

Auto Antenna Tracker

Manual V 2.0



Precautions

Thank you for purchasing the AAT (Automatic Antenna Tracker, hereafter referred to as Crossbow AAT).

Please familiarize yourself with this product and its operation method described in this document. This product is a precision electromechanical device. Please read this document carefully to prevent damage to the device and minimize the risks of damage to property or people's lives.

Please only use this device according to local laws, rules, and regulations. Its performance may be affected by a number of factors such as but not only: Strong electromagnetic interference, poor GPS status, etc. All these reasons can lead to unexpected results. All risks and consequences resulting from the use of this product are borne by the user.

We reserve the right to continuously improve and improve the performance of our products, so the content of this document does not necessarily match the specifications of your products. Please download the latest version of this document from our website:

1. Product Introduction

Crossbow AAT is designed for use with unmanned aerial vehicle (UAV) on-board antenna system. Its purpose and objective is to point the antenna precisely in the current direction of the aircraft thus allowing the video receiver to pick up the strongest signal possible at given distance and other factors.

In order to obtain better signal reception quality, it is advised to use high-gain receiving antennas. High-gain antennas are known for very narrow angles of effective reception. For its successful operation, Crossbow AAT requires the flight data such as latitude and longitude of the tracked target (UAV) at every given moment, as well as its altitude. This is achieved by the following:

1. Transmitting information of the tracked target over a wireless analog video link from the UAV to the ground station. For that, the UAV must be equipped either by a MFD Auto Pilot, or a MFD Crosshair Auto Pilot, or in case a third party AP is used with a MFD TeleFlyTiny tracking module.

ATTENTION: Using TeleFlyTiny module is possible with many third party flight controllers. MFD does not guarantee that it works with any particular make or model of the autopilot, nor that it will continue to work with any third party autopilot after its firmware or software is updated.

2. Transmitting information of the tracked target over a wireless High Definition video link from the UAV to the ground station. For that, the UAV must be equipped either by a MFD Auto Pilot, or a MFD Crosshair Auto Pilot, or a MAVLink-compatible Auto Pilot, or in case a third party AP is used, an MFD TeleFlyTiny tracking module. The signal containing encoded tracking data

from the TeleFlyTiny module on the aircraft will be transmitted to the Crossbow AAT through the serial port .

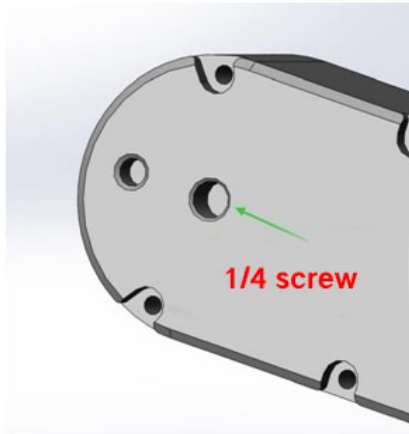
3. Transmitting information of the tracked target over a wireless digital data link from the UAV to the ground station.

MAVLink protocol allows to transmit the information from the UAV through the digital radio link. If the on-board system already includes the digital radio, and the flight controller that supports MAVLink protocol, Crossbow AAT will be able to receive all flight information necessary to track the UAV through the shared TXD line of the digital radio station.

miniCrossbow Specifications		
Tracking Ability	MAX Pan-Speed	400deg/s
	MAX Tilt-Speed	120deg/s
	MAX Pan-Angle	360deg
	MAX Tilt-Angle	0deg~90deg
Mechanical/Electrical specifications	Weight	470g
	MAX Tilt Torque	10kgf.cm
	Operating Voltage	12~16V DC
	Power Consumption	< 10W (Typical)
Protocol Interface	MFD VBI	All MFD Autopilots/TeleFlyPro/TeleFlyTiny supported
	MAVLink	MAVLink V1.0/V2.0 supported

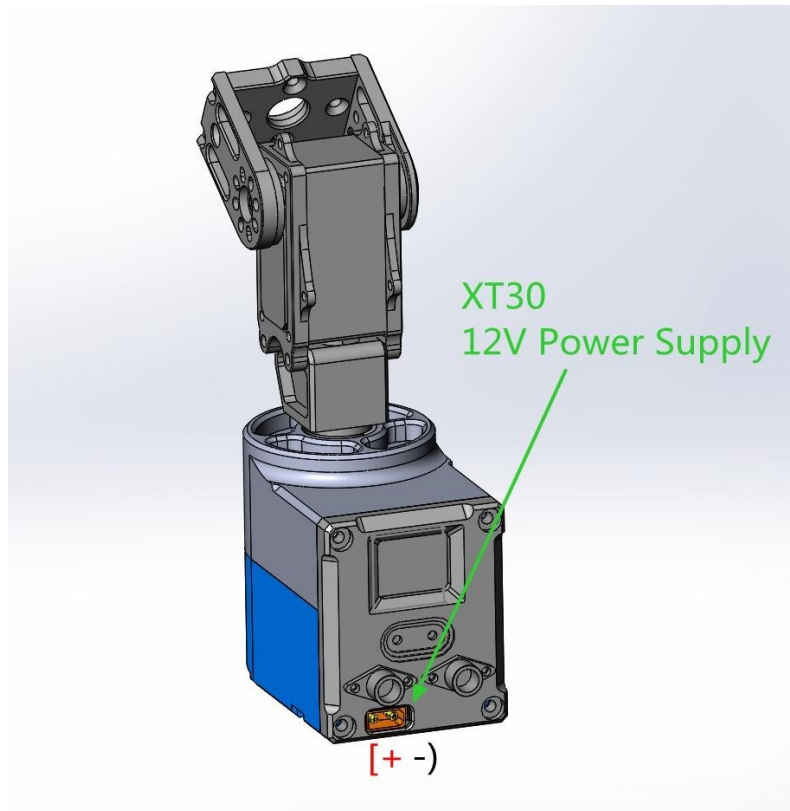
2.Installation and wiring

1. The AAT can be fixed on the head of a regular camera/camcorder tripod by the means of a standard 1/4-20 threaded interface at the bottom of the main unit. Make sure the tripod you use is capable of supporting the size, weight, and leverage of the battery+AAT+Antenna assembly. Correct choice of a tripod is the user's responsibility. Please make sure that the quick release plate of the tripod is compatible with the threaded interface on the bottom of the AAT main unit.



mini Crossbow AAT requires =12V to 16V (3S~4S) DC power supply.

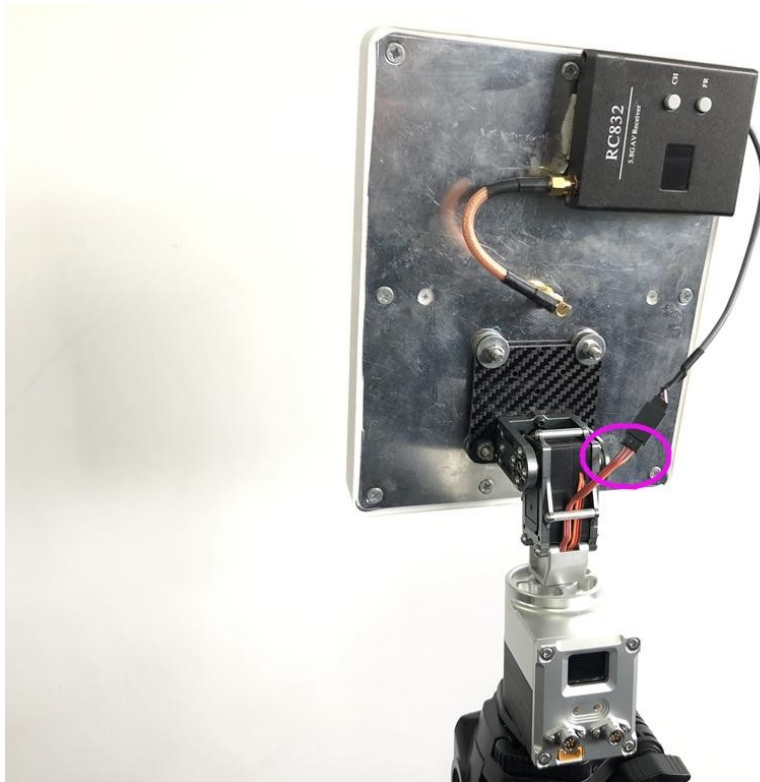
The tracker is powered on by simply plugging the XT30 connector into the corresponding power socket of the AAT, as shown in the picture:



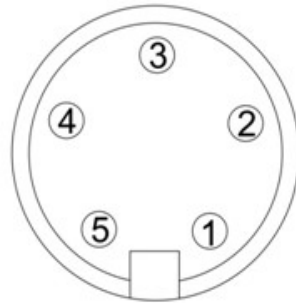
2. The antenna has to be mounted on the Crossbow AAT with the use of a special bracket. In order to prevent tampering with the normal operation of the compass built into the Crossbow

AAT it is recommended to avoid using antennas made with ferromagnetic materials. Wherever possible, use non-magnetic stainless steel bolts, aluminum and other non-magnetic materials. There is 3 pin connector beside the tilt servo (in the purple circle). The diagram below shows the wiring.

Wiring Diagram	
Wiring Color	Definition
1 Yellow	Analog video input
2 Red	12V~16V power supply (shared AAT power supply voltage)
3 Brown	GND

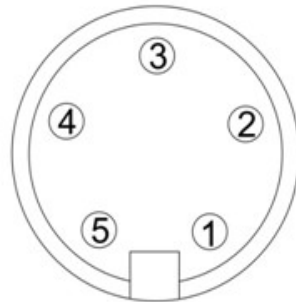


3. There are 2 aviation type connectors on the front panel. See the diagram below for wiring:



MFD Crossbow Mini L-Connector

1	+5V
2	RX3(GPS/FW Update/ MAVlink RX/S.Port-Inv)
3	TX3(GPS/Update)
4	GND
5	TX2(Bluetooth)



MFD Crossbow Mini R-Connector

1	Rx1(GPS/MAVLink RX/ S.Port-Inv)
2	CAN-H
3	CAN-L
4	GND
5	VIDE OUT

Connector Type: XS-6 (5pin)

To expand functionality of the tracker and make it compatible to more kinds of input, such as MAVLink, the front connectors have to be user-configurable. The user needs to solder the "yellow" cable to an intermediate interface PCB according to the desired configuration. The interface PCB can be fitted to left or right port:



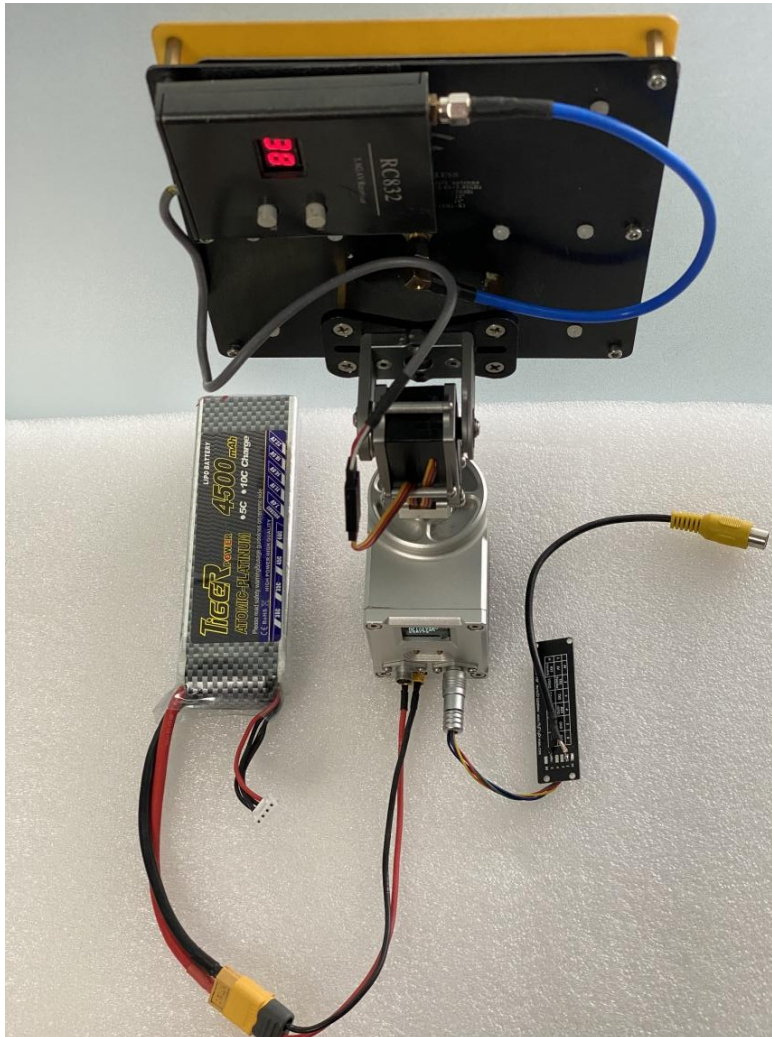
The "L" row matches the LEFT port. Pin1=5V, Pin2=TX2, Pin3=TX3, Pin4=RX3, PIN5=GND.
 The "R" row matches the RIGHT port. Pin1=RX1, Pin2=Video, Pin3=CAL_L, Pin4=CAN_H,
 Pin5=GND. The right side vertical Pin#1~Pin#6 match the numbers in the top of row, and this is
 where the "yellow" cable wires need to be soldered.

The yellow video cable in the picture below is part of standard retail kit.



To use this cable as simple video cable, solder its wires to VIDEO and GND (Pins 2 & 5, as suggested in R row). The interface PCB should therefore be connected to the right connector of the tracker.

In this configuration the video monitor can be connected to the yellow connector head on the end of this cable.



If you wish to use MAVLink protocol to provide tracking data through digital radio link, feed MAVLink data to PIN#1 of the RIGHT connector or to the PIN#2 of the LEFT connector. Sharing the TX line of the data radio link with mini Crossbow AAT will not affect the normal ground station operation. And don't forget to set proper baudrate in the menu of mini Crossbow to match your data radio.

Note: With the most update V2.0 firmware, the PIN#2(RX3) of the LEFT port has been upgraded to support these 4 functions: Compass+GPS module / MAVLink Input / S.Port(Inverted) / Firmware update.

Also the PIN#1 (RX1) of the RIGHT port has been upgraded to support these 3 functions: Compass+GPS module / MAVLink Input / S.Port(Inverted).

*S.Port (SmartPort) is a telemetry system developed by FrSky. It's a inversed Serial signal. But our RX3-LEFT port and RX1-RIGHT port can only accept standard Serial data. To feed the S.Port data to mini Crossbow you need to use an "Inverter" or hack your FrSky Transmitter.

3. Test

Please make sure the tripod is securely set up, and its legs are well tightened. Then power on the AAT.

Normally, after power on the tilt angle will return to the horizontal 0 degrees (pointing to the horizon). The following information will be displayed on the OLED screen of the Crossbow AAT

```
GPS: 12 (Batt:12.1V)
DIST:N/A
Alt: N/A
AZim: N/A
VLink: 0%
Dir: 0
```

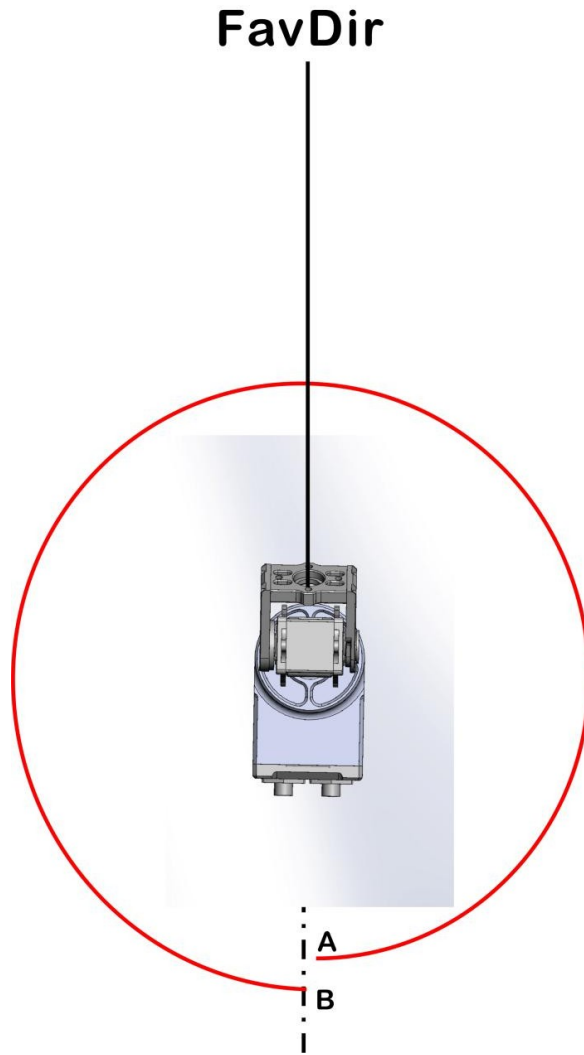
Main Screen Descriptions	
Display Item	Description
GPS/LocalGPS Batt	GPS Satellites locked. If an external GPS is connected, GPS/LocalGPS will be displayed in GPS:12/L:11 formation (GPS=12, Local=11) Batt (Voltage of the main battery) will be displayed alternatively here.
Dist	Distance of the plane (Not Available before SetHome)
Alt	Altitude of the plane (Not Available before SetHome)
Azim	Azimuth of the plane (Not Available before SetHome)
VLink/DLink	Video/Data downlink quality. (in %, ref to the "Downlink" chapter)
Dir/ExDir	Current heading diretion of the tracker. If an external compass is connected, EDir will be displayed alternatively

When you get enough satellites locked (usually 8 or more), press the right button on the base to SetHome for the tracker. With MFD AP/MFD Crosshair you can SetHome for your plane, meanwhile the Home location of the tracker will also be set.

Once the distance between the plane and the tracker reaches 10 meters, the tracker starts to track.

The min Crossbow is not able to continuously rotate. When it reaches its limit (Facing back to the back side), it will rotate 360 degrees and keeps tracking. Before you fly please point the tracker to the zone that the plane mostly will fly in. Try not to fly your plane in the opposite direction. In the below picture we call this best direction "FavDir" (Favorite Direction)

Take the below picture as an example. The plane is circling clockwise (top view, see from the sky). When the plane reaches A point, the tracker limits its limit. It is not able to track the plane in clockwise direction anymore. So the tracker will rotate 360degrees, counterclockwise to point B to continue tracking.



4. Downlink

The mini Crossbow AAT needs a downlink to get the information of the tracking plane.

Usually this is the most difficult part to get your system to work. Because you have to merge several devices came from different manufactories.

We may extend this chapter in the future. Currently we discuss only VBI solution and dataradio solution(Based on MAVLink).

1. VBI

VBI stands for "vertical blanking interval". It's a term of the analog video signal technology. Many

MFD products use VBI to carry flying information from the plane to the tracker.

The advantage of VBI is that you don't need an extra dataradio if you already have a video TX and RX. These MFD products will encode the necessary data on your analog video signal (usually comes from an onboard camera). Your VideoTX emits it. Once your Video Receiver receives the video signal, and feeds the signal to a MFD tracker, the tracker will extra tracking data from the analog video signal and use the data to track.

Early MFD AP / TeleFlyPro support our VBI protocol V1. Our Crossbow supports V1. (Menu "VBIVersion=>V1") Later MFD Crosshair / TeleFlyTiny support V1 and V2. V2 works better in long range.

To use VBI for the tracker, please setup your plane correctly. Make sure your video RX outputs clear videos (check with an AV monitor) . Connecte your Video RX to the 3pin servo-style connector on the tracker.

Note that you need to make sure the plane side and the tracker are using the same VBI version.

If the tracker decodes information from the video signal successfully, the main screen will display like"VLink:90%".

2. DataRadio (MAVLink):

With a pair of DataRadio you can send data from the plane to your tracker. There are many protocol can be use to establish a downlink, private ones, and open ones. MAVLink is one of the most popular ones. It's not perfect but it's common. Many autopilots support it, including MFD Crosshair AP.

If you use a Pixhawk/ArduPilot device, I assume you already connect your DataRadios and they are working well. You can mount your DataRadio on the back side of your antenna and share the TXD line of your DataRadio with the tracker. Connect the TXD line to PIN#1 of the right connector of your tracker.

More and more HighDefinition Video devices are available on the market. Most of them also support a built-in serial port datalink. (For example, the OpenHD project). If you are using this kind of video link and running MAVLink protocol on it, you can simply consider it's serial port as a DataRadio output. Feed data to PIN#1 of the right connector of the tracker to establish a downlink.

Finally you have this solution:

The tracker pitch/yaw the antenna only. Your VideoRX and DataRadio stay on the ground and connect with your antenna via feeder cables.

No matter where you install your DataRadio, you need to share its TXD line to #1 of the right connector of the tracker.

Note: About the MAVLink

The MAVLink protocol has been used/implemented in many Flight Controllers, Ground Control Stations(GCS) and trackers. But actually many devices use the MAVLink in their own way. One of the reasons is that MAVLink is not clear enough to define how to send some important data between the Plane And GCS. There are so many different MAVLink messages which can be used to send GPS Coordinates, Altitudes...

Crossbow AAT needs both these 2 MAVLink messages to track.

MAVLINK_MSG_ID_GPS_RAW_INT

MAVLINK_MSG_ID_GLOBAL_POSITION_INT

If the Crossbow AAT receives some correct MAVLink data packs (Heartbeat?) but not able to find the above 2 messages, it will display "DLink:1% msg?" to remind you to check if the above 2 messages are sent at 1Hz or a higher frequency.

In Crossbow AAT, If you choose menu "Protocol->ALT=BARO",

MAVLINK_MSG_ID_GLOBAL_POSITION_INT.relative_alt is used as the data source of the altitude.

This works for most ArduPilots. (APM), and MFD Crosshair AP.

You can check "FlightInfo-> ALT/BARO" to read the current GPS-ALT and Baro-Alt.

Crossbow uses "Baro" Alt to track.

Another option is "Protocol->ALT=GPS". In this case, **MAVLINK_MSG_ID_GPS_RAW_INT** will be used as the data source of the altitude. This works for most PIX4 Flight Controllers.

In this case, "FlightInfo-> ALT/BARO" are both from **MAVLINK_MSG_ID_GPS_RAW_INT** message.

We recommend our users to set the update frequency of the above 2 messages higher to get better tracking performance. The method varies from different Flight Controllers. Take the ArduPilot Mega as an example, you can search for string"SR1_" in Mission Planner "All parameters List" to get a table of MAVLink messages updating frequency for Telemetry1 port.

Please set SR1_POSITION to 5Hz or higher in this case. 0=Disable.

SR1_EXTRA2	0	Hz	0 10	Stream rate of VFR_HUD to ground
SR1_EXTRA3	0	Hz	0 10	Stream rate of AHRS, HWSTATUS
SR1_PARAMS	0	Hz	0 10	Stream rate of PARAM_VALUE to g
SR1_POSITION	0	Hz	0 10	Stream rate of GLOBAL_POSITION
SR1_RAW_CTRL	0	Hz	0 10	Stream rate of RC_CHANNELS_SC
SR1_RAW_SENS	0	Hz	0 10	Stream rate of RAW_IMU, SCALED
SR1_RC_CHAN	0	Hz	0 10	Stream rate of SERVO_OUTPUT_R

TroubleShooting:My DataRadio doesn't work with Crossbow. Only VLink:0% is displayed

1. Check if the tracker is receiving data from your date radio. Check Menu item "Factory->CoreData->RX". This number will increase when the tracker receives any data from U3RX (Datalink port) or U2RX(External GPS port). If the RX doesn't increate at all, please check your cables again and make sure your DataRadio is sending out date on its TX wire.
2. Check menu "BaudRate" again to make sure you are using a proper baudrate, especially after you apply a new firmware.

3.BETAFLIGHT:

<https://www.expresslrs.org/software/mfd-crossbow/>

5. AAT menu operation guide

After power on the screen shows main parameters of the current status.

```
GPS: 12
DIST:N/A
Alt: N/A
AZim: N/A
VLink: 0%
```

Dir: 0

To enter/quit the menu system, hold the LEFT button for 2 seconds or longer.

You can also choose "Exit" in the menu to quit the menu system.

Please use the LEFT button to browse the menu.

Use the RIGHT button to enter sub-menu or change values.

```
MAIN MENU
YawTrim
HomePos
CalCompass
MotorCurr
CalPitch
CompassMod
L-BaudRate
R-BaudRate
FlightInfo
PayloadSel
OSDLevel
VBISetting
Protocol
TrackerID
SysInfo
Factory
Exit
```

YawTrim:

```
<<[-][+]>>
Yaw:0
Pitch:0
Exit
```

If the tracker is slightly tracking the plane left or right, you can apply some YawTrim to make it more accurate. Use Negative values to trim the tracker to LEFT. Use Positive values to trim the tracker to RIGHT.

You can also use the Pitch item to trim the tracker UP/DOWN.

The valid parameter range is [-20,20]

HomePos:

```
UsePreHome
H1:D:0
H2:D:0
```

```
H3:D:0
H4:D:0
H5:D:0
AutoLoad=N
Exit
```

H1~H5 is the Home Positions which you recently have used. H1 is the most recent home position. H5 is the earliest one.

The distances between your plane and the H1~H5 stored home positions are displayed in a D:XXXXX formation. Also the longitude and latitude of each home position will be displayed alternatively to help the user to decide which Home Position should be load to use.

Click the right button to load a high-light (selected) home position.

If you forgot to Set Home before takeoff, this function will be helpful especially you have a proper pre-saved home position in the tracker.

AutoLoad=N means the tracker will not load the most recent home position when it starts up.

Click the right button to set AutoLoad=Y to enable it.

CalCompass:

```
CalCompass
MAX:125
...
...
Exit
AutoLoad=N
Exit
```

Click the right button to execute a compass calibrate the compass of the tracker.

Before doing that please make sure the tracker is locked on the tripod well.

It takes about 20 seconds to finish the calibration. You can ignore the parameters showing on the screen during the procedure.

MotorCurr:

```
MotorCurr
Pit:2000
Yaw:2000
AutoDetect
Exit
```

Use the right button to set the maximum current for the Pitch or Yaw motor. (in mA)

Valid range of these parameters are [0,4500] mA

You can also use "AutoDetect" to measure the proper settings of your setup. Remember to fasten your tracker and clear all objects nearby before doing that. Because the tracker may yaw and pitch to any direction during the procedure.

CalPitch:

```
MotorCurr
Pit:2000
Yaw:2000
AutoDetect
Exit
```

Use this function to calibrate the pitch sub-system of your tracker.

Tracker needs to know the horizontal position to work well.

Please follow these instructions to Cal. Pitch:

1. Use "Pitch UP" and "Pitch DOWN" to adjust the tracker until it points to horizon. (Imaging that the plane is very far and low).
2. Use "Save L Pos" to save this Low Position.
3. Use "Pitch UP" and "Pitch DOWN" to adjust the tracker until it is about 110 degrees. (Not restrict 110 degrees, but it must > 90 degrees.) That means the tracker reaches vertical position and goes further.
4. Use "Save H Pos" to save this High Position.
5. Save & Exit.

CompassMod:

```
UseCompass
InitOnly
Always
Never
Exit
```

This setting is about how to use the compass of the tracker.

InitOnly: The tracker only reads the compass to know where is North when starting up. Later it will use an internal optical-encoder to work smoothly without the compass. In this case you can't rotate your tripod because the tracker is not able to sense that movement.

Always: The tracker use the compass all the time (Just like our 1st generation MFD AAT). With this option you can even mount your tracker on a vehicle and keep tracking (with an external Compass+GPS). But if you are using the built-in compass, this option is not recommended because the internal compass is not very accurate when the motors work at high-payload status.

Never: The tracker doesn't use the compass at all. You are responsible to point the tracker to North. (That means facing the AAT Screen to South). If you are going to fix the tracker on a building you can use this option.

L-BaudRate:

```
Baud Rate
115200
57600
38400
19200
9600
```

```
4800
1200
Exit
```

Choose a baudrate for TX3(PIN#3) / RX3(PIN#2) of your LEFT-port. To use our Compass+GPS module you need to use 115200bps. If you use RX3 as telemetry input (MAVLink / S.Port-Inv), set the baudrate according to your devices.

R-Baudrate:

Almost same as above.

Choose a baudrate for RX1(PIN#1) of your RIGHT-port. RX1(PIN#1) can also accept telemetry input (MAVlink / S.Port-Inv)

FlightInfo:

```
FlightInfo
Lon:EAST
0.000000
Lat:NORTH
0.000000
ASL:0m
BARO:0m
Exit
```

This screen displays some useful information of the plane which is being tracked.

Lon/Lat is the GPS coordinates of the plane.

ASL: AboveSeaLevel altitude of the plane. Usually comes from the GPS data of the plane.

BARO: Barometer altitude of the plane. Usually comes from the barometer of the plane.

PayloadSel:

```
Payload
Light
Midium
Heavy
UltraHeavy
Exit
```

Choose the payload level of your setup.

Light: Light Weight antennas, high acceleration and fast movements.

UltraHeavy: Very Heavy antennas, low acceleration and slow movements.

OSDLevel:

```
Brightness
Level:90
Exit
```


Choose the OSD(OnScreenDisplay) brightness level of the tracker. The tracker is able to overlay some graphics information on the analog video signal. Higher value will choose brighter OSD images. With the CAN-BUS and our new "FlyTogether" feature, users now can connect up to 10 trackers. Everybody can see other's relative position/altitude on the screen.

Valid range of this parameter is [0,100].

VBISetting:

```
VBISetting
VER:V1
Exit
```

Choose V1 to work with old MFD products (MFD AP, MFD TeleFlyPro).

Choose V2 to work with new MFD products(MFD Crosshair AP, MFD TeleFlyTiny. You can also choose V1 for Crosshair/TeleFlyTiny with their own menu).

This is about how to use the analog video to carry flying information.

MFD devices can encode information to the analog video signal.

The tracker will extract necessary information from it. V2 works better in long range.

Protocol:

```
Protocol
ALT=BARO
Exit
```

Choose ALT=BARO or ALT=GPS to determine what altitude data of the MAVLink data stream will be used to track. We will discuss this in the chapter "5. **Downlink**".

TrackerID:

```
TrackerID
ID= 1
Exit
```

Choose the numeral ID of the tracker. When you use "FlyTogether" function, your ID will be displayed on other's OSD screen. You need a unique ID when you joining a "FlyTogether" CAN-Bus network.

The valid range is [0,9]

SysInfo:

```
SysInfo
Ver.:1.83
2:21.8.23
12:40:22
Hw:1
Exit
```

This screen shows version number of the firmware (1.83) and Hardware (1)

Factory:

Test

YawTest

PitchTest

AllTest

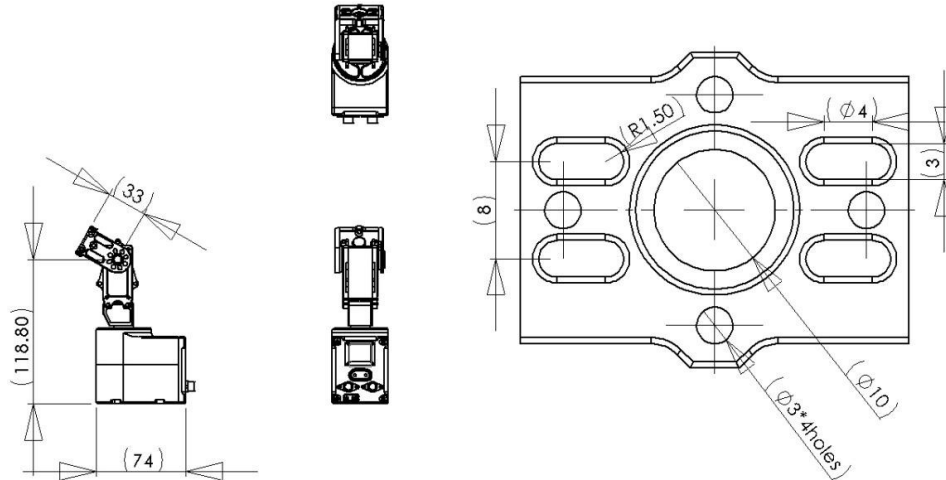
CoreData

Exit

This screen is reserved for the manufacture.

Appendix A:

Some Dimensions of the tracker and the mounting interface of antenna



Appendix B

How to use the external GPS+Compass module for mini Crossbow

With the GPS+Compass module the system can track more accurately, or keep tracking while the system is moving (Set option `CompassMod=Always`). And you don't need to SetHome before takeoff.

Please align your GPS+Compass module parallel with the mini Crossbow main unit as the below picture. Connect the GPS+Compass module to the left port of the Crossbow. Then choose 115200 in the "L-Baudrate" menu. Finally choose "L:ExtGPS" in the "Protocol" menu (Not necessary if the GPS is the only device that connected to the left port).

When the GPS+Compass connected and setup correctly, the bottom line of the screen will displays "ExDir" to indicate that an external Compass module is being used. The internal compass module will be shutdown. Please calibrate the system with menu item "CalCompass" and rotate the miniCrossbow and GPS+Compass module together until the procedure is done.

