

Magu Manual

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Revision History

The following table shows the revision history of this document.

Date	Description
June 2013	Initial release
January 2017	Emsis and Horis support.
April 2019	Some clarifications and examples were added.
December 2020	Example for the second calibration step.

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1 Introduction

First of all, we would like to thank you for purchasing our product. MAGU is electronic magnetic compass, designed especially for use in avionics.

We strongly recommend you to carefully read this manual, before you start connecting MAGU unit with your Nesis or Emsis system. The manual provides information about the installation of the MAGU unit and calibrating it for best results.

The introduction chapter contains some general information, later chapters reveal the details.

1.1 General Description

MAGU is an electronic device used to detect a magnetic field vector. It is especially suited for the Earth magnetic field detection and processing.

MAGU is particularly well suited for the use in the avionics, where it can serve as a simple compass or as a bank (roll) corrected compass.

MAGU comes in two versions, for nose or tail installation in your aircraft. Both versions are shown on Figure 1.



(a) Tail install - cable connects on the front. (b) Nose install - cable connects on the back.

Figure 1: Magu versions.

Features

Below is the list of MAGU's main features. All features are explained in detail throughout the rest of this manual.

- Calculation of current magnetic heading.
- Calculation of bank corrected magnetic heading, when pitch and roll Euler angles are available.
- Calculation of true heading when current geographic position and time are available.
- Advanced calibration algorithm provides self calibration ability for removing soft and hard iron errors.
- Each unit is carefully calibrated in the factory. The results of this calibration can always be restored.
- Small size, weight and power consumption.

Please note that the output of the MAGU is effected by the input information it receives, roll and pitch, for example.

1.2 Technical Specification

Table 1 shows some basic technical specification of MAGU unit.

2 Installation

Here we would like to emphasize the importance of good compass positioning and calibration.



An imprecise compass will yield to bad results, no matter how well Nesis, Aetos, Emsis, Horis and MAGU devices were aligned to the reference pitch. Furthermore, it may even deteriorate roll and pitch indication or make them completely useless.




Each unit is factory calibrated. However, this does not do much as every aircraft has its own disturbances. The MAGU calibration must be performed after the installation.

Description	Value
Weight	57 g
Size	62 x 62 x 23 mm
Operational voltage	7 to 19 V
Current	25 mA at 12 V
Power consumption	0.25 W
Operating temperature	-30 ~ +85 °C
Humidity	30 ~ 90 %, non condensing
Processor	Cortex M3, 60 MHz
Sensors	Magneto-inductive, 3 separate sensors
3D calibration	This calibration is done in factory
2D calibration	Must be done by user
Connector	Standard RJ 45
Communication	CAN bus, 29 bit header, 500 kbit, Kanardia protocol
Time from power up to first packet	< 250 ms

Table 1: Technical specifications for Magu.

2.1 Position in Aircraft

Finding a good place for compass in an aircraft is a difficult task. It may easily happen that selected place will yield bad results. It may be necessary to move Magu position two or three times, before a good place is found. 

Each aircraft has a lot of magnetic disturbances. Any compass is interfered with electromagnetic fields and it is worth to put some effort in finding a good spot before the installation. A simple hand-held compass can be used in search for such a spot.

Search away from any parts that may contain iron or any other magnetic material (Cobalt, Nickel or ferromagnetic compounds) and, for God's sake, away from any devices which contain permanent magnets (all electro-motors, servos, pumps ...) and away from electronic devices, which consume large electrical current or emit/radiate electromagnetic fields. Steel rods and tubes are very strong sources of disturbances. The same is true for steel cables and wires. Even an antenna rod will may cause troubles. Sometimes a single steel bolt can be source of problems.

Turn your avionics on (radios, transponders, etc.), allow electronics to warm

up and start searching for a spot. When you find a candidate for such spot, check it with a hand-held compass first. Here you need to observe two things. The compass needle should not deviate, if the compass is moved around the spot and the needle should point to a direction, which is close to magnetic North direction measured outside of the aircraft. The needle should also not react (too much) to the radio transmission. So, press “push to talk” to transmit a couple of times and observe the needle. Also turn transponder transmitting on and off and the needle must not change. If you have large current consumers (like strong landing lights, strobes, etc.) turn them on and off and observe the needle movement.

2.2 Alignment

1. Make sure the AHRS unit in Nesis or Emsis is currently adjusted for the cruise flight position. This defines reference axes of your aircraft.
2. Make sure that compass axes are aligned with the reference axes described above.

This will ensure best pitch and roll corrections and provide good compass heading even in steep turns, climbs and descends.

3 Calibration

The MAGU unit (magnetic compass) is carefully calibrated in our lab. However, like any magnetic device, MAGU is affected by nearby ferrous materials as well as by local electromagnetic fields produced by other electronic devices. Earth-magnetic field (which is what we want to detect) is combined with the unwanted magnetic fields produced by ferrous materials and electromagnetic devices.

3.1 Background

The calibration process can efficiently remove a large part of the error caused by the unwanted magnetic fields, but only if such fields are not too strong. Therefore, it is of ultimate importance to install MAGU away from ferrous materials (like engine or steel rods) and away from electromagnetic devices (like speakers, radio transmitter, transponder, etc.)

Since electromagnetic devices emit their magnetic field only when they are turned on, you must turn on all electric devices before you start the compass calibration and keep them activated for the time of calibration. You should also make your aircraft as level as possible.

Instruments shall be running at least 10 minutes before calibration. This will warm up the electronics and stabilize filters.

The calibration is done in two steps. Both steps are briefly explained first and later a more detailed step by step procedure is given.

- The first step requires turning the aircraft for a little bit more than one full circle, about 400° . This step efficiently removes a large portion of the nonlinear error. However, some error, which is more or less constant in all directions, remains. This is called the offset error. Usually it is small, typically less than 3° .
- In the second step, this remaining offset error is entered manually. In order to obtain the offset error, aircraft shall be directed into a couple of reference magnetic headings. Write down the differences between the reference magnetic heading and the heading shown on the dialogue on Figure 3. Average value of the differences, gives the final offset, which should be entered into the device. Note that the second step can be done much later (a few days or weeks) than the first step.

IMPORTANT: Before you start with the calibration procedure, please make sure that:



- You have completed AHRS Level procedure and that AHRS is set for the level flight.
- Instruments are running for at least 10 minutes. This means that they have warmed up and all numerical filters has been stabilized. If you turn instrument off, you have to wait for another 10 minutes for the best results.

The device will illustrate the magnetic error in a circular diagram. A circle (or an ellipse) with a center, which is slightly offset indicates a successful calibration.



A kidney like shape or a circular/elliptic shape with a large offset from the center indicate a bad place and MAGU must be moved.



It may happen that you are turning the aircraft and the turning procedure never completes successfully – you simply can't finish it, no matter how many



times you try. This usually means that magnetic field disturbances are too high for the algorithm to complete the job. You must move MAGU to some other place.

3.2 Tools

A reference compass is needed for the second step. We highly recommend using some high quality compass, which will allow you to take precise readings with at least one degree resolution. The reference compass shall have a precise direction aiming capability. One example of a good reference compass is shown on Figure 2.



Figure 2: An example of quality handheld compass with good aiming capability.



Do not use runway directions as *known headings*. The runway designations are not precise enough. Say you have runway 11. In theory this shall indicate 110° , but it does not. It can be anything between 105° - 115° . Also note that magnetic direction changes in time (years).

3.3 Calibration with Nesis

3.3.1 The First Step

Here are the instructions needed to perform the first step of the calibration. Please, be sure that you will be able to turn the aircraft for more than one full circle in a position, which is as close to the level flight as possible.

Figure 3 shows compass calibration dialog.

1. Select the `User Options` page in Nesis.

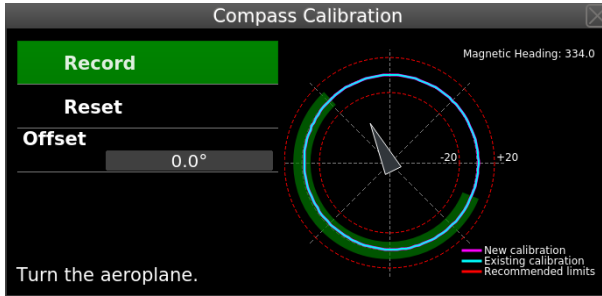


Figure 3: Compass calibration dialog - first step is in the progress.

2. Select the **Compass** icon and enter the password 314 if required.
3. Press the **Record** button and turn the aircraft for more than one full circle. Try to keep constant angular rate when turning. The recording stops automatically, when thick the green line makes full circle on the Nesis screen.
4. Observe the *new calibration line*. In most situations, this line should be within the red dotted line interval. The calibration line shows magnetic compass correction calculated at given heading. These corrections can reach up to $\pm 20^\circ$ and in rare cases even more.
5. If you are happy with the results, close the window and Nesis will keep new calibration. Otherwise, press **Reset** button and go back to the turning step.

You must exit the compass calibration window before you continue with the second step. Closing will assure that calibration from first step becomes active and you are able to take the difference measurements needed in the second step.

When MAGU is installed in a bad place, it may happen that you are unable to complete the *Record* step mentioned above – you are unable to complete the full circle. The only solution is to move it to another place and to try again.



3.3.2 The Second Step

Here we assume that the first step was completed successfully. Now, a constant offset error remains. You need to obtain this error by observing difference

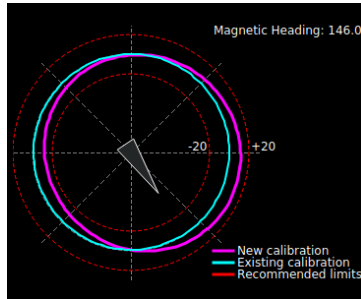
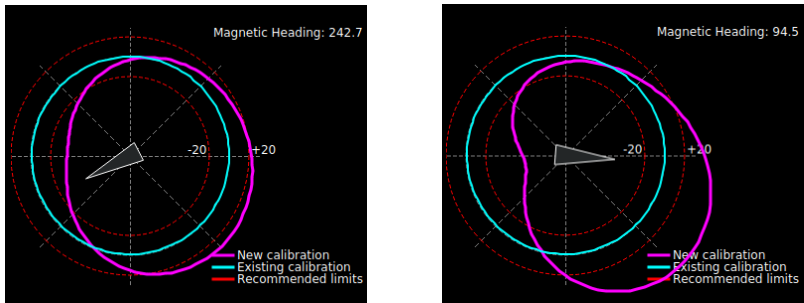


Figure 4: Calibration result (magenta line) is acceptable.



(a) Large magnetic field disturbance. Shape is pseudo-elliptical. Calibration results will be poor.

(b) Very large magnetic field disturbance. A kidney shape is visible. Calibration results will be poor.

Figure 5: Examples of bad calibration results. Magu must be moved to a different place.

between known reference magnetic headings and by the headings shown on the dialogue on Figure 3. This error is more or less constant regardless to the direction.

Write down this difference for a few different directions and calculate the average. Set this average into the unit. An example is shown in section 3.6.

1. Open the Compass window and enter the password.
2. Press the `Offset` button and enter the offset.
3. Close the windows.

This completes the magnetic compass calibration.

3.4 Calibration with Emsis

Emsis calibration follows the same logic as Nesis calibration. It is a two step process. In order to start the procedure,

1. select the **Emsis Setup** page and then
2. select the **Service** item from the menu. Enter password **314** to proceed. This will open up service menu.
3. From this menu, select **Compass calibration** for the first step and **Compass offset** for the second step.

3.4.1 The First Step

When ready, you need to rotate the aircraft for about 400 degrees. Direction of rotation and start azimuth are not important. When rotating, try to keep a steady pace for the best results – this will result in a constant angular velocity. When turning aircraft, the progress bar grows and the procedure is complete when it reaches full and turns to green. You have to make more than a full circle because the initial readings are not used in computation.

At this point a blue ellipse is drawn on the chart. Corrections up to 15° are generally accepted as appropriate. If you constantly get correction curve larger than 15°, then you probably need to find a better location for Magu. The correction on Figure 6 reaches about 8 degrees.

Important: If you are happy with the results, you must close the window using the check button. This will also save the results. Closing with the cross button does not save the results.

When MAGU is installed in a bad place, it may happen that you are unable to complete the progress bar mentioned above. The only solution is to move it to some other place and to try again.



3.4.2 The Second Step

The procedure mentioned above removes most of the compass error and in most cases this is more than enough. However, some constant error in all direction remains. You need to obtain this error by observing difference between known reference magnetic headings and by the headings shown on the

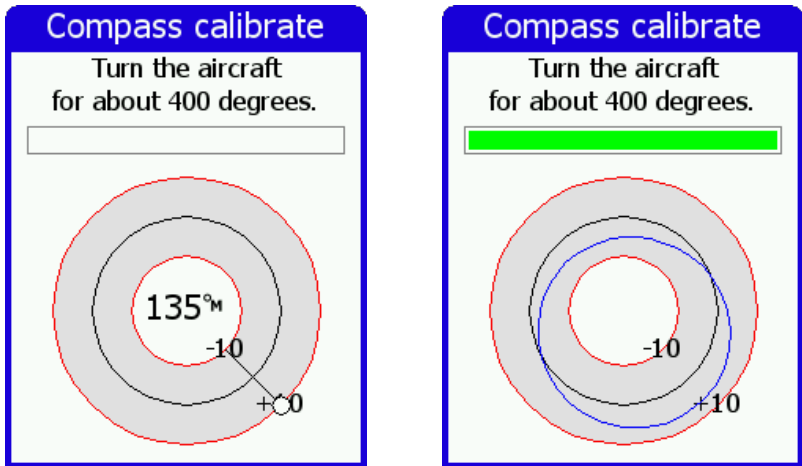


Figure 6: Emsis Magu calibration example. Left figure shows situation before and right figure shows situation when calibration is complete.

window. This error is more or less constant regardless to the direction. Write down this difference for at least a few different directions and calculate the average. Enter this final correction using the **Compass Offset** option. See Figure 7.

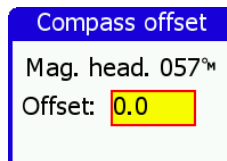


Figure 7: Compass offset window – final adjustment of compass.

When the compass readings were too large, enter negative value and vice versa.

3.5 Calibration with Horis

Important: Your Horis must have software version 2.15 or later. If this is not the case, Magu calibration is not possible. Please contact Kanardia for possible software update in your Horis.

Horis calibration follows the same logic, too. In fact, it is almost identical to the Emsis above.

1. Push the button and hold it to bring up the main menu.
2. Select the **Settings** item from it. This opens a new **Settings** menu.
3. Select **Compass cal.** item for the first step and **Compass off.** item for the second step.

3.5.1 The First Step

The window and the procedure is almost identical to the Emsis procedure. Please read the Emsis section first. If you push the knob, while the calibration is not complete, Horis will simply close the window and reject the measurements.

However, if the procedure was complete and you got a green progress bar and blue circular diagram and you push the knob, Horis will ask you whether to save the new calibration or to reject it.

3.5.2 The Second Step

Again, this is practically identical to Emsis. Please refer to Emsis section for details.

3.6 Second Step Example

Here we show a numeric example for the second step. In this case an aircraft is turned into three different directions, which are separated for about 120° . For each direction a magnetic value shown by the device (Nesis/Emsis/Horis) and a corresponding reference measurement with a high quality compass are recorded. The recordings were put into Table 2.

Reference	Device	Error
22	20	+2
137	134.5	+2.5
258.5	256.5	+2
Average error		+2.17

Table 2: Example for offset calculation of the second step.

Error of each measurement is calculated as a difference between reference and device reading (error = reference - device). Final offset is the average of all errors.

This offset (=average error) is then entered in the second step.

4 Limited Conditions

Although a great care was taken during the design, production, storage and handling, it may happen that the Product will be defective in some way. Please read the following sections about the warranty and the limited operation to get more information about the subject.

4.1 Warranty

Kanardia d.o.o. warrants the Product manufactured by it against defects in material and workmanship for a period of twenty-four (24) months from retail purchase.

Warranty Coverage

Kanardia's warranty obligations are limited to the terms set forth below:

Kanardia d.o.o. warrants the Kanardia-branded hardware product will conform to the published specification when under normal use for a period of twenty-four months (24) from the date of retail purchase by the original end-user purchaser ("Warranty Period"). If a hardware defect arises and a valid claim is received within the Warranty Period, at its option and as the sole and exclusive remedy available to Purchaser, Kanardia will either (1) repair the hardware defect at no charge, using new or refurbished replacement parts, or (2) exchange the product with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the original product, or, at its option, if (1) or (2) is not possible (as determined by Kanardia in its sole discretion), (3) refund the purchase price of the product. When a refund is given, the product for which the refund is provided must be returned to Kanardia and becomes Kanardia's property.

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