Operating Handbook
IG-500 in airborne applications

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This document explains how to install and setup an IG-500A, IG-500E or IG-500N 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*

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

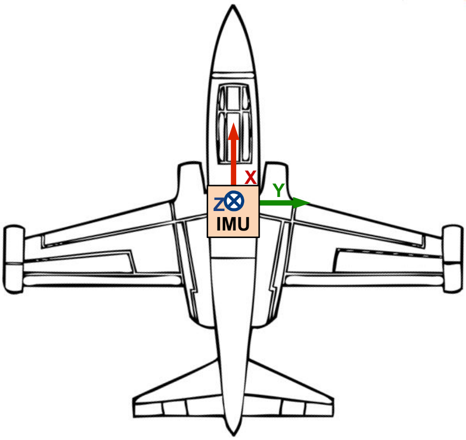
In application subject to vibrations, an efficient mechanical vibration isolation is required for good operation. Silicon dampers can be used for that purpose.

IG-500 Alignment in the vehicle

Install the device with the *X* axis in the direction of flight (***X* pointing forward**). In the case of helicopter or multi-rotor UAV application, *X* axis should be turned in the *preferred* direction of flight.

***Z* axis points down** and ***Y* axis points to the aircraft right side**.

By this way the sensor must be fixed relatively to the aircraft.



Note: *If such mechanical alignment is not possible, a software alignment can be performed (pre-rotation). Please check Software orientation alignment section for more information.*

Placement considerations

The IG-500 should be placed as close as possible to the center of rotation (most of the time the center of gravity).

Magnetic environment

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

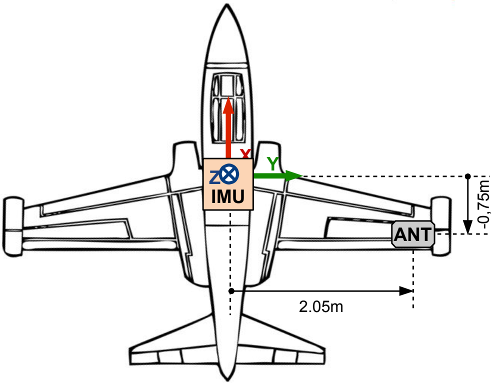
The IG-500 **magnetometers require** for good operation a **clean magnetic field**. The sensor should be placed away from any magnetic interference such as: DC motors, radios, strobe lights, power supplies etc.

GPS Antenna placement (IG-500N & IG-500E)

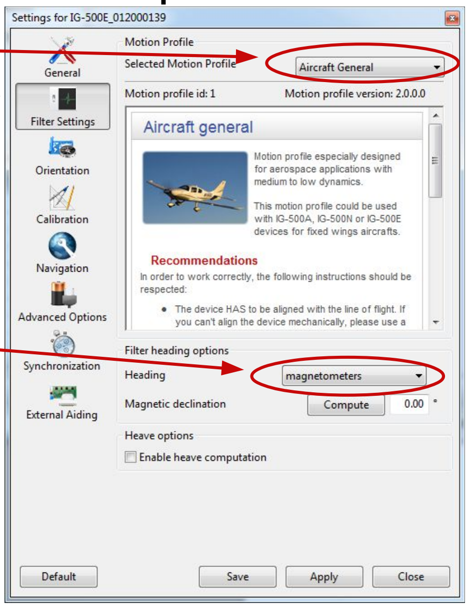
On IG-500N and IG-500E devices, GPS antenna can be placed away from the device.

The distance between IMU and Antenna must be **measured within 5cm accuracy**.

This distance (lever arm) **should not exceed 3 meters** for best accuracy.



Software configuration – Kalman filter parameters



Step 1: The motion profile should be set to one of the following:

- **Aircraft General** for fixed wing aircraft or UAV with medium dynamics
- **Aircraft High Dynamics** for fixed wing aircrafts or UAV with aggressive flight.
- **Helicopter** for rotary wing UAV and standard helicopter applications.

Step 2: Heading source should be set to one of the following:

- **Magnetometers** for most applications. **Check calibration section!**
- **GPS Accelerations** for high dynamic applications. The sensor needs to be regularly accelerated (turn, acceleration).
- **None (IG-500A):** If the sensor is used as a vertical gyroscope (roll / pitch only).
- **GPS Course** is not recommended for most airborne applications

Step 3: Press “**Apply**” button and then “**Save**” in order to save configuration to flash memory.

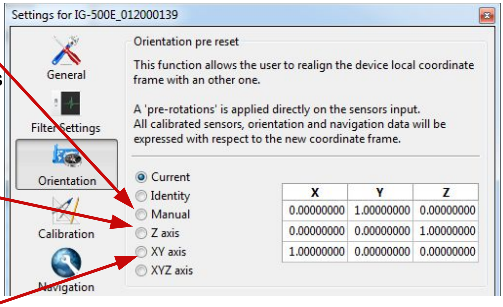
> ***Note about magnetic declination:*** *On IG-500A, it's possible to enter the declination value here. The sbgCenter can compute automatically the local declination, given a latitude and a date.*
>
> *On IG-500E and IG-500N, the magnetic declination is automatically computed when the GPS has a fix.* ***It's possible to enter an initial declination for faster startup.***

Software orientation alignment

If the sensor is not accurately aligned to the vehicle coordinate frame, the software “pre-rotation” feature should be used as follows:

There are 3 ways to make a software alignment:

1. **Manual reset:** Used if you know the rotation matrix to apply. Each matrix parameter is entered in the table on the right. **Best accuracy method.**
2. **XY reset**: Used if the sensor is aligned in heading with the vehicle, but not in roll and pitch angles. The vehicle must be accurately horizontal and not moving during alignment.



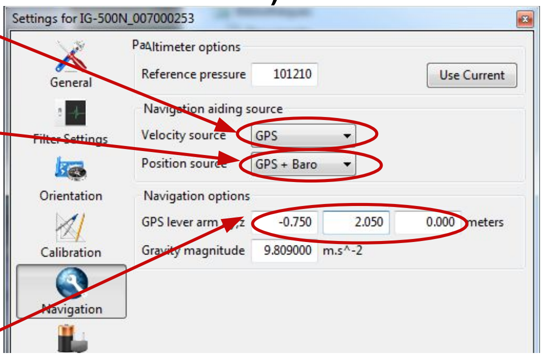
3. **XYZ reset:** Used if the sensor is placed in a fully arbitrary orientation (not recommended). The vehicle must be horizontal and facing North before applying the reset.

Navigation options (IG-500N and IG-500E)

Step 1: Velocity source set to GPS.

Step 2: Position source is set to:

- **GPS+Baro** (IG-500N only) in case of non pressurized cabin.
- **GPS** on IG-500E , or when the sensor is placed in a pressurized environment, or if altitude flights exceeds 20km.



Step 3: GPS lever arm is entered as measured in previous section.

Step 4: Press “Apply” button and then “Save” in order to save configuration to flash memory.

> ***Note*** *Local gravity magnitude can be entered on IG-500A. GPS aided products automatically compute the local gravity value when a GPS fix is available.*

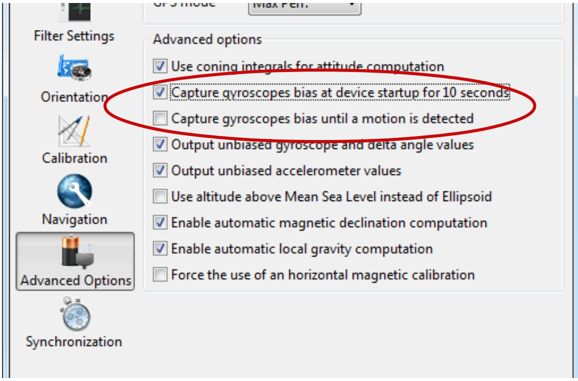
Faster startup with bias estimation

If the IG-500 is not moving at power up, it's possible to use this option to increase performance during warm-up time.

Choose either 10s or “until a motion is detected” in case of long stationary sequences.

This option is particularly useful in the case of a **vertical gyro** application, or with **“GPS + Acceleration”** heading source**.**

Don't forget to save configuration.



Magnetic calibration in airborne applications

When magnetometers are used as heading, 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 a few persons, a 3D calibration, made on the ground is desirable. 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**” and finally press “**Save to Flash**” button in order to store the calibration into non volatile memory.
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 IG-500 during calibration procedure.

Note: *Check the IG Devices Magnetometers Calibration Tools documentation to get more information about the use of log files for magnetometers calibration.*

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:

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

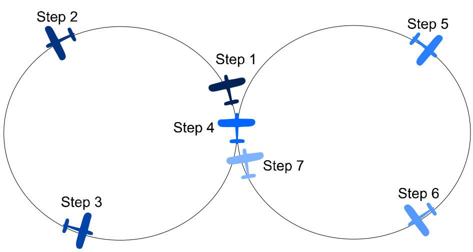


Figure 1: Trajectory performed during calibration

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 an 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**" button, then "**OK**" button, and finally "**Save to Flash**" button in order to store calibration results into flash memory.

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.

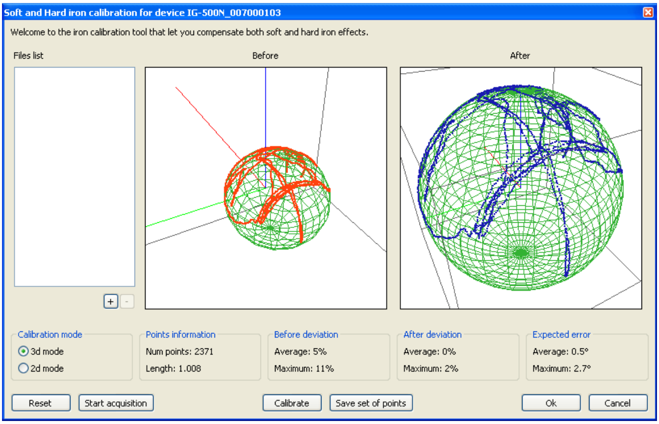


Figure 2: Calibration with the procedure described in paragraph

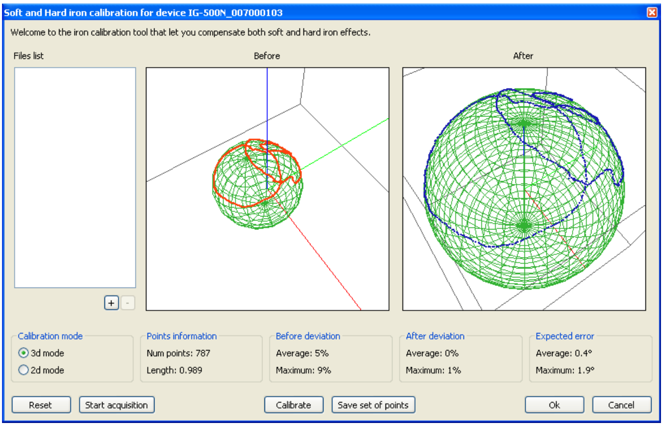


Figure 3: Calibration with only two 360° turns, describing a 8.

Support

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