Horis - Installation and User Manual

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Software Version 4.00

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A lot of useful and recent information can be also found on the Internet. See `http://www.kanardia.eu` for more details.

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Some open source code is used in the Nesis software:

- https://angusj.com/clipper2/
- https://flatbuffers.dev/

- https://www.oberhumer.com/opensource/lzo/
- https://rapidxml.sourceforge.net/
- https://www.sqlite.org/index.html
- https://www.nayuki.io/page/free-small-fft-in-multiple-languages
- https://rapidjson.org/
- https://design.ubuntu.com/font

Some icons used in this manual and in Horis are contributed to `https://www.flaticon.com`, in particular, by Freepik, Flat icons, Maxim Basinski, Prosymbols, Juicy Fish, Vectors Market, Maswan, Muhammad Usman.

WEEE Statement

Disposal of Waste Electrical and Electronic Equipment. This electrical item cannot be disposed of in normal waste. Check with your local authority for kerbside collection, or recycle them at a recycling centre.

EU Battery Directive

This statement applies only for Horis which is equipped with integrated backup battery.
This product contains a battery that is used to provide power when the primary source of power is unavailable and is designed to last the life of the product. Any attempt to service or replace this battery should be preformed by a qualified service tehnician.

Acknowledgement

We thank Mr. John Delafield from LX Avionics UK for revising the manual. We also thank all users who pointed to the manual shortcomings and helped us to improve the manual and the product.

Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
4.3	Oct 2024	Updated maintenance section. A warning was added to charge the battery if the instrument is not in use.
4.2	May 2024	Transponder output option.
4.1	May 2024	Specification corrections.
4.0	Oct 2023	Update via SD card, logger support, density altitude, software 4.0, minor graphics changes. Revision now matches SW version.
1.17	Jan 2023	Backup battery reverse power leak clarification.
1.16	Aug 2021	The max output current on RS-232 port changed to 50 mA.
1.15	May 2021	Internal backup battery support in Horis 57.
1.14	Nov 2020	Autopilot support, minor corrections.
1.13	Jul 2020	Instrument pictures updated.
1.12	May 2020	Support for special time zones and TQ-KTX2 transponder.
1.11	Dec 2019	Chrono screen was added.
1.10	Jul 2019	Roll, pitch and yaw section was added.
1.9	Mar 2019	Initial brightness and GNSS info.
1.8	Sep 2018	Pinout description completed.
1.7	Jul 2018	Added SBAS GPS symbol and a photo of broken LCD.
1.6	Jan 2018	Adjustable turn rate bar on AHRS screen.
1.5	Sep 2017	Added G-Meter screen and its settings. RS232 pin 4 declared as not used.
1.4	May 2017	Minor corrections and clarifications.
1.3	Jan 2017	Compass, direction indicator, white line.
1.2	Jun 2016	Horis 80 mm.
1.1	Nov 2015	RS-232 pin desciption and NMEA out.
1.0	Jul 2015	Initial release.

Contents

1 Introduction

First of all we would like to thank you for purchasing our Horis device. Horis AD-AHRS is an electronic device, which includes several state of the art sensors and combines them into a small PFD display. It fits into a standard 57 mm ($2\frac{1}{4}$") / 80 mm ($3\frac{1}{8}$") panel hole. It can serve as a standalone PFD display and it may be used as primary instrument or as a perfect backup.

This manual describes the technical description of the unit, installation and operation.

> CAUTION: Horis is not TSO approved as a flight instrument.

1.1 Latest Manual Version

The Horis manual changes with time. Your printed manual may be out of date. Please check our web site `https://www.kanardia.eu/product/horis/` for the latest manual version.

1.2 Transport Mode

Horis equipped with a backup battery is delivered in the transport mode and must be connected to some external power source before first use. See also Section 2.7.4.

1.3 General Description

Horis is an electronic device. It consists of a set of sensors and an LCD display. Majority of sensors are built into its compact housing: static pressure, dynamic pressure, 3 axis accelerometer, 3 axis angular rate and GPS receiver. Only GPS antenna and OAT sensor are externally mounted. All sensors are solid state - there are no moving parts, which means less problems with fatigue and aging.

Horis has two processors: sensor processor and display processor. The sensor processor reads sensors and calculates airdata, attitude, GPS and other values using special sensor fusion algorithms. These values are passed to CAN bus where other CAN devices may use also them. The display processor monitors the CAN bus and it displays the information on LCD display.

One push/rotate knob is used for the operations. User interface is optimized so only minimal interaction is required to operate the instrument.

1.4 Technical Specification

Tables 2–4 starting on page 9 list basic technical specifications of Horis.

Description	Value
Operational voltage	5 to 32 V
Operating temperature	-30 $\sim$ +85 °C
Humidity	30 $\sim$ 90 %, non condensing
Barometric sensor	24 bit, 10 to 1200 hPa, 20 cm resolution
QNH range	590 to 1080 hPa, (17.42 to 31.89 inHg)
Airspeed sensor Specify on order, if you need hi-speed (100 hPa) version!	12 bit, 0 to 69 hPa, 381 km/h, 205 kt resolution $<$ 0.1 km/h or 14 bit, 0 to 100 hPa, 459 km/h, 248 kt resolution $<$ 0.1 km/h
Acceleration	16 bit, 3D, dynamic range 0 to 16 g, typical resolution 0.12 mg
Angular rate	16 bit, 3D, 250°/s, resolution 0.009°/s
GNSS	10 Hz, 66 channel, hot start 1 s, cold start 35 s, sensitivity -165 dBm GPS, Galileo, Glonass
OAT	12 bit, range -55 to 125°C, 0.5°C accuracy
Communication	CAN bus, 29 bit header, 500 kbit, Kanardia protocol RS 232, NMEA out, 9600 baud (default)
Sensor processor	32 bit, ARM Cortex M3, 80 Mhz
Display processor	32 bit, ARM Cortex M3 - LCD, 120 Mhz
Start-up time	System less than 1 s, AHRS about 5 s.

Table 2: Technical specifications of Horis instrument.

1.4.1 Micro SD Card

A micro SD card is included in the Horis package. This card is used for software updates and for logbook copies, as described in sections 3.2 and 6.

Description	Value
Weight (model with backup battery)	186 g (274 g with GNSS antenna and OAT cable) add 33 g
Size	62 x 62 x 52 (71 with connectors) mm
Current (model with backup battery)	180 mA at 12 V, full brightness 270 mA at 13 V, when charging
Power consumption (model with backup battery)	2.16 W (full brightness) 3.51 W, when charging
Panel hole	57 mm (2.25 inch) diameter, standard fit
Display	320 x 240 pix, diagonal 2.55”, 16 bit full colour, super bright
SD card slot	micro SD, since Jan 2020 (v2)

Table 3: Additional specifications for 57 mm Horis version.

Description	Value
Weight (model with backup battery)	268 g (356 g with GNSS antenna and OAT cable) add 40 g
Size	82 x 82 x 52 (71 with connectors) mm
Current (model with backup battery)	240 mA at 12 V, full brightness 320 mA at 13 V, when charging
Power consumption (model with backup battery)	2.16 W (full brightness) 3.51 W, when charging
Panel hole	80 mm (2.25 inch) diameter, standard fit
Display	320 x 240 pix, diagonal 3.45”, 16 bit full colour, super bright
SD card slot	micro SD, since June 2023 (v2)

Table 4: Additional specifications for 80 mm Horis version.

If you want to use a third-party micro SD card, please make sure:

- It is formatted to FAT32 (or FAT16).
- Its size is 32 GB or less.
- It is not XC variant (eXtended Capacity). Horis will not recognize any extended capacity (XC) card.
- Also, try to avoid SD cards with very high speeds.

Although you follow the recommendations above, it may still happen that Horis will not recognize the card. In this case, please try to use some other brand/size. Older cards seem to work the best.

1.5 Roll, Pitch and Yaw

The AD-AHRS-GPS module (a.k.a. AIRU), which is built-in Horis is responsible for calculation of roll, pitch and yaw angles (a.k.a. Euler angles).

The module holds several sensors, which readings are combined together using sophisticated algorithms. Our implementation follows ideas of Extended Kalman filtering, which combines mathematical model with measurements.

The mathematical model is based on gyroscope integration and it gives *short term* response. MEMS gyroscopes sense angular velocity. This angular velocity is integrated in time domain to obtain angles. Numerical integration is performed about 100 times per second where angular velocities are assumed to be constant between two integration steps. All MEMS gyroscopes have same error, which integrated in time quickly render angles (roll, pitch, yaw) unusable unless they are corrected with some independent measurements.

Two measurements are used to stabilize the angles. One measurement is apparent gravity. This is combination of measured values from accelerometers, angular rates, true airspeed and airspeed acceleration. This apparent gravity is then used to stabilize roll and pitch angles, but it can't be used to stabilize yaw. The second measurement is the direction measurement. GPS track is used to stabilize yaw.

A combination of angular rate time integration and corrective measurements are resulting in final solution. They are combined using Extended Kalman filtering technique.

Although we are talking about roll, pitch and yaw angles the mathematical model does not use these angles and is using a more suitable quaternion implementation instead.

CAUTION: A coordinated flight (no slip or skid) is essential. Precision of roll, pitch and yaw is very good if such flight is maintained.

Short deviations from the coordinated flight do not represent a problem.

A long time deviation from the coordinated flight yields to false roll and pitch. When a coordinated flight is resumed, the false roll and pitch will vanish after some time (about 30 secs).

Sustained turns do not harm the indication as long the coordinated flight is maintained. Some minor deviation is obtained in very steep turns – steeper than 50°. The main reason for this is that heading rate is so fast that GNSS track is lagging behind and corrective yaw measurements are slightly incorrect. This effects all three angles.

Aerobatics will make roll, pitch and yaw useless pretty quickly as they violate coordinated flight principle. Once coordinated flight is resumed, the angles will stabilize around correct values. Typical time required is 1-2 minutes, while almost correct angles shall be established after 30 seconds.

2 Installation & Maintenance

Horis requires a standard size 57/80 mm hole in the instrument panel. Position of the hole must ensure good access for knob operations and it must be always visible from the pilot's perspective.

2.1 LCD Display Damage Warning

The LCD display can be damaged during the installation. This happens when mounting screw reaches the LCD display. We strongly advise you to double check the screw lengths. Even screws that are originally supplied with the instrument can damage the LCD display. Figure 1 illustrates the danger and Figure 2 shows an example.

When original screws are used, make sure that there is *at least* 1.5 mm spacing between the screw head and Horis mask. This means that the minimal instrument panel thickness must be 1.5 mm or more.

Our experiences show that the LCD is often damaged even before it is installed. Some users simply take a screwdriver and tighten the screws for no apparent reason.

We do not grant warranty for any broken LCD display, even if you used originally supplied screws.

When you use your own M4 screws, please make sure that screw will never touch the LCD screen behind the front mask. Cut the screw to proper length!

2.2 Mounting Procedure

The mounting screw holes are located on a circle of 66/89 mm diameter. The instrument is mounted using three screws type M4 and one M6 insert[1]. To

[1] Only Horis 80 mm.

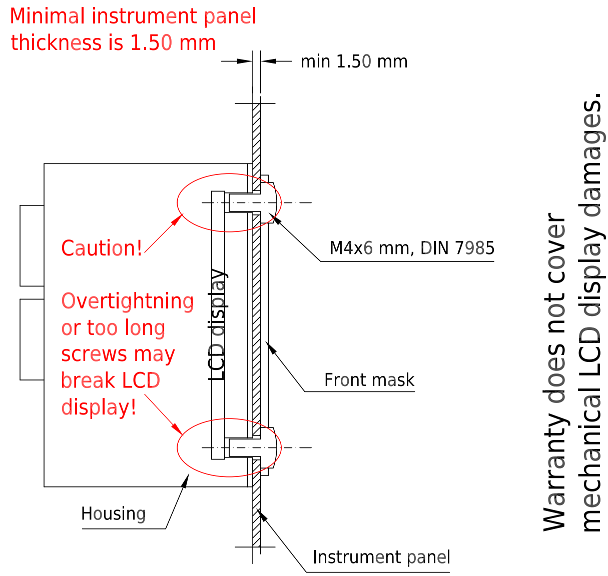


Figure 1: Screw can damage LCD screen behind the mask.

Figure 2: Example of broken LCD screen. Edge of the LCD display is visible behind the bezel.

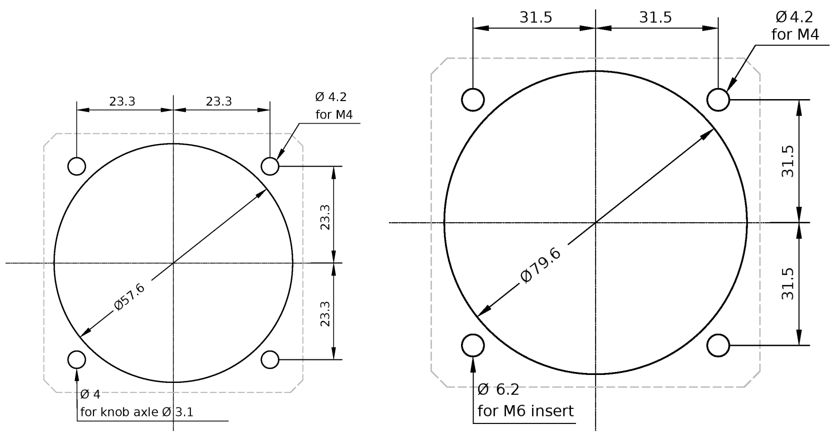
prevent internal stresses, please make sure that the instrument panel is flat. The fourth hole is used for the knob axle. Figure 4 illustrates the mounting hole.

Remove the mounting screws from the instrument and then remove the knob. Use finger nail or sharp knife to remove the cap from the knob, but be careful not to cut the cup away. Once the cap is removed, use flat screwdriver and loosen the screw. Slide the knob from its axle. Figure 3 shows an example of the knob with its cap removed.

Figure 3: Photo of the knob with its cap removed.

Some older Horis 80 have an additional M6 nut that is used as an axle guide. This nut must be also removed.

Insert the instrument from the back side of the instrument panel. Fix three mounting screws[2]. Then insert the knob back to the axle, tighten the knob. Please make sure it does not rub the panel and ensure that it can be pushed in and out for the system operation. Put the cap back.



(a) 57 mm (b) 80 mm

Figure 4: Instrument panel cutout and mounting holes. Some tolerance has been incorporated. Warning: Figures are not in scale.

[2] In the older Horis 80 case, fix also the M6 nut (axle guide).

2.3 Space Behind the Panel

Horis requires only minimal space behind the instrument panel. Depth of housing is 52 mm, connectors require additional 19 mm and cables and tubing require about 20 mm as shown on Figure 5.

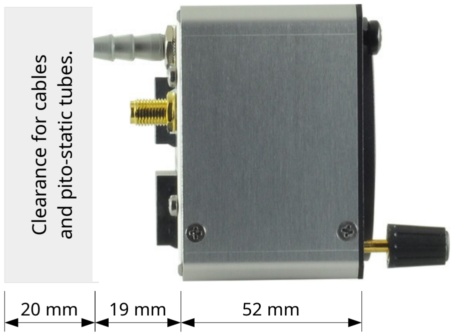


Figure 5: Side view of Horis. Only minimal space is required behind the panel. Figure shows 57 mm version, but side dimensions for 80 mm Horis are the same.

2.4 Connections

> Horis must be connected to the pitostatic system.
> AHRS will not work properly when pitostatic is not connected.

2.4.1 Static - `Pst`

The instrument must be connected to the static pressure source. Static source is usually obtained from pressure sources located on fuselage side surfaces or from the static port on pitot tube.

For the connection, use a tube with 4 mm inner diameter and about 8 mm outer diameter. Locate the existing tube, cut it at an appropriate place and insert a T junction. Install a new tube from junction to the instrument.

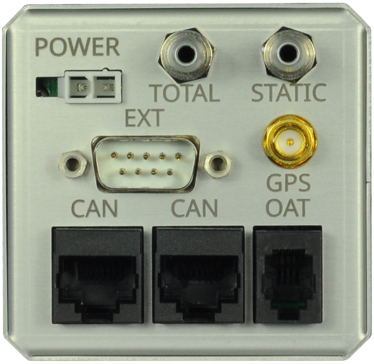


Figure 6: Back view of the instrument with connections. 57 mm version is shown.

It is highly recommended to keep the static tubing as short as possible. The tubing must avoid sharp bends and twists. The tubing must be airtight. Water must not be allowed to enter the tubing.

We strongly recommend labelling each tube before connecting to Horis or any other instrument. If you ever have to remove Horis from the instrument panel, this will help a lot during re-installation.

Two standard plastic T junctions are included in the Horis package.

2.4.2 Total Pressure - `Ptot`

Total pressure connection comes from the pitot tube. Same principles as with static connection apply.

2.4.3 CAN Bus

Connection to the CAN bus is optional and is not required for normal operation.

When Horis is not connected to the bus, a terminator plug (Figure 7) must be inserted into one CAN connector. The terminator plug is a plain RJ45 plug with 120 Ω resistor connected across pins 4 and 5, while pins 1,2,3 and 6,7,8 are not connected.

Figure 8 and Table 5 defines the pin out of the CAN bus.

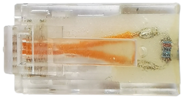


Figure 7: If Horis has an emtpy CAN port, then one terminator must be plugged in.

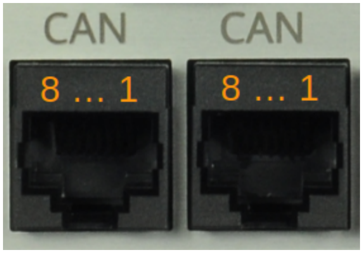


Figure 8: Illustration of the pin out of the CAN ports.

Pin	Description
1	+12V out.
2	+12V out.
3	+12V out.
4	CAN low.
5	CAN high.
6	GND – ground.
7	GND – ground.
8	GND – ground.

Table 5: Description of pins for the CAN bus communication.

When connected to the bus, Horis will transmit a large amount of information: attitude, altitude, position, temperature, baro-settings, health status etc. Slave units connected on the bus (round altimeter, airspeed indicator, etc.) are capable of using this information.

Use standard RJ45 Ethernet cable to connect Horis with other Kanardia equipment. Both connectors are equivalent.

Note that the CAN bus should be terminated at both ends, though short buses works well also with only one terminator. Please make sure that at least one terminator is present on the bus. The terminators are: Daqu, Magu or special terminator plugs, Figure 7. If you see *red crosses*, the most probably reason is that the CAN bus in not terminated properly.

For the time being, only Kanardia CAN devices are compatible with our CAN system. Never connect a third party CAN device to our CAN bus. A serious damage may occur in the hardware. Some third companies also use RJ45 plugs and you may be tempted to connect them with our CAN system. However, they are using different pinout and different/conflicting message protocol.

2.4.4 Power - PWR

Connect supplied power cable at the back of the instrument. Power connector has a notch on one side, which protects against wrong polarity, see Figure 9.

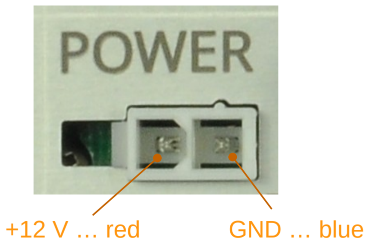


Figure 9: Pins of the power connector.

Connect blue lead to negative (ground) terminal and red lead to positive (+12-24 V) terminal.

A 1 ampere slow fuse or a similar circuit breaker shall be used on the positive lead.

2.4.5 GNSS Antenna

Please consider mounting GNSS antenna, as follows:

- Find a good spot in a cabin where the antenna is able to see blue sky during most of the aircraft movement. Such a good spot can be usually found on the top of the instrument panel cover, just below the canopy.
- Mounting surface should be flat, clean and rigid.
- Avoid close proximity to any transmitting antennas like radio stations, transponders or any other active GNSS antennas (GNSS antennas may interfere each other).

- Antenna must not be covered or obstructed by metals (metals sheets, rods) or any other conductive material (like carbon fibres).
- The triangle/GNSS text must point upwards, to the sky. For the installation use self-adhesive tape and fix the antenna on a rigid and clean surface. Supplied antenna is not intended to be installed on the aircraft exterior. If you need to install the antenna on the external surface, search a suitable antenna in your local avionics shop. Any 3.3 V active antenna with SMA male connector can be used.

The antenna is used as an additional stabilisation of artificial horizon and as a source for the tracking azimuth.

2.4.6 Outside Air Temperature - `OAT`

Outside air temperature (OAT) probe is shipped with Horis. This is a digital temperature sensor[3] glued inside a threaded aluminium housing. Default OAT cable length is 1.5 meters but other lengths are available on request.

OAT connector is standard RJ12 type, as shown on Figure 10. Description of individual pins is given in Table 6.

Figure 10: Pins of the OAT connector.

OAT information is required to calculate true airspeed from indicated airspeed and altitude, as well as to provide you with the outside temperature information.

In order to provide accurate measurements, OAT probe must be installed on a proper place where the probe is not exposed to the disturbing sources of heat:

[3] Digital thermometer – DS18B20.

Pin	Description
1	+3.3V
2	Data
3	GND
4	Not connected

Table 6: Description of the OAT pins.

- engine heat and exhaust heat,
- direct sunlight,
- heated air exited from cabin.

We also do not recommend installing the probe in the heated cabin area, since the elevated temperature in the cabin may influence the back side of the probe, though such influence is usually small.

Please follow these steps to install the OAT probe:

1. Locate a spot in the aircraft taking into account the considerations from above and drill a ϕ 8 mm hole.
2. Remove the external nut from the probe but keep the washer, internal nut and plastic insulation tube on the probe.
3. Install the probe into the hole from the interior. Guide the cable to the Horis back panel.
4. Apply some lock-tight and thread the external nut to the probe. The lock-tight is necessary to avoid losing the cap due to vibrations.
5. Tighten the internal nut so that the probe sits firmly and apply lock-tight on the nut. Do not over tight it.
6. Slide the plastic insulation tube over the exposed threads of the probe and cover as much threads as possible. Shrink the tube using hot air blower. Do not use open flame. Plastic insulation (shrink) tube also serves as thermal insulation for the sensor located in the tip.

2.4.7 RS-232 Port (NMEA Out)

Important: Instruments produced before 1.7.2016 may not have this port active.

Note: Horis 57 model produced since Jan 2020 and Horis 80 produced since July 2023 are using different connector. See section 2.4.8 on page 22.

The RS-232 port is used for communication with other instruments. You need a standard RJ12 (6P6C) connector to connect to the port. The table 7 defines the pinout and figure 11 illustrates pin ordering and connector position.

Figure 11: Illustration of the pin out of the RS-232 port.

Pin	Description
1	GND – ground.
2	RX – receive data.
3	TX – transmit data.
4	Not used.
5	Not used.
6	+12V out – used to power some device, max 50 mA.

Table 7: Description of pins for the serial RS-232 communication.

In most cases you only connect two or three pins – pins 1-3. Pins 4 and 6 are used only when you use Horis as a power source.

By default Horis transmits NMEA GGA and RMC sentences on pin 3. In order to listen to these sentences, you need to connect pin 1 (GND) with GND on the listening device and pin 3 (TX) with the RX pin on the listening device. Default settings are 9600 baud, 8 bit data size, no parity and one stop bit a.k.a. 9600 8N1. You can choose different baud rate, but you can't change parity or stop bit.

Please note that max current output on RS-232 port is 50 mA at 12 V (0.6 W). A larger current may damage Horis. There is no short-circuit protection. If pins 1 and 6 are in short, this will damage Horis.

2.4.8 D-sub 9 Port

This port replaces the port shown on figure 11. The new D-sub 9 port has more pins and allows for more features in future.

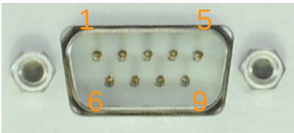


Figure 12: Illustration of the pin out on the D-sub 9 port.

Pin	Description
1	Reserved for future use, do not connect.
2	Reserved for future use, do not connect.
3	Reserved for future use, do not connect.
4	+12V out – used to power some device, max 50 mA.
5	GND
6	RS-232 RX 1 (receive line)
7	RS-232 TX 1 (transmit line)
8	Reserved for future use, do not connect.
9	Reserved for future use, do not connect.

Table 8: D-sub 9 pin description.

Currently only transmit line can be used for GPS NMEA senstences. Typically, pin 5 (GND) and pin 7 (TX 1) are connected to some receiveing device.

Other pins are currently not supported by firmware and may become active with future updates.

2.5 Levelling AHRS

During assembly of the AHRS unit into the Horis and during installation of Horis into the instrument panel, a small misalignment may appear. This means that internal axes of the AHRS unit are not parallel to the aircraft axes – the AHRS unit is slightly rotated. Such misalignment can be perfectly adjusted without loss of precision using the procedure described in this section.

2.5.1 Yaw Misalignment

Roll and pitch angle can be adjusted automatically, but yaw angle must be set explicitely, before the procedure starts.

When the instrument panel is perfectly flat and perpendicular to the airplane x-axis (longitudinal axis) than there is no yaw misalignment and the correction angle is zero. This perfect situation is illustrated on figure 13 left.

Some instrument panels are rotated regarding the airplane x-axis (longitudinal axis). In this case the misalignment angle Ψ must be measured and its value entered. Figure 13 defines positive and negative Ψ angle.

When Ψ is known, enter its value into *Yaw misalign.* item as shown on Figure 14.

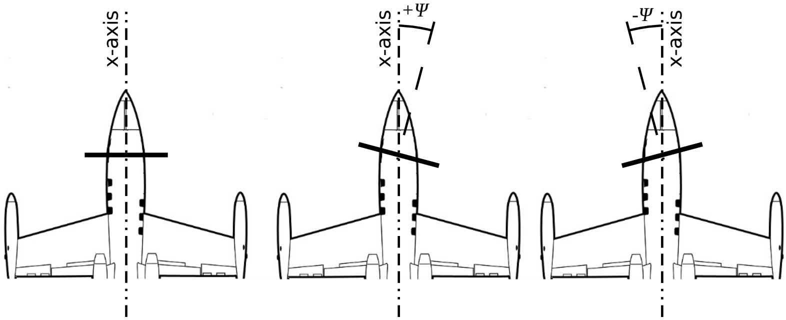


Figure 13: Top-down view illustration of possible yaw misalignment: perfect position (left), positive yaw misalignment angle (middle), negative yaw misalignment angle (right).

2.5.2 Procedure

Once the Ψ yaw angle is known, proceed with the leveling. In vast majority of cases it is safe to assume $\Psi = 0$.

- Place aircraft on flat surface and put it into cruise attitude. Use supports and lift tail or nose if necessary.
- Please make sure that aircraft is level for both, roll and pitch. Make also sure that Horis is turned on for at least five minutes – this warms up the internal electronics and stabilises numerical filters.
- Once the aircraft is level and steady, select the AHRS level option from the settings menu.
- Set the `Yaw misalign.` value first. In most cases, this value is zero.
- Then select the `Start leveling`. This will start the leveling procedure.
- Wait for the progress bar to finish and observe the roll and pitch numerical values. At the end they should stabilise. These values tell the misalignment angles and Horis will use them for the compensation. Window closes automatically.

Figure 14: Illustration of AHRS levelling procedure.

2.6 Compass Calibration

If Magu magnetic compass is connected to Horis, then it is essential to perform the compass calibration procedure. Please refer to the Magu manual (not included here) for the compass installation and calibration procedure. The latest versions of manuals can be always found on our web site `www.kanardia.eu`.

2.7 Internal Backup Battery

Both Horis 57 mm and Horis 80 mm can be ordered with *internal* backup battery.

If Horis is ordered with internal backup battery the battery module is installed into the Horis. The battery module consists of power electronics and battery cell.

2.7.1 Battery Module

The battery module inside Horis is complete system for battery charging, protection and monitoring. Backup battery module inside Horis has its characteristics and limitations listed in Table 9. Module is using multi level protection to avoid use of battery in any situation which would damage the battery cell.

Description	Horis 57	Horis 80
Weight (electronics+cell)	33 g	40 g
Run-time (full brightness)	1.2 h	1.2 h
Charge time	3 h	3h 45m
Min charge voltage	12.0 V	12.3 V
Min charge temperature	0 °C	0 °C
Max charge temperature	55 °C	55 °C
Min operating temperature	-20 °C	-20 °C
Max operating temperature	70 °C	70 °C

Table 9: Horis backup battery module operating conditions.

Internal battery cell specification is given in Table 10. Chemistry of the cell is based on lithium ferrophosphate and it is cobalt-free and nickel-free. This type of lithium based battery is considered much safer. We are NOT using more common Li-ion (NMC) or Li-Po batteries on purpose. The main drawback of lithium ferrophospahte chemistry is lower power density, so the total run-time is lower than in Li-ion (NMC) or Li-Po case.

2.7.2 Operation

Horis with internal battery is able to start even when external power is not present. It is started with a short press on rotating knob. Horis will start only when battery charge is sufficient.

Note: Horis is delivered in *transport mode*, see Section 2.7.4.

Description	Horis 75	Horis 80
Type	LiFePO4	LiFePO4
Capacity	820 mAh	1100 mAh
Weight	26 g	29 g
Cell voltage	3.2 V	3.2 V

Table 10: Internal backup battery cell specification.

When external power is applied to Horis it will start just like normal Horis. When external power is switched off, Horis remains powered from internal battery as long as in-flight condition is detected or user is interacting with the knob.

If no in-flight condition is detected or if there is no user action with rotating knob, Horis will turn off after 5 minutes.

When Horis is operating on internal battery, it can be turned off by a long – 5 second press. You can't turn Horis off, if it is powered externally.

When Horis is in the backup mode (running on a backup power) there is some minimal leak over the electronic diode reverse power protection circuit. The leak is the range of 1 or 2 mA. This could be enough to barely power some led, but not enough power for anything else. When Horis is turned off, there is no leak and the internal backup battery is not drained.

When external power is applied to Horis, it may take up to 1 minute for charging to begin, which will be indicated by the charging symbol in Table 11. For the voltage required to start charging refer to Table 9.

2.7.3 Status Icon

If Horis is equipped with internal battery the battery icon appears in the top-right corner of the screen. This icon is present on all pages. It indicates current battery status. Figure 15 shows two examples.

Battery status has several states. Each state is described with corresponding icon. Icons and their meaning are given in Table 11.

Note: When Horis does not detect internal battery presence, no battery symbol is shown. This is an error condition for cases where Horis is equipped with an internal backup battery.

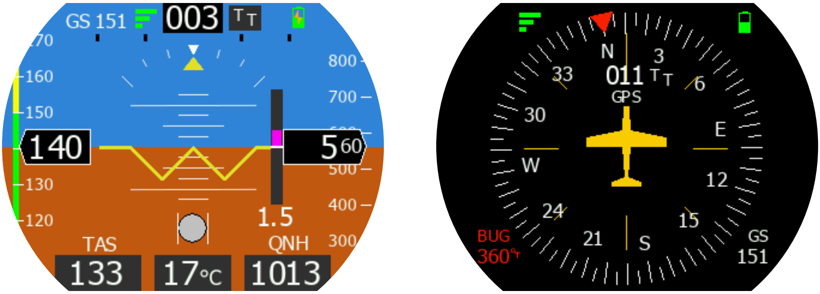


Figure 15: Battery symbol appears in the top right corner.

	Battery full and not charging.
	Battery half full.
	Battery almost empty - less than 10%.
	Battery charging and almost full.
	Battery almost empty and charging.
	Battery is currently too cold/hot for charging.

Table 11: Battery status.

2.7.4 Transport Mode

Horis equipped with a backup battery is delivered in the *transport mode*. This is a *safety mode*, which prevents accidental activation of the instrument. In the transport mode, you can NOT turn the instrument on by pushing the knob. The transport mode ends automatically when Horis detects external power. Hence it must be connected to the external power before the first use.

2.8 Maintenance

2.8.1 Static Leak Test

A static leak test should be performed annually and calibration check biannually. In case of small deviation use the procedure described in Section 5.5.8.

2.8.2 Backup Battery

If the unit with a backup battery is left unused and not connected to a power supply, we recommend charging the battery every 3 months to prevent potential battery defects. If the battery remains discharged for too long, it can damage the battery and significantly reduce its performance.

2.9 Repair

Horis has no repairable parts inside. In case of malfunction it must be sent to factory for repair.

2.10 Transport

Horis with a backup battery must be put into the *transport mode* before shipping. In order to activate the transport mode, enter `81154` as PIN number. See Section 5.5.15 on page 52.

2.11 Horis Use in Gliders

Experience shows that Horis can be successfully used also in gliders. Sustained turns do not effect Horis, as long as turns are coordinated (no significant slips or skids) and even in the continuous slip case, only minor error in the bank appears.

However, low battery voltages may affect Horis operation. Although Horis works also with voltages as low as 9 V, a problem may appear even at higher voltages. A typical scenario (where gyros inside Horis go crazy) happens when battery is at its low end (say at 11 V – with only one or two percent of capacity left). All seems to work OK until push-to-talk radio button is pressed. The radio transmission requires much more amperage (power) from the battery. For a very short time, measured in milliseconds, voltage may drop down to 3-4 V, which in turn causes instability of electronic gyros inside Horis. Unfortunately, gyros do not recover when voltage returns back to normal and hard reset (power off/on) is necessary.

This problem can be avoided in several ways.

- Most gliders use two main batteries. When Horis is needed, always fly on the battery which is more full.
- Horis may be equipped with internal backup battery.

- If your Horis does not have a backup battery, you can use our external backup battery module, P/N: `UPS-L`. This will make sure that there is enough voltage available for Horis. See Figure 16. Please note that UPS-L has limited capacity and it can serve one Horis only.

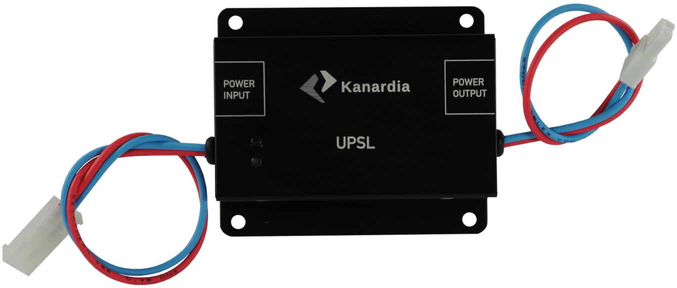


Figure 16: UPS-L – light Li-Po external backup battery.

3 Software Update

There are two ways to update Horis and install a new software:

- Update with the help of the *Blu* dongle and the Android app called Kanja. This is suitable to all Horis models.
- Update with the help of the micro SD card. This is suitable only for models equipped with the SD card slot.

3.1 Update With a *Blu* Module

Most Horis models have no means (SD card, USB slot) for a direct software update. It can be updated with a help of the *Blu* device and an Android telephone or tablet, which is running our *Kanja* app. Figure 17 shows the *Blu* module.

Blu must be plugged at the back of Horis and once a communication with Kanja is established, new software is transferred to Horis and AD-AHRS module.

Below are step-by-step instructions for the update. Refer also to *Blu Manual* for more details.

Figure 17: A small CAN bus to Bluetooth bidirectional interface module.

1. Plug *Blu* device into one of free CAN ports. A terminator shall be inserted in to other port. If Horis is connected to other devices, make sure that at least one terminator is present on the bus.
2. Start the *Kanja* app on the Android device. Each time Kanja is started, it automatically downloads the latest firmware from our server. An Internet connection is needed on the device.
3. Connect Kanja and Blu device. Once connection is established, a list of units detected on the CAN bus will appear. As minimum, *Horis* and *Airu* must be on the list. The exact list depends on number of Kanardia instruments connected to the CAN bus.
4. Select *Horis* from the list and then select *Update*.
5. Confirm the selection – press *Yes* and Kanja will start the firmware update.
6. Once the update has been completed, press the *Back* arrow on the top left corner of the Kanja app. This brings back the device list.
7. Select *Airu* from the list and then select *Update*. This will update the AD-AHRS-GPS module, which is hidden inside the Horis. (Slave Horis does not have such module inside.) Red crosses will appear on the Horis screen during the update. This is normal.
8. Once the update has been completed and red crosses has disappeared, Kanja can be disconnected and Blu removed. New firmware is installed and ready to use.

3.2 Update With Micro SD Card

Only Horis models that have SD card slot can be updated this way. If Horis does not have the SD card slot, *Blu* must be used. See section 3.1.

The procedure differs depending on the software currently installed in your Horis. You can see current software version, if you take a look at the `About` window:

1. Open the `Quick menu` – press and hold the knob.
2. Select `Settings` from the menu. A new window appears.
3. Select `About` from the menu. Figure 18 illustrates two options.

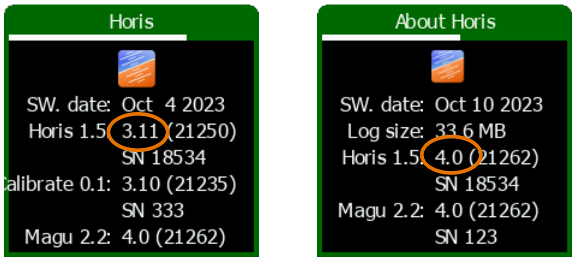


Figure 18: Version 3.xx (left) and version 4.xx (right).

3.2.1 Micro SD Card Preparation

Horis was delivered along with a micro SD card. Please use this provided micro SD card whenever possible. However, since micro SD cards can be easily lost or misplaced, you may consider using an alternative SD card. Here are some guidelines for the alternative:

- The alternative card should not exceed 32 GB in size. In principle, less capacity is better.
- Try to find an older card. Very new and modern cards may cause hardware compatibility problems.
- The card must be formatted as FAT32 or FAT16. Other formats will not be recognized.
- Keep fingers crossed :).

3.2.2 Horis Versions 3.xx

In this case, the update must be done twice. First, the Horis software will be upgraded to version 4.0 (or later). Once this is achieved, it shall be updated once more, following the procedure for version 4.xx.

1. Download the `Horis.bin` file from our website and copy it to the micro SD card. Make sure to use *Safe remove* (or similar) before removing the SD card from the PC.

2. Ensure that the `Horis.bin` is the only file on the SD card. Delete other files if they are present.

3. Make sure Horis is powered off. Insert the SD card into Horis and power it on. Horis will check for the presence of the SD card during boot.

4. When the Horis.bin file is found on the SD card, an update procedure will commence. A black/white flashing screen informs that the update is in progress. It takes about 9-10 seconds to finish the update.

5. After the update, Horis displays a window informing you about the update's success. This window is displayed only once after each successful update. You should see version 4.0 or above.

6. The procedure has set your Horis to version 4.0 (or above). Nevertheless, the update is not complete yet. You must perform the update procedure for version 4.xx, which is described in the next section.

Note: If flashing finishes after 4 seconds and the update success window is not shown, then the update file is probably corrupt. Download the file again from our website and try again. Do not forget to use *safe remove* option after copying, before the SD card is removed from the PC.

3.2.3 Horis Versions 4.xx

Once Horis is equipped with version 4.xx, the update is made in two steps. The first step updates Horis and the second step updates firmware in devices connected to Horis over the CAN bus. Please note that each Horis PFD hosts the AD-AHRS-GNSS device called Airu. This one is present event when nothing else is plugged in.

Part One

1. Download the HO-4_XX.kus file from our web page. The XX in the name represents current Horis sub-version. Copy the file to the SD card. Make sure to use Safe remove option before removing the card from PC.

2. Turn Horis on.

3. Insert the SD card and select the Quick menu->Settings->Software update option.

4. This opens a window, which displays all files on the root folder of the SD card with the .kus extension. In most cases there is only one, but there may be more. Select the latest sub-version identified by the number in the name.

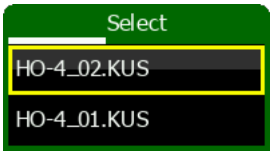


Figure 19: Kus selection example. Usually only one kus is present on the SD card.

Note: If this window does not open and you are sure that at least one kus files is present on the SD card, eject the SD card, wait a second and insert it back. This will restart the SD detection process. Select the Software update option again.

5. After the file is selected, the extraction process starts. The kus file holds several binaries; one for Horis and several ones for other firmware. These files are extracted directly to the SD card. The Horis binary is in Horis.bin and firmware binaries are stored in the FIRMWARE folder. First the integrity of the kus file is checked and next binaries are extracted. Keep SD card inserted.

6. Once the extraction was complete, Horis displays a message as shown in Figure 20 and reboots. During the boot, screens starts flashing indicating that Horis binary is being copied. At the end, an information window is shown indicating success of the first part.

   Note: If the extraction was successful, but flashing and information window do not appear after the reboot, turn Horis off, wait a second

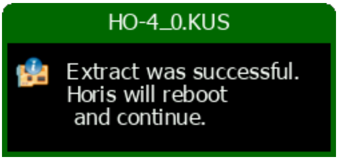


Figure 20: Message shown after the extract has been completed.

and turn it back on. Now the flashing should appear. If flashing and info window still don't appear, it may be that the `Horis.bin` file on the SD card is older than the current Horis software and Horis ignores it.

7. Keep the SD card inserted and start with the `Part Two`.

Part Two

During Part One, several binary files were extracted to the micro SD card. Now, a firmware update is performed for all devices detected on the CAN bus. Please note that Airu (AD-AHRS-GNSS) device is present on the CAN bus even if nothing is plugged into the Horis.

1. Make sure the SD card is inserted.
2. Select the `Quick menu->Settings->Firmware update` option.
3. An automatic process of device detection and firmware update starts. Wait until devices are processed.

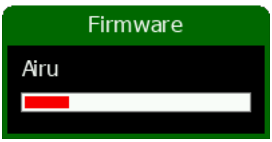


Figure 21: An example of progress window shown during firmware update.

Note: If the `firmware update` does not start, eject the SD card, wait a second and insert it back. This starts the SD card detection. Then try again.

Troubleshooting

If for some reason the firmware update fails and device *disappears* from the CAN bus or red crosses appear and do not go away, try to repeat the second part again.

4 Horis Screens

Horis can show four different screens: AD-AHRS, Direction Indicator, G-Meter and Chrono. Please refer to section 5.5.5 on how to change the order of screens or how to enable/disable them.

Push the knob to change between screens.

4.1 AD-AHRS

Typically, the AD-AHRS screen appears as soon as Horis is powered on. The screen layout has been optimised to show all relevant flight information. Figure 22 shows the screen.

Figure 22: Horis AD-AHRS screen with markings.

The following parameters are shown on the screen:

1. Indicated airspeed indicator shows airspeed obtained from the differential pressure sensor and the speed tape.

2. Ground speed.

3. GNSS status signal. Three green bars indicate normal operation (3D fix). A small green diamond next to three green bars means that GNSS position is further enhanced with SBAS (EGNOS, WAAS, etc.) One yellow bar indicates marginal 2D fix and and a red cross of the gray bars indicates loss of signal. Note that GNSS reception is not mandatory for AHRS – AHRS will function properly without it.

4. Azimuth (direction) indication. If Magu (magnetic compass) is connected and magnetic heading is selected as direction source, then you shall always see a heading here. However, if GNSS track is in use, then the aircraft must move above some threshold speed in order to show tracking azimuth. If speed is too low or aircraft is standstill, dashes are shown instead.

5. Azimuth markings: The left letter tells which azimuth reference is used. It can be either:

   - `T` ... true azimuth.
   - `M` ... magnetic azimuth.

   The right letter tells the source for the azimuth. It can be either:

   - `T` ... tracking taken from the GNSS receiver.
   - `H` ... heading taken from AHRS coupled with electronic magnetic compass[4]. By heading we mean direction into which nose is pointed. In case of strong wind this can be significantly different from tracking.

   Default combination is TT. This means true azimuth and tracking obtained from GNSS.

   Some symbols may appear in this place:

   - A stopwatch symbol appears when stopwatch is running in the background.

[4] Electronic magnetic compass (Magu) is an external device and is not a part of Horis system. With Magu connected and properly calibrated, the AD-AHRS unit in Horis can determine heading and it can calculate wind direction and speed.

- A backup battery symbol indicates the battery status. Note that Horis is not equipped with a backup battery by default.

6. Altitude indicator is composed of altitude value and altitude tape moving in the background.

7. Density altitude is shown on the ground only. As soon as take off was detected, this value is hidden.

8. Rate of climb a.k.a. vario. Small bar shows climb or descent and a value on the bottom expresses it in numbers.

9. Baro correction a.k.a. QNH.

10. Outside air temperature a.k.a. OAT. Numerical value is displayed.

11. True air speed a.k.a. TAS is derived information obtained from indicated airspeed, outside air temperature and static pressure. [5]

12. The inclinometer (slip-skid) indicator.

13. Artificial horizon with a reference line, roll arc and pitch lines. Reference line can be used for 45°turns, short roll arc dashes define 15°and 30°marks and longer dash defines 45°mark. In pitch, long line defines 10°, medium 5°and short 2.5°markings.

    When autopilot is active, a magenta line appears. It shows desired attitude as it is calculated by the autopilot.

14. Relative wind indication arrow, wind speed and direction. This is shown only when Magu (electronic magnitic compass) is connected to CAN bus.

15. The turning rate scale. Yellow horizontal bar is used to show turning rate. Depending on settings, inner black points indicate either standard turn (3°per second), double turn (6°per second) or glider turn (12°per second). Outer black points indicate twice the turn rate of inner points.

Some elements of the AD-AHRS screen are configurable. Please refer to Section 5.5 starting on page 44 for more details.

[5] TAS, OAT and DA will be crossed if OAT sensor is not connected.

4.2 Directional Indicator

The Directional Indicator screen is optional and it may not be enabled by default. You have to enable it in settings. Please see section 5.5.5 on page 47 for the details.

Typically direction indicator is used as a second screen.

Figure 23: Direction Indicator screen with markings.

Figure 23 shows the screen with several important points marked.

1. The yellow line as an extension of aeroplane symbol points to current azimuth (direction). The azimuth is also shown in numeric value, followed by two letters. Their meaning is identical to description of item 5 on page 36. Below the azimuth number is also written source of the data. This can be:
    - `Compass` when Magu is direction source or
    - `GNSS` when GNSS track is used as direction source. A flushing airplane symbol means that ground speed is too low and the tracking azimuth sent by the receiver is not reliable. As soon as aircraft gains enough speed, flashing stops.
2. Heading bug is used as reference marker. Simply turn the knob to move the reference marker.

When Horis is coupled with an autopilot the bug is in sync with autpilot direction setting. When autipilot direction reference is changed, the bug will be automatically adjusted.

3. Heading bug value is shown next to the knob. It tells current value/ position of the bug.
4. Ground speed is shown here for your convenience.
5. GNSS status in graphical form as is described in item 3 on page 36.
6. Symbols for stopwatch running in background and battery status.

4.3 G-Meter

The G-Meter screen is optional and it may not be enabled by default. When not visible, it must be enabled in settings. Please see section 5.5.5 on page 47 for the details.

Typically, G-Meter is used as a third screen.

Figure 24: Horis G-Meter screen with markings.

Figure 24 shows the screen with several important points marked.

1. Scale neutral point is at 1 G and it is located exactly at 9 o'clock. Scale has green range, low and high yellow range and low and high red range. Scale span and ranges are defined in settings. Please refer to section 5.5.7 on page 48 for more details.
2. White pointer indicates current G-load on the scale. It is slightly filtered to prevent too vivid movement.
3. Min and max markers define the minimal and maximal detected G-load. In order to reset these markers, simply turn knob left or right.
4. Min and max detected G-load value together with current G-load are also presented in numeric form.

Knob rotation will reset min and max markers and values.

4.4 Chrono

The Chrono screen is optional and it may not be enabled by default. When not visible, it must be enabled in settings. Please see section 5.5.5 on page 47 for the details.

Figure 25: Horis chrono screen with markings.

Figure 25 shows the screen with several important points marked.

1. UTC time and GNSS reception symbol. Horis gets time from GNSS module and the time will be shown only when the GNSS signal is available.
2. Local, sunrise and sunset times. They all depend on GNSS signal as well and they are visible only when GNSS signal is available. Local time requires correct time zone - see section 5.5.10 for more details.
3. Stopwatch can be used by turning the knob. Symbols on the left an right side of the stopwatch time define available actions.
   - Turn right to start the stopwatch.
   - Turn either left or right to stop for lap.
   - Turn left to reset or right to continue.

   You can switch the pages even when the stopwatch is running. In this case, a stopwatch symbol appears on the top right part of each screen.
4. Flight time starts counting automatically when takeoff conditions is detected and stops when landing is detected. The time restarts with zero on next takeoff.

   Note, false landings may be detected when Horis is used in a rotorcraft. A slow speed or hovering will falsely trigger landing event and flight time will reset when movement is resumed.

5 Operations

Horis is operated using a single push knob. You can do the following actions with the knob:

- Rotate the knob to change something.
- Push the knob to confirm something.
- Push the knob for about two seconds to enter a main menu[6].
- For Horis equipped with a backup battery a looong push on the button (about 5 seconds) turns Horis off, but only if the main power is also switched off. If main power is still on, the command will be ignored.

[6] We opt for this approach to avoid accidental activation of the main menu during flight.

Horis does not have a *close* button. When a window is opened and editing mode is not active, a white bar appears across the window caption. This bar indicates the timeout. When the bar is full, window closes automatically.

The followng flight operations can be selected:

- Depending on active screen, a knob rotation adjusts the BARO correction value (QNH), sets a heading bug, resets min/max G load markers or starts stopwatch.
- setting the neutral pitch,
- changing the brightness,
- opening a logbook window,
- opening a settings window.

Figure 26: Illustration of Horis main menu. The `Pitch Reset` option is the default one. Slave Horis menu is slightly different.

5.1 Knob Rotation

5.1.1 Adjusting Baro Correction (QNH)

Baro correction is adjusted by turning the knob when you are on AD-AHRS page. As baro correction changes, the indicated altitude changes accordingly. All changes are visible on the screen.

5.1.2 Adjusting Direction Indicator

When the Direction Indicator screen is visible, the bug is set by turning the knob. Slow turning changes the bug position for one degree while quick turning moves the bug in larger steps. All changes are visible on the screen.

5.1.3 Reseting Min And Max G-Load Markers

When the G-Meter screen is visible simply turn the knob to reset markers. All changes are visible on the screen.

5.1.4 Stopwatch

With the Chrono screen being active, a stopwatch can be started, reset or restarted. Follow the symbols shown on the screen.

5.2 Setting the Neutral Pitch

Neutral pitch – zero pitch indication line changes with the aeroplane gross weight and flight regime. Horis allows resetting neutral pitch for the current flight regime.

- Open the main menu by pushing the knob for a few seconds. The `Pitch Reset` option is selected by default. See Figure 26.
- Push the knob once again in order to activate the option.

Horis needs a few seconds to adjust for new neutral pitch value. Do not use this function in a turbulence or in an unstable flight regime.

5.3 Diminishing the Brightness

Horis starts with a pre-defined initial brightness. Default initial brightness is 100%. If the brightness is not adequate, it can be changed using procedure below:

- Open the main menu by pushing the knob for a few seconds.
- Rotate the knob to select the `Brightness` option and push it to start the change.
- Rotate the knob to adjust the brightness to an appropriate level.
- Push the knob again to accept new value.
- Wait for the main menu to close automatically.

Initial (start-up) brightness is specified in settings. See section 5.5.14 for more details.

5.4 Logbook

Logbook operations got its own section. See page 55 for more details.

5.5 Settings

Horis can be configured with several options described next. The settings screen is accessed via the main menu. Figure 27 illustrates the settings menu and all available options.

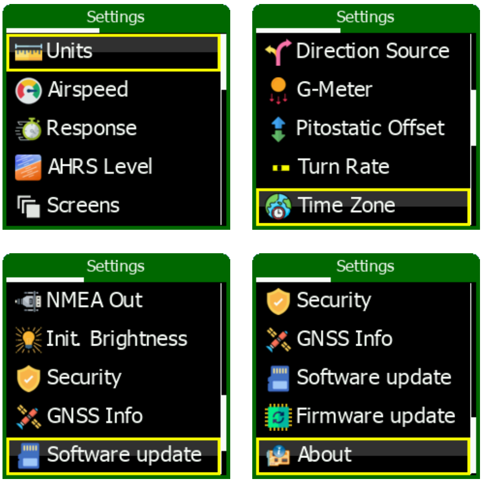


Figure 27: Horis settings menu and major options.

5.5.1 Units

This option allows fine tuning of units for almost any parameter of the main screen. Figure 28 shows the window where units may be changed. Table 12 lists all possible options.

5.5.2 Airspeed

This option is used to define the speed tape colours of the airspeed indicator. Figure 30 illustrates the window and figure 29 defines meanings of individual values on the speed tape.

The following values are used:

Unit Type	Options
Heading	True, Magnetic
Speed	kts, km/h, mph
Vario (rate of climb)	m/s, ft/min, kts
Wind	m/s, km/h, kts
Altitude	meter, feet
QNH	hPa, inHg
Temperature	°C, °F

Table 12: Unit options.

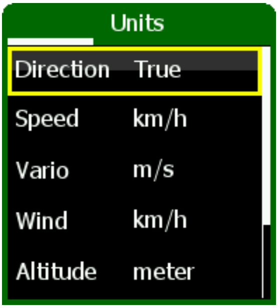


Figure 28: Units selection window.

- `Start` defines the bottom of the speed tape. At this speed the tape starts. Typically, this is the stall speed.
- `Yellow end` defines the end of the low speed part of the yellow range. Put into another words, speeds between `Start` and `Yellow end` define the bottom yellow part of the speed tape.

  If you do not want to have yellow range on the bottom part, set `Yellow end` to the same value as `Start`.
- `Green end` defines the end of the green range on the speed tape.
- VNE defines V_{NE} (velocity never exceeded) airspeed. At this speed the yellow upper range ends and the red range begins. The red range never ends. Yellow upper range is defined automatically between `Green end` and `VNE`.

You can also mark valid extended flap position region on the speed tape. In this case you also set:

- `White start` defines the start of the white part.
- `White end` defines the end of the white part.

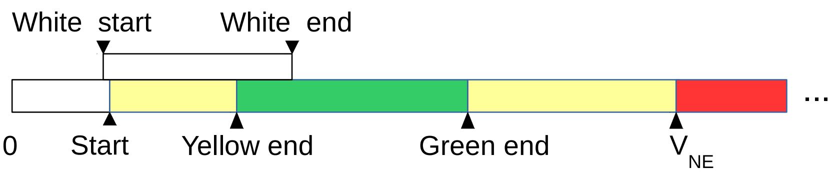


Figure 29: Definition of the speed tape colours.

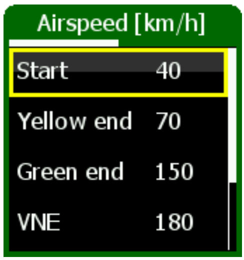


Figure 30: Illustration of the airspeed window used to define the speed tape.

5.5.3 Response

This option defines sensitivity of individual parameters of artificial horizon, Figure 31. Each parameter may be set to one of the following:

- `Lazy` – pretty slow response.
- `Slow` – slow response.
- `Normal` – normal response, default.
- `Vivid` – vivid response.
- `Wild` – very fast response.

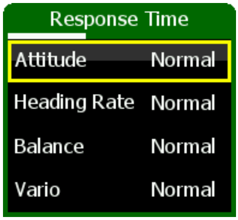


Figure 31: Illustration of the response time options window.

5.5.4 AHRS Level

After the installation of Horis into an instrument panel, Horis internal axes must be aligned to the aircraft axes. The `AHRS Level` procedure is used to do this.

Selecting the `AHRS Level` option from the settings menu starts the procedure. The procedure is automatic and can't be cancelled after it has been started.

See Section 2.5 on page 23 for more details.

5.5.5 Screens

Horis may show up to four different screens. For each screen you can define its content. See figure 32. It can be one of the following options:

- AD-AHRS Screen,
- Direction Indicator Screen,
- G-Meter Screen,
- Chrono Screen,
- Empty - i.e. do not show the screen.

Optionally, you can have less screens. In this case set the screens that are not used to `Empty`.

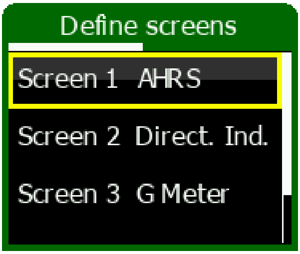


Figure 32: Illustration of screen editing.

5.5.6 Direction Source

Only the *Data source* parameter can be set for direction indicator. Two options are available here.

- MAGU – Magu electronic compass is used as direction source or
- GNSS track – GNSS track is used as direction source.

If MAGU is selected as direction source and Magu is not present, this selection will be ignored and Horis will take GNSS track instead.
If MAGU is present and *GNSS track* is selected as data source, magnetic compassed is disabled. This option can be useful, when MAGU is connected to the CAN bus, but its calibration is poor or one of its sensor is defective.

5.5.7 G-Meter

The G-Meter screen can be configured with the following parameters, see also figure 33:

- **Scale** defines overall range of the scale shown on the screen. You can choose the following ranges:
  - **-2 : 4** defines low end to -2 G and upper end to +4 G.
  - **-3 : 5** defines low end to -3 G and upper end to +5 G.
  - **-5 : 7** defines low end to -5 G and upper end to +7 G.
- **Red low** defines negative G red limit.
- **Green low** defines negative G green limit.

- **Red high** defines positive G red limit.
- **Green high** defines positive G green limit.

Any valid range between green and red values is drawn in yellow color automatically.

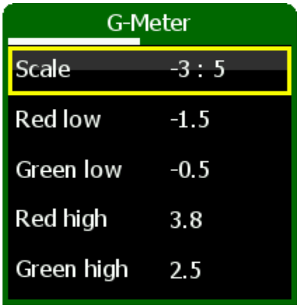


Figure 33: Illustration G-Meter parameters.

5.5.8 Pitostatic Offset

Modern digital sensors used for IAS and altitude measurements may drift a little bit over time, especially after being exposed to a prolonged period of severe cold. Selecting the `Pitostatic Offset` option from the settings menu opens a window illustrated on Figure 34. This window allows you to change altitude and airspeed offset.

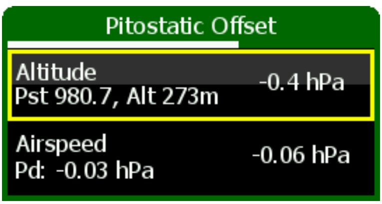


Figure 34: Illustration of the sensor offset window.

Altitude

In order to set the altitude offset you need a reference altimeter. Set the baro correction (QNH) on Horis and reference altimeter to the same value, say

1013 hPa.

- Use the knob to select the altitude offset frame. This is already selected when the window is opened.
- Push the knob to start the offset.
- Rotate the knob in order to match the altitude shown below the frame with the altitude shown by the reference altimeter. Horis shows two values: `Pst` is the static pressure and is shown in hPa and `Alt` is the altitude shown in metres. These metric units are used regardless the units selected by user.
- Push the knob to finish editing and wait for timer to close the window.

Airspeed

Important: Please make sure that aeroplane is either inside hangar or there is absolutely no wind and that pitot tube is not covered. Failing to do so may result in wrong offset and it may worsen airspeed precision.

- Rotate the knob and highlight the airspeed frame.
- Push the knob to start editing.
- Rotate the knob and observe the differential pressure value below. The differential pressure value shall read zero (or almost zero).
- Push the knob to finish editing and wait for the timer to close the window.

5.5.9 Turn Rate

Horizontal turn rate bar that appears on the AHRS screen can have different sensitivities:

- Standard 3°/s (two minutes turn, default),
- Double 6°/s (one minute turn),
- Glider 12°/s (30 seconds turn).

This selection defines the inner dot of the turn rate bar. So, if you want to keep the correct turn rate, you have to aim to the inner dot. The outer dot defines twice the turn rate of inner dot.

5.5.10 Time Zone

Set the local time offset. Positive values are used for countries with Eastern longitudes, while Western latitudes have negative values. The time zone is defined combining two values. The first one takes whole hours and the second is an additional offset given in minutes. For most part of the world the additional offset is zero and only major offset is given.

For example, Moscow has local time defined as UTC +3h. In this case specify 3 for hours and 0 for minutes.

Another example is Adelaide, South Australia. Local time is defined as UTC+10:30. Here, set hours to 10 and minutes to 30.

Yet another one is Newfoundland and Labrador, where local time is UTC -2:30. In this case set hours to -2 and minutes to 30.

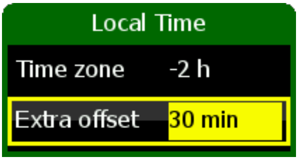


Figure 35: An example of local time set for *Newfoundland and Labrador*, which is UTC - 2h 30min.

Horis does not automatically adjust for Summer daylight savings time.

5.5.11 Compass Calibration

This option is available only when Magu magnetic compass is connected to the CAN bus. Please refer to the Magu manual for the details.

5.5.12 Compass Offset

This option is available only when Magu magnetic compass is connected to the CAN bus. Please refer to the Magu manual for the details.

5.5.13 NMEA Out

Here you can select the baudrate for the RS232 output port and the output format. 9600 bauds and *Standard* are default values, see Figure 36. Your (device) transponder may expect different speed or format. The standard format will send RMC, GGA and GSA NMEA sentences every second. The *TQ-KTX2* format will send only RMC sentence every second.

The *GNSS+Alt* will send encoded altitude in “Icarus” format beside standard NMEA output.

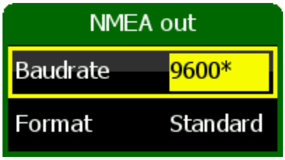


Figure 36: An example of the NMEA Out window with default values.

5.5.14 Initial Brightness

Use this option to set the Horis LCD display brightness at startup. Default value is 100%, but if find Horis display too bright, you may set it to a lower value here.

5.5.15 Security

Access to the settings option of the main menu can be protected by PIN (personal identification number). By default, there is no protection and Horis does not ask for PIN.

A few PINs act as special commands. E.g. tranport mode activation PIN or password reset PIN. These PINs can’t be used as protection.

In order to set your own PIN, select the `Security` option and enter new PIN. You have to confirm the PIN and if they match, a new PIN is set. This means that the next time you enter the `Settings` menu, Horis will ask for this PIN.

We suggest that you do not use PINs longer then three digits.

If you forgot the PIN, enter `75213` and you will get access to the `Settings` menu.

You can also set an empty PIN. In this case Horis does not ask for password.

5.5.16 GNSS Info

Horis can show the GNSS satellite constallation currently in use. Figure 38 illustrates an example.

Figure 37: You can specify your own PIN to limit access to the `Settings` menu. Try not to use PINs longer than three digits.

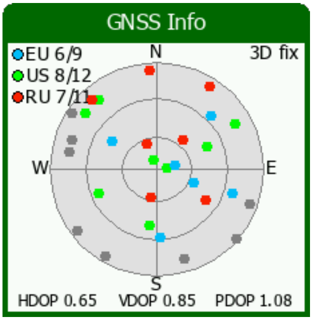


Figure 38: An example of GNSS constallation where Galileo, GPS and Glonass satellites are visible. Distribution is poor. Northern latitudes are not present.

The window shows positions of the satellites on the sky. Galileo (EU) constallation is represented by blue dots, GPS (US) by green dots and Glonass (RU) by red dots. All detected positions are shown. Grey color means that a satellite is being tracked, but it is not being used in fix solution. Under unobstructed sky, satellites should be evenly distributed.

Numbers in the top left corner tell how many of visible satellites are used in solution. For example, *EU 6/9* means that 9 Galileo satellites are detected but 6 are used in position calculation.

HDOP, VDOP and PDOP[7] values indicates quality of the solution. The meaning of the DOP values is given in Table 13. In general, HDOP shall be always be less than 5.

Solution fix is shown in the top right corner. It can be one of the following values:

[7] Abbrevations: DOP – Dilution Of Precision. HDOP – horizontal DOP, VDOP - vertical DOP, PDOV – combined position DOP.

DOP	Rating	Description
< 1	Ideal	Highest possible confidence level.
$1 - 2$	Excellent	Measurements are considered accurate.
$2 - 5$	Good	Still acceptable for route navigation.
$5 - 10$	Moderate	Position is useful, but it should be improved.
$10 - 20$	Fair	Measurements indicate a very rough location.
> 20	Poor	Inaccurate measurements.

Table 13: How to interpret DOP values.

None ... there is no fix. Position is not known.

2D fix ... only 2D fix is obtained. Position measurements are poor.

3D fix ... 4 or more satellites are used in solution. Position quality should be good. See also DOP.

3D+SBAS ... 3D position is further enhanced with the SBAS system. Please refer to Wikipedia for more details on SBAS.

5.5.17 Software Update

Use this option to update Horis software usind micro SD card. Please see section 3 for more details.

5.5.18 Firmware Update

Once Horis software was updated, firmware of connected devices shall be updated as well. You can consider this as a second step of the update process when micro SD card is used. Please see section 3 for more details.

5.5.19 About

The About window shows some information about Horis; its serial number, software version and software creation date. Total logger capacity expressed in mega bytes is shown next. In addition it shows information about all devices connected to the CAN bus. Left of the colon is the device name and hardware version, right of the colon are software version, development version in parenthesis and serial number.

Turn the knob to see all the units connected to the CAN bus.

Figure 39: An example of the about window.

6 Logbook

This option is not available on the Horis slave model.

Horis automatically keeps a log of flights and stores them in a logbook. It keeps recording as long as Horis is powered on. When logs are requested, it extracts takeoff and landing events and combines them in flights. An example is given in Figure 40.

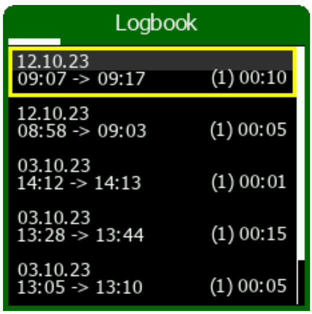


Figure 40: A logbook example.

The window shows a list of logbook entries sorted by the date and time. Most recent come first. The list itmes show only basic information about each flight, like date, takeoff and landing time, flight duration and number of flights (touch-and-goes).

Note that the logbook has a limited capacity. When the limit is reached, the oldest log entries will be overwritten. Horis is logging all the time and not only when flying. Flight shorter than one minute are not shown.

When an item from the logbook is selected, three options are available:

1. Show details,
2. Copy flight,
3. Copy logbook

6.1 Show Details

The *Show Details* option opens a window with more details about selected flight. Figure 41 gives an example.

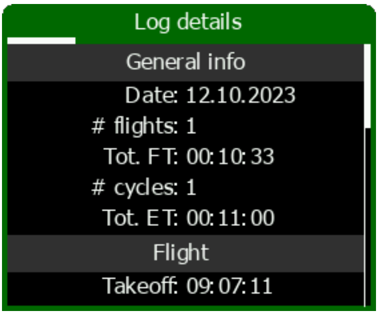


Figure 41: An example of logbook entry details.

These details are organized into groups: General info, Flight, Engine, Statistics. The engine group and engine related parameters in the statistics are shown only if `Daqu` is connected with Horis on the same CAN bus.

Please note that the fuel used and average fuel consumption strongly depend on the fuel flow measurement/estimation. If fuel flow is wrong, these two items will be wrong, too.

6.2 Copy flight

This option extracts the information from the log and creates two files on the micro SD card for the selected flight. One file has .kml extension and the other has .tab extension. Upon success, a message similar to Figure 42 is shown.

The generated file name is a combination date and flight made on this date. It always starts with the letter 'F'. For example a file name *F121023B* means:

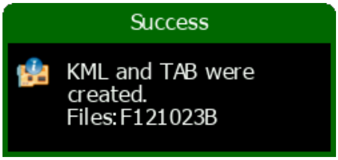


Figure 42: Message example after the copy was made.

flight was taken on 12-th of October 2023 and letter *B* means that this was the second flight of the day.

6.2.1 The KML File

The kml file stores 3D points of the flight and can be viewed in any third party software, which accepts such format. One such software is Google Earth, but many others are supporting this format as well. Figures 43 and 44 show two examples. The first is the top view of a flight and the second one is a detail with visible vertical profile.

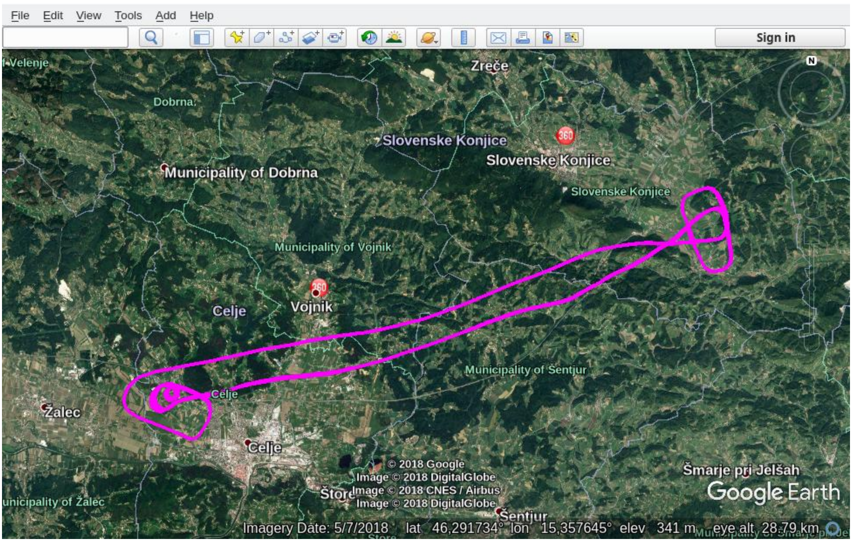


Figure 43: A flight file with kml extenstion opened in Google Earth.

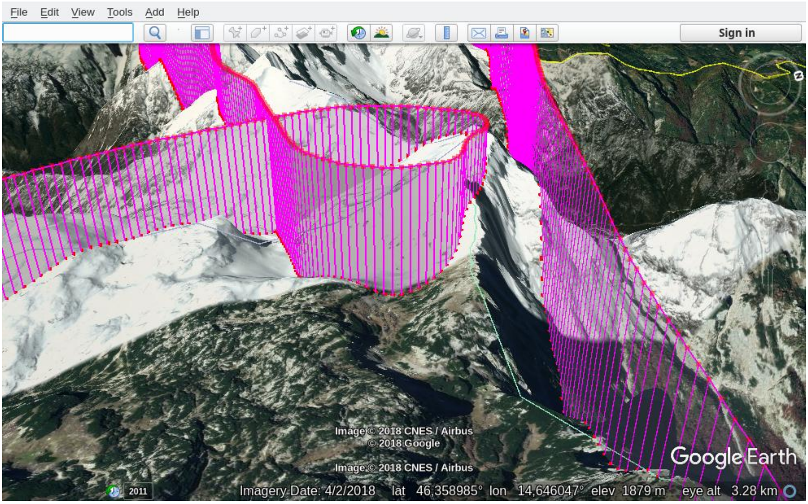


Figure 44: A detail of flight opened in Google Earth. Vertical profile is visible here.

6.2.2 The TAB File

The tab file stores a detailed information for every recorded second. When `Daqu` is present on the CAN bus, the recording typically starts when engine start is detected and ends when engine is stopped. When there is no Daqu, takeoff or landing are used instead.

The *TAB* file format is a plain text format, where each row represents one record and parameters in the record are separated by a tab character. Each record has several flight and engine parameters like: date, time, position, altitude, static pressure, velocities, wind speeds, engine temperatures, engine pressures, RPMs and many others. Typically, the file is opened with Microsoft Excel or with LibreOffice Calc.

Here are the steps needed to open the file in LibreOffice Calc. Steps in Microsoft Excel are similar.

1. Start the LibreOffice Calc.
2. Select the *File:Open* from the menu.
3. In the selection window, set *Filter* to *All Files*.

4. Search for file with the tab extension. An example is *F121023B.TAB*
5. Calc detects that a text file is being imported and it opens a window as shown in Figure 45. Please make sure that the *Tab* option is selected as the separator and *English (USA)* as the language. This makes sure that decimal values are properly imported.
6. The result of the import is then shown in Figure 46. Some column widths were adjusted and some cells were hidden.

Plase note that figure 46 is symbolic. Your case will be slightly different.

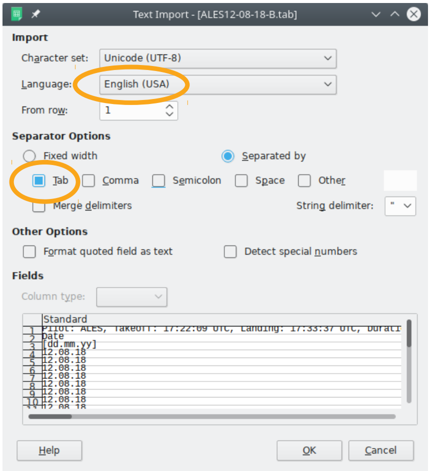
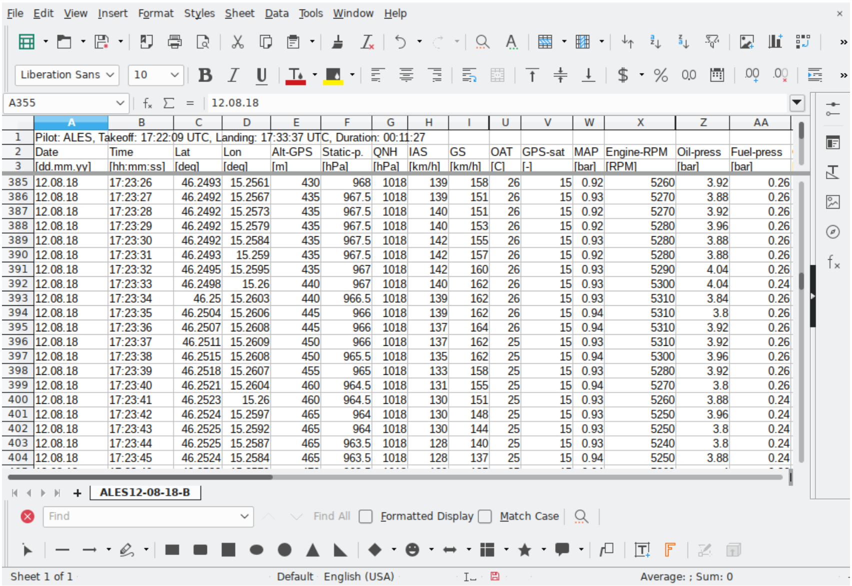


Figure 45: An example of Calc Text Import window.

6.3 Copy Logbook

This command creates a logbook file in *html* format and copies it to a micro SD card. Figure 48 shows an example. Upon success, a message similar to Figure 47 will be shown. The filename always starts with the `LB` then follows day, month and year of the latest flight and it ends with the `.HTM` extension.



	A	B	C	D	E	F	G	H	I	U	V	W	X	Z	AA
1	Pilot: ALES, Takeoff: 17:22:09 UTC, Landing: 17:33:37 UTC, Duration: 00:11:27														
2	Date	Time	Lat	Lon	Alt-GPS	Static-p.	QNH	IAS	GS	OAT	GPS-sat	MAP	Engine-RPM	Oil-press	Fuel-press
3	[dd.mm.yy]	[hh:mm:ss]	[deg]	[deg]	[m]	[hPa]	[hPa]	[km/h]	[km/h]	[C]	[-]	[bar]	[RPM]	[bar]	[bar]
385	12.08.18	17:23:26	46.2493	15.2561	430	968	1018	139	158	26	15	0.92	5260	3.92	0.26
386	12.08.18	17:23:27	46.2492	15.2567	435	967.5	1018	139	151	26	15	0.93	5270	3.88	0.26
387	12.08.18	17:23:28	46.2492	15.2573	435	967.5	1018	140	151	26	15	0.92	5270	3.92	0.26
388	12.08.18	17:23:29	46.2492	15.2579	435	967.5	1018	140	153	26	15	0.92	5280	3.96	0.26
389	12.08.18	17:23:30	46.2492	15.2584	435	967.5	1018	142	155	26	15	0.93	5280	3.88	0.26
390	12.08.18	17:23:31	46.2493	15.259	435	967.5	1018	142	157	26	15	0.92	5280	3.88	0.26
391	12.08.18	17:23:32	46.2495	15.2595	435	967	1018	142	160	26	15	0.93	5290	4.04	0.26
392	12.08.18	17:23:33	46.2498	15.26	440	967	1018	140	162	26	15	0.93	5300	4.04	0.24
393	12.08.18	17:23:34	46.25	15.2603	440	966.5	1018	139	162	26	15	0.93	5310	3.84	0.26
394	12.08.18	17:23:35	46.2504	15.2606	445	966	1018	139	162	26	15	0.94	5310	3.8	0.26
395	12.08.18	17:23:36	46.2507	15.2608	445	966	1018	137	164	26	15	0.94	5310	3.92	0.26
396	12.08.18	17:23:37	46.2511	15.2609	450	966	1018	137	162	25	15	0.93	5310	3.92	0.26
397	12.08.18	17:23:38	46.2515	15.2608	450	965.5	1018	135	162	25	15	0.94	5300	3.96	0.26
398	12.08.18	17:23:39	46.2518	15.2607	455	965	1018	133	158	25	15	0.93	5280	3.92	0.26
399	12.08.18	17:23:40	46.2521	15.2604	460	964.5	1018	131	155	25	15	0.94	5270	3.8	0.26
400	12.08.18	17:23:41	46.2523	15.26	460	964.5	1018	130	151	25	15	0.93	5260	3.88	0.24
401	12.08.18	17:23:42	46.2524	15.2597	465	964	1018	130	148	25	15	0.93	5250	3.96	0.24
402	12.08.18	17:23:43	46.2525	15.2592	465	964	1018	130	144	25	15	0.93	5250	3.8	0.24
403	12.08.18	17:23:44	46.2525	15.2587	465	963.5	1018	128	140	25	15	0.93	5240	3.8	0.24
404	12.08.18	17:23:45	46.2524	15.2584	465	963.5	1018	128	137	25	15	0.94	5250	3.88	0.24

Figure 46: An example of flight details upon successful import. This figure is symbolic and your case will be different.

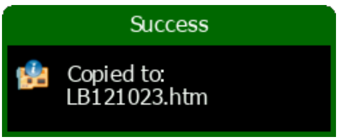


Figure 47: Message example after the copy was made.

7 Autopilot

The AD-AHRS-GPS module, which is hidden inside Horis, can be used to drive an autopilot. It provides all sensor information required by autopilot. However, Horis has only one knob for all its operation, which is not enough for the required autopilot input. This shortcomming can be overcome with the help of Amigo. Together with autopilot servos they form a very neat autopilot system.

This means that the following devices are required for an autopilot system. All these devices are connected via CAN bus.

Logbook: from 03.10.2023 to 12.10.2023

#	Date	PIC	COP/Instr	Take off	Landing	Flight time	Flight total	Engine on	Engine off	Run time	Engine time
1	12.10.23	-	-	09:07	09:17	00:10:33	0.7	09:06	09:17	00:11:00	0.6
2	12.10.23	-	-	08:58	09:03	00:05:06	0.5	08:57	09:03	00:06:18	0.4
3	03.10.23	-	-	14:12	14:13	00:01:21	0.4	14:12	14:13	00:01:34	0.3
4	03.10.23	-	-	13:28	13:44	00:15:25	0.4	13:28	13:44	00:15:54	0.3
5	03.10.23	-	-	13:05	13:10	00:05:19	0.1				0.0
6	03.10.23	-	-	11:27	11:29	00:02:20	0.0	11:27	11:30	00:02:41	0.0

Figure 48: An example of logbook opened in Firefox browser.

1. Horis 80 or 57 mm. It must be a master Horis. Slave Horis can not be used. The AD-AHRS-GPS module, which is inside each master Horis has all required sensors.
2. Amigo is used to operate the autopilot; to set desired direction and altitude, to setup the autopilot and to tune its parameters. It also allows quick autopilot disconnect.
3. Two servos are attached to the airplane command system.

Much more details can be found in the *Autopilot – Installation Manual.*

7.1 Intended Use

The autopilot is designed to help a pilot in stable, controllable flight conditions during cruising. If such conditions are met, the autopilot can be engaged to take some relief from the pilot, who can perhaps focus a bit more on ATC communication or to do some navigation task. Nevertheless, it is still pilot's responsibility to monitor the autopilot and airplane behavior all the time.

7.2 Operation Limitations

Always respect the following limitations.

- The autopilot shall be only used in VFR (Visual Flying Rules) conditions.
- Information from the Aircraft Operating Handbook always supersedes information given in this manual.

- The autopilot is designed to be used only in cruising conditions. It will not work at low and high speeds. It can't fly approaches and departures and it can't do takeoffs and landings.
- The autopilot shall not be used in turbulence.
- Do not use the autopilot with flaps extended.
- In any case of abnormal activity, the autopilot must be deactivated and the pilot must take over the commands immediately. Never wait for autopilot to deactivate itself automatically.
- Autopilot does not use any information from Magu (magnetic compass).

8 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.

8.1 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.

Exclusions and Limitations

This Limited Warranty applies only to hardware products manufactured by or for Kanardia that have the "Kanardia" trademark, trade name, or logo affixed to them at the time of manufacture by Kanardia. The Limited Warranty does not apply to any non-Kanardia hardware products or any software, even if packaged or sold with Kanardia hardware. Manufacturers, suppliers, or publishers, other than Kanardia, may provide their own warranties to the Purchaser, but Kanardia and its distributors provide their products *AS IS*, without warranty of any kind.

Software distributed by Kanardia (with or without the Kanardia's brand name including, but not limited to system software) is not covered under this Limited Warranty. Refer to the licensing agreement accompanying such software for details of your rights with respect to its use.

This warranty does not apply: (a) to damage caused by use with non-Kanardia products; (b) to damage caused by accident, abuse, misuse, flood, fire, earthquake or other external causes; (c) to damage caused by operating the product outside the permitted or intended uses described by Kanardia; (d) to damage caused by service (including upgrades and expansions) performed by anyone who is not a representative of Kanardia or an Kanardia Authorized Reseller; (e) to a product or part that has been modified to significantly alter functionality or capability without the written permission of Kanardia; (f) to consumable parts, such as batteries, unless damage has occurred due to a defect in materials or workmanship; or (g) if any Kanardia serial number has been removed, altered or defaced.

To the extent permitted by applicable law, this warranty and remedies set forth above are exclusive and in lieu of all other warranties, remedies and conditions, whether oral or written, statutory, express or implied, including, without limitation, warranties of merchantability, fitness for a particular purpose, non-infringement, and any warranties against hidden or latent defects. If Kanardia cannot lawfully disclaim statutory or implied warranties then to the extent permitted by law, all such warranties shall be limited in duration to the duration of this express warranty and to repair or replacement service as determined by Kanardia in its sole discretion. Kanardia does not warrant that the operation of the product will be uninterrupted or error-free. Kanardia is not responsible for damage arising from failure to follow instructions relating to the product's use. No Kanardia reseller, agent, or employee is authorized to make any modification, extension, or addition to this warranty, and if any of the foregoing are made, they are void with respect to Kanardia.

Limitation of Liability

To the extent permitted by applicable law, Kanardia is not responsible for indirect, special, incidental or consequential damages resulting from any breach of warranty or condition, or under any other legal theory, including but not limited to loss of use; loss of revenue; loss of actual or anticipated profits (including loss of profits on contracts); loss of the use of money; loss of anticipated savings; loss of business; loss of opportunity; loss of goodwill; loss of reputation; loss of, damage to or corruption of data; or any other loss or damage howsoever caused including the replacement of equipment and property, any costs of recovering, programming, or reproducing any program or data stored or used with Kanardia products and any failure to maintain the confidentiality of data stored on the product. Under no circumstances will Kanardia be liable for the provision of substitute goods or services. Kanardia disclaims any representation that it will be able to repair any product under this warranty or make a product exchange without risk to or loss of the programs or data. Some jurisdictions do not allow for the limitation of liability for personal injury, or of incidental or consequential damages, so this limitation may not apply to you.

8.2 TSO Information — Limited Operation

This product is not TSO approved as a flight instrument. Therefore, the manufacturer will not be held responsible for any damage caused by its use. The Kanardia is not responsible for any possible damage or destruction of any part on the airplane caused by default operation of instrument.