

Horis PDF — Installation and User's Manual

Kanardia d.o.o.

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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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Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
1.0	July 2015	Initial release

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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 ($2\frac{1}{4}$ ") 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 General Description

Horis is an electronic device. It consists of a set of sensors and an LCD display. Majority of sensors are build 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.

1.2 Technical Specification

Table 1 on page 5 lists basic specifications of Horis.

2 Installation & Maintenance

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

2.1 Mounting Procedure

The mounting screw holes are located on a circle of 66 mm diameter. The instrument is mounted using three screws type M4. To prevent internal stresses, please make sure that the instrument panel is flat. The fourth hole is used for the knob axle. Figure 1 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 lid from the knob, but be careful not to cut the lid away. Once the lid is removed, use flat screwdriver and untight the screw. Slide the knob from its axle.

Description	Value
Weight	176 g (cca 230 g with GPS antenna and OAT cable)
Size	62.5 × 62.5 × 45 (64 with connectors) mm
Operational voltage	4.5 to 32 V
Power consumption	1.98 W
Current	165 mA at 12 V
Operating temperature	-30 °C to +85 °C
Humidity	30 % to 90 %, non condensing
Panel hole	57 mm (2.25 inch) diameter, standard fit
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	12 bit, 0 to 50 hPa, 325 km/h, resolution less than 0.1 km/h Option: 0 to 100 hPa, 460 km/h
Acceleration	16 bit, 3D, dynamic range 0 to 16 g, typ. resolution 0.12 mg
Angular rate	16 bit, 3D, 250°/s, resolution 0.009°/s
GPS	10 Hz, 66 channel, hot start 1 s, cold 35 s, sensitivity -165 dBm
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 only, 19200 baud (after September 2015)
Sensor processor	32 bit, ARM Cortex M3, 80 Mhz
Display processor	32 bit, ARM Cortex M3 - LCD, 120 Mhz
Display	320 × 240 pix, diagonal 2.55", 16 bit full colour, super bright
Start-up time	System less than 1 s, AHRS cca 5 s.

Table 1: Technical specifications of Horis 57 mm instrument.

Insert the instrument from the back side of the instrument panel. Fix three mounting screws and insert the knob back to the axle. Tighten the knob and make sure it does not rub the panel. Put the lid back.

2.2 Space Behind the Panel

Horis requires only minimal space behind the instrument panel. Depth of housing is 40 mm, connectors require additional 19 mm and cables and tubing require about 20 mm as shown on Figure 2.

2.3 Connections

Figure 3 illustrates all connections at the back side of the instrument.

2.3.1 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.

Locate the existing tube, cut it at an appropriate place and insert a T junction. Install a new tube from junction to the instrument.

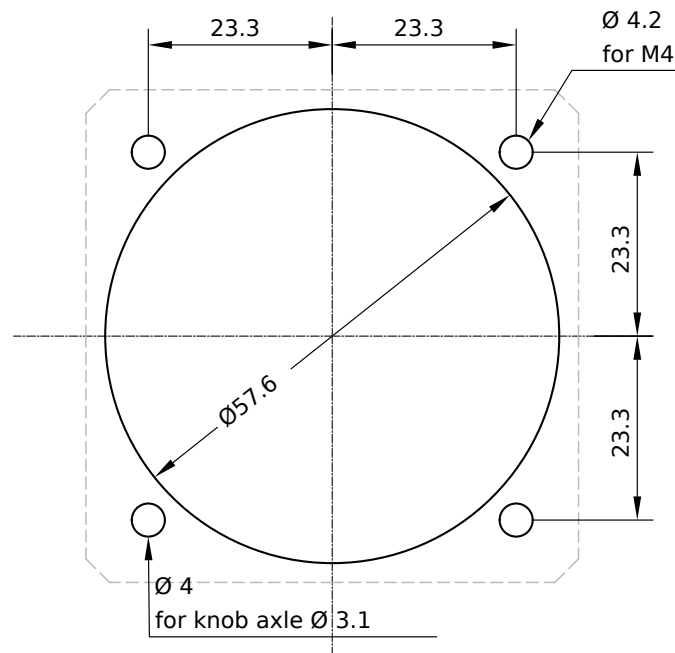


Figure 1: Instrument panel cutout and mounting holes. Some tolerance was already added.
Warning: Figure may not be in scale.

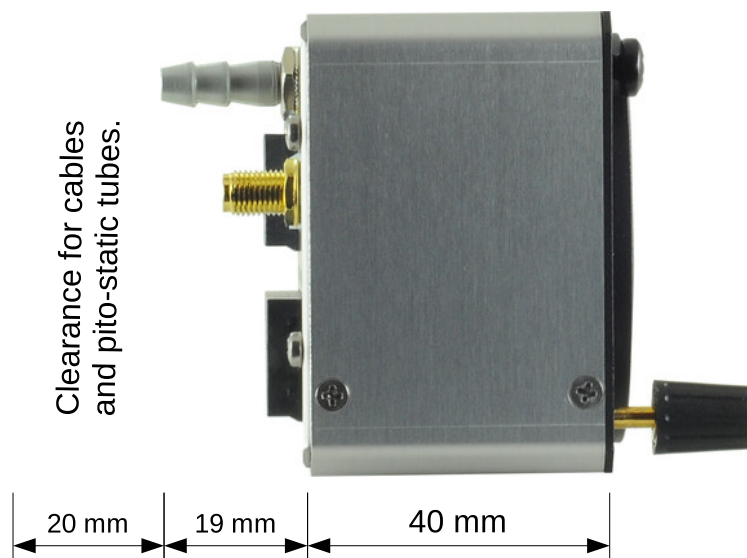


Figure 2: Side view of Horis. Only minimal space is required behind the panel.

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.



Figure 3: Back view of the instrument with connections.

2.3.2 Total Pressure - Ptot

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

2.3.3 CAN Bus

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

When Horis is not connected to the bus, you need to insert the terminator plug into one CAN connector. The terminator plug is a plain RJ45 plug with 120 Ω resistor.

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.

2.3.4 Power - PWR

Connect supplied power cable at the back of the instrument. Power connector has a notch on one side, which protects wrong orientation.

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

A 1 A slow fuse or similar shall be used on the positive lead.

2.3.5 GPS Antenna - GPS

Please consider mounting GPS antenna using next recommendations:

- 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 GPS antennas (GPS 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/GPS 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 stabilization of artificial horizon and as a source for the tracking azimuth. In general, it is not required and artificial horizon works well even without it.

2.3.6 Outside Air Temperature - OAT

Outside air temperature (OAT) probe is shipped with Horis. This is a digital temperature sensor inserted into a threaded aluminium tube. Default OAT cable length is 1.5 meters but other lengths are available on request.

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:

- 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 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 next.

- 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 stabilizes numerical filters.
- Once the aircraft is level and steady, select the AHRS level option from the settings menu to start the automatic calibration procedure. See also Section 4.4.4 on page 14.
- Wait for the progress bar to finish and observe the roll and pitch numerical values. At the end they should stabilize. These values tell the misalignment angles and Horis will use them for the compensation. Window closes automatically.

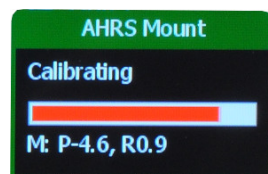


Figure 4: Illustration of automatic AHRS leveling procedure.

Horis can easily compensate misalignments in roll and pitch up to 20° or even more. However it can't compensate for heading misalignment. Thus, please make sure that the part of instrument panel where Horis is mounted is perpendicular to the flight direction. If this is not the case, Horis will not function properly, even if roll and pitch compensations were perfectly made.

2.5 Maintenance

No special maintenance is required. A static leak test should be performed annually and calibration check biannually. In case of small deviation use the procedure described in Section 4.4.5.

2.6 Repair

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

3 The Main Screen

The main screen appears as soon as Horis is powered on. The screen layout was carefully optimized. Figure 5 shows the main screen.



Figure 5: Horis main screen with the 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. GPS status signal. Three green bars indicate normal operation (3D fix), one yellow bar indicates marginal 2D fix and a red cross of the gray bars indicates loss of signal. Note that GPS reception is not mandatory for AHRS – AHRS will function properly without it.
3. Azimuth (direction) indication. Dashes represent that azimuth was not yet established (You need to move for GPS receiver to calculate the azimuth.) Once established tracking from GPS will be shown.
4. 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 GPS receiver.

- H ... heading taken from AHRS coupled with electronic magnetic compass¹. 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 GPS.

- Altitude indicator is composed of altitude value and altitude tape moving in the background.
- Rate of climb a.k.a. vario. Small bar shows climb or descent and a value on the bottom expresses it in numbers.
- Baro correction a.k.a. QNH.
- Outside air temperature a.k.a. OAT. Numerical value is displayed.
- True air speed a.k.a. TAS is derived information obtained from indicated airspeed, outside air temperature and static pressure.
- The inclinometer (slip-skid) indicator.
- 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.
- The turning rate scale. Yellow horizontal bar is used to show turning rate. Inner black points indicate one minute turn (6° per second) while outer black points indicate 30 seconds turn (12° per second).

Main screen is highly configurable. Please refer to Section 4.4 starting on page 12 for more details.

4 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 a few seconds to enter a main menu. We opt for this approach to avoid accidental activation of the main menu during flight.

Horis does not have a *close* button. When some helper 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.

There are only three flight operations: adjusting the QNH value, setting the neutral pitch and changing the brightness. There are more settings, but they are not accessed frequently.

¹ 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.



Figure 6: Illustration of Horis main menu. The **Pitch Reset** option is the default one.

4.1 Adjusting QNH

QNH is adjusted by turning the knob. As QNH changes, the indicated altitude changes accordingly. All changes are directly visible on the screen.

4.2 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 6.
- 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.

4.3 Diminishing the Brightness

Horis always starts with maximal, 100% brightness. If the screen becomes too bright, you can diminish it 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.

4.4 Settings

Horis can be configured with several options described next. The settings screen is accessed via the main menu. Figure 7 illustrates the settings menu and some of the options.

4.4.1 Units

This option allows fine tuning of units for almost any parameter of the main screen. Figure 8 shows the window, where units may be changed. Table 2 lists all possible options.



Figure 7: Horis settings menu and major options.

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 2: Unit options.

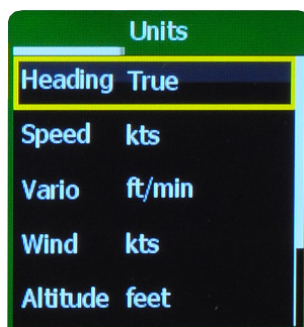


Figure 8: Tuning the units.

4.4.2 Airspeed

This option is used to define the speed tape colours of the airspeed indicator. Figure 10 illustrates the window and figure 9 defines meanings of individual values on the speed tape. The following values are used:

- **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**.



Figure 9: Definition of the speed tape colours.

Airspeed [kts]	
Start	50
Yellow end	60
Green end	115
VNE	140

Figure 10: Illustration of the airspeed window used to define the speed tape.

4.4.3 Response Time

This option defines sensitivity of individual parameters of artificial horizon, Figure 11. 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.

4.4.4 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 2.4 on page 9 for more details.

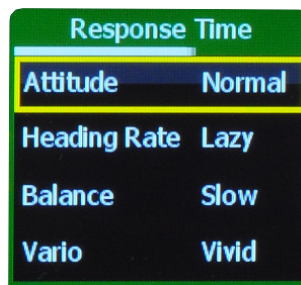


Figure 11: Illustration of the response time options window.

4.4.5 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 12. This window allows to change altitude and velocity (airspeed) offset.

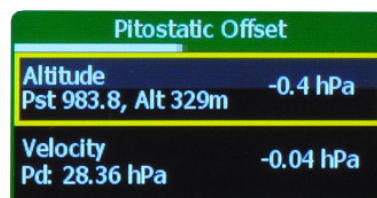


Figure 12: Illustration of the sensor offset window.

Altitude

In order to set the altitude offset you need a reference altimeter. Set the 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.

Velocity

- Rotate the knob and highlight the velocity (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.

4.4.6 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.

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.

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.

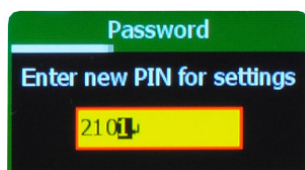


Figure 13: You can specify your own PIN to limit access to the **Settings** menu.

4.4.7 About

The About window shows some relevant information about Horis:

- S/N – serial number of Horis.
- SW. ver. – version of the software in Horis.
- SW. date – release date of the software in Horis.
- Airu – Software version of the AD-AHRS unit.
- Magu – Software version of magnetic compass unit, when such unit is connected to the CAN bus.



Figure 14: An example of the about window.

5 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.

5.1 Two Years 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.

5.2 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.