AIM XTRA/BASE v4.x.x Manual

February 2, 2025

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1 Introduction

Thank you for purchasing an AIM XTRA flight computer! The AIM XTRA is a fully integrated GPS flight control, simulation, tracking and data recording computer. By using the AIM BASE receiver connected to a laptop, a full telemetry and tracking system is available. The AIM XTRA is fully USB compliant and is a *plug-n-play* device.

Please download the AIM XTRA/BASE software from an Authorized Service Center (see section 7.2) to access all the features of your flight computer.

1.1 Computing Requirements

1.1.1 Minimum Requirements

Computer:

- Windows 7/8/10/11
- 3D Graphics Accelerator supporting DirectX 9
- Screen Resolution 1024x768 pixels
- 512 Megabytes RAM
- 50 Megabytes free disk space
- One 1.1 (or higher) USB port
- Google Earth (free version)

Note that Apple products are currently not supported.

Accessories (not included):

- One USB Cable with a male Type A (Standard) and a male Micro-B Type connector
- One three meter (nine foot) or longer USB Cable with a female Type A and a male Type A connector (optional but preferred for BASE unit operation)
- Two button wheel/rollerball mouse (optional but preferred for the manipulation of graphs)

1.2 The System

1.2.1 Hardware

AIM XTRA: This is a GPS flight computer with a Radio Frequency (RF) transceiver.
AIM BASE: A radio transceiver which connects to your laptop.
Antenna: Supplied for use with the AIM XTRA.
Antenna: Supplied for use with the AIM BASE. Additional antennas may be acquired from your closest Authorized Service Center (see section 7.2).

Note: The antennas should only be hand tightened when attaching them to AIM XTRA/BASE units. ***Do not use a wrench to attach the antennas!***

1.2.2 Firmware

This is the software that runs on the device (AIM XTRA/BASE) which is preloaded. Updates may be downloaded and installed by the user from the internet.

1.2.3 Computer Software

AIM XTRA: Is used to test, configure, download, view flight data, and simulate flights with the AIM XTRA hardware.

AIM BASE: Is used to monitor and collect live flight data sent from the AIM XTRA via the AIM BASE hardware.

1.3 Supported Versions

This manual supports all version 4 releases of the AIM XTRA/BASE system. It is recommended that you always use the correct manual for your hardware and firmware version. If your hardware or firmware is of an earlier version, diagrams among other items may differ. If a new firmware version is available when shipping, it will generally be preloaded, but the associated changes may not be reflected in the preprinted manual.

1.3.1 Manual Supports AIM XTRA Versions

- Hardware v4.0.0, 4.1.0
- Firmware v4.0.0, 4.1.0
- Software v4.00, 4.1.0, 4.1.1

1.3.2 Manual Supports AIM BASE Versions

- Hardware v4.0.0
- Firmware v4.0.0, 4.1.0
- Software v4.00, 4.1.0

1.4 System Features

1.4.1 Features Inventory

Hardware

- 100% USB connectivity - no drivers needed!
- Swiss engineered aeronautical GPS (uBlox MAX-10Q) (sampling period: 200 ms position, 500 ms time)
- USA FCC Approved 150 mW 902 MHz to 926 MHz and EU Approved 863 MHz to 870 MHz digital transceiver
- 100,000 foot barometric sensor (sampling period: 20 ms)
- 100 g linear accelerometer (sampling period: 10 ms)
- 16 g triple axis accelerometer (sampling period: 10 ms)
- 2000 degree/second triple axis gyroscope (sampling period: 10 ms)
- Triple axis magnetometer (sampling period: 100ms)
- Four MiB non-volatile flash memory (enough for hours of data)
- Up to four 40 amperes (continuous) outputs (software selectable) (sampling period: 10 ms)
- Up to four auxiliary inputs (software selectable)
- On-board temperature sensor (sampling period: 500 ms)
- Flight Event Status (sampling period: 100 ms)
- Antennas included - no need for expensive Yagi antennas
  - One antenna included for the AIM XTRA
  - One antenna included for the AIM BASE
- Power consumption reduced to 90 mA XTRA Dimensions: 109.6 mm L x 30 mm W x 15.25 mm D (4.315" L x 1.181" W x 0.6" D) without antenna, approximately 154.25 mm (6.0725”) L with the antenna
- BASE Dimensions: 80 mm L x 40 mm W x 20 mm D (3.15" L x 1.575" W x 0.79" D) without the antenna, 131.7 mm (5.185") L when the antenna is attached.

Software

- Free custom designed software for setting parameters, simulation, viewing and downloading data
- Support for metric and imperial units
- Ejection line settings
  - Apogee
  - Time
  - Accent altitude
  - Decent altitude
  - Peak velocity
  - Input
- 32 user selectable radio transmission channels (8 for EU band)
- GPS Position, Time, Satellites Locked, and Altitude
- Graphical display of critical flight data over time including:
  - Altitude
  - Vertical Acceleration
  - Lateral (X & Y axes) Acceleration
  - Rotational Rate of Change (X, Y, & Z axes)
  - Magnetic Flux (X, Y, & Z axes)
  - Atmospheric Pressure
  - Temperature
  - Computer and Ejection Voltage Levels (sampling period: 100 ms)
  - Ejection and Input Line Voltage Levels (sampling period: 100 ms)
  - Received Signal Strength Indicator
  - Ejection Line Continuity
  - Launch Detect
  - Apogee Detection
  - Rocket Orientation (sampling period: 100 ms)
  - Cesium Ion integration for real time vehicle tracking and visual location
- User specified data write and transmission rates for each sensor/line during pre-launch, pre-apogee, post-apogee, and ground time intervals
- Low voltage power source protection – critical for preventing LiPo battery damage

Capabilities

- Kalman filtered ejection using GPS, barometric sensor and two accelerometers - high altitude ejection!
  - For sealed altimeter bays user may disengage Barometric sensor from Kalman filter algorithm
  - Ejection upon ascent – useful for altitude competitions, boost glider separation, etc.
- > 30 km (≈18 ¾ miles) line of sight range with AIM BASE receiver using provided antennas!
  - XTRA range with the antenna is over 25 km (15 ½ miles).
  - Use of Yagi antennas on the BASE will extend the range to over 100 km (≈62 miles)!
  - Immune to data loss due to Doppler effects
  - Data rate increased to ~1200 bps
- Maximum GPS altitude (above sea level) reporting of 80 km (≈50 miles).
- Maintains GPS lock up to approximately 10 g with rapid lock reacquisition (e.g., a flight on an CTI O25,000 to over 30,000 feet (≈79 g boost for 1.2 sec) lost and reacquired lock within 5.4 sec).

- GPS uses SAW (Surface Acoustic Wave) filters to remove signals that interfere with the GPS thereby enhancing the reception and performance of the GPS.
- Uses multiple Global Navigation Satellite Systems: GPS, Galileo and GLONASS.
- Supports remote firing of pyro channels for ground testing

Recommendations

- Recommended battery: 3.7 V or 7.4 V 1000 mAh LiPo which provides approximately seven (7) hours of operation. Use of a separate battery for ejection activation is recommended based on your igniter/e-match requirements.
- One three meter (nine foot) or longer USB Cable with a female Type A and a male Type A connector (facilitates AIM BASE operation).

1.4.2 Software version changes

1.4.2.1 Software 4.2.1

- Add Max GPS AGL altitude to the AIM XTRA Notes tab.

1.4.2.2 Software 4.1.1

- Altitude rendering now includes graphs for Barometric and GPS in addition to the Kalman filter
- Optimized Kalman filter
- Sensor time base fix

1.4.2.3 Software 4.0.0

- Allow for the use of Google Earth externally to the AIM BASE software

1.4.2.4 Software 3.0.5

- TBD

1.4.2.5 Software 3.0.4

- Add rocket state to CSV output

1.4.2.6 Software 3.0.3

- Add new firmware version 3.0.2

1.4.2.7 Software 3.0.2

- Add ability to download raw flash data

1.4.2.8 Software 3.0.1

- Fix Cesium Ion view in AIM XTRA application

1.4.3 Firmware version changes

1.4.3.1 Firmware 4.2.1

- Fixed a bug causing ejection line testing to be inconsistent

1.4.3.2 Firmware 4.2.0

- Added minimum velocity and minimum altitude options to the Peak Velocity pyro channel setting.

1.4.3.3 Firmware 4.1.1

- Sensor time base fix

1.4.3.4 Firmware 4.1.0

- Added GLONASS constellation for GNSS
- Added remote ejection for testing
- Added EU radio band support
- Improvements to vertical acceleration computation
- Reduce AIM BASE interference susceptibility

1.4.3.5 Firmware 4.0.0

- Doubled the data transmission rate
- Eliminated Doppler data loss effects
- Added use of Galileo constellation for GPS
- Improved GPS reception and performance with SAW filter
- Improved algorithm for angle from vertical computations
- Transitioned from 433 MHz to 915 MHz radio transmission system

1.4.3.6 Firmware 3.0.3

- Improve tilt accuracy

1.4.3.7 Firmware 3.0.2

- Fix acceleration clipping at 16 g

1.4.3.8 Firmware 3.0.1

- Improve vertical acceleration accuracy
- Improve sensor data timing

1.4.4 Hardware version changes

1.4.4.1 Hardware 4.1.0

- MAXM8 GNSS module upgraded to MAX10S

1.4.4.2 Hardware 4.0.0

- Eliminated Doppler data loss effects
- Improved GPS reception and performance with SAW filter
- Transitioned from 433 MHz to 915 MHz radio transmission system

1.4.5 Changes from version 2 to 3

- New TXCO system
- USB connector updated to new Micro USB standard
- More reliable SMT crystal
- New higher resolution accelerometer and gyro
- Reduced accelerometer and gyro noise
- New GLONASS compatible GNSS antenna

1.4.6 Previous Version 2 Release Changes

1.4.6.1 Changes in Firmware v2.10 Software v2.10 Release

- Increased the number of radio channels from 16 to 256

- Added voice notification of flight events
- Added rocket orientation graphics
- Added staging detection to the software configuration for pyro activation
- Added angle detection to the software configuration for pyro deactivation

1.4.6.2 Changes in Firmware v2.07 Software v2.08 Release

- Fixed prompt when out of date firmware is detected
- Improved handling of pressure sensor data

1.4.6.3 Changes in Firmware v2.06 Software v2.07 Release

- Added RF compensation to improve transceiver reception
- Fixed misspellings

1.4.6.4 Changes in Firmware v2.05 Software v2.06 Release

- Fixed metric to imperial temperature conversion
- Corrected use of Imperial units in Temperature and Pressure graphs
- Corrected XTRA Vertical Acceleration graph label
- Corrected spelling errors in Settings and Notes tabs
- Reordered Open and Close buttons to standard configuration in Tools menu
- Fixed Windows 8 USB Power shutdown issue
- Fixed Low Temperature shutdown issue
- Released updated manual

1.4.6.5 Changes in Firmware v2.04 Software v2.05 Release

- Fixed time-based ejection setting (in order to ground test these settings the emulations must be run in real-time).
- Improved Windows 8.1 integration
- Fixed XTRA/BASE software crashes which occasionally occurred if there was a long delay before receiving a USB packet.
- Fixed Fahrenheit conversion
- Vastly improved GPS data usage for initial pressure calibration within the control loop
- Reduced AIM BASE latency
- Improved AIM BASE USB connection indicator
- Added AIM BASE RF received data rate display
- Added RF TCXO frequency offset between XTRA and BASE display
- Added imperial unit conversions for temperature and pressure

1.4.6.6 Changes in Firmware v2.03 Software v2.04 Release

- Notes tab now includes useful flight information
- Improved prevention of false launch detects
- Improved support for imperial units

1.4.6.7 Changes in Hardware 1.11 Firmware 1.20 Software 1.20 Release

- The AIM XTRA v2.00 now includes the latest MAX7Q GPS module
- Ultra-sensitive RF front end transceiver, offering a link budget of over 145 dB
- Multiple radio channels for interference free operation
- 1.5 ppm TCXO for ultra-narrow band operation
- Lower power requirements (< 150 mA peak)
- Improved GPS sensitivity (better and faster fixes)
- Operation from a single cell Lithium polymer battery (3.7 V nominal)

- Four (4) output lines capable of 40 amps
- All output lines software reconfigurable as input lines
- Now only 30 mm wide!

2 Installation

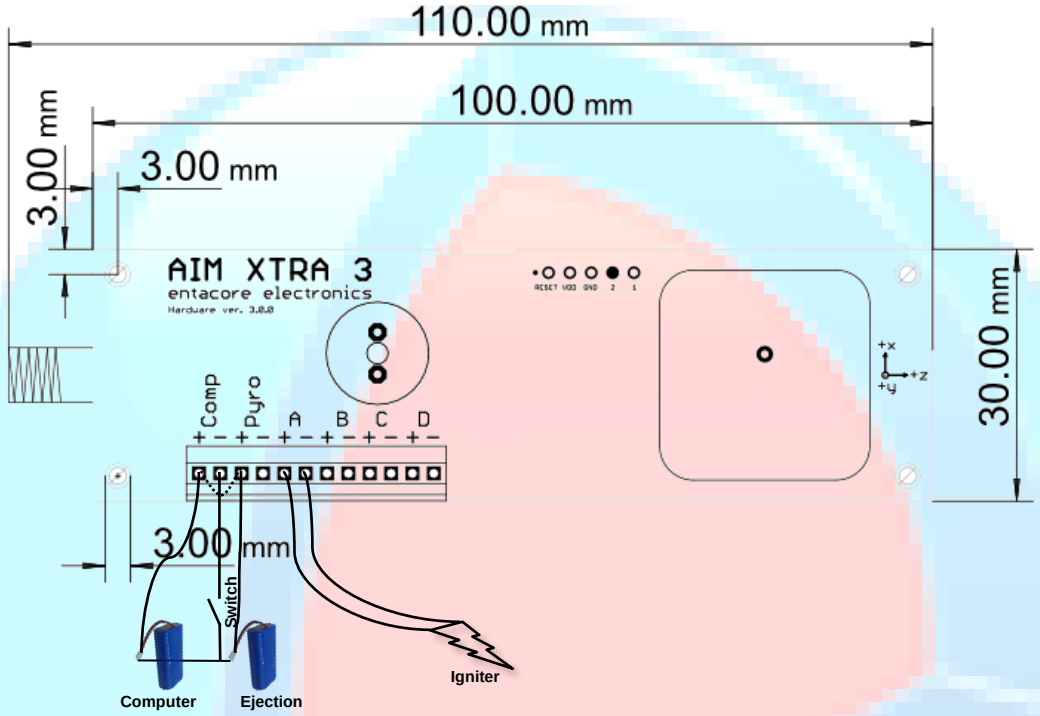


Figure 1 - Standard Configuration

2.1 Overview

Typically, the AIM XTRA is used for flight control, data recording, and vehicle tracking. For tracking, the user should set up a laptop or similar device capable of running Windows 7/8/10/11 with the AIM BASE on the launch field.

In order to set up the AIM XTRA system you will need to download and install the AIM XTRA and BASE software. The AIM XTRA and AIM BASE software is provided as separate single install files. The AIM XTRA installation includes this manual.

When the AIM XTRA is turned on it will beep once indicating a successful completion of pre-launch checks (not applicable when powered via the USB connection).

The AIM BASE is powered through the USB connection to your computer. When it is plugged in you will see a **red** light activate which indicates that the AIM BASE is receiving power and is active.

2.2 Basic Configuration

2.2.1 Software Installation/Updates

The AIM XTRA/BASE is not delivered with the computer software however it is available (at no cost) over the internet from our Authorized Service Centers (see section 7.2). Please go to the site and download the software (including updates) at your convenience. All the software/updates are contained within an install exe file. Once downloaded you will need to

select and run the install exe file. During the install process you will need to follow the instructions and select a directory where the software will be installed. Once installed verify that the shortcuts established on your desktop start the applications.

Cesium Ion is used for 3D mapping. Additionally, Google Earth can be used as a separate application to view your flight data graphically.

Google Earth Pro may be downloaded at: https://www.google.com/earth/versions/#earth-pro. Follow the instructions downloading and installing the free version onto your computer.

2.2.2 Initial Connections

AIM XTRA
In order to configure the AIM XTRA you will need to start the AIM XTRA software and then connect the AIM XTRA to your computer/laptop. Please note that when you make this connection the AIM XTRA will be powered via the USB connection so you should not have the AIM XTRA Comp terminals powered with a battery. If the AIM XTRA is powered by a battery when you plug it into your computer's USB port the AIM XTRA will be in a "waiting for launch state" and will not accept any configuration settings, download requests, updates, etc. that you may attempt to apply from your computer.

The first time you connect the AIM XTRA to your computer, it might take some time to recognize the device. You may be asked to restart your computer, but this is not necessary and can be ignored.

You will be able to tell that the AIM XTRA has successfully connected to the AIM XTRA software if the USB symbol in the Console section of the screen changes color from Red to Green (see bottom left circle in Figure 3).

Once connected and recognized a message will appear in the Console indicating successful initialization along with the firmware version (see leftmost circle in Figure 3). At this point the device can be tested, settings and satellite almanacs loaded and flight simulations run.

AIM BASE
In order to collect telemetry and track the AIM XTRA you will need to start the AIM BASE software and then connect the AIM BASE to your computer/laptop. Please note that when you make this connection the AIM BASE will be powered via the USB connection. No additional power source is required.

The first time you connect the AIM BASE to your computer, it might take some time to recognize the device. You may be asked to restart your computer, but this is not necessary and can be ignored.

You will be able to tell that the AIM BASE has successfully connected to the AIM BASE software if the USB symbol in the Console section of the screen changes color from Red to Green (see bottom left circle in Figure 4). Additionally, you will see a Red light come on within the AIM BASE case which indicates that it is receiving power.

Once connected and recognized a message will appear in the Console indicating successful initialization along with the firmware version (see leftmost circle in Figure 4). At this point the device may be used to receive transmissions from the AIM XTRA.

2.2.3 Firmware Updates

Warning: *Prior to updating the firmware any flight data on the AIM XTRA should be downloaded and saved. If not done this flight data will be lost during the firmware updating process.*

Firmware updates are included in the software updates you've downloaded from an Authorized Service Center (see sections 7.2 & 2.2.1). When the AIM XTRA software is started the software opens up on the Control Panel tab. Once you've successfully connected the AIM XTRA look for the ***Update firmware*** button in the *Firmware update* section. In order to perform the update, just select the ***Update firmware*** button (see Figure 10). During this process do not disconnect the AIM XTRA or you will corrupt the firmware on the device. Note that during the update progress is reported in the Console screen. Once the update is completed you should see a "Success" message (note you may need to scroll down the Console screen to fully see the progress and completion messages).

Similarly, when starting the AIM BASE software, it also opens in the *Control Panel* tab and also has a section labeled *Firmware update*. Select the ***Update firmware*** button to perform the firmware update (see Figure 4). During this process do not disconnect the AIM BASE or you will corrupt the firmware on the device. Note that during the update progress is reported in the Console screen. Once the update is completed you should see a "Success" message (note you may need to scroll down the Console screen to fully see the progress and completion messages).

2.3 Battery Power

Figure 1 shows the standard setup for the AIM XTRA device. The AIM XTRA features a dual power system, allowing you to have separate batteries for the flight computer and the ejections. This can be bypassed by simply connecting the two positive terminals together with a short wire. A single battery is not recommended unless you are not using ejections with the AIM XTRA, or you are using a battery with a high current discharge capability. The left pair of terminal blocks are for the computer and the adjacent pair for the pyro/ejection batteries. Note that the terminal blocks are designed to accept 18 gauge or smaller wires.

2.3.1 Computer Battery

The input voltage range for the AIM XTRA computer is from 3.5 volts to 8.4 volts inclusive. It is recommended that either a single cell LiPo, a two cell LiPo, or a two cell LiFePo4 battery be used as a power source. One or two cell LiPo batteries from Turnigy or MaxAmps are suggested. Because the AIM XTRA is designed to work with single cell LiPo batteries, it is not recommended to use 9 volt batteries. The AIM XTRA has to convert the excess voltage to heat, which could cause reliability issues. However, if there is a desire to run off of 9 volt batteries, a single high current LED (or ~22 Ohm resistor) in series with the positive terminal will provide enough of a voltage drop to ensure trouble free operation. The minimum capacity for the computer battery is 200 mAh (approximately one and a half hours of use). The recommended capacity is 1000 mAh or larger. For LiPo's it is suggested that the battery mah value times the battery's C (current) rating does not exceed 40 Amps.

2.3.2 Ejection Battery

The ejection battery should be chosen appropriately based on your igniter/e-match current requirements. The ejection battery voltage should not exceed 10 volts.

2.3.3 Single Battery

A single battery can be used to power both the computer and for firing the ejections. This should only be done when the battery can supply enough current such that the voltage does not drop while the ejections are being fired. A high discharge LiPo battery is recommended.

2.4 Igniters/e-Matches

The four terminal block pairs on the right of the two power terminal block pairs may be used for igniters/e-matches. Wire your igniters/e-matches as shown in Figure 1. Please ensure that your igniters/e-matches do not draw more than 40 amps as an absolute maximum, and that they do not short out after being fired. If these precautions are not followed, the transistor switches might be damaged. Note that the terminal blocks are designed to accept 18 gauge or smaller wires.

2.5 Board Placement

There are four mounting holes that accept standard M3 sized bolts, with enough room for spacers. Because the board has components on both sides, it is recommended that spacers be used to create a gap between the board and the mounting plate. The board should be placed vertically (z axis – see Figure 1) inside the rocket, with the transmitting antenna either pointing upwards or downwards. The ideal alignment is for the antenna to face towards the tail of the rocket. If the antenna is facing upwards in your rocket, the firmware includes an auto-detection feature that will automatically correct the acceleration readings accounting for the inversion.

Furthermore, in order to obtain the most accurate readings from the altimeter you should adhere to the following recommendations:

- The mounting plate material should be transparent to radio frequencies which eliminates the use of metal or carbon fiber materials.
- The supports for the mounting plates should not be metallic in order to avoid GPS reception issues.
- The AIM XTRA should be well aligned with the vehicle's z axis to provide the most accurate vertical acceleration readings.
- The mounting plate should be positioned so that the AIM XTRA's axis is centered on the vehicle's Z axis in order to give the most accurate lateral acceleration and gyro rotational values.
- The avionics bay containing the AIM XTRA should be transparent to radio frequencies (e.g., fiberglass, phenolic, etc.).
- The AIM XTRA transceiver and GPS antennas should not be located near any RF oblique materials (e.g., carbon fiber, aluminum, etc.) or other sensitive circuitry.

2.6 Static Port(s)

Unless you choose not to use barometric sensor data for your flight make sure to include a static port(s) so that external pressures may be sensed by the device.

During flight the pressure within the avionics bay must rapidly equalize with the external atmospheric pressure in order to provide an accurate altitude reading. As the volume of the avionics bay changes the volume of air flow required for pressure equalization changes proportionally. Assuming that pressure equalization should occur within the same time period regardless of volume (in order to maintain reading accuracy) then the area of the hole(s) needed for pressure equalization must be directly proportional to the volume of the chamber where the altimeter is located. We have determined that the following equation accurately

models the size of the static port hole(s) required for accurate barometric sensor readings assuming that the flow is not choked. The equation and its derivation may be found at: http://www.offwegorocketry.com/userfiles/file/Documents/Static%20Port%20Holes.pdf

Figure 2 depicts the results of this equation for a single port based on AV Bay size and Mach velocity. Note that we recommend the use of three or four static ports so the sizes in the chart need to be converted to the number of ports you are using. $d_n = \frac{d_1}{\sqrt{n}}$ where n is the number of ports and d_1 is the value from Figure 2.

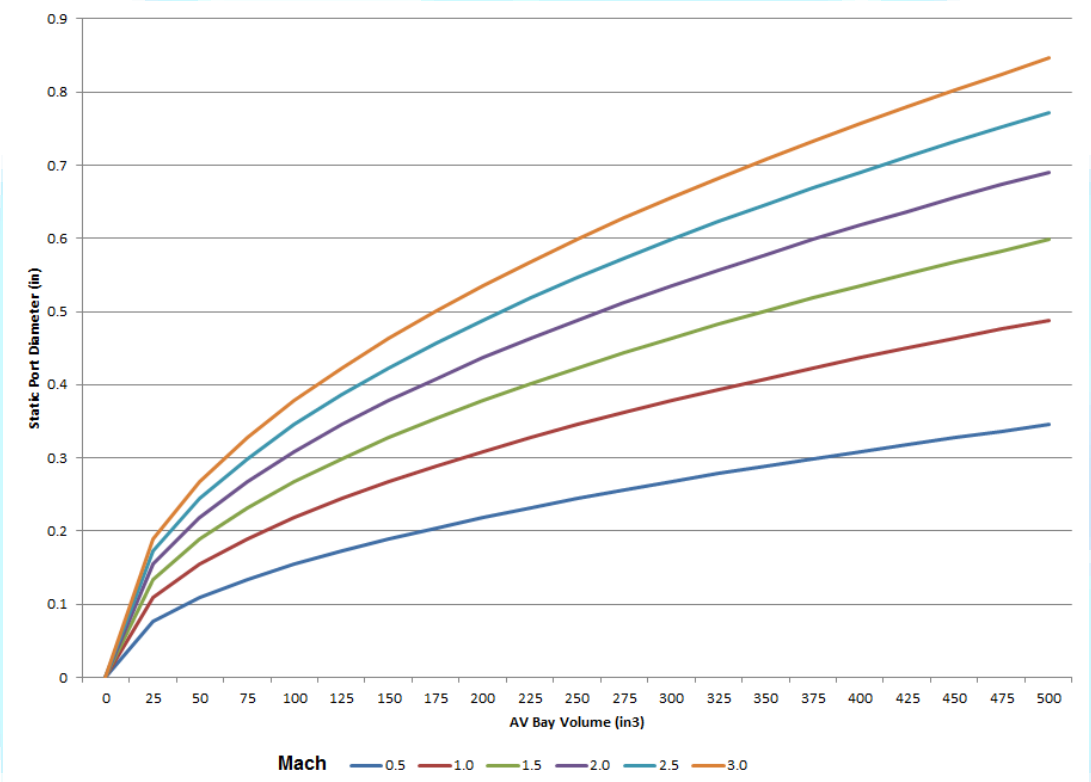


Figure 2 - Single Port Size by Mach Velocity

2.7 Data Transmission/Reception

By default, the AIM XTRA transceiver does not transmit when the AIM XTRA is connected to a laptop since it is designed to be configured and not operating in this state. The user may activate/deactivate the transceiver by checking/unchecking the “RF Transmitter on” checkbox (see rightmost circle in Figure 3).

When settings are changed in the XTRA software they are not automatically saved to the AIM XTRA unit. Once you have adjusted the settings to the desired values you must select the “Write Settings” button in order to have them saved to the AIM XTRA unit. The Console will indicate if your settings have been written successfully to the AIM XTRA unit.

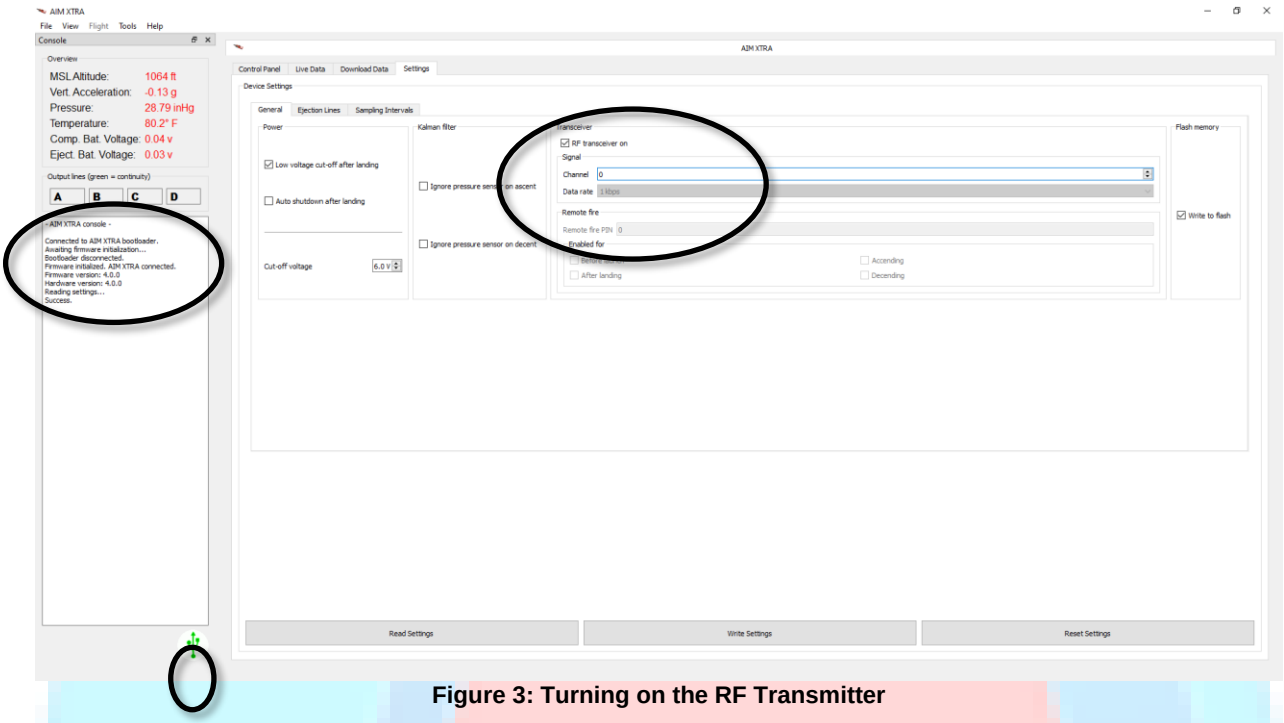


Figure 3: Turning on the RF Transmitter

2.7.1 Channel Selection

The channel allows you to choose from a set of unique channels for your radio link (see Table 1). The channel bandwidth is 500 kHz. Only transmissions matching the channel set in the AIM BASE software will be received (see rightmost circle in Figure 4). You can change the transmission channel for the AIM XTRA on the settings tab (see rightmost circle in Figure 3).

Channel	Frequency (MHz)
0	902.750
1	903.500
2	904.250
3	905.000
4	905.750
5	906.500
6	907.250
7	908.000
8	908.750
9	909.500
10	910.250
11	911.000
12	911.750
13	912.500
14	913.250
15	914.000
16	914.750
⋮	⋮
31	926.0000

Table 1: Channel/Center Frequency Map

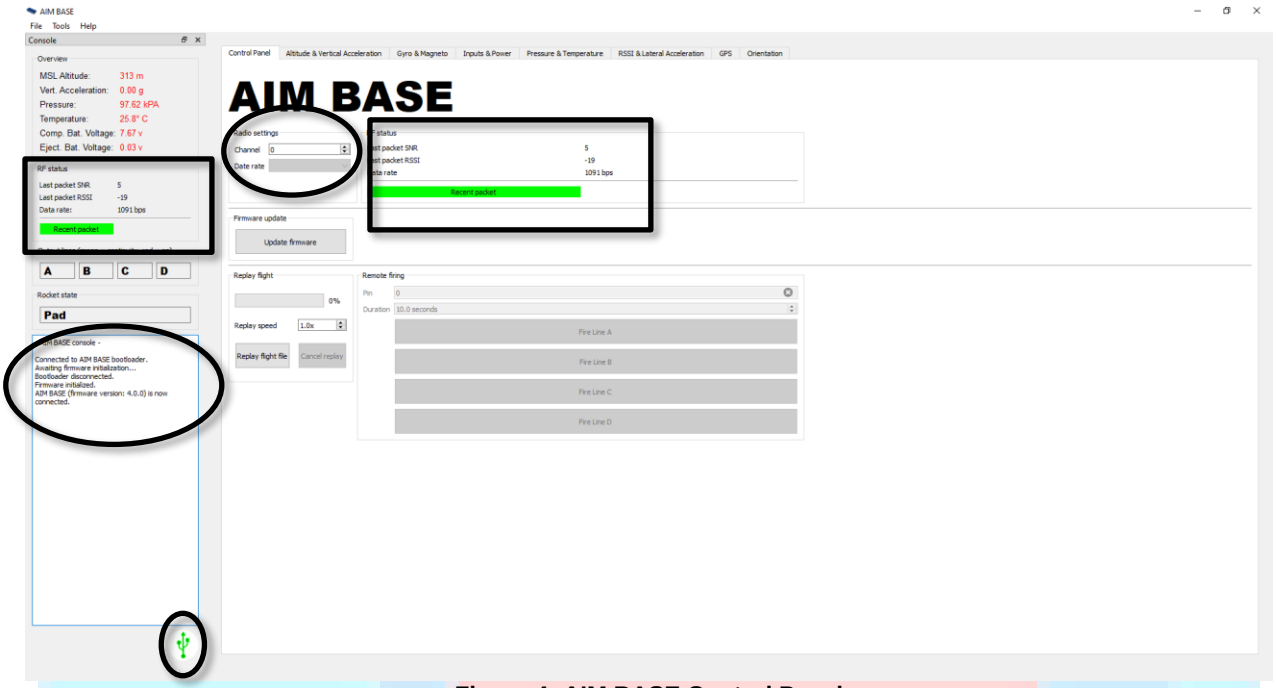


Figure 4: AIM BASE Control Panel

2.7.2 Radio Band

You can select the AIM XTRA to operate in the EU 868 radio band. When doing so, you will need to select the same in the AIM BASE to ensure reception.

2.7.3 Data Rate

You can change the rate at which data is transmitted to the AIM BASE (future implementation). Lower data rates increase the reliability of your transmission. If you change this setting on the AIM XTRA, you also have to select the same data rate on the AIM BASE software.

The AIM BASE *Control Panel* tab and *Console* both contain *RF status* sections (see rectangle boxes in Figure 4Figure 4). In these sections the transmission data rate is displayed in bits per sec (bps) along with Frequency error (difference between transmitter and receiver frequencies) in hertz (Hz) and a *Recent packet* graphic which is Green if a data packet is received gradually turning to Red over time if data packets are not received. Provided the Frequency error is between -400 Hz and 400 Hz you should not have any reception issues.

2.7.4 Reception

For the best reception the AIM BASE should be raised as high as possible off the ground. The recommended minimum height above the ground is 3 meters (9 feet). The AIM BASE supporting structure should not be made out of a RF oblique material and the AIM BASE antenna should not be adjacent to the structure but rather projecting above it. A USB extension cable can be used to connect the AIM BASE to your computer in the field.

2.8 External Inputs

Each of the four ejection lines can be used as input lines if configured as such in the AIM XTRA software (see Figure 5). Simply connect the **positive sensor output** to the **negative terminal** on the appropriate AIM XTRA line and the **negative sensor output** to either the **Comp or Pyro negative terminal**. The inputs are protected against over-voltage (maximum of 12 volts), but

will only display values from 0 up to ≈3.3 volts. If your input is not within this range, you can use a resistive potential divider to reduce the voltage. Note that the voltage divider will have three wires one from the sensor output to the resistor divider the second one from between the resistors which is connected to the line's **negative terminal** and the third which follows both resistors and is connected to the **Comp or Pyro negative terminal**. Inputs **cannot be negative** as this will damage the device. Again, note that these terminal blocks are designed to accept 18 gauge or smaller wires.

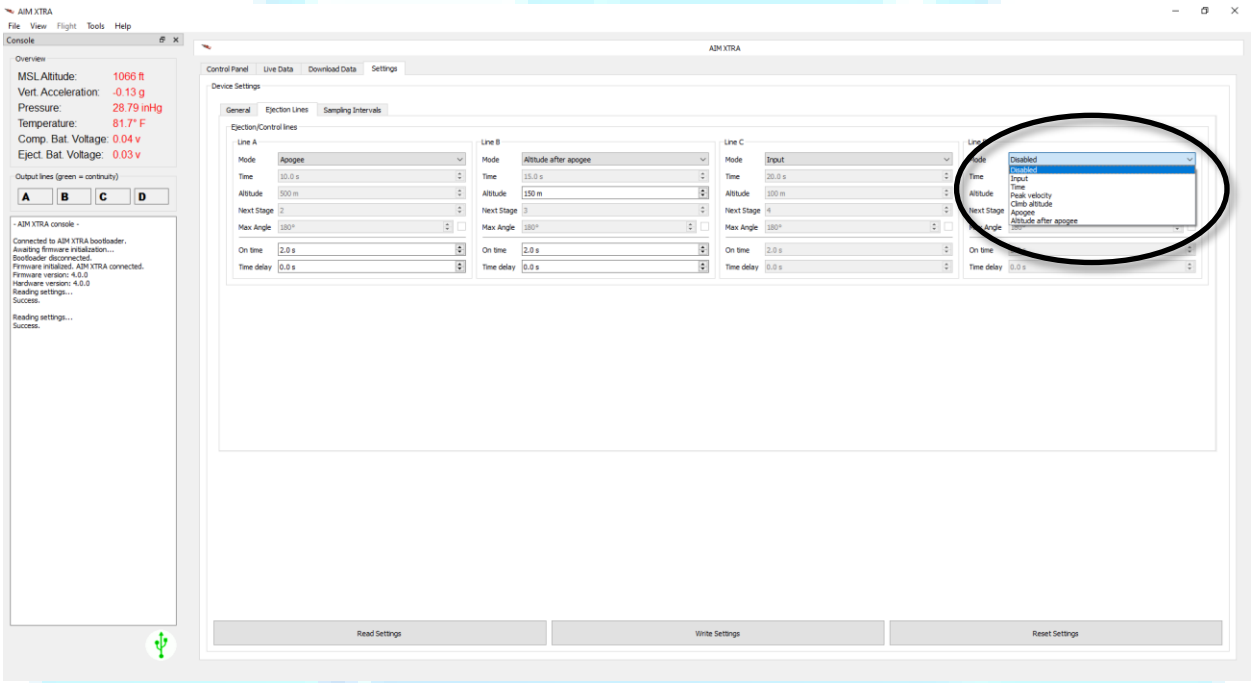


Figure 5: XTRA Ejection Line Settings

3 Preparing for Launch

3.1 Configuration

In order to configure the AIM XTRA for flight you will need to connect it to your computer running the AIM XTRA software as described in section 2.2.2. Similarly, you will need to do the same when configuring the AIM BASE. Note that if an item is greyed out it is unavailable in the current system configuration or the feature is unavailable at this time.

3.1.1 XTRA Tools Menu

The Settings menu item under the Tools Menu is used to select the GPS coordinates format and the unit system displayed within the XTRA application (see pop-up window in Figure 6). The options are to display GPS coordinates in one of the following formats: decimal degrees; degrees, minutes, seconds; or degrees and decimal minutes (default). The unit options are either metric or imperial.

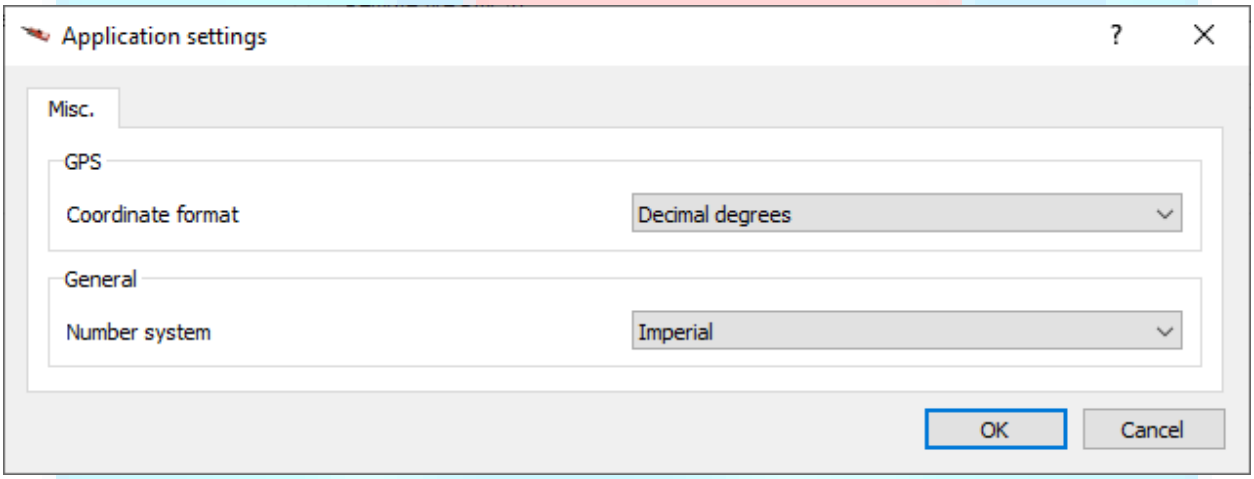


Figure 6: Settings Pop-up Window

3.1.2 XTRA Settings Tab

This area of the interface is where all the AIM XTRA settings may be viewed and adjusted (see Figure 7). Whenever the AIM XTRA unit is connected to the AIM XTRA software the unit's current settings are read and stored into the software. There are three buttons at the bottom of the Settings tab: ***Read Settings***, ***Write Settings***, and ***Reset Settings***. ***Read Settings*** will read the configuration of the AIM XTRA unit and adjust the software to reflect those values. If you make any changes to the settings in the software, they will not take effect until you select the ***Write Settings*** button which stores the configuration on to the AIM XTRA unit. Finally, the ***Reset Settings*** button resets the AIM XTRA unit to the factory settings. The Console will reflect the status of the Read, Write, and Reset processes.

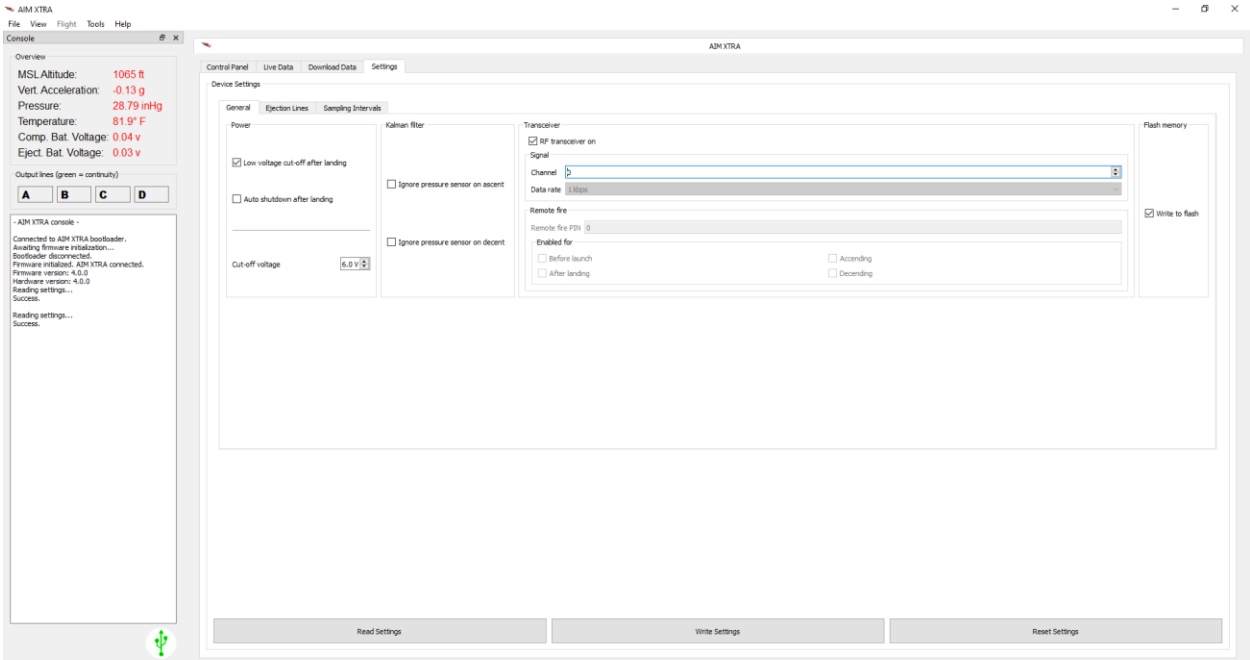


Figure 7: XTRA General Settings

3.1.2.1 General

There are four sections within this tab: Power, Kalman filter, Transmitter and Flash memory (see Figure 7).

Power Section

The Power section is used to control battery usage and contains two check boxes:

- ***Low voltage cut-off after landing*** – when checked monitors the computer battery and shuts the altimeter off when the ***cut-off voltage*** is reached.
- ***Auto shutdown*** *after landing* – when checked shuts the altimeter off upon landing

The spinner control labeled ***Cut-off voltage*** allows you to set the voltage at which the altimeter will shut down provided that the ***Low voltage cut-off after landing*** is checked. Note that this setting should be used to protect your LiPo batteries. The recommended settings are as follows:

- For a 7.4V LiPo – 6.0V or higher
- For a 3.7V LiPo - 3.5V (the voltage must not fall below 3.4V for the altimeter to operate so to preserve the data collected and allowing for a margin of error this value is the minimum permitted)

Allowing a LiPo battery to discharge below 3.0V per cell will damage the battery so when using LiPo's use of the cut off voltage controls is strongly recommended.

Kalman Filter Section

This section is used to control altimeter computations and is comprised of two check boxes:

- ***Ignore pressure sensor on ascent*** – if checked the barometric sensor data is not used in the computation of variables such as altitude during ascent. This setting is used if your avionics bay is totally enclosed during ascent (e.g., no static ports).
- ***Ignore pressure sensor on descent*** – if checked the barometric sensor data is not used in the computation of variables such as altitude during descent. This setting is used if your avionics bay is totally enclosed during descent (e.g., no static ports).

Transmitter Section
This section is used to configure RF transmissions and is comprised of the ***RF Transmitter on*** checkbox. If ***RF Transmitter on*** is checked the unit will transmit the data it is capturing. In addition, there is a text box entitled ***HAM Callsign***. The text placed in this box is sent with each transmission in order to be compliant with government communication agency requirements. This is where you would enter your unique identification code provided to you by your local government agency for amateur radio communications. The ***Channel*** spinner control allows you to select the channel you wish to use for your transmission. Acceptable values are 0 to 31 (see Table 1). The ***Data Rate*** spinner control is currently unavailable but will be used to specify the rate at which data is transmitted from the XTRA to the BASE unit.

Flash Memory Section
This section is to control data recording and is comprised of one checkbox: ***Write to flash***. When checked all data collected by the altimeter is stored in flash memory. If you do not check this box no data will be stored internally in memory, hence, no data will be able to be viewed or downloaded from the altimeter.

Remote Fire Section
This section is under development but when available will be used to ground test the ejection lines.

3.1.2.2 Ejection Lines

Under this tab are sets of spinner controls used to configure each output/input line. Since the options for all four lines are identical, we will only cover one set of these controls (see Figure 5).

The ***Mode*** spinner control consists of the following seven options:

- *Disabled* – When selected the line is non-functional. All other spinner controls are unavailable.
- *Input* – When selected the line is configured to accept data from an external source via the associated negative terminal. The acceptable voltage range is between 0v and 3.3v. Negative voltages will damage the unit. All other spinner controls are unavailable.
- *Time* – When selected the line will act as an output line and fire the specified amount of time after launch. When selected the following spinner controls are also available: ***Time***, ***On Time*** and ***Time Delay***.
- *Peak velocity* – When selected the line will act as an output line and fire when the velocity of the rocket begins to decrease after launch. This will occur near or after motor burnout so is used for staging or air starting. When selected the following spinner controls are also available: ***Min. Altitude, Next Stage, Max Angle, Min. Velocity, On Time,*** and ***Time Delay***.
- *Climb altitude* - When selected the line will act as an output line and fire when the altitude of the rocket reaches the specified altitude prior to apogee. This can be used to eject a boost glider or ejecting parachutes at a specific altitude in competitions. When selected the following spinner controls are also available: ***Altitude***, ***On Time*** and ***Time Delay***.
- *Apogee* – When selected the line will act as an output line and fire when the rocket reaches apogee. Typically, this setting is used to eject a drogue chute in dual deploy or main parachutes in single deploy recovery systems. When selected the following spinner controls are also available: ***On Time*** and ***Time Delay***.
- *Altitude after apogee* - When selected the line will act as an output line and fire when the altitude of the rocket reaches the specified altitude following apogee. Typically, this

setting is used to eject a main parachute in dual deploy recovery systems. When selected the following spinner controls are also available: ***Altitude***, ***On Time*** and ***Time Delay***.

The ***Time*** spinner is used to set a time following the launch at which the output line will activate.

The ***Altitude*** spinner specifies the above ground level (AGL) altitude (metric units only) at which the output line will activate. Note that whether this occurs before or after apogee is dependent upon the ***Mode*** spinner.

The ***Min. Altitude*** spinner specifies the minimum above ground level altitude (metric units only) at which the output line may activate and is only available in the ***Peak velocity Mode***.

The ***Next Stage*** spinner specifies the position in the ignition sequence under which the pyro channel is active. For example, setting the spinner to 2 (default) activates the pyro channel after the first motor burn and may be used for a second stage or an air start ignition. In this example the pyro channel will no longer be active once the second motor burn is completed.

The ***Max Angle*** spinner specifies the maximum angle from vertical under which the pyro channel is active. The default value is 180° so if you are using the pyro channel to initiate a staging event (e.g., motor ignition) then the setting should be reduced to an angle deemed safe for your launch considering the rocket design and area (0° is considered vertical so the setting is often in the range of 5° to 10°). Note that this spinner is only available if the adjacent check box is selected.

The ***Min Velocity*** spinner specifies the minimum speed (metric units only) at which the output line may activate and is only available in the ***Peak velocity Mode***.

The ***On Time*** spinner specifies the duration for which the output line is active. Unless testing of your igniters/e-matches has demonstrated otherwise it is recommended that a setting of two seconds or longer be used. Note that since a time duration may be specified this setting can be used to operate motors, servos or other devices.

The ***Time Delay*** spinner specifies the amount of time to wait after the ***Mode*** spinner setting has been reached before activating the output line.

3.1.2.3 Sampling Intervals

This tab is broken up into two sections: Flash write intervals and RF Transmit priorities (see Figure 8).

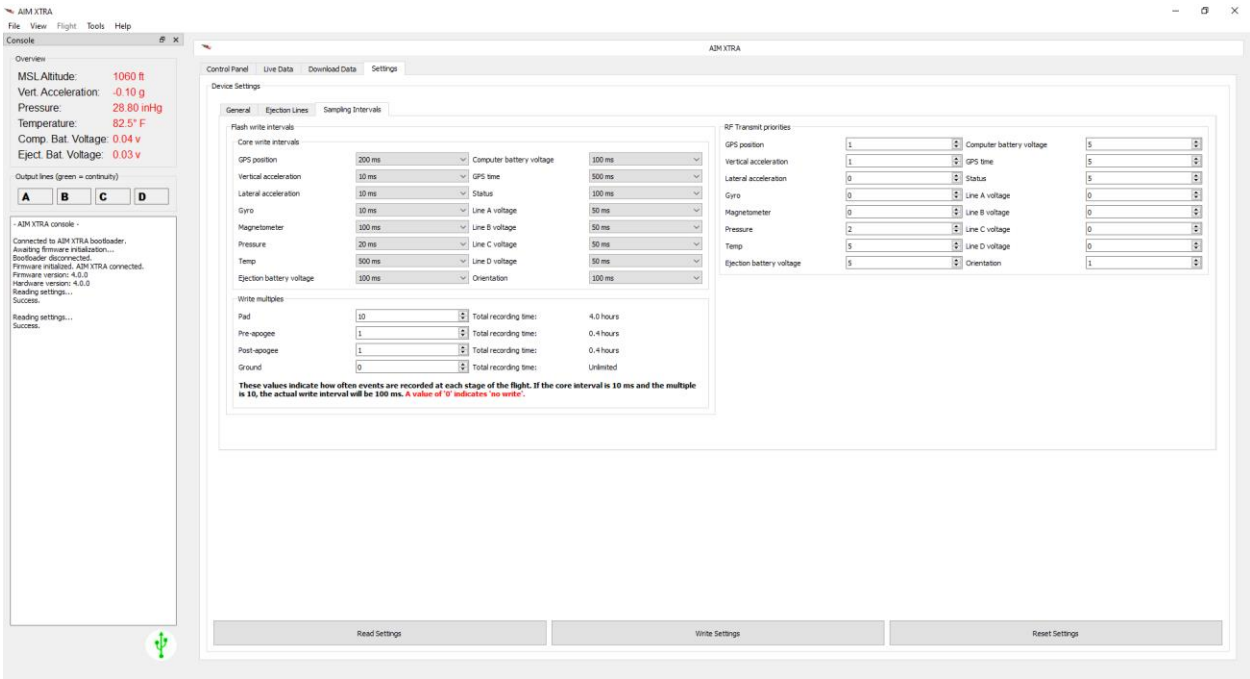


Figure 8: XTRA Sampling Intervals Settings

Flash Write Intervals Section

This section is divided into two subsections: *Core write intervals* and *Write multiples*.

Core Write Intervals Subsection

This subsection consists of 15 drop down list boxes each of which specifies the frequency in milliseconds at which sensor data is written to flash memory for the following data items: GPS position, Vertical acceleration (Z axis), Lateral acceleration (X & Y axes), Gyro (X, Y & Z axes), Magnetometer (X, Y & Z axes), Pressure, Temp, Ejection battery voltage, Computer battery voltage, GPS time, Status (output line continuity), Line A input (and output) voltage, Line B input (and output) voltage, Line C input (and output) voltage, Line D input (and output) voltage, and Orientation. The update frequency is limited by each sensor or transmission rate in the case of GPS values. The most rapid settings values are depicted in Figure 9. Note that values for these sensors may not be set to obtain data faster than the depicted settings.

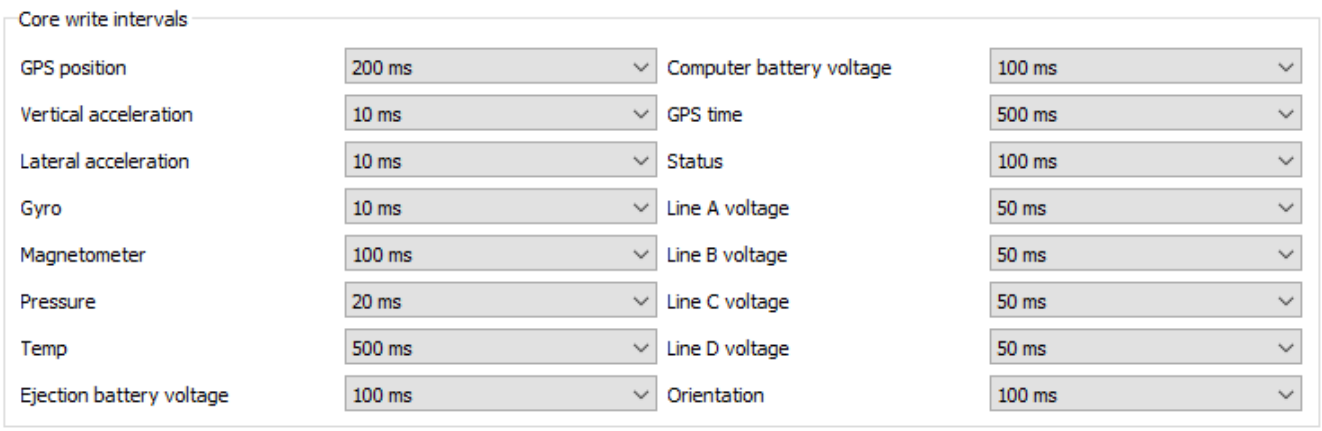


Figure 9 – Sensor Maximum Write Interval Rates

Write Multiples Subsection
This subsection consists of four spinner controls each of which specifies a multiplicative factor used to compute how frequently sensor data is written to flash memory in each of the following states: Pad (Pre-launch), Pre-apogee, Post-apogee, and Ground (Landing). The spinner values consist of non-negative integers. While the rocket is in each of the spinner control states the value of the control is multiplied times the sensor value in the *Core Write Intervals* subsection. The resulting number is the frequency at which the sensor data is written. For example, if Vertical acceleration is set to 10ms and Pad is set to 10 then while the rocket is on the Pad this data is written once every 100ms (10ms*10), if Pre-apogee is set to 1 then the data is written once every 10ms after launch to apogee, if Post-apogee is set to 5 then the data is written once every 50ms after apogee to landing, and if Ground is set to 0 then the data is not written at all after landing.

Note that given the *Core Write Interval* and the *Write Multiples* settings the amount of data that can be stored in flash memory is specified for each state in terms of time.

RF Transmit Priorities Section
This section consists of 15 spinner controls each of which specifies the priority in which sensor data is transmitted to the BASE unit for the following data items: GPS position, Vertical acceleration (Z axis), Lateral acceleration (X & Y axes), Gyro (X, Y & Z axes), Magnetometer (X, Y & Z axes), Pressure, Temp, Ejection battery voltage, Computer battery voltage, GPS time, Status (output line continuity), Line A input (and output) voltage, Line B input (and output) voltage, Line C input (and output) voltage, Line D input (and output) voltage, and Orientation. The highest priority is 1 which implies that the data will be sent the most often followed by 2, then 3, etc. Zero means that the data will not be transmitted to the BASE unit. The actual frequency of transmission will depend on computational activity, signal strength, and data rates (when implemented) among other factors.

3.2 Operation Verification

Please ensure that you have fully tested the AIM XTRA and also its integration into your rocket. Although all units are fully tested before shipping, it is essential that you test all aspects of the device, especially the ability to supply enough current to the igniters/e-matches. You should also ensure that all settings are correct, even if you didn't change them yourself. Please also ensure that the radio link to the AIM BASE is working as expected. You should be able to achieve a link with both antennas disconnected when the devices are placed within a meter or so (few feet) of each other (when activated).

3.2.1 XTRA Control Panel Tab

The Control/Diagnostic section in this tab consists of five subsections three of which are used to verify altimeter operations: *High current output lines*, *Calibration*, and *Emulation* (see Figure 10).

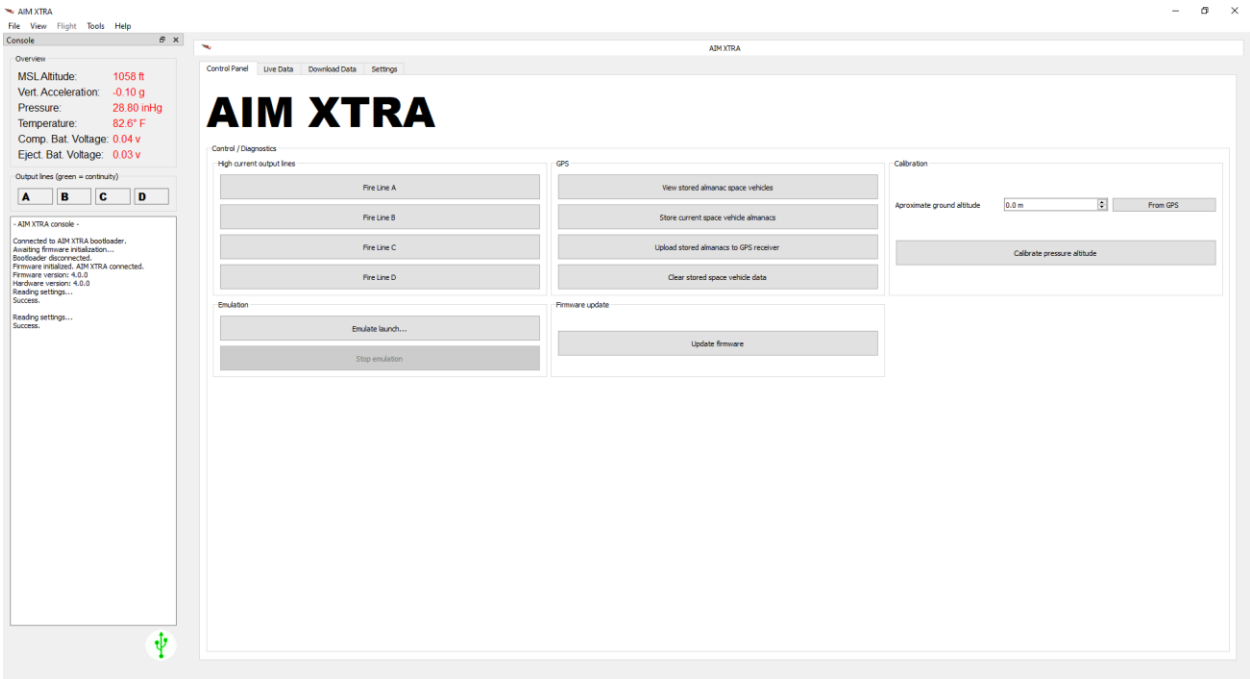


Figure 10: XTRA Control Panel

In the *High current output lines* subsection, there is a button for each of the AIM XTRA output lines. When the AIM XTRA is connected to your computer these buttons are active and may be selected to test your pyro battery and igniters/e-matches. Just connect an igniter/e-match to the line(s) you want to test along with your pyro battery to the AIM XTRA then select the button for the line you want to test. When selected the igniter/e-match should fire if the battery has the power to initiate ignition. **Warning:** Igniters/e-matches generate significant amounts of heat and should be placed on non-flammable surfaces when tested. They should never be placed on or next to the AIM XTRA unit during testing.

The *Calibration* subsection is used to adjust the altitude readings from the barometric sensor data. The altimeter uses Standard Atmospheric table data combined with the barometric sensor data to compute its altitude. Since atmospheric pressure varies not only with altitude but also with temperature as well as low and high pressure weather fronts the altitude specification from the barometric sensor may vary from day to day (or within the same day) as temperature changes and weather fronts move through an area. Therefore, the ***Approximate ground altitude*** spinner control may be used to set the altitude (if you know what it is) or you may select the ***From GPS*** button to fill the spinner control with the current GPS altitude (you will receive a warning message if the GPS altitude is not within an internally specified accuracy range – e.g., no GPS lock). When the spinner control contains the value you desire (metric units only) select the ***Calibrate pressure altitude*** button to set the interpretation of the current barometric sensor data to the ground altitude. *In order to improve correlation between the barometric sensor and GPS data it is recommended that you perform this calibration each day prior to launch.*

The *Emulation* subsection allows you to test the operation of the AIM XTRA under simulated flight conditions. Any previous AIM XTRA flight may be used in the emulation provided that the flight has been exported into a *.csv file. When the AIM XTRA is connected to your computer the ***Emulate launch…*** button is active. Once selected a pop-up window appears which allows you to select csv file to use for the emulation. Once you have selected the emulation file another pop-up window appears requesting you to specify a file name and location to save the results of

your emulation (also in csv format). Finally, a pop-up window will appear which asks whether you would like to perform a real time emulation or not:

- Real time: emulation is run in normal time for accurate testing of pyro line firing, etc.
- Non-real time: the emulation is accelerated (useful if you just need emulation data).

Once you make your real time selection the emulation will begin. While the emulation is running you will receive progress messages in the AIM XTRA console. If you desire to discontinue the emulation prior to completion the ***Stop emulation*** button is active and may be selected. Once completed you may look at your emulation results file to assess the AIM XTRA operation. Additionally, during the emulation if any the ejection charges were connected, they should have fired. **Warning:** Igniters/e-matches generate significant amounts of heat and should be placed on non-flammable surfaces when tested. They should never be placed on or next to the AIM XTRA unit during testing.

3.2.2 Basic System Test

Prior to checking the telemetry link you should validate operation of the AIM XTRA.

3.2.2.1 AIM XTRA

Run the AIM XTRA software and connect the AIM XTRA hardware to your computer (note that the Comp battery should not be connected or turned off). Verify that the XTRA is configured as you have set it (the values are read from the AIM XTRA when it is attached to your computer). Once verified select the *Live Data* tab (see Figure 10). Under this tab are five subtabs each of which depicts graphs of different AIM XTRA sensor data. When examining the data in each graph you should move/rotate the device to see the values changing. The AIM XTRA is marked with X, Y (perpendicular to the board), and Z axes to assist in this verification (see Figure 1). It is imperative that all sensor data is checked as sensor failure will result in incorrect operation.

Figure 11: Altitude & Acceleration Live Data

MSL Altitude & Acceleration Subtab

The two graphs available on this tab are MSL Altitude and Acceleration. The MSL altitude shows the altitude above sea level (meters or feet) while the Acceleration graph depicts the

accelerations along the X, Y, and Z axes in G's (see Figure 11). Note that absolute acceleration data is reported for the Z axis which means that earth's gravity is included. This means that the readings will be approximately 1 g higher than acceleration values relative to the earth's surface.

Gyro & Magneto Subtab

The two graphs available on this tab are Gyro and Magneto. The Gyro graph depicts rotations around the X, Y, and Z axes in degrees/sec while the Magneto graph portrays the magnetic field variations around the X, Y and Z axes measured in Tesla's (see Figure 12).

Figure 12: Gyro & Magneto Live Data

Inputs & Power Subtab

The two graphs available on this tab are Inputs and Battery Voltages. The Inputs graph shows the voltage values of each of the four input/output lines while the Battery Voltages graph describes the voltages for the Computer and the Ejection batteries (see Figure 13).

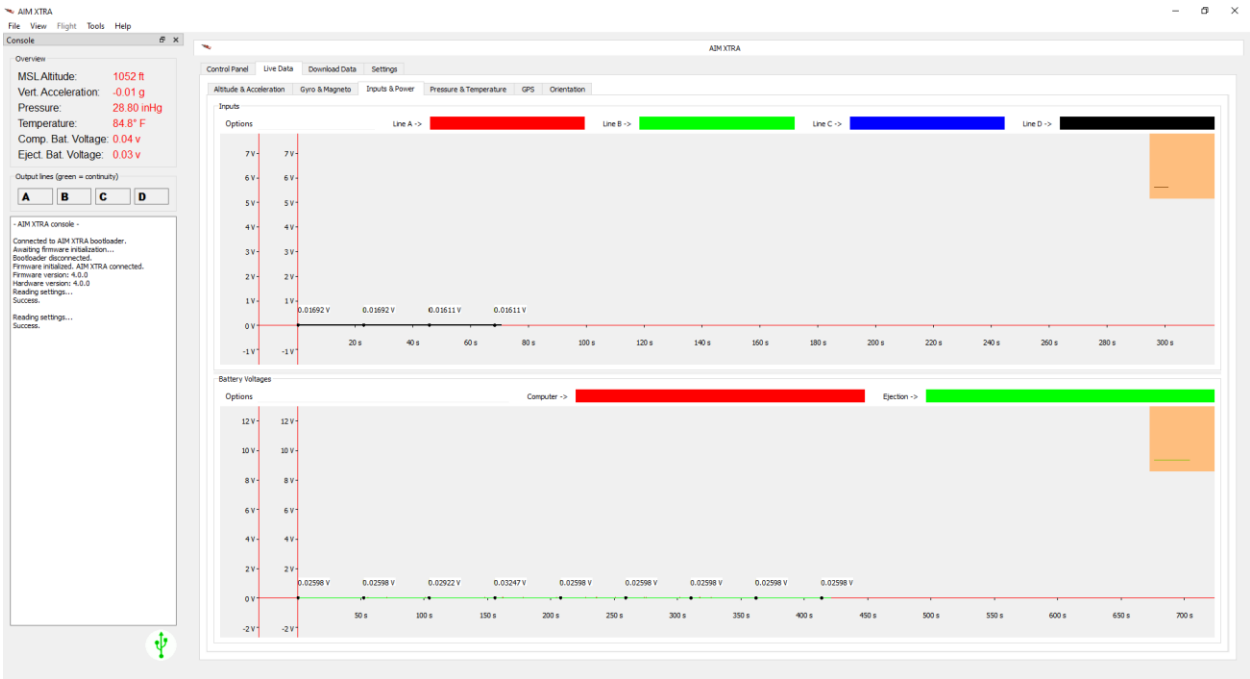


Figure 13: Inputs & Power Live Data

Pressure & Temperature Subtab

The two graphs available on this tab are Temperature and Pressure (see Figure 14). The Temperature graph represents the measured temperature (in degrees C or F) while the Pressure graphs displays the barometric pressure (in kPa or inHg).

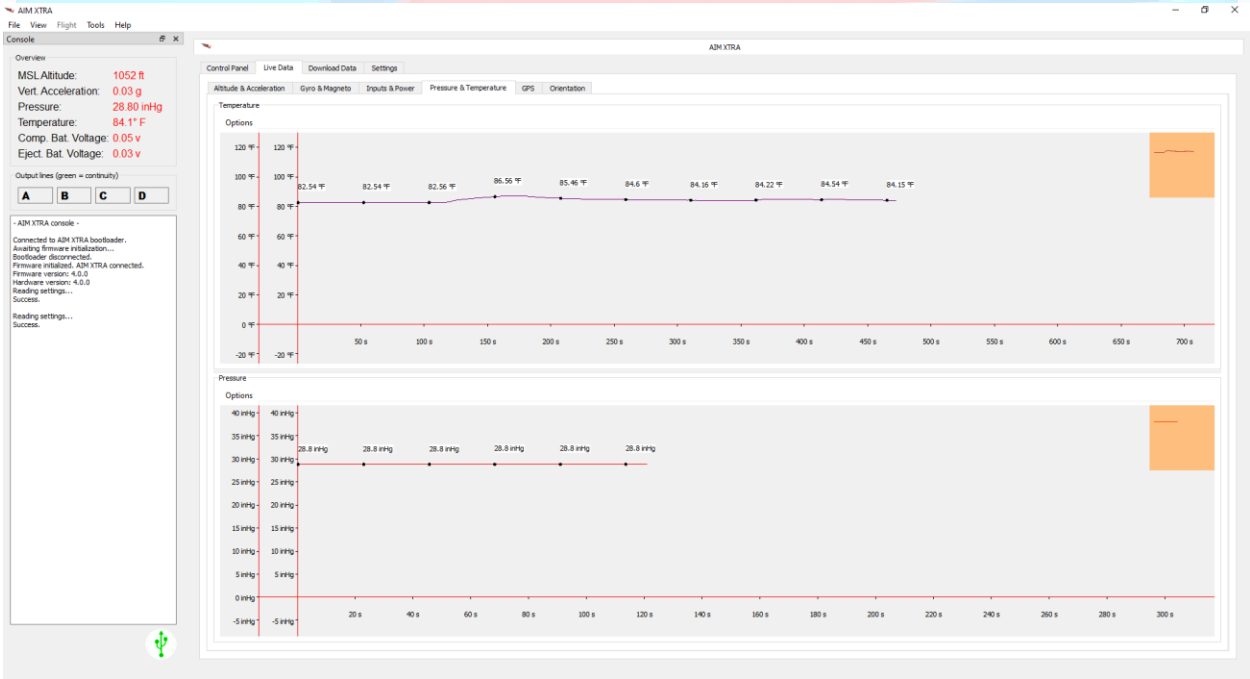


Figure 14: Pressure & Temperature Live Data

GPS Subtab

This subtab is different in that it presents a number of specific data values (see Figure 15):

- GPS Time: Time reported by the GPS satellites
- Satellites used in solution: The number of satellites detected by the AIM XTRA

- GPS fix: Type of GPS solution available which should be “3D solution”
- Lat: The AIM XTRA’s current latitude
- Long: The AIM XTRA’s current longitude
- MSL Altitude: The AIM XTRA’s current altitude

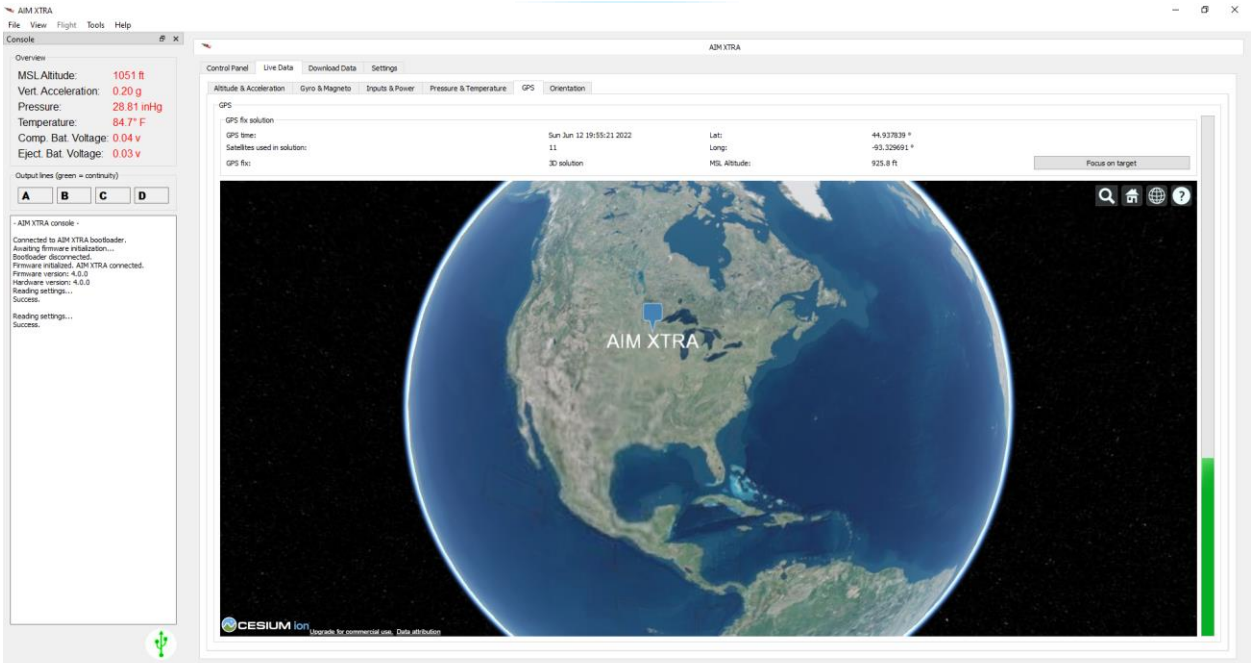


Figure 15: GPS Live Data

Below these values an image of the Earth will appear (the software automatically connects to Cesium Ion) if you are connected to the internet. Otherwise, a field of stars will appear. Along the right side of the image is a vertical Green bar which graphically depicts the quality of the GPS satellite locks. Finally, there is a ***Focus on target*** button which when selected and connected to the internet zooms the image to the AIM XTRA’s current location (see Figure 16).

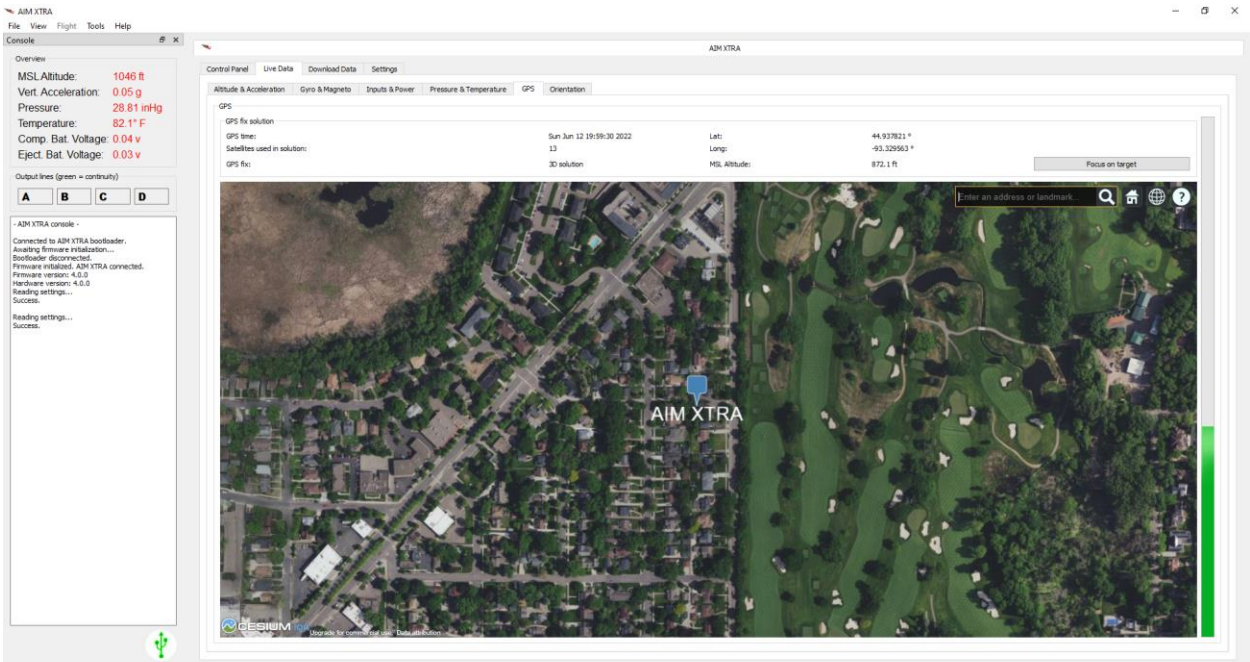


Figure 16: GPS Focused on Target

An AIM XTRA pin marks the current position of the AIM XTRA on the map while a Red line marks the flight path and a Yellow line marks the projection of the flight path over the ground (see Figure 29).

Orientation Subtab

This subtab displays the real-time orientation of the AIM XTRA (see Figure 17). This is useful as a visual tool to observe the orientation (and by extrapolation the rocket) throughout the flight. For example, upon landing you should be able to determine if the rocket is on land or in a tree.

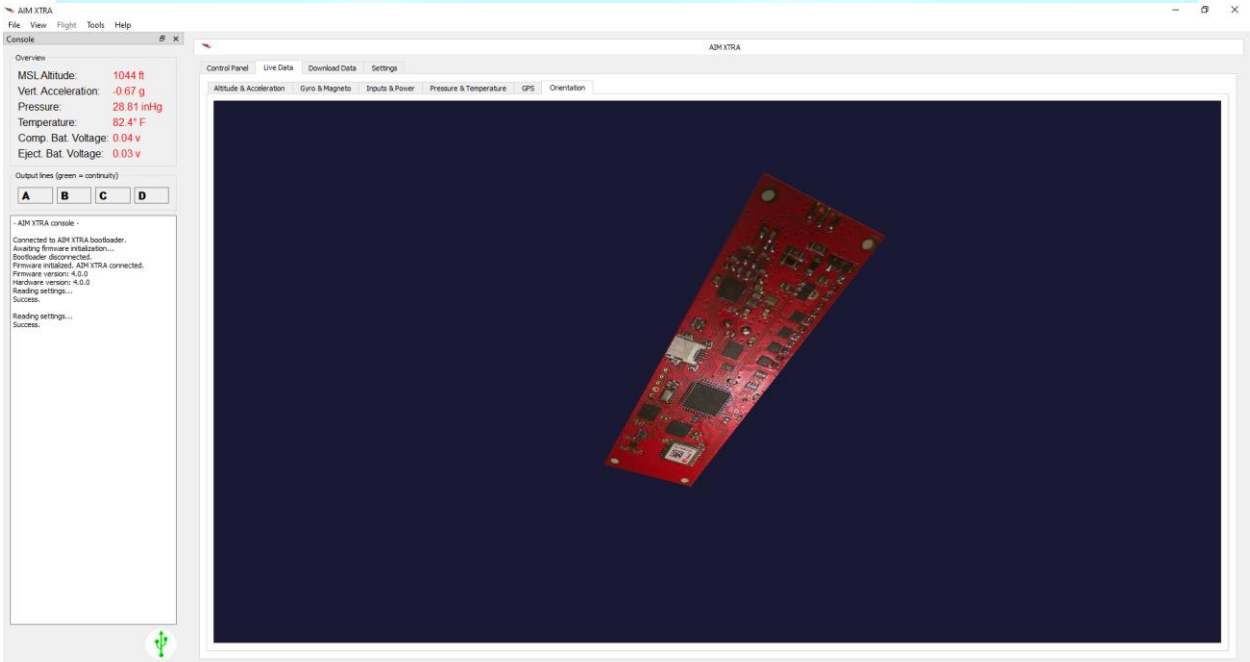


Figure 17: Orientation

3.2.2.2 AIM BASE

Start the AIM BASE software, connect the quarter wave antenna to the AIM BASE, and then connect the AIM BASE receiver to your computer/laptop. You will be able to tell that the AIM BASE has successfully connected to the AIM BASE software if the USB symbol in the Console section of the screen changes color from Red to Green (see bottom left circle in Figure 4). Additionally, you will see a Red light come on within the AIM BASE case which indicates that it is receiving power. Additionally, a pop-up window will appear asking for the name of a file and location to store the data collected from the AIM XTRA. Finally, make sure that the Channel setting is identical to the AIM XTRA Channel setting. *The AIM BASE will not receive any data unless you have activated the AIM XTRA RF Transmitter (see section 3.1.2.1).*

3.2.2.3 AIM XTRA/BASE System

To test that the AIM XTRA/BASE system is working together correctly connect one of the helical antennas and the main computer battery to the AIM XTRA (with no ejection explosives attached) then turn it on. The device will once to indicate that it has run through its pre-launch checks (see section 4.1.3). In order to ensure that you lock onto a sufficient number of GPS satellites conduct this test with the AIM XTRA outside in the open free from obstructions. The AIM BASE should now be receiving a steady stream of data which will be displayed in the AIM BASE software.

With three minor differences the AIM BASE graphs are identical to those described for the AIM XTRA (see section 3.2.2.1). The exceptions are in the *Altitude & Vertical Acceleration, RSSI & Lateral Acceleration, and the GPS* tabs.

Altitude & Vertical Acceleration Tab

The Vertical Acceleration (Z) graph only depicts the Z axis acceleration (see Figure 18). Again, note that absolute acceleration data is reported for the Z axis which means that earth's gravity is included. This means that the readings will be approximately 1 g higher than acceleration values relative to the earth's surface.

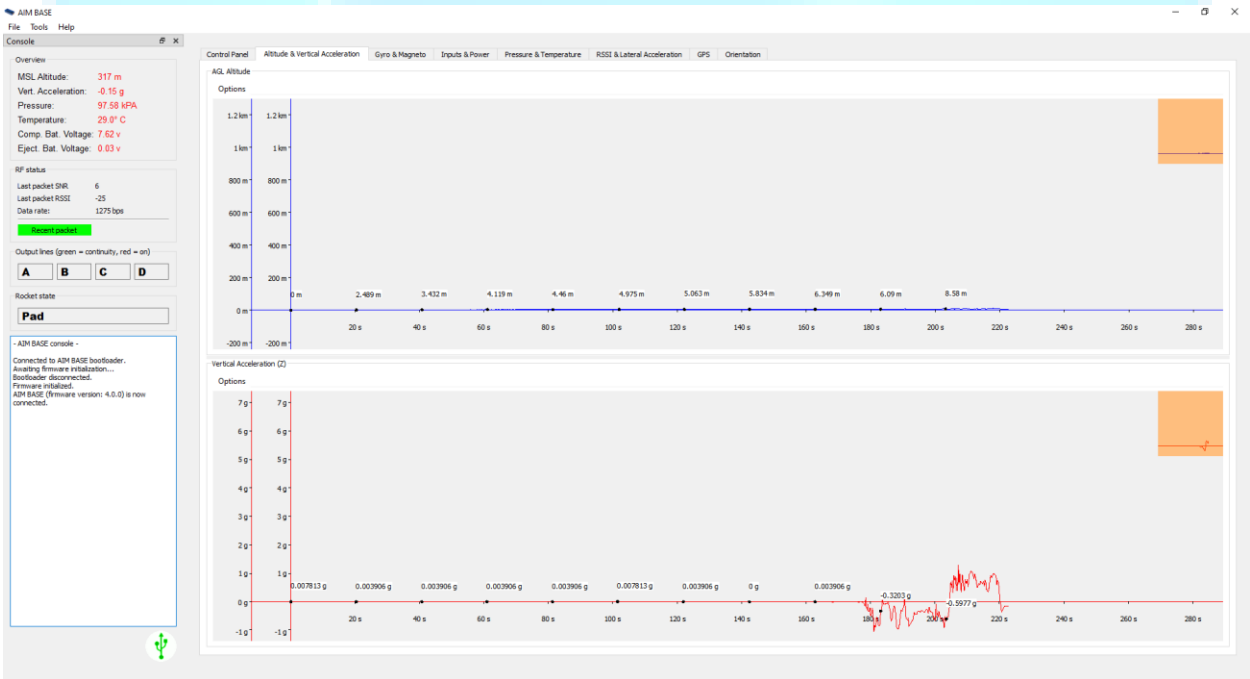


Figure 18: BASE Altitude & Vertical Acceleration

RSSI & Lateral Acceleration Tab

This tab does not exist in the XTRA software. It contains two graphs (see Figure 19). The Lateral Acceleration (X/Y) graph is similar to the XTRA Acceleration graph except that it only depicts the X & Y accelerations. The Received Signal Strength Indicator (RSSI) graph has no corresponding equivalent in the XTRA software since it does not receive RF signals. The graph depicts the strength of the RF signal received in decibels (dBm).

Look at the BASE graphs and move/rotate the XTRA to make sure that the received data is reasonable. The GPS location should also be accurate to within at least 20m (once more than four satellites are locked).

Once you have confirmed that the BASE is operating as designed you can exit the BASE software application and disconnect the BASE unit from your computer. You can then turn off the XTRA unit and connect it to your computer. Once connected select the *Download Data* tab, then select the ***Download Flights*** button. When the flights are downloaded, they appear in the flights section and you may now select one to test from the *Flights* section. When you select a flight you have the option of loading the test data into the AIM XTRA software (see section 5.1). Once loaded, make sure all the data is reasonable.

Figure 19: BASE RSSI & Lateral Acceleration

GPS Tab

Although similar to the AIM XTRA tab as described in section 3.2.2.1 if you are connected to the internet but if not, you have two options:

1. Cesium Ion –
2. Google Earth Pro –Google Earth Pro must be loaded on your computer to support this function (see section 2.2.1)

If you are using Cesium Ion online or offline you will see your location (Figure 20). Otherwise, an X/Y graph will appear with the X axis aligned with east and west while the Y axis will be aligned with north and south (Figure 21). Along the right side of the image is a vertical Green bar which

graphically depicts the quality of the GPS satellite locks. Finally, there is a set of Options buttons (circled in Figure 21):

- ***2D / 3D*** changes view to Cesium Ion (see Figure 20). Note an internet connection is required.
- ***Export KML*** exports a KML file for future viewing in Google Earth Pro.
- ***Zoom to target*** zooms the Cesium Ion image to the AIM XTRA's current location (see Figure 22). Use your mouse wheel to zoom in and out.
- ***Launch Google Earth*** opens Google Earth Pro to view the flight path of the rocket. Note that the Google Earth Pro application will start and in the left Places menu of the screen you will see AIM XTRA under Temporary Places (circled). Double left click it to go to your launch location and view the rocket flight (Figure 23).
- ***Zoom closer to target*** zooms closer to the AIM XTRA's current location in Cesium Ion.

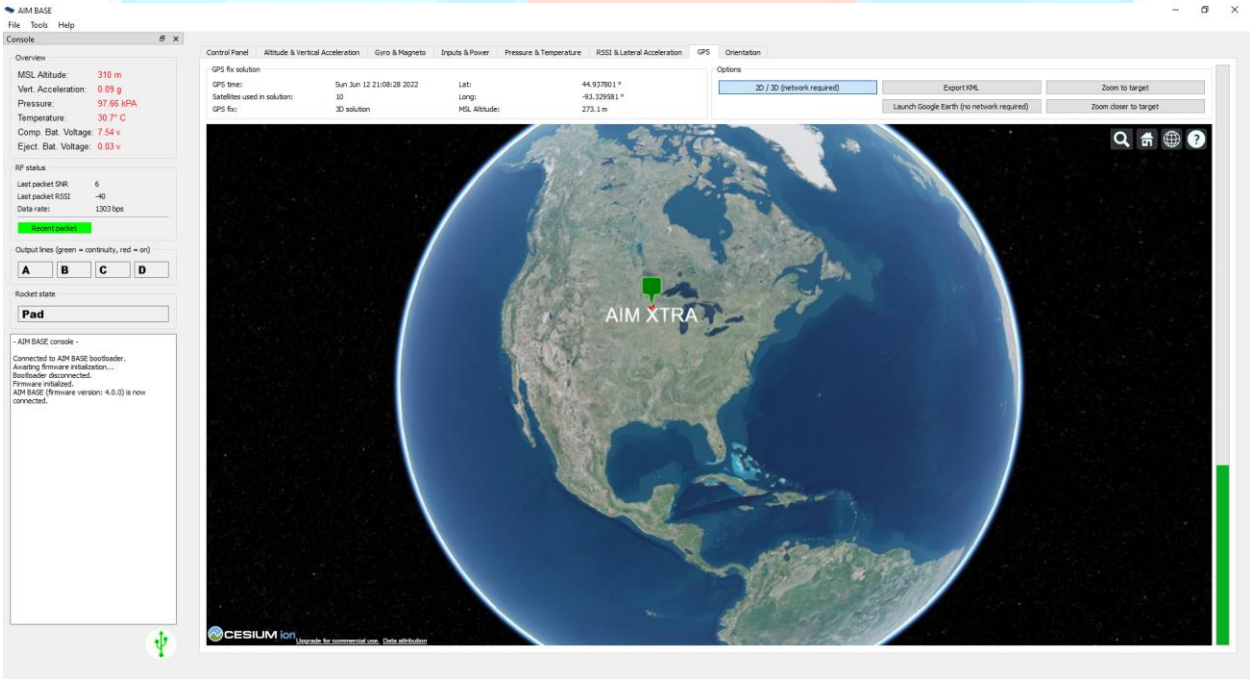


Figure 20 - AIM BASE GPS Tab using Cesium Ion

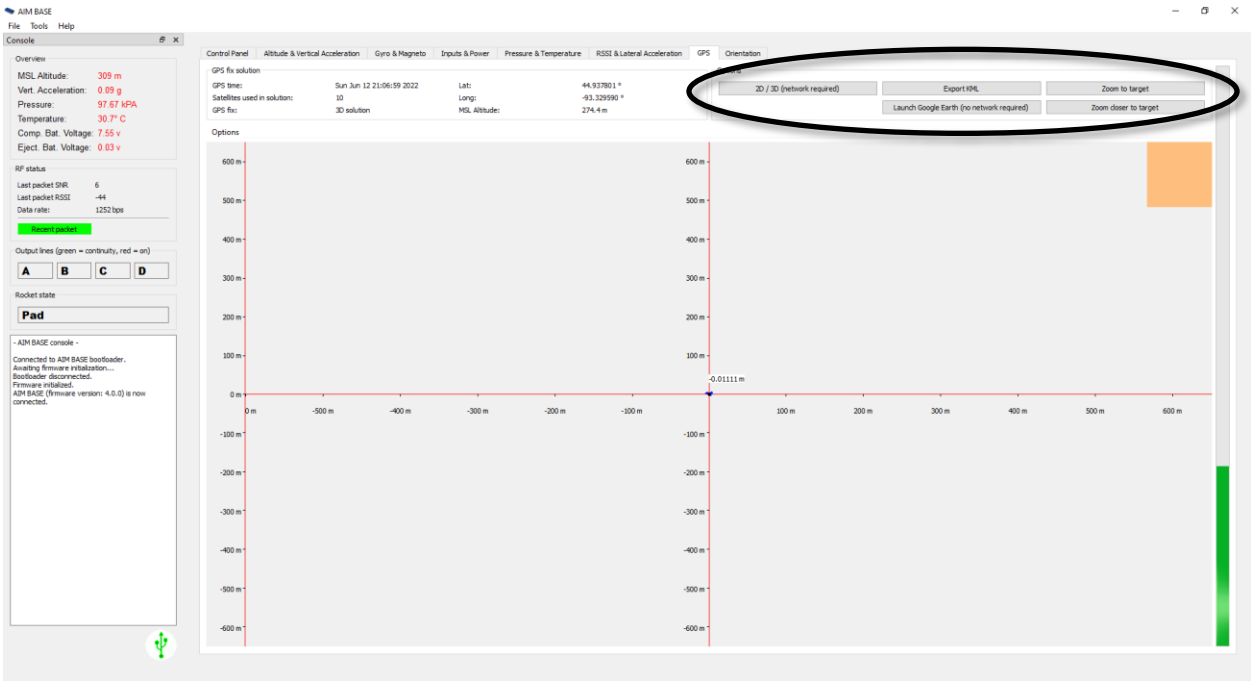


Figure 21 - AIM BASE GPS Tab using XY Graph

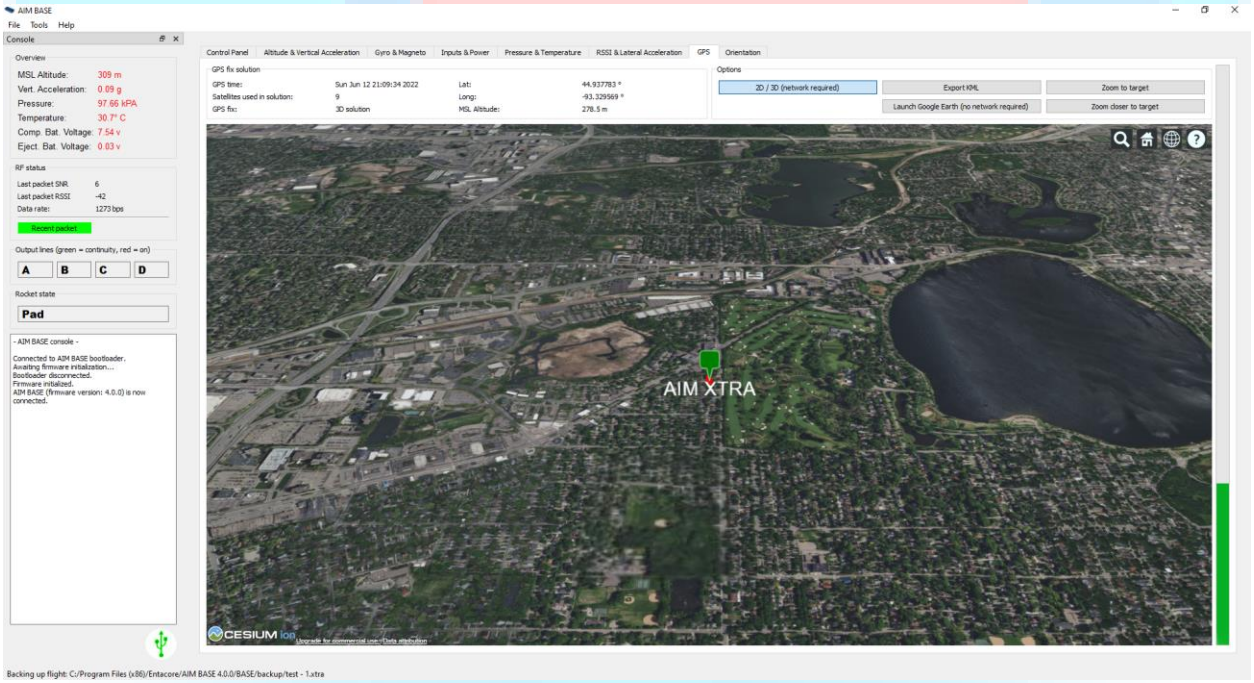


Figure 22 - AIM BASE Zoom to Target

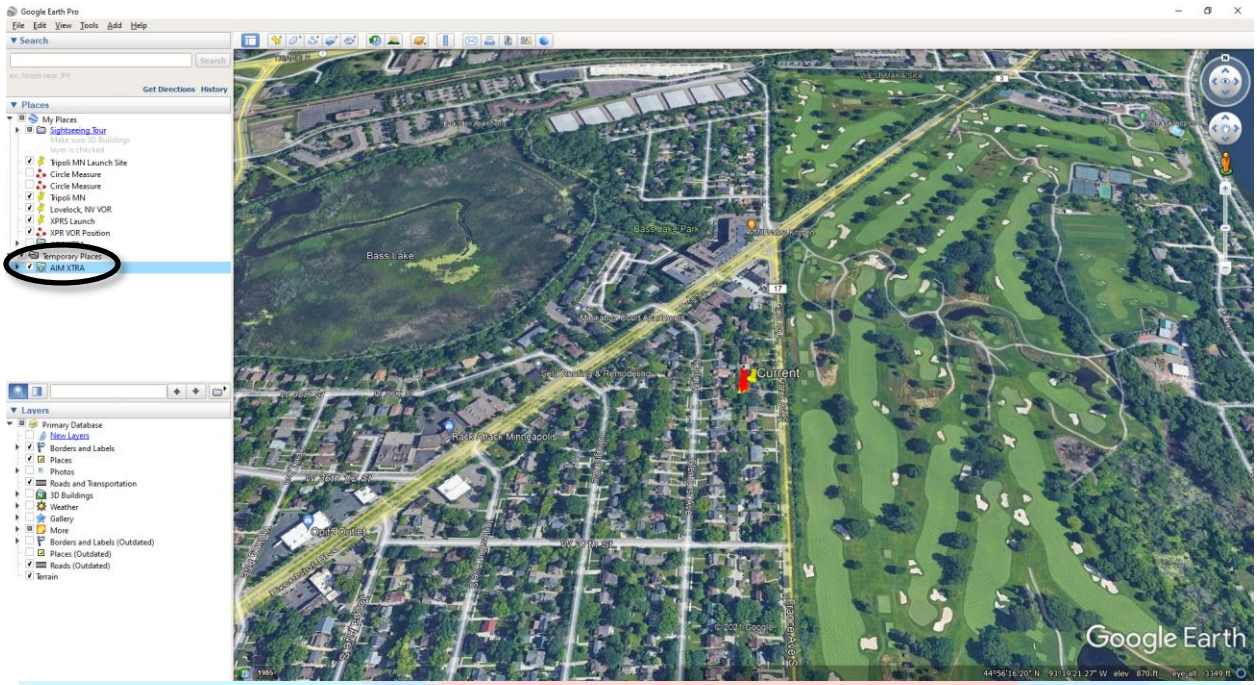


Figure 23 – AIM BASE Launch Google Earth

3.3 Achieving Faster GPS Lock

To achieve faster GPS lock on the launch pad, a feature has been included to store available satellite data before going to the launch field. Although there is no range limit to this data it does degrade over time but will be valid for approximately one week. This data is called the *satellite almanac*.

To pre-load the AIM XTRA with this data, you should connect the AIM XTRA to your computer and place it where it has an unobstructed view of the sky (the more visibility the better). Once a 3D lock has been achieved, you should wait at least 15 minutes for all the almanac data to be downloaded from the GPS satellites.

Now select the AIM XTRA Control Panel tab and look at the GPS section. You will notice four buttons (see Figure 10):

- ***View stored almanac space vehicles:*** Reads the satellite almanac data from the software which can be viewed in the Console
- ***Store current space vehicle almanacs:*** Stores the satellite almanac data in the software
- ***Upload stored almanacs to GPS receiver:*** Stores the satellite almanac data on the AIM XTRA by overwriting any prior almanac data
- ***Clear stored space vehicle data:*** Erases the almanac data from the software

In order to store the satellite almanac data, you should first select the ***Clear stored space vehicle data*** to remove any existing data and then select the ***Store current space vehicle almanacs*** button to save the satellite almanac data.

On or just before the day of your flight connect the AIM XTRA to your computer and select the ***Upload stored almanacs to GPS receiver*** button in order to accelerate the GPS locking process. Again, since this data is only valid for a few days this process should be performed as close to the launch date as possible.

Now, when the AIM XTRA is turned on, it will not need to download this data again and will achieve a much faster lock. Additionally, use of the ***Gate by GPS Lock*** in the XTRA Settings will also expedite GPS locking. It is still recommended to wait at least five minutes before launching, even if you have a good 3D lock.

3.4 Graph Navigation

3.4.1 Menu Navigation

When viewing graphs from previous flights in the AIM XTRA software the *Flight* menu item is available and consists of the following submenu items:

- ***Trim time…*** - A pop-up window appears which allows you to enter the start time at which you want to view the graphs (useful for trimming off time while rocket is on the pad waiting for launch) to begin. Additionally, another pop-up window appears which allows you to enter the end time of the graph (useful for trimming off the time after landing). Note that this action cannot be undone.
- ***Zero time…*** - A pop-up window appears which allows you specify a time you now want to consider as time zero (useful if you specify the launch time as zero). Note that this action cannot be undone.
- ***Auto trim and zero*** – Combines the above two functions.

Additionally, the *Tools* menu item is available and consists of the menu items:

- ***Settings*** –allows you to change the GPS data format and the unit system (metric or imperial) for the displays (see Figure 6).

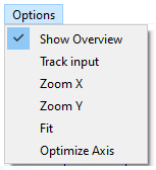
When viewing graphs in the AIM BASE software the *Tools* menu item is available and consists of the menu items:

- ***Clear and Zero*** - which will clear all the graphs and empty out their data.
- ***Settings*** –allows you to change the GPS data format and the unit system for the displays (metric or imperial).

The graphs in the AIM XTRA and BASE software all have the same options so the description of their operation is consolidated into this section.

In each graph there is an *Options* menu which contains the following menu items:

- ***Show Overview*** – Toggles on and off the high-level view of the graph in the upper right corner.
- ***Track Input*** – Moves the graphs so the last added point is displayed.
- ***Zoom X*** – Zooms in on the X axis. May be selected multiple times.
- ***Zoom Y*** - Zooms in on the Y axis. May be selected multiple times.
- ***Fit*** – Adjusts the size of the graph to fit the available screen.
- ***Optimize Axis*** – Calculates the X & Y axes extremes and then sizes the axes so that they are centered in the display.



Finally, by right clicking on any graph a pop-up menu will appear providing options to:

- **Add time line** – adds a vertical line at the time where the mouse click was made
- **Remove time line** – removes the time line near mouse click

Adding a time line adds it to all of the graphs simultaneously. Similarly, removing a time line eliminates the time line from all the graphs. There is no limit to the number of time lines may be added to the graphs. The first time line added is colored red while the remaining time lines are

colored green. If the first time line is removed than the second time line that was added turns green. This is of special significance with respect to the Orientation tab which does not display a graph but an image of the AIM XTRA in the specified orientation. The orientation depicted is the one associated with the red time line.

3.4.2 Mouse Navigation

You may use your mouse to navigate around each graph in the following manner:

- *Left Mouse Button Down* – Mouse image is a hand. When holding the mouse button down you grab the graph and may scroll it vertically/horizontally by moving the mouse.
- *Right Mouse Button Down* – Mouse image is a hand. When holding the mouse button down you grab the graph and may scroll it vertically/horizontally by moving the mouse.
- *Wheel/Rollerball* - Mouse image is a hand. When moving forward the graph zooms in and when moving backward the graph zooms out.

4 Pre-Launch

4.1 Normal Flight Operations

4.1.1 Computer

During field operations there are often distractions that take our focus away from launch activities. In order to avoid AIM XTRA/BASE system problems we strongly recommend that your computer Power Settings be adjusted so that your computer ***does not go into sleep mode***. If your computer does go into this mode and the AIM XTRA or AIM BASE are connected to your computer they will lose power and shut down.

If you are planning to use the GPS tracking capability and will not have internet access at the field there are two available options:

1. Tether your computer to your smart phone to provide internet access (see your smart phone manual for instructions) or
2. Pre-load Google Earth for your launch location. This is accomplished by opening Google Earth and then locating your launch site in the application. Once located put your computer in sleep mode and take it to the launch site. When you take your computer out of sleep mode Google Earth will retain the map of the launch location which will be accessed by the AIM XTRA/BASE software when running. Do not close the Google Earth application until you have completed your flight activities.

4.1.2 AIM BASE

If you are using the RF transmission capability start the AIM BASE software, go to the Control Panel tab then set the Channel to the Channel setting selected for the AIM XTRA when you prepared it for launch (see Figure 4). Note that if you power down (unplug) the AIM BASE the channel will reset to 0 and you will need to update the BASE channel setting to match the XTRA in order to receive data. Attach the quarter wave antenna to the AIM BASE, raise the BASE on your support structure (see section 2.7.3) and then connect the AIM BASE to your laptop. You will not receive data until the AIM XTRA is activated.

Note that in the **Tools>Settings…** item there are options for selection the presentation of GPS coordinates data as well as number system (Metric or Imperial) during BASE operations. In addition, there is a Voice checkbox. Select this checkbox if you would like to hear voice reports of the key events during your rocket's flight.

4.1.3 AIM XTRA

Once the rocket is on the launch pad the device may be turned on as part of your normal launch preparation sequence. The device will produce one beep: indicating that it has successfully completed its pre-launch checks.

After power up the flight memory is scanned to locate the next free available memory region. If the device is full of previous flight data this can take a significant amount of time and delay GPS locking. It is therefore recommended to clear your device before launching (see section 3.3). Once the memory scan is complete the AIM XTRA will begin transmitting data to the AIM BASE if set to do so in the AIM XTRA settings dialog. The device will continuously monitor all its sensors while waiting for a launch detect condition.

One distinctive feature of the AIM XTRA is that you can turn the device on while the rocket is horizontal on the pad. If you take advantage of this capability, you simply have to ensure that

the rocket is in its launch position for at least five (5) seconds before launching. This will allow the detection algorithm to correctly establish z-axis orientation. Again, to ensure that you are collecting valid GPS data, it is recommended to wait at least five (5) minutes before launching, even if you have a good 3D lock.

After activating the AIM XTRA if you are using its RF transmission capabilities validate that the AIM BASE is receiving data prior to launch. You should also validate that each of the output lines being used are depicted as Green (indicating continuity) above the BASE Console.

4.1.4 Launch Detection

The AIM XTRA uses an advanced Kalman filter approach for sensor fusion as well as a state machine to determine its current "state". When in the *launch detect* state, the computed Kalman velocity will be monitored. If the velocity exceeds 30 m/s for 0.5 s, the state will change to *boost*. Please ensure that your rocket will exceed these parameters during launch. This method of launch detection is very robust, due to its use of all the necessary sensors of the AIM XTRA (including the GPS). However, violent shaking and rapid rotations could cause a false launch detect and should be avoided.

4.2 Flight

Assuming that the RF transmission capability is in use upon launch you can watch the real time data being displayed on any of the BASE graphs or the GPS position charted on the Cesium Ion map/graph (see Figure 24). Additionally, above the Console are Launch and Apogee blocks. When these states are detected by the AIM XTRA it is graphically indicated by changing the color of these blocks to Green. Similarly, there are continuity blocks for each output line. If these lines are in use and have continuity they are depicted in Green once activated they turn Red.

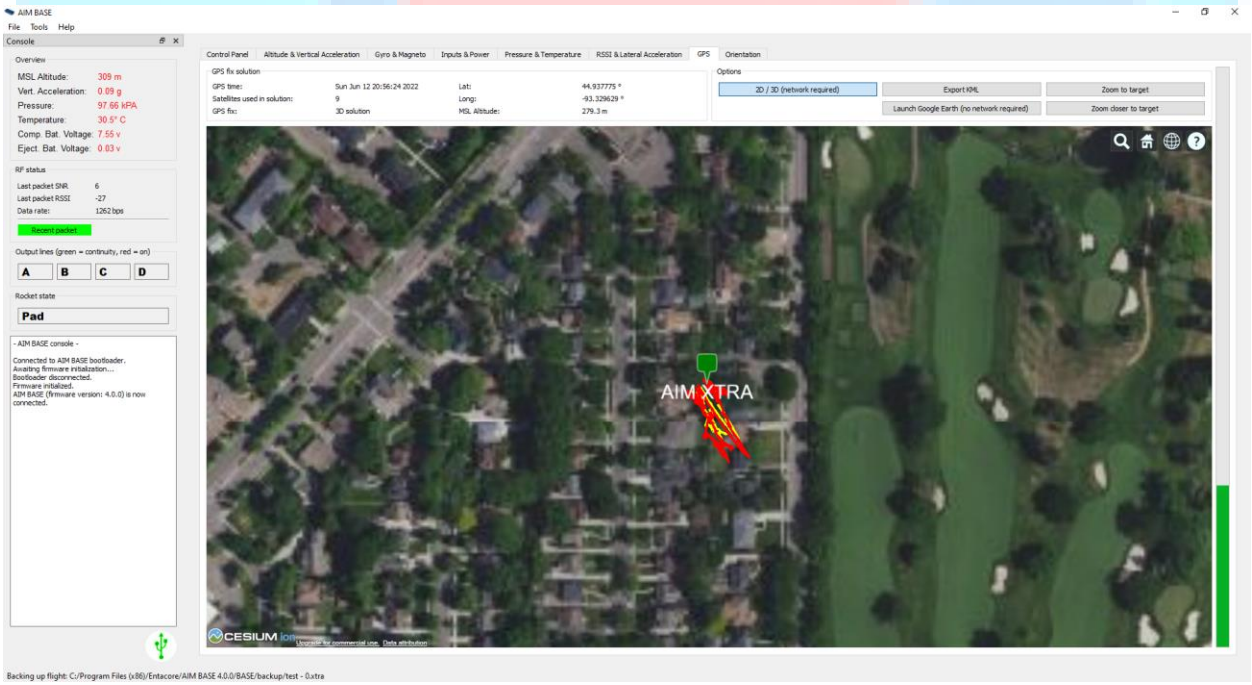


Figure 24: BASE GPS View

In addition, if you turn on your computer's speakers (or connect your computer to a speaker system) you will hear audio reports of flight events. These include GPS Lock, Launch Detect, Coast (Motor Burnout), Apogee Detect, and periodic altitude data.

4.3 Retrieval

If using the RF transmission capability, the AIM BASE software should have recorded the GPS location of the rocket upon or just prior to landing. Assuming you have configured the XTRA to transmit data after landing you may still be receiving transmissions showing its current position. If you have an internet connection on the field or you preloaded the launch area map when you did have a connection the embedded Google Earth map will be shown with a marker depicting the location of your rocket. Otherwise, if you do not have an internet connection on the field and you did not preload a launch area map a graph will be displayed showing the landing distance from where you turned on the AIM XTRA. Regardless, the GPS coordinates will also be displayed.

These coordinates can be entered into a GPS application on a smart phone or other GPS device in order to direct you right to your rocket if you do not want to take your computer with you during its retrieval.

Once you have found your rocket, you should switch off the power. If the auto cut-offs are not configured the AIM XTRA will keep transmitting until it is turned off. Continued operation combined with the use of LiPo batteries will result in the batteries being damaged (LiPo batteries are damaged if their voltage drops too low). Even if the AIM XTRA cut-offs are configured a LiPo battery will eventually be damaged if you do not disconnect it from the circuit (manually or via a switch) since the AIM XTRA continues to draw a small amount of power in this state.

5 Post Launch

5.1 Data Download

Since the data collected by the AIM XTRA will be more detailed than that of the AIM BASE after you have retrieved your rocket you will want to download the data from the AIM XTRA onto your computer. Just start the AIM XTRA software and connect the AIM XTRA to your computer. Select the *Download Data* tab followed by the ***Download Flights*** button. Adjacent to this button is a blank horizontal bar marked 0%. After the button is selected all the flights stored on the AIM XTRA will be downloaded to your computer. During the download process a green bar will appear and the percentage value will increase until all of the flights are downloaded (100%). Depending on the number and length of flights stored on the AIM XTRA this process may take a few minutes to complete (see Figure 25).

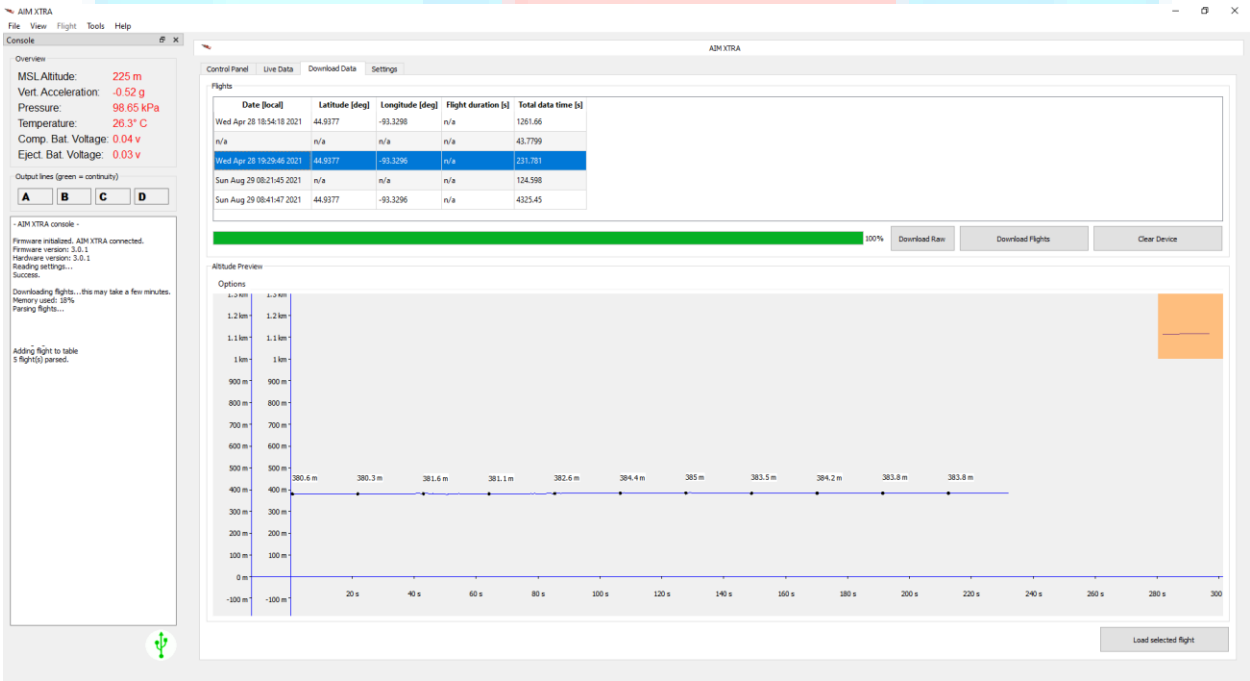


Figure 25: XTRA Download Data

Once downloaded you may select one of the flights listed in the *Flights* section to load into the AIM XTRA software. This is done by selecting a flight (which is highlighted along with the altitude preview graph being populated) and then selecting the ***Load selected flight*** button. A new tab (named Untitled* at the same level as the AIM XTRA tab) will be created containing all the flight data (graphs, settings, notes). By selecting this tab, you will be able to view and manipulate the selected flight data (see Figure 26). In addition, you will have the following options under the *File* menu:

- ***Save As*** – Allows you to save your data as an *.xtra file. Do this to retain your data for later viewing and analysis. The name you use for saving the file will now appear in the tab allowing you to identify which flight it contains.
- ***Export to Excel…*** – Allows you to save your data as a CSV file. Save a copy of the data in this format if you intend to conduct customized analysis of your data.
- ***Export emulation data…*** - Allows you to save your data as a CSV file. Save a copy of the data in this format if you intend to run emulations with this flight data.

Figure 26: Downloaded Flight

If you wish to close this tab just right mouse on the tab and a ***Close*** menu item will appear. Selecting it will close the file without exiting the application.

Once you have completed downloading data you may clear all the data from the AIM XTRA in preparation for future flights. This is done by selecting the ***Clear Device*** button. Once this action is taken the data is not recoverable from the device.

Each data download will contain a new tab called *Notes* which is not available until the flight's completion. This tab contains summary data of the flight along with a *Flight Notes* subsection where you may add any specific notes you have on the flight (see Figure 27).

Once you've completed your download and are finished using the AIM XTRA/BASE applications you may shut them down by selecting the *File* menu followed by the ***Exit*** menu item.

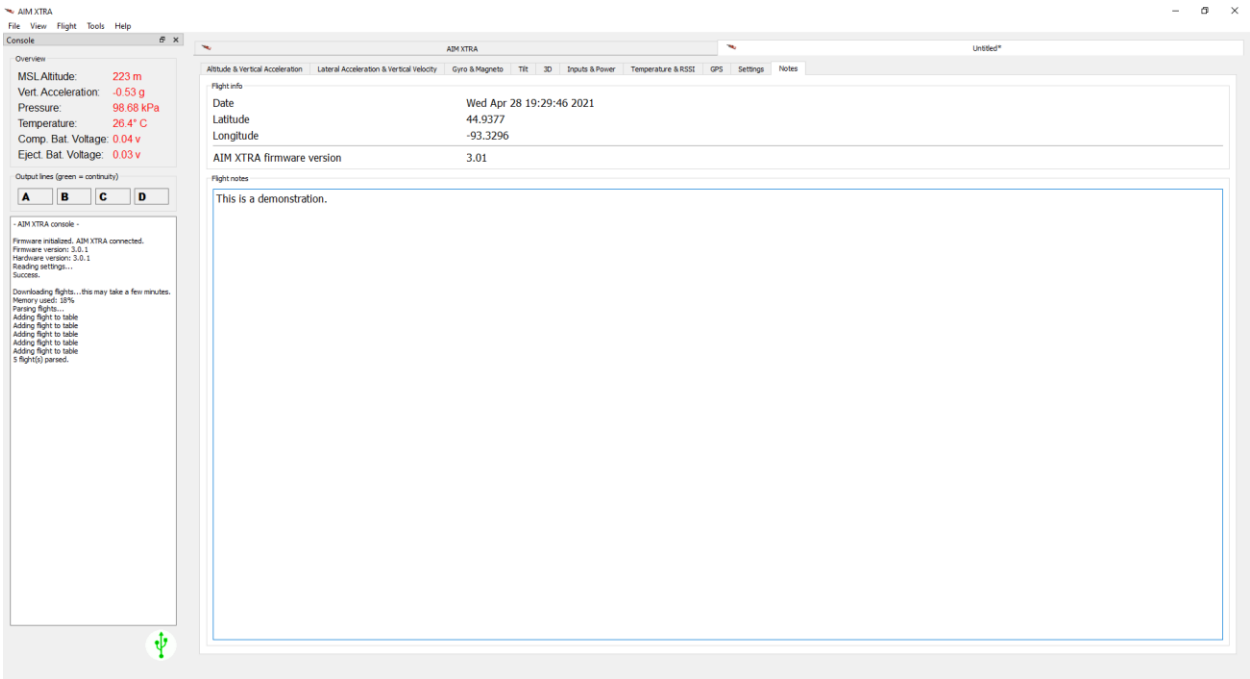


Figure 27: AIM XTRA Notes Tab

5.2 Data Analysis

Sometime after your flight you may wish to examine the data. In order to view the data in the AIM XTRA software select the *File* menu followed by the ***Open*** menu item. Find and select the *.xtra data file to open it. The data will appear in its own tab which will be labeled with the name of the file.

You can read exported data to Excel (or any other spreadsheet package) for further analysis (see Table 2). Combining the exported data with other available rocket data will allow you to compute a variety of useful information including but not limited motor impulse or drag coefficients. The possibilities are endless! Note that there are multiple *time* columns. Each *time* column applies to the columns to its right until another *time* column is reached.

time	acceleration	time	Gyro X	Gyro Y	Gyro Z	time	lat. X accel.	lat. Y accel.	time	pressure	Pressure MSL	Pressure AGL	time	Mag X	Mag Y	Mag Z	time	eject. bat. voltage
0.108	-0.01172	0.109	-2.24	-3.15	1.89	0.11	-1.05469	-0.15625	0.202	100182	95.5823	0	1.022	-0.001	0.001433	-0.00083	1.028	0.032471
0.209	0	0.21	1.05	0	6.65	0.211	-1.04297	-0.13281	0.404	100183	95.4978	-0.08455	2.035	-0.00093	0.001435	-0.00084	2.037	0.032471
0.309	-0.01172	0.313	0.77	0.42	1.05	0.312	-1.00781	-0.15625	0.714	100186	95.2441	-0.33821	3.038	-0.00089	0.001429	-0.00084	3.047	0.032471
0.409	0	0.414	-1.75	0.14	1.61	0.413	-1.03125	-0.12109	0.934	100185	95.3286	-0.25366	4.054	-0.00095	0.001425	-0.00084	4.056	0.032471
0.623	0	0.631	-4.55	-25.83	0.42	0.631	-1.05469	-0.13281	1.145	100183	95.4978	-0.08455	5.066	-0.00101	0.00143	-0.00084	5.068	0.032471
0.734	0	0.746	-2.31	-9.1	-2.31	0.745	-1.03125	-0.16797	1.36	100188	95.0776	-0.50468	6.079	-0.00107	0.001434	-0.00077	6.08	0.032471
0.84	-0.01172	0.858	-0.98	-7.56	-0.7	0.858	-1.06641	-0.13281	1.576	100187	95.1622	-0.42012	7.086	-0.00111	0.001434	-0.00071	7.095	0.032471
0.951	-0.01172	0.971	-0.63	34.16	2.45	0.975	-0.86328	-0.14453	1.788	100185	95.3286	-0.25366	8.093	-0.0011	0.001423	-0.00071	8.105	0.032471
1.064	-0.03516	1.082	2.73	53.27	-3.15	1.089	-1.10547	-0.12109	2.003	100187	95.1622	-0.42012	9.106	-0.00109	0.001424	-0.00066	9.125	0.035718

time	comp. bat. voltage	time	launch detect	apogee detect	A cont.	B cont.	C cont.	D cont.	A on.	B on	C on	D on	time	temperature	time	GPS Time of Week	time	lat	long	GPS MSL
1.029	4.22444	1.029	0	0	0	0	0	0	0	0	0	0	5.036	17.58	5.037	5600	162.997	44.93784	-93.3296	283.104
2.047	4.22444	2.048	0	0	0	0	0	0	0	0	0	0	10.056	17.62	10.052	10600	164.996	44.93784	-93.3296	282.69702
3.054	4.22444	3.055	0	0	0	0	0	0	0	0	0	0	15.066	17.62	15.063	15600	167.003	44.93784	-93.3296	282.18701
4.071	4.22769	4.071	0	0	0	0	0	0	0	0	0	0	20.081	17.66	20.078	20600	169	44.93784	-93.3295	281.43301
5.08	4.22444	5.086	0	0	0	0	0	0	0	0	0	0	25.097	17.68	25.089	25600	171.002	44.93783	-93.3295	280.56403
6.095	4.22444	6.096	0	0	0	0	0	0	0	0	0	0	30.112	17.01	30.102	30600	172.999	44.93782	-93.3296	279.81802
7.111	4.21794	7.117	0	0	0	0	0	0	0	0	0	0	35.129	16.43	35.118	35600	175.003	44.93782	-93.3296	278.673
8.123	4.22769	8.129	0	0	0	0	0	0	0	0	0	0	40.1409	15.88	40.1279	521237200	177.004	44.93781	-93.3296	278.384
9.129	4.22444	9.14	0	0	0	0	0	0	0	0	0	0	45.1529	15.21	45.1449	521242200	179.005	44.93781	-93.3296	278.293

Table 2: Excel export data format

The AIM XTRA software also allows you to view your 3D flight path under the *GPS* tab using the GPS data. If desired you can alter the data used to draw the flight path to the Kalman filtered data by selecting the ***Kalman filtered altitude*** checkbox. Finally, you can export this flight path to a KML (Google Earth) file (see Figure 28) to share with others by selecting the ***Export Google Earth KML*** button.

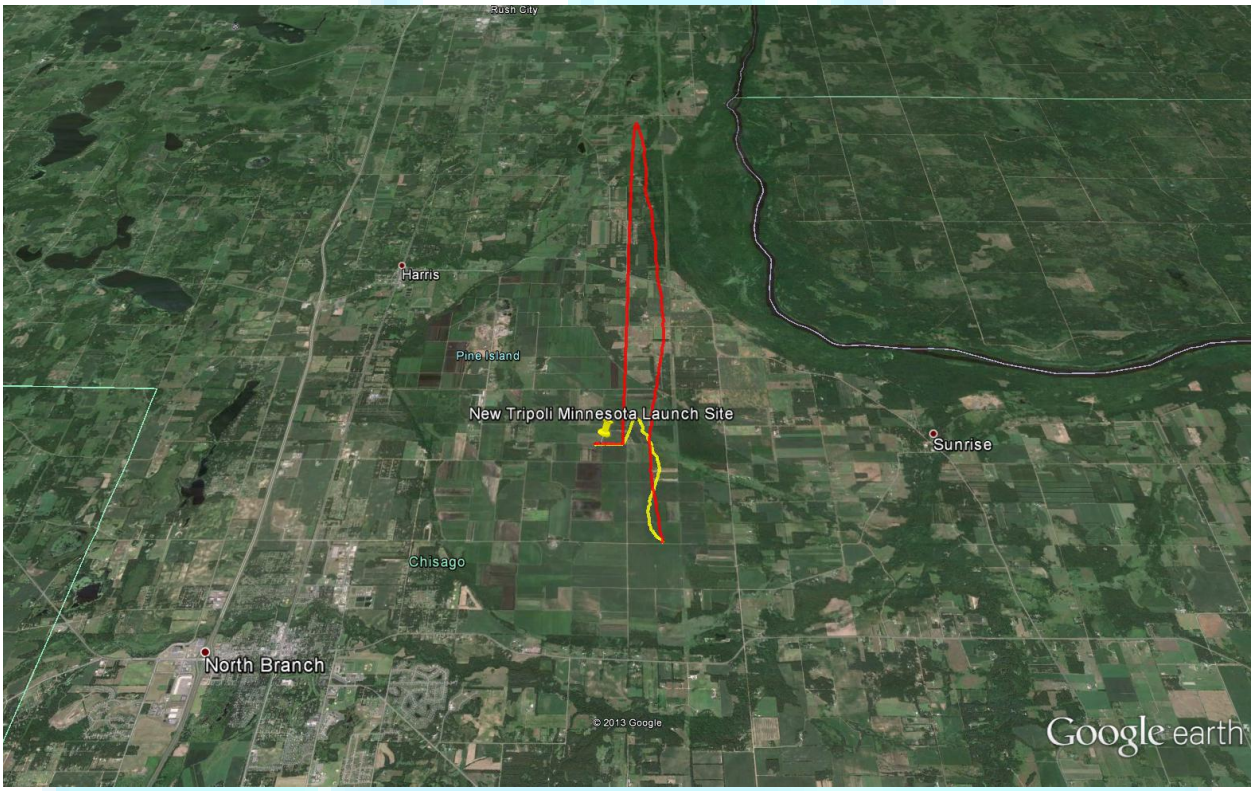
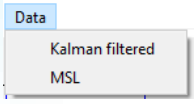


Figure 28: Google Earth Export

Altitude & Vertical Acceleration Subtab
Similar to the MSL Altitude and Acceleration subtab under flight conditions this tab displays two graphs one depicts the Above Ground Level altitude using the barometric sensor data and the other the vertical (z-axis) acceleration data.

Additionally, when viewing past flights, the AGL Altitude graph also has a *Data* menu which contains the following menu items:

- **Kalman filtered** – Displays the Kalman filtered altitude data rather than the barometric sensor only data.
- **MSL** – Alters the graph to display Mean Sea Level altitude instead of Above Ground Level altitude.



Lateral Acceleration & Vertical Velocity Subtab
This subtab is identical to that of the BASE unit described in section 3.2.2.3.

Gyro & Magneto, Inputs & Power, and Orientation Subtabs
These subtabs are identical to those described in section 3.2.2.1.

Temperature & RSSI Subtab

This subtab contains two graphs Temperature and RSSI which are identical to the corresponding graphs described in section 3.2.2.3.

GPS Subtab

This subtab displays the flight path in Cesium Ion. The following options are available (Figure 29):

- ***Kalman filtered altitude*** when checked displays the altitude using the Kalman filtered data from all the barometric, accelerometer and GPS sensors (otherwise the barometric sensor data is used).
- ***Populate Data*** focuses on the flight data so you can view it on the display. Use your mouse wheel to zoom in or out.
- ***Export Google Earth KML*** exports the data in KML format to use within Google Earth Pro.

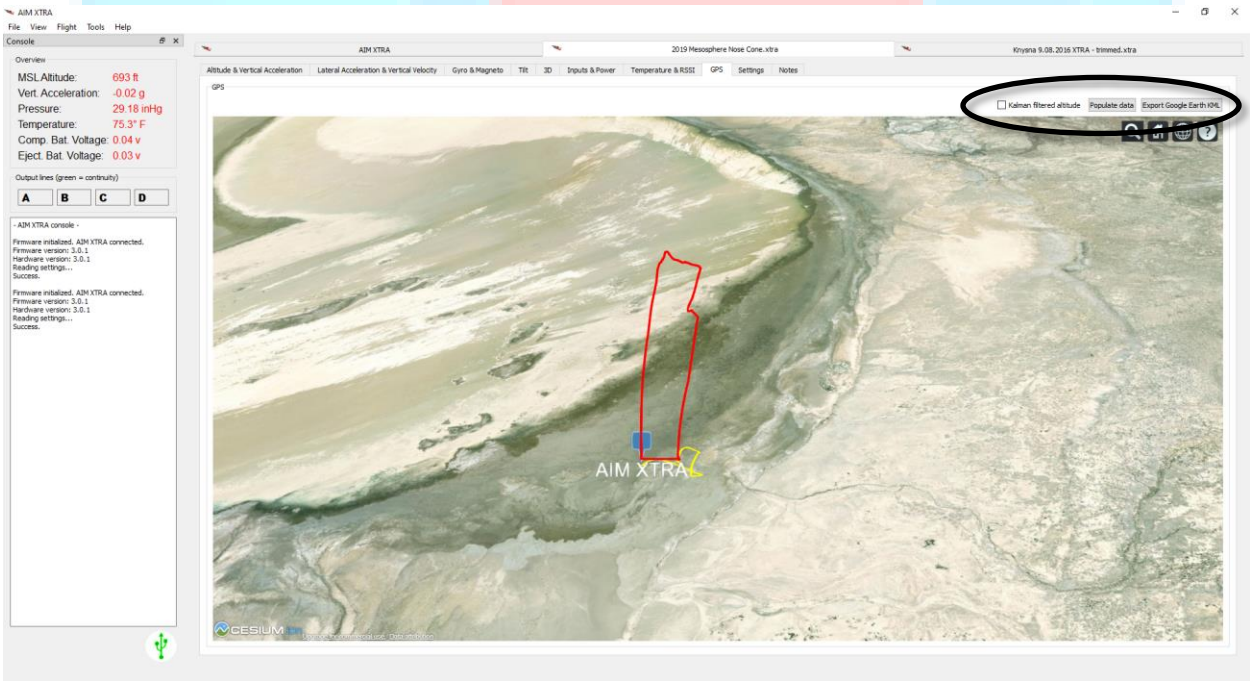


Figure 29 - AIM XTRA GPS Subtab

Tilt Subtab

This subtab consists of a graph the tilt angle as measured from the vertical (z-axis). Note that there is no directionality associated with this measurement so the value will always be depicted as positive (see Figure 30).

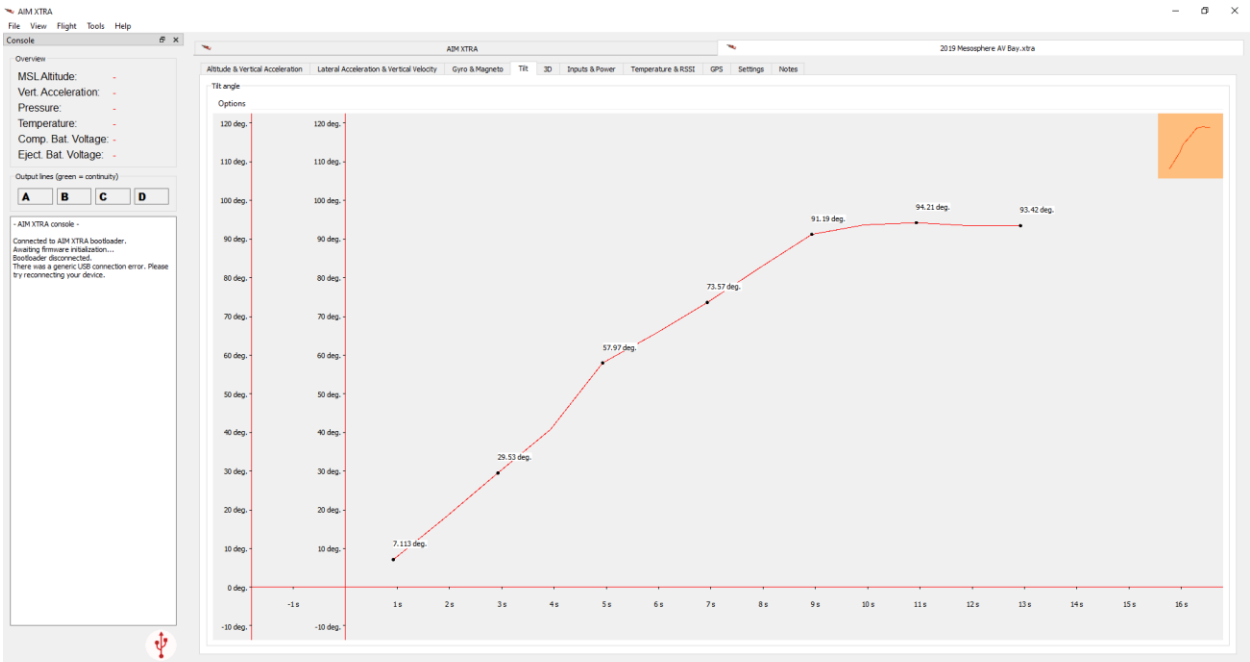


Figure 30 - AIM XTRA Tilt Subtab

Settings Subtab

This subtab depicts the configured settings used by the AIM XTRA during the flight (Figure 31). You can view the General, Ejection Lines, and Sampling Intervals settings.

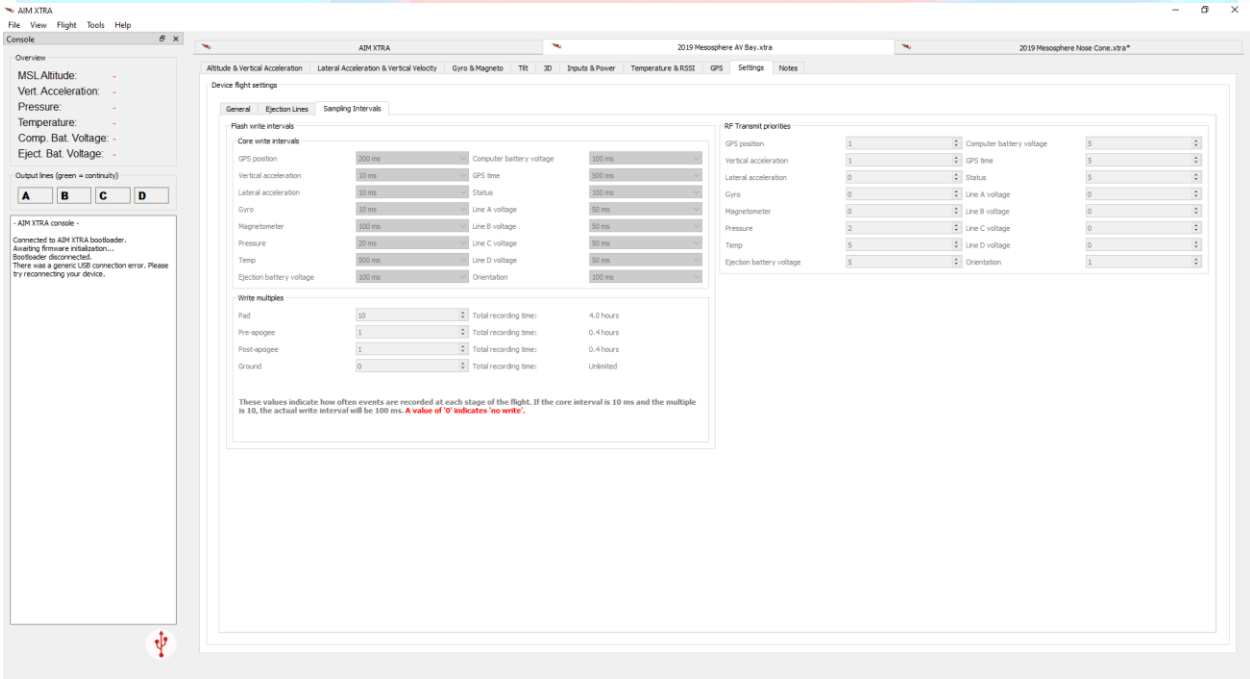


Figure 31 - AIM XTRA Settings Subtab

Notes Subtab

This subtab depicts a summary of the flight data along with any notes the flyer would like to add regarding the flight (Figure 32).

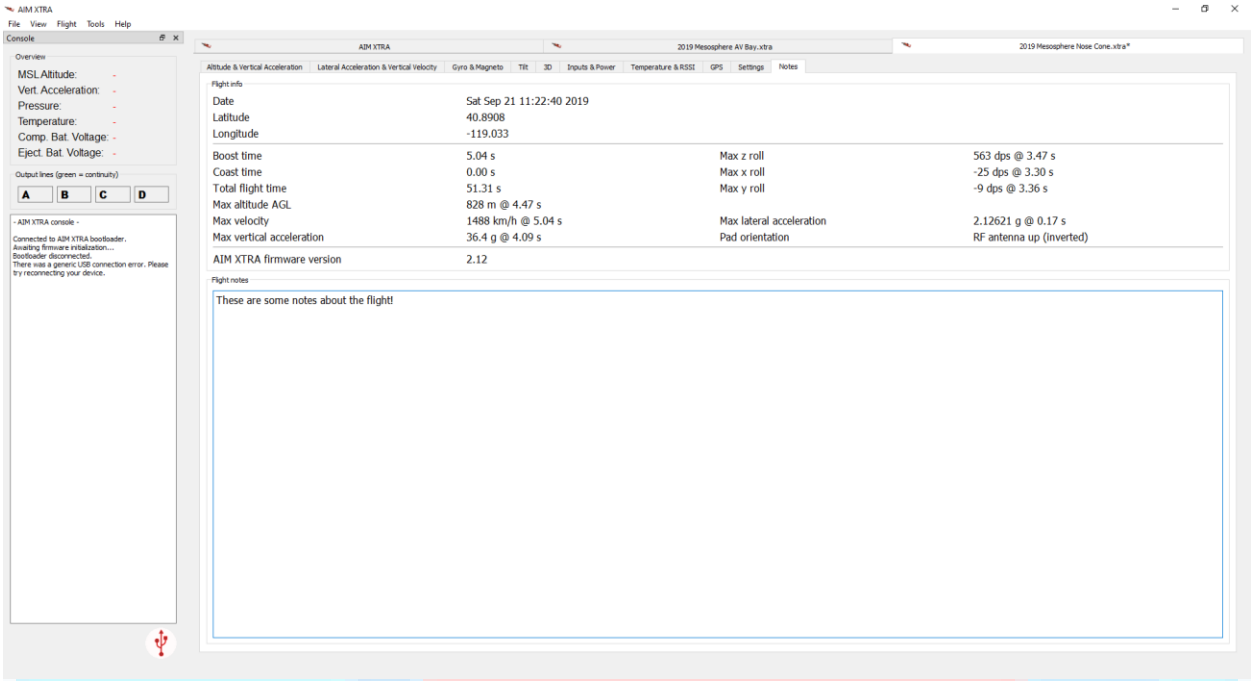


Figure 32 - AIM XTRA Notes Subtab

6 Important Notes & FAQs

6.1 Disclaimer

Due care has been employed in the design and construction of this product so as to minimize the dangers inherent in its use. As the installation, setup, preparation, maintenance, and use of this equipment is beyond the control of the manufacturer, the purchaser and user accept sole responsibility for the safe and proper use of this product. The principals, employees, and vendors of the manufacturer shall not be held liable for any damage or claims resulting from any application of this product. If the purchaser and user are not confident in their ability to use the product in a safe manner it should be returned to the point of purchase immediately. Any use of this product signifies acceptance of the above terms by the purchaser and user.

6.2 Vital Details

- Check that the settings on your device are correct before launching, even if you didn't change them yourself.
- Make sure that your battery is fully charged. We recommend single cell or two cell LiPo (1000 mAh or larger) batteries.
- Make sure your vent hole on the rocket is large enough to sense the air pressure as the rocket is launched and descends.
- Seal the flight computer from the ejection bay/s to prevent damage from ejection gases and large spikes in the readings when the charges fire.
- Make sure the device is switched off after your flight in case the charges have not yet fired, and to prevent battery drain.
- Make sure that the altimeter can fire your type of charges, and that your charges are the correct size for your rocket.
- There should be minimal metal near the AIM XTRA, and especially its antennas.
- The AIM BASE should be as high off the ground as possible. We recommend a minimum of three meters. This is crucial for good signal reception!
- There should be no metal near the AIM BASE. Please use a wooden/plastic pole to raise the AIM BASE off the ground.

6.3 FAQs

1) **I have connected the AIM XTRA to my PC and nothing is happening. What's wrong?**

   The AIM XTRA does not need any special drivers, but you do need to download the software needed to interface with the hardware. You can find the software for your device on the Authorized Service Center websites (see section 7.2). Once downloaded, run the application. If your device still will not connect (a red USB logo will be displayed), please contact an Authorized Service Center (see section 7.2).

2) **My rocket has crashed – none of the parachutes were deployed! Help!**

   Check that your parachutes were not too tight for your ejection charges and that they were properly sized. Also make sure that your ejections charges were not faulty, especially if they were assembled from a kit. It is usually very easy to determine when the AIM XTRA did indeed attempt to initiate the charges. If the unit is still intact, you can view the graph of the flight. The software indicates when the altimeter attempted to send current through the charges. You can also see if your parachutes might have gotten

stuck, as there will usually be a noticeable pressure spike shown on the graph when charges have fired.

3) How do I connect a switch?

Simply place a switch in-line with the plus wire. You can also use a switch to route both minus wires through (they are common). This will allow one switch to disconnect both batteries. Please remember to use a vibration-resistant switch!

4) Does it matter which way around the AIM XTRA is placed?

No. The AIM XTRA includes an auto-orientation detection algorithm. The default is with the RF antenna facing down. If your cone is transparent to RF, you could make the AIM XTRA antenna face upwards.

5) Does the AIM XTRA support staging?

Yes, it can! There are dedicated settings for staging which you can access using the software provided (download from our website). The AIM XTRA can use the peak Kalman filtered velocity to determine when to ignite the specified charge. This is the best method and is preferred over time-based delays.

6) Is it possible to get custom software written for my device?

We can do custom software without too much trouble. If it's something we like, and think it will be used by others, we will attempt to incorporate it into the official product. Send us an email for more information (see section 7.2.2).

7) Can Entacore develop custom software?

Yes, we can. We have a range of capabilities from hardware design to software engineering. Contact us (see section 7.2.2) if you are interested in what we can offer you!

7 Warranty

7.1 Limited Warranty

7.1.1 Limited Warranty Coverage

If your product does not work properly because of a defect in materials or workmanship, Entacore Electronics (“the warrantor”) will, for the period of one year, which starts with the date of original purchase (“warranty period”), at its option either (a) repair your product with new or refurbished parts, or (b) replace it with a new or refurbished product. The decision to repair or replace will be made by the warrantor. During the warranty period there will be no charge for parts or labor. You must carry-in or mail-in your product during the warranty period. This warranty only applies to products purchased and serviced in the United States. This warranty is extended only to the original purchaser of a new product which was not sold “as is”. A purchase receipt or other proof of the original purchase date is required for warranty service. For our international warranty policy, please email Entacore (see section 7.2.2).

7.1.2 Carry-in or Mail-in Service

For carry-in or mail-in service contact the Authorize Service Center supporting your geographic region (see section 7.2).

This warranty ONLY COVERS failures due to defects in materials or workmanship, and DOES NOT COVER normal wear and tear or cosmetic damage. The warranty ALSO DOES NOT COVER damages which occurred in shipment, or failures which are caused by products not supplied by the warrantor, or failures which result from abnormal physical or electrical stress, abnormal environmental conditions, misuse, negligence, accident or rental use of the product, service by anyone other than a Factory Service center or other Authorized Servicer, damage that is attributable to acts of God, or is licensed for beta, evaluation, testing or demonstration purposes.

THERE ARE NO EXPRESS WARRANTIES EXCEPT AS LISTED UNDER “LIMITED WARRANTY COVERAGE”. THE WARRANTOR IS NOT LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OF THIS PRODUCT, OR ARISING OUT OF ANY BREACH OF THIS WARRANTY. (As examples, this excludes damages for lost time, travel to and from the servicer, loss of data or other memory content. The items listed are not exclusive, but are for illustration only.) ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING THE WARRANTY OF MERCHANTABILITY, ARE LIMITED TO THE PERIOD OF THE LIMITED WARRANTY.

Some states do not allow the exclusion or limitation of incidental or consequential damages, or limitations on how long an implied warranty lasts, so the exclusions may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from state to state. If a problem with this product develops during or after the warranty period, you may contact your dealer or Service center. If the problem is not handled to your satisfaction, then write to the warrantor’s Consumer Affairs Department at the addresses listed for the warrantor in section 7.2.2.

PARTS AND SERVICE WHICH ARE NOT COVERED BY THIS LIMITED WARRANTY ARE YOUR RESPONSIBILITY.

7.2 Authorized Service Centers

Please carefully pack and ship, prepaid and insured, to the Authorized Service Center.

7.2.1 United States

Off We Go Rocketry, LLC
3600 France Ave S
St Louis Park, MN 55416
Tel: +1 952 201 3002
Skype: gary.stroick
Web Site: www.OffWeGoRocketry.com
eMail: president@OffWeGoRocketry.com
AIM XTRA Software Download:
http://www.offwegorocketry.com/product_info.php?cPath=220&products_id=1203

7.2.2 International/South Africa

Entacore Electronics
2 Muller Street
Sutherland
6920
South Africa
Tel: +27 72 466 8590
Skype: dawie.debruyn
Web Site: http://entacore.com
eMail: info@entacore.com
AIM XTRA Software Download: http://entacore.com/electronics/aimxtra