Single-Stage Rocket (SSR)

Avionics Instructions

Department of Defense
DoDSTEM
Science · Technology · Engineering · Mathematics

SOUTHERN ILLINOIS UNIVERSITY
EDWARDSVILLE

UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

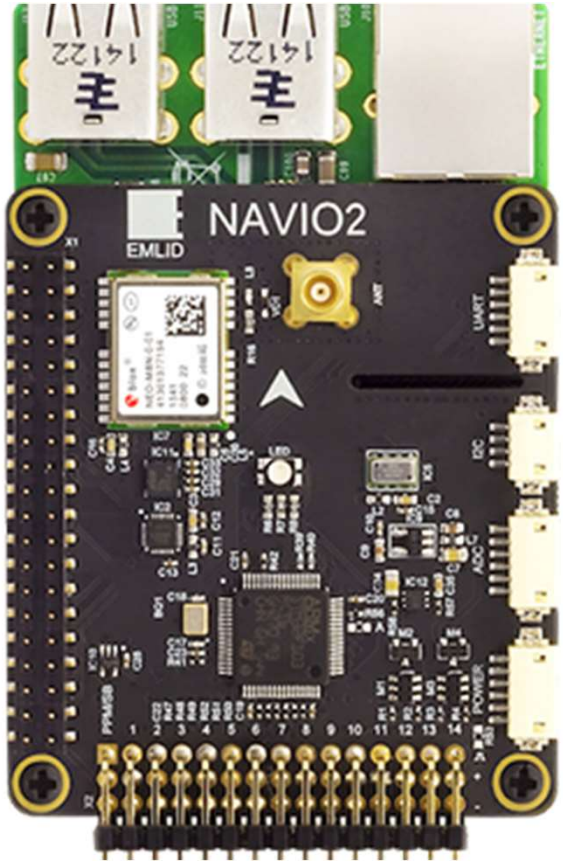
USB Flash Drive

Everyone is provided a flash drive with the following:

- Shortcut Links
  - Links to various helpful sites and content including OpenRocket, Github, National Association of Rocketry
- Example Data
  - This includes SSR data for previous launches in the event we are unable to launch this Friday
- Full Instructions
  - Includes both Rocketry and Avionics instructions
- PD Documentation
  - Includes schedules, pre-work, additional information
- Data Analysis
- Log Folder
  - This is where your launch files will be downloaded to when extracting data from your Avionics.

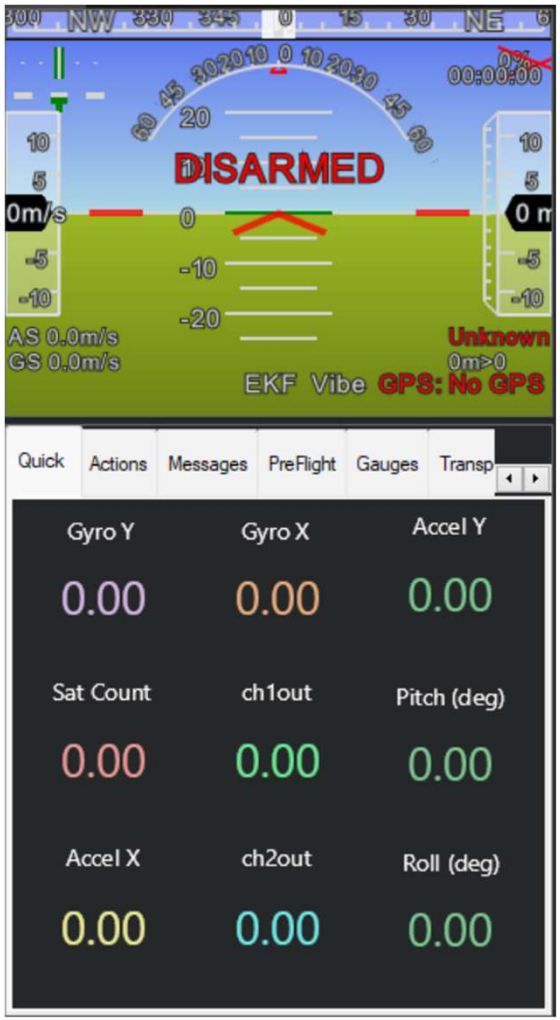
https://github.com/Brandonh291/Ready-Set-Launch-PD

Raspberry Pi and Navio2 Configuration



- Avionics Kit
- Power Supply
- SD Card Reader
- Internet Connection

Ardupilot and Mission Planner Configuration



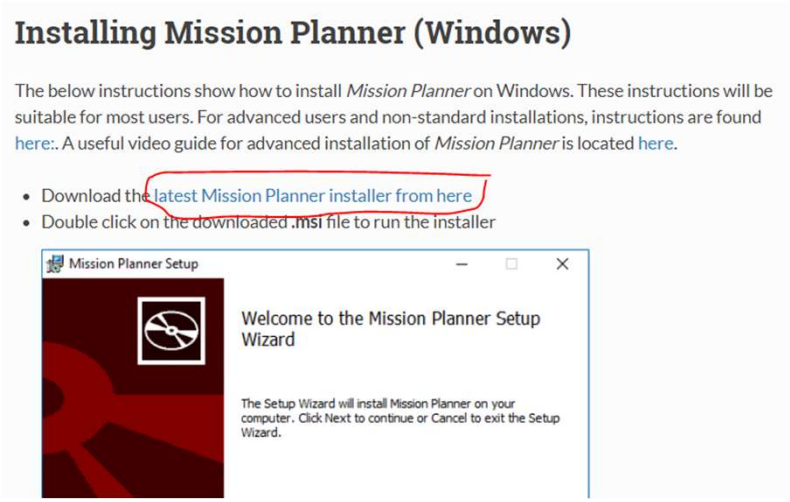
- Avionics Kits
- Telemetry Radio Kit
- Power Supply
- Internet Connection

Step 0 Install Mission Planner

0.1 Mission Planner is a software that acts as a Ground Control Station which sends and receives telemetry data from our rocket

0.2 The instructions for installing this software is listed in the Prework section of GitHub under “2023 SIUE PD Software Prework”

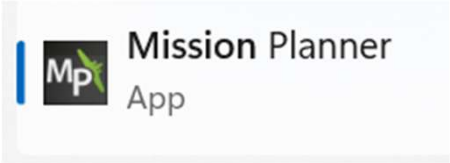
https://github.com/Brandonh291/Ready-Set-Launch-PD/tree/main/PD%20Documents%20and%20Prework



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. The instructions for installing the specific drivers are in the Prework section.

1.2 Open Mission Planner



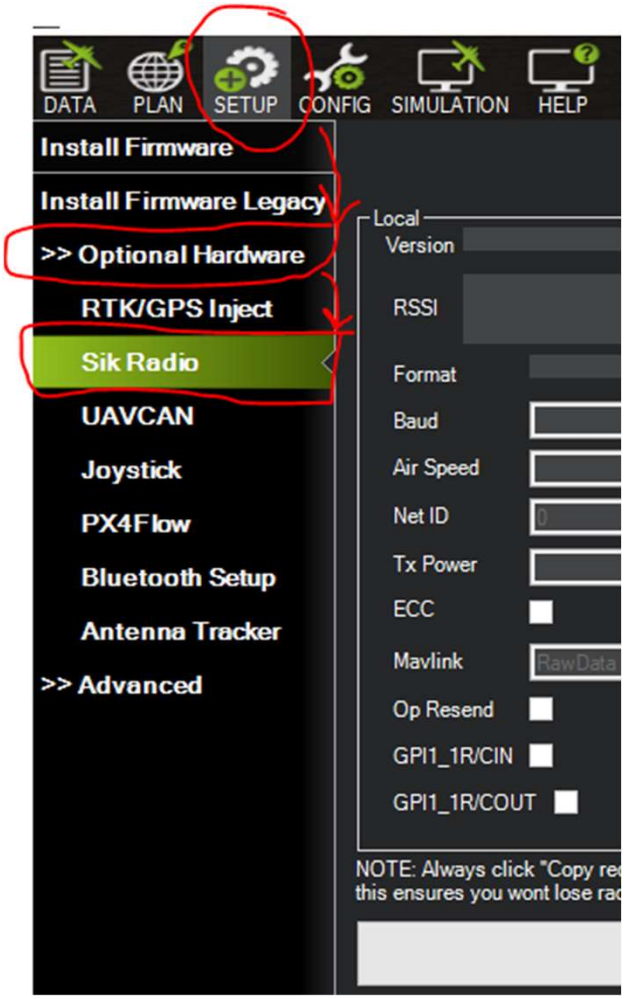
1.3 Plug one of your telemetry radios into your computer. For the sake of this tutorial we will be doing one radio at a time, however you are able to configure both radios at the same time

Step 1 Setup Mission Planner Telemetry

1.4 Navigate to the Telemetry Radio Section

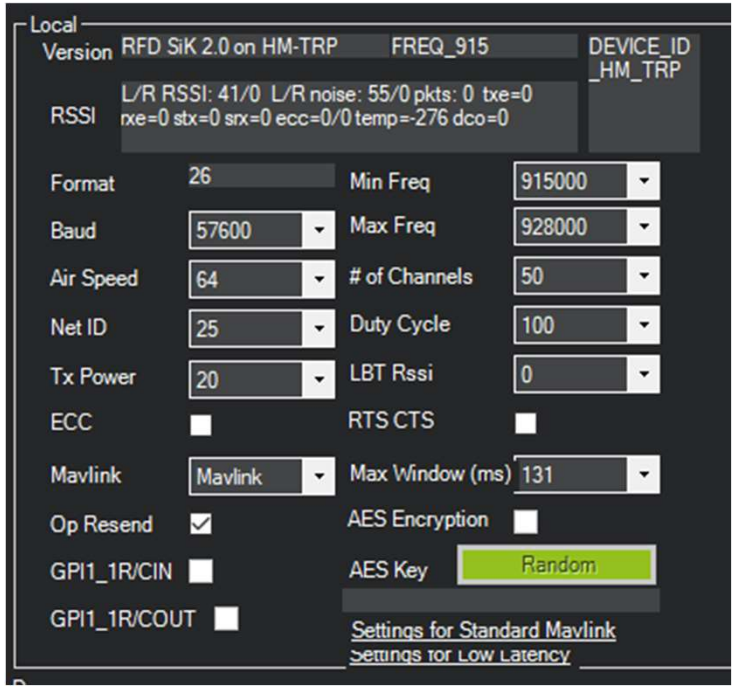
In mission planner, click the “Setup” tab at the top then open the “Optional Hardware” Tab on the side bar followed by clicking the “Sik Radio” tab that appears in the dropdown of the “Optional Hardware” tab.

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

1.15 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.



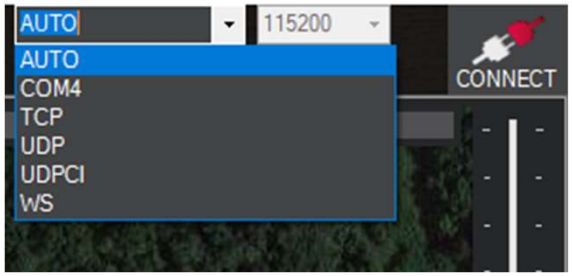
1.16 Most of these settings we will not need to change from the default. Our main two changes are the “Baud Rate” and “Net ID”.

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)

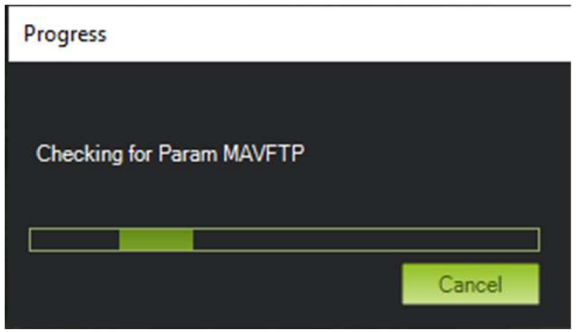
- Net ID: This is the identity for our radios, if there are multiple radios going it will be best to change the Net ID to a number different from every other radio, else you run the risk of communications affecting other people's vehicles. The default is 25 but you can select any number between 0 and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

Step 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

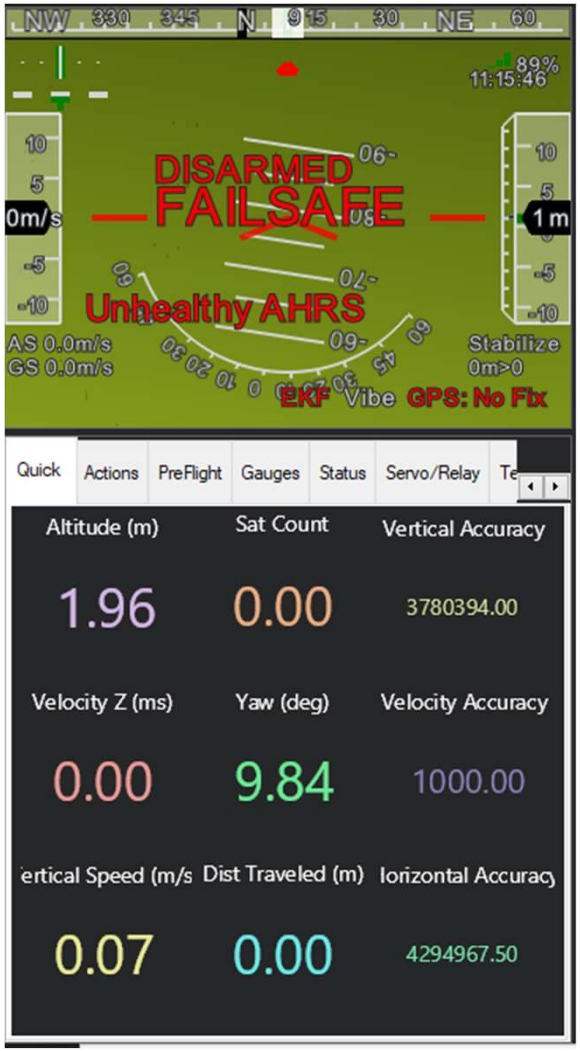


2.2 Press Connect, You will see a pop-up as the parameters load



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.

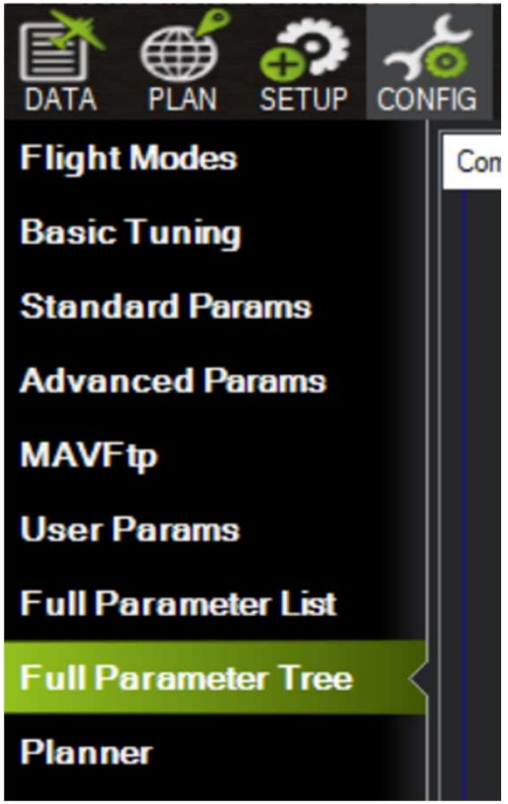


Step 3 Adjusting Parameters

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 4 Setting Custom AHRS Orientation

4.1 Because we have the navio2 mounted in the rocket tube point straight down, our initial set orientation is incorrect and will confuse our system given that at launch the navio2 would believe it was moving backwards instead of upwards.

We want our system to recognize moving backwards (negative x-acceleration) as position z-acceleration. To do this we have to rotate about our y-axis (pitch) with a set offset that cancels the current orientation of our Navio2. In this case, it is a negative 90 degree pitch.

Step 5 Disable Auto-Disarm

5.1 So currently if you tried to arm the Navio2, it would arm then disarm after a few seconds. This is because the system has a set timer for when it expects you to start moving after you arm and if it doesn't it will disarm. Since our rocket sits on the launchpad for varying amounts of time we want to be able to keep it armed.

5.2 Go to config -> Full Parameter List

Search for DISARM_DELAY

DISARM_DELAY	0	s	0 127	Delay before automatic disarm in seconds. A value of zero disables auto disarm.

5.3 Set value to 0. This disables the auto disarm.

5.4 Write Parameter to the Navio2

Step 6 Adjust Logging Parameters

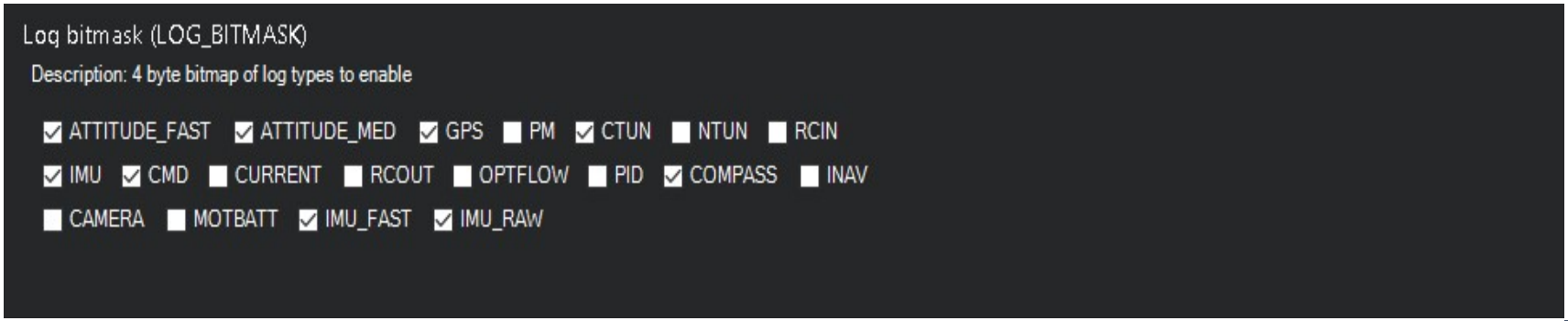
6.1 So the Navio2 has the ability to save its information into data flash logs onboard the Navio2, so even if you lost connection with the Navio2 during its flight, you could still recover the logs from the Navio2 afterwards. We had a crash where the battery cut off, but we were still able to view logs 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:
ATTITUDE_FAST, ATTITUDE_MED, GPS, CTUN, IMU, CMD, COMPASS, IMU_FAST, IMU_RAW

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 Removing Fail-Safe Triggers

7.1 The purpose of this is to prevent the rocket from entering a fail-safe mode and disarming, which results in a loss of data. This is only for the rocket as you would not want a Drone or Rover to continue operating through fail safes.

7.2 Go to config -> Full Parameter List

Search for THR_FAILSAFE

THR_FAILSAFE	0		0:Disabled 1:Enabled 2:EnabledNoFailsafe	0 disables the failsafe. 1 enables failsafe on loss of RC input. This is detected either by throttle values below THR_FS_VALUE, loss of receiver valid pulses/data, or by the FS bit in receivers that provide it, like SBUS. A programmable failsafe action will occur and RC inputs, if present, will be ignored. A value of 2 means that the RC inputs won't be used when RC failsafe is detected by any of the above methods, but it won't trigger an RC failsafe action.

7.3 Set value to 0. This disables the Throttle failsafe that would activate if it losses RC Input. Because our system does not use a remote control, this would trigger constantly otherwise.

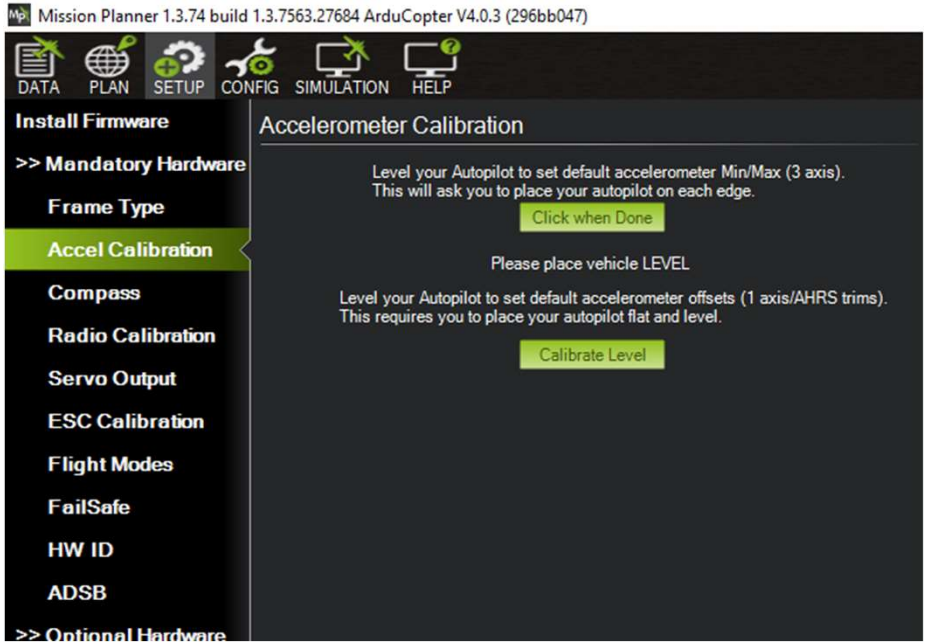
7.4 Write Parameter

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

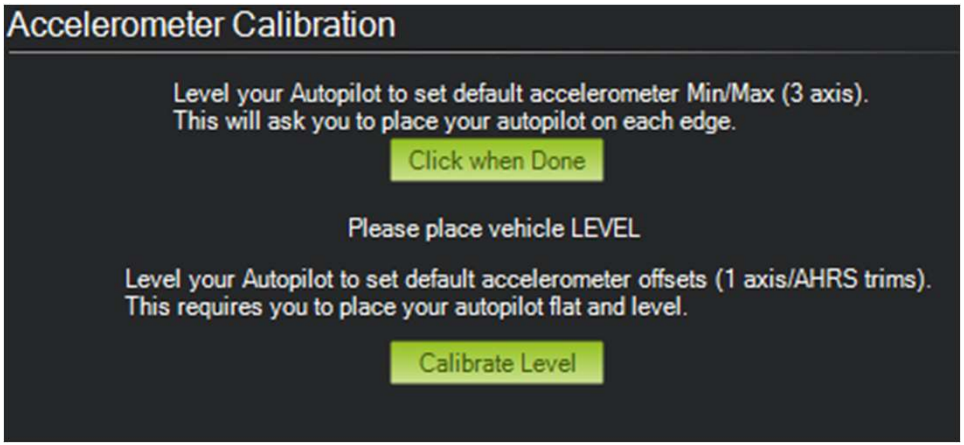
8.3 Select the button for “Level Your Autopilot to set default Accelerometer Min/Max (3 axis). Follow its guide on how to place for each step then press the “click when done” for each step.



Step 8 Calibrating IMU

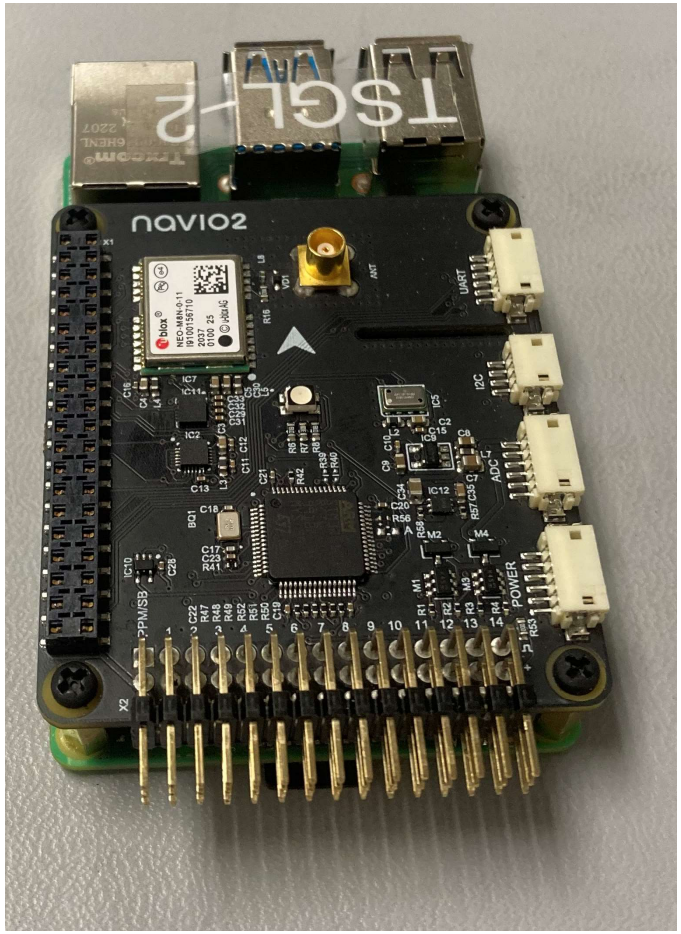
8.4 It will tell you each Orientation, set it in that orientation then press the “Click when Done”

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.



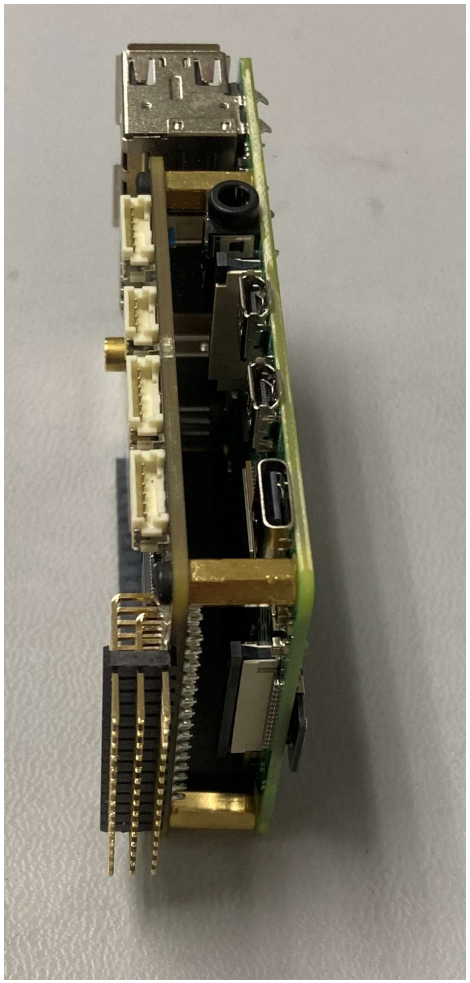
Step 8 Calibrating IMU

8.5 Level



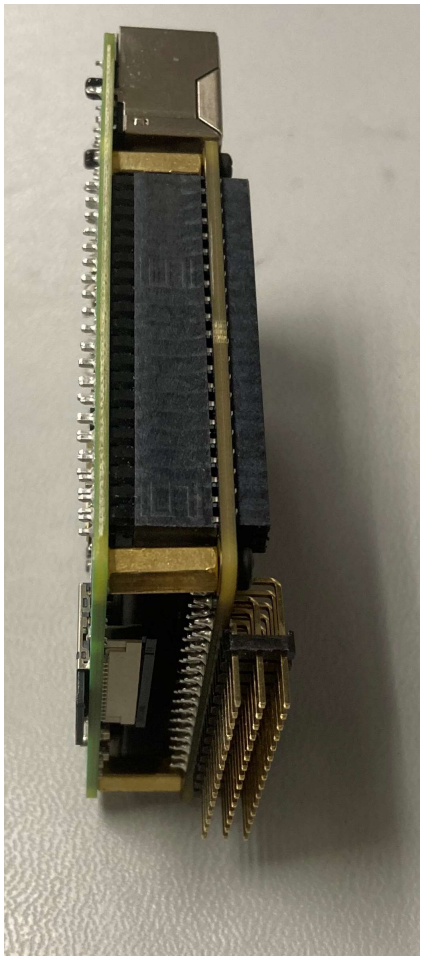
Step 8 Calibrating IMU

8.6 Left



Step 8 Calibrating IMU

8.7 Right

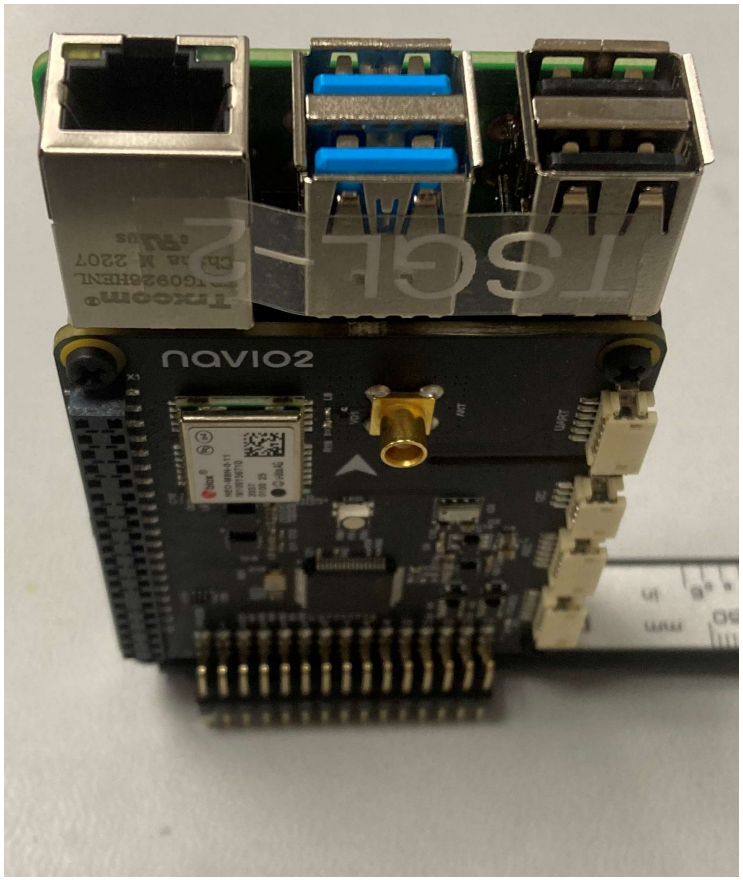


Step 8 Calibrating IMU

8.8 Nose Down

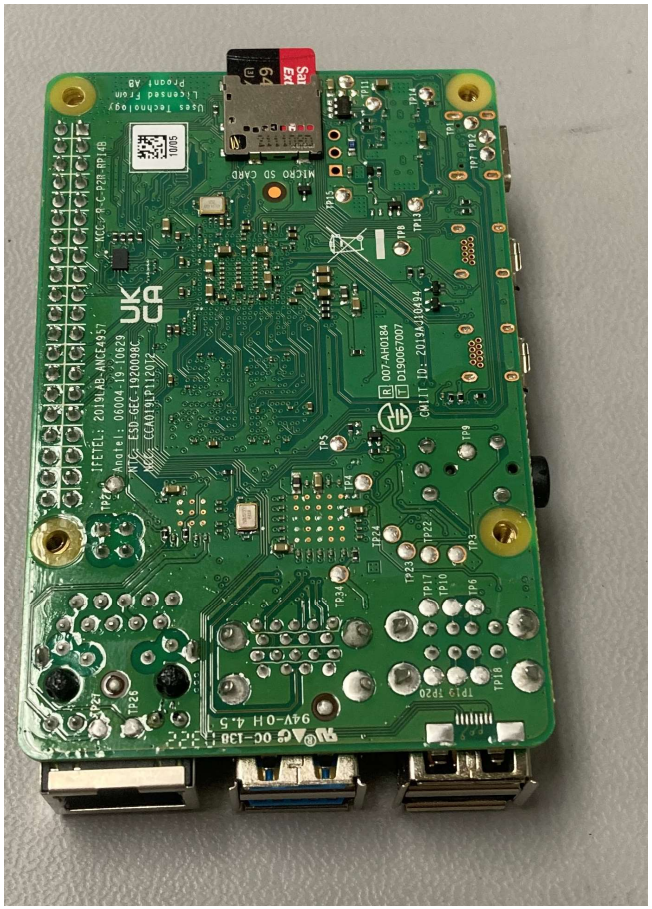
Step 8 Calibrating IMU

8.9 Nose Up



Step 8 Calibrating IMU

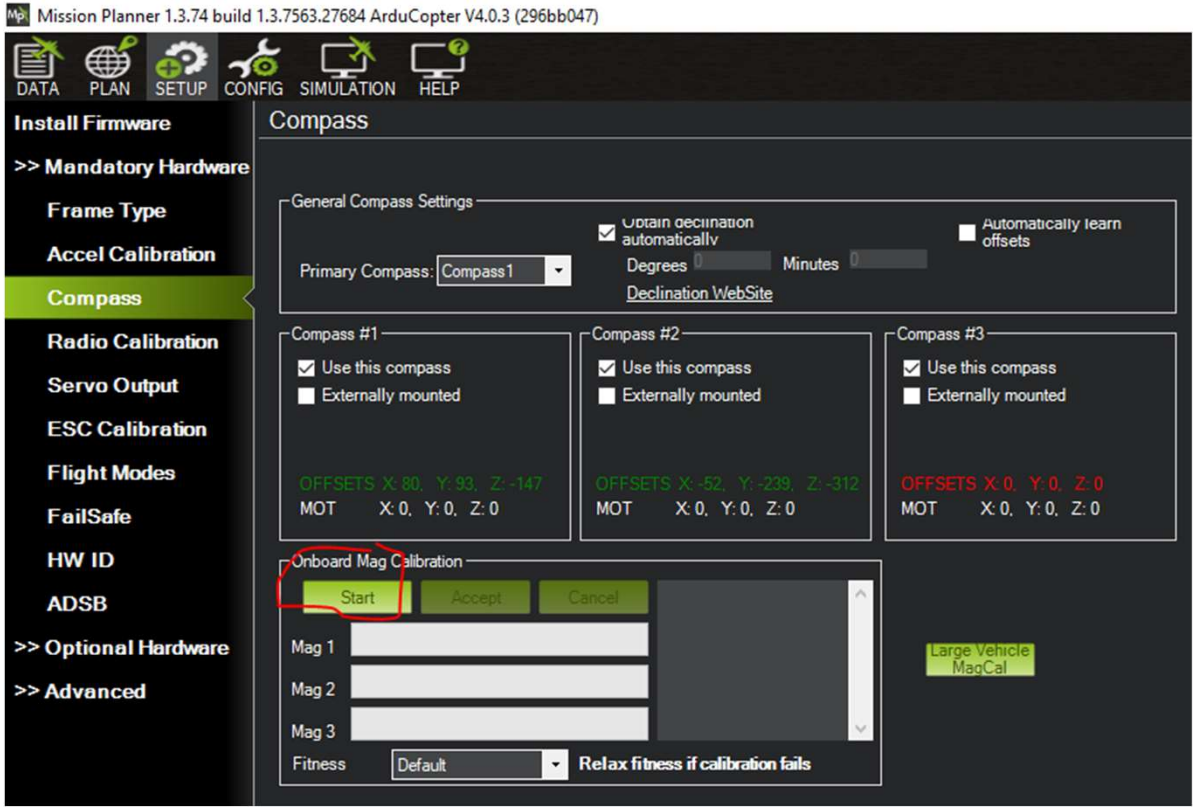
8.10 Back



Step 9 Calibrating Compass

9.1 Open Mission Planner and go to Setup -> Compass

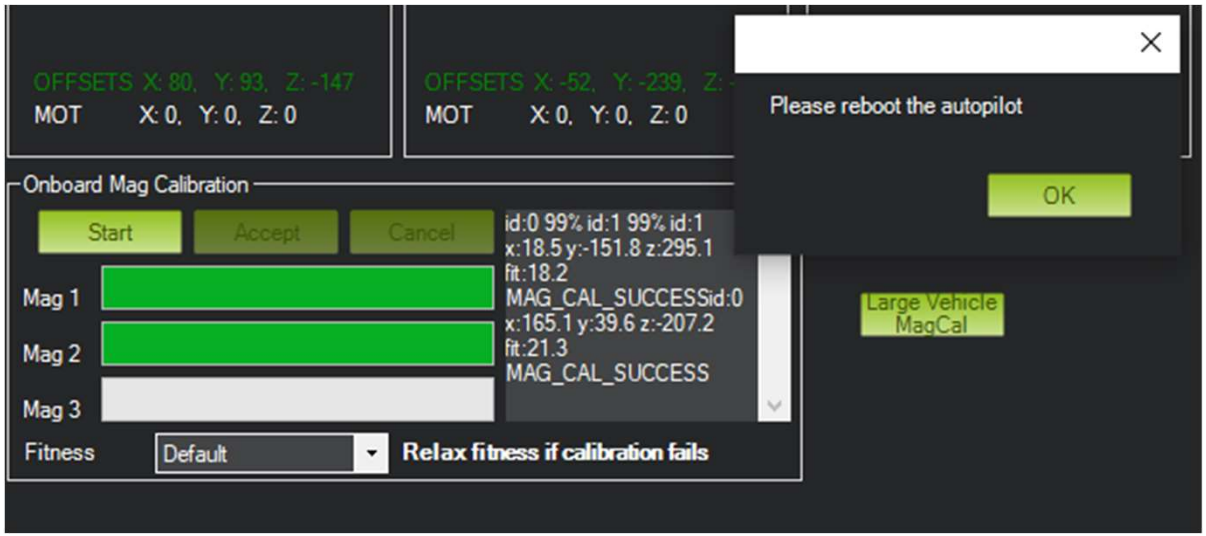
9.2 Click on “Start” for Onboard Calibration



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.

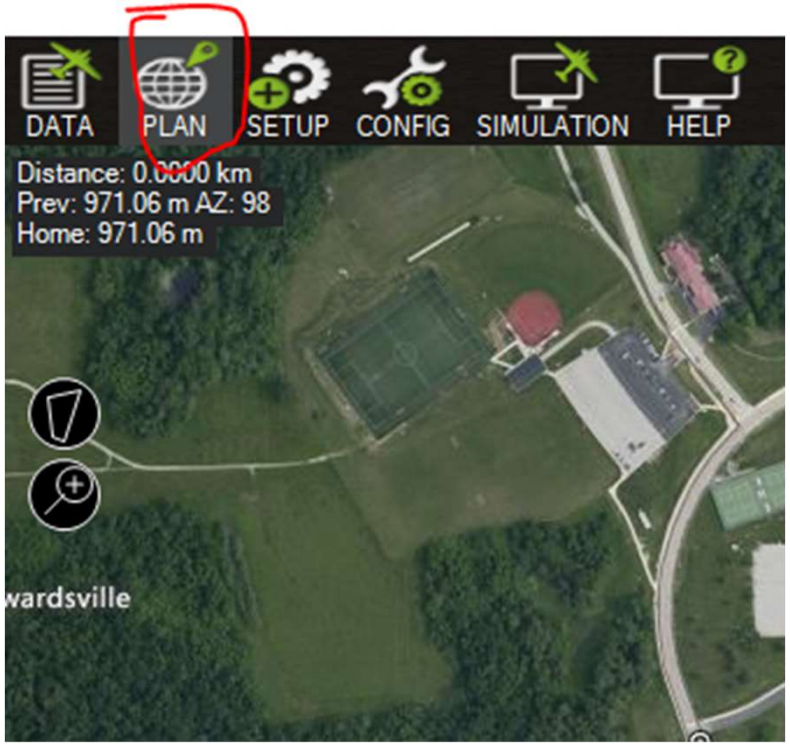
9.4 Once both are finished you will be prompted to restart the navio2 which you can do by pressing CTRL+F and clicking the “reboot Pixhawk” option



Step 10 Prefetching Maps

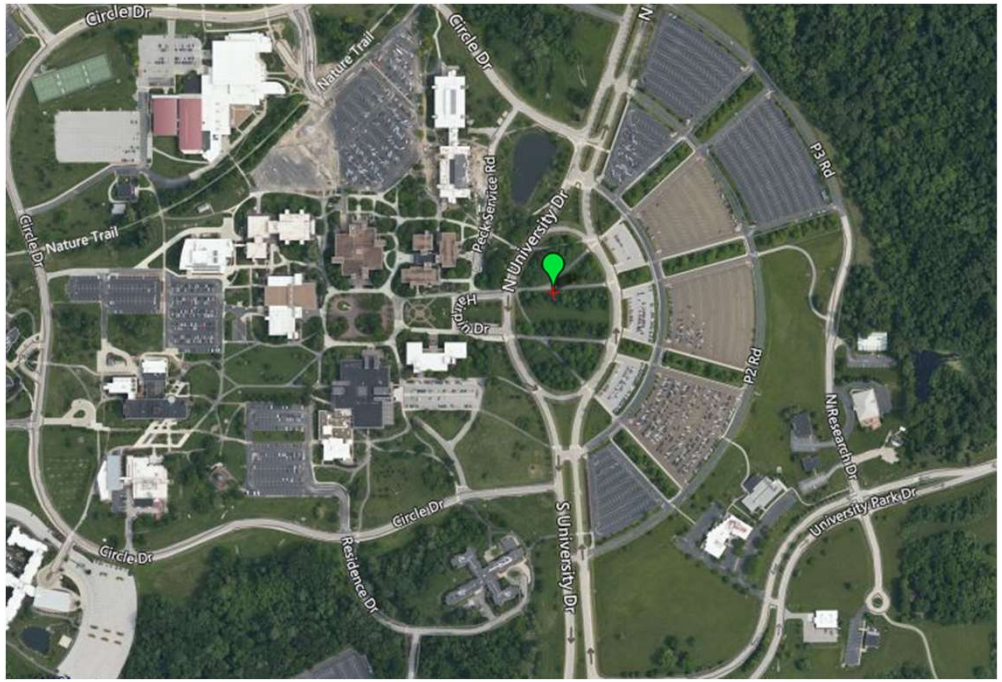
10.1 While connected to the internet, your ground control will show a high-quality map to reference your location, however if you are in an area without internet access your map will not be as good. To fix this, we will download a portion of the map that we plan to fly to maintain high quality visuals.

10.2 Go to Plan



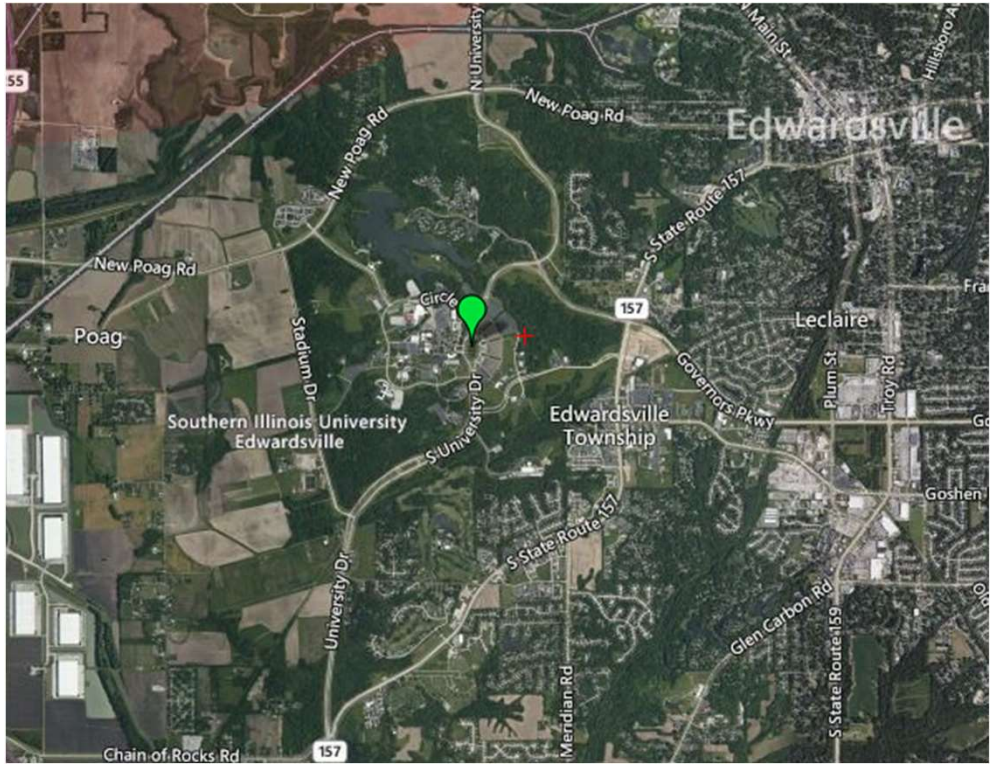
Step 10 Prefetching Maps

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



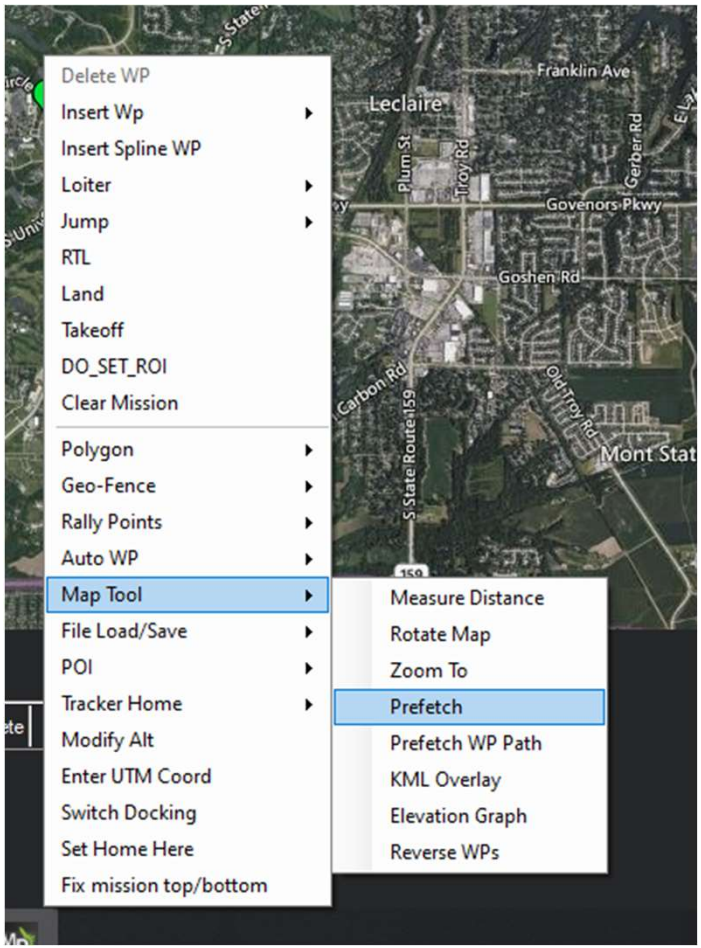
Step 10 Prefetching Maps

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



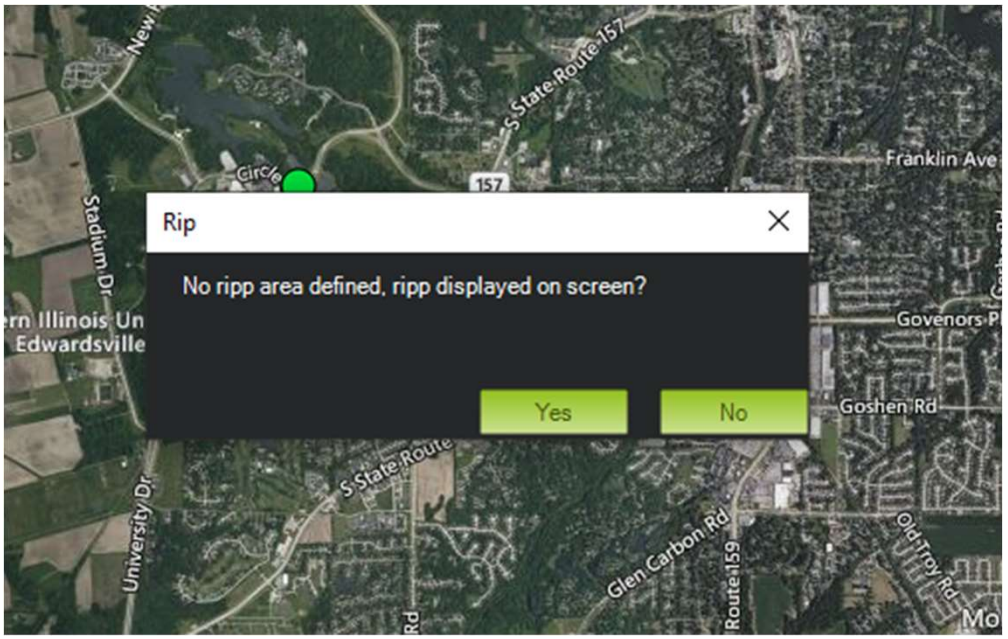
Step 10 Prefetching Maps

10.5 Right click and go to Map Tool - > Prefetch



Step 10 Prefetching Maps

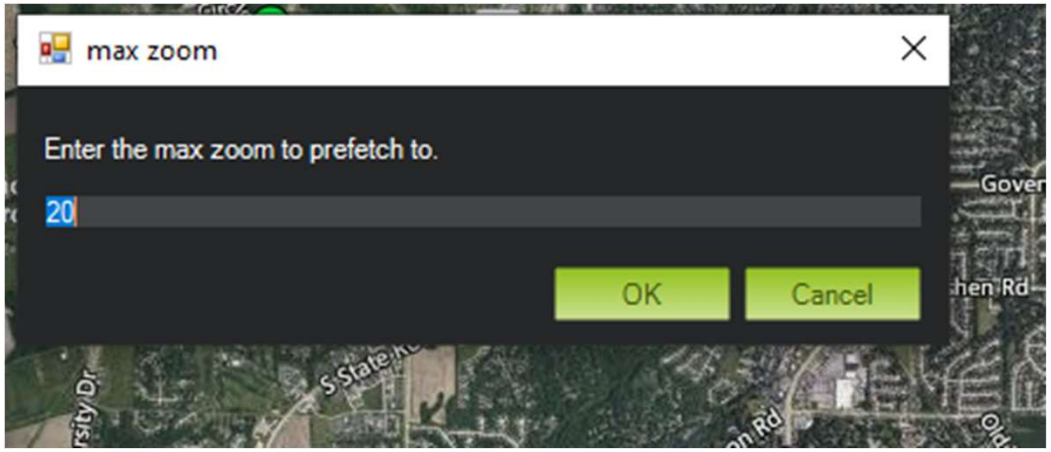
10.6 It will say “ No ripp area defined, ripp displayed on screen?”. Select yes, this will prefetch the entire map shown on your display



Step 10 Prefetching Maps

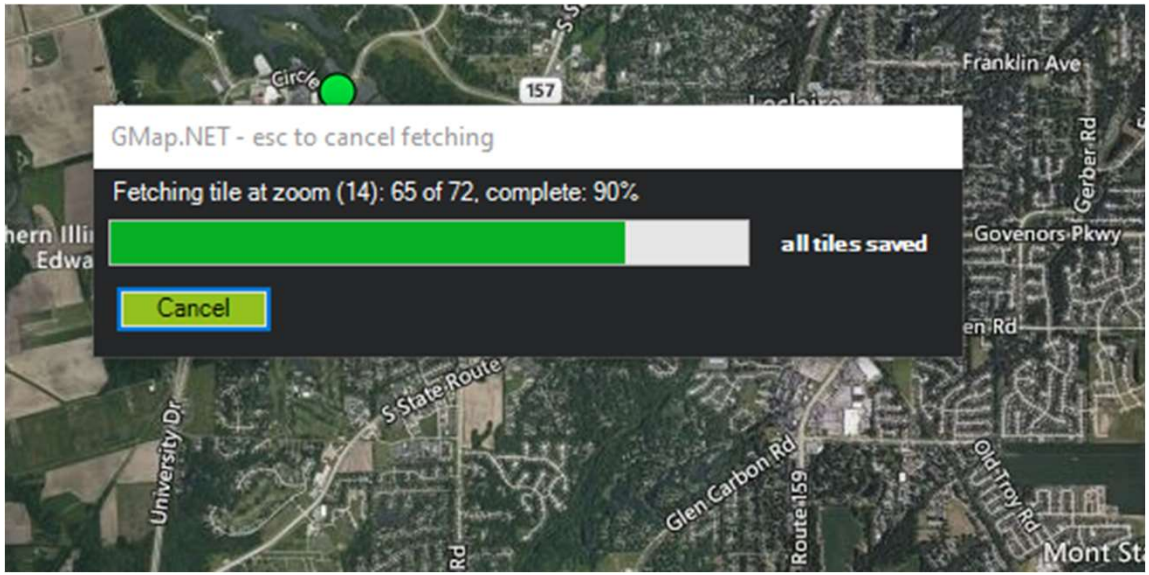
10.7 Select your desired zoom, the larger the number the longer it will take as it is zooming in and saving the more detailed zoomed images.

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.

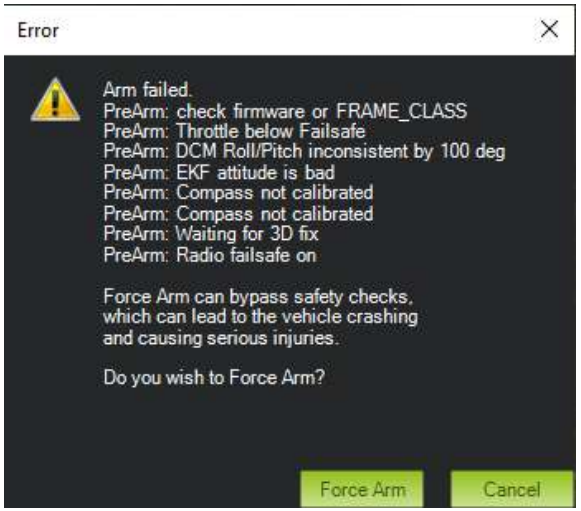


Step 11 Test Arming and Disarming

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.

Questions?

Data Extraction and Analysis

- Avionics Kit
- Power Supply
- Flash Drive
- Internet Connection

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/
```

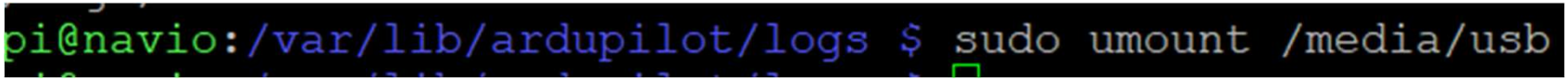
When you hit enter this might take a second depending on how many logs you have. give it some time

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.



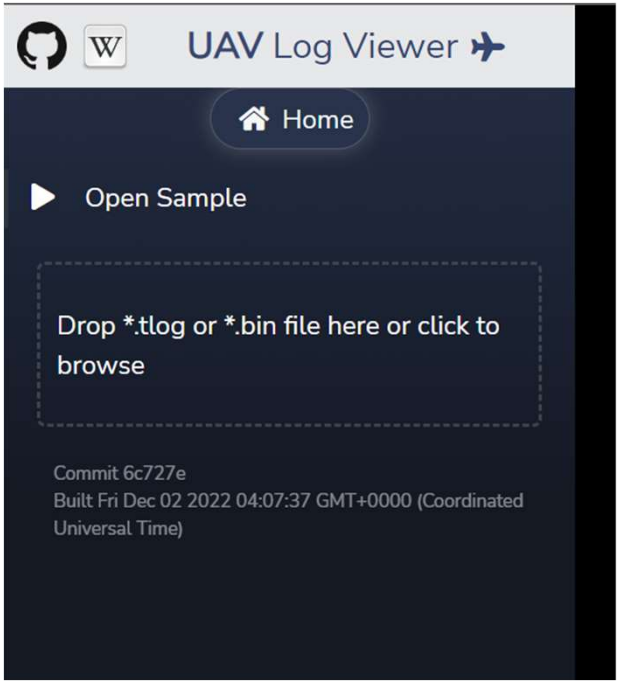
1b.12 Now you should have a flash drive full of your desired logs in the form of BIN files!

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

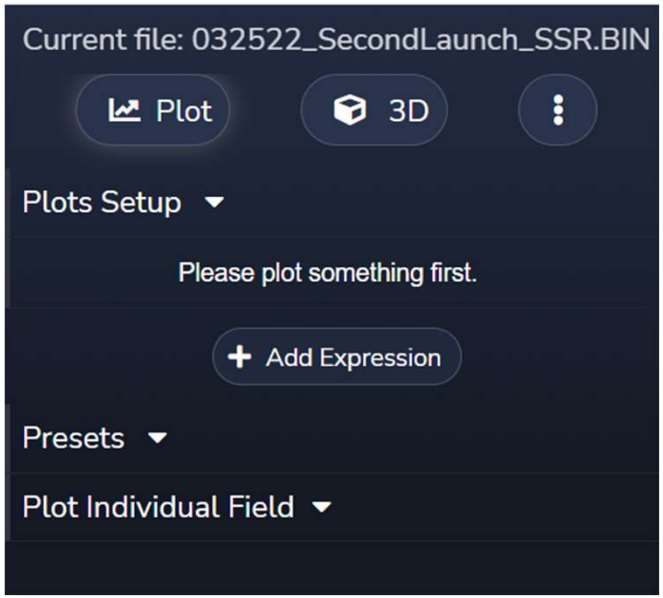


Step 2 Viewing BIN Files in UAV Log viewer

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.

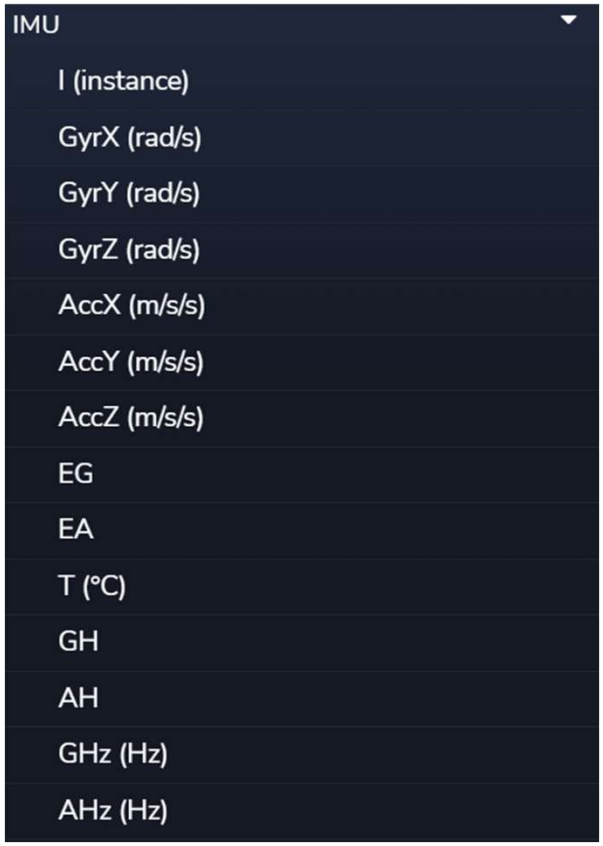
2.6 If you select the “Plot Individual Field” it will list the groups you can view such as IMU data.



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.

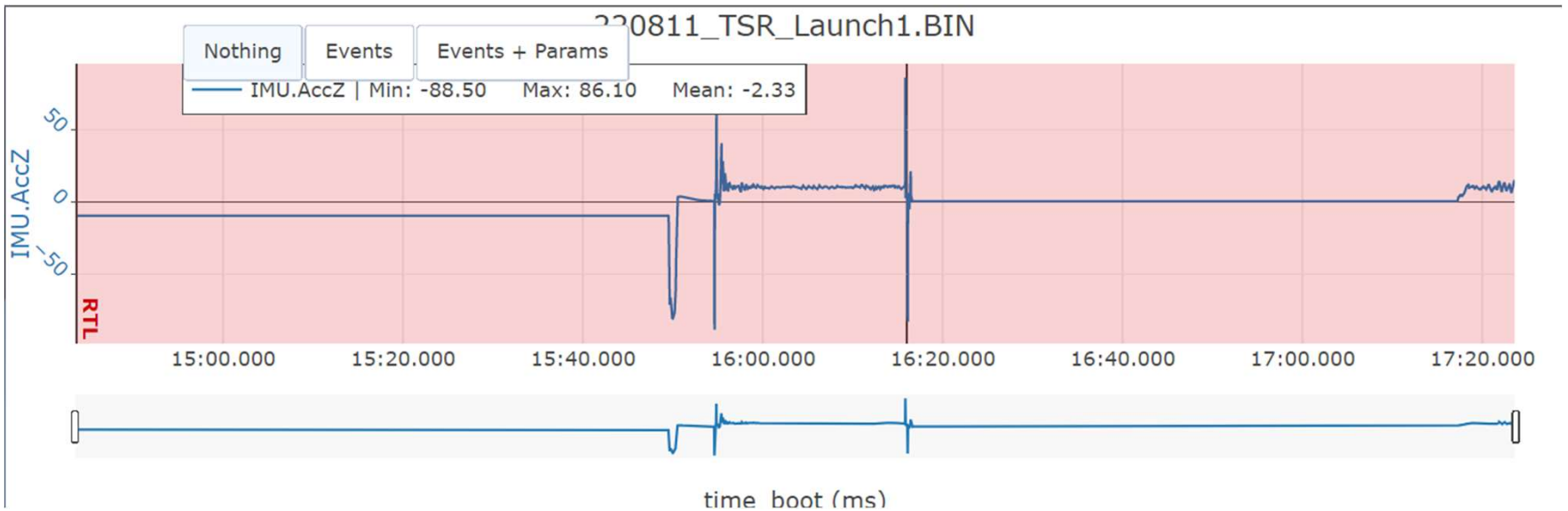
2.8 Open up the Plot Individual Field and scroll to the “IMU” tab and open it. You will see all IMU parameters listed there.



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.

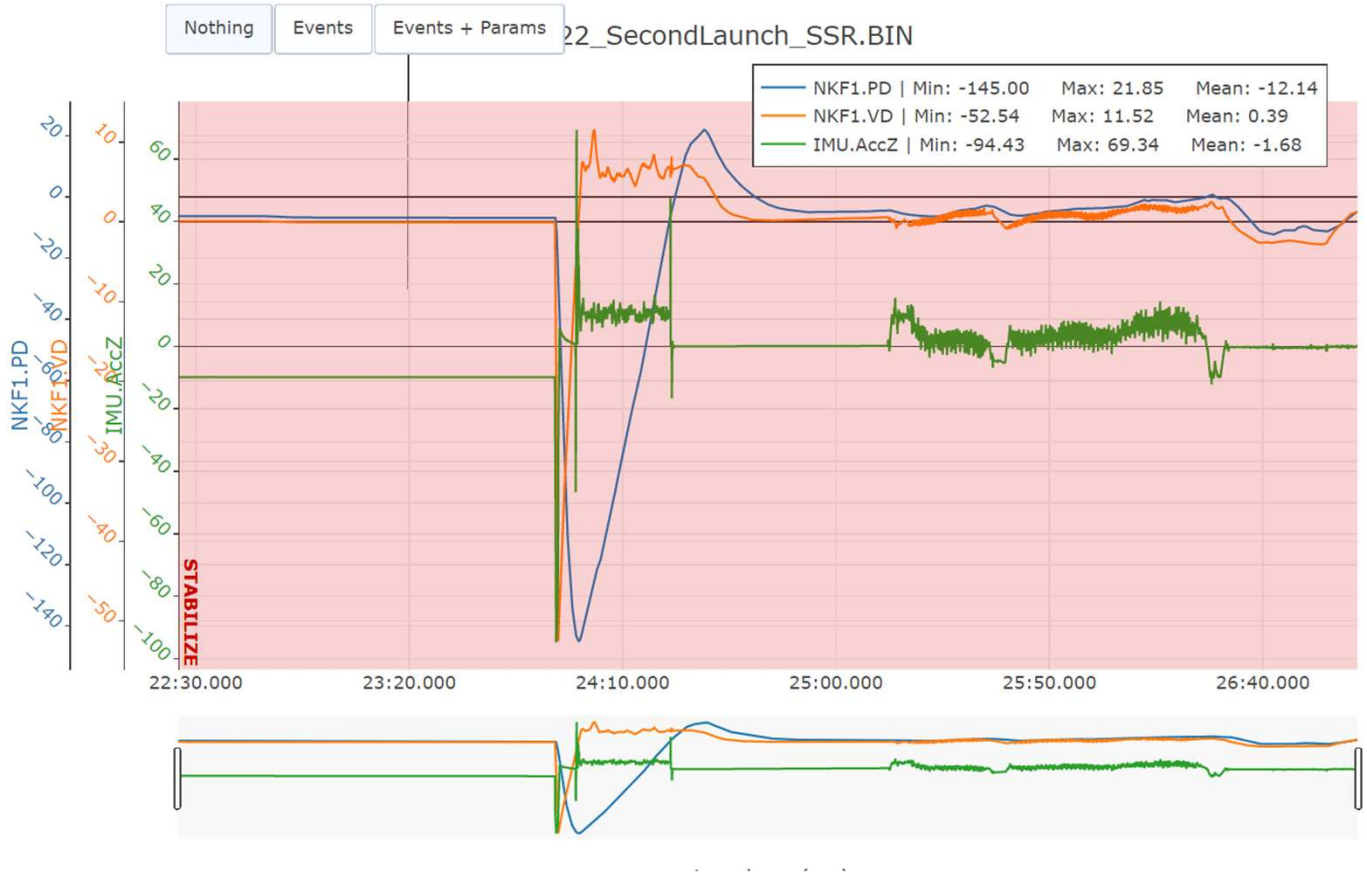


Step 2 Viewing BIN Files in UAV Log viewer

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)

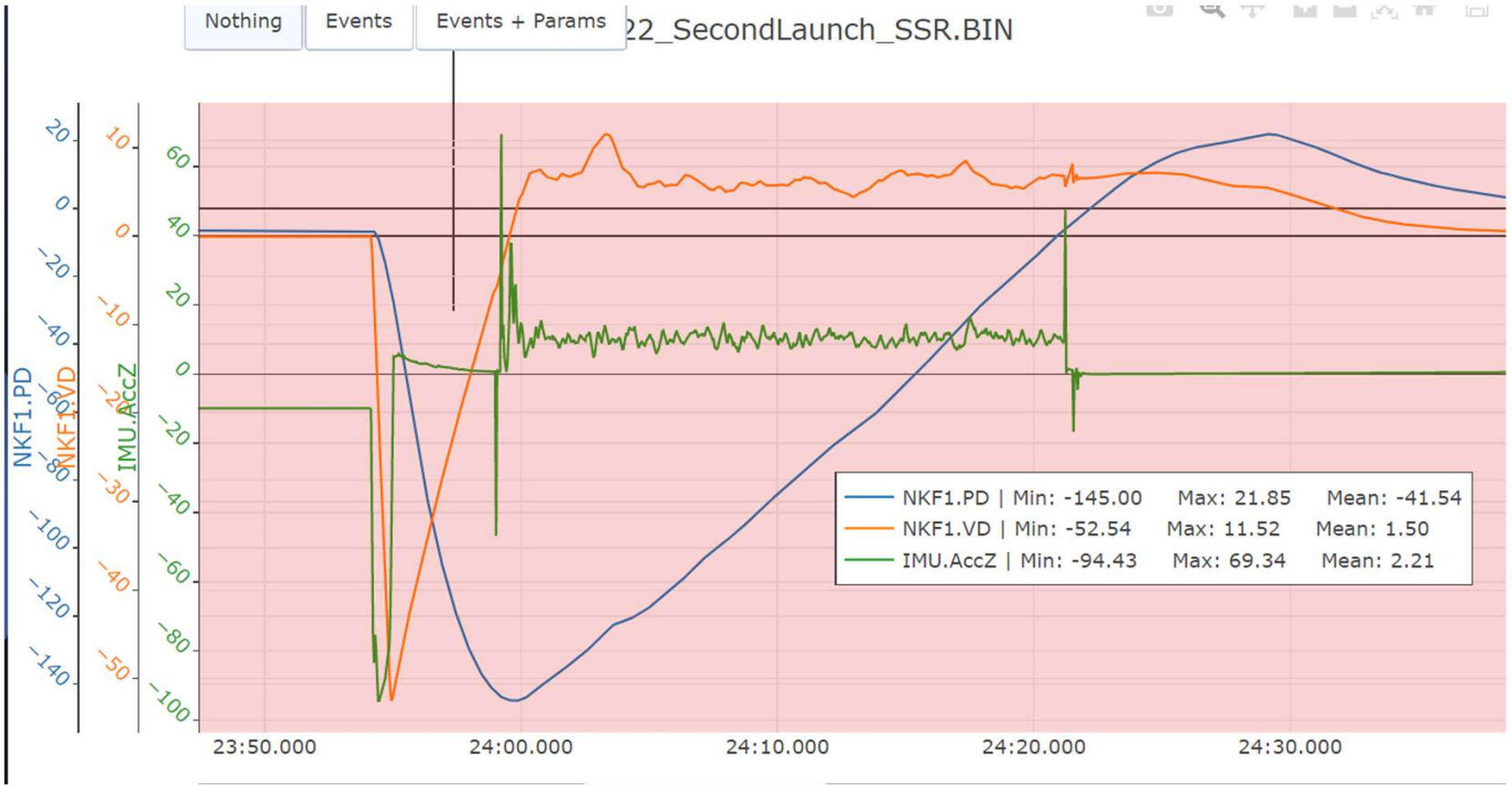
Step 2 Viewing BIN Files in UAV Log viewer

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



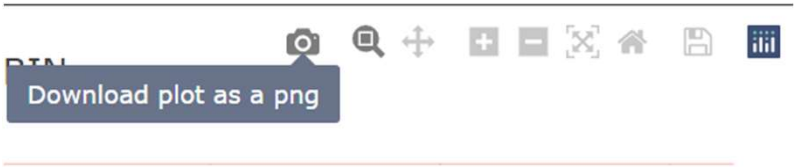
Step 2 Viewing BIN Files in UAV Log viewer

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.

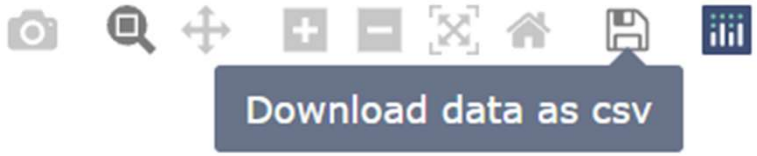


Step 3 Exporting Data from UAV Log Viewer

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.