Xflight Technologies LLC

AHRS User & Installation Guide

Version 1.5

March 2020

Xflighttech.com

A. Terms, Conditions and Warranty

These products are only intended to be used in LSA Class Experimental Aircraft or Ultralights (as defined by the FAA in the USA) under the full responsibility of the pilot. AHRS and Autopilot components are intended to be used for informational purposes or to manipulate secondary control surfaces only, allowing the pilot full manual control of the aircraft

See Appendix A for details

B. Setup and wiring:
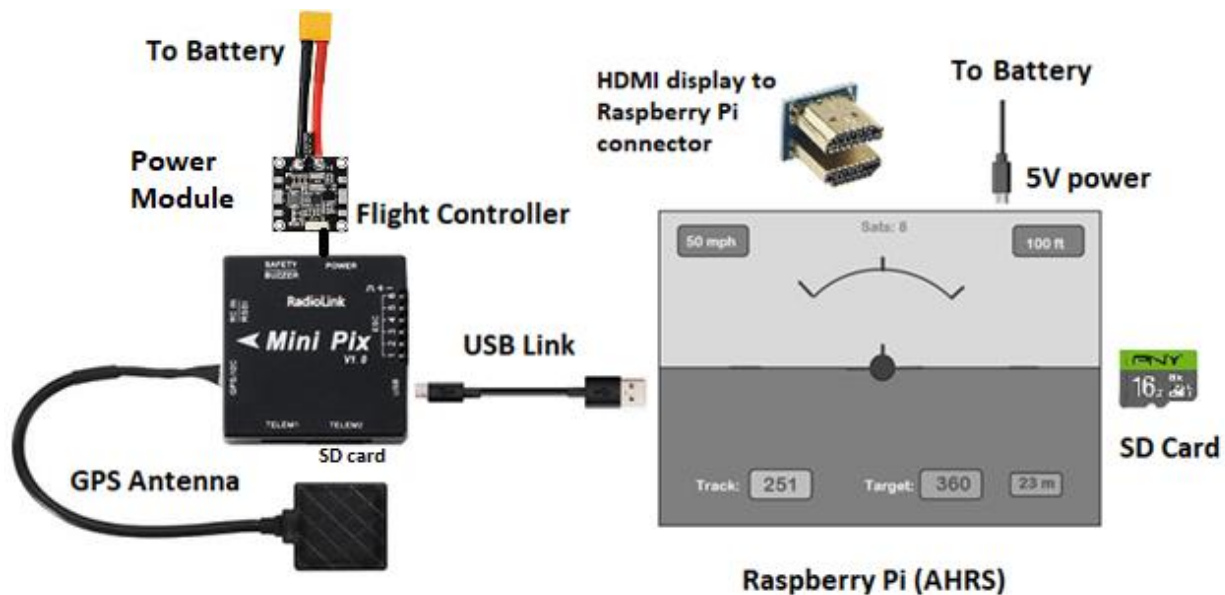
Raspberry Pi (AHRS)

1. Ensure the Display is firmly seated and connected via the HDMI connector

2. Connect the GPS antenna to the Flight Controller GPS/12C socket

3. Connect the Flight Controller micro USB socket to one of the Raspberry Pi (AHRS) USB sockets

4. Connect the 5v DC power supply to the Raspberry Pi (AHRS) micro USB connector
(A backup power supply may be used and connected to the touchscreen micro USB connector)

5. Connect the Power Module to the Flight Controller

6. Make sure the SD card (AHRS software) is firmly seated inside the Raspberry Pi

7. Make sure the SD card in the Flight Controller is also firmly seated (used for logging)

C. Installation Overview

Additional details in section F.

1. Mount the Flight Controller horizontally facing forward, sitting on a padded or foam base to reduce vibration. (Adjustments for setting perfect level and for tail-wheel aircraft will be covered later, under section G - Calibration).

2. Mount the GPS antenna on the dash or somewhere with line of sight to the sky, facing forward.

3. Connect the AHRS power supply and Flight Controller Power Module to the battery via a separate switch and 5A fuse.

4. When installing the AHRS behind the instrument panel, it is necessary to ensure there is an insulated layer between the touchscreen display surface and the metal panel for proper operation. The plastic frame of the case makes for a good insulating layer.

5. The USB port on the Flight Controller needs to be easily accessible in order to make configuration changes, and access flight logs once installed, unless you have the optional wireless telemetry unit (in order to change configuration parameters and access logs, the USB cable to the Raspberry Pi (AHRS) will be disconnected and a USB cable from the Flight Controller to a PC/Laptop will need to be temporarily connected). Complete calibration (section G) before final Flight Controller installation.

D. Startup

1. Make sure you are outside with a view to the sky. Upon startup the AHRS will connect to the Flight Controller (maintaining a heartbeat), and then perform a calibration and verification check (Ignore the login prompt). If the Flight Controller is not able to lock onto more than 5 satellites, the AHRS will keep trying, via a countdown. If it still cannot get a good lock after the countdown, it will start up anyway, and you will be able to see the satellite count for yourself. It will be red if below 6, otherwise green. A red cross will appear if the satellite count is less than 5. (A flashing green light on the GPS antenna also indicates satellites have been acquired). If the satellite count is zero you will need to restart.

2. Make sure the Flight Controller remains stable during startup. Once the AHRS has started it will lock in the current GPS location, and use this as its Home reference.

3. If either the Flight Controller link is broken (loss of heartbeat) or the satellite count falls below 5, you will see a large red cross appear on the display; the AHRS is still working, but the flight data readings cannot necessarily be trusted. Once the AHRS has reconnected, and the satellite count goes back up to 5 or above, the AHRS will resume normal operation.

E. Operation:
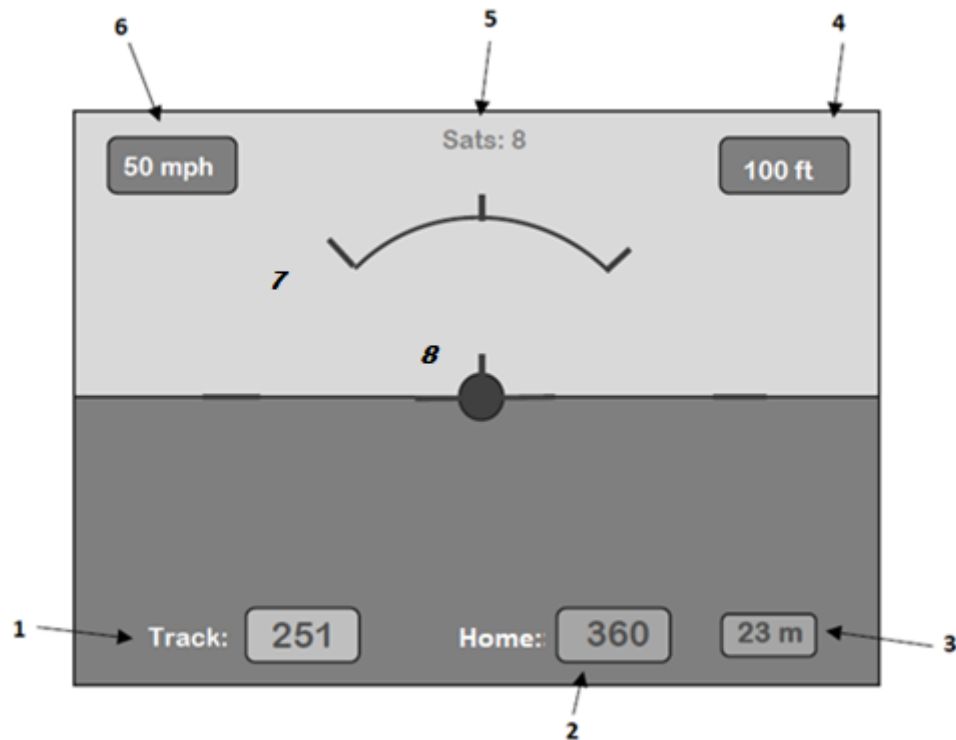
When operating normally the display will provide a smooth indication of attitude as well as the various flight data parameters detailed below.

1. Current heading

2. GPS Heading to Home location

3. Ground distance to Home location in miles

4. GPS Altitude above mean sea level (AMSL) in feet

5. Number of satellites locked on (if this drops below 5, you will see a large red cross appear on the display; the AHRS is still working, but the flight data readings cannot necessarily be trusted). Once the satellite count goes back up to 5 or above, the AHRS will resume normal operation.

6. Groundspeed in miles per hour

7. Bank angle graduations: 0, 30, 45, 60 degrees

8. When on the ground touching the center yellow reference plane will calibrate the AHRS to straight & level (AP OFF mode)

F. Physical Installation

It is recommended that a separate physical fuse and switch be used to supply power to the AHRS.

| AHRS, Flight Controller Power Module and touchscreen	Switch and 5A fuse

A backup power supply may be used and connected to the touchscreen micro USB connector.

1. AHRS

The optimal location for the AHRS is behind the instrument panel. (Make sure to leave sufficient room for the USB connections).
The rectangular cut-out required will be approx. 3 inches x 2 1/4 inches (76mm x 57mm).
Metal instrument panels will require an insulated layer between the touchscreen display surface and the panel for proper operation. The plastic frame of the case provided makes for a good insulating layer. Simply remove the 4 screws, mount the AHRS behind the instrument panel with the frame in place, and secure the AHRS with the screws from the front of the instrument panel.
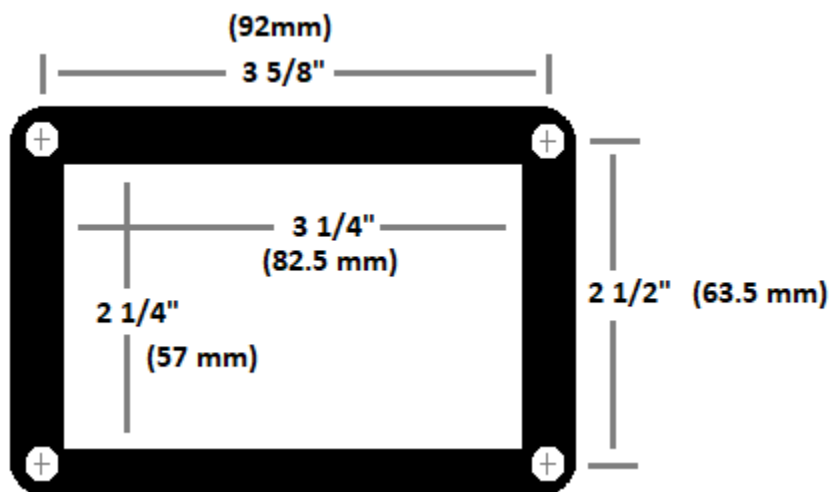
Overall dimensions of the AHRS (Raspberry Pi) + Screen are approx. 4" (102mm) x 3" (76mm) x 1.5" (38mm)

2. **Flight Controller**

Note: Complete the calibration in section G before final Flight Controller installation as this will need to be manipulated as part of the calibration process.

The Flight Controller needs to be close enough to the AHRS to connect via the USB link cable (this can be substituted for a longer cable) and close enough to the GPS antenna which is typically mounted on the dashboard. Mount the Flight Controller horizontally and flat facing forward, sitting on a padded or foam base (provided) to reduce vibration, and make sure it cannot move in flight.

The GPS antenna needs to be installed facing forward as it also has a built-in compass and must have a good line of sight to the sky. Satellite reception is good through glass, plastic, wood, fabric, etc., but not through conducting surfaces such as metal.

The Flight Controller (Mini Pix) dimensions are 1.5" (38mm) square x 0.5" (12.7mm)

The GPS antenna dimensions are 1.25" (31.75mm) square x 0.5" (12.7mm)

G. Calibration

Basic calibration for straight and level is achieved by touching the central reference plane and waiting a few seconds (this only works on the ground when not moving)

The PC USB connection should be sufficient to power the Flight Controller (if not switch on the AHRS to power up the Flight Controller power Module)

1. The AHRS uses the RadioLink MiniPix as its Flight Controller, running opensource ArduPlane software.
   Configurations are made using the ArduPilot Mission Planner application available as a free download from here: http://firmware.ardupilot.org/Tools/MissionPlanner/MissionPlanner-latest.msi

2. Note that you must have the Microsoft .NET framework already installed, this is usually installed by default on the latest Windows OS. It can be downloaded here:
   https://dotnet.microsoft.com/download/dotnet-framework/net462

3. Mission Planner installation:
   Once you have downloaded the Mission Planner software, double click the executable or **.msi** file, and install on your PC. Allow the device driver to be installed by your operating system.

4. Start the Mission Planner application. Remove the USB cable connecting the AHRS to the Flight Controller and connect the PC running Mission Planner to the Flight Controller (unless you have the optional wireless telemetry unit)

5. You will now need to see which COM port your PC is using for Mission Planner. The COM port should appear in the Mission Planner **<CONNECT>** drop-down box or you can go into your PC settings/device manager and look for the STMicroelectronics device.
   See example below using COM4:
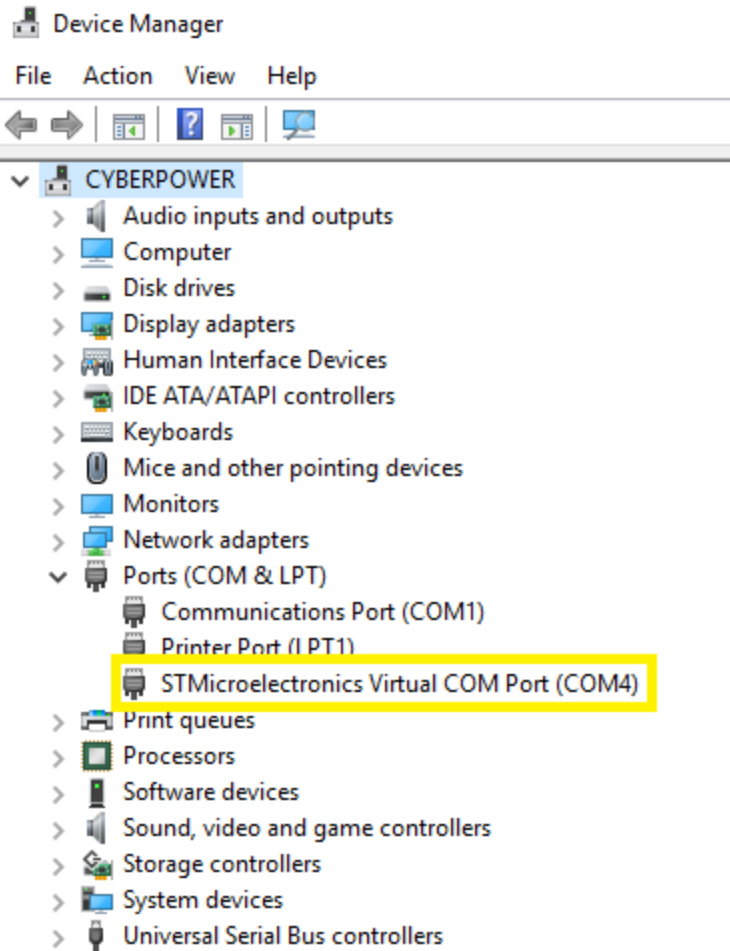
Wait a few seconds for the Flight Controller to initialize after USB connection.
The top right corner of the Mission Planner will show a **<CONNECT>** button. First select the COM port previously identified from the drop-down box, specify 115200 baud rate and hit **<CONNECT>.** Once connected it will download the Flight Controller parameters and the connection icon will turn green.


Once connected the Flight Controller parameters will be read, and available to view/modify (the first time connecting will take longer as all the parameters are downloaded).

AHRS Calibration

Make sure the aircraft is straight and level. For tailwheel aircraft make sure that the tail is lifted up, so the aircraft is straight and level to the horizon, as it would be flying.

Use the top left navigation buttons and select **<INITIAL SETUP>** and select **<Accel Calibration>.** Hit the **<Calibrate Level>** button. This will automatically update the **AHRS_TRIM_X** and **AHRS_TRIM_Y** parameters for you. Navigate to **<FLIGHT DATA>** and you should see a properly leveled AHRS display.
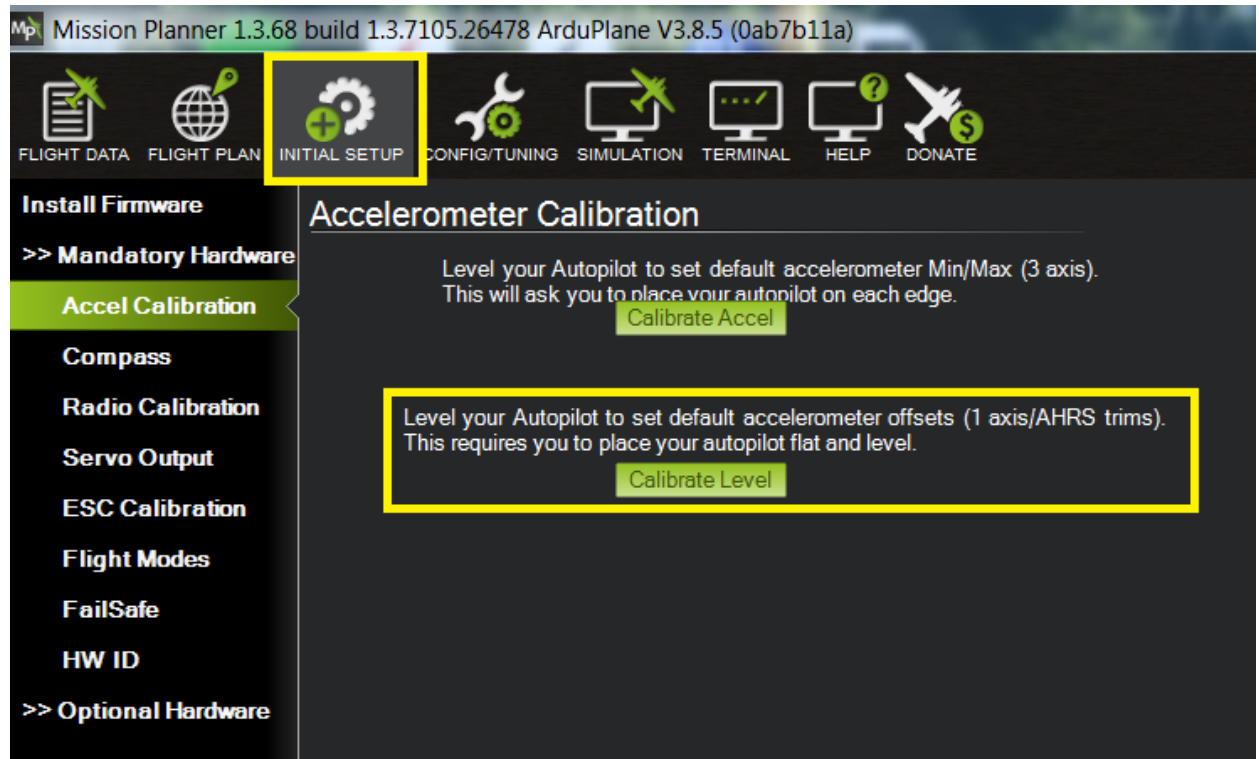
These parameters can also be edited directly:
Use the top left navigation buttons and select **<CONFIG/TUNING>** to view the parameters, then use the left option list to select **<Full Parameter Tree>.** Under the AHRS section you will find the **AHRS_TRIM** parameters (see screenshot). These fine tune the AHRS to straight and level (as the Flight Controller may not be installed perfectly flat). Once you make a change be sure to click the **<Write Params>** button on the right to save the changes to the Flight Controller. The Mission Planner AHRS display under **<Flight Data>** will update in real-time as these parameters are written. Make sure this appears straight and level, with the red reference plane at the horizon. It is also advisable to take a backup copy of all parameters with **<Save to file>**. It is important to ensure the AHRS is straight and level when the aircraft is trimmed and flying straight and level.

For tailwheel aircraft make sure that the tail is lifted up, so the aircraft is straight and level to the horizon, as it would be flying.

| AHRS_TRIM_X | Roll angle tuning in radians* (positive to roll the AHRS reference plane left) |
| AHRS_TRIM_Y | Pitch angle tuning in radians* (positive to pitch the AHRS reference plane down |

note 0.01 radians is approx. 0.6 degrees.

If the Flight Controller needs to be installed in a different orientation than flat and pointing straight ahead, this can be accommodated by appropriately setting the **AHRS_ORIENTATION** parameter.

Compass / Accelerometer Calibration

Compasses

The Compasses have been calibrated, however fine adjustments can be made manually in order to ensure the direction is properly indicated in your aircraft, depending on proximity of metal in the airframe and other effects. The full automated calibration process will also be explained.

The AHRS uses 2 compasses and the GPS. Compass #1 is inside the externally mounted GPS antenna, and Compass #2 is inside the Flight Controller.

Under the COMPASS section you will find the **COMPASS_OFS** parameters (see screenshot). These can be manually modified to fine tune the compass heading. Once you make a change be sure to click the **<Write Params>** button on the right to save the changes to the Flight Controller. The Mission Planner heading display under **<Flight Data>** will update in real-time as these parameters are written. It is also advisable to take a backup copy of all parameters with **<Save to file>**.

|	
COMPASS_OFS_X	Offset for Compass 1 in X direction in mGauss
COMPASS_OFS_Y	Offset for Compass 1 in Y direction in mGauss
COMPASS_OFS_Z	Offset for Compass 1 in Z direction in mGauss
COMPASS_OFS2_X	Offset for Compass 2 in X direction in mGauss
COMPASS_OFS2_Y	Offset for Compass 2 in Y direction in mGauss
COMPASS_OFS2_Z	Offset for Compass 2 in Z direction in mGauss

Compasses can also be enabled / disabled in the parameters:

COMPASS_USE	1	0:Disabled 1:Enabled	Enable or disable the use of the compass (instead of the GPS) for determining heading
COMPASS_USE2	1	0:Disabled 1:Enabled	Enable or disable the second compass for determining heading.
COMPASS_USE3	0	0:Disabled 1:Enabled	Enable or disable the third compass for determining heading.

You can perform the full compass and accelerometer calibration process prior to installation if desired, by selecting **<INITIAL SETUP>** from the navigation buttons, then follow the setup wizard prompts under **>> Mandatory Hardware**.

Select **<Compass>,** then for a simple calibration select **<Pixhawk/PX4>** and follow the prompts. Ensure the GPS antenna and Flight Controller are taped together when performing this and oriented in the same direction (the GPS antenna has a built-in compass). This needs to be done outside.

For a more comprehensive calibration select **<Live Calibration>**, and follow the prompts, moving the flight controller / external compass around as directed.
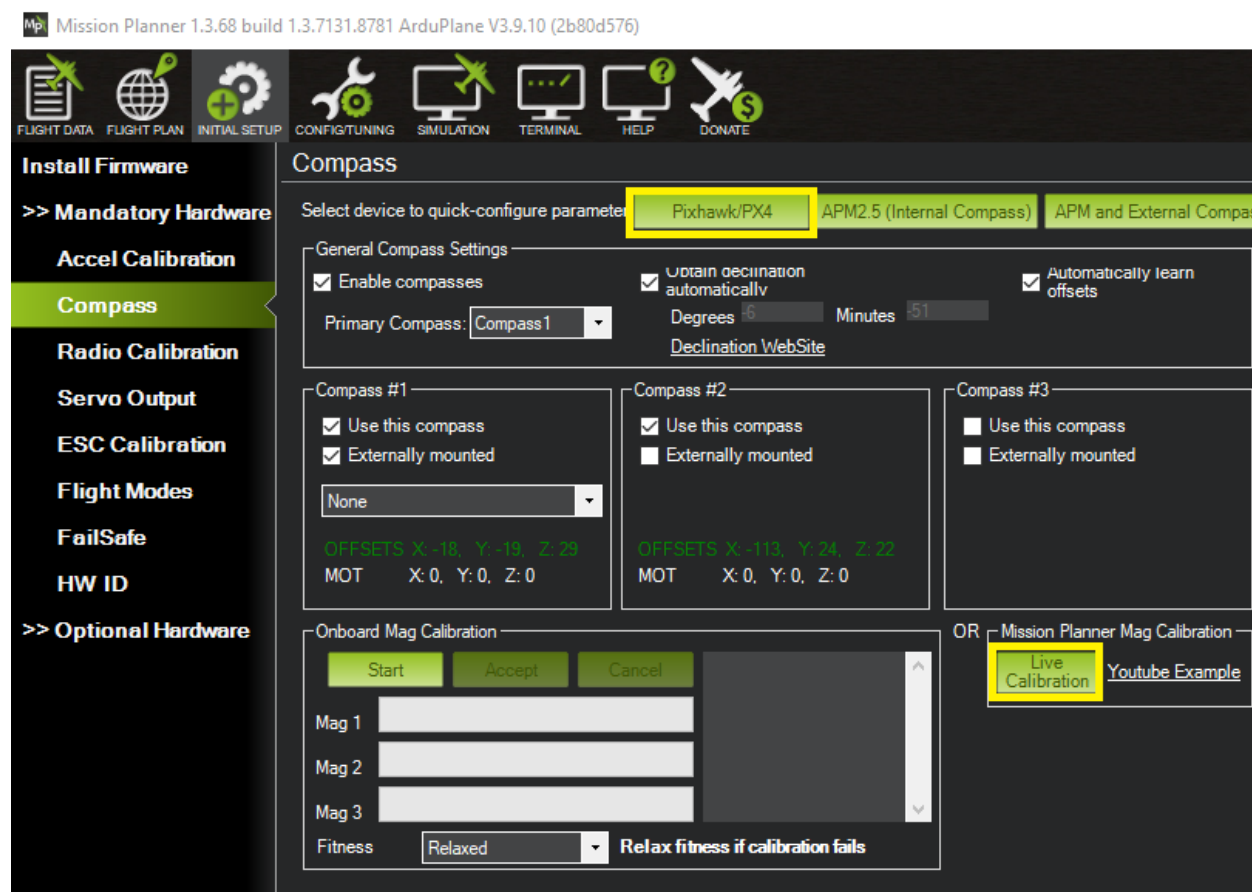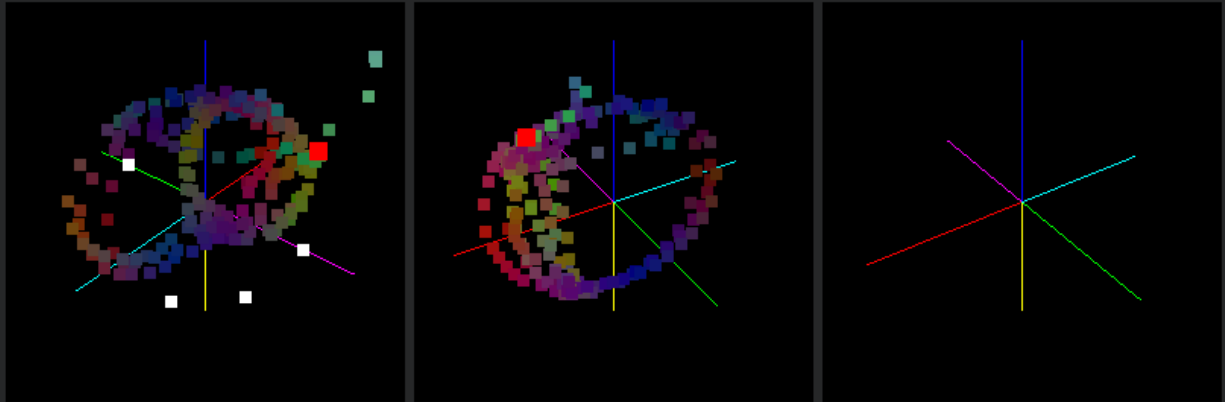
Live Calibration:

Move the flight controller / GPS antenna as directed: Point North, and rotate around pitch axis until level, then turn 90 degrees and rotate around the roll axis until level, hitting every white dot.

Accelerometers

Select **<Accel Calibration>**, select the two calibration options and follow the prompts.
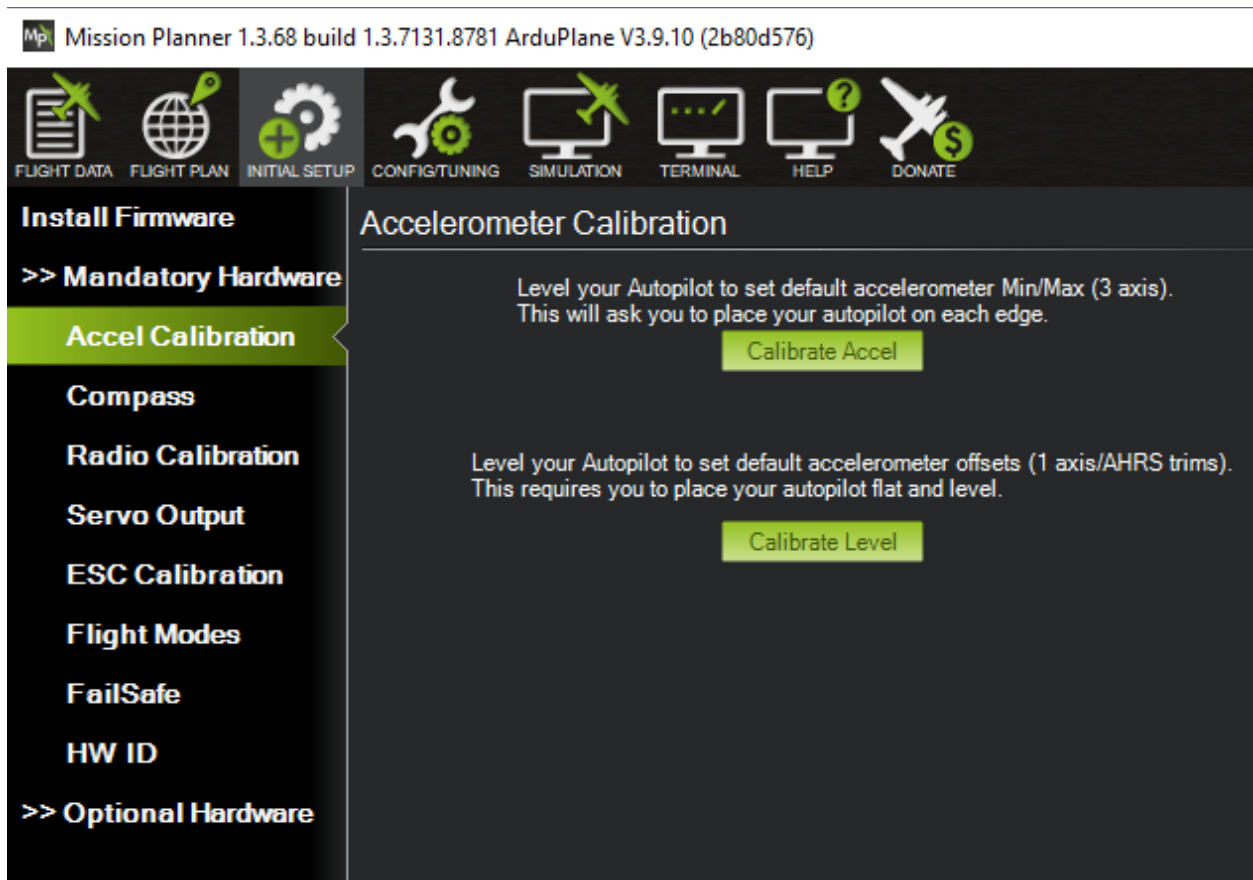
H. LOGFILE Access

Log files are available via the Mission Planner. This will give you access to many different flight parameters as well as the ability to view your flight track on Google Earth.

The PC USB connection should be sufficient to power the Flight Controller (if not connect the Flight Controller power module). Remove the USB cable connecting the AHRS to the Flight Controller and connect the PC running Mission Planner to the Flight Controller

While connected to the Flight Controller, select **<FLIGHT DATA>** from the navigation buttons, then select **<DataFlash Logs>** from the tabs at the bottom. Select **<Download DataFlash Log Via Mavlink>** (if you get a message requesting to disarm the controller hit **<OK>**). This will bring up a Log Downloader box, where you can download all or individual logs.
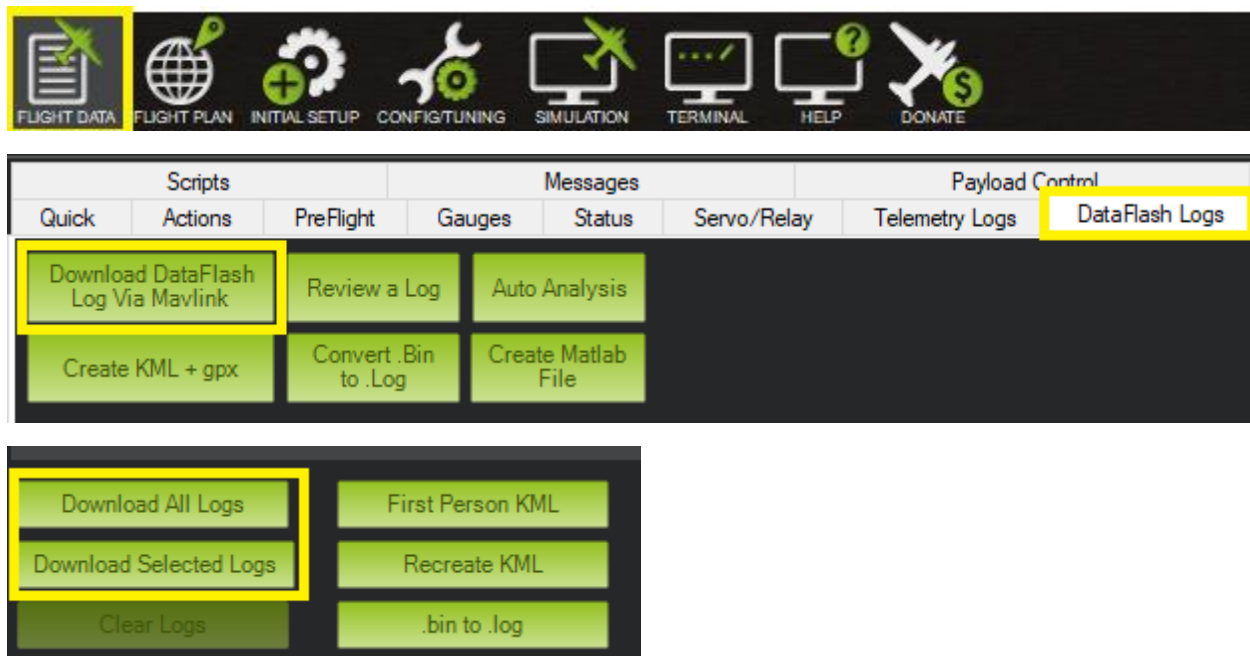
The Logs will be saved in your Mission Planner directory:
(typically - C:\users\<*Your Name*>\Documents\Mission Planner\logs\FIXED_WING\1)

Once loaded you can either review the logs within the Mission Planner graphing function **<Review a Log>** or view the flight path in Google Earth with the **.kmz** and **.gpx** files. These files are automatically created.

To see the flight path in Google Earth, simply drag the files from the Mission Planner directory into Google Earth.

The **.kmz** file will show your flight path and altitude and the **.gpx** file will show your GPS waypoint data in KML format.

You can also create the **.gpx** and **.kmz** files from the **.bin** file manually by selecting <**Create KML + gpx**> from the options:
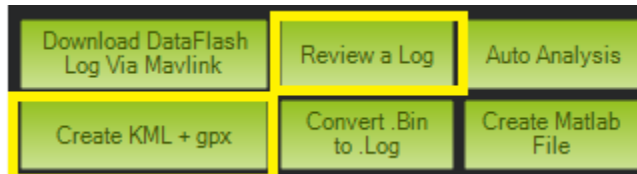
Note that you will NOT have the tlogs (telemetry logs)

A more detailed description of the logs and graphing options is available here:
http://ardupilot.org/copter/docs/common-downloading-and-analyzing-data-logs-in-mission-planner.html

Track and Elevation Profile (speed/altitude) on Google Earth
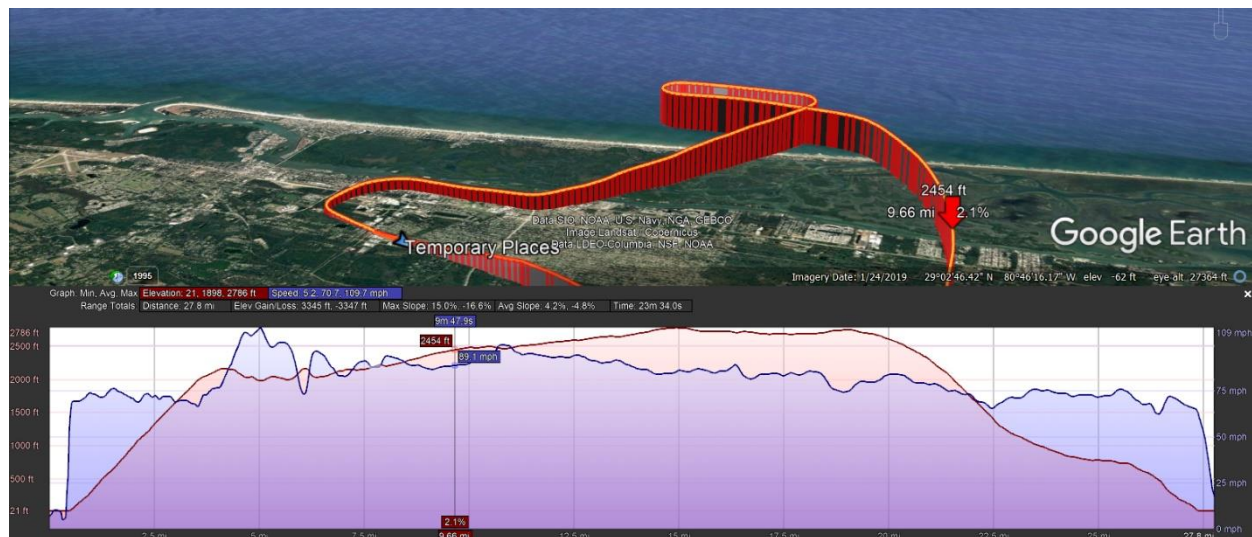
For a full description of all parameters please visit: http://ardupilot.org/plane/docs/parameters.html

But please note this includes all the ArduPlane parameters, which are not all relevant for the AHRS product.

Appendix A.

Xflight Technologies LLC Terms, Conditions and Warranty

1. **PARTIES.** This Contract represents the terms and conditions of sale of Xflight Technologies Products by and between Xflight Technologies LLC, of 1982 State Rd 44, New Smyrna Beach, Florida 32168, USA ("Seller"), and Buyer ("Buyer").

2. **ITEMS PURCHASED**. Seller agrees to sell, and Buyer agrees to buy, one or more of the following products (the "Goods") in accordance with the terms and conditions of this Contract:

Products
Xflight AutoPilot and related sub-components
Xflight AHRS and related sub-components

3. **FLIGHT CONTROLLER.** Note that the use of the Ardupilot opensource firmware, as used in 3rd party Flight Controllers, in this application is contrary to Ardupilot's Code of Conduct for use in Manned Vehicles, for more info see**: https://firmware.ardupilot.org/**

4. **INTELLECTUAL PROPERTY.** Intellectual property created, made, or originated by the officers, employees, or contractors of Seller shall remain the sole and exclusive property of Seller. Any intellectual property associated with Goods, specifically the software, shall remain the property of Seller. Seller retains all rights to its pre-existing intellectual property and any intellectual property it creates in connection with the development and manufacturing of the Goods of this agreement. Parties agree that Seller will retain ownership of all rights in any invention and work product developed pursuant to the agreement and acknowledges that all materials created by the Seller pursuant to and related to the agreement belong to the Seller under United States intellectual property laws.

5. **WARRANTIES.** The Goods are sold on an "AS IS" basis. SELLER SHALL IN NO EVENT BE LIABLE FOR ANY INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES OF ANY NATURE, EVEN IF SELLER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. Seller's liability, if any, for defective Goods, is limited to replacement, repair or refund of the defective Goods, at Seller's option for up to 30 days from date of purchase.

6. **PERSONAL USE**. Buyer agrees to limit the operation and use of purchased Goods to personal recreational use. Buyer agrees to not develop or resell Goods, its components, or documentation to another party without Seller's written authorization.

7. **PRODUCT RISKS**. Buyer acknowledges that the ownership and operation of newly developed autopilot and AHRS products, including the subject Goods contemplated by

this contract, comes with many unforeseeable risks and potential hazards. Buyer has reviewed the risks, safety hazards and recommendations provided by Seller in the User Guide. Buyer has considered these risks and represents himself as a consumer with a sophisticated understanding of aircraft operation and mechanics, vehicle physics, flying safety protocols, and the concepts underlying the Goods' design. Buyer accepts all foreseeable and unforeseeable risks associated with the ownership and operation of the Goods, components, and related equipment.

8. **INDEMNIFICATION.** Buyer shall defend, indemnify, and hold harmless Seller, including its officers and agents, from any and all actual or alleged claims, demands, causes of action, liability, loss, damage and/or injury (to property or persons, including without limitation wrongful death), associated with the ownership and operation of the Goods of this contract. This indemnity shall apply in all actions, whether brought by an individual or other entity, or imposed by a court of law or by administrative action of any federal, state, or local governmental body or agency, arising out of or incident to any acts, omissions, negligence, or willful misconduct of Buyer, its personnel, employees, agents, contractors, or volunteers in connection with or arising out of Buyer's actions. This indemnification applies to and includes, without limitation, the payment of all penalties, fines, judgments, awards, decrees, attorneys' fees, and related costs or expenses, and any reimbursements to Seller for all legal expenses and costs incurred by it.

9. **REMEDIES ON DEFAULT.** In addition to any and all other rights a party may have available according to law, if a party defaults by failing to substantially perform any provision, term or condition of this Contract (including without limitation the failure to make a monetary payment when due), the other party may terminate the Contract by providing written notice to the defaulting party. This notice shall describe with sufficient detail the nature of the default. The party receiving such notice shall have 30 days from the effective date of such notice to cure the default(s). Unless waived by a party providing notice, the failure to cure the default(s) within such time period shall result in the automatic termination of this Contract.

10. **ARBITRATION**. Any controversies or disputes arising out of or relating to this Contract shall be resolved by binding arbitration in accordance with the then-current Commercial Arbitration Rules of the American Arbitration Association. The parties shall select a mutually acceptable arbitrator knowledgeable about issues relating to the subject matter of this Contract. In the event the parties are unable to agree to such a selection, each party will select an arbitrator and the two arbitrators in turn shall select a third arbitrator, all three of whom shall preside jointly over the matter. The arbitration shall take place at a location that is reasonably centrally located between the parties, or otherwise mutually agreed upon by the parties. All documents, materials, and information in the possession of each party that are in any way relevant to the dispute shall be made available to the other party for review and copying no later than 30 days

after the notice of arbitration is served. The arbitrator(s) shall not have the authority to modify any provision of this Contract or to award punitive damages. The arbitrator(s) shall have the power to issue mandatory orders and restraint orders in connection with the arbitration. The decision rendered by the arbitrator(s) shall be final and binding on the parties, and judgment may be entered in conformity with the decision in any court having jurisdiction. The agreement to arbitration shall be specifically enforceable under the prevailing arbitration law. During the continuance of any arbitration proceeding, the parties shall continue to perform their respective obligations under this Contract.

11. **NOTICE.** Any notice or communication required or permitted under this Contract shall be sufficiently given if delivered in person or by certified mail, return receipt requested, to the addresses listed above or to such other address as one party may have furnished to the other in writing. The notice shall be deemed received when delivered or signed for, or on the third day after mailing if not signed for.

12. **ASSIGNMENT.** Neither party may assign or transfer this Contract without prior written consent of the other party, which consent shall not be unreasonably withheld.

13. **ENTIRE CONTRACT.** This Contract contains the entire agreement of the parties regarding the subject matter of this Contract, and there are no other promises or conditions in any other agreement whether oral or written. This Contract supersedes any prior written or oral agreements between the parties.

14. **SEVERABILITY.** If any provision of this Contract shall be held to be invalid or unenforceable for any reason, the remaining provisions shall continue to be valid and enforceable. If a court finds that any provision of this Contract is invalid or unenforceable, but that by limiting such provision it would become valid and enforceable, then such provision shall be deemed to be written, construed, and enforced as so limited.

15. **WAIVER OF CONTRACTUAL RIGHT.** The failure of either party to enforce any provision of this Contract shall not be construed as a waiver or limitation of that party's right to subsequently enforce and compel strict compliance with every provision of this Contract.

16. **APPLICABLE LAW.** This Contract shall be governed by the laws of the State of Florida in the USA.

EXCHANGE OF GOODS

The following provisions relate to the physical exchange of Goods and payment forming the transaction of this agreement.

17. **TITLE/RISK OF LOSS.** Title to and risk of loss of goods shall pass to the buyer upon delivery F.O.B. at the seller's place of home or business to an agent of the buyer including a common carrier, notwithstanding any prepayment or allowance of freight by the seller.

18. **INSPECTION.** Buyer, upon receiving possession of Goods, shall have a reasonable opportunity to inspect the Goods to determine if the Goods conform to the requirements of this Contract. If Buyer, in good faith, determines that all or a portion of the Goods are non-conforming, Buyer may return the Goods to Seller at Buyer's expense. Buyer agrees to securely mail the goods back to buyer with electronic tracking to the address listed above.

19. **PAYMENT.** Payment due shall be made to Xflight Technologies LLC by cash, bank transfer, credit card or PayPal prior to shipment of Goods. If an invoice is not paid when due, seller will not ship Goods to Buyer. In addition to any other right or remedy provided by law, if Buyer fails to pay for the Goods when due or reverses credit card charges after shipment of Goods, Seller has the option to treat such failure to pay as a material breach of this Contract, and may cancel this Contract and/or seek legal remedies.

20. **PAYMENT OF TAXES.** Buyer agrees to pay all taxes of every description, country, federal, state, and municipal, that arise as a result of this sale, excluding income taxes.