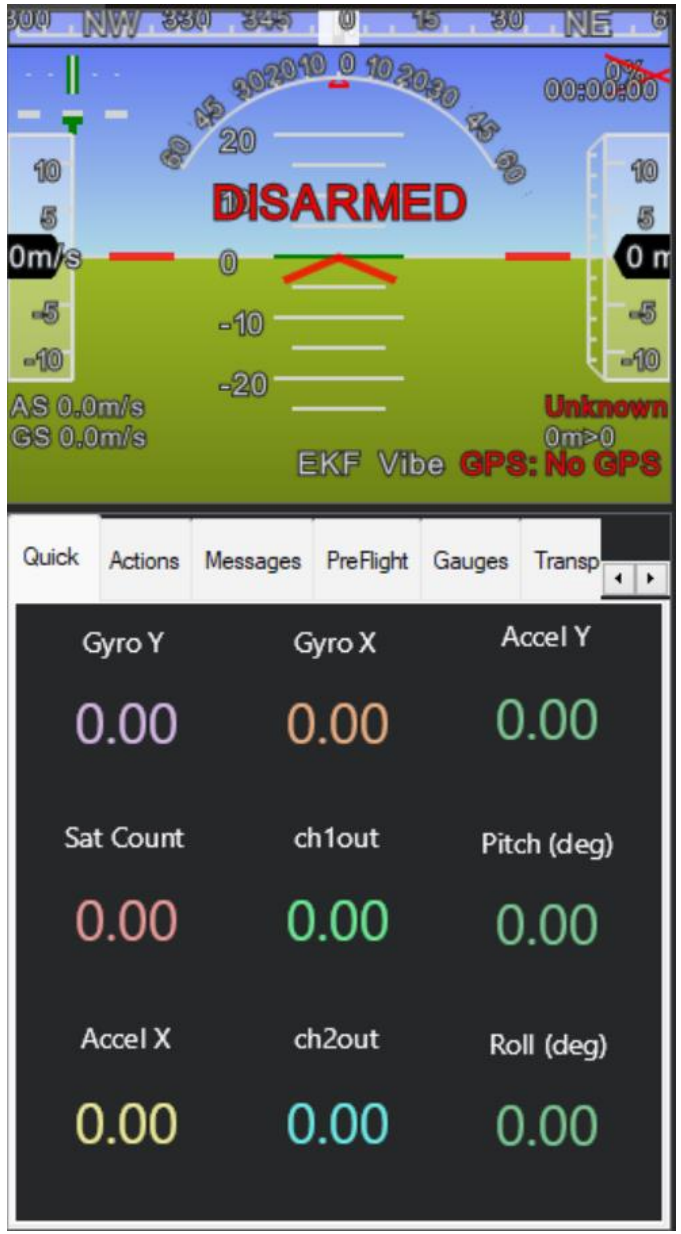
```
# Default settings for ArduPilot f
# The file is sourced by systemd f

TELEM1="-A udp:127.0.0.1:14550"
#TELEM2="-C /dev/ttyAMA0"

# Options to pass to ArduPilot
ARDUPILOT_OPTS="$TELEM1 $TELEM2"
```

```
TELEM1="-C /dev/ttyUSB0"
TELEM2="-A /dev/ttyAMA0"
# Options to pass to ArduPilot
ARDUPILOT_OPTS="$TELEM1 $TELEM2"
```

6.5 Press “Ctrl+x” to exit, press “y” to save, then hit enter

Finally, Reboot using the command , “sudo reboot”

Ardupilot and Mission Planner Configuration

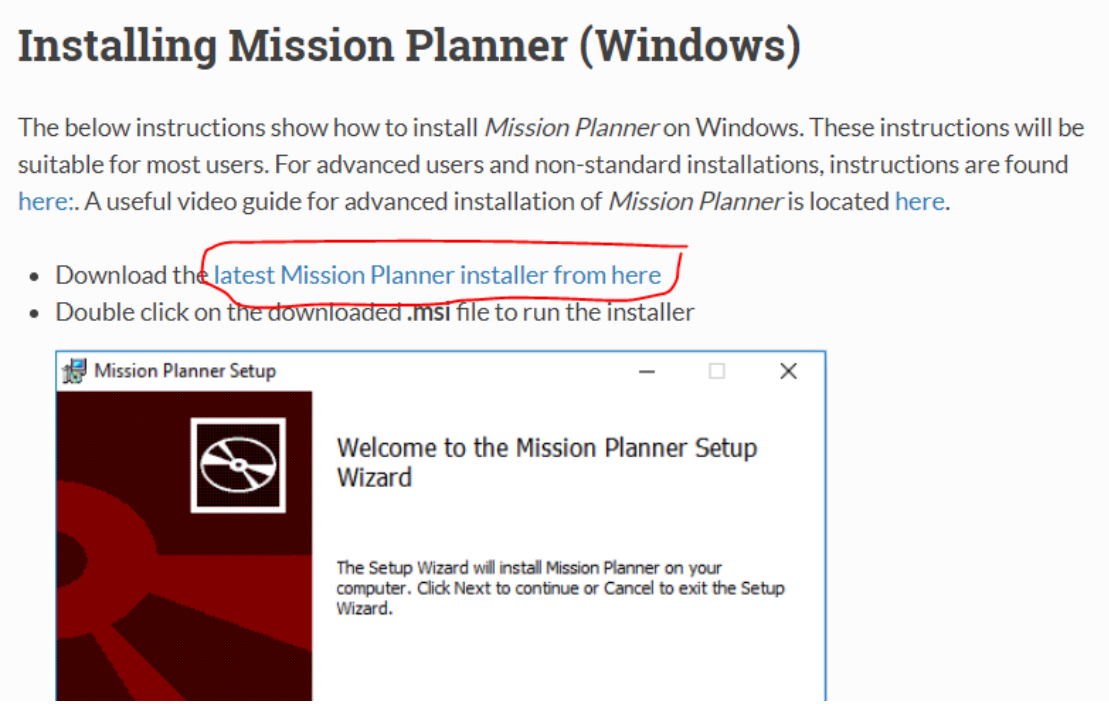


- Avionics Kits
- Telemetry Radio Kit
- Power Supply
- Internet Connection

Step 0 Install Mission Planner

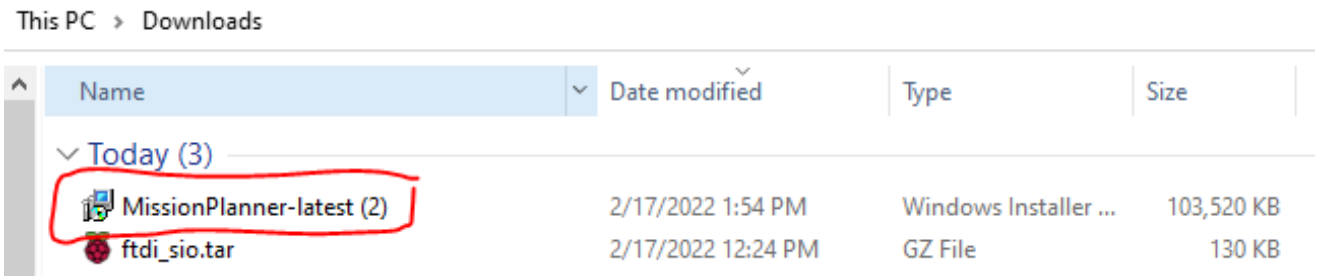
0.1 Mission Planner is our Ground Control Station which relays telemetry information to the user while the vehicle is in operation

0.2 Using the link provided below, go to the Ardupilot website and click the link https://ardupilot.org/planner/docs/mission-planner-installation.html this will begin downloading the installer to your computer.

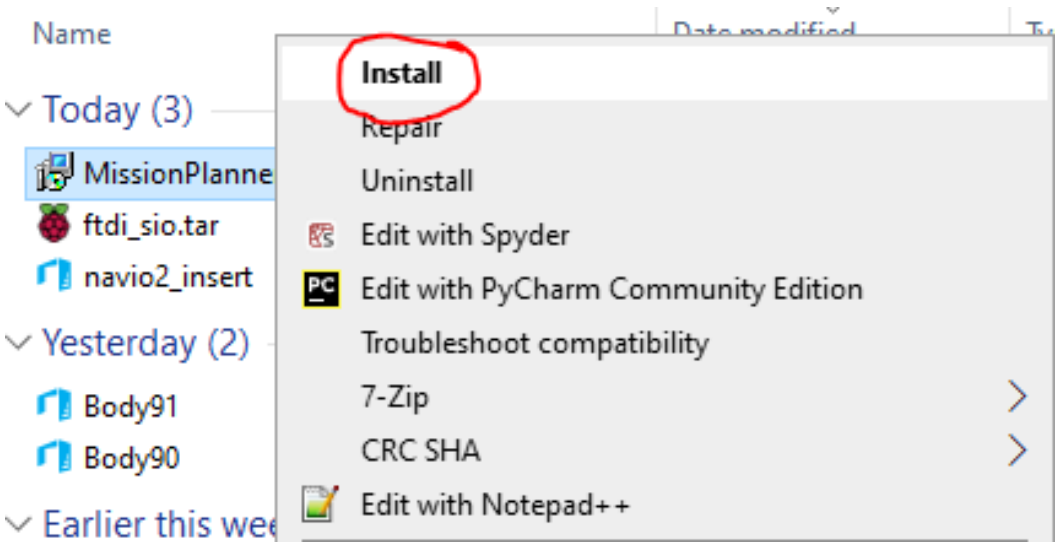


Step 0 Install Mission Planner

0.3 After downloading the installer, locate the file. This will likely be in your downloads folder or you can open it from your internet browser.



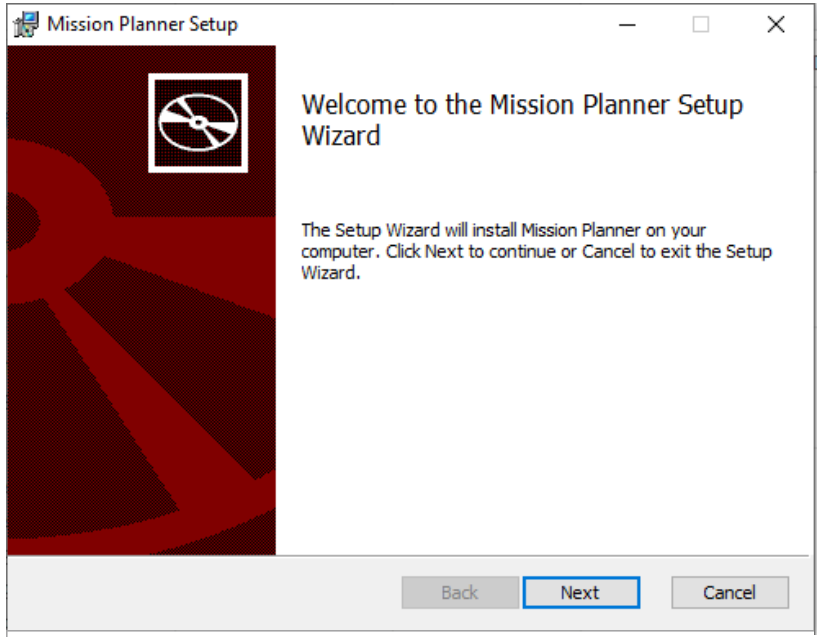
0.4 Open Installer by right clicking and selecting the “Open” or “Install” Option

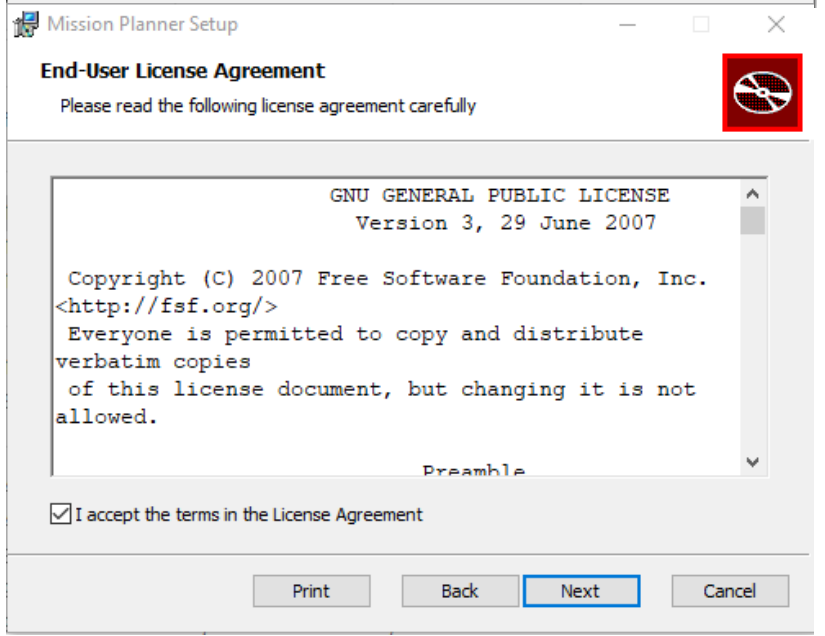


Step 0 Install Mission Planner

0.5 This will create a new program that will appear, follow these instructions

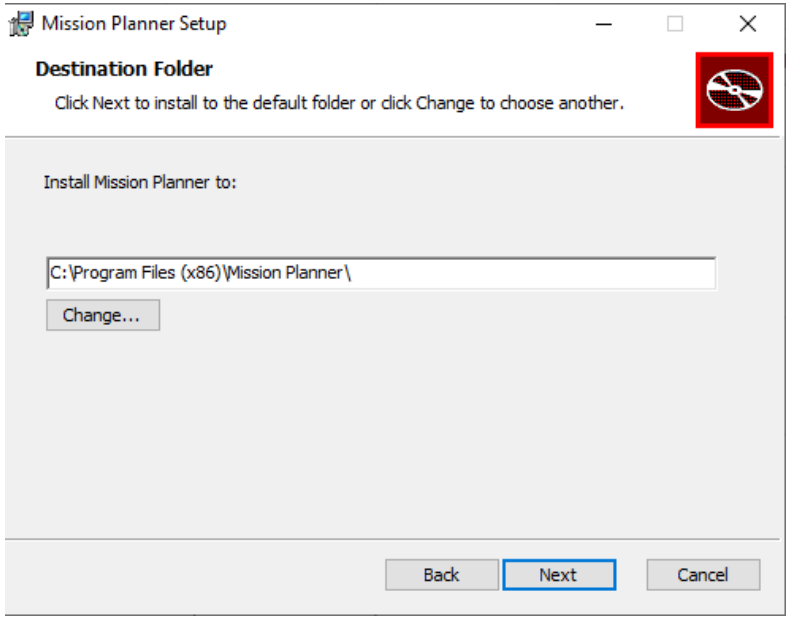
0.6 Press Next, then read the terms of agreement, agree to it, then select next



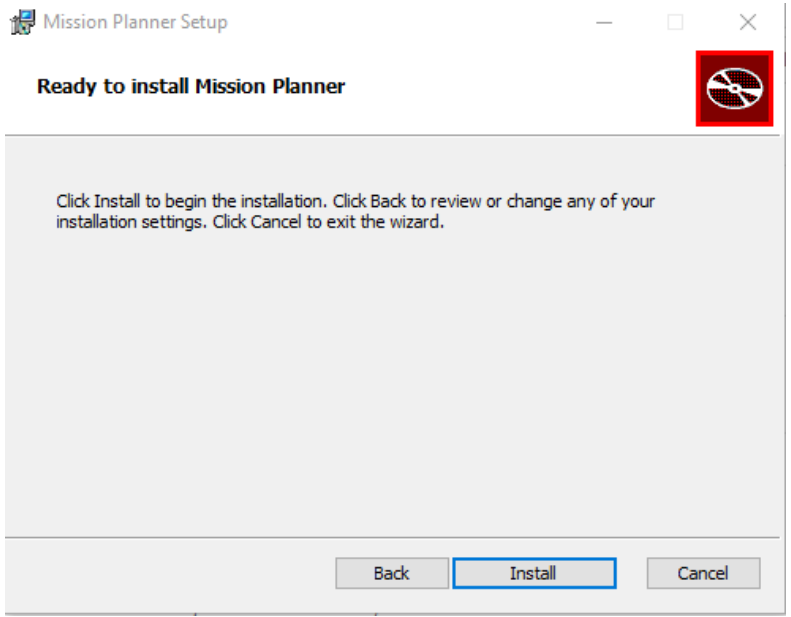


Step 0 Install Mission Planner

0.7 Select where you want to install Mission Planner on your computer or leave it at the default location selected. Then press “Next”

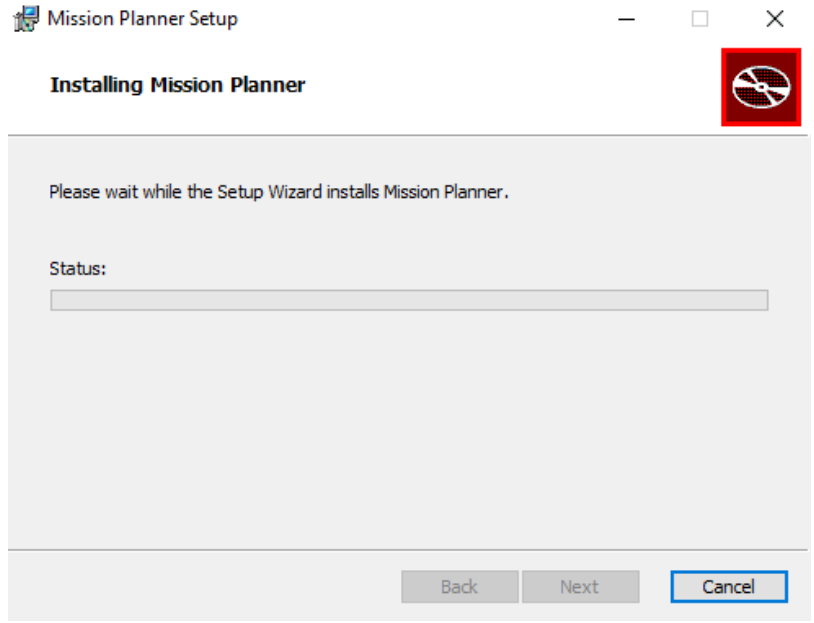


0.8 Confirm starting the installation by pressing “Install”

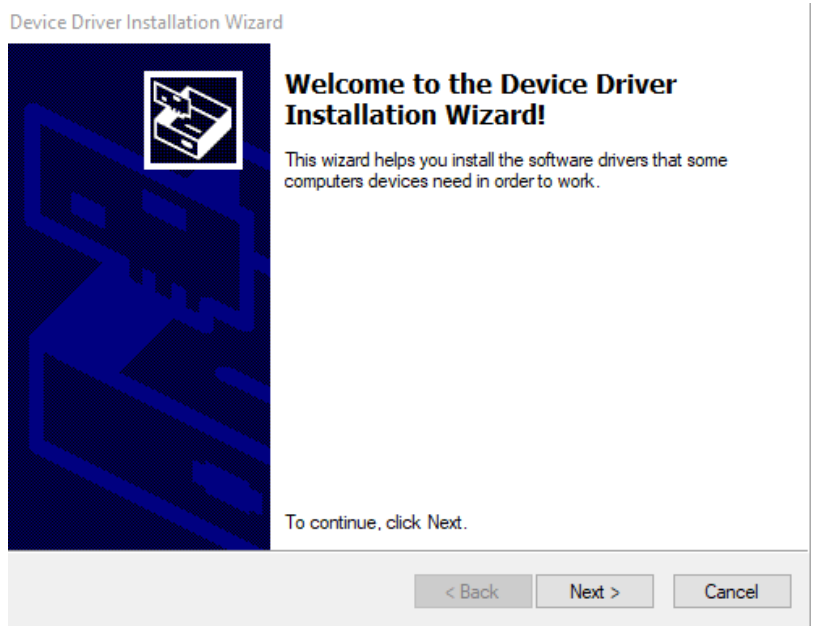


Step 0 Install Mission Planner

0.9 This will begin an installation that will finish when the status bar is filled. You might have another bar pop up asking for permission to install, allow the program permission for the installation to continue.

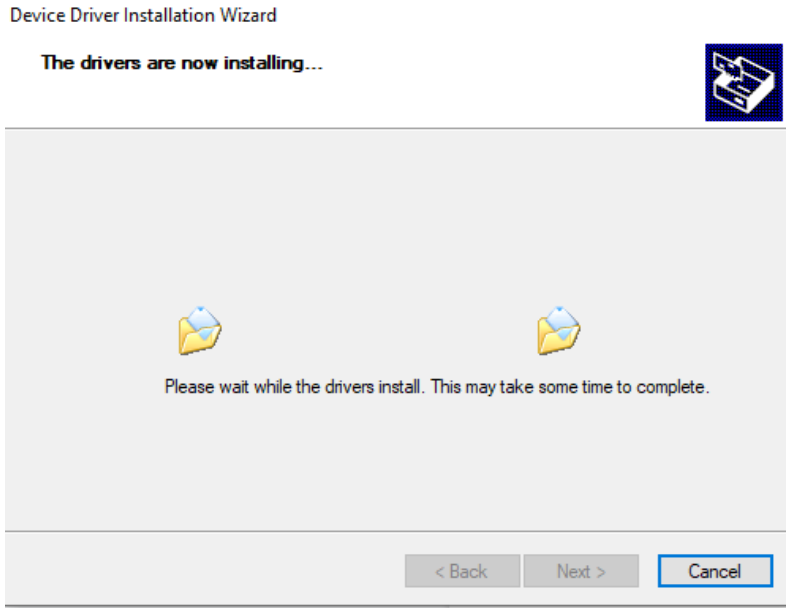


0.10 During the installation, some extra command consoles will open and close. This is normal. Additionally, you will get an installer for required drivers. These are required for interfacing with some telemetry components.

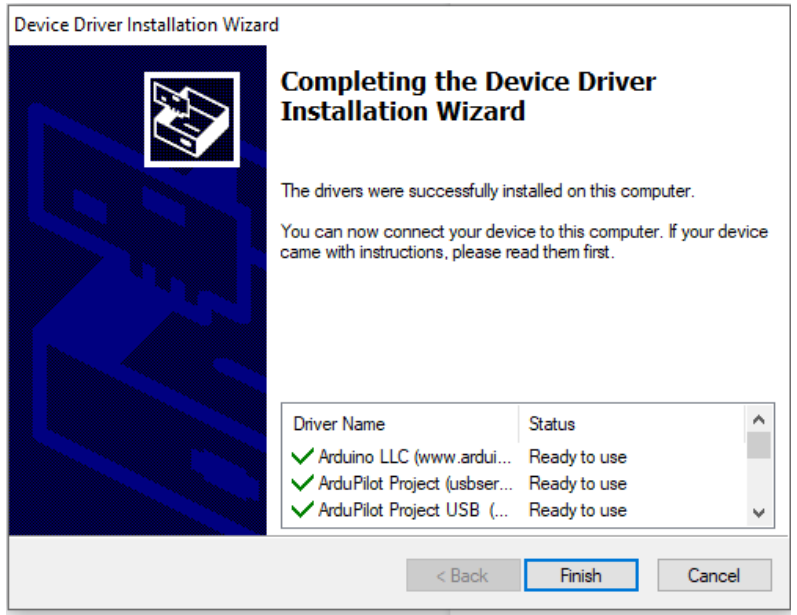


Step 0 Install Mission Planner

0.11 This will begin additional installations. You will note that the Mission Planner installation will not finish until you install these Device Drivers.

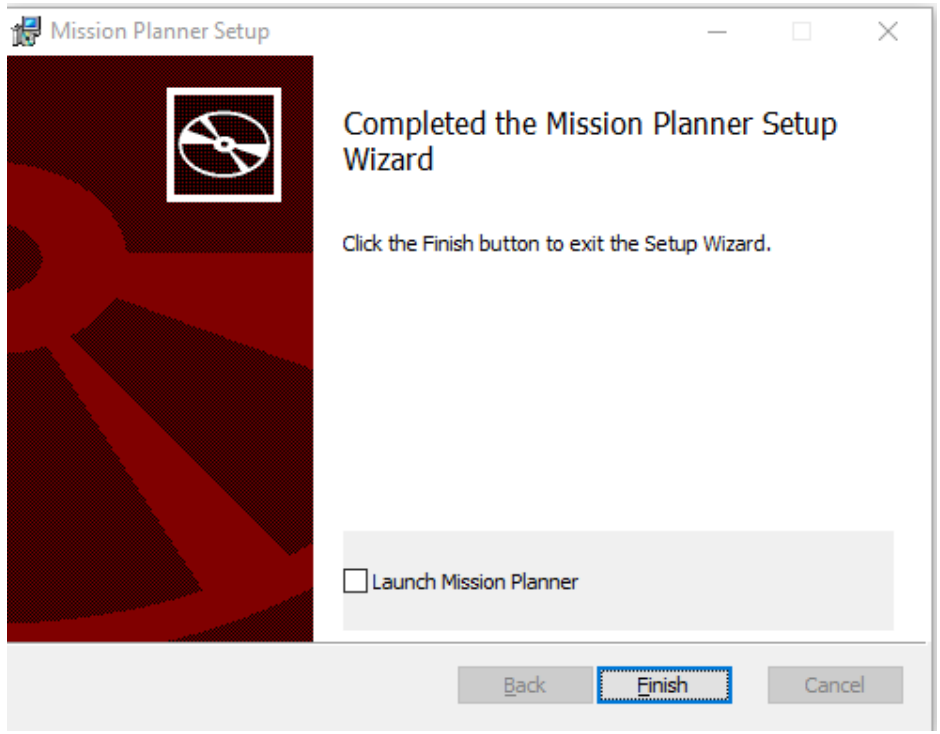


0.12 Once it is finished you will see the following screen. Press “finish” to close the document and the Mission Planner installation will resume progress.



Step 0 Install Mission Planner

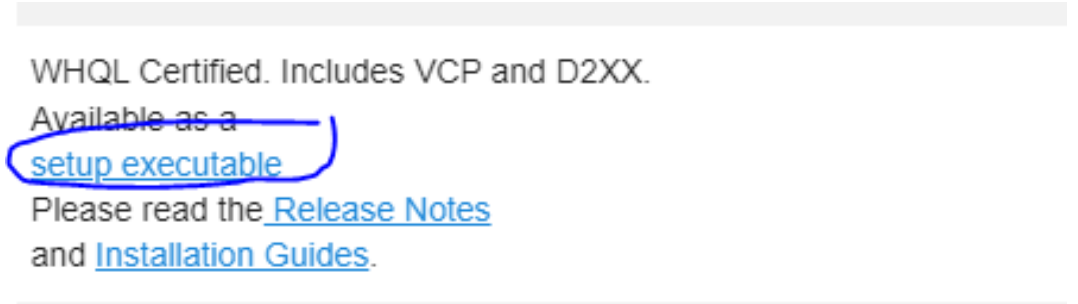
0.13 Once Mission Planner is finished you can click “finish” and have Mission Planner open after closing the setup wizard, or you can manually open it.

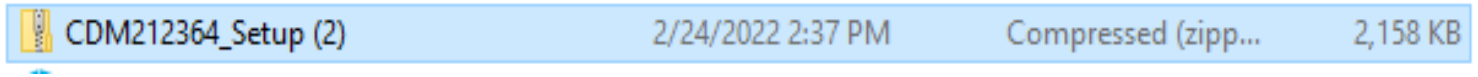


Step 0 Install Additional Drivers – FTDI Chips (cont.)

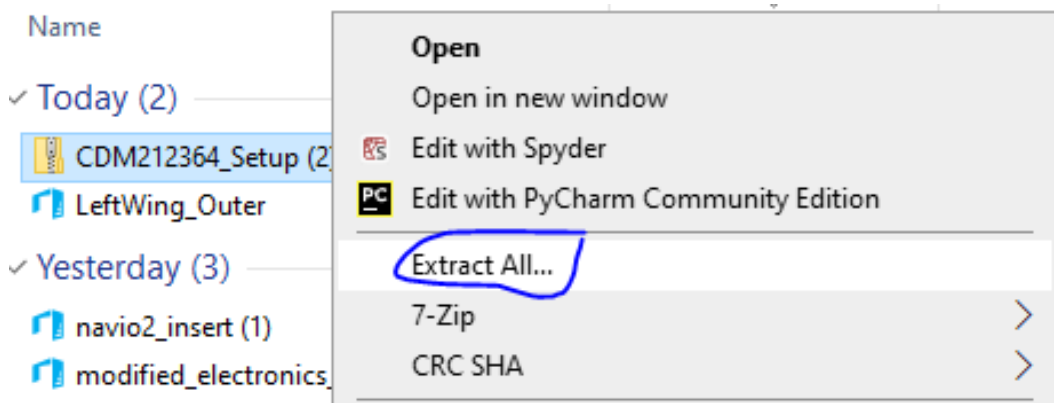
0.14 First, we will head to the FTDI Chip Driver website to find the required VCP driver for our telemetry radio : https://ftdichip.com/drivers/vcp-drivers/

Scroll till you see your operating system. For the purposes of this guide, we are using a Windows 10 system. So, we would use the Windows (Desktop) option. If you look to the right under “Comments” you will see a hyperlink labeled as **setup executable**. Click it to download the Zip file containing the driver. **The file should appear in your downloads folder**.



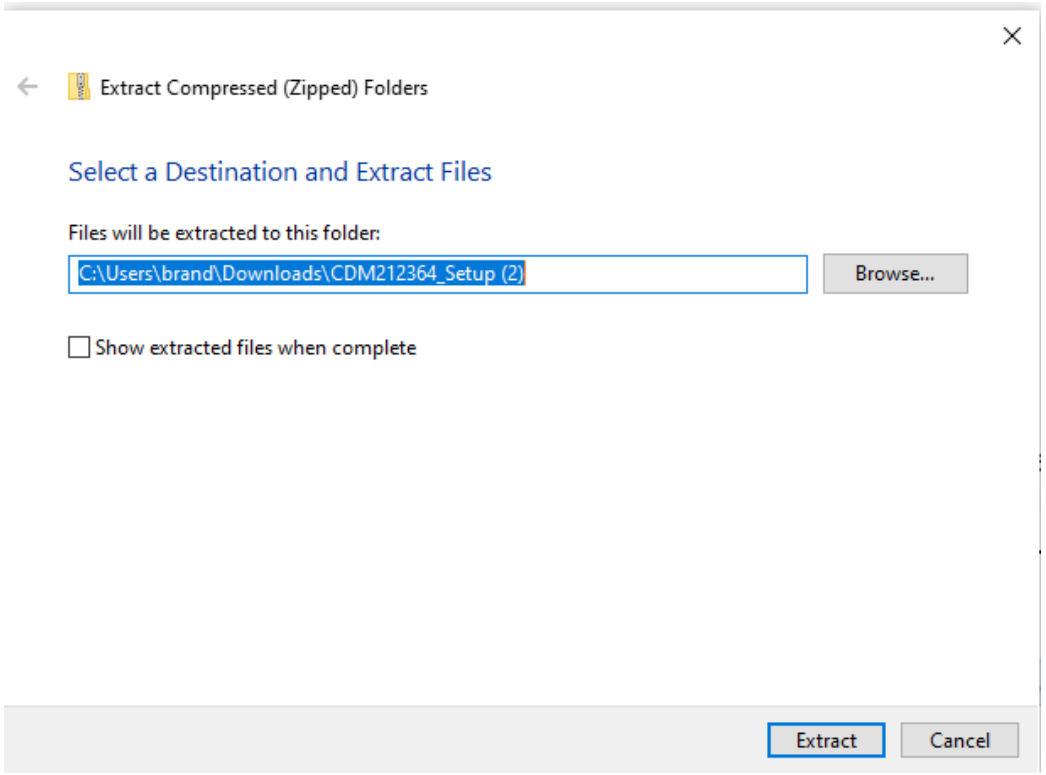


0.15 Unzip the file by right clicking on it and selecting “Extract All”

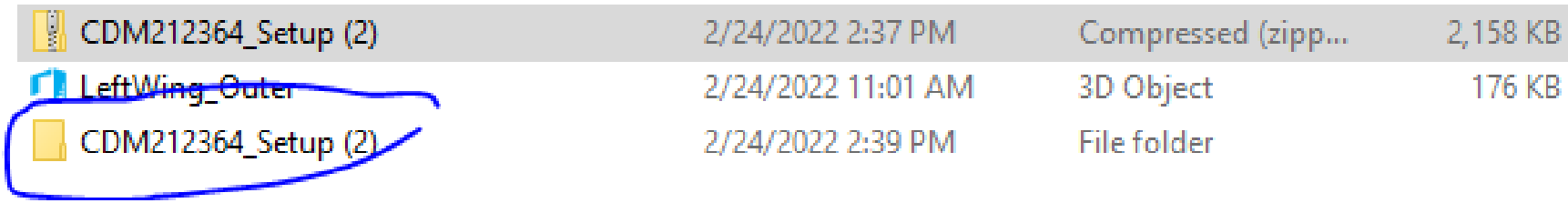


Step 0 Install Additional Drivers – FTDI Chips

0.16 Select the location, or leave the default location of where you want the extracted file to go. Then press “Extract”



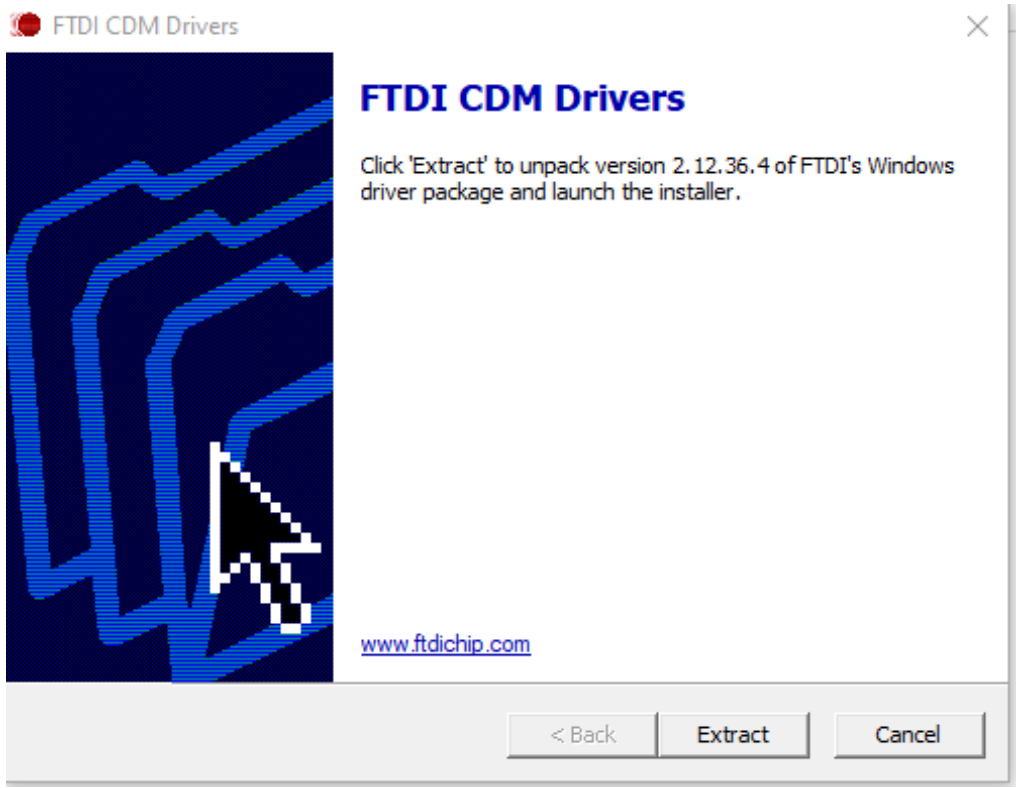
0.17 Once it is finished extracting, you should see a new file folder where you selected the extracted files to be sent.



Step 0 Install Additional Drivers – FTDI Chips

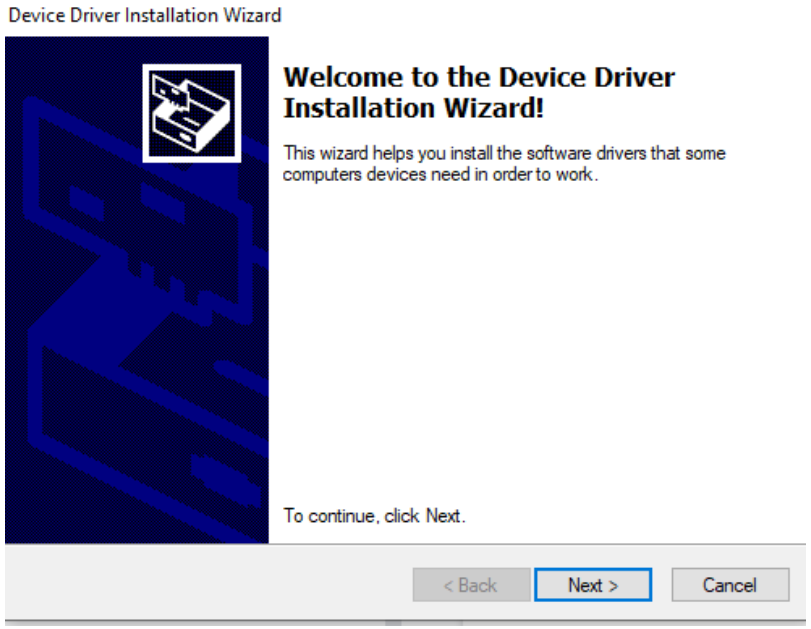
0.18 Open up the folder, there will be an application file, either double click, or right click and select open.

0.19 This will open the installer. Select “Extract”

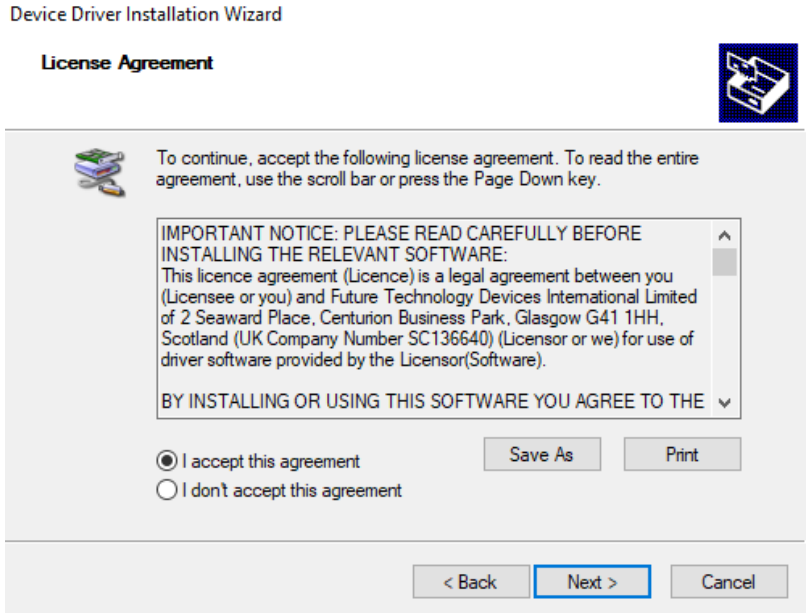


Step 0 Install Additional Drivers – FTDI Chips

0.20 This will perform the driver extraction and then open up another window for the installer. Select “next”

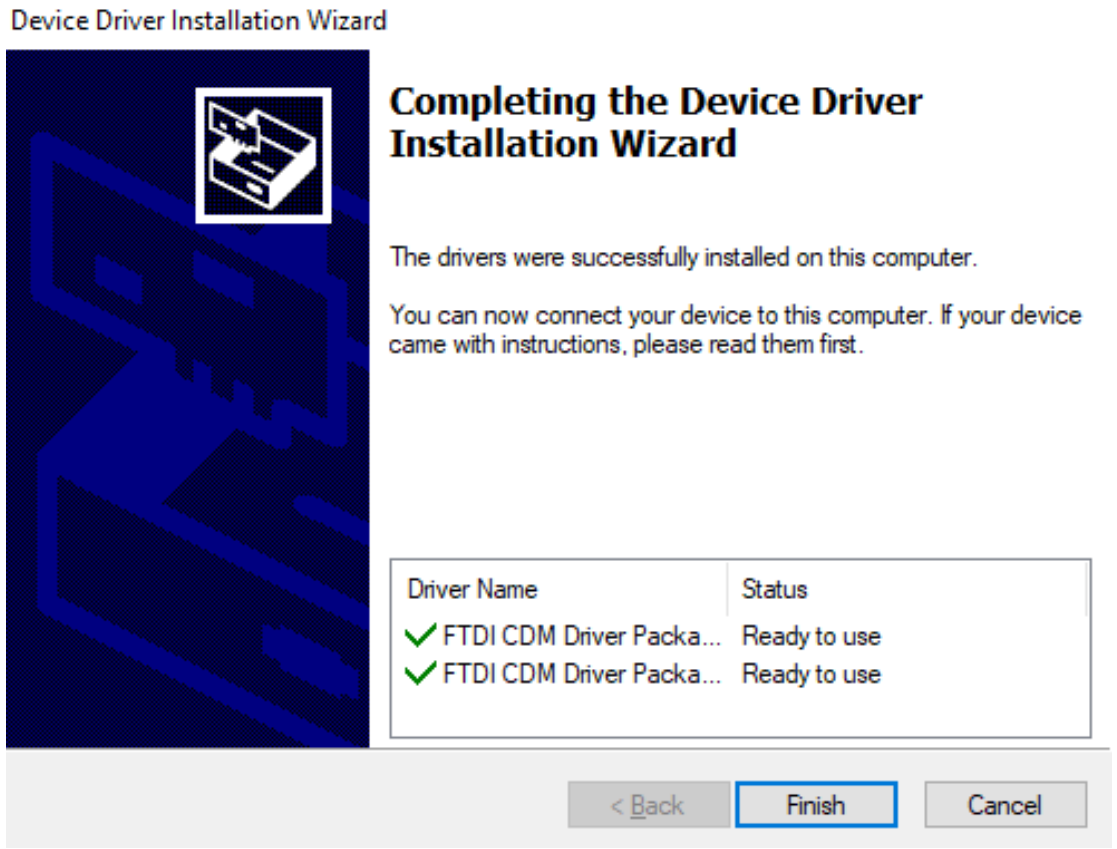


0.21 Read and Accept the license agreement and click “next”



Step 0 Install Additional Drivers – FTDI Chips

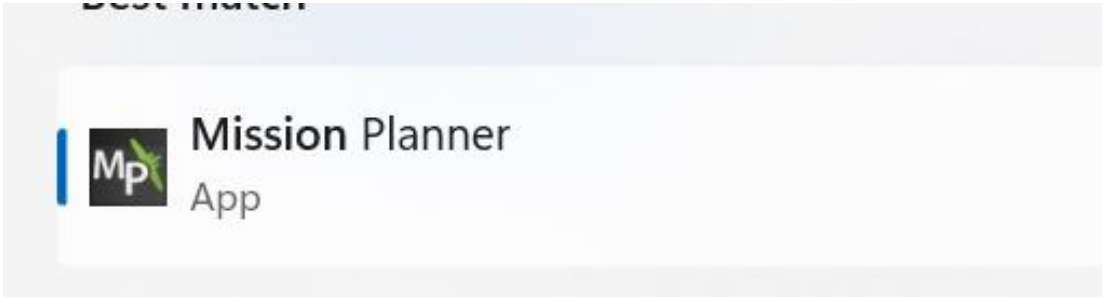
0.22 This will perform the installation and once you are finished will bring you to a final window to show your drivers are ready to use. Select the “Finish” button.



Step 1 Setup Mission Planner Telemetry

1.1 Depending on your Telemetry Radio, there is a possibility that the Mission Planner installation did not install the required drivers. So for our specific telemetry radios, we have found the drivers to be installed manually.

1.2 Open Mission Planner



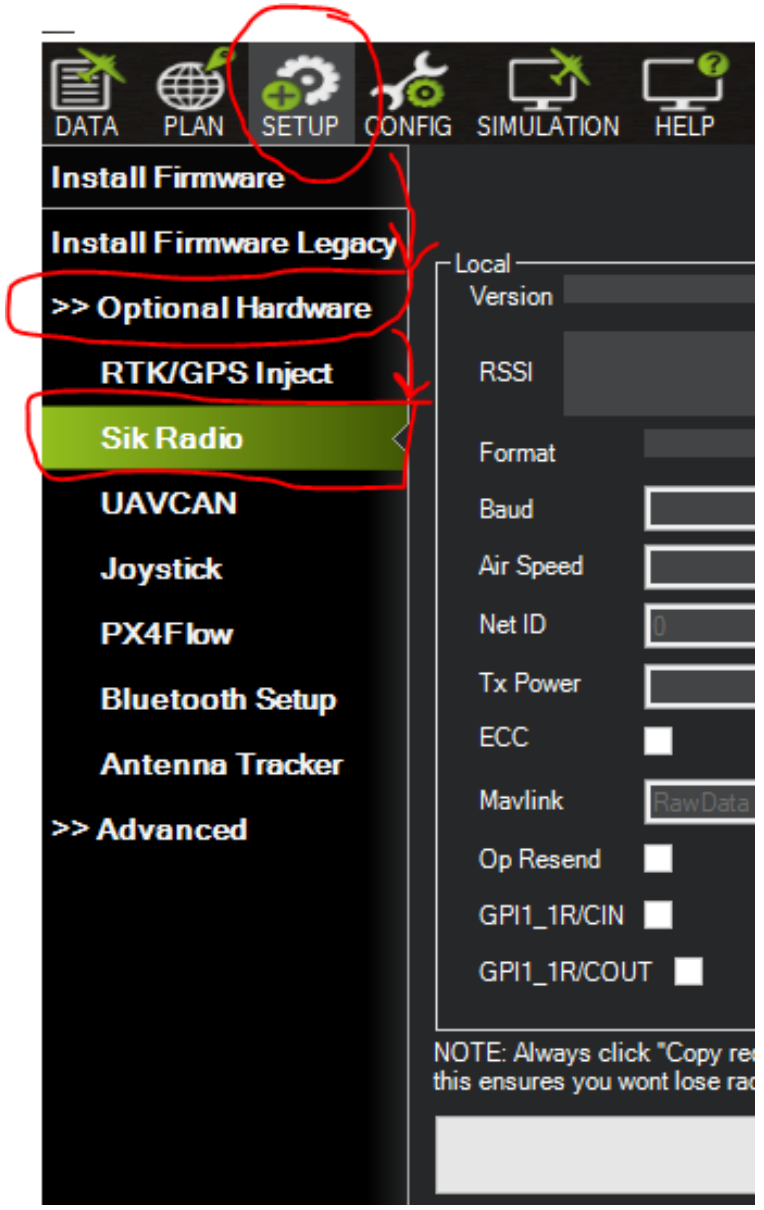
1.3 Plug one of your telemetry radios into your computer. For the sake of this tutorial we will be doing one radio at a time, however you are able to configure both radios at the same time

Step 1 Setup Mission Planner Telemetry

1.4 Navigate to the Telemetry Radio Section

In mission planner, click the “Setup” tab at the top then open the “Optional Hardware” Tab on the side bar followed by clicking the “Sik Radio” tab that appears in the dropdown of the “Optional Hardware” tab.

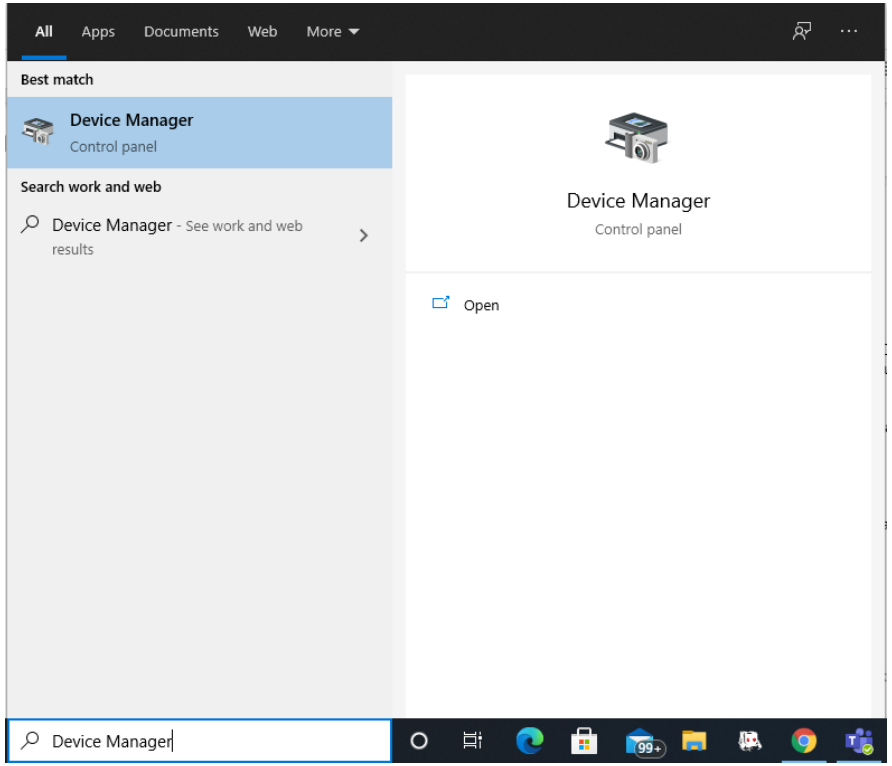
1.5 This opens the Radio configuration menu, which will allow you to adjust the configuration of your radio to fit your Navio2 setup.



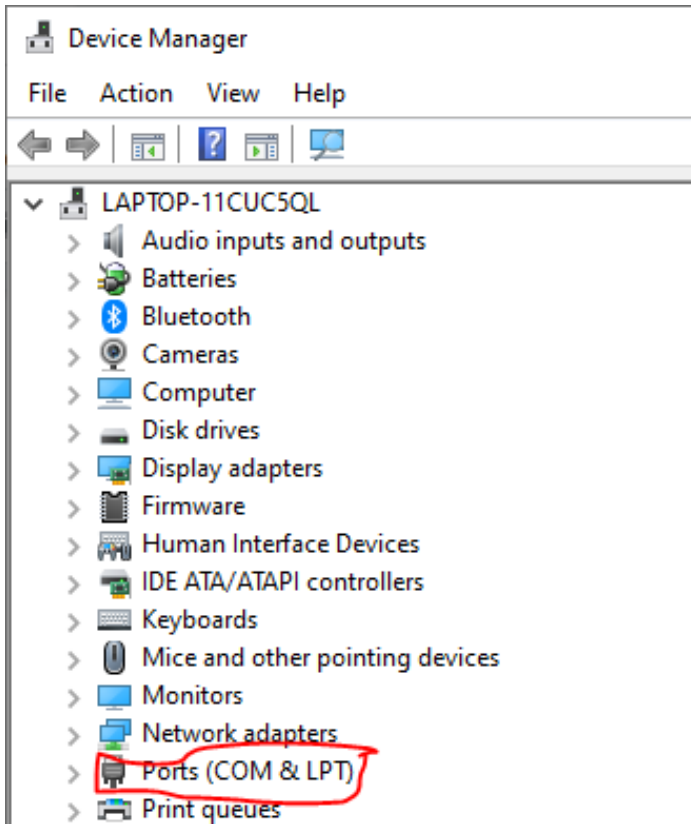
Step 1 Setup Mission Planner Telemetry

1.6 Find Telemetry Radio COM Port

In order to work with the radio you will need to know the COM port. To do this we can open “Device Manager” to find the currently in use COM ports. Enter “Device Manager” Into your search bar and open it.

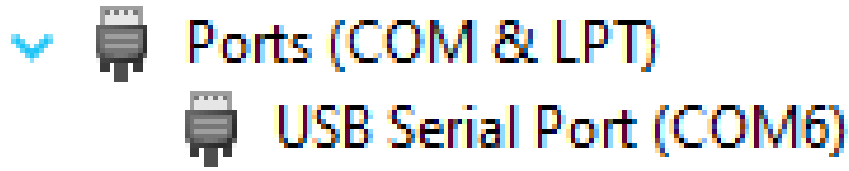


1.7 The resulting program should look like the image below:



Step 1 Setup Mission Planner Telemetry

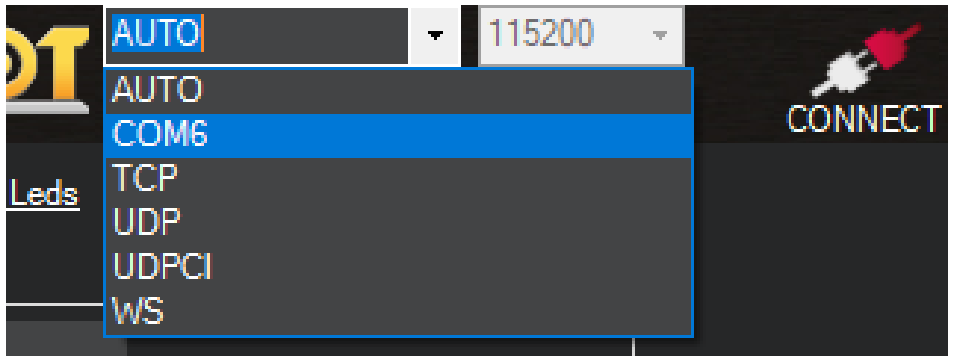
1.8 Our COM ports will be in the Ports tab highlighted in red above. If you click the drop-down box you will see the available COM ports.



1.9 Currently I only have one COM port active (COM6). In this case, COM6 is my radio port, if you have more than one COM port showing, try unplugging and plug the radio back in to see which COM port disappears and reappears, that will be your radio COM port.

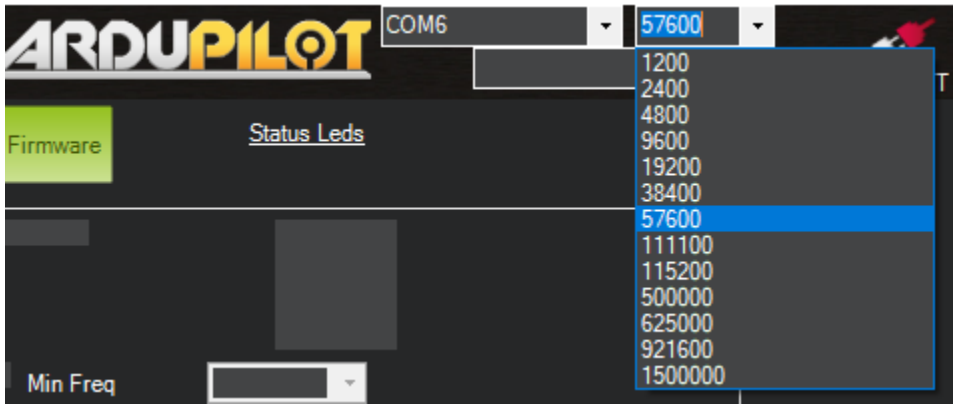
Step 1 Setup Mission Planner Telemetry

1.10 In order to do this we must select the correct COM port and Baud rate in the top right corner , **YOU WILL NOT PRESS CONNECT**. Pressing connect will tell the mission planner to try talking to the Navio2, we are just trying to talk to the radio so we do not need to connect to it since it is already plugged in.



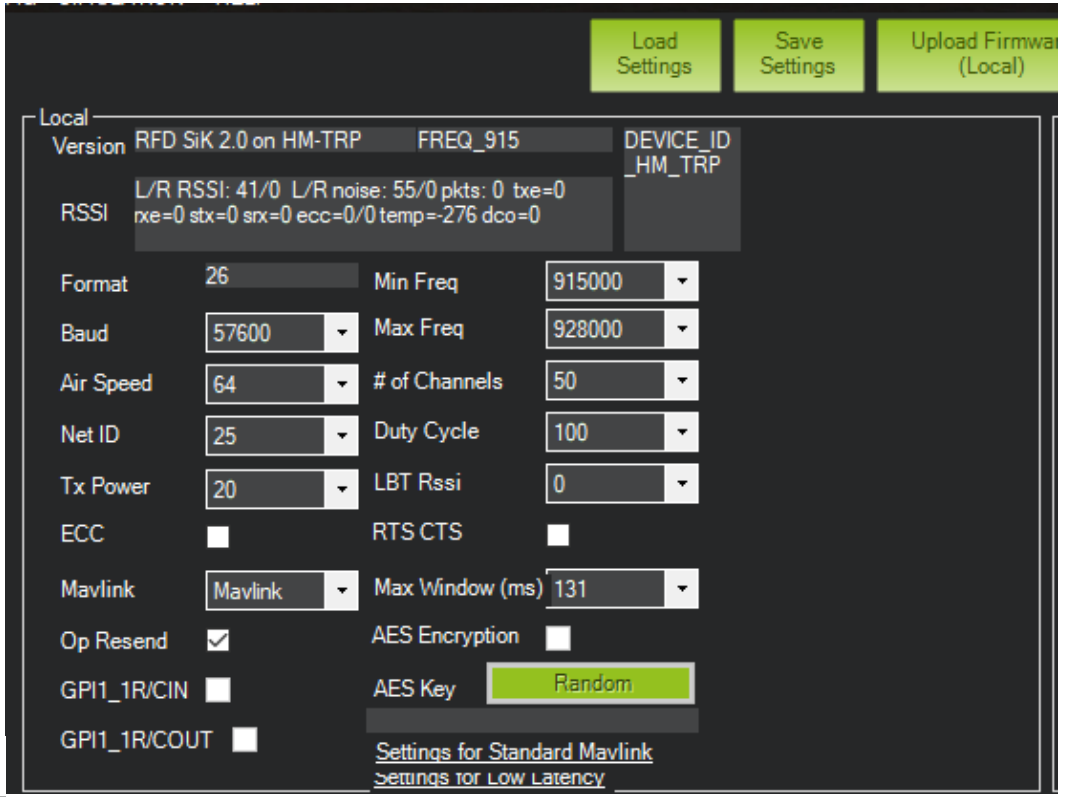
1.11 For COM port, select the drop down tab and select your COM port, remember we found the COM port for our radio.

1.12 Next we will select the baud rate, most radios default to 57,600 baud rate so we must select this to start. After we adjust the baud rate of the radio we will need to change our desired baud rate to the new baud we chose.

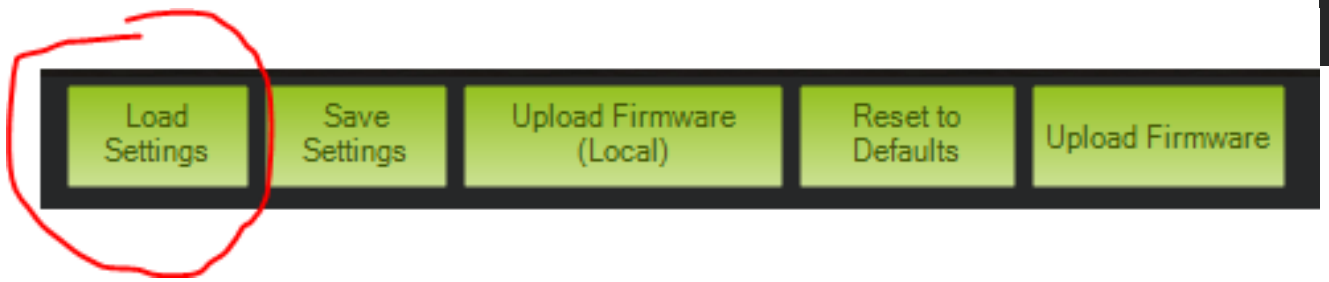


Step 1 Setup Mission Planner Telemetry

1.13 Now with the correct COM port and Baud settings we can read the configuration of the radio.

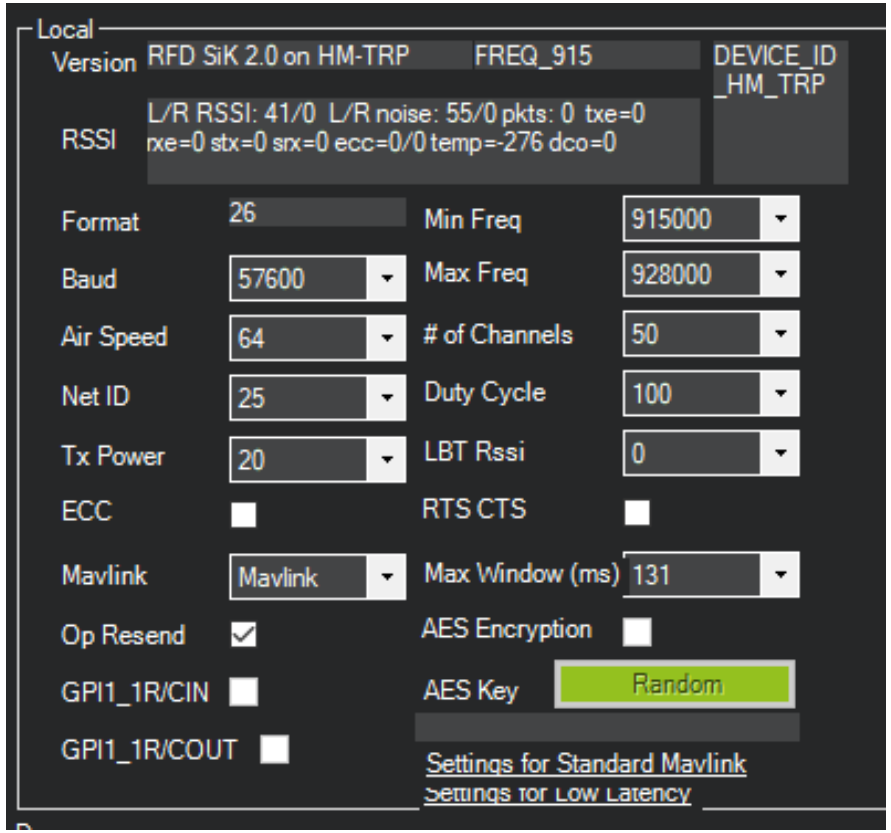


1.14 In the “Ski Radio” tab, press the “Load Settings” option at the top, this will read the current configuration of the radio and display it in the screen below.



Step 1 Setup Mission Planner Telemetry

1.15 Notice that only the Local settings were read, that is because we only have one radio connected which is the one connected to the ground control station.



1.16 Most of these settings we will not need to change from the default. Our main two changes are the “Baud Rate” and “Net ID”.

1. Baud Rate: The speed at which the radio communicates with the ground control station or navio2. (Radio to Navio2 and Radio to Ground Control)
2. Air Speed: The speed at which the radios communicate to each other. (Local to Remote)

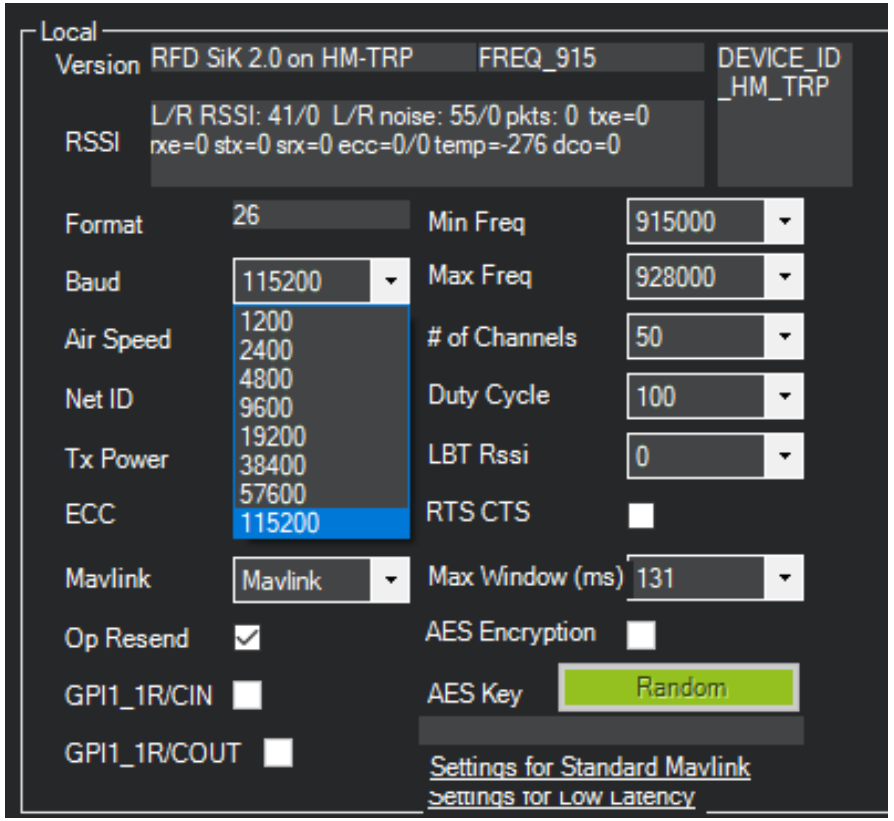
- Net ID: This is the identity for our radios, if there are multiple radios going it will be best to change the Net ID to a number different from every other radio, else you run the risk of communications affecting other people's vehicles. The default is 25 but you can select any number between 0 and 499. The settings for the radios **MUST BE THE SAME**.

Step 1 Setup Mission Planner Telemetry

1.17 Select the Baud rate drop down tab and select the new baud rate you desire (115,200).

1.18 Change NetID to a number that is different from the default 25, if you have multiple Radio Pairs, use a different ID for each pair.

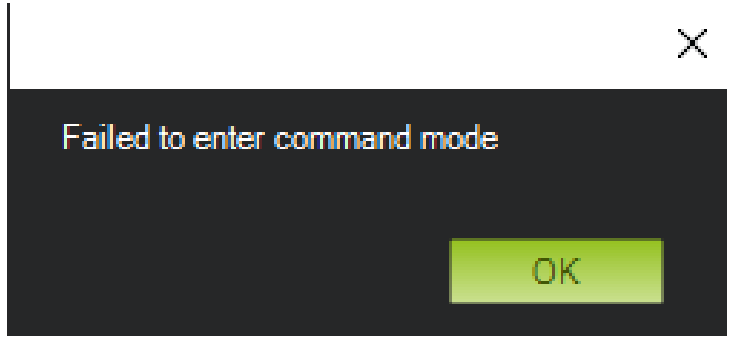
The Pairs must have the same ID.



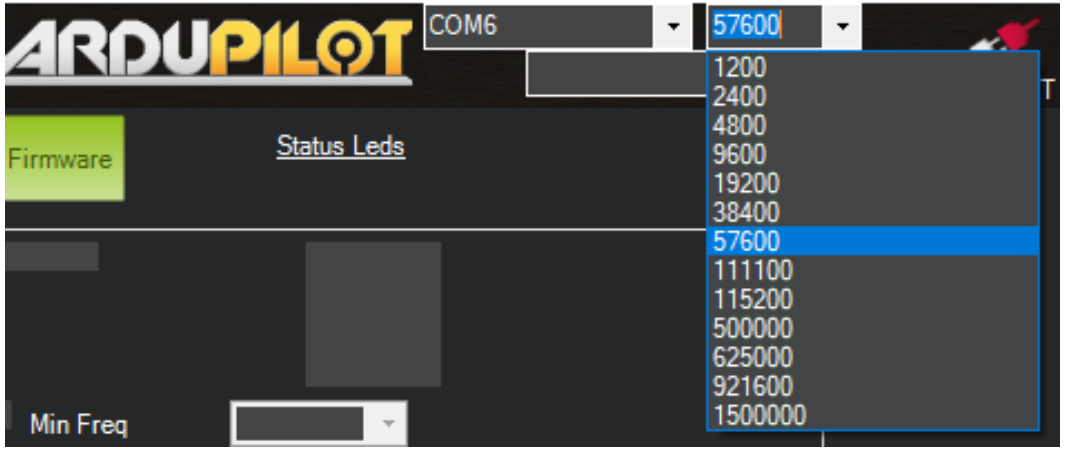
Step 1 Setup Mission Planner Telemetry

1.19 Now click the “Save Settings” Option in the top, this will save the new configuration to the radio.

1.20 Now if you tried to click load settings again with the same baud rate (57,600) you will receive an error



1.21 This is because now your radio communicates at 115,200 baud, so you need to change your baud rate in the top right to your need baud rate

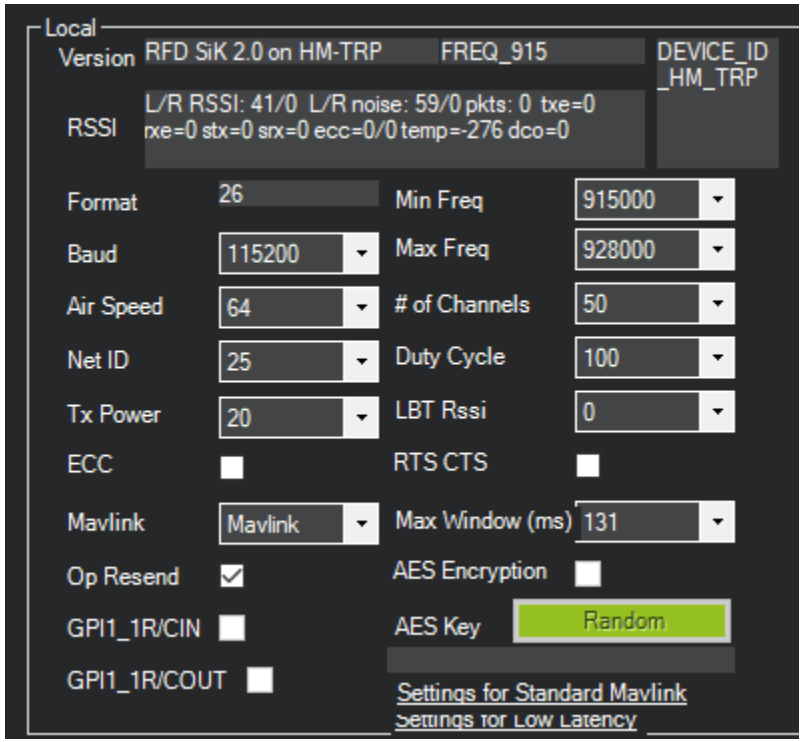


Step 1 Setup Mission Planner Telemetry

1.22 If you change the baud rate to 115,200 and click load settings you should see your radio appear, this time with the new baud rate.

1.23 In the “Ski Radio” tab, press the “Load Settings” option at the top, this will read the current configuration of the radio and display it in the screen below.

1.24 Now to do the second radio!

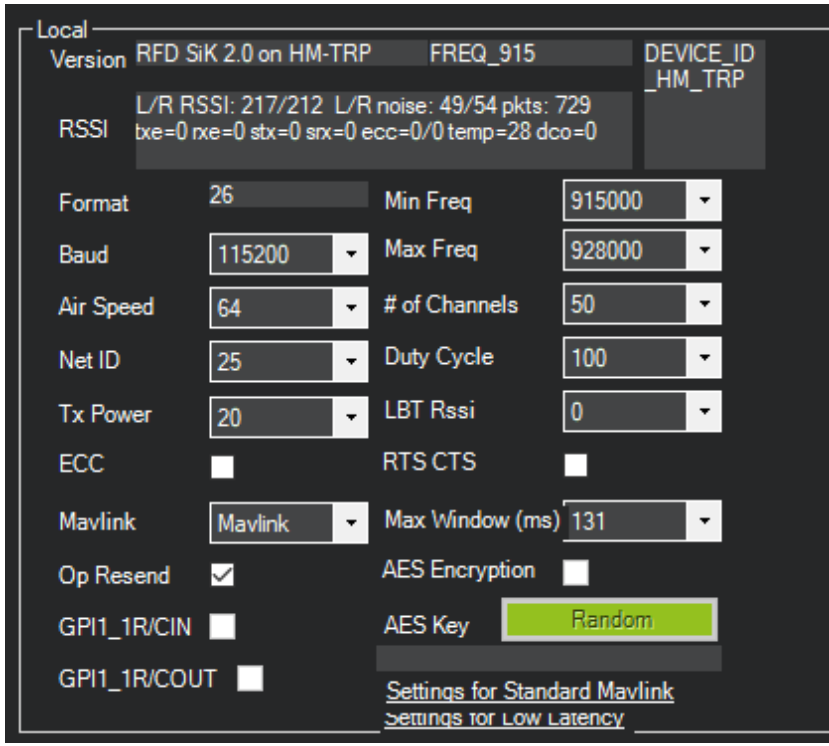


Step 1 Setup Mission Planner Telemetry

1.25 Unplug Current Telemetry Radio and Plug in Second Telemetry Radio

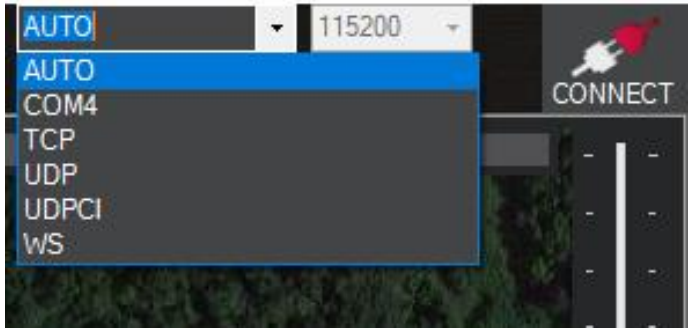
1.26 You will now do the same steps as before and give it the exact same settings as the first telemetry radio. Since this is a different radio, you will once again need to find the COM Port of this second radio.

1.27 Confirm Settings, ensure that both devices are using the 115200 baud, and that they both have the same Net ID.

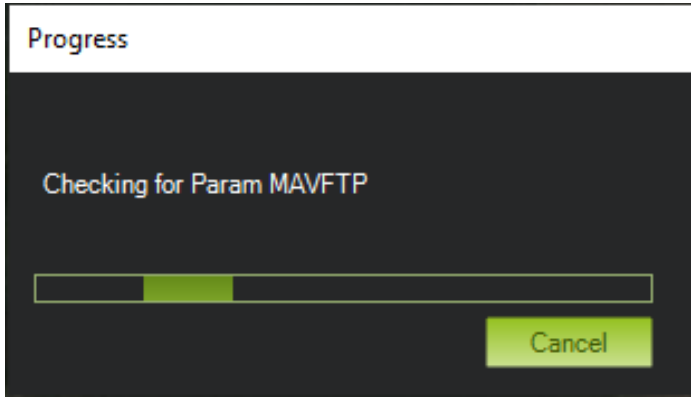


Step 2 Connect to Navio2 Using Telemetry

2.1 Select the correct COM Port and Baud Rate, remember we changed our baud rate to 115,200

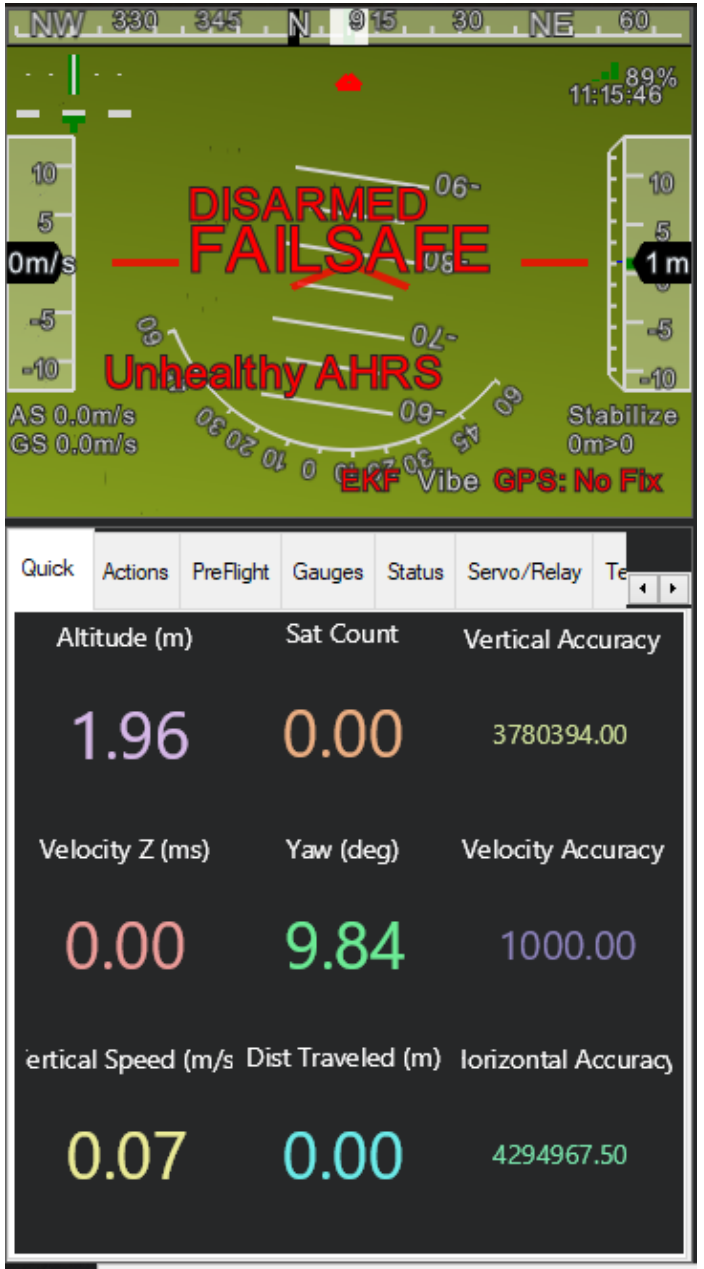


2.2 Press Connect, You will see a pop-up as the parameters load



Step 2 Connect to Navio2 Using Telemetry

2.3 If everything is correct, the pop-up should close and you will start seeing data flow into your left-side tabs including orientation and other data points. This means you are properly connected.

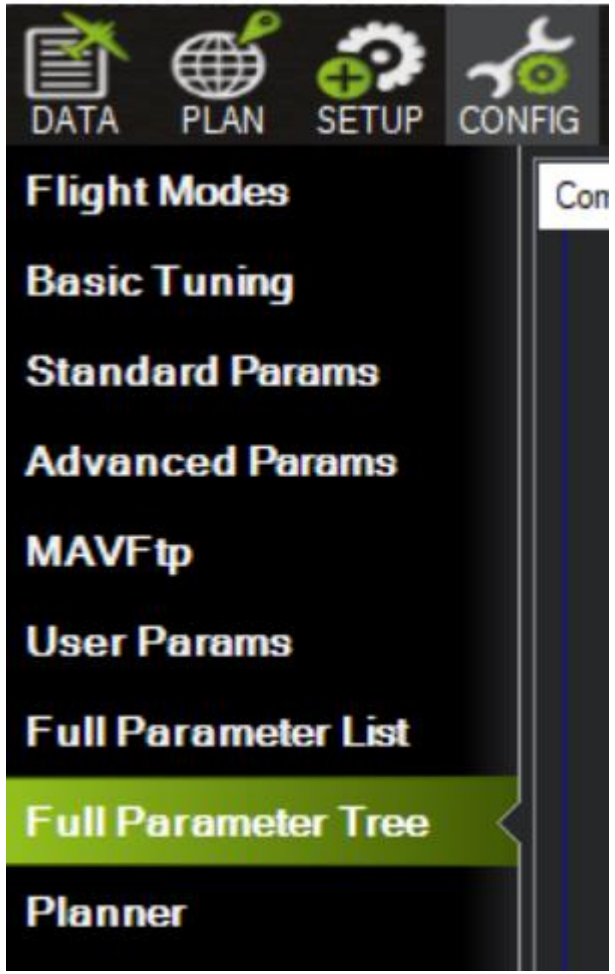


Step 3 Adjusting Parameters

3.1 One of the benefits of Ardupilot is the ability to adjust parameters and settings using your ground control station. To Do this, we will navigate to the “Full Parameter List”

3.2 In the top left, go to “Config” and then on the left side select either “Full Parameter List” or “Full Parameter Tree”

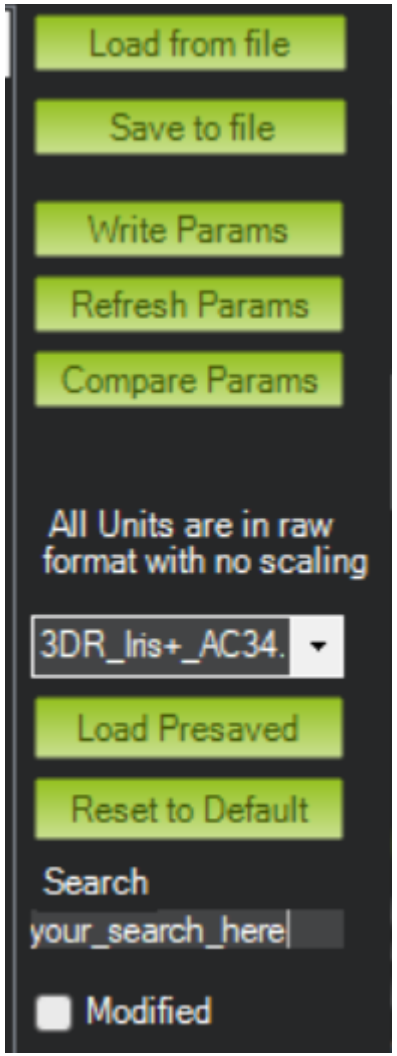
3.3 Select the Full Parameter List



Step 3 Adjusting Parameters

3.4 To find the parameter you wish to change, you can either scroll through the entire list of parameters (not recommended) or you can use the search bar on the right (recommended).

3.5 To change a parameter, first select the value cell of the parameter you wish to change. This will either pop up a list of options you can select, or allow you to enter in a new value. Notice in the “Options” Column to the right. This tells you the range of values you can enter.



Step 3 Adjusting Parameters

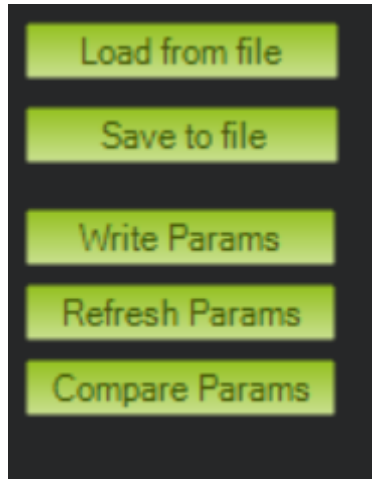
3.6 For example, look at the AHRS_GPS_USE parameter

AHRS_GPS_USE	1		0:Disabled 1:Use GPS for DCM position 2:Use GPS for DCM position and height	This controls whether to use dead-reckoning or GPS based navigation. If set to 0 then the GPS won't be used for navigation, and only dead reckoning will be used. A value of zero should never be used for normal flight. Currently this affects only the DCM-based AHRS: the EKF uses GPS according to its own parameters. A value of 2 means to use GPS for height as well as position - both in DCM estimation and when determining altitude-above-home.

3.7 Currently the value is "1" which represents the option "Use GPS for DCM Position". Now if we want to disable this, we will change the value of 1 to 0. You will notice that after changing the value, the cell is green to indicate a change has been made.

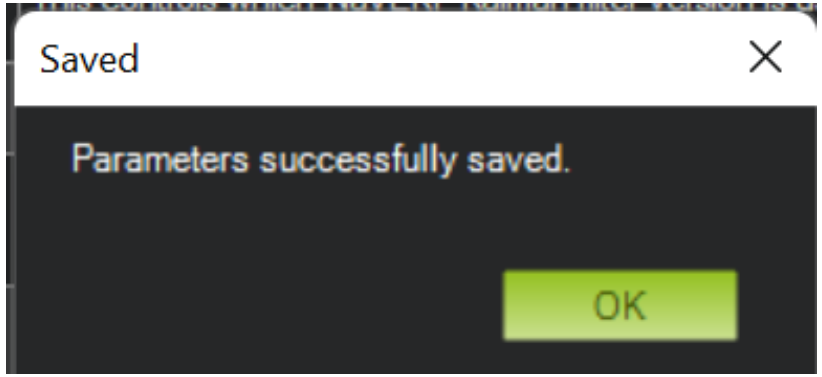
AHRS_GPS_USE	0		0:Disabled 1:Use GPS for DCM position 2:Use GPS for DCM position and height	This controls whether to use dead-reckoning or GPS based navigation. If set to 0 then the GPS won't be used for navigation, and only dead reckoning will be used. A value of zero should never be used for normal flight. Currently this affects only the DCM-based AHRS: the EKF uses GPS according to its own parameters. A value of 2 means to use GPS for height as well as position - both in DCM estimation and when determining altitude-above-home.

3.8 Now we will submit the changes by pressing the "Write Params" Option on the right



Adjusting Parameters

3.9 After it is written, if things are done correctly you will see a pop-up saying that the parameters were successfully saved.



3.10 And that is how to change parameters!
Note: Make sure to change that parameter back to 1 if you were following these instructions.

Step 4 Motor Configuration

4.1 We are operating our Rover in what is known as a “Skid-Steer” method. This means that the left and right wheels will spin at different speeds to create movements. Ardupilot has dedicated channels for this method of driving that will be enabled by setting our Outputs to specific settings.

4.2 Navigate to the Parameter List and Search for “SERVO1_FUNCTION”

This is where you will designate the motor option.

Set the value to 73 which represents the setting “ThrottleLeft” or the left motors of your rover.

SERVO1_FUNCTION	73		98:Script5 99:Script6 100:Script7 101:Script8	Function assigned to this servo. Setting this to Disabled(0) will setup this output for control by auto missions or MAVLink servo set commands. any other value will enable the corresponding function

Step 4 Motor Configuration

4.3 Next search “SERVO3_FUNCTION” and set this value to 74.
This is “ThrottleRight” or the right motors of your rover.

SERVO3_FUNCTION	74		96:Script3 97:Script4 98:Script5 99:Script6 100:Script7 101:Script8	Function assigned to this servo. Setting this to Disabled(0) will setup this output for control by auto missions or MAVLink servo set commands. any other value will enable the corresponding function

4.4 Next, we are going to disable pivot turns. Pivot turns are where the vehicle will stop to try and turn in place instead of moving in an arc. Unfortunately, in rough terrain, like tall grass, this will sometimes cause the motor to stall. If a motor stalls for too long, the high current will destroy the motor.

4.5 We are going to set Pivot Angle to 0 degrees, disabling it in the Parameter settings. This will depend on the surface you plan to operate on. If you are operating on flat surfaces such as dirt, roads, pavement, etc then you can use Pivot turns.

Do not use pivot turns on grass and difficult terrains where the wheels could get caught. Otherwise, the motors will stall and burn out if not stopped.

If you plan to operate on hard surfaces such as concrete or sidewalks, you can use pivot turns, but do not use it in rougher terrain such as grass.

SERVO3_FUNCTION	74		96:Script3 97:Script4 98:Script5 99:Script6 100:Script7 101:Script8	Function assigned to this servo. Setting this to Disabled(0) will setup this output for control by auto missions or MAVLink servo set commands. any other value will enable the corresponding function

4.6 Write Parameters

Step 4 Motor Configuration

4.7

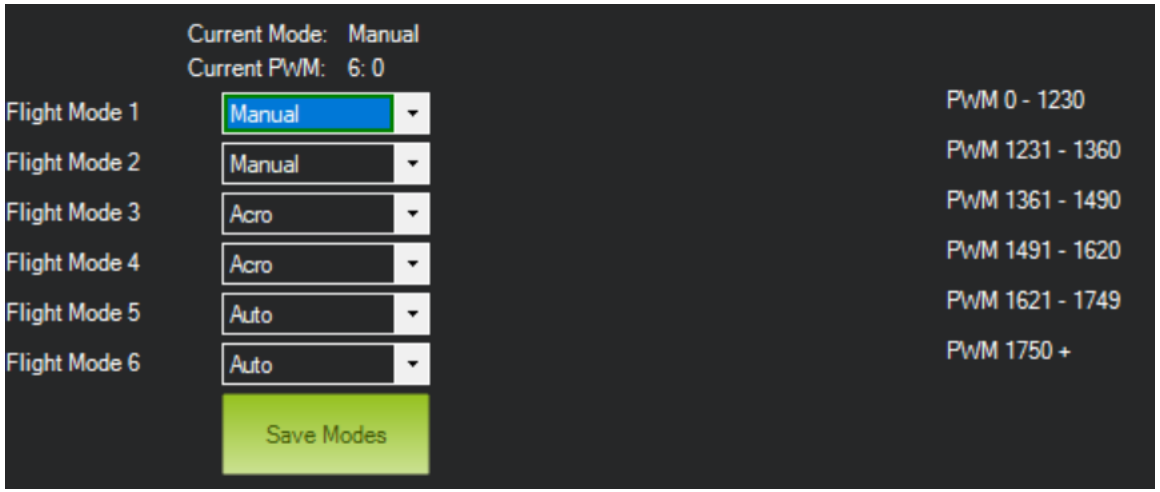
- When operating with a standard 6-channel remote-controller, you will only need 2 channels: throttle and steering.
- For a normal controller, you will see the following channel setup
  - Moving the right stick left to right is channel 1
  - Moving the right stick up and down is channel 2
  - Moving the left stick up and down is channel 3
  - Moving the left stick left and right is channel 4
- You then have 2 additional channels that can be set to either 2-point switches (High/Low), 3-point switches (High/Middle/Low), or Potentiometer (Range of values from High to Low).
- As default, channel 3 would be throttle while channel 1 would be your steering. While you can keep this setting, we are going to move throttle over to channel 2 to allow for single-stick operation.
- To do this, you will go into the parameter list and adjust the parameter “RCMAP_THROTTLE” to equal 2, which represents the channel to interpret as throttle.

RCMAP_THROTTLE	2		1 16	Throttle channel number. This is useful when you have a RC transmitter that can't change the channel order easily. Throttle is normally on channel 3, but you can move it to any channel with this parameter. Reboot is required for changes to take effect.

Step 4 Motor Configuration

4.8

- Next, we are going to set some different drive modes to the 3-point switch that will be set to act as channel 6 of our remote-controller.
- First go into the parameter list and set “MODE_CH” to 6, which is setting the mode control to channel 6.
- Next you can go to the Setup -> Flight Modes to select your flight modes that correspond to the input from the mode channel. Since we are using a 3-point switch, we can select up to three modes.
- Notice that I select 2 modes for each mode, this is because the switch will only go from High to Medium to Low, so the in-between values around PWM: 1000, 1500, and 2000 will not be important.
- We are using Manual, Acro, and Auto to have control of our rover (Manual/Acro) as well as a switch that will allow us to start a waypoint mission with a flip of the switch.



Step 5 Remote-Control Radio Calibration

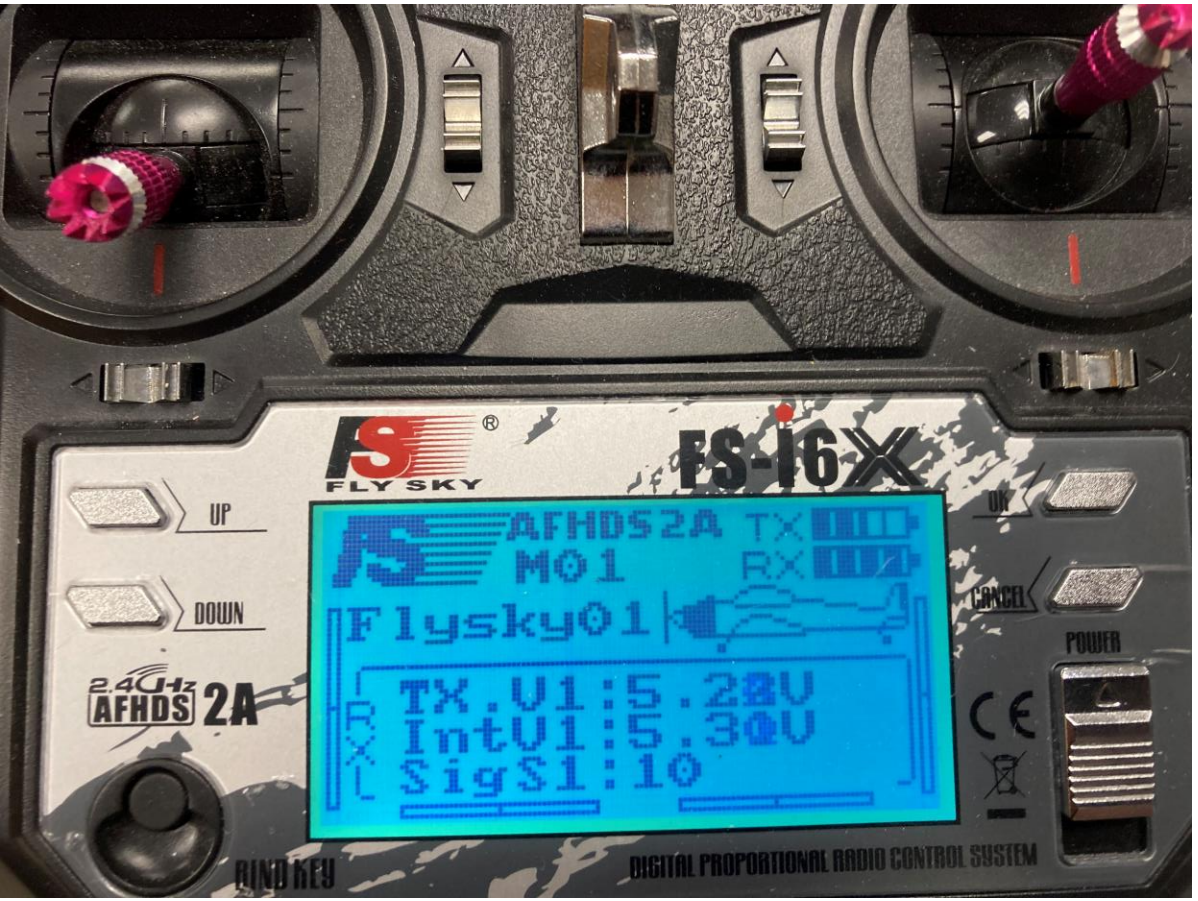
5.1 When using a remote-control, Ardupilot must be able to determine what is an acceptable range of values to receive from the remote control to then translate into desired movement and speed.

5.2 To do so, we must first make sure that our Controller is sending the correct data format. Because the Navio2 supports SBUS or PPM data inputs, we must make sure our radio is providing those signal types.

The following are instructions for the Flysky FS-I6 Remote Controller we use in this build.

Step 5 Remote-Control Radio Calibration

5.3 Hold the “OK” Button to open the Menu

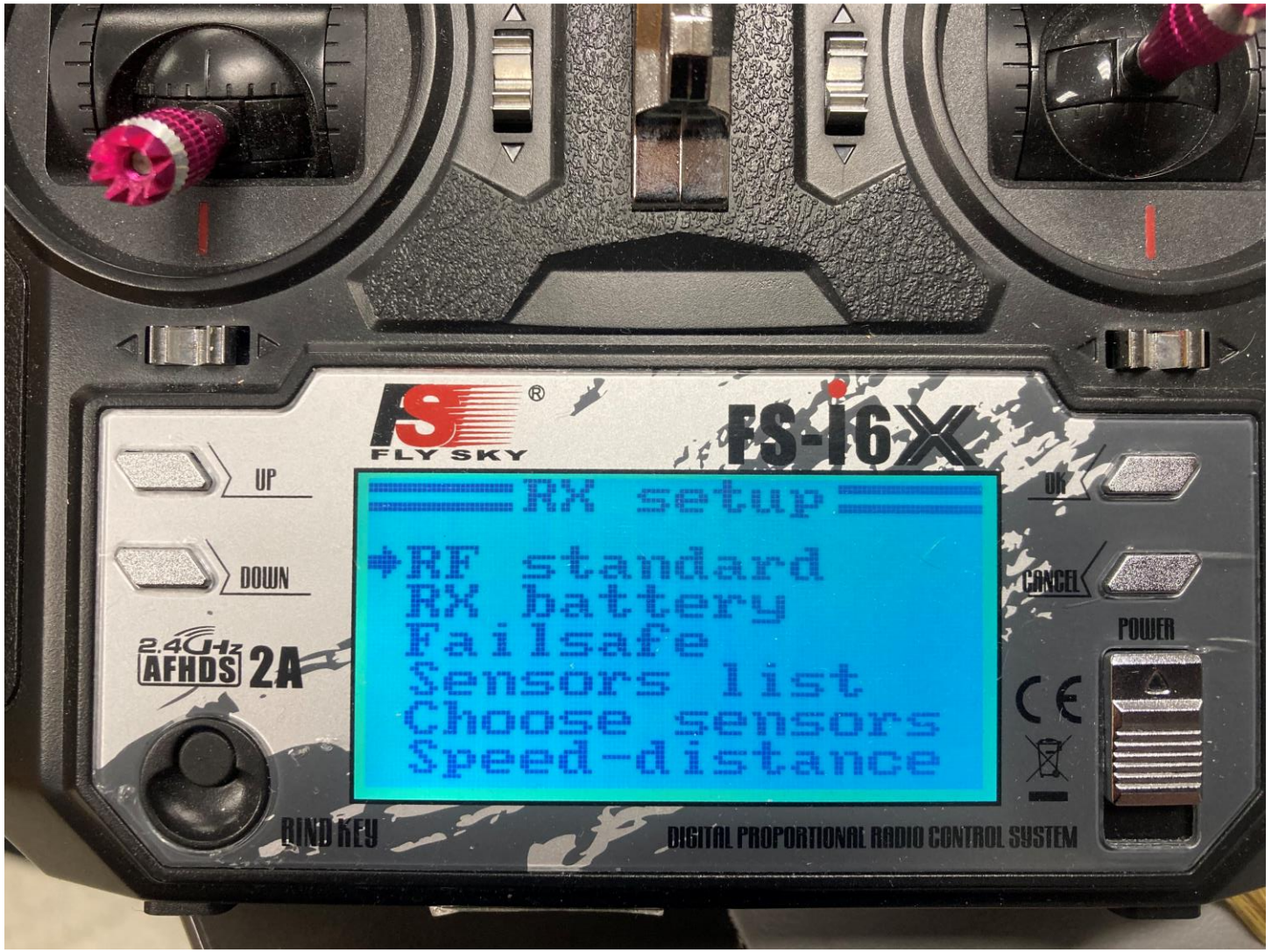


Remote-Control Radio Calibration

5.4 Press OK again to go to the system menu

Step 5 Remote-Control Radio Calibration

5.5 Use the Down keys on the left to navigate to RX SETUP and Press OK to Enter RX SETUP



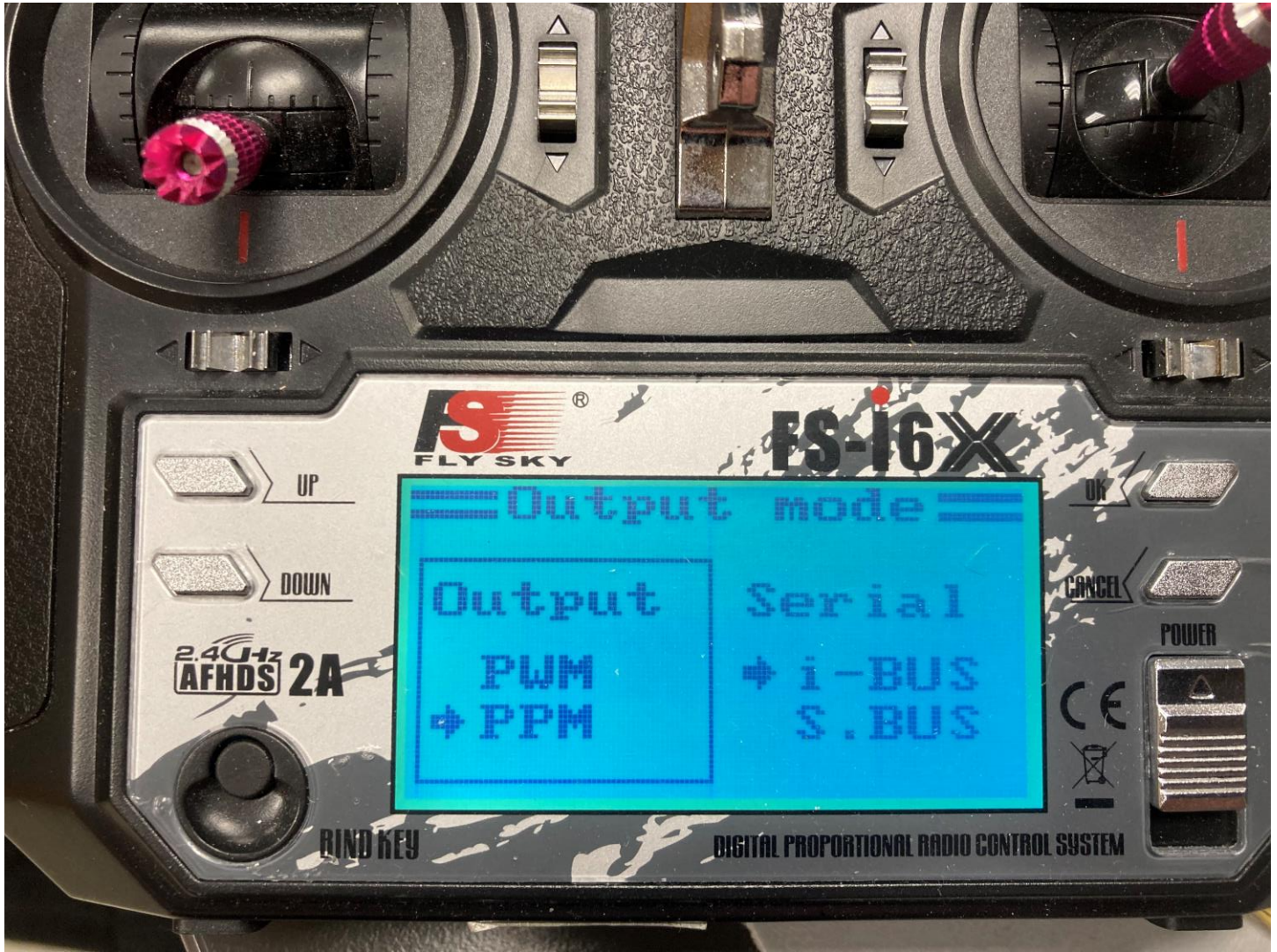
Remote-Control Radio Calibration

5.6 Use the Down Button to navigate to OUTPUT MODE then press OK to Enter OUTPUT MODE

Remote-Control Radio Calibration

5.7 Using the Up/Down Keys, set the Arrow of OUTPUT to PPM

Press OK and set the Serial to I-BUS

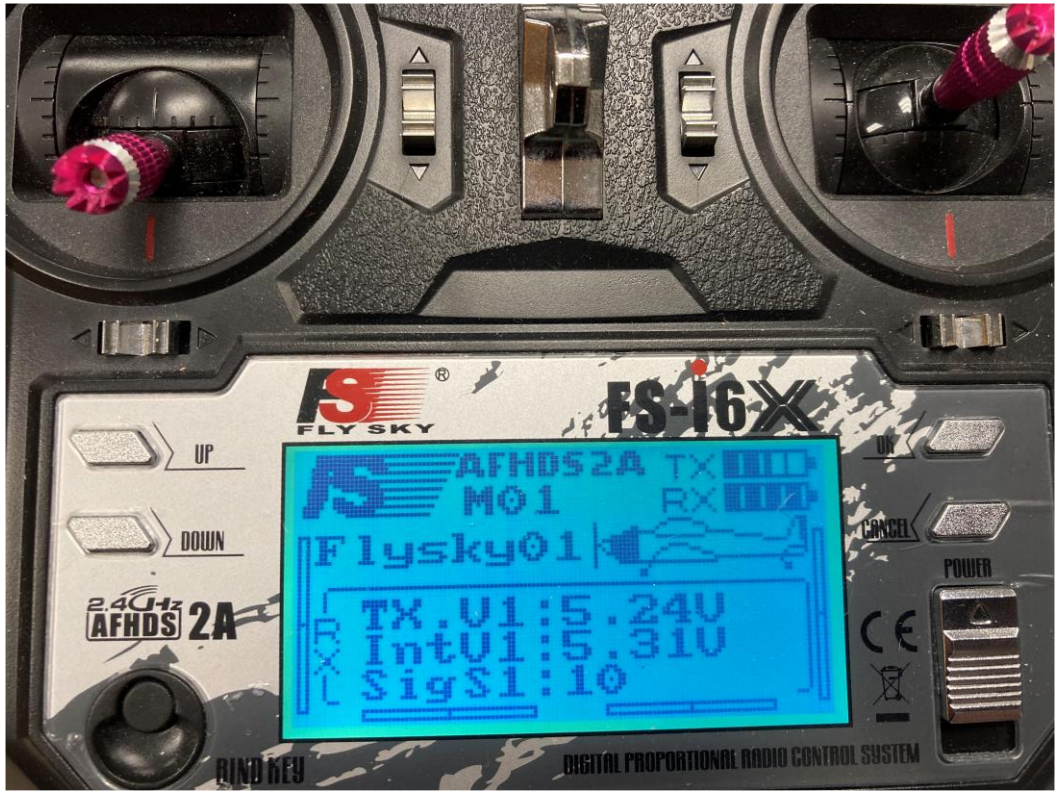


Step 5 Remote-Control Radio Calibration

5.8 Now hold the cancel button to save these settings.

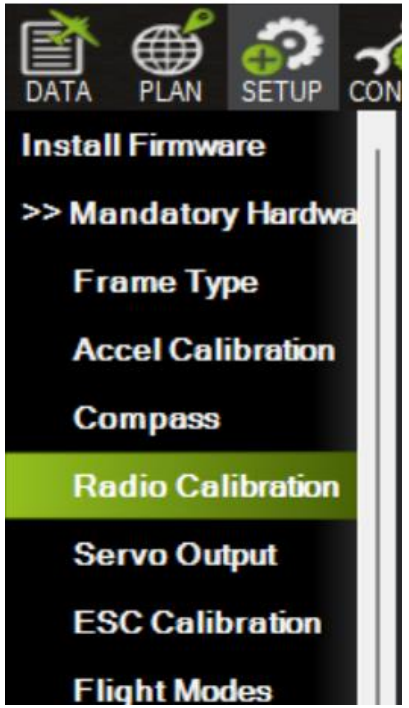
Now your Radio should be sending properly formatted data to your Flight Controller

Press Cancel to back out to the main screen

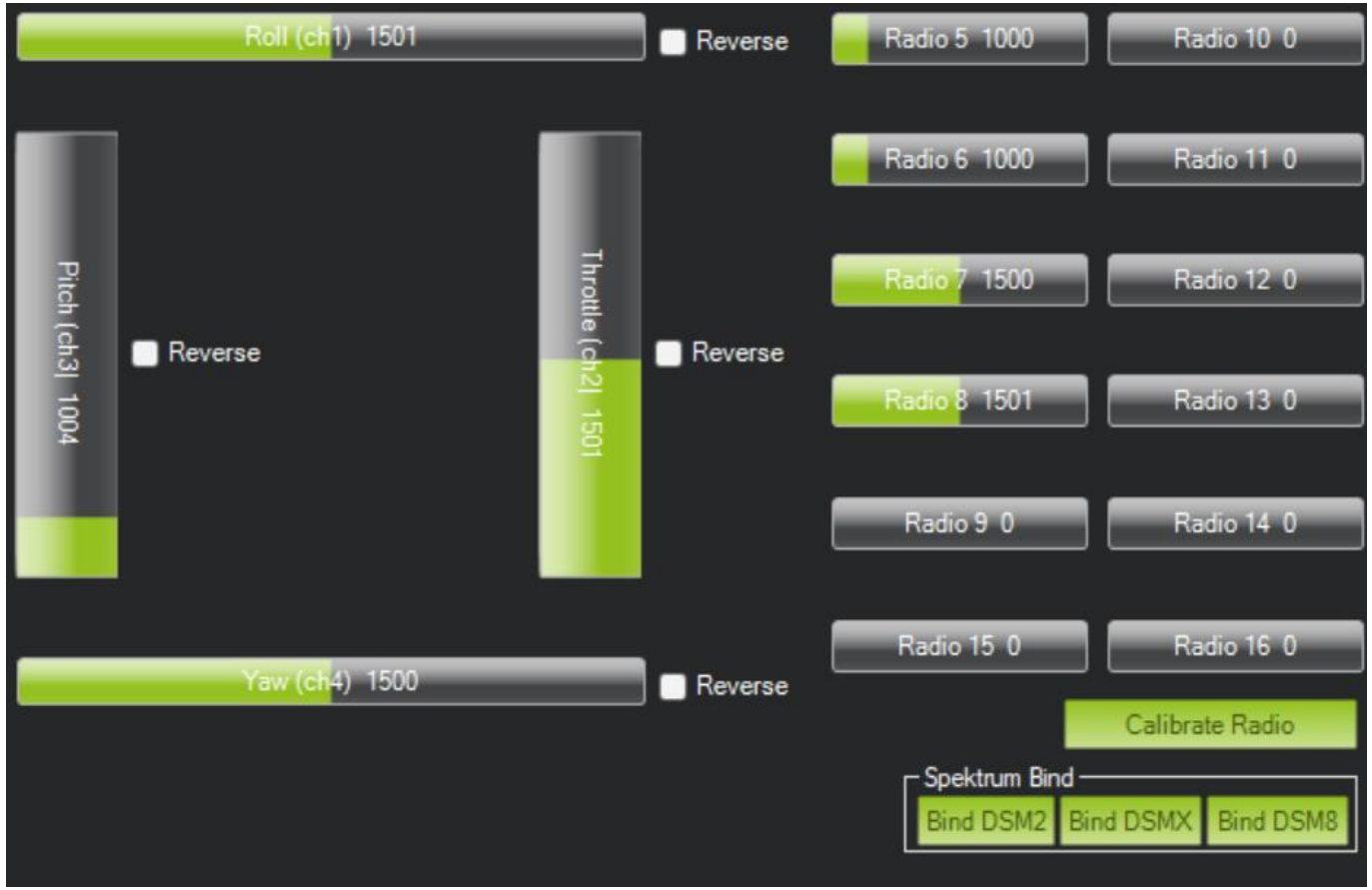


Step 5 Remote-Control Radio Calibration

5.9 Now, navigate to Mission Planner and Open the Radio Calibration Tab



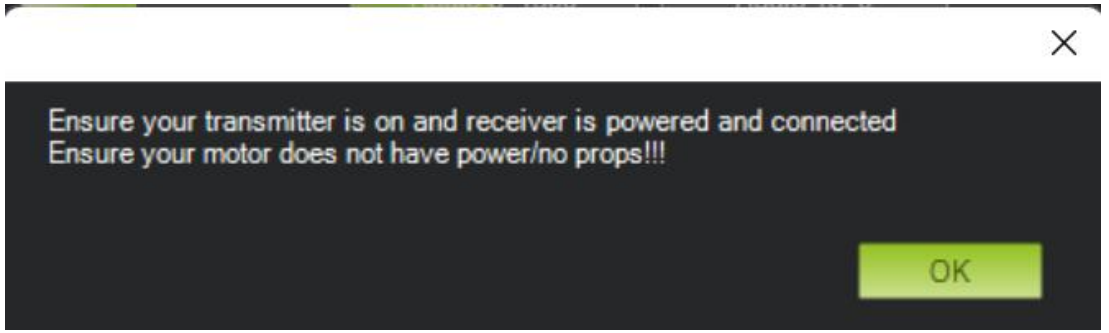
5.10 Here you can see the input from your Remote Control. If you move the sticks, you will see a resultant change in this tab.



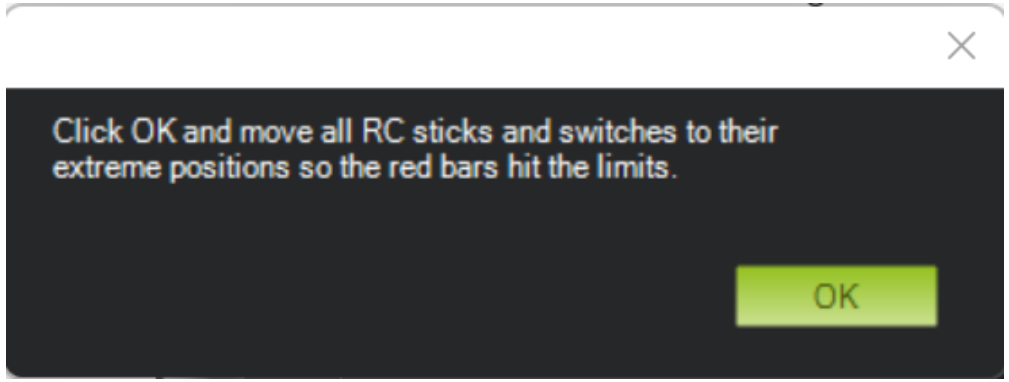
Step 5 Remote-Control Radio Calibration

5.11 Select the Calibrate Radio Button in the Bottom Right.

It will warn you not to have power attached to your motors.

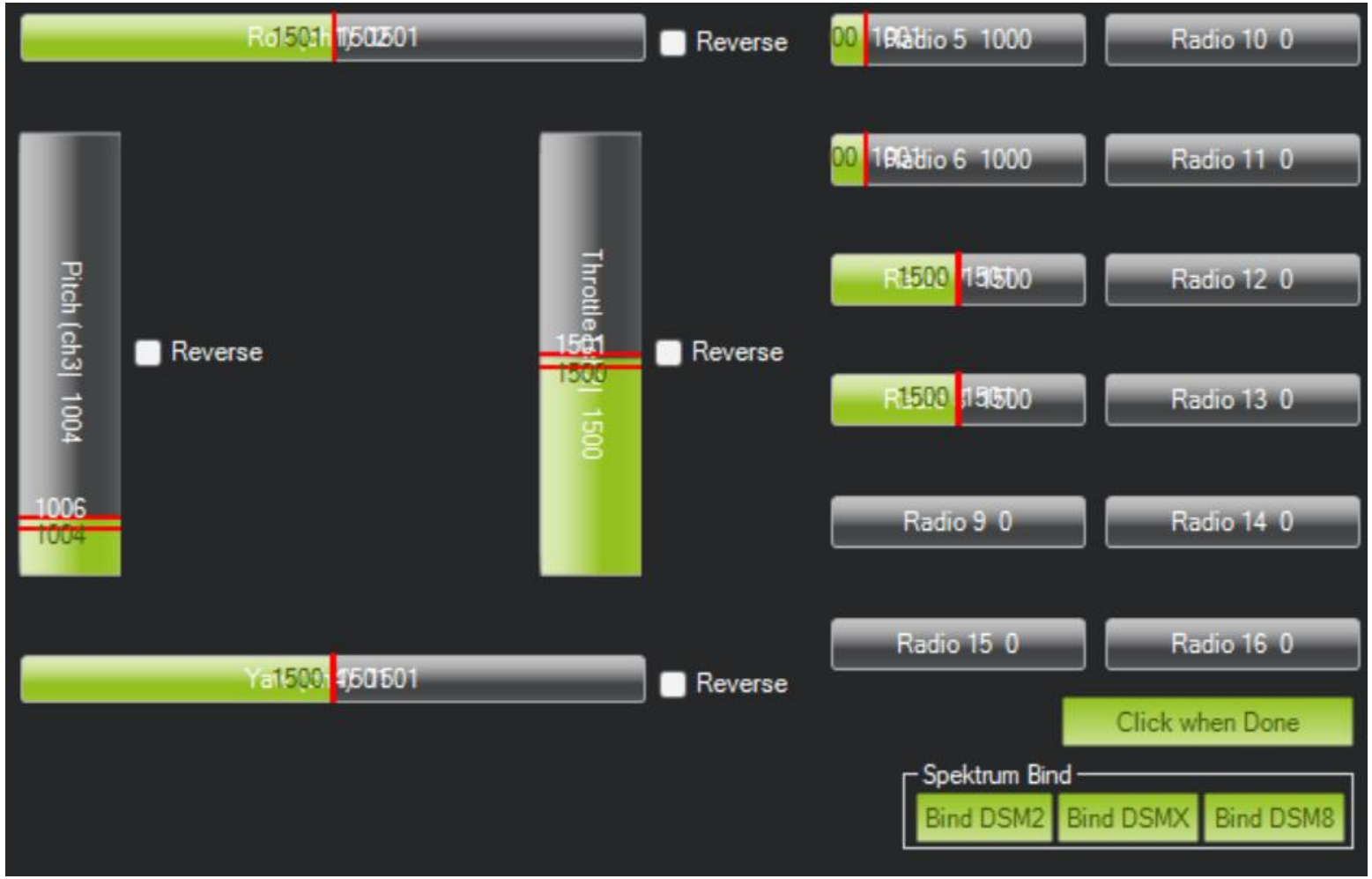


5.12 Now it will tell you to adjust the sticks on your remote control and all other input channels to create the range of acceptable values indicated by a red line on your control.



Step 5 Remote-Control Radio Calibration

5.13 Notice to start the lines are very close to your center, but if you move one stick you will see the red bar move.

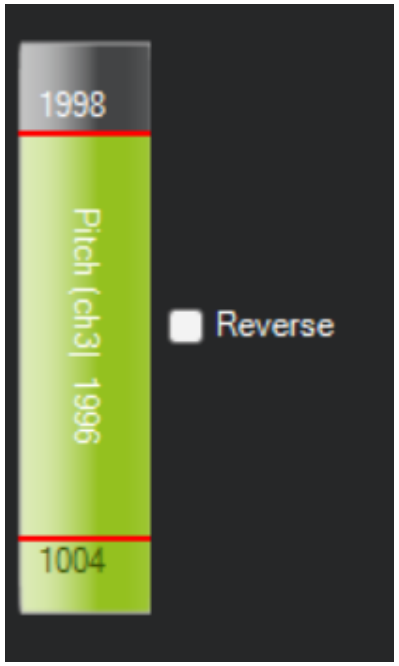


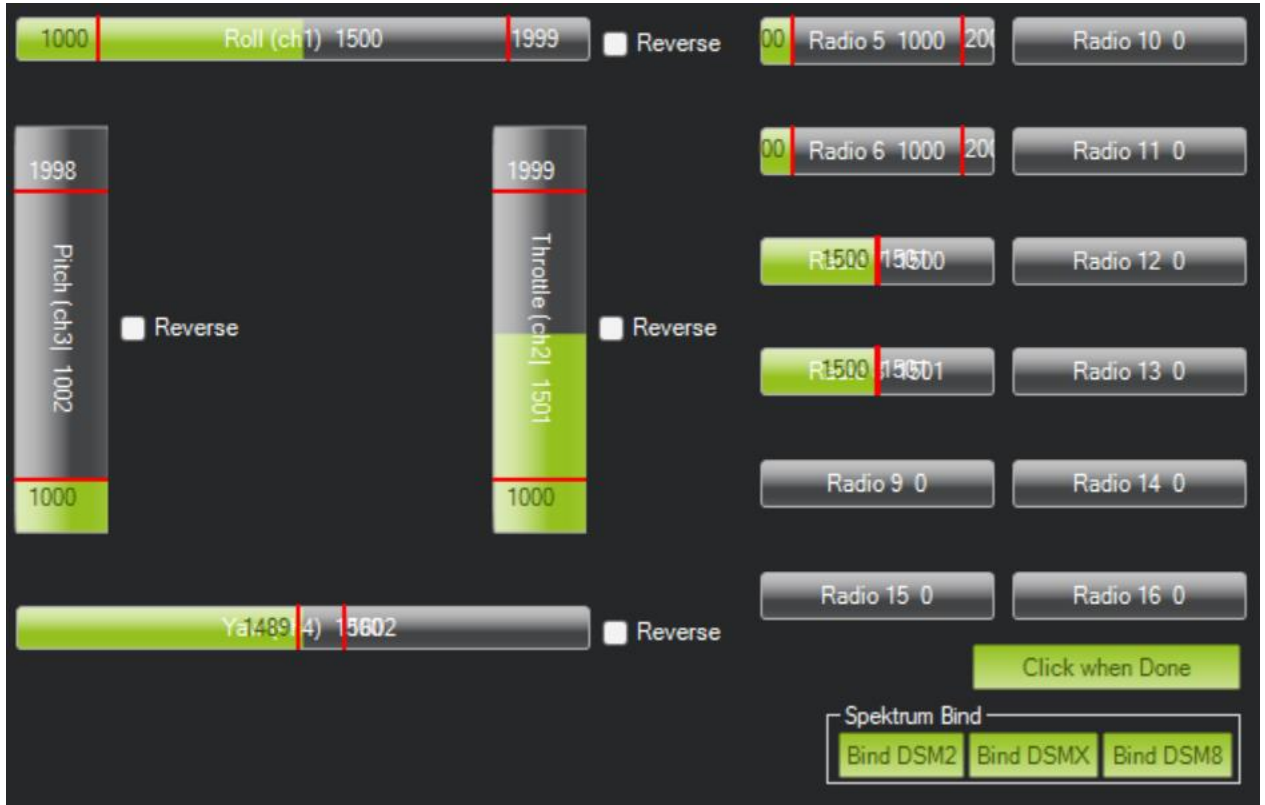
Step 5 Remote-Control Radio Calibration

5.15 Watch as I move the Throttle Stick to the maximum, you can now see the max (1998) and min (1004) values that have been received.

5.16 Now do this for all channels. It should look something like this when you are done.

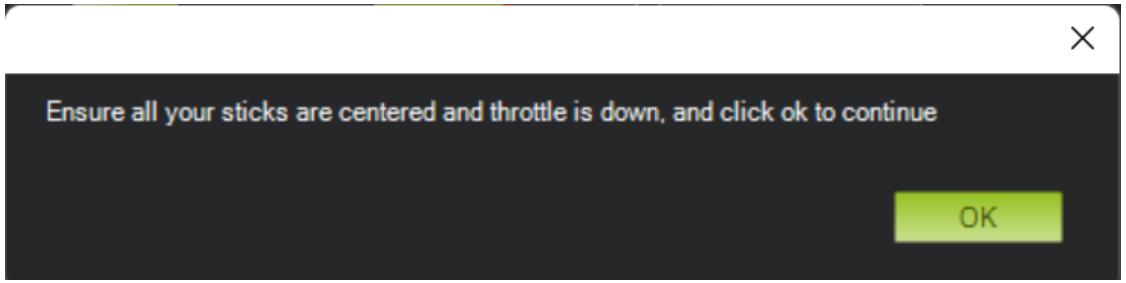
You may notice that Channels 7 and 8 did not move, this is because our radio is only has 6 Channels, so it did not receive any input during calibration.



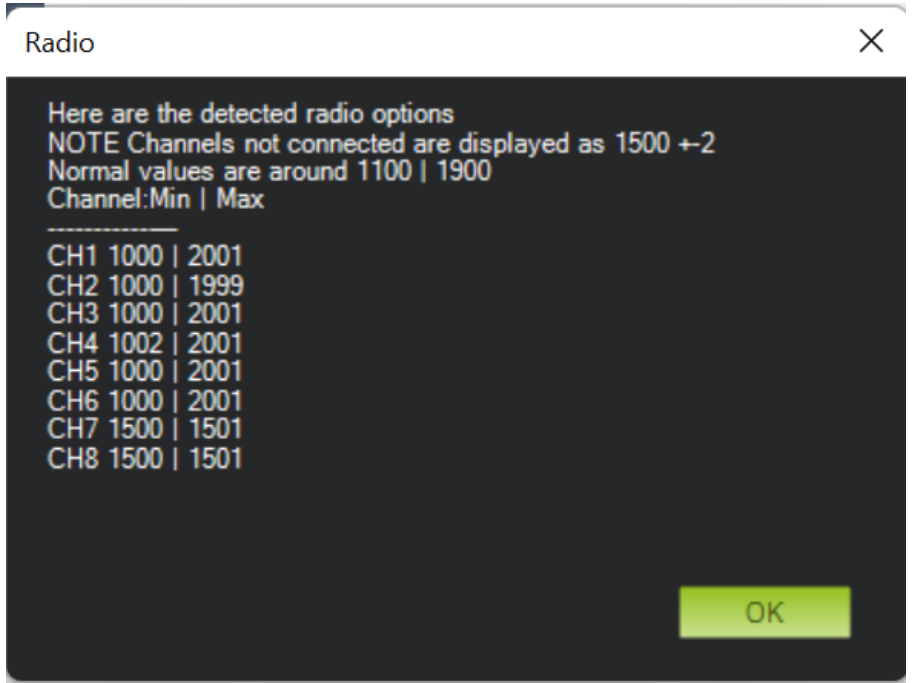


Step 5 Remote-Control Radio Calibration

5.17 Now when you press the “Click When Done” button, it will tell you to make sure that the throttle is all the way down and all other sticks are centered. After you hit OK, the screen will pause for a moment as it records these new ranges.



5.18 It will now display these values to you, press OK and now your RC is calibrated.



Step 6 Adjust Logging Parameters

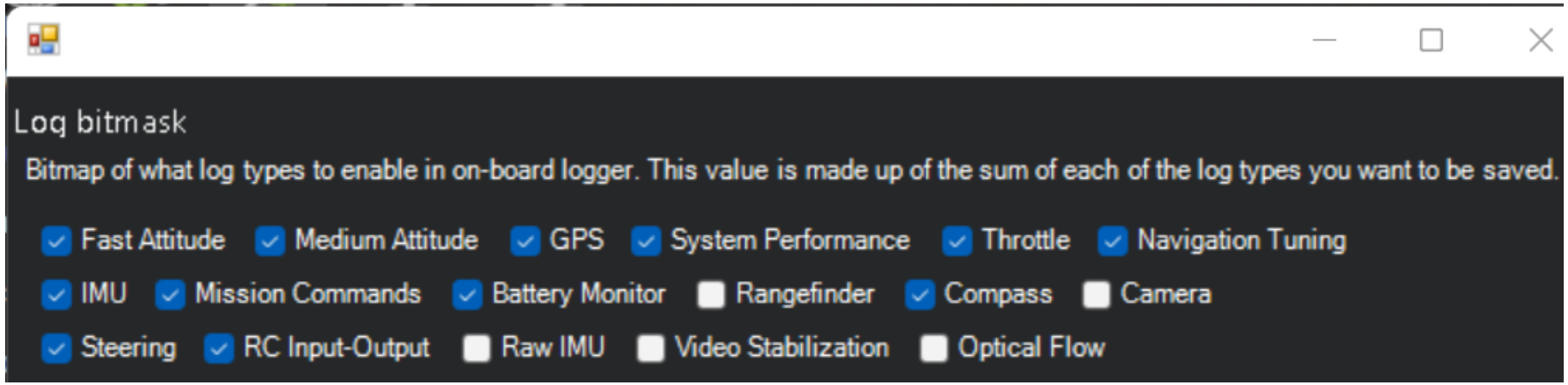
6.1 So the Navio2 has the ability to save its information into data flash logs onboard the Navio2, so even if you lost connection with the Navio2 during its flight, you could still recover the logs from the Navio2 afterwards. We had a crash where the battery cut off, but we were still able to view logs of information that stopped right as the battery died meaning that we do not lose the entire flight during a failure such as power loss.

6.2 Go to config -> Full Parameter List

Search for LOG_BITMASK

LOG_BITMASK	65535		0:Disabled 65535:Default	Bitmap of what log types to enable in on-board logger. This value is made up of the sum of each of the log types you want to be saved. On boards supporting microSD cards or other large block-storage devices it is usually best just to enable all basic log types by setting this to 65535.

6.3 If you select the value it will open a check-box to select your desired logging options



6.4 Enable the following log types:
Fast Attitude, Medium attitude, GPS, System Performance, Throttle, Navigation Tuning, IMU, Mission Commands, Battery Monitor, Compass, Steering, RC Input-Output

Step 6 Adjust Logging Parameters

6.5 Disable LOG_DISARMED
This is to ensure that we are only logging while our system is armed, preventing our system from producing extremely large data files while doing nothing.

LOG_DISARMED	0		0:Disabled 1:Enabled 2:Disabled on USB connection	If LOG_DISARMED is set to 1 then logging will be enabled at all times including when disarmed. Logging before arming can make for very large logfiles but can help a lot when tracking down startup issues and is necessary if logging of EKF replay data is selected via the LOG_REPLAY parameter. If LOG_DISARMED is set to 2, then logging will be enabled when disarmed, but not if a USB connection is detected. This can be used to prevent unwanted data logs being generated when the vehicle is connected via USB for log downloading or parameter changes.

6.6 Enable LOG_FILE_DSRMROT
This will create a separate log for each instance that we arm the Navio2. Separates our launches so we can sort them easier.

LOG_FILE_DSRMROT	1		0:Disabled 1:Enabled	When set, the current log file is closed when the vehicle is disarmed. If LOG_DISARMED is set then a fresh log will be opened. Applies to the File and Block logging backends.

6.7 Disable LOG_REPLAY
This is for debugging issues with the Kalman filter and not necessary for most users. This is disabled by default generally.

LOG_REPLAY	0		0:Disabled 1:Enabled	If LOG_REPLAY is set to 1 then the EKF2 and EKF3 state estimators will log detailed information needed for diagnosing problems with the Kalman filter. LOG_DISARMED must be set to 1 or 2 or else the log will not contain the pre-flight data required for replay testing of the EKF's. It is suggested that you also raise LOG_FILE_BUFSIZE to give more buffer space for logging and use a high quality microSD card to ensure no sensor data is lost.

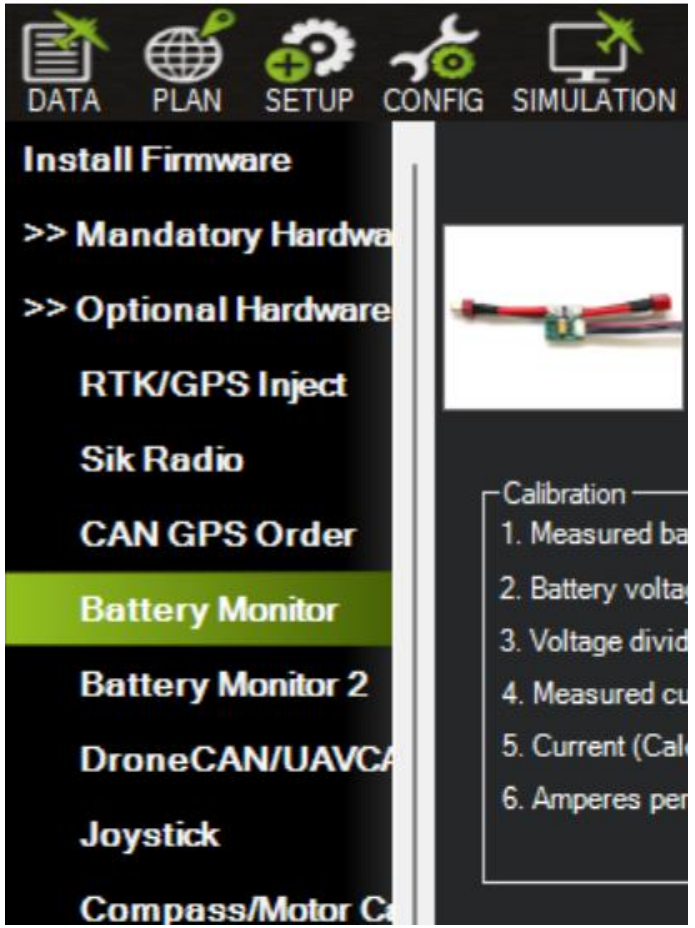
6.8 Write Parameters

Step 7 Configuring Battery Monitoring

7.1 When you are operating your rover, you want to be able to determine your current battery life and whether you should end a mission or tell your rover to return to base. Using Ardupilot's Battery monitoring capabilities you are able to do just that.

7.2 Go to Setup -> Optional Hardware -> Battery Monitor

7.3 Here you can change the type of power module and hardware version of your system as well as calibrating the voltage and current reading. For our rover we are focused on the Voltage Reading to act as an indicator of battery life.

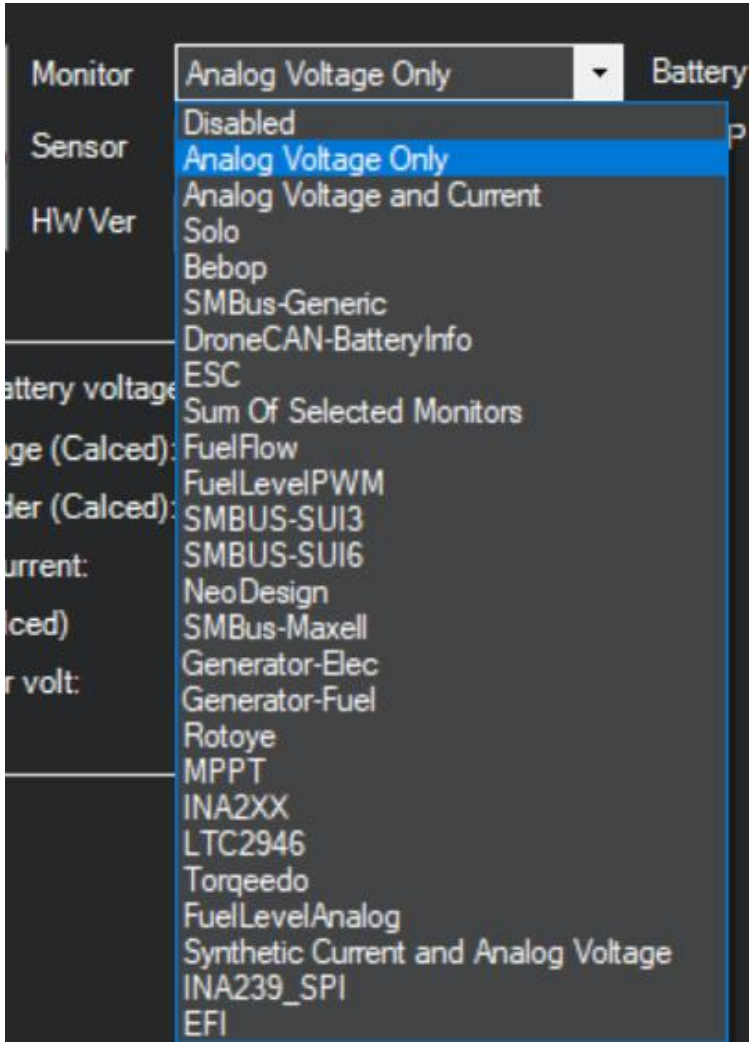


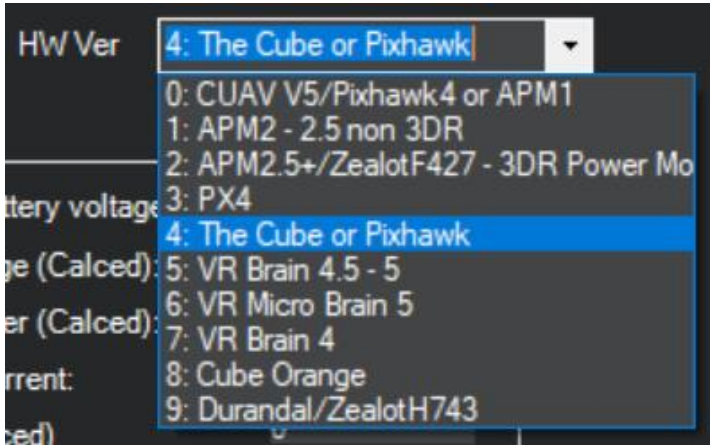
Step 7 Configuring Battery Monitoring

7.4 In the Monitor Section, select Analog Voltage Only

7.5 For Sensor, if you have the option to select, choose “0: Other”

7.6 For Hardware Ver., select “4: The Cube or Pixhawk”



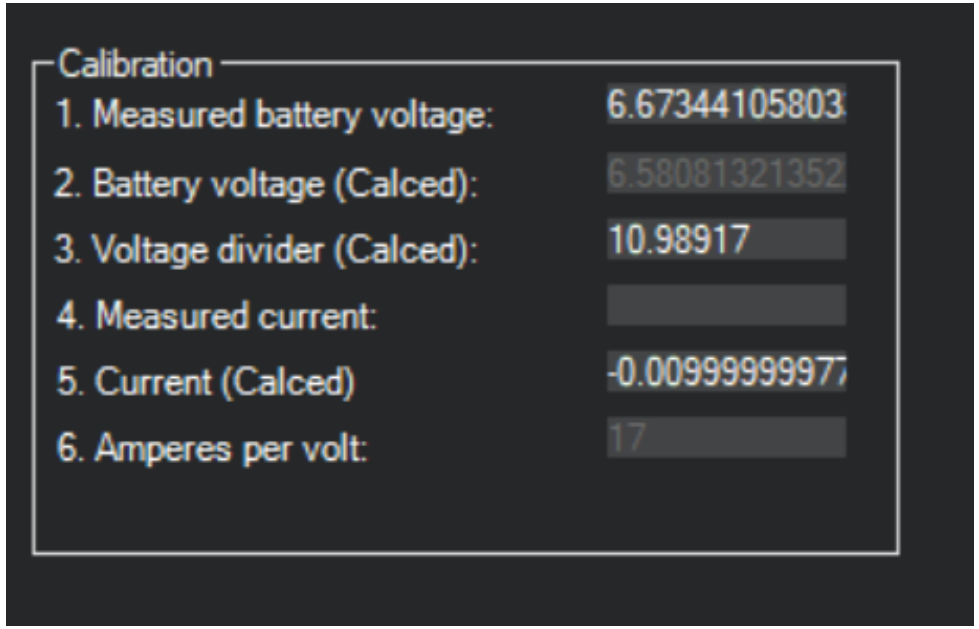


Step 7 Configuring Battery Monitoring

7.7 At this point, you should reboot your system using the “CTRL+F” shortcut menu

7.8 After it has rebooted and you are connected to the Navio, go back to the page and look at the calibration options.

7.9 Here, you will need either a multimeter or battery voltage measurement device.

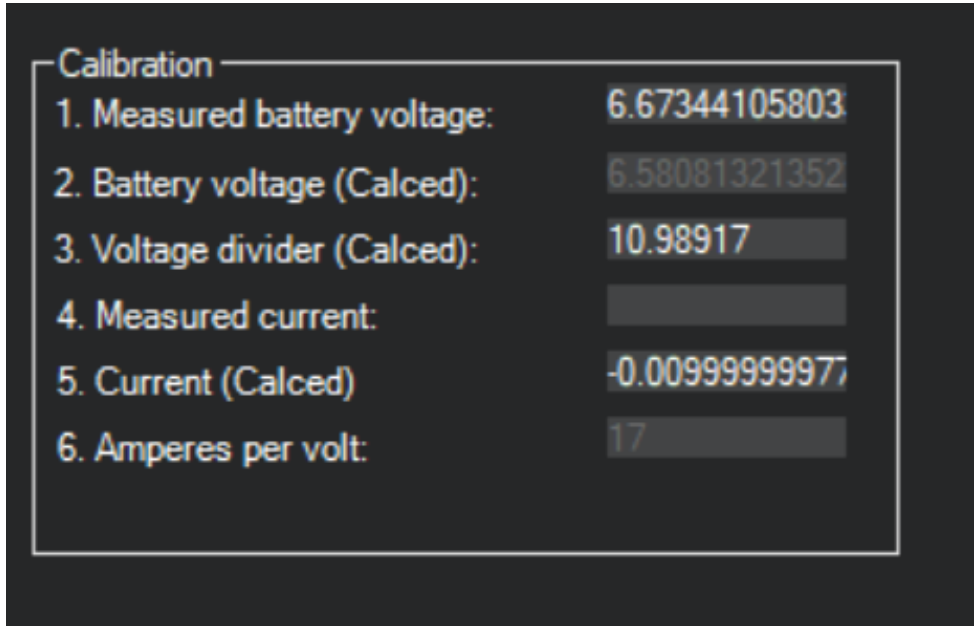


Step 7 Configuring Battery Monitoring

7.10 **Note: To do this you will need a battery pack installed, not the USB-C power supply.**

With the battery pack connected, measure the voltage of your pack and enter the value in the “Measured Battery Voltage” section of the calibration page.

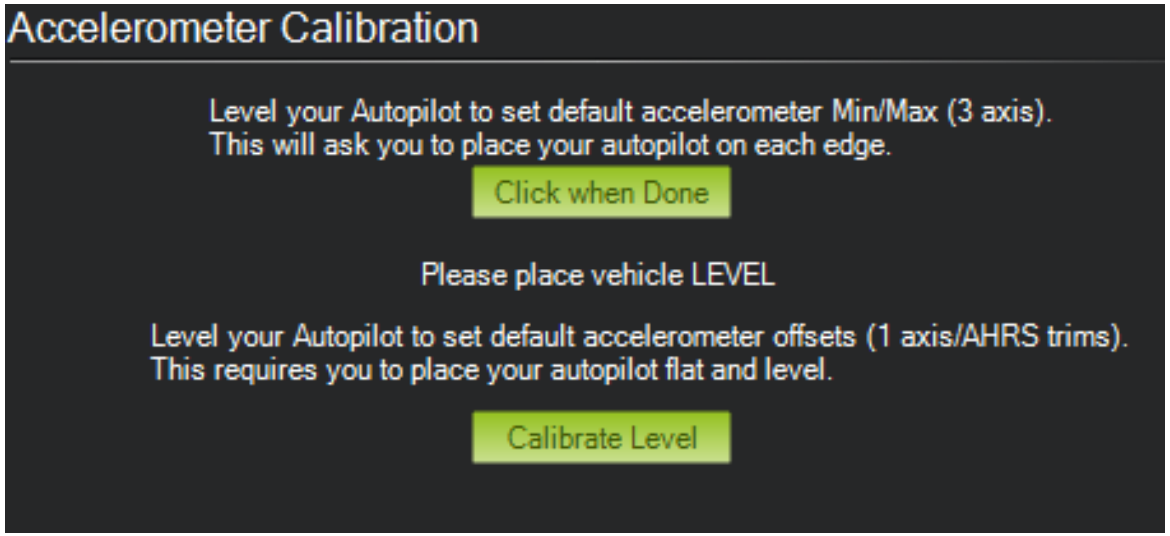
7.11 This should calculate the required divider and output the correct voltage value in the “Battery voltage (Calced)” section of the calibration page.



Step 8 Calibrating IMU

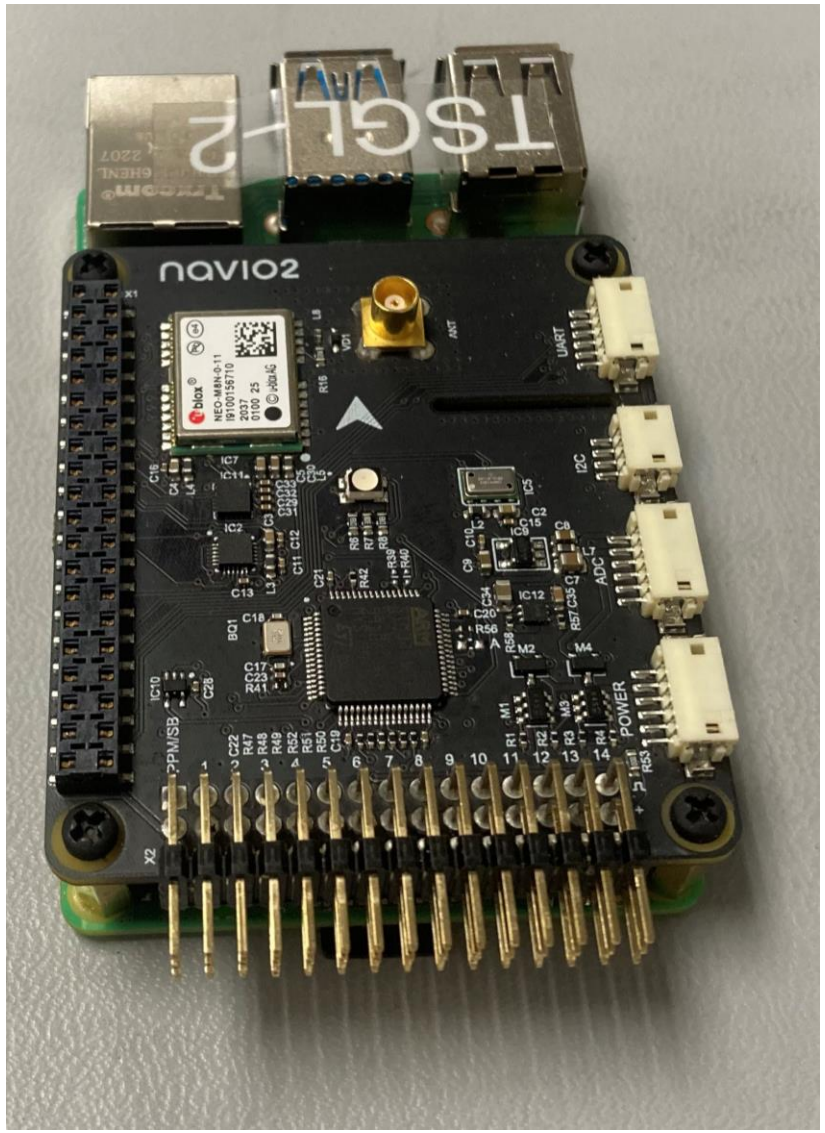
8.4 It will tell you each Orientation, set it in that orientation then press the “Click when Done”

If you are using the Navio2 on its own outside of a casing, you may need to hold it in place while calibrating or using something to prop it up in specific orientations.



Calibrating IMU

8.5 Level

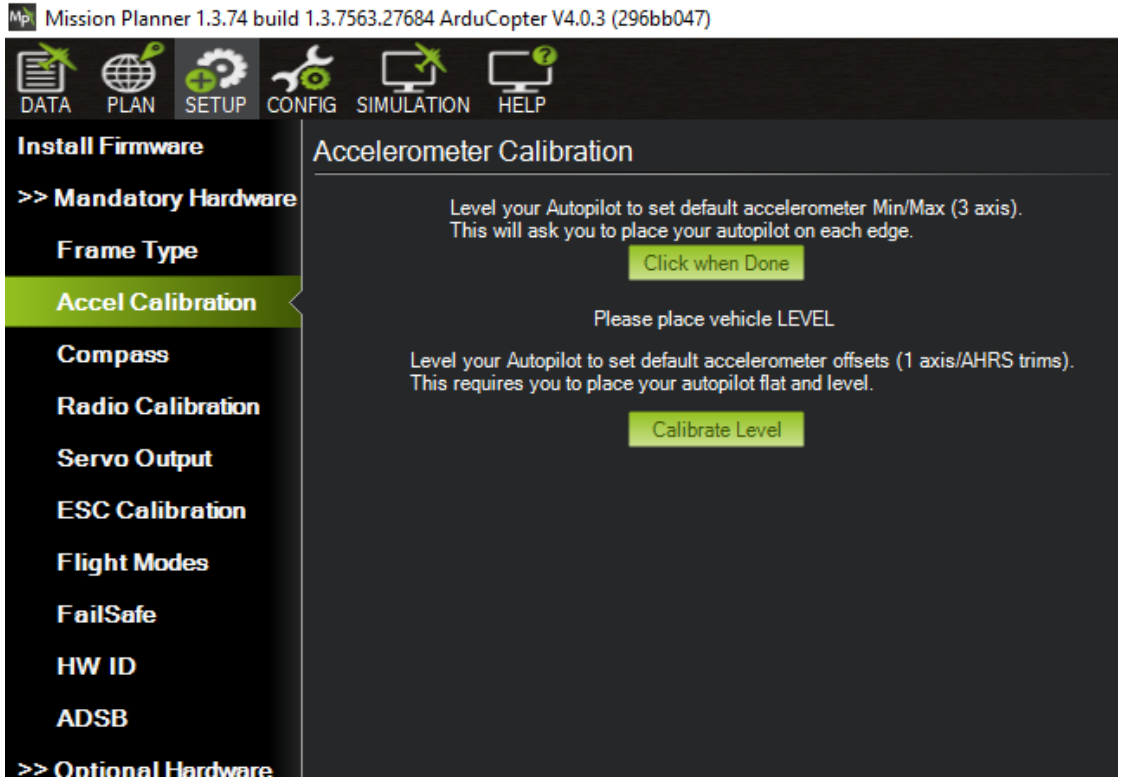


Step 8 Calibrating IMU

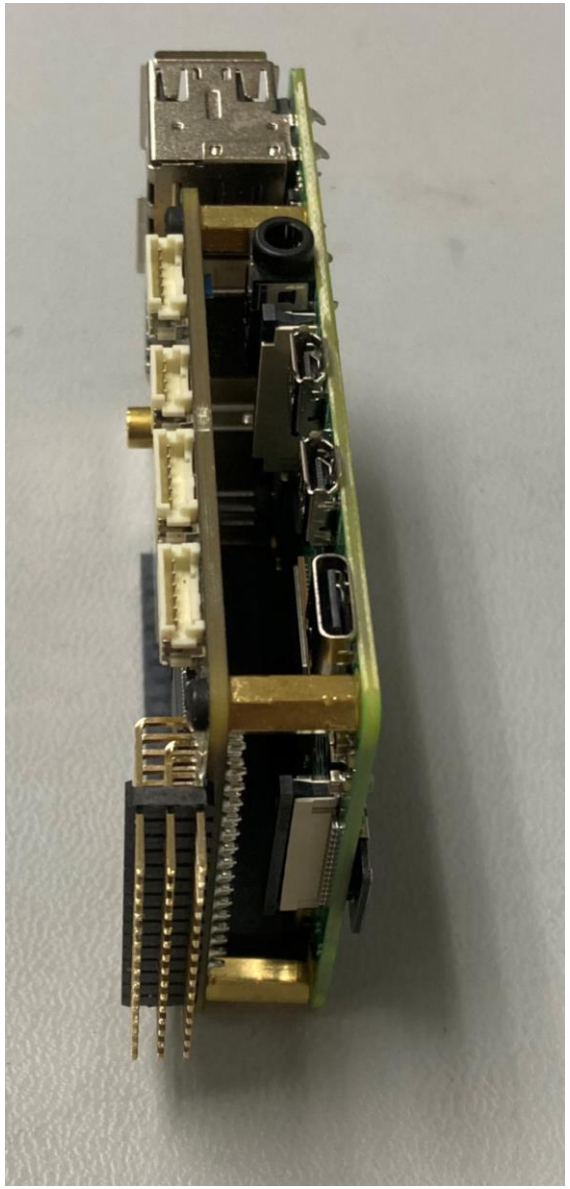
8.1 In order to correctly identify accelerometer information, we must calibrate our system. This will involve placing the Navio2 in different orientations to record readings at each placement.

8.2 Go to Setup -> Mandatory Hardware - > Accel Calibration

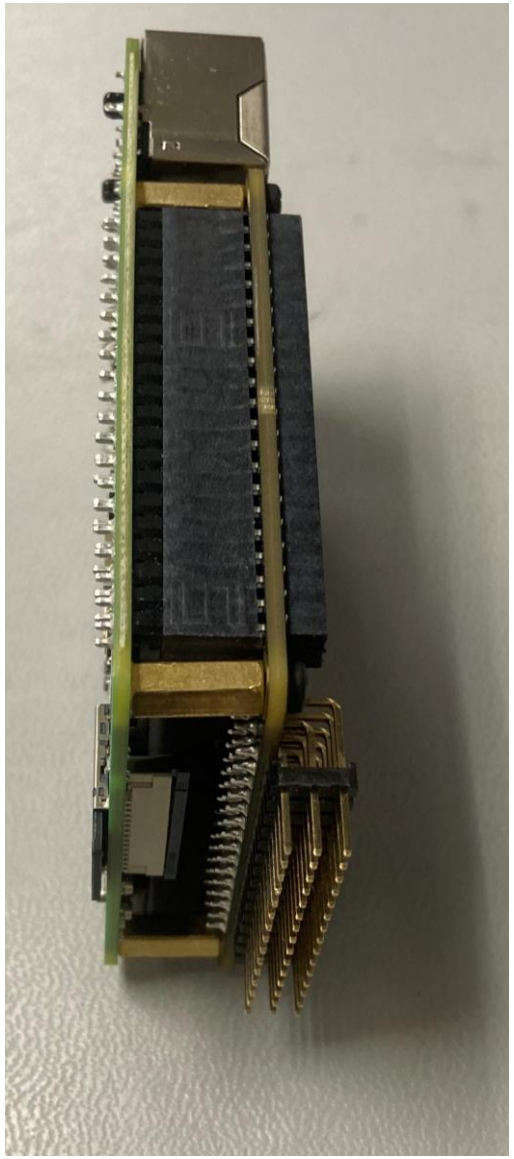
8.3 Select the button for “Level Your Autopilot to set default Accelerometer Min/Max (3 axis). Follow its guide on how to place for each step then press the “click when done” for each step.



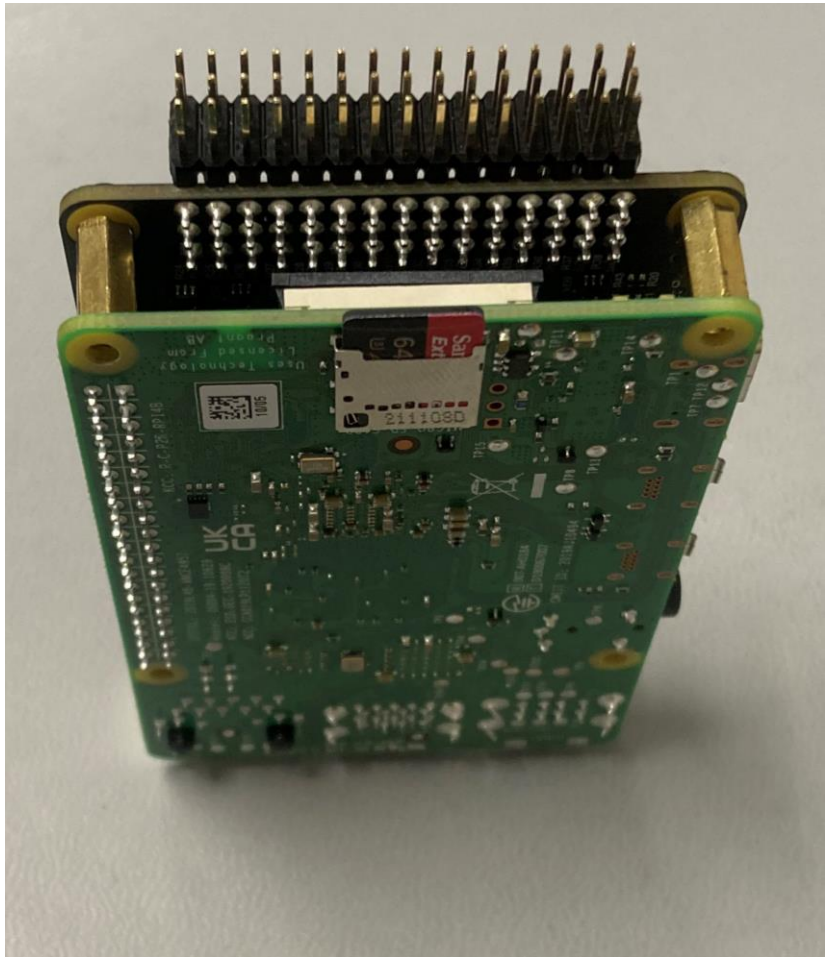
8.6 Left



8.7 Right

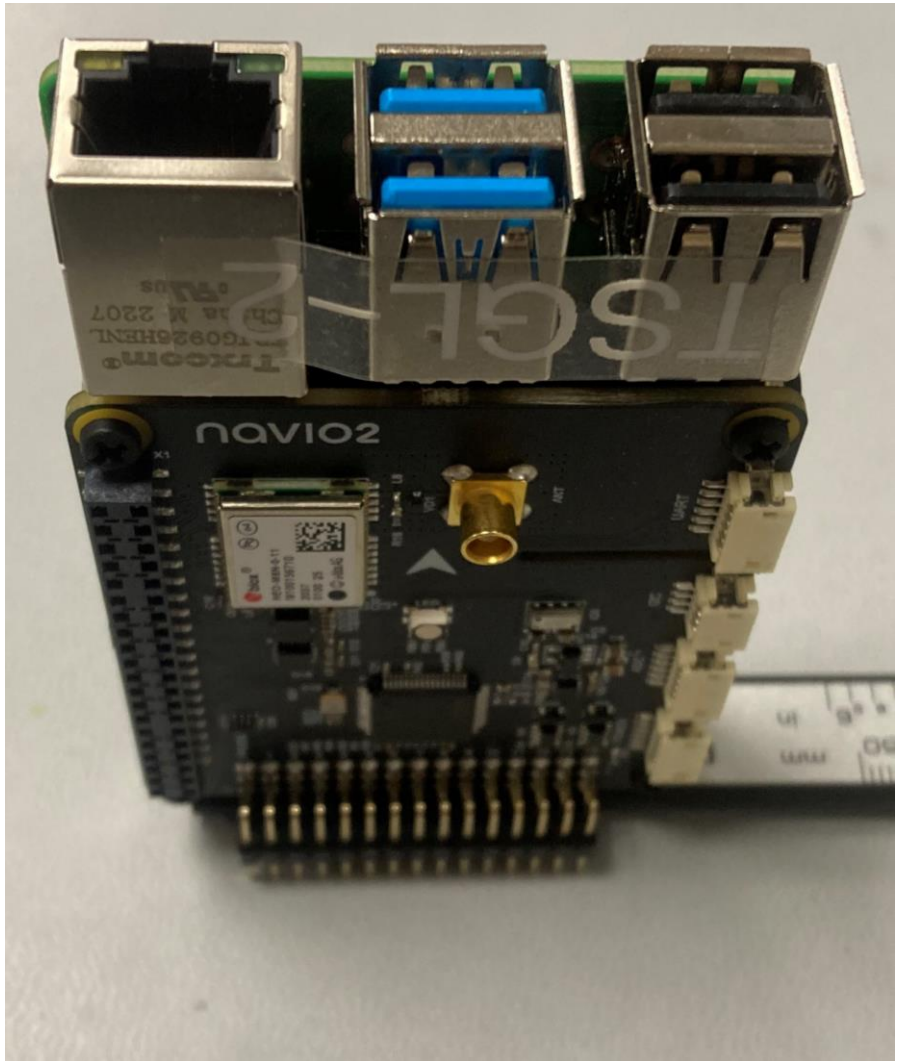


8.8 Nose Down

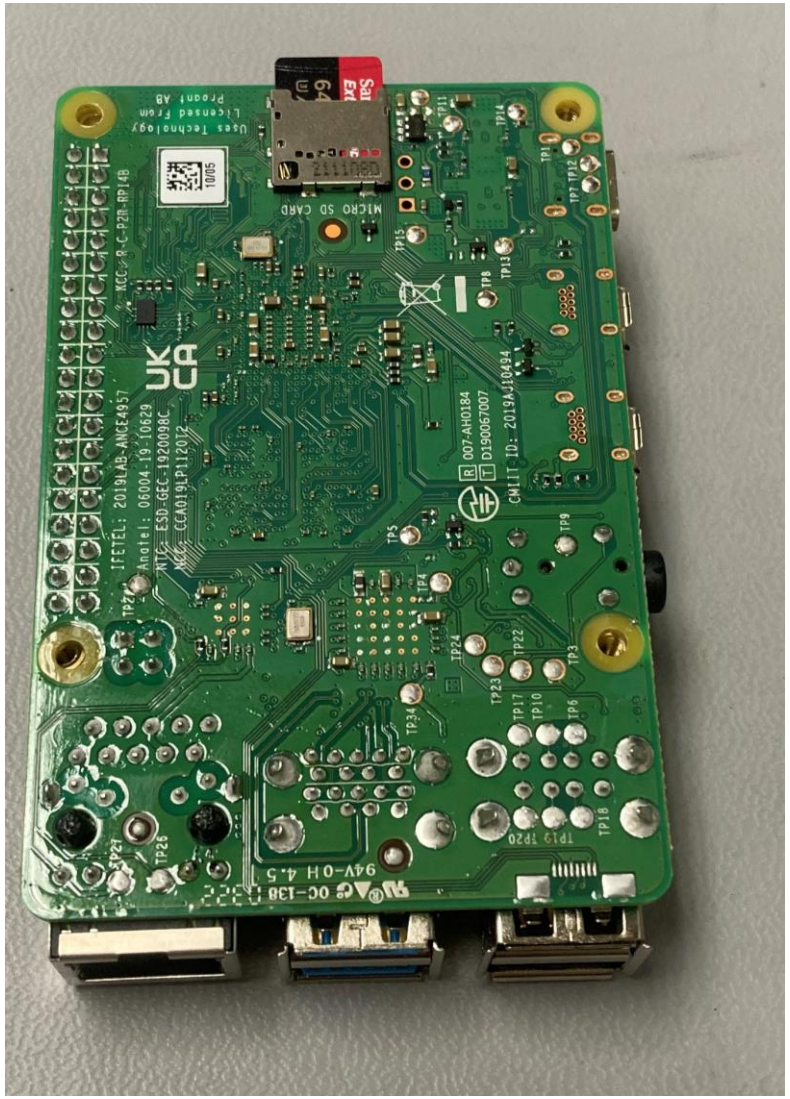


Calibrating IMU

8.9 Nose Up



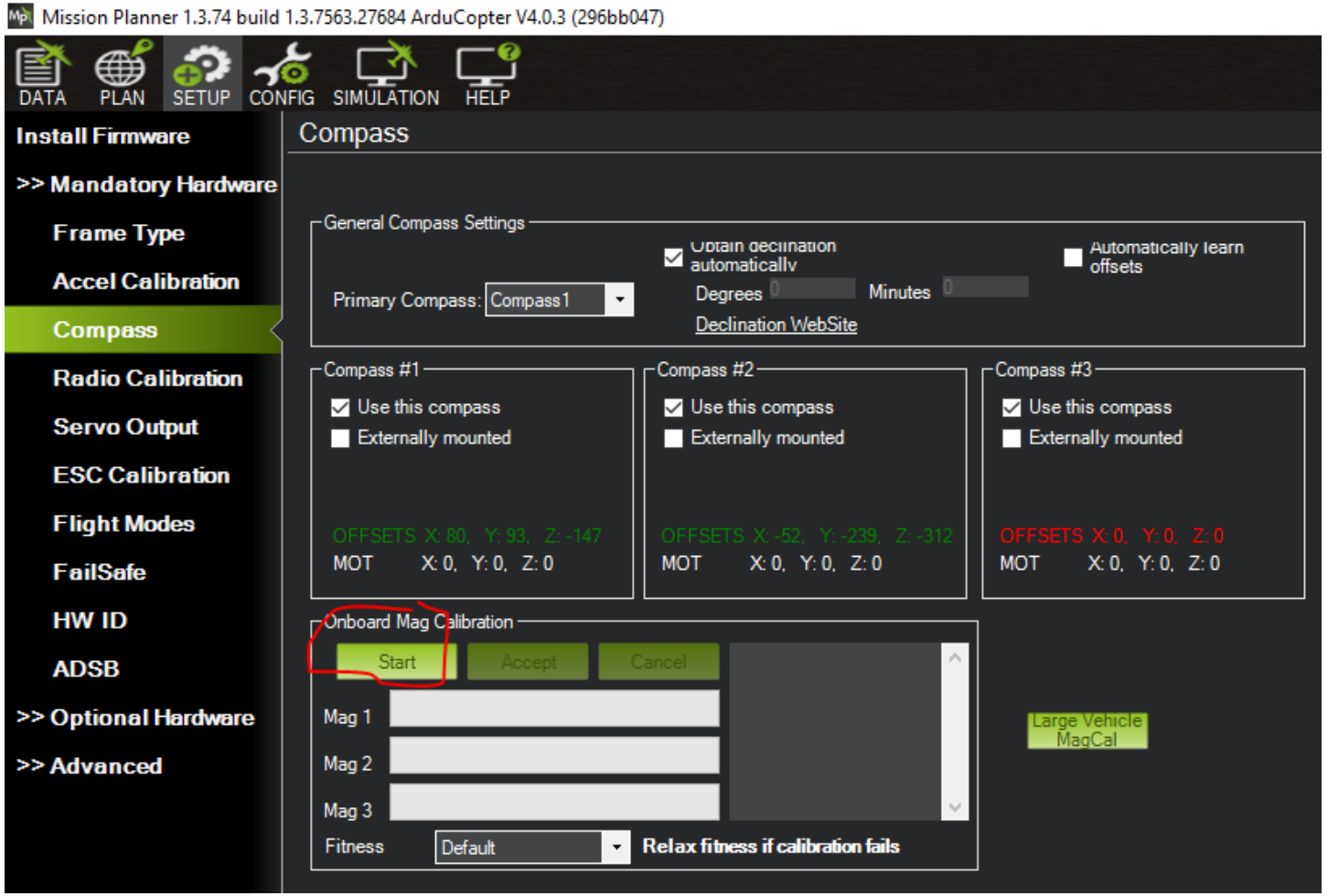
8.10 Back



Step 9 Calibrating Compass

9.1 Open Mission Planner and go to Setup -> Compass

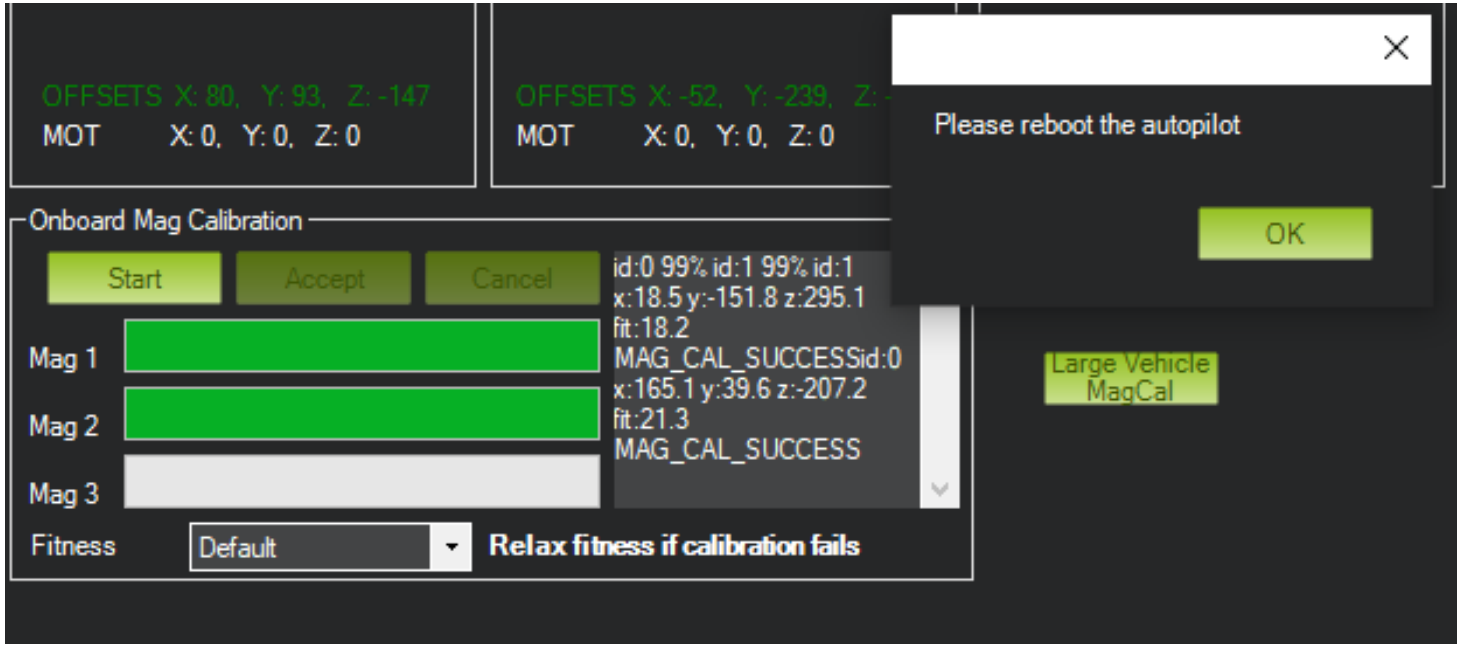
9.2 Click on “Start” for Onboard Calibration



Step 9 Calibrating Compass

9.3 Begin moving the Navio2 in all directions and orientations. You will see the first two bars start to fill as the compass calibrates.

9.4 Once both are finished you will be prompted to restart the navio2 which you can do by pressing CTRL+F and clicking the “reboot Pixhawk” option



Step 10 Prefetching Maps

10.1 While connected to the internet, your ground control will show a high-quality map to reference your location, however if you are in an area without internet access your map will not be as good. To fix this, we will download a portion of the map that we plan to fly to maintain high quality visuals.

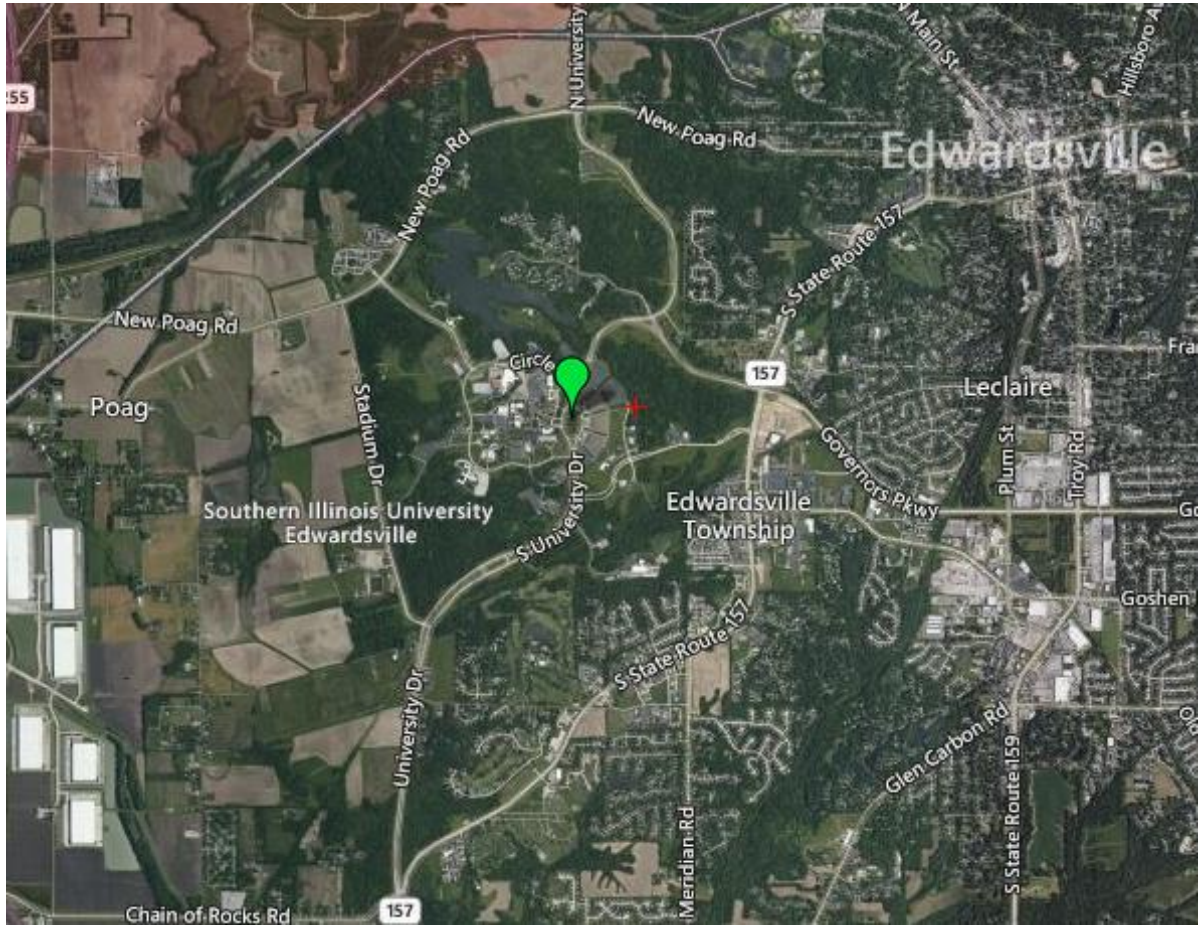
10.2 Go to Plan

Step 10 Prefetching Maps

10.3 Find where you plan to fly/launch/operate your navio2

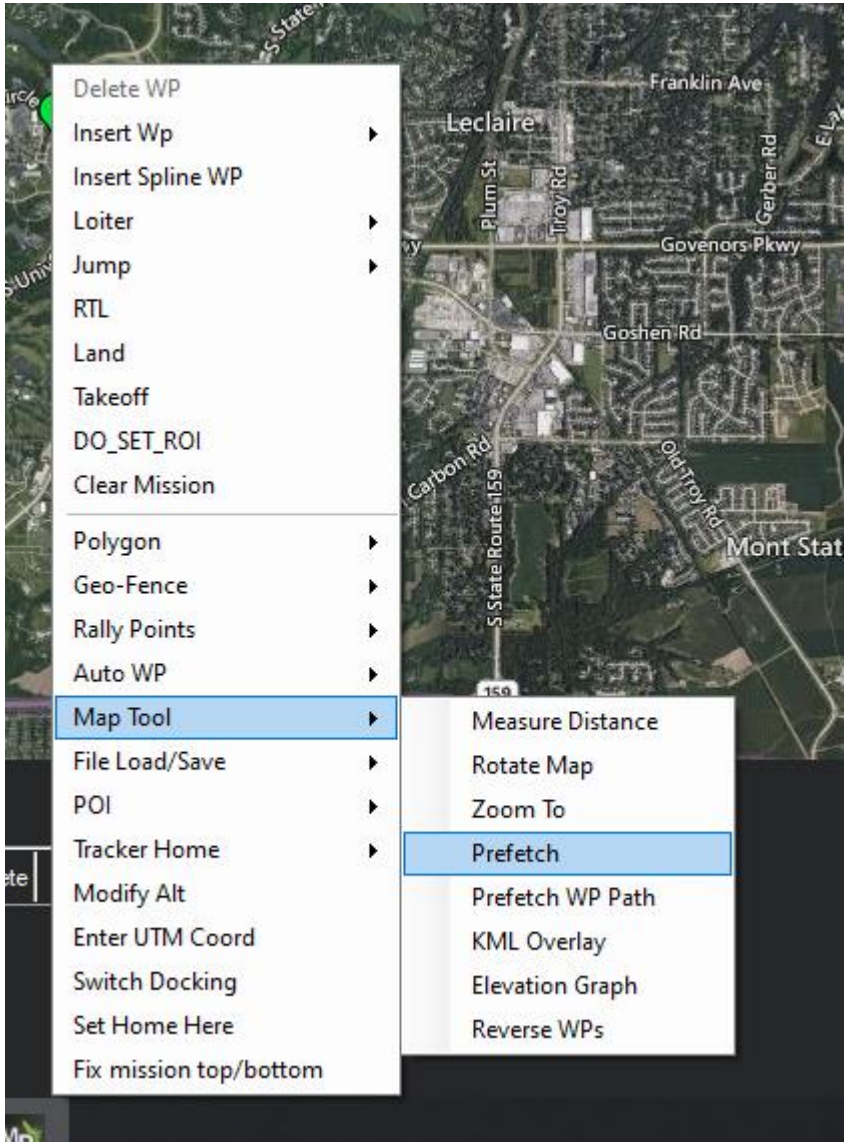
Step 10 Prefetching Maps

10.4 Zoom out enough to cover your potential flight area and then some



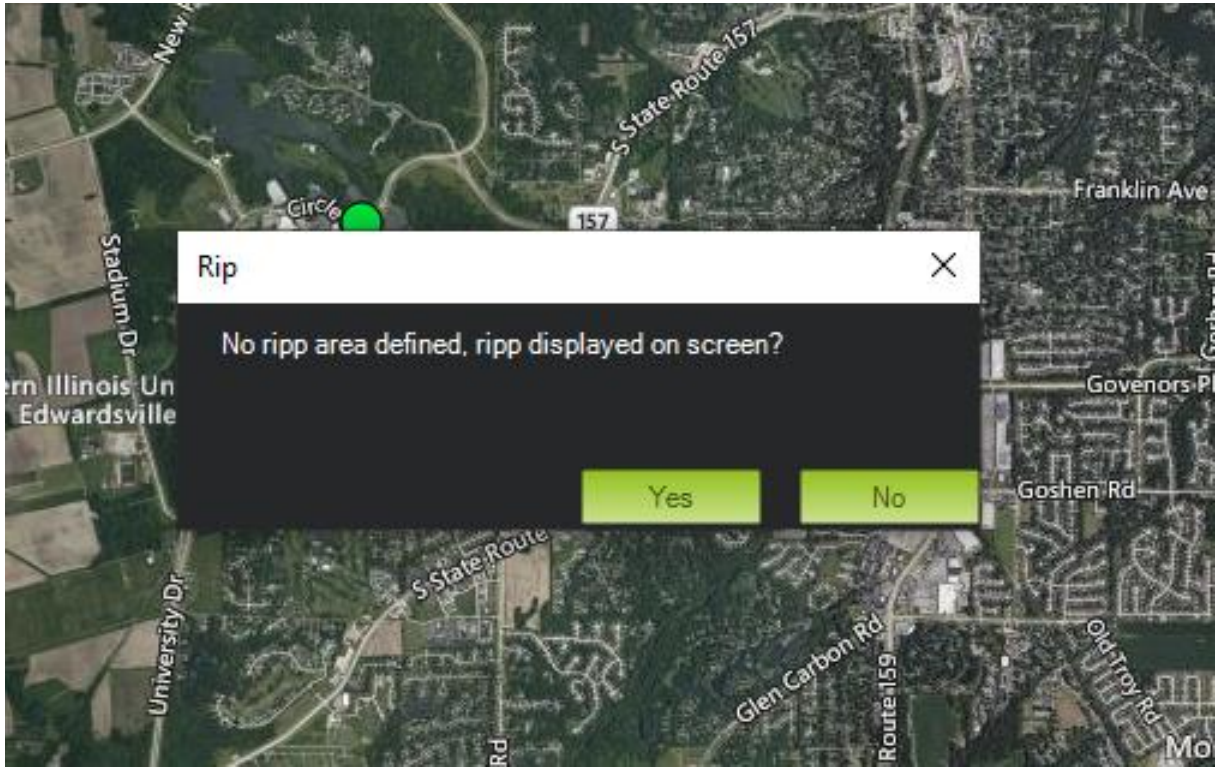
Step 10 Prefetching Maps

10.5 Right click and go to Map Tool - > Prefetch



Step 10 Prefetching Maps

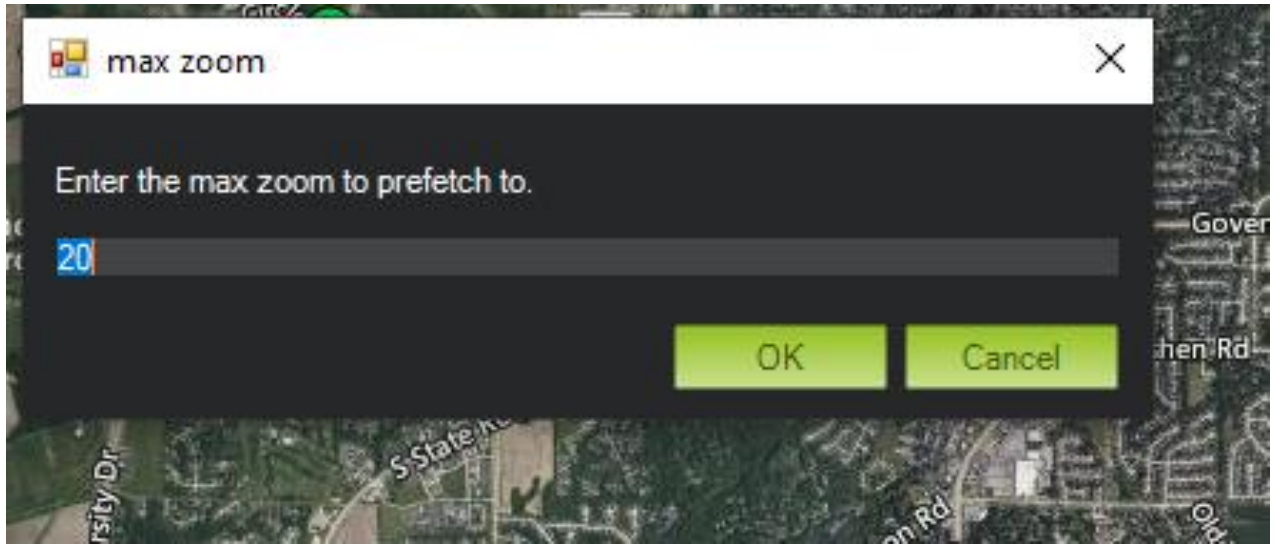
10.6 It will say “ No ripp area defined, ripp displayed on screen?”. Select yes, this will prefetch the entire map shown on your display



Step 10 Prefetching Maps

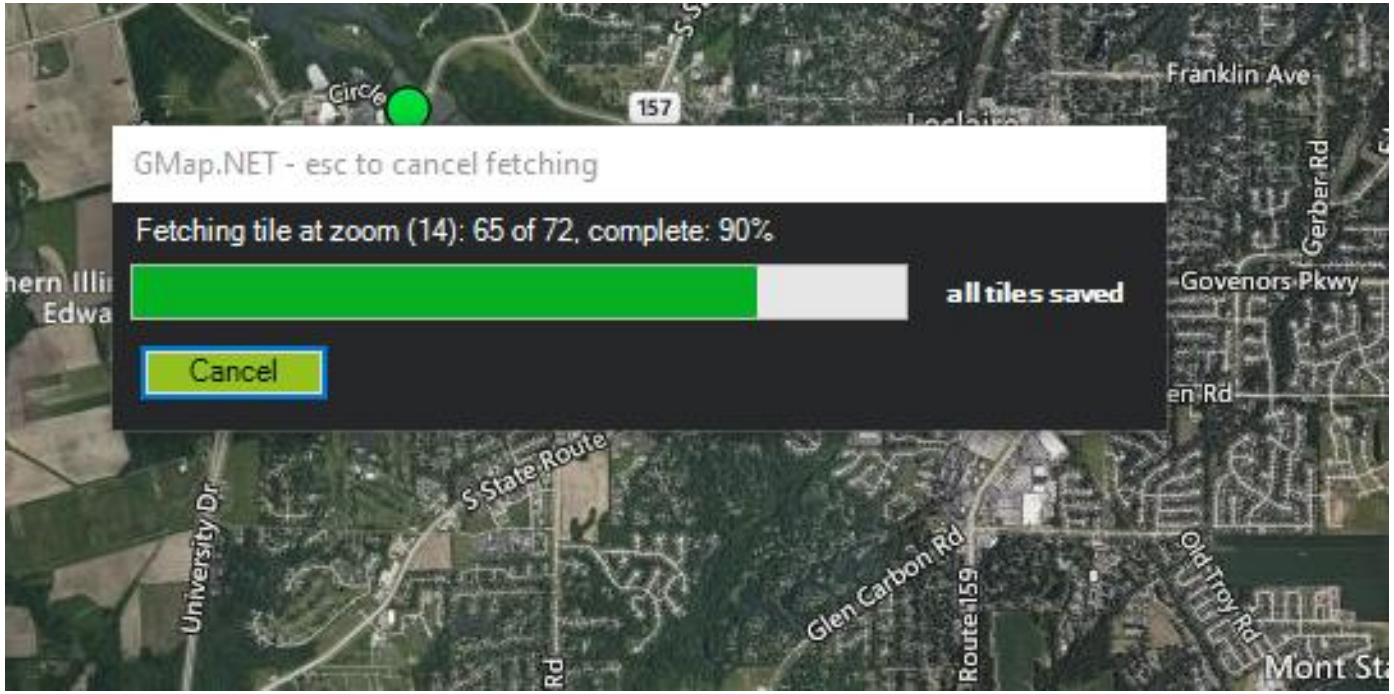
10.7 Select your desired zoom, the larger the number the longer it will take as it is zooming in and saving the more detailed zoomed images.

A good option is 17 for most flights



Step 10 Prefetching Maps

10.8 Once it is finished with the download you now are able to have access to the map data even if you are not connected to the internet as long as you are operating within your prefetched area.

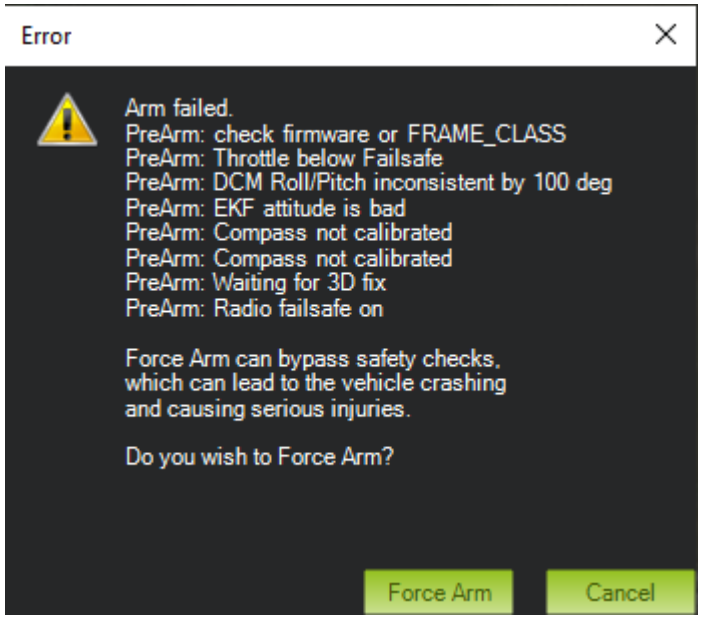


Step 11 Test Arming and Disarming

11.1 Now we will run a quick test to ensure we are able to arm and disarm the system

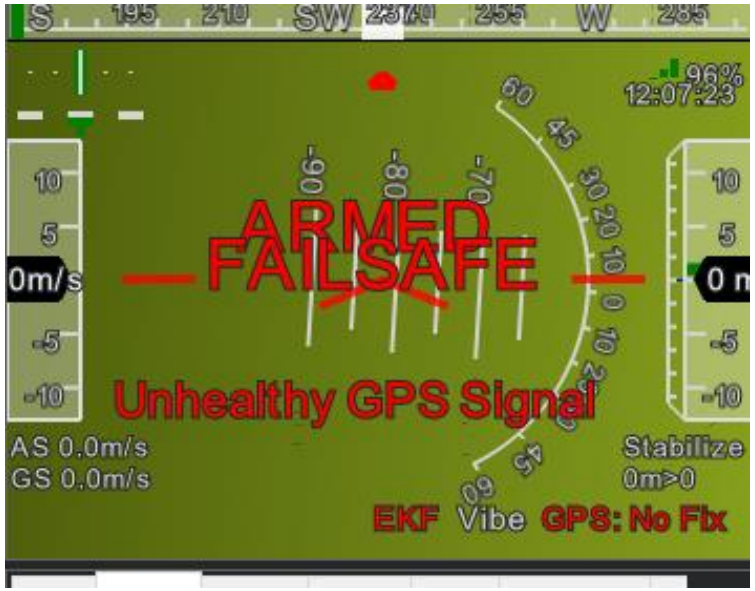
11.2 Go to Data and then the actions tab in the bottom left

11.3 Now press the “Arm/Disarm” Button. This is to force arm, you might get warnings telling you that the rocket isn't ready. This is fine as we generally will not have all the arming conditions meant as the rocket will not have radio connection so it will not have a radio or throttle. If you are inside testing this you also will not get a proper EKF information or GPS information so those are also normal.

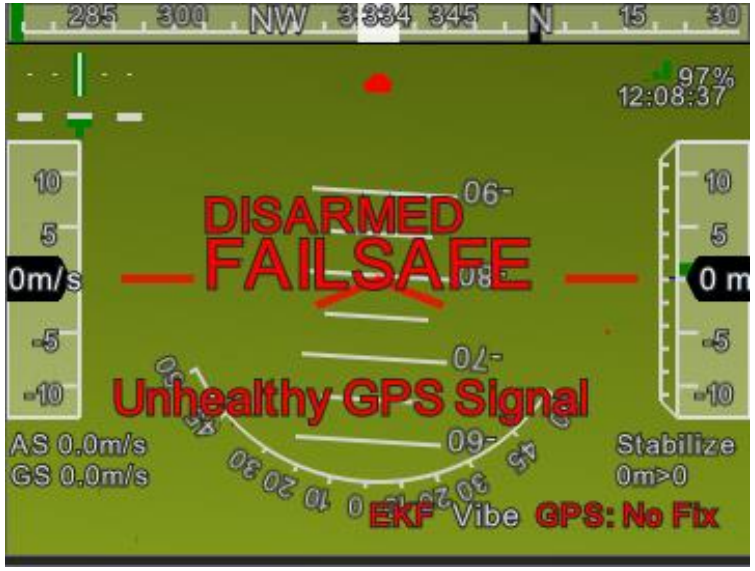


Step 11 Test Arming and Disarming

11.4 When it is armed you will see the “ARMED” pop up in the top left box before disappearing, your system is now armed.

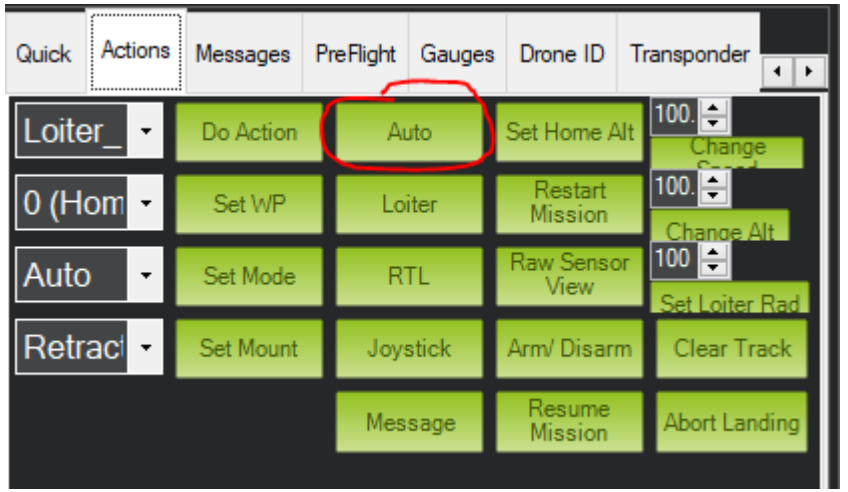


11.5 Currently while armed your system should be logging data and saving it. You can move your system around for acceleration info. When you are done messing with your Navio2, disarm it by pressing the same button. You will know it's disarmed with the “Disarmed” appearing in the top left.

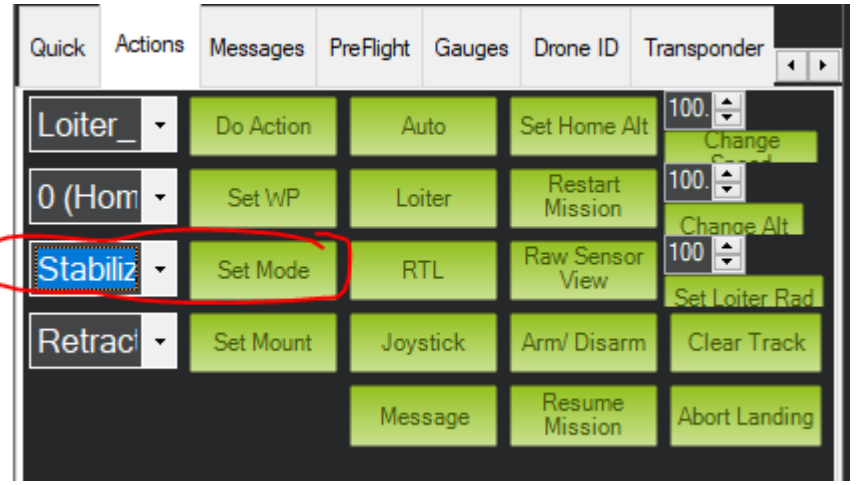


Step 11 Test Arming and Disarming

11.6 If you wish to start a waypoint mission, select the “Auto” Button instead, this will start the rover’s written waypoint missions.



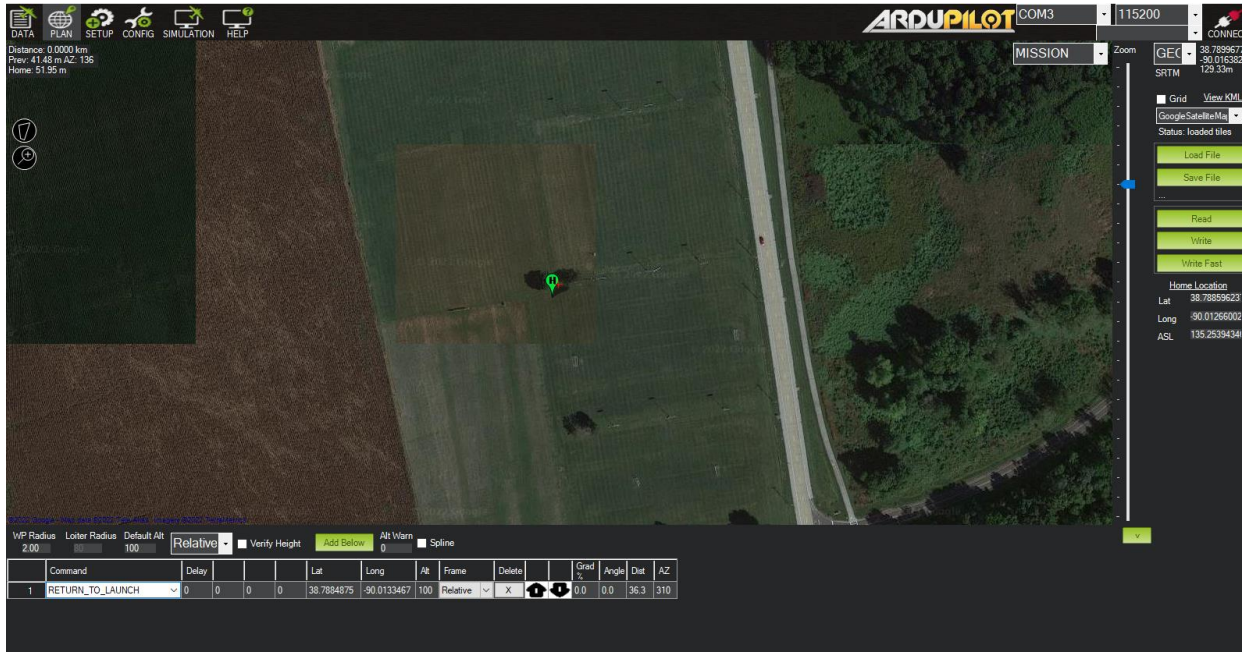
11.7 If you want to take back control during a waypoint mission, use your remote-controller mode select channel to switch back to manual, or select Stabilize and press “Set Mode” in the third row of the Actions Tab.



Step 12 Creating Waypoint Missions

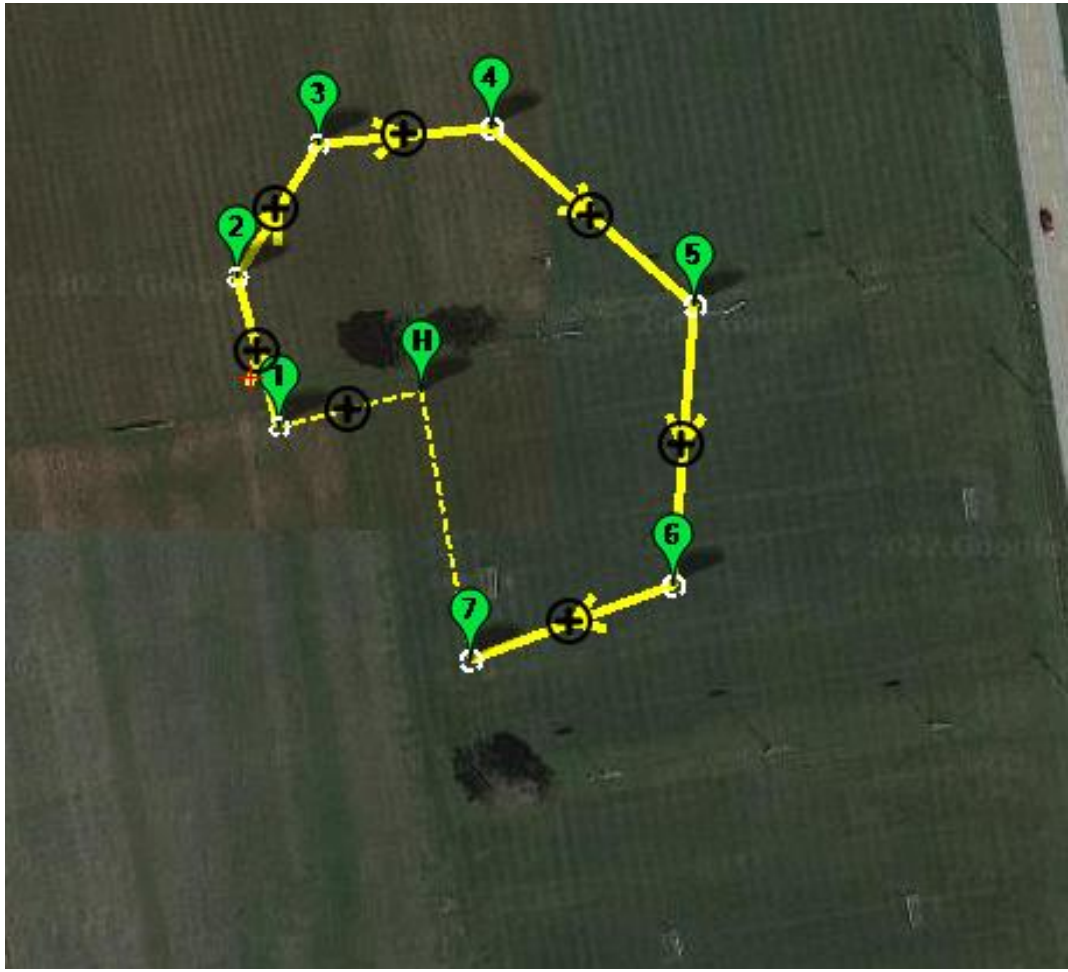
12.1 An important part to a Rover or Drone is the ability to conduct autonomous missions to designated GPS waypoints. Not only can you have the vehicle moving to those points, but you can also decide actions to take while at those points such as taking data or photos.

12.2 Navigate to the “Plan” Tab in the top left. This will bring you to a map where you can move towards where you plan to operate your vehicle. In this example I will use the Soccer fields near campus.

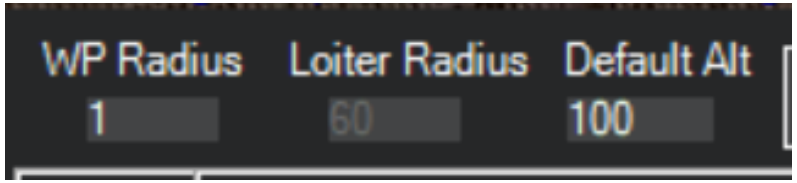


Step 12 Creating Waypoint Missions

12.3 By selecting a point on the map, you will see a marker dropped that is numbered. If you place several, you will see a path drawn between waypoints in numerical order. The dotted line represents the path from your vehicles home position (normally the point where it is armed from). During the start of a mission, normally a vehicle will move towards its home point, then begin to complete waypoints until it reaches the last waypoint, where it will then return to the home point.

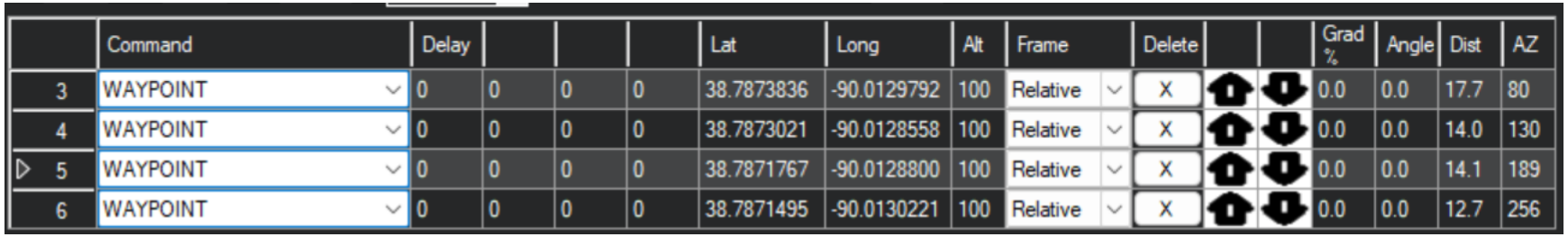


12.4 On the screen you can see little white circles around each waypoint. This is your Waypoint Radius, which is the minimum distance from the waypoint the vehicle must be to consider itself at the waypoint. You can change this value by adjusting the “WP Radius” value at the bottom of the screen.



Step 12 Creating Waypoint Missions

12.5 If you look at the bottom of the screen, you can also see a list of all waypoints.



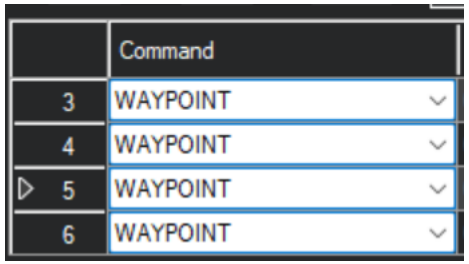
	Command	Delay				Lat	Long	Alt	Frame	Delete			Grad %	Angle	Dist	AZ
3	WAYPOINT	0	0	0	0	38.7873836	-90.0129792	100	Relative	X			0.0	0.0	17.7	80
4	WAYPOINT	0	0	0	0	38.7873021	-90.0128558	100	Relative	X			0.0	0.0	14.0	130
5	WAYPOINT	0	0	0	0	38.7871767	-90.0128800	100	Relative	X			0.0	0.0	14.1	189
6	WAYPOINT	0	0	0	0	38.7871495	-90.0130221	100	Relative	X			0.0	0.0	12.7	256

12.6 This includes information such as the specific command, wait time, GPS information, altitude, frame, and so on. One important feature is the Frame, which is the method of determining movements either “Relative” to the previous waypoint, or by “absolute” which is using a global reference.

An example would be if you wanted to ascend to 150 feet. If you were in the relative frame, you could simple designate a altitude of 150 feet above the previous waypoint. However, if it is using a global frame you might need to ensure that your vehicle is ascending 150 feet above whatever your current Barometer reading altitude is, especially if you are not living at sea level.

Creating Waypoint Missions

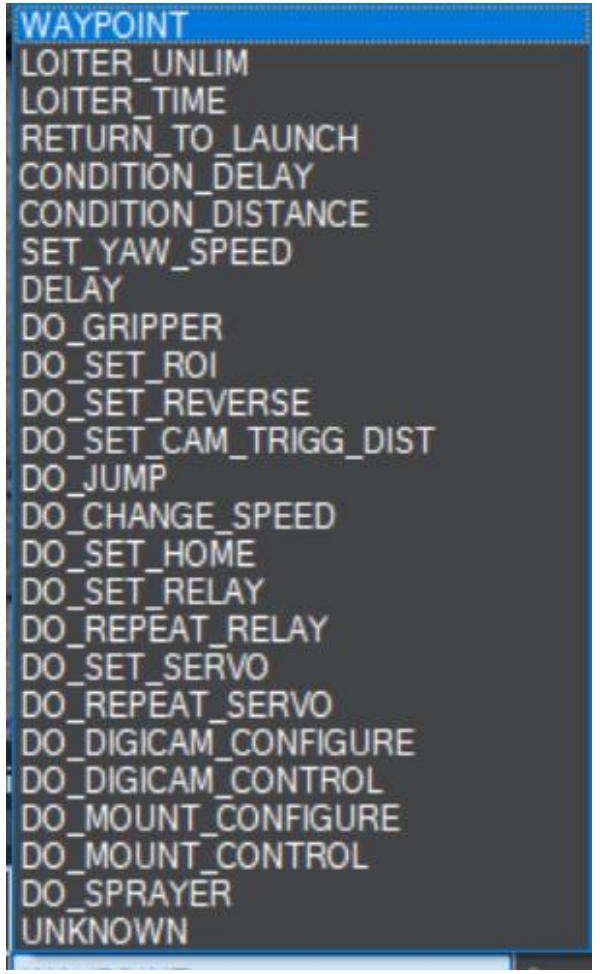
12.7 Waypoint Commands are specific actions to have the vehicle take at that point. These include basic commands like “Waypoint” which is movement to that point, “Delay” which is to wait at that point for a set time.



It also includes more complex commands such as activating various equipment that could be attached such as cameras, grippers, and sprayers.

You can find more information on these commands here:

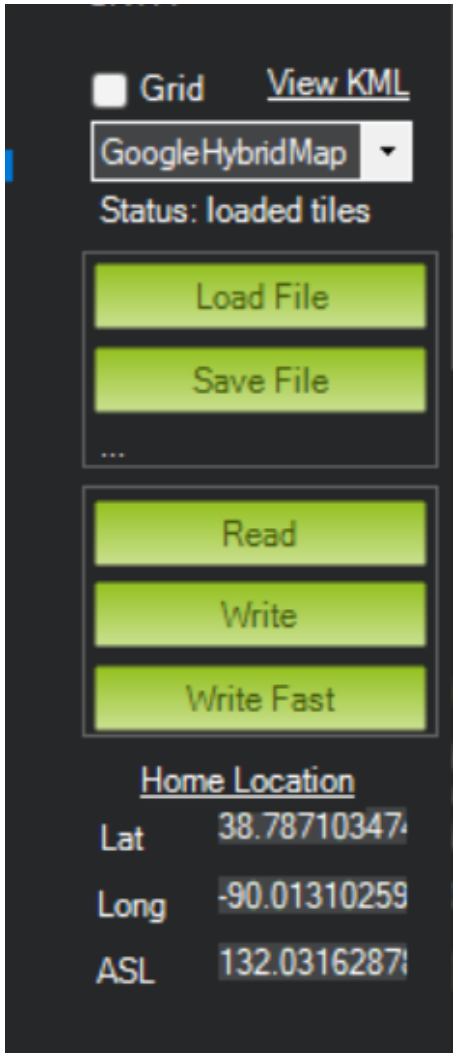
https://ardupilot.org/copter/docs/common-mavlink-mission-command-messages-mav_cmd.html#mav-cmd-do-gripper



Step 12 Creating Waypoint Missions

12.8 Once you have your mission created, you can save it to your computer using the “Save File” Option, or you can write it to your vehicle using the “Write” Option.

12.9 If you ever want to know what the mission on your vehicle looks like, you can also use the “Read” option to read the save waypoint mission to display in Mission Planner, which allows you to make changes to the current plan and then write the changes to the vehicle.



Creating Waypoint Missions

12.10 A good Waypoint mission for a Rover will include two main features: waypoints and a return to launch command.

At the end of your mission, you should add one point and change it to be a RETURN_TO_LAUNCH (RTL) command. This will tell the rover to head back for home using the shortest path.

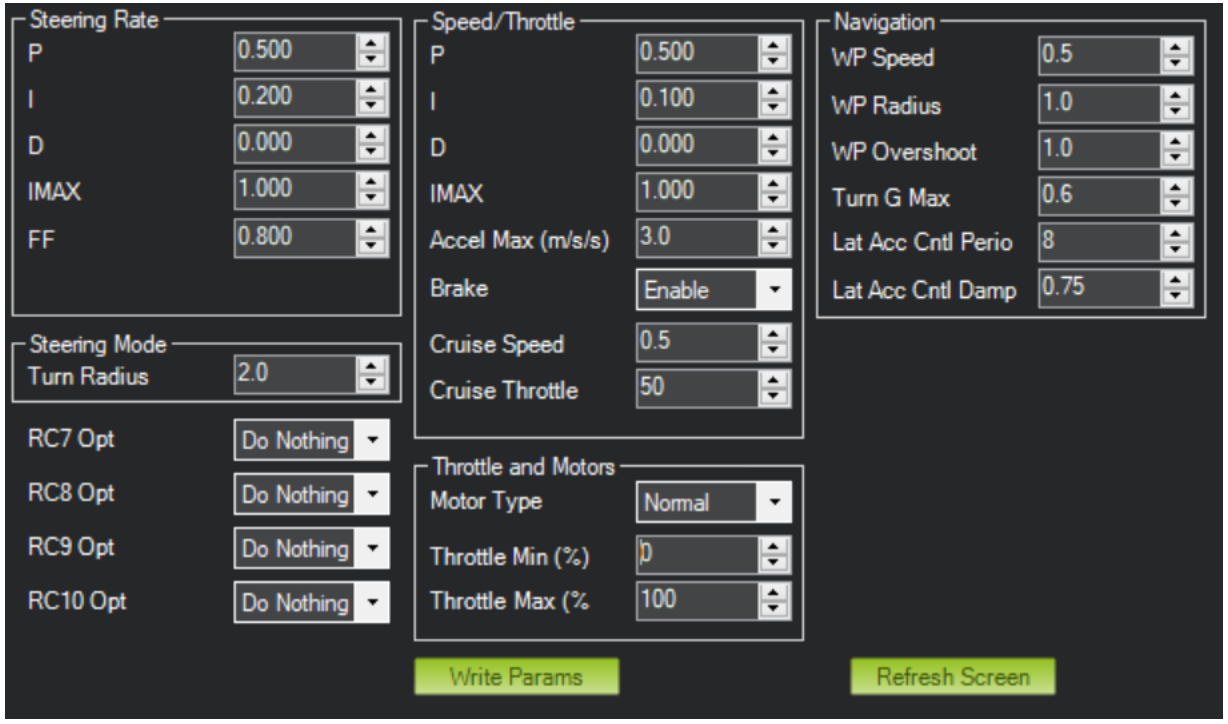
If you have obstacles in your way, it may be better to forgo the RTL command and add extra waypoints to navigate the rover back home.

	Command					Lat	Long
3	WAYPOINT	0	0	0	0	38.7873836	-90.0129792
4	WAYPOINT	0	0	0	0	38.7873021	-90.0128558
5	WAYPOINT	0	0	0	0	38.7871767	-90.0128800
6	RETURN_TO_LAUNCH	0	0	0	0	38.7871495	-90.0130221

Step 13 Tuning Rover Turning and Operation

13.1

- When you first use your rover, it will likely not turn well in most operations. This is because you must tune your vehicle's steering rate and throttle rate. These parameters will affect all driving modes, but especially your waypoint and autonomous movement.
- Go to Config -> Basic Tuning, this is where all your tuning parameters are.
- https://ardupilot.org/rover/docs/rover-tuning-steering-rate.html Here is a link to some well-written instructions involving tuning your steering rate. However, you may find with your rover moving so slowly that it can be hard to correct quickly and easily. Another method you can use is to setup a simple waypoint path in basic shapes like squares or circles and adjust the gain values during the mission.



Data Extraction and Analysis

Materials Needed:

- Avionics Kit
- Power Supply
- WinSCP – Installation Instructions Attached
- Internet Connection

Step 0 Downloading Required Software

0.1 Get WinSCP - https://winscp.net/eng/index.php
WinSCP is a software to download files from other devices on the same Wi-Fi network. We can use this to download the Dataflash logs much faster than through the radio and save them in specific directories with desired naming conventions.

0.2 Get the IP Address of your Raspberry Pi

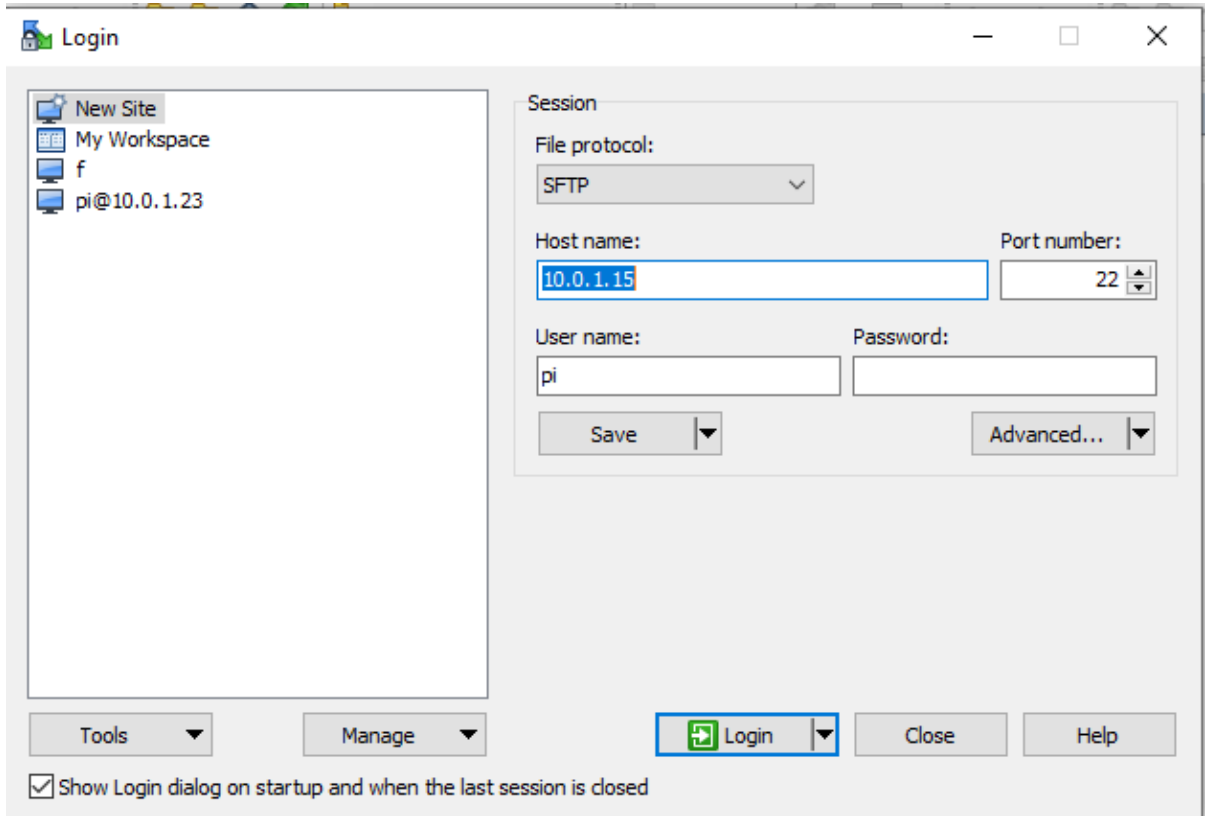
Step 1a Importing Logs using WinSCP

1a.1 Open WinSCP

You will get a terminal like this, it's similar to Putty in which you must enter the IP address of the Navio2 along with the username and password (username: pi, password: raspberry).

Or if you have the hostname (Default is "navio"), you can just enter that in place of the IP Address.

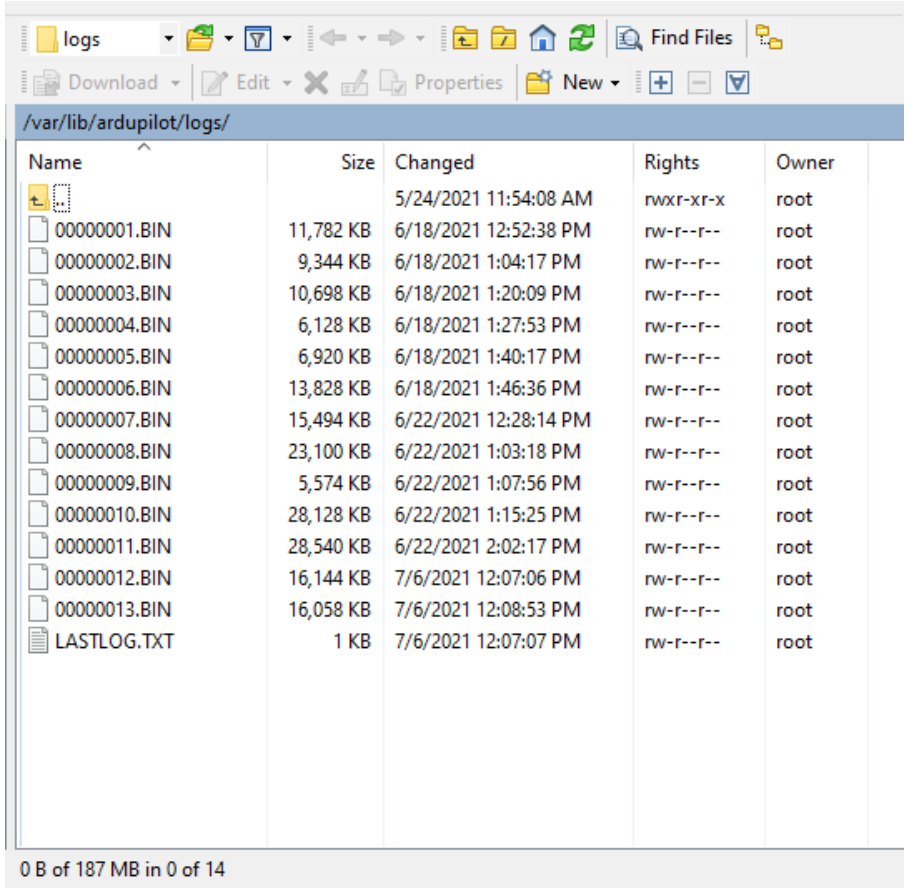
Once you log in you will be able to look through all the files available on the Navio2.



Step 1a Importing Logs using WinSCP

1a.2 Once you have logged in to WinSCP, navigate to where the Dataflash logs are stored on the Navio2. Go to /var/lib/ardupilot/logs/ to find them.

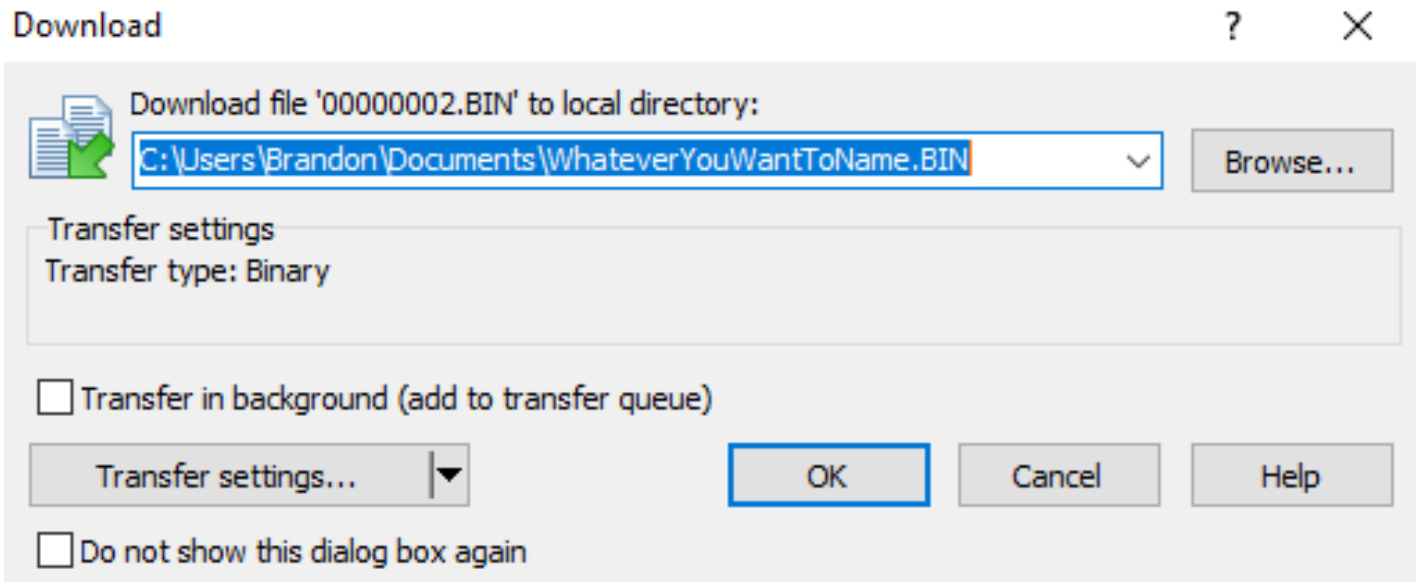
The logs are made in order, so “00000001.BIN” was made first, and “00000013.BIN” was made last.



Step 1a Importing Logs using WinSCP

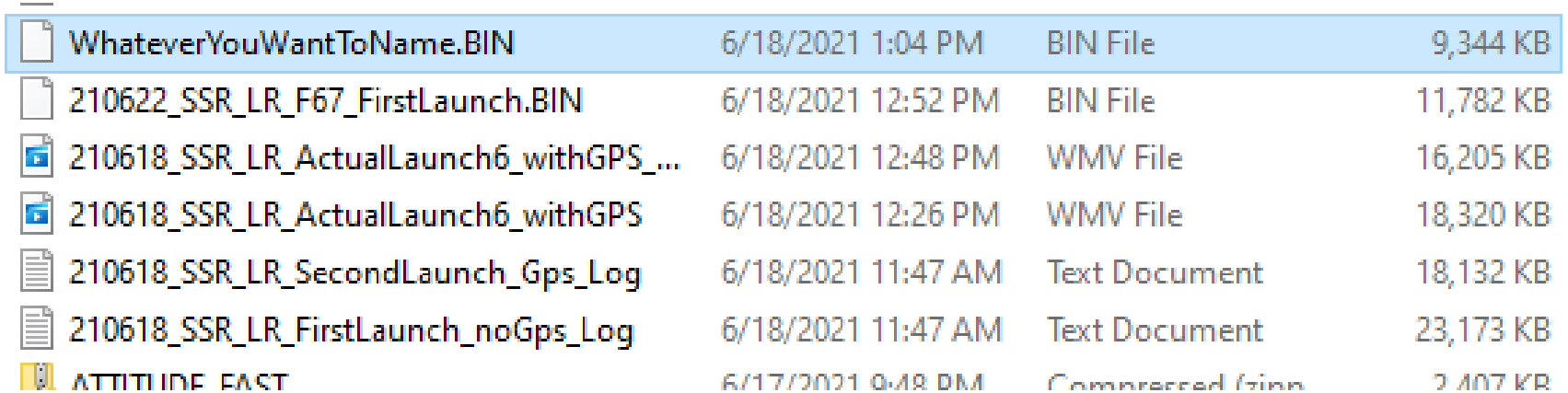
1a.3 Click on the BIN file you wish to download to your computer and click the Download button.

1a.4 Once you have clicked the download button, the below pop-up will appear allowing you to specify the name and location of the file you want to transfer. I have selected the file to be downloaded in my Documents folder for easy access. You then can name the file whatever you want as long as at the end you add the ".BIN" this will make sure the file is transferred as a BIN file. Select OK when you are ready to transfer.



Step 1a Importing Logs using WinSCP

1a.5 After hitting “OK” the file will download and you can then view it on your own computer in the location you saved the file. Once you have the BIN file downloaded you can disconnect from WinSCP as you have the files you need. From here you can now look at the results of the launch with mission planner or UAV Log Viewer.



Step 1b Importing Logs Using a Flash Drive

1b.1 This is an alternative method to the WinSCP method discussed in other documentation to circumvent issues connecting the Navio2 to an internet network.

First Connect a Monitor and Keyboard to your Navio2 and power it on.

Make sure you have a formatted flash drive with the “FAT” format style and have created a folder labeled “Logs”

1b.2

The SD cards we provide should have a usb folder with them, so you should not have to format the folder. However, if you need to create a folder, follow the instructions below

1. Log in to your Raspberry Pi using the standard Username and Password (pi/raspberry)
2. Create the USB Directory using the following command
   `"sudo mkdir /media/usb"`
3. Added permissions to the folder
   `"sudo chmod 775 /media/usb"`
4. You should now have a folder we will use as our USB directory

Step 1b Importing Logs Using a Flash Drive

1b.3 Now we must find the address of our flash drive. Each device has its own address that we need to know in order to interface. To confirm which address is our flash drive. We will first check the available addresses without the flash drive plugged in. Then we will plug in the flash drive and check addresses again. This way the new address we know corresponds to our flash drive.

1b.4 Without the flash drive plugged in, enter the command `"ls -l /dev/disk/by-uuid/"`

```
pi@navio:~ $ ls -l /dev/disk/by-uuid/
total 0
lrwxrwxrwx 1 root root 15 May  6 20:42 c01a67e8-c560-4be5-bb51-1514a5b342bb ->
./../mmcblk0p2
lrwxrwxrwx 1 root root 15 May  6 20:42 CC1C-A424 -> ../../mmcblk0p1
```

Step 1b Importing Logs Using a Flash Drive

1b.5 Now insert the flash drive and run the command again

```
pi@navio:~ $ ls -l /dev/disk/by-uuid/
total 0
lrwxrwxrwx 1 root root 10 May  6 21:30 68B8-90E0 -> ../../sdc1
lrwxrwxrwx 1 root root 15 May  6 20:42 c01a67e8-c560-4be5-bb51-1514a5b342bb ->
./../mmcblk0p2
lrwxrwxrwx 1 root root 15 May  6 20:42 CC1C-A424 -> ../../mmcblk0p1
```

1b.6 We can see that the new ID has an address "../../sdc1" in this case, "sdc1" is our address that we will want to take note of.

1b.7 Now we want to connect to our flash drive using the mounting command
"`sudo mount /dev/***  /media/usb -o uid=pi,gid=pi`"

```
pi@navio:~ $ sudo mount /dev/sdc1 /media/usb -o uid=pi,gid=pi
```

In our case, the "***" will be "**sdc1**" the address of our flash drive.

Step 1b Importing Logs Using a Flash Drive

1b.8 Now we can view the available logs that we want to export to our flash drive using the command

"cd /var/lib/ardupilot/logs" followed by the "ls" command to list all files

```
pi@navio:~ $ cd /var/lib/ardupilot/logs/
pi@navio:/var/lib/ardupilot/logs $ ls
00000001.BIN  00000012.BIN  00000023.BIN  00000034.BIN  00000045.BIN
00000002.BIN  00000013.BIN  00000024.BIN  00000035.BIN  00000046.BIN
```

1b.9 If you want to just copy one file (Say the first log "00000001.BIN")
"sudo cp /var/lib/ardupilot/logs/00000001.BIN /media/usb/Logs"

```
pi@navio:/var/lib/ardupilot/logs $ sudo cp /var/lib/ardupilot/logs/00000001.BIN
/media/usb/Logs/
```

1b.10 If we want to download all available logs, use
"sudo cp -R /var/lib/ardupilot/logs /media/usb/Logs"

```
pi@navio:/var/lib/ardupilot/logs $ sudo cp -R /var/lib/ardupilot/logs /media/usb
/Logs/
```

When you hit enter this might take a second depending on how many logs you have. give it some time

Step 1b Importing Logs Using a Flash Drive

1b.11 Now that we have our data downloaded, we will unmount our flash drive.

Use the command "`sudo umount /media/usb`"

You should always unmount the flash drive after you are done, otherwise if you plug it back in the address will have changed.

```
pi@navio:/var/lib/ardupilot/logs $ sudo umount /media/usb
```

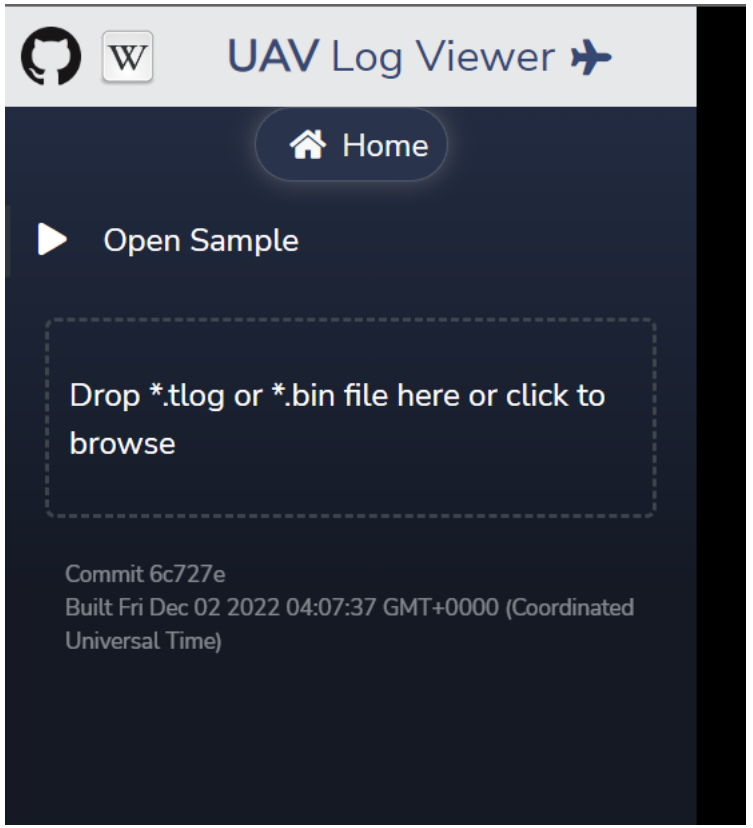
1b.12 Now you should have a flash drive full of your desired logs in the form of BIN files!

Step 2 Viewing BIN Files in UAV Log viewer

2.1 UAV Log viewer is a Web-Based file viewer for Ardupilot flight logs. You do not need to download any additional software to use it. It also has the capability of creating CSV files of selected flight data for you to look at in programs such as Excel

2.2 First Navigate to the site : https://plot.ardupilot.org/#/

2.3 You will see a Page like this with the option to load in either .tlog or .bin files

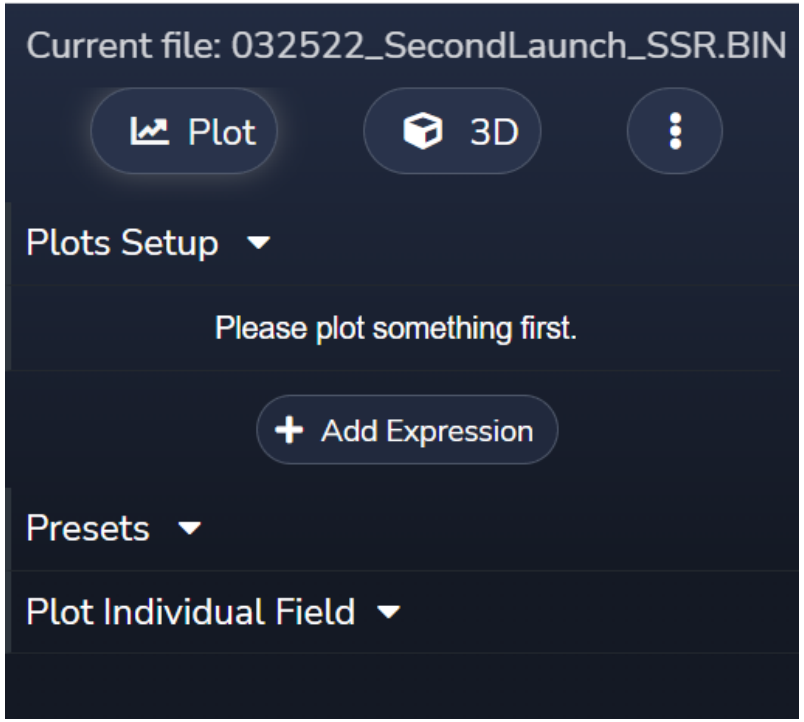


Step 2 Viewing BIN Files in UAV Log viewer

2.4 Click the box to open up a file browser to select your desired bin file you wish to view

2.5 Once you have selected your file, it will load it and show you a map containing your flight data along with the available data you can plot.

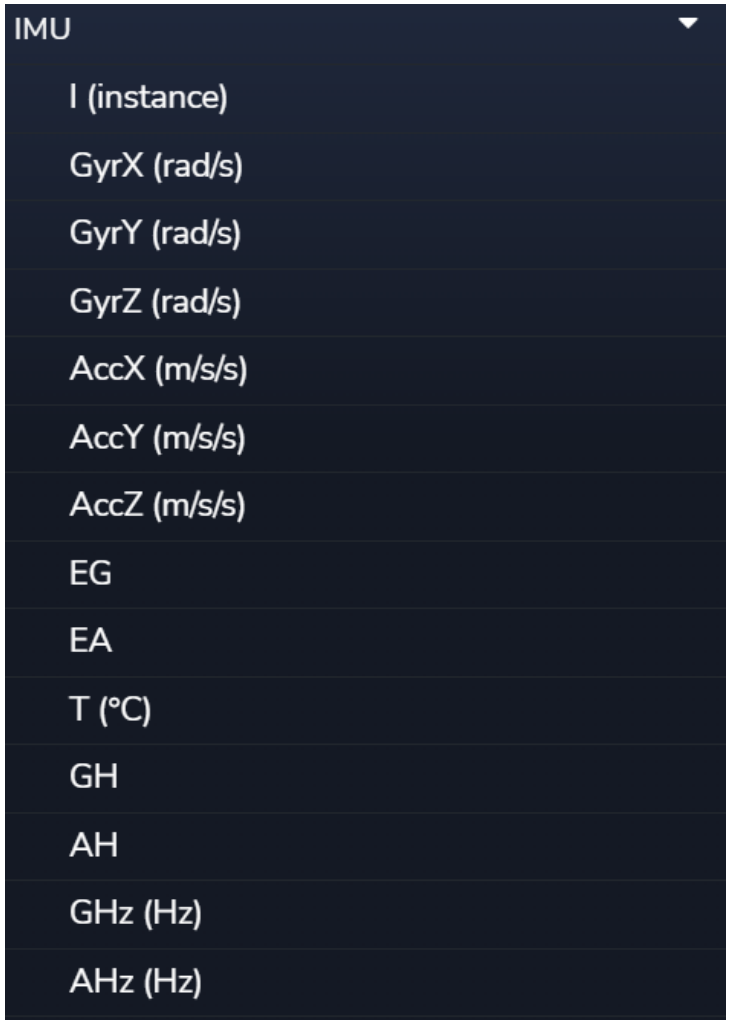
2.6 If you select the “Plot Individual Field” it will list the groups you can view such as IMU data.



Step 2 Viewing BIN Files in UAV Log viewer

2.7 For the Single-Stage Rocket, we are focused on three sets of data, Z-Acceleration, Altitude, and Z-Velocity.

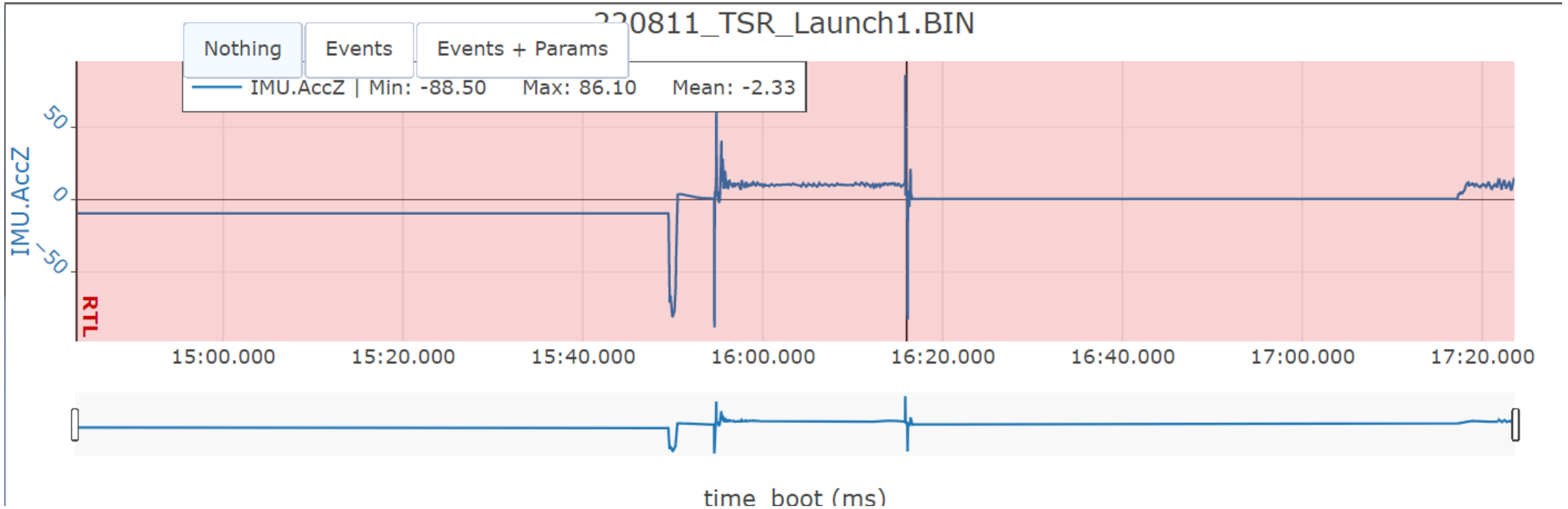
2.8 Open up the Plot Individual Field and scroll to the “IMU” tab and open it. You will see all IMU parameters listed there.



Step 2 Viewing BIN Files in UAV Log viewer

2.9 If you Select the AccZ (Z-Acceleration), it will create a plot on the right side.

If you only wish to look at the plot, you can select the “X” on the map to close it in the lower half of the screen. This will remove the map and only show you plots.

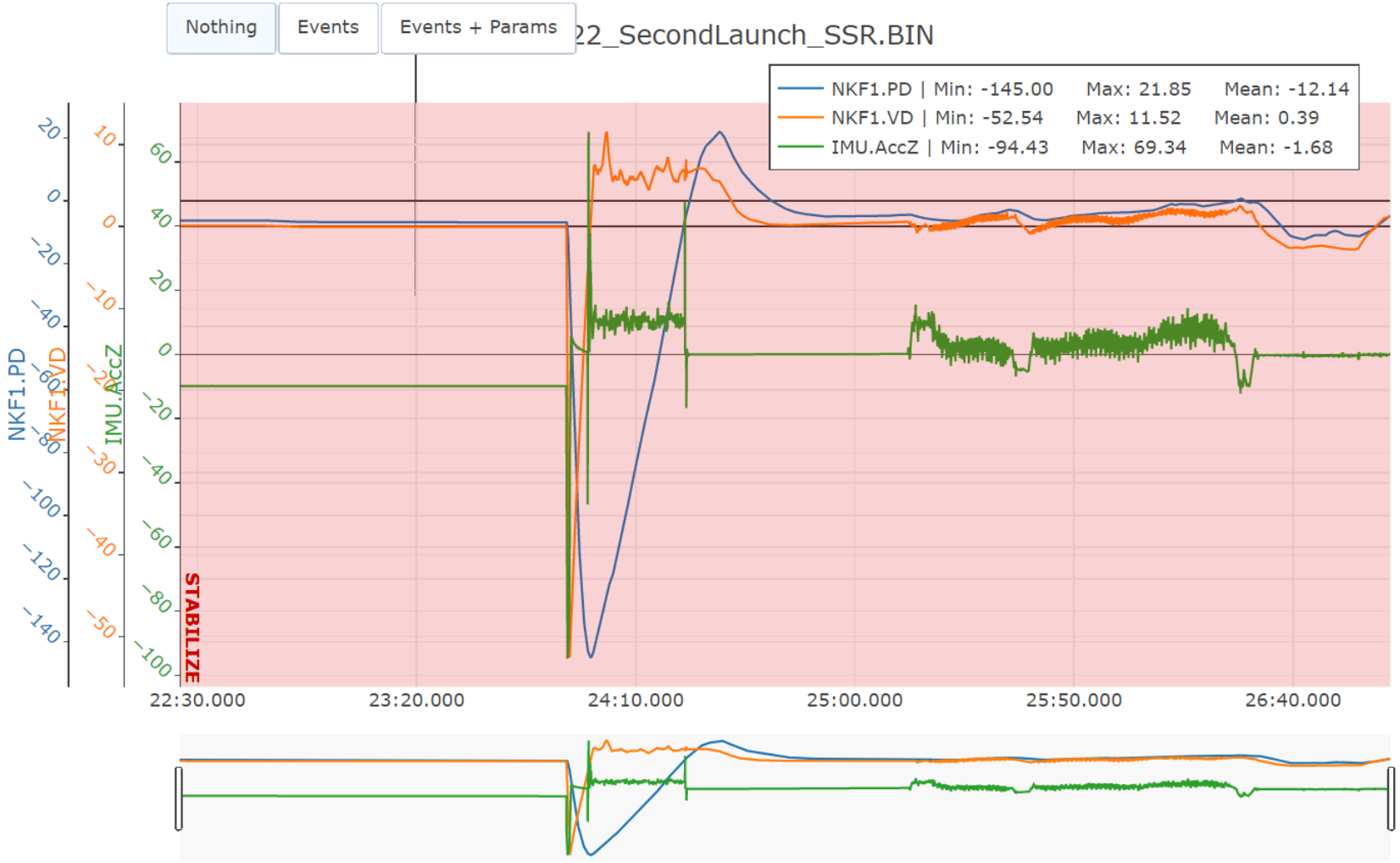


Step 2 Viewing BIN Files in UAV Log viewer

2.10 Now lets add the other two data points:
Altitude is in the NKF1.PD parameter (Representing Position in the downward direction)
Velocity in the Z-Axis is NKF1.VD (Representing Velocity in the Downward Direction)

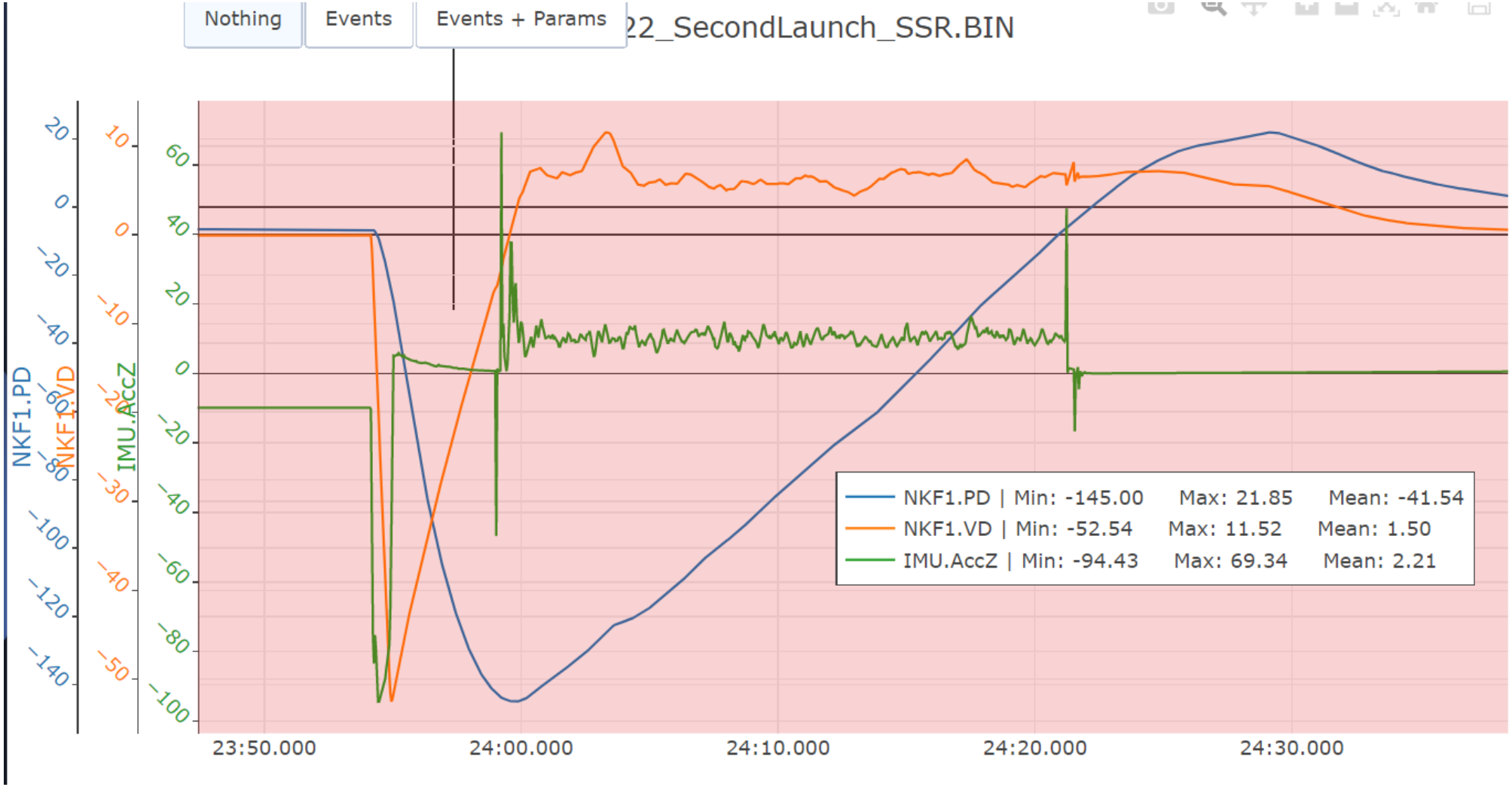
Step 2 Viewing BIN Files in UAV Log viewer

2.11 With all three selected, you should have a Log viewer single plot with all data on it. You may notice multiple Y-Axis bars, these are representing the different Y-Values for each plot



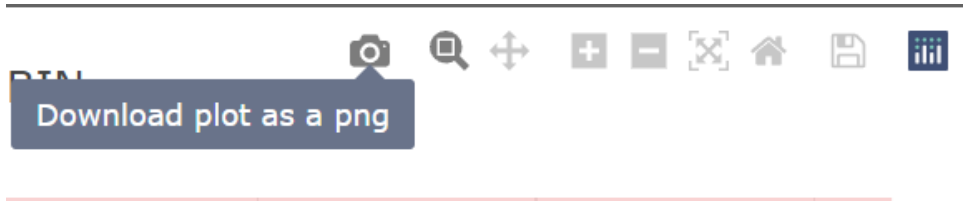
Step 2 Viewing BIN Files in UAV Log viewer

2.12 Now if you hold left click and drag around the center of the graph, you can select a zoom area to for the data. When you let go, it will now zoom in to the highlighted area.

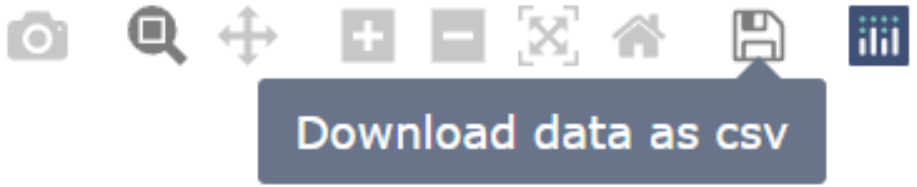


Step 3 Exporting Data from UAV Log Viewer

3.1 If you'd like you can now take screen shots of this zoomed portion using the save as a .png option in the top right



3.2 Or, if you'd like to save these three data sets as a CSV, you can select the download as a CSV option. Note this will save the entirety of the three data sets, not just your zoomed in portion.



3.3 Once you have downloaded the data set, it will appear with a simple name “data.csv” in your downloads folder. From here you can rename it and open in excel.