Ekinox AHRS & INS

Use in airborne applications

Operating handbook

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SBG SYSTEMS

This operating handbook explains how to install and setup an Ekinox in airborne applications such as aircraft, helicopter, or UAV. Mechanical installation is explained as well as software configuration and magnetic calibration.

- *Mechanical installation with alignment, vibration and magnetic field considerations*
- *Software configuration with motion profile, GPS antenna lever arm*
- *Magnetic calibration in case of magnetometers use*

You don't need to use the sbgCenter to configure the products except for the magnetic calibration procedure.

Mechanical installation

Inertial Systems are very sensitive to their environment and the location of the inertial system into the aircraft is a key point to get accurate and reliable measurements.

Sensor accuracy can be greatly compromised if following instructions are not followed.

Vibrations

Ekinox is designed to handle vibrations. Nevertheless in case of highly vibrating environment, or vibrations above 1kHz, an efficient mechanical vibration isolation is required for proper operation. Silicon dampers can be used for that purpose.

Ekinox placement in the aircraft

The vehicle coordinate frame is defined as follows:

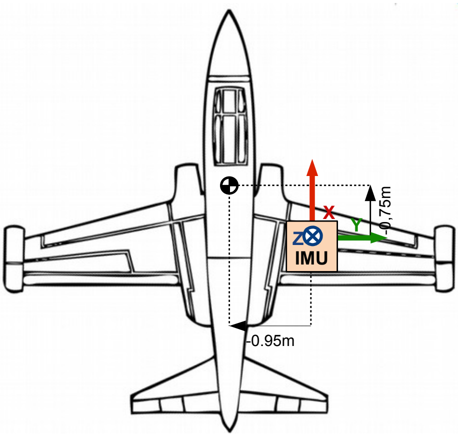
- X axis points to the front of the aircraft
- Y axis points rightward.
- Z axis points downward.

The Ekinox MUST be mechanically aligned with the vehicle coordinate frame, as explained in the following diagram. **Alignment accuracy should be better than 0.5°.**

Note: If a correct mechanical alignment is not possible, then a software alignment can be used. Please refer to the Ekinox User Manual for such operation.

The main lever arm is the signed distance, expressed in the vehicle coordinate frame, **FROM** the Ekinox center of measurements **TO** the vehicle center of rotations. It can be used to deport the velocity and position outputs to this specified location.

The main lever arm can be measured in order to get remote velocity and position measurements.



Magnetic environment

If magnetometers are used for heading observation, user should also consider the magnetic environment.

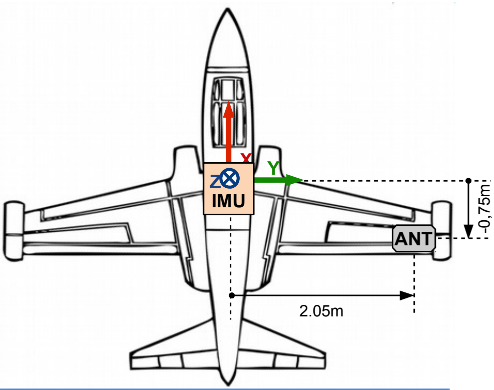
The Ekinox **magnetometers require** for good operation a **clean magnetic field**. The sensor should be placed away from any magnetic interference such as: DC motors, radios, strobe lights, power supplies etc.

GPS Antenna placement

GPS antenna must be fixed with respect to the Ekinox. It should have a clear view of sky.

The GPS lever arm is the signed distance, expressed in the vehicle coordinate frame, from the Ekinox center of measurements, to the GPS antenna. It must be measured within 5cm accuracy.

In addition, this lever arm should be lower than 10m for best performance.



Note: In case of dual antenna GPS receivers, only the main antenna lever arm must be considered. In addition to this lever arm, the absolute distance between the two antennas must be entered, and the orientation offset between the antennas and the Ekinox must be entered as well.

Software configuration

All Ekinox configuration is done through the web interface.

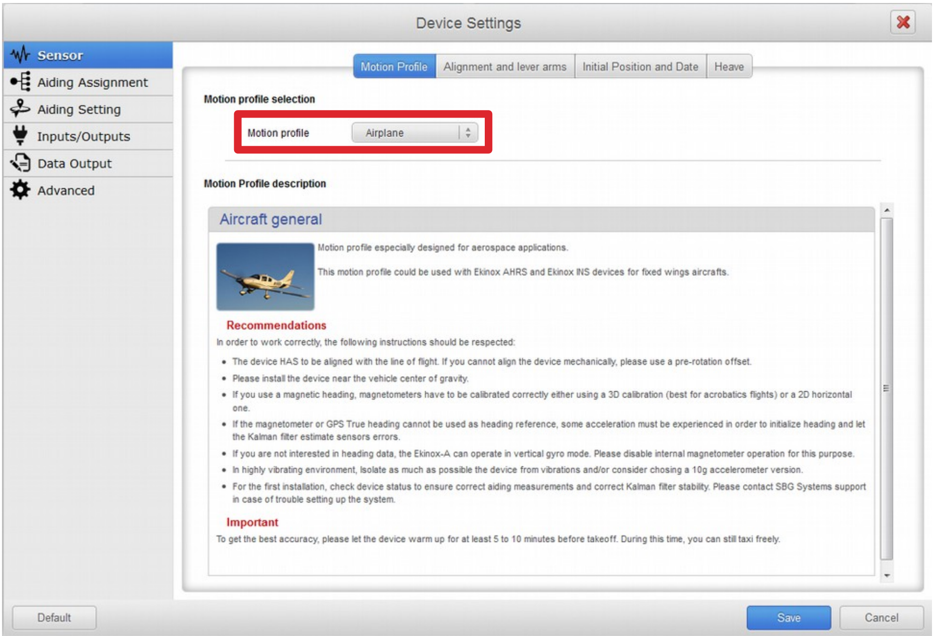
> **Note:** At the first access or if the device firmware has been updated, the Ekinox will cache the entire embedded website to optimize the responsiveness. This preload operation may take up to two minutes depending on your system configuration.

Sensor

Motion Profile

For airborne application, several motion profiles are available:

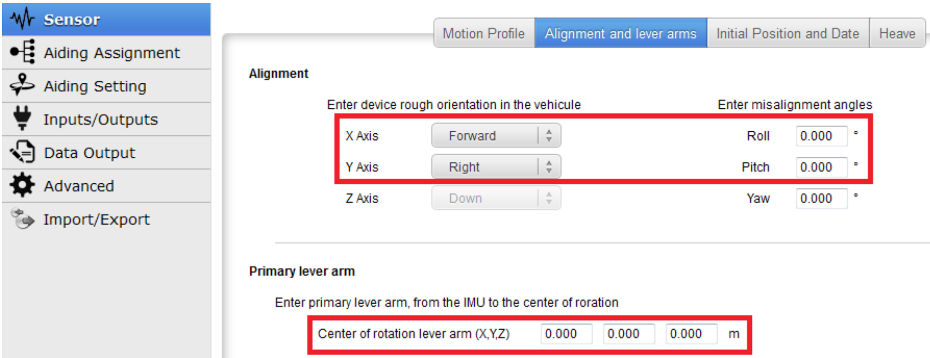
- Aircraft General for fixed wing aircraft or UAV
- Helicopter for rotary wing UAV and standard helicopter applications



Alignment and lever arms

Here you can configure the alignment of the device and its lever arm in regard to the center of rotation of the aircraft.

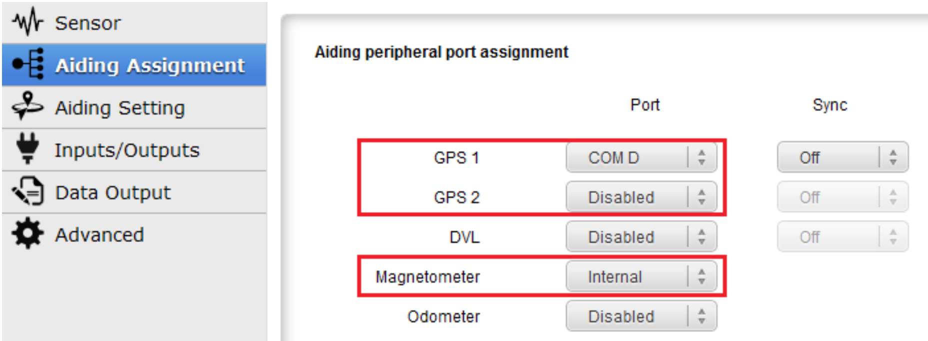
On the alignment settings you only need to set up the first two axis, then the third one will be automatically computed.



Aiding Assignment

You can enable one or two GPS on this panel and in case of Ekinox N or D, you can chose if you want to use the internal GPS or not.

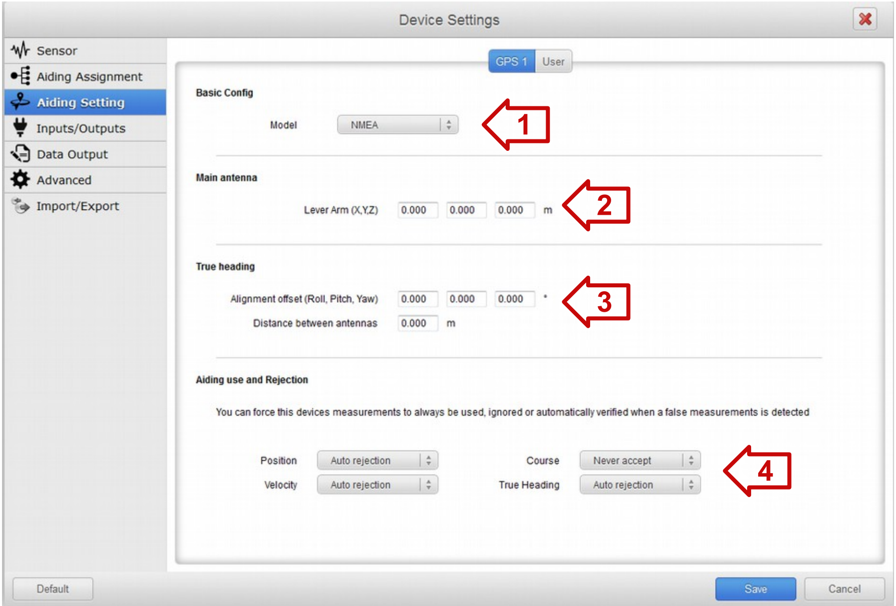
In case of a clean magnetic environment and if you can run a calibration procedure, you should be able to use the internal magnetometers. Please check the calibration section!



Aiding Settings

GPS Configuration

Please check following point at the GPS configuration level:



1. Choose this parameter depending on the GPS you are using (NMEA or Novatel), you can refer to the corresponding manual to know how to configure the GPS.
2. Set up the lever arm of the GPS depending on its position on the aircraft (GPS Antenna placement).
3. If two antennas are used you have to define here the distance between antennas and the antennas misalignment with respect to the aircraft coordinate frame.
4. Auto-rejection is advised for velocity and position. **Course should be set to "Never Accept"** and True Heading should be set to Auto Rejection if available. "Auto Rejection" mode automatically detects if a measurement can be trusted or not.

Note: It is not recommended to use GPS Course in airborne application because of possible side slip (either because of wind or aircraft behavior).

Magnetic calibration in airborne applications

When magnetometers are used as heading reference, a **magnetic calibration is mandatory for normal sensor operation.** Different calibration methods are provided, depending on accuracy or ease of use requirement.

Light UAV calibration

As long as a UAV (fixed or rotary wings) is light enough to be held by a few persons, a 3D calibration, made on the ground is to be preferred. The basic procedure is the following:

1. Install the sensor as described in previous sections, and place the whole system **away from external magnetic disturbances** (buildings, other vehicles, etc)
2. Press "Start acquisition" button on sbgCenter calibration window
3. **Rotate the system as much as possible**. The main point is to cover the whole flight profile, but a larger amount of points, beyond the flight profile will provide even better results.
4. Press "**Calibrate**" and check calibration results. Press "**OK**" to finalize the calibration procedure.
5. Power cycle the sensor if you need immediate operation after calibration.

Airplanes, helicopter and large UAV applications

In flight 3D calibration

This calibration will give the best results as it allows to map the magnetic field in real 3D so that magnetometers readings are kept consistent even during turns and pitching.

In order to perform the calibration procedure, user can use the integrated sbgCenter calibration tool, or a data-logger to store the "magnetic calibration data" outputted by the Ekinox during calibration procedure.

Procedure

Once the aircraft is in steady flight at a reasonable altitude, the goal is to cover different orientations which are representative of the flight domain of the aircraft.

The calibration accuracy does not depend on any precise orientation (facing true North for example) and rather depends on how many significantly different orientations have been covered. The calibration algorithms are able to map the 3D magnetic field in orientation that have not really been covered during calibration; however, it is good to cover the full flight domain to get the best results.

For example an Extra 300 aerobatic airplane should get the best results by performing several representative aerobatic maneuvers in different directions in order to get a good 3D coverage of the magnetic field. In the other hand, a Cessna 172 private airplane could only perform high inclination eights to get optimal results.

Procedure tested on a private airplane

The following procedure has been tested with success on a piston private airplane.

The calibration starts in a steady flight. Two 360° turns will be performed decomposed in the following steps:

Step 1: Calibration Start. Press "**start acquisition**" button.

1. High bank right rolling – without turning.
2. High bank 120° left turn

Step 2:

1. High bank right rolling – without turning.
2. High bank 120° left turn

Step 3:

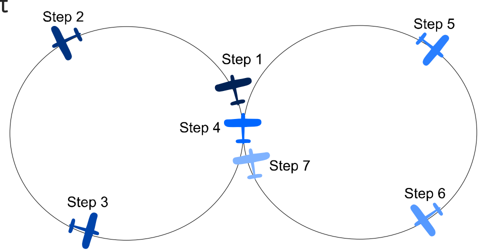


Figure 1: Trajectory performed during calibration

1. High Pitching : + 20° then -20° then return to level flight
2. High bank right rolling – without turning.
3. High bank 120° left turn

Step 4:

1. High bank 120° right turn

Step 5:

1. High bank left rolling – without turning.
2. High bank 120° right turn

Step 6:

1. High Pitching : + 20° then -20° then return to level flight
2. High bank left rolling – without turning.
3. High bank 120° right turn

Step 7: Calibration end. Press "**Calibrate**" button, then "**OK**" button, and finally "**Save to Flash**" button in order to store calibration results into flash memory.

Once these tests are done the calibration can end. It is not crucial to perform exact 120° turns, but the procedure should perform rolling points at significantly different headings. In addition the pitching in the first should not be performed at the same heading as the one done in the second turn.

> **Note:** This procedure can be easily transposed to rotorcrafts. The procedure can be performed in a stationary flight, by making several pitching and rolling maneuvers at different heading values. The goal is to expose the sensor to as much orientations as possible.

Ground calibration (fixed wing only!)

Although this method is not the most accurate, it's possible to calibrate the magnetometer on the ground, using the "2D horizontal" calibration method. This method only works with fixed wing airplanes.

The procedure is really simple and only requires a few steps on the ground to be performed:

1. Install the sensor as described in previous sections, and place the whole system away from external magnetic disturbances (buildings, other vehicles, etc).
2. Place the aircraft on a horizontal platform. The aircraft must be kept horizontal (in its line of flight level). This is the case with most tricycle landing gears airplanes, but this should be a concern with conventional landing gears.
3. **Calibration Start.** Start the sbgCenter calibration tool and press "**start acquisition**" button.

4. Perform a 360° circle with the aircraft. The calibration mode has to be set on "2D Horizontal". The aircraft should be at least 10m away from any metal building or other aircraft.
5. **Calibration end.** Press "**Calibrate**" and check calibration results. Press "**OK**" to finalize the calibration procedure.

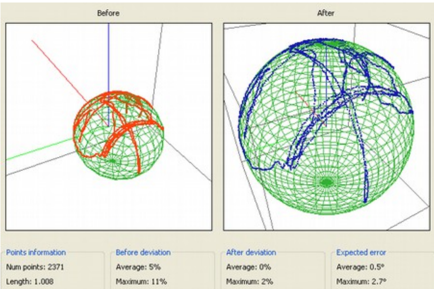
When using the 2D Horizontal calibration, the aircraft will only rely on magnetometer in steady level flight. During turns and maneuvers, the IG-500 heading will only rely on gyroscopes.

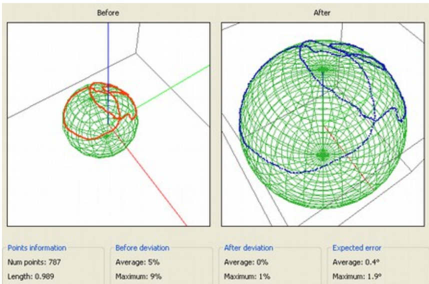
Therefore, compared to a full 3D calibration, a small heading drift may be observable when the aircraft has a significant inclination over extended periods.

Note: For highest performance, please consider the 3D calibration.

Calibration result examples

On the following screen-shots, it is possible to see that the calibration coverage is not a full 3D sphere but covers significantly different orientations. The first screen shows an example of the calibration procedure explained above. The second one shows a calibration only performed with a simple "8" performed.





Support

If you have any trouble or question with the use of the Ekinox, feel free to contact our support team by email, at support@sbg-systems.com.