User & Installation Manual

LT-500 AHRS
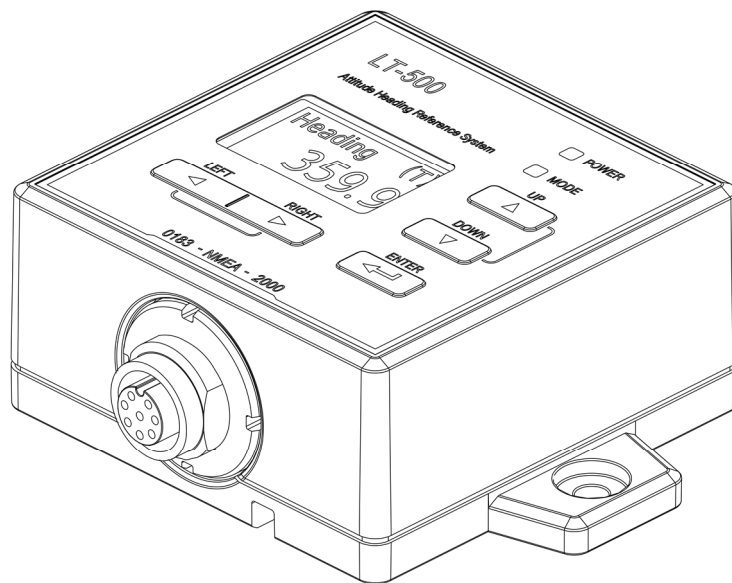
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Disclaimer

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Disposal

Old electrical and electronic equipment marked with this symbol can contain substances hazardous to human beings and the environment. Never dispose these items together with unsorted municipal waste (household waste). In order to protect the environment and ensure the correct recycling of old equipment as well as the re-utilization of individual components, use either public collection or private collection by the local distributor of old electrical and electronic equipment marked with this symbol. Contact the local distributor or dealer for information about what type of return system to use.

IMO and SOLAS

The equipment described in this manual is intended for use on leisure and commercial marine boats not covered by the International Maritime Organization (IMO) and Safety of Life at Sea (SOLAS) regulations.

⚠ Safety Instructions for Installer & Operator

The following safety instructions must be observed during all phases of operation, installation, service and repair of this equipment. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture and intended use of the equipment.

Lars Thrane A/S assumes no liability for the customer's failure to comply with these requirements.

Instructions for the Installer

⚠ WARNING - Product installation

To ensure correct performance of this equipment, it is strongly recommended that professionals, with expertise, properly trained, and likewise authorized within the industry is completing the installation.

⚠ WARNING – Turn off power switch

Turn off the main power switch before installing the equipment described in this manual. Do not connect or disconnect equipment when the main power switch is on.

⚠ WARNING – Use only the supplied cable

Use only the supplied power and communication cable for connecting the equipment.

⚠ WARNING – Input Power

The input voltage range is: 9-40 VDC.

⚠ WARNING – Power supply protection

Make sure that the power supply is adequately protected by a fuse or an automatic circuit breaker when installing the equipment.

⚠ WARNING - Explosive atmosphere

Do not operate the equipment in the presence of flammable gases or fumes. Operation of any electrical equipment in such an environment constitutes a definite hazard.

⚠ WARNING - Compass safe distance

The compass safe distance for standard and steering compasses is 0.3 m (1 ft). Observe this distance to prevent interference to a magnetic compass.

Instructions for the Operator

⚠ WARNING – Do not disassemble

Do not disassemble or modify this equipment. Fire, electrical shock, or serious injury can result.

⚠ WARNING – Keep away from live circuits

Operational personnel must not remove product enclosure. Do not service the equipment, with the communication cable connected. Always disconnect and discharge unit, cable and circuits before touching them.

⚠ WARNING - Permanent watch

In case of smoke or water leaks into the equipment, immediately turn off the power. Continued use of the equipment can cause fire or electrical shock. Keep access and permanent watch of the equipment in order to prevent any unwanted escalation.

⚠ WARNING - Safe navigation

This product is intended only as an aid to navigation and must never be used instead of sound navigation judgement.

No one navigation device should ever be solely replied upon for the navigation of a vessel. Always confirm position against all available aids to navigation, for safety of vessel and crew.

⚠ WARNING - Turn off the autopilot

During deviation calibration and offset adjustment of the product, it is strongly recommended to turn off the autopilot in order to avoid rapid changes in the heading of the boat.

If the safety precautions and warnings above are not followed, warranty will be void.

Required information for the reader

Throughout this document, essential information will be presented to the reader. The following text (emphasized) has the following meaning and/or implication:

WARNING: A 'Warning' is an Operation or Service procedure that, if not avoided, may cause a hazard situation, which could result in personnel death or serious injury.

IMPORTANT: Text marked 'Important' provides essential information to the reader, and is key information to the user in order for the equipment to work properly. Damage to the equipment can occur if instructions are not followed.

NOTE: A 'Note' provides essential information to the reader.

About this manual

Intended readers

This is a User & Installation Manual for LT-500 Attitude Heading Reference System, LT-500 AHRS. The manual is primarily intended for installers and service personnel.

Personnel installing or servicing the system should be professionals, with technical expertise, properly trained, and likewise authorized.

All safety instructions and guidelines in this manual must be observed. The safety instructions are listed in the beginning of the manual. The guidelines are to be found in the separate chapters, where it is needed.

Manual overview

This manual has the following chapters:

- **Introduction** - *provides a high-level description of the product, technology, performance, installation options, and installation steps to be completed.*
- **Quick Installation Guide** - *a short guide providing a minimum of information to complete an installation.*
- **Pre-Installation** - *provides a short description of mounting and installation considerations.*
- **Installation Procedure** - provides a *short description of the installation procedure, which is required to complete.*
- **Mounting** - *mounting of the unit, a step-by-step description.*
- **Connecting** - *a description of the connector, 8-pin multi cable, connecting to NMEA 0183, connecting to NMEA 2000, connecting to power, and connecting the LT-Service Tool.*
- **Configuration -** *listing of all the relevant setup functions, which needs to be considered during the installation.*
- **Deviation calibration** - *a description of the deviation calibration pattern, which needs to be completed to provide reliable heading output.*
- **MMI Description** - a complete description of the LEDs, buttons, and display (incl. menus).
- **LT-Service Tool** - *a short description of the LT-Service Tool. A PC-program, communicating over NMEA 0183, which is supporting configuration and maintenance functions.*
- **Troubleshooting** - *if the unit is not working as expected, please check this guide to help resolve the problem*
- **Service and repair** - *a short description of what to do in case of a defective unit.*

This manual has the following appendixes:

- Outline Drawings
- Performance
- Specifications
- NMEA 0183 Sentences
- NMEA 2000 PGNs
- Variation Modes
- Auto level
- LT-Service Tool (commands)
- Declaration of Conformity

Software versions

This manual is applicable to the following software:

Software Versions	
Description	**Version**
LT-500 AHRS	1.04
LT-Service Tool	1.05

TABLE 1: SOFTWARE VERSIONS

Record of Revisions

Rev.	Description	Release Date	Initials
1.00	Original document	May 17, 2016	PT
1.01	Document is updated with the following new features: • Configuration of deviation calibration options • Configuration of attitude filter • Configuration of NMEA 0183 sentences • Updated MMI layout	October 31, 2016	PT

Table of Contents

Introduction

Congratulations on your purchase of the LT-500 Attitude Heading Reference System (AHRS)!

The LT-500 Attitude Heading Reference System (AHRS) is a maritime navigation product from Lars Thrane A/S. The LT-500 AHRS is designed for the leisure as well as the professional maritime market. The LT-500 AHRS meets all standards and certification requirements needed for worldwide maritime navigation equipment.

Performance

The LT-500 AHRS is a small, compact, and very advanced unit with 11 precision sensors. With the use of sensor-fusion and Kalman filtering, the LT-500 AHRS outputs: true heading[1], magnetic heading, roll, pitch, air pressure, and temperature in real-time, with high precision and resolution. The LT-500 AHRS includes advanced technologies such as:

- Kalman filtering & sensor fusion
- Compensation of variation by use of the World Magnetic Model (WMM)
- Compensation of soft and hard iron (deviation)
- Automatic magnetometer calibration algorithm

The LT-500 AHRS is designed and built for the demanding and rough environment at sea and with an operational temperature range from -25°C to +55°C (-13°F to +131°F).

Installation & Navigation

The LT-500 AHRS is easy to mount and supports NMEA 0183, NMEA 2000, and power on a single cable. The LT-500 AHRS may be installed in any position. The LT-500 AHRS has a built-in user interface (display and buttons) for installation and service. Navigation output from the LT-500 AHRS is available in the user interface. The LT-500 AHRS supports automatic levelling (pitch and roll), which can be used during the installation. The built-in magnetometer calibration algorithm will compensate for deviation. The external LT-Service Tool is available for optional configuration and maintenance of the LT-500 AHRS.

More than 40 years of experience have been put into the design and construction of the advanced LT-500 AHRS, with an exceptional performance and specification level.

1: If position and time is available from either NMEA 0183, NMEA 2000, or variation is manually entered during installation, the unit will output both magnetic heading and true heading. Otherwise, calculation of the magnetic variation based on the WMM model will not be possible, and the unit will output only magnetic heading.

Installation Guide

The following steps, with reference to relevant chapters, will provide you with information, considerations, and guidance on how to complete a successful installation:

Step 1:   Pre-installation and considerations   See *Pre-Installation* on page 5.

Step 2:   Mounting the unit   see *Mounting* on page 8.

Step 3:   Connecting the unit   see *Connecting* on page 11.

Step 4:   Configuring the unit   see *Configuration* on page 17.

Step 5:   Calibrating the unit   see *Deviation calibration* on page 22.

Step 6:   Configuring the unit (optional)   see *Configuration* on page 17.

NOTE: A quick installation overview is presented in the *Quick Installation Guide* on page 3. Here most of the necessary information is provided to perform a fast installation and take the product in use. It is recommended to use the entire LT-500 User & Installation Manual as guidance for the best possible and complete installation.

NOTE: A more detailed installation procedure is available in *Installation Procedure* on page 7.

Quick Installation Guide

LT-500 Attitude Heading Reference System

Congratulations on your purchase of the LT-500 Attitude Heading Reference System (AHRS)!

The LT-500 AHRS is a small, compact and very advanced unit with 11 precision sensors: Magnetometers, Gyros, Accelerometers, Barometer, and Thermometer. Use the built-in MMI interface for configuration of the unit.

NOTE: Refer to the 95-100225 LT-500 User & Installation Manual for detailed information on installation requirements and guidance.

Unpacking

Unpack the LT-500 AHRS and check that the following items are present:

- LT-500 AHRS (incl. screws for installation)
- 10m Cable Multi 8-pin Simple-Cut (M)
- Screw-in Conn. NMEA 2000 Micro-C (M)
- Quick Installation Guide
- Safety Instructions Sheet
- Unit Test Sheet

> ⚠️ **WARNING**
>
> Refer to the 95-100225 LT-500 User & Installation Manual for Safety Instructions.

Installation

The LT-500 AHRS is configured to 4800 baud (NMEA 0183) and 'Open' (NMEA 2000) from the factory. Alternative settings are 38400 baud (NMEA 0183) and 'Terminated' (NMEA 2000). Changes can be applied via the built-in MMI interface or via the PC LT-Service Tool.

Mounting considerations:

- Mount the unit indoor (ventilation hole shall be free and not exposed to direct water)
- Mount the unit in any position (for further details see LT-500 User & Installation Manual)
- Mount the unit on a rigid structure with a minimum of exposure to vibration and shock
- Mount the unit in an area with an ambient temperature between -25°C to +55°C (-13°F to +131°F)
- Mount the unit as far as possible from magnetic interference and power cables

IMPORTANT: Use the non-magnetic self-cutting A4 stainless steel screws, which are included in the box or screws with similar non-magnetic characteristics.

Connecting cables: The LT-500 AHRS 8-pin female connector and the multi cable (simple-cut) interconnect details are listed in Table 2 and Figure 1.

LT-500 AHRS Interconnect Details		
Pin No.	**Wire Color**	**Wire Designation**
1	Brown	TxD-
2	Yellow	TxD+
3	Black	GND
4	White	CAN_H
5	Blue	CAN_L
6	Orange	RxD+
7	Green	RxD-
8	Red	Vsupply

TABLE 2: LT-500 AHRS MULTI CABLE WIRE COLOR AND DESIGNATION.
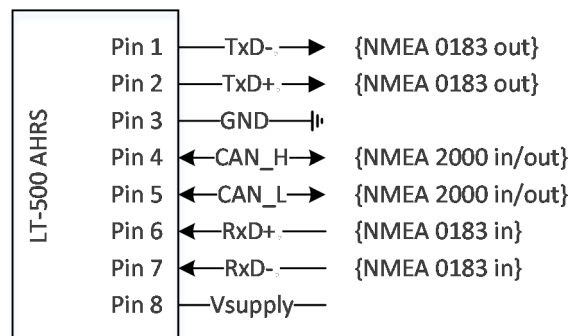
FIGURE 1: LT-500 AHRS TRANSMIT AND RECEIVE

LT-500 AHRS		
Pin 1	TxD- →	{NMEA 0183 out}
Pin 2	TxD+ →	{NMEA 0183 out}
Pin 3	GND	
Pin 4	← CAN_H →	{NMEA 2000 in/out}
Pin 5	← CAN_L →	{NMEA 2000 in/out}
Pin 6	← RxD+	{NMEA 0183 in}
Pin 7	← RxD-	{NMEA 0183 in}
Pin 8	Vsupply	

Deviation calibration

The LT-500 AHRS requires a deviation calibration, as illustrated in Figure 2, when mounting, connecting, and configuration has been completed. The calibration must be performed in open and calm waters, and will determine the ship's influence on the magnetic sensors.

The LT-500 AHRS will indicate absence of a valid calibration by outputting heading (true and magnetic) with a 5 degrees resolution. When a calibration has been successful, the heading will be output with full resolution.

The LT-500 AHRS will automatically perform a calibration when it detects the vessel is sailing a specific pattern. To trigger a calibration, guide the vessel through the following pattern. The best result is achieved at low speed (SOG), low rate of turn (ROT) and in calm waters.

Step 1
Keep a steady course (± 5°) for min. 10 s.
SOG: 2–12 knots

Step 2
Make a full circle (360-450°) clockwise or counterclockwise
ROT: 2-6°/s (1 -3 min.)
SOG: 2-12 knots

Step 3
Make a full circle (360-450°) in opposite direction
ROT: 2-6°/s (1 -3 min.)
SOG: 2-12 knots

Step 4
Keep a steady course (± 5°) for min. 10 s.
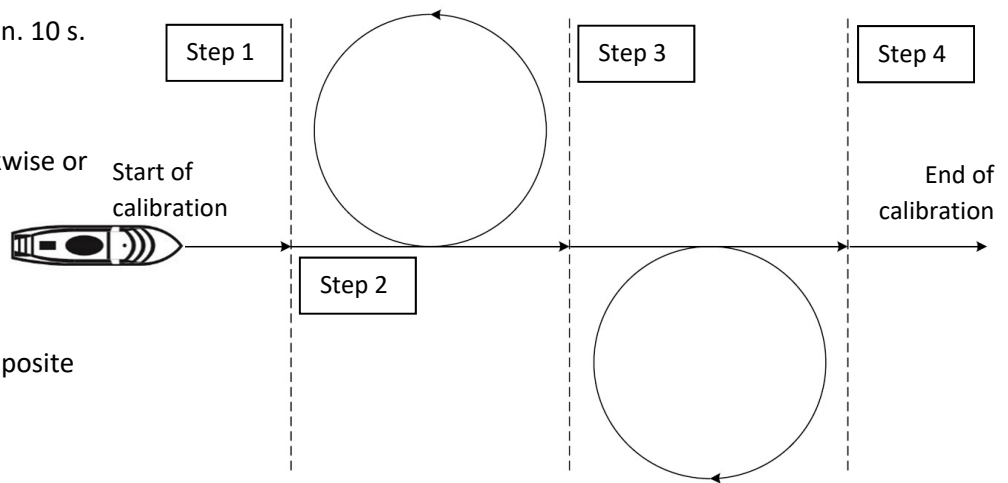SOG: 2–12 knots

FIGURE 2: DEVIATION CALIBRATION PATTERN FOR THE LT-500 AHRS.

IMPORTANT: If the LT-500 AHRS is physically moved or rotated, it is required to perform a new calibration. Use the LT-500 MMI interface to reset or deactivate the deviation calibration pattern. The number of successful deviation calibrations can be readout from the LT-500 MMI, in the submenu Status.

Configuration

Use the LT-500 AHRS built-in MMI interface for configuration and offset adjustments. All relevant settings and setup installation features are available from the MMI interface. Use the LT-Service Tool for additional configuration and service of the LT-500 AHRS.

MMI interface (subset of features):

- NMEA 0183 baud rate
- NMEA 2000 termination
- Deviation calibration & options
- Variation
- Auto level
- Heading offset
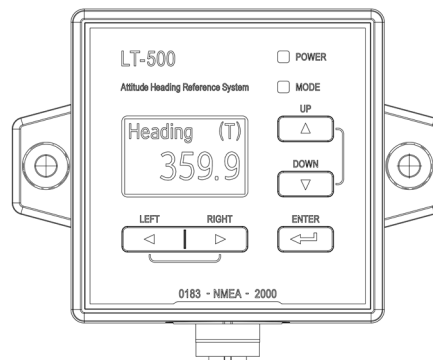- Roll offset
- Pitch offset
- Vertical offset

FIGURE 3: LT-500 AHRS MMI INTERFACE (LEDs, PUSH BUTTONS, AND DISPLAY).

Pre-Installation

Unpacking (in-the-box)
Unpack your LT-500 AHRS and check that the following items are present:

- LT-500 AHRS (incl. screws for installation)
- 10m Cable Multi 8-pin Simple-Cut (M)
- Screw-in Conn. NMEA 2000 Micro-C (M)
- Quick Installation Guide
- Safety Instructions Sheet
- Unit Test Sheet

Inspection
Inspect the shipping cartons and/or wooden box immediately upon receipt for evidence of damage during transport. If the shipping material is severely damaged or water stained, request that the carrier's agent be present when opening the cartons and/or wooden box. Save all box packing material for future use.

After unpacking the system and opening the cartons, inspect it thoroughly for hidden damage and loose components or fittings. If the contents are incomplete, if there is mechanical damage or defect, or if the system does not work properly, notify your dealer.

WARNING: To avoid electric shock, do not apply power to the LT-500 AHRS if there is any sign of shipping damage to any part of the unit or the outer cover. Read the Safety Instructions at the front of this manual before installing or operating the unit.

Mounting and installation considerations
For optimum system performance, some guidelines on where to install or mount the LT-500 AHRS must be followed. It is recommended to mount the unit in a location, which fulfills these requirements:

- Mount the unit indoor (ventilation hole shall be free and not exposed to direct water)
- Mount the unit in any position
- Mount the unit on a rigid structure with a minimum of exposure to vibration and shock
- Mount the unit in an area with an ambient temperature between -25°C to +55°C (-13°F to +131°F)
- Mount the unit away from possible magnetic disturbances (e.g. loudspeakers) and power cables
- Mount the unit at least 1 m. (3 ft.) away from radio transmitting antennas (VHF, UHF, MF-HF, Inmarsat, Iridium, Transmitting VSAT, etc.)
- Mount the unit at least 50 cm. (20") away from the following: Engines, generators, steel fuel and water tanks, bilge pump, anchor, anchor chain, and iron mast support
- Mount the unit as close as possible to the ship's center of gravity and center line

IMPORTANT: Use the non-magnetic self-cutting A4 stainless steel screws, which are included in the box or screws with similar non-magnetic characteristics.

Ventilation and water intrusion

Make sure not to cover the ventilation hole on the right side of the connector in the bottom part. This hole is used for ventilation of the construction and for the pressure sensor.

The LT-500 AHRS is designed as indoor equipment with an IP rating of 42. Do not use pneumatic tools or other water-spouting tools for cleaning the LT-500 AHRS.

IMPORTANT: Make sure to install the LT-500 AHRS, so that water or other fluids cannot drain into the ventilation hole.

Any position

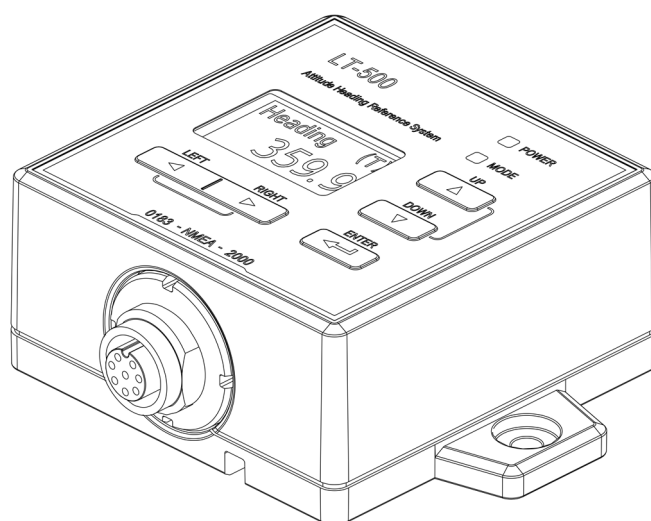The LT-500 AHRS can be mounted in any position/orientation.

FIGURE 4: LT-500 AHRS.

NOTE: The LT-500 AHRS can be mounted in any position/orientation and thus, no additional bracket is required. It is mandatory to 'run' the auto level function after the LT-500 AHRS has been fastened. By applying the auto level function, the LT-500 AHRS horizontal plane is adjusted to the surface orientation (output of pitch and roll becomes zero). For further details on the auto level function, see *Auto level* on page 19.

Installation Procedure

The LT-500 AHRS has to be installed and configured according to the procedure described in this chapter. The LT-500 AHRS installation procedure is illustrated in Figure 5.

Mounting on page 8

The LT-500 AHRS has to be mounted indoor, on a rigid structure, and away from any external magnetic disturbances (see *Mounting and installation considerations* on page 5).

Connecting on page 11

The LT-500 AHRS is connected to NMEA 0183, NMEA 2000, and power via the proprietary 8-pin multi cable, which is included in the box. This chapter describes how to connect the 8-pin multi cable to NMEA 0183, NMEA 2000, and power.

Configuration on page 17

The LT-500 AHRS has to be configured with respect to the specific installation requirements. The following configurations shall be considered during installation:

- NMEA 0183 baud rate
- NMEA 2000 termination
- Deviation calibration & options
- Variation
- Auto level
- Heading, Roll & Pitch offset
- Vertical offset
- Attitude filter

All of these settings can be configured via the MMI interface, see *MMI Description* on page 25. Additional configuration options are available via the LT-Service Tool. A complete description of configuration options are presented in *Configuration* on page 17.

FIGURE 5: LT-500 AHRS INSTALLATION PROCEDURE TO BE COMPLETED FOR OPTIMAL PERFORMANCE.

Deviation calibration on page 22

The LT-500 AHRS requires a deviation calibration before outputting heading in full resolution. The LT-500 AHRS will output heading data in 5 degrees resolution, until the deviation calibration is complete (deactivation of the 5 degrees heading resolution is an option).

Configuration (optional)

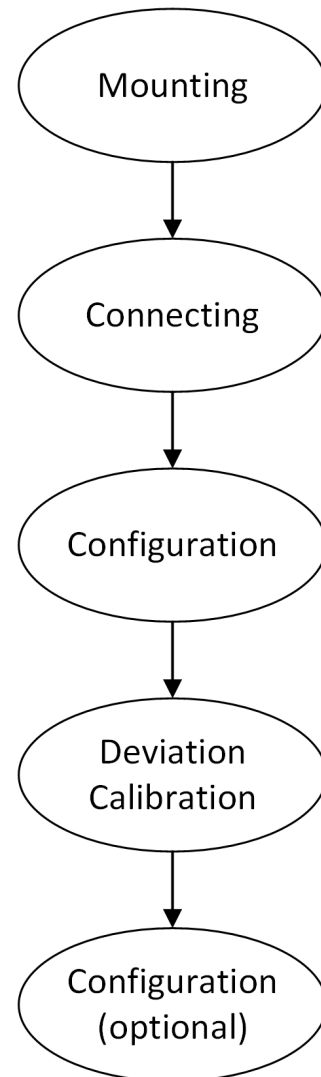LT-500 AHRS might need a heading offset after the unit has successfully passed the deviation calibration.

Mounting

Step 1: Unpack the LT-500 AHRS and make a record of the unit serial number for support or warranty issues that could occur in the future.
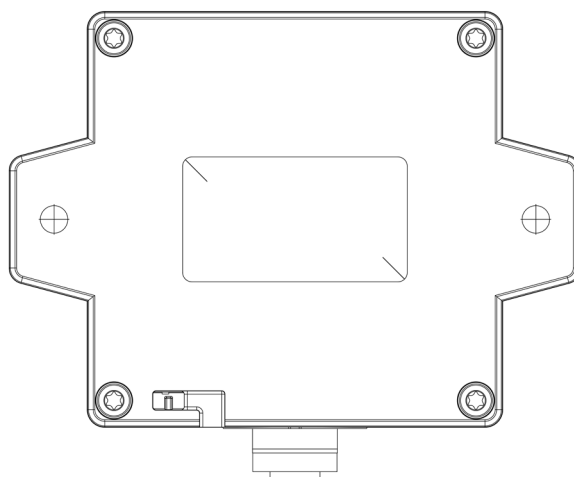

FIGURE 6: LT-500 AHRS INSTALLATION STEP 1 (BOTTOM OF LT-500 AHRS).

Step 2: Use the 2 non-magnetic self-cutting A4 stainless steel screws for attaching the LT-500 AHRS to a rigid structure with a minimum of exposure to vibration and shock.
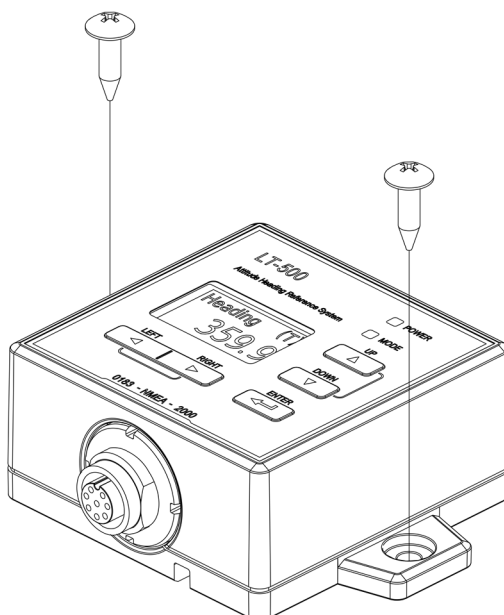

FIGURE 7: LT-500 AHRS INSTALLATION STEP 2 (USE A4 STAINLESS STEEL SCREWS)

IMPORTANT: Make sure that there are no magnetic disturbances (see *Mounting and installation considerations* on page 5 for details) or compass within 0.3 m. (1 ft.) of the LT-500 AHRS. Mount the unit at least 50 cm. (20") away from the following: Engines, generators, steel fuel and water tanks, bilge pump, anchor, anchor chain, and iron mast support.

Step 3: Connect the proprietary 8-pin multi cable, which is supporting NMEA 0183, NMEA 2000, and power. The cable is optional available in 30 meter. For further details on the 8-pin multi cable pin-out and designation, see *Connector and cable definition* on page 11.
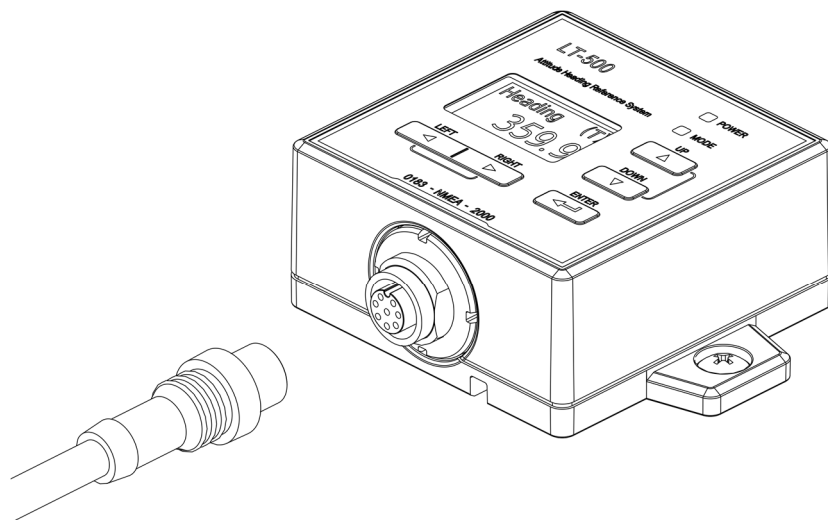

FIGURE 8: LT-500 AHRS INSTALLATION STEP 3 (CONNECTING 8-PIN MULTI CABLE)

Step 4: After the 8-pin multi cable has been connected to the LT-500 AHRS. External power can be applied to the unit. Hereafter it is required to perform some additional installation steps.

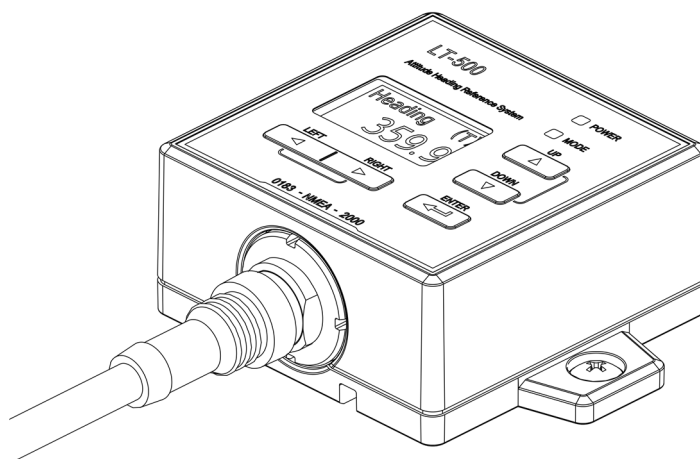FIGURE 9: LT-500 AHRS INSTALLATION STEP 4.

NOTE: After connecting the 8-pin multi cable to the LT-500 AHRS, it is necessary to configure the unit from the MMI interface, see *Configuration* on page 17 and *MMI Description* on page 25.
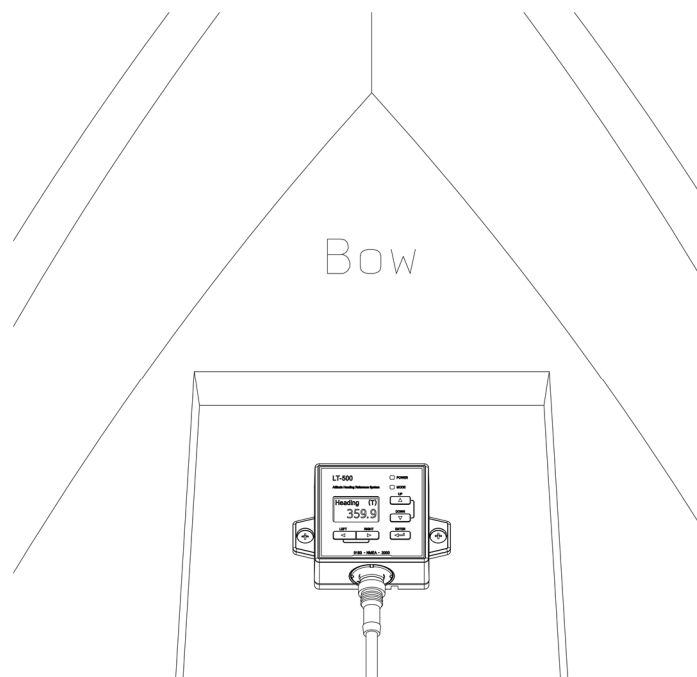
FIGURE 10: LT-500 AHRS INSTALLATION PICTURE 1.
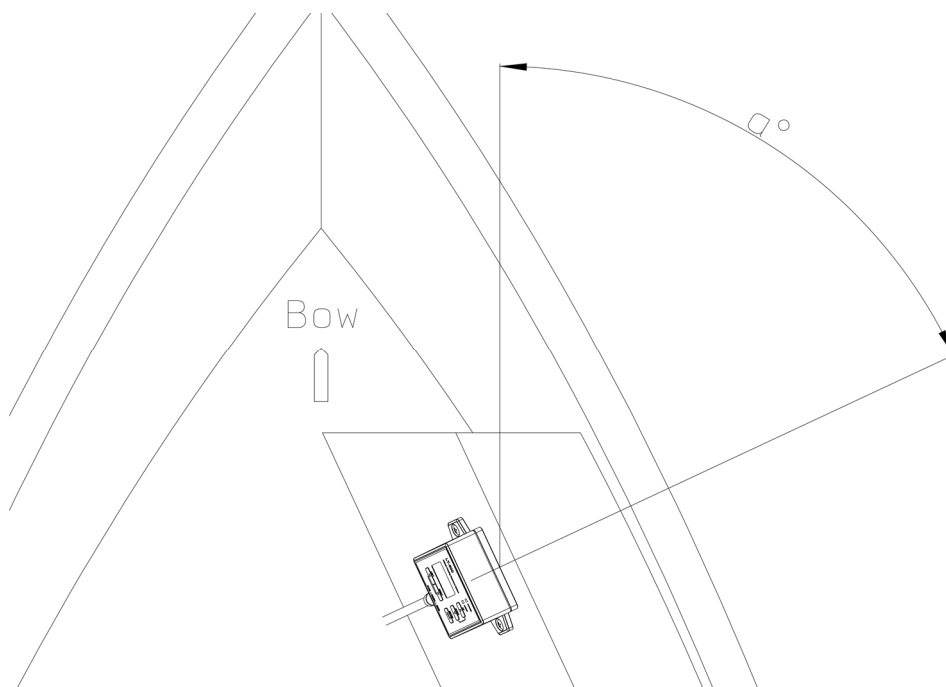

FIGURE 11: LT-500 AHRS INSTALLATION PICTURE 2.

NOTE: Two different LT-500 AHRS installations are illustrated in Figure 10 and in Figure 11. Both of these installations shall follow the standard LT-500 AHRS installation procedure, which is described in *Installation Procedure* on page 7 (the minimum procedure is: auto level, heading offset, and a deviation calibration).

Connecting

This chapter provides relevant information for connecting the LT-500 AHRS to NMEA 0183, NMEA 2000, power, and the LT-Service Tool.

Connector and cable definition

The LT-500 AHRS has an 8-pin connector, which is supporting simultaneously data on NMEA 0183, NMEA 2000, and power. The placement of the LT-500 AHRS connector is illustrated on Figure 12. A detailed connector pin out with pin numbering is illustrated in Figure 13.
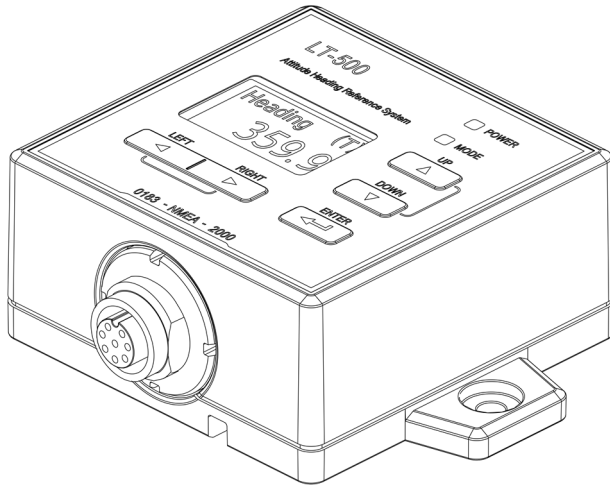

FIGURE 12: LT-500 AHRS. 8-PIN CONNECTOR USED FOR CONNECTING THE LT-500 AHRS TO NMEA 0183, NMEA 2000, AND POWER.
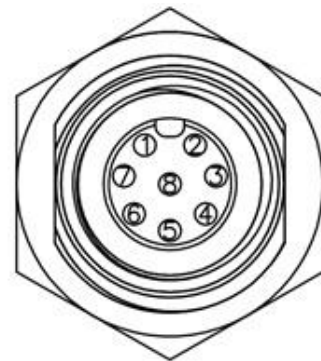
FIGURE 13: LT-500 AHRS CONNECTOR PIN NUMBERING

The LT-500 AHRS connector has a proprietary pin out and therefore a communication cable is always included in-the-box, see *Unpacking (in-the-box)* on page 5. The communication cable is available in two lengths: 10 or 30 meters. The LT-500 AHRS is delivered including a 10 meter cable (simple-cut). The communication cable, wire color and designation, is illustrated in Table 3.

LT-500 AHRS Interconnect Details		
Pin No.	Wire Color	Wire Designation
1	Brown	TxD-
2	Yellow	TxD+
3	Black	GND
4	White	CAN_H
5	Blue	CAN_L
6	Orange	RxD+
7	Green	RxD-
8	Red	Vsupply

TABLE 3: LT-500 AHRS MULTI CABLE WIRE COLOR AND DESIGNATION.

FIGURE 14: TRANSMIT AND RECEIVE DIRECTIONS FOR THE LT-500 AHRS.

NOTE: To avoid any misinterpretation, the transmit (Tx) and receive (Rx) directions are illustrated in Figure 14, relative to the LT-500 AHRS.

Connecting to NMEA 0183

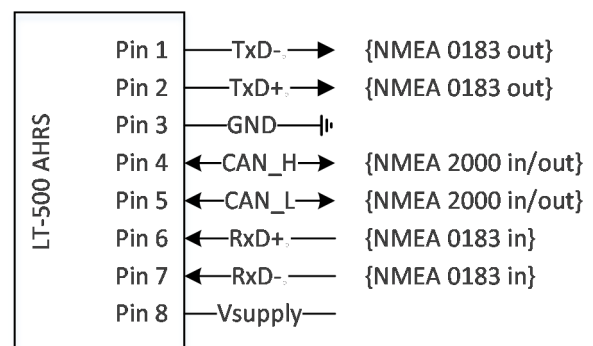If connecting the LT-500 AHRS to a NMEA 0183 device, then it is only required to connect the transmit part of the NMEA 0183 wires TxD- (Brown) and TxD+ (Yellow) from the communication cable. If it is required to receive position and time, then also the NMEA 0183 wires RxD- (Green) and RxD+ (Orange) shall be connected. Reception of position and time is relevant, when variation 'Auto' has been configured. For further details, see *App. F – Variation Modes* on page 39.

IMPORTANT: It is recommended to connect the LT-500 AHRS with a balanced NMEA 0183 connection (RS-422) as illustrated in Figure 15. An unbalanced connection (RS-232), as illustrated in Figure 16, is less robust and should only be considered, when using a short communication cable.

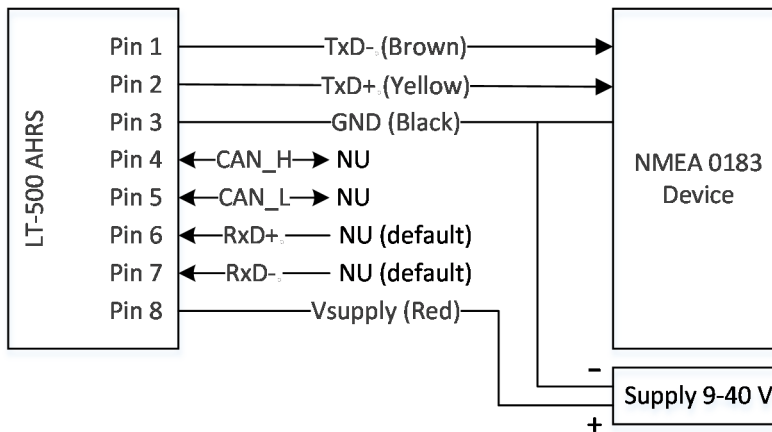FIGURE 15: CONNECTING THE LT-500 AHRS TO A BALANCED NMEA 0183 DEVICE.
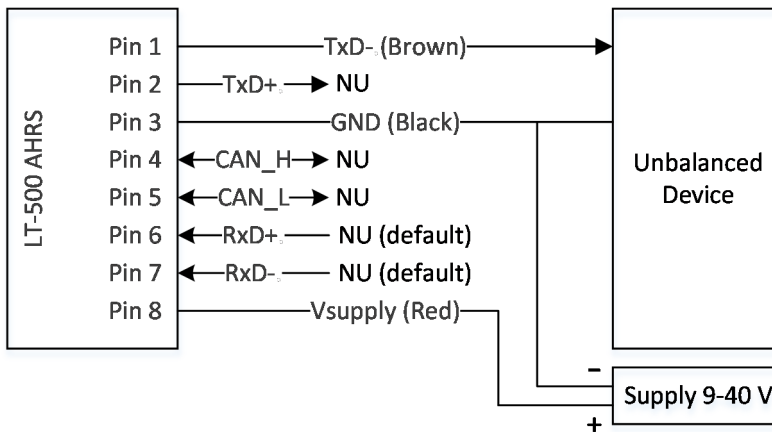
FIGURE 16: CONNECTING THE LT-500 AHRS TO AN UNBALANCED DEVICE.

NOTE: Make sure that the LT-500 AHRS is configured for the desired baud rate (4800 or 38400 baud), see *Configuration on page* 17. Check that both the NMEA 0183 receive device and the LT-500 AHRS have the same GND reference, as illustrated in Figure 15 and Figure 16.

Connecting to NMEA 2000

If connecting the LT-500 AHRS to a NMEA 2000 network (drop or backbone), then it is required to use a screw-in connector as illustrated in Figure 17. The screw-in connector is in-the-box together with the LT-500 AHRS.
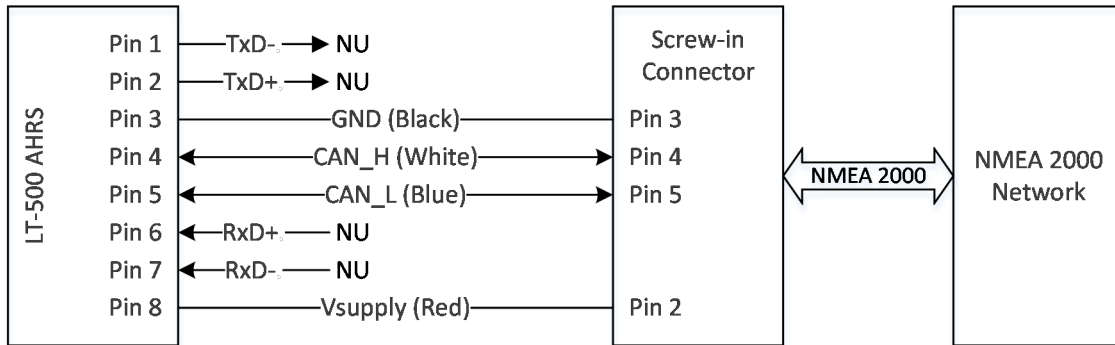
FIGURE 17: CONNECTING THE LT-500 AHRS TO A NMEA 2000 BACKBONE. A SCREW-IN CONNECTOR IS REQUIRED FOR CONNECTING THE LT-500 AHRS TO A NMEA 2000 NETWORK.

NOTE: The screw-in connector is connected to the communication cable by cutting the cable in the right length, stripping the wires, screwing the specific wires to the connector, and then re-assemble the connector again.

The screw-in connector outline is illustrated in Figure 18. The pin-out and numbering of the screw-in connector is illustrated in Figure 19, while the wiring details for interconnection with the communication cable is shown in Table 4.
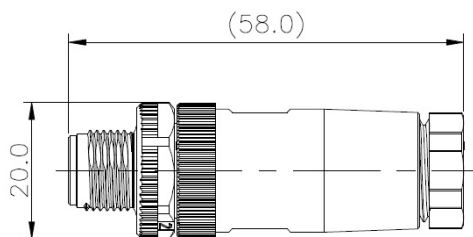
FIGURE 18: NMEA 2000 SCREW-IN CONNECTOR (M) OUTLINE
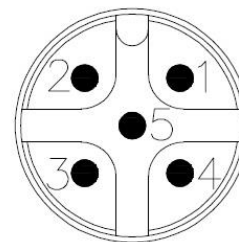
FIGURE 19: NMEA 2000 SCREW-IN CONNECTOR PIN NO.

NMEA 2000 Screw-in Conn. Wiring		
Cable Wire Color	Cable Wire Designation	Screw-in Conn. Pin No.
-	-	1
Red	Vsupply	2
Black	GND	3
White	CAN_H	4
Blue	CAN_L	5

TABLE 4: ILLUSTRATES HOW THE LT-500 AHRS 8-PIN MULTI CABLE IS CONNECTED TO A NMEA 2000 SCREW-IN CONNECTOR.

NOTE: The LT-500 AHRS does not require a connection on Pin No. 1: drain/shield. The unit is designed to work with open cable shield.

NOTE: There are two possibilities for the LT-500 AHRS to be connected to an NMEA 2000 network: drop cable or backbone. The MMI interface can be used to change configuration from 'Open' to 'Terminated' (factory default is 'Open'). The LT-500 ARHS MMI interface is described in details in *MMI Description* on page 25.

The remaining figures in this sub-chapter does not show the screw-in connector for simplicity.

NMEA 2000 Installation

The LT-500 AHRS is delivered together with a NMEA 2000 screw-in connector, which is used to connect the communication cable with the NMEA 2000 backbone. The MMI interface or LT-Service Tool can be used to configure the LT-500 AHRS to either 'Open' or 'Terminated' (factory default is 'Open'). The LT-500 ARHS MMI is described in details in *MMI Description* on page 25. Figure 20 and Figure 21 are illustrating two options for connecting the LT-500 AHRS to a NMEA 2000 network.

NMEA 2000 ('Open')

If the LT-500 AHRS is installed as illustrated in Figure 20, no internal NMEA 2000 bus termination is required (default 'Open'). The LT-500 AHRS is connected to the NMEA 2000 backbone using a drop-cable.

NOTE: Make sure that the communication cable, delivered together with the LT-500 AHRS, is shortened to a maximum length of 6 meters as defined in the NMEA 2000 standard for a drop cable.
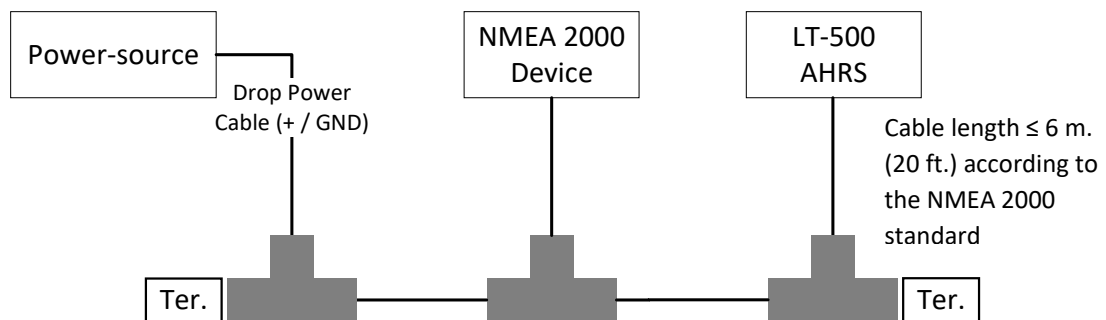
FIGURE 20: LT-500 AHRS CONNECTED TO A NMEA 2000 BACKBONE WITH NMEA 2000 CONFIGURED TO 'OPEN'. THE NMEA 2000 SCREW-IN CONNECTOR IS NOT ILLUSTRATED IN THIS FIGURE.

NMEA 2000 ('Terminated')

If the LT-500 AHRS is installed as illustrated in Figure 21, internal LT-500 bus termination is required and configuration must be changed from 'Open' to 'Terminated' (default: 'Open'). The NMEA 2000 termination can be configured from the MMI interface, see *MMI Description* on page 25. The LT-500 AHRS is connected to the NMEA 2000 using a standard backbone cable.

FIGURE 21: LT-500 AHRS CONNECTED TO A NMEA 2000 BACKBONE WITH NMEA 2000 CONFIGURED TO 'TERMINATED'. THE NMEA 2000 SCREW-IN CONNECTOR IS NOT ILLUSTRATED IN THIS FIGURE.

Details on how to connect the communication cable with the NMEA 2000 screw-in connector, see *Connecting to NMEA 2000* on page 13.
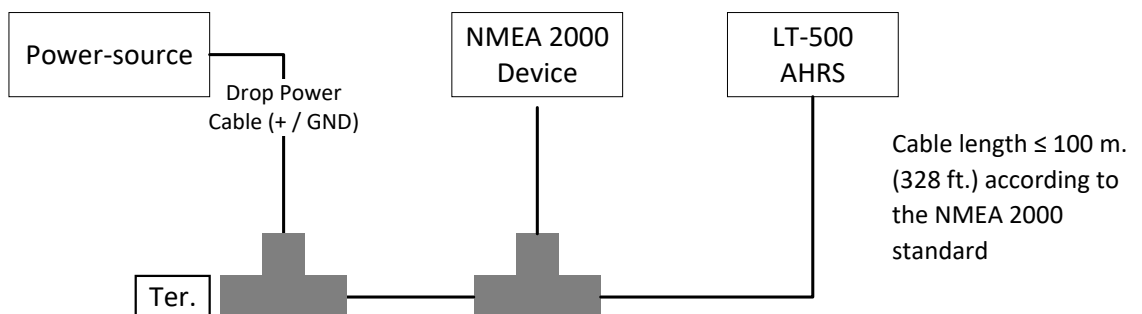
Connecting LT-Service Tool

The LT-Service Tool is a PC program made for configuration, maintenance, and service of the LT-500 AHRS. Use of the LT-Service Tool is optional. For details and functionality, see *LT-Service Tool* on page 28. This sub-chapter is describing how to physically connect a PC (with the LT-Service Tool), to a LT-500 AHRS. The LT-Service Tool is using the NMEA 0183 interface for communicating with the LT-500 AHRS (both Tx and Rx directions).

Use either a 'USB to RS-422 converter' or connect a serial port directly to the LT-500 AHRS as described in the following sub-sections. The LT-500 AHRS requires an input voltage of 9-40 VDC. Most of the USB to RS-422 converter's and serial interfaces are only providing 5 VDC. Make sure that GND on both devices (PC and LT-500 AHRS) are connected to the same GND reference.

NOTE: The LT-Service Tool will automatically detect all LT-Navigation devices, which are connected to the PC's peripheral interfaces (USB and serial). Make sure that Tx and Rx wires are connected correctly. The LT-Service Tool will automatically try both 4800 and 38400 baud to search for possible LT-Navigation devices. If the LT-Service Tool does not automatically detects the LT-500 AHRS, check automatically and manual connection modes, described in *LT-Service Tool* on page 28.

USB to RS-422 converter

A standard USB to RS-422 converter, as illustrated in Figure 22, is perfect for providing a communication link between the LT-Service Tool and the LT-500 AHRS. The PC is connected to the 'USB to RS-422 converter' through a standard USB cable.
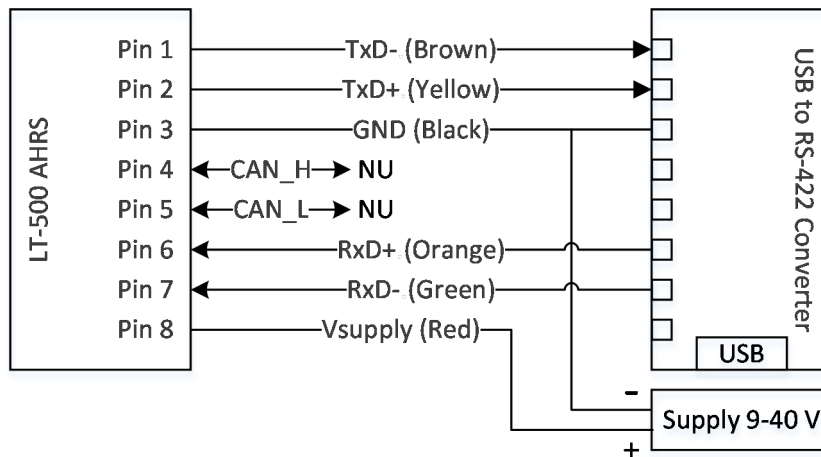
FIGURE 22: USB TO RS-422 CONVERTER PROVIDING THE COMMUNICATION LINK BETWEEN THE PC (LT-SERVICE TOOL) AND THE LT-500 AHRS.

NOTE: Windows may wrongfully recognize an USB to Serial device, as a mouse, if the device is transmitting when being plugged into the PC. Avoid this by giving Windows time to recognize the USB to Serial device before powering up the LT-500 AHRS.

Serial Port (RS-422)

The LT-Service Tool can be connected to the LT-500 AHRS via a RS-422 interface as illustrated in Figure 23.

NOTE: The RS-422 interface is using both Tx and Rx transmission lines (balanced/differential) and is therefore a more robust communication link than the RS-232 interface. The LT-500 AHRS is supporting both RS-422 and RS-232 communicating link to the LT-Service Tool.

FIGURE 23: RS-422 (BALANCED) SERIAL INTERFACE PROVIDING THE COMMUNICATION LINK BETWEEN THE LT-SERVICE TOOL AND THE LT-500 AHRS.

Serial port (RS-232)

 The LT-Service Tool can be connected to the LT-500 AHRS via a RS-232 interface as illustrated in Figure 24.

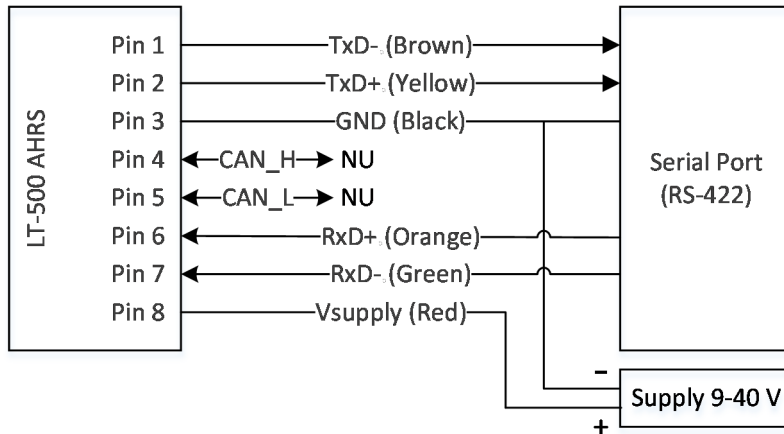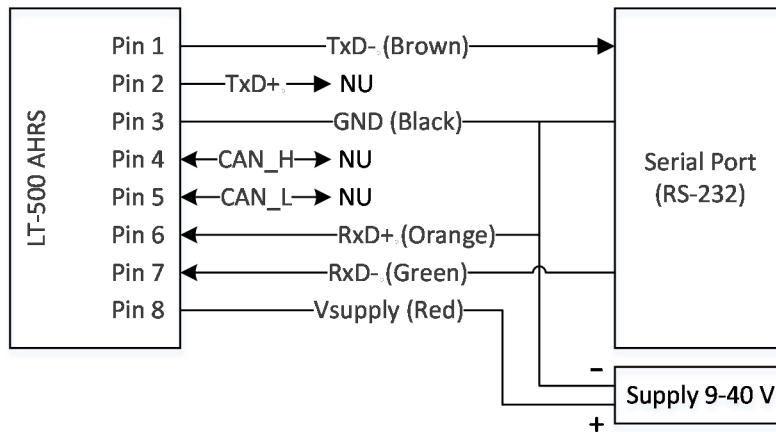FIGURE 24: RS-232 (UNBALANCED) SERIAL INTERFACE PROVIDING THE COMMUNICATION LINK BETWEEN THE LT-SERVICE TOOL AND THE LT-500 AHRS.

NOTE: When using the RS-232 (unbalanced) serial communication link, it is important that the RxD-signal level from the serial port is > 5 VDC for proper operation.

Configuration

This chapter describes how to configure the LT-500 AHRS. The LT-500 AHRS can be configured via the built-in MMI interface (see *MMI Description* on page 25) or via the LT-Service Tool (see *LT-Service Tool* on page 28).

The following configurations are described in this chapter:

- NMEA 0183 baud rate
- NMEA 2000 termination
- Attitude filter
- Deviation calibration & options
- Variation
- Auto level
- Heading offset
- Roll offset
- Pitch offset
- Vertical offset
- NMEA 0183 sentences (not available in the MMI)
- Factory default

NMEA 0183 Baud rate

The NMEA 0183 baud rate can be configured to 4800 or 38400 baud.

NMEA 0183 Baud rate			
Configuration	**Options**	**Default**	**Comments**
Baud rate	4800 or 38400	4800	MMI: Setup -> NMEA 0183 Baud rate

TABLE 5: LT-500 AHRS CONFIGURATION OF NMEA 0183 BAUD RATE.

NOTE: Changing the baud rate will reset sentence configuration to default for that baud rate.

NMEA 2000 Termination

The NMEA 2000 can be configured to 'Open' or 'Terminated'. See *NMEA 2000 Installation* on page 14 for further details on whether the LT-500 AHRS shall be connected with a drop cable ('Open') or directly to the backbone ('Terminated').

NMEA 2000 termination			
Configuration	**Options**	**Default**	**Comments**
Termination	Open or Terminated	Open	MMI: Setup -> NMEA 2000 Open/Term

TABLE 6: LT-500 AHRS CONFIGURATION OF NMEA 2000 TERMINATION.

Attitude filter

The attitude data from the LT-500 AHRS (heading, roll, and pitch) can be low-pass filtered for a more smooth data presentation. The same attitude filter configuration will be applied respectively on the NMEA 0183 and NMEA 2000 interface. The time constant can be varied from 0.0 to 9.9 seconds.

Attitude Filter			
Configuration	**Options**	**Default**	**Comments**
Attitude filter	0.0 to 9.9 s.	0.0 s.	MMI: Setup -> Attitude filter

TABLE 7: LT-500 AHRS CONFIGURATION OF ATTITUDE FILTER.

Deviation calibration & options

The deviation calibration can be configured to On, Off or Reset.

Calibration			
Configuration	**Options**	**Default**	**Comments**
Calibration	On, Off or Reset	On	MMI: Setup -> Deviation -> Calibration

TABLE 8: LT-500 AHRS CONFIGURATION OF DEVIATION CALIBRATION.

Deviation calibration is per default On. After a successful deviation calibration, the deviation calibration can be switched Off, and hereafter the deviation calibration will not be overwritten. It is also possible to Reset the deviation calibration (remove the calibration). Deviation calibration is described in details in *Deviation calibration* on page 22.

No cal res

Per default, the LT-500 AHRS will output heading with a resolution of 5 degrees, when the unit has no valid calibration (e.g. initially or after reset).

No Cal Res			
Configuration	**Options**	**Default**	**Comments**
No cal res	5° or 0.1°	5°	MMI: Setup -> Deviation -> No cal res

TABLE 9: LT-500 AHRS CONFIGURATION OF DEVIATION CALIBRATION NO CAL RES.

To suppress the 5 degrees heading resolution, the No cal res can be configured to '0.1°'.

Update notify

Completion of a successful deviation calibration is indicated by pausing the heading output for 15 seconds.

Notify Update			
Configuration	**Options**	**Default**	**Comments**
Notify update	Yes or No	Yes	MMI: Setup -> Deviation -> Notify update

TABLE 10: LT-500 AHRS CONFIGURATION OF DEVIATION CALIBRATION NOTIFY UPDATE.

The 15 seconds heading pause can be disabled by changing the notify update to 'No'.

Variation

The variation can be configured to Off, User, or Auto.

Variation			
Configuration	**Options**	**Default**	**Comments**
Variation	Off, User or Auto	Off	MMI: Setup -> Variation

TABLE 11: LT-500 AHRS CONFIGURATION OF VARIATION.

Variation is per default configured to Off. If Variation is configured to Auto, and position and time is received on either NMEA 0183 or NMEA 2000, the unit will calculate the variation and output true heading. An alternative to Auto is to manually enter the variation by selecting User and supply a static variation. Further details on configuration of the variation and heading output data is available in *App. F – Variation Modes* on page 39.

Auto level

The auto level function has the following modes: Run or Reset.

Auto level			
Configuration	**Options**	**Default**	**Comments**
Auto level	Run or Reset	NA	MMI: Setup -> Auto level

TABLE 12: LT-500 AHRS AUTO LEVEL FUNCTION.

IMPORTANT: The Auto level function shall always be applied. Make sure that pitch and roll output is stabilized (ship is not moving) and constant before applying the Auto level function.

NOTE: After applying the Auto level function, it is always required to perform a new deviation calibration.

The auto level function is explained in more details in *App. G – Auto Level* on page 40.

Heading offset

The LT-500 AHRS can configure a heading offset.

Heading offset			
Configuration	**Options**	**Default**	**Comments**
Heading offset	±180.0°	+000.0°	MMI: Setup -> Heading offset

TABLE 13: LT-500 AHRS CONFIGURATION OF HEADING OFFSET.

Heading offset can be applied after (or before) the deviation calibration has been completed. The heading offset compensate for a possible installation offset in the heading direction. A heading offset adjustment will not require a new deviation calibration.

Roll offset

The LT-500 AHRS can configure a roll offset.

Roll offset			
Configuration	**Options**	**Default**	**Comments**
Roll offset	±10.0°	+00.0°	MMI: Setup -> Roll offset

TABLE 14: LT-500 AHRS CONFIGURATION OF ROLL OFFSET.

Roll offset can be applied after the 'auto level' function. A roll offset adjustment will not require a new deviation calibration.

Pitch offset

The LT-500 AHRS can configure a pitch offset.

Roll offset			
Configuration	**Options**	**Default**	**Comments**
Pitch offset	±10.0°	+00.0°	MMI: Setup -> Pitch offset

TABLE 15: LT-500 AHRS CONFIGURATION OF PITCH OFFSET.

Pitch offset can be applied after the 'auto level' function. A pitch offset adjustment will not require a new deviation calibration.

Vertical offset

The LT-500 AHRS can configure a vertical offset.

Vertical offset			
Configuration	**Options**	**Default**	**Comments**
Vertical offset	±99 m. / ft.	+00.0 m.	MMI: Setup -> Vertical offset

TABLE 16: LT-500 AHRS CONFIGURATION OF VERTICAL OFFSET.

Vertical offset can be applied anytime. The vertical offset compensates the pressure output. If the LT-500 AHRS is installed, e.g. +5 meters above sea level, then a vertical offset of +5 meters shall be applied for the pressure output to be adjusted to sea level.

NMEA 0183 Sentences

From factory, the LT-500 AHRS has a default NMEA 0183 sentence configuration that determines which sentences are output at a given baud rate (4800 and 38400), their rate, and talker ID. Using the LT-Service Tool, sentences can be enabled/disabled, and their rate and talker ID configured.

NMEA 0183 Sentences			
Configuration	**Options**	**Default**	**Comments**
NMEA 0183	Enable or disable	See comments	See *App. D - NMEA 0183 Sentences*
Talker ID	XX	HC	User defined (e.g. HC, HE, HN, etc.)
Output rate	0.1 to 40 Hz	See comments	See *App. D - NMEA 0183 Sentences*

TABLE 17: LT-500 AHRS NMEA 0183 SENTENCES.

The default configuration of the NMEA 0183 sentences for respectively 4800 and 38400 baud is illustrated in *App. D - NMEA 0183 Sentences* on page 36.

NOTE: If changing the NMEA 0183 baud rate, the NMEA 0183 sentences configuration will be reset to factory default.

The LT-Service Tool is providing support and guidance when configuring the NMEA 0183 sentences. The LT-Service Tool is providing some functions to verify the correct configuration of the NMEA 0183 sentences:

- stat -> analyzing function showing statistics, hereunder utilization of bandwidth
- mon -> dumping the NMEA 0183 data, to visualize data stream

Example on the LT-Service Tool NMEA 0183 sentences configuration (syntax):

<div align="center">lt>nmea0183 sentences HCHDT:100 HCROT:100</div>

Additional help can be found in the LT-Service Tool by writing help in front of the command.

Factory Default

The factory default configuration can always be used to reset the LT-500 AHRS back to the default configuration and originally starting point.

Factory Default			
Configuration	**Options**	**Default**	**Comments**
Factory default	Activate	See *Configuration* on page 17	MMI: Setup -> Factory reset

TABLE **18: LT-500 AHRS** FACTORY DEFAULT.

After the factory default configuration has been activated, the user configurations will be deleted and default configuration will be restored.

Deviation calibration

The magnetometer sensors in the LT-500 AHRS may be affected by magnetic disturbances from the vessel, which needs to be corrected in order to deliver magnetic heading (and thus true heading). The source of these magnetic disturbances could be, but not limited to; engines, power cables, etc. This discrepancy between magnetic and compass heading is called the "deviation".

Deviation will cause incorrect heading data if not compensated. To compensate for deviation, it is necessary to complete a deviation calibration of the magnetometers, after installation of the LT-500 AHRS.

NOTE: The LT-500 AHRS will indicate absence of a valid calibration by outputting heading (true and magnetic) with a 5 degrees resolution. When a calibration has been successful, the heading will be output with full resolution.

Calibration pattern

**End
calibration**

Step 4

Sail straight:
±5° for min. 10 s.
SOG: 2-12 knots

Step 3

Make circle:
360°-450°
ROT: 2-6°/s.
SOG: 2-12 knots

Step 2

Make circle:
360°-450°
ROT: 2-6°/s.
SOG: 2-12 knots

Step 1

Start
calibration

Sail straight:
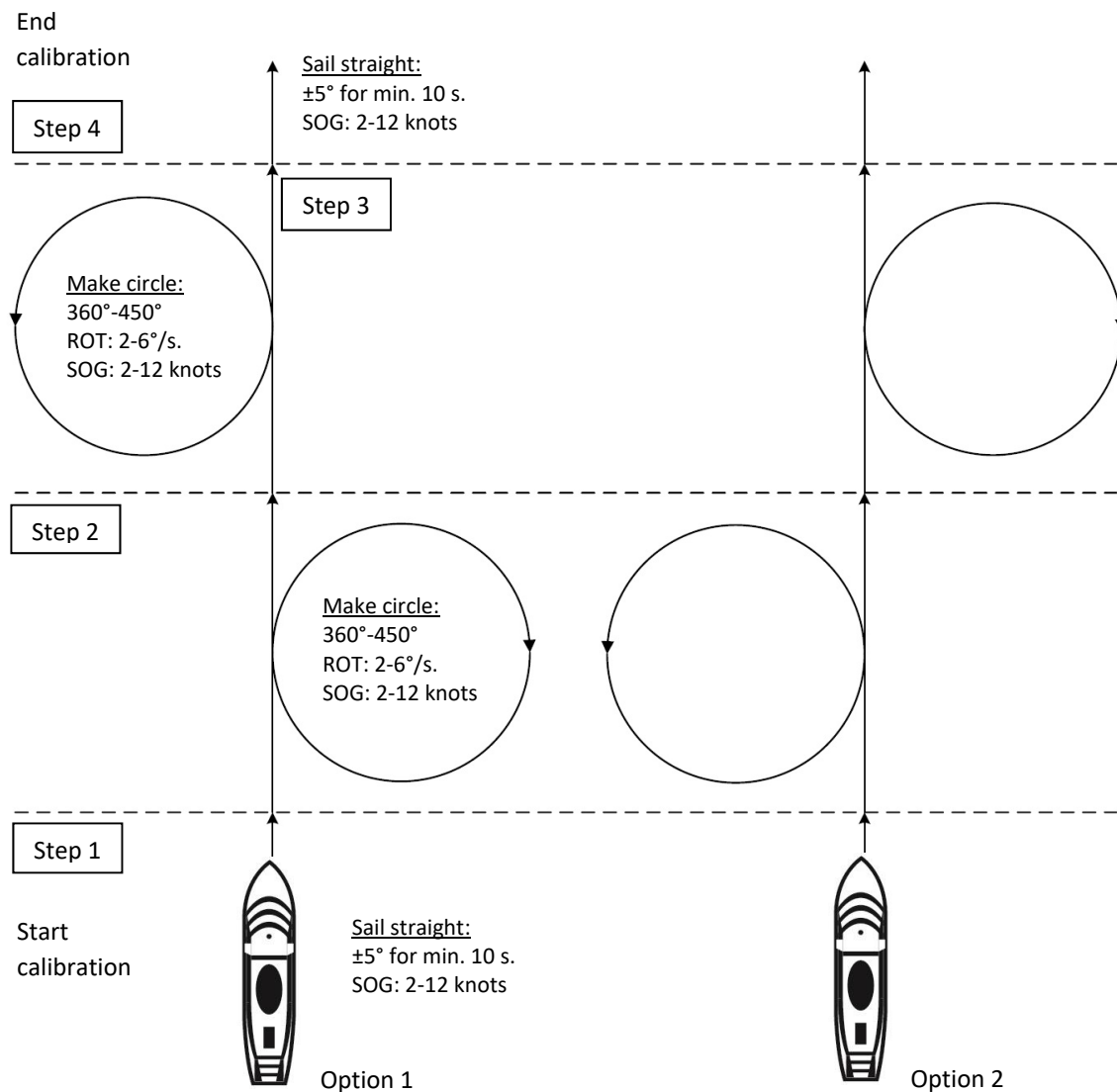±5° for min. 10 s.
SOG: 2-12 knots

Option 1

Option 2

FIGURE 25: DEVIATION CALIBRATION FOR THE **LT-500 AHRS** (OPTION **1** OR **2**)

Calibration procedure

The auto level of pitch and roll has to be completed prior to the deviation calibration. The calibration must be performed in open and calm waters, and will determine the ship's influence on the magnetic sensors.

The LT-500 AHRS will automatically perform a calibration when it detects the vessel is sailing a specific pattern. To trigger a calibration, guide the vessel through the patterns (option 1 or 2), which are illustrated in Figure 25.

NOTE: The best result is achieved at low speed (SOG), low rate of turn (ROT), and in calm waters.

Procedure (step by step):

Step 1:   Keep a steady course (± 5 degrees) for minimum 10 seconds
                 SOG: 2-12 knots

Step 2:   Make a full circle (360-450°) clockwise or counterclockwise
                 ROT: 2-6 degrees/second (1-3 minutes pr. circle)
                 SOG: 2-12 knots

Step 3:   Make a full circle (360-450°) in opposite direction
                 ROT: 2-6 degrees/second (1-3 minutes pr. circle)
                 SOG: 2-12 knots

Step 4:   Keep a steady course (± 5 degrees) for minimum 10 seconds
                 SOG: 2-12 knots

If the calibration fails, please repeat step 1 to 4 again.

NOTE: In order to get the best possible heading accuracy on the LT-500 AHRS, it is required to compensate for the heading mounting offset. The heading offset can be configured from the MMI interface, see *MMI Description* on page 25.

IMPORTANT: If the LT-500 AHRS is physically moved or rotated, it is required to perform a new calibration. The deviation calibration will not be valid, if the LT-500 AHRS has been moved after completed deviation calibration.
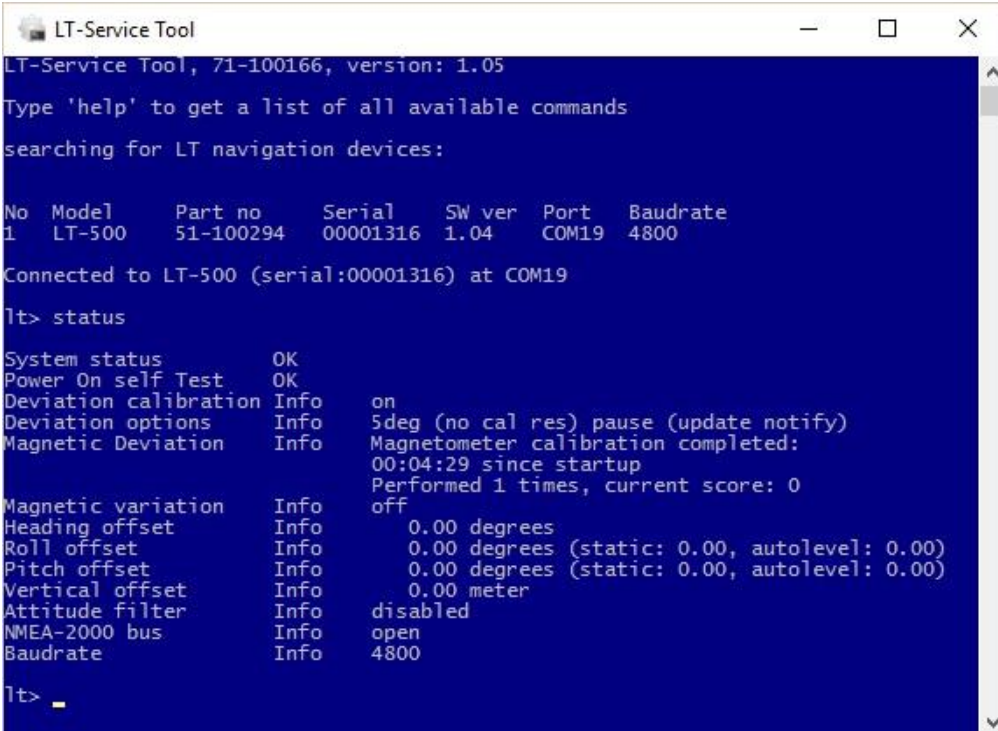
NOTE: The LT-500 AHRS has a MMI interface, from where the deviation calibration can be reset (for further details, see *MMI Description on page* 25). If resetting the deviation calibration, the LT-500 AHRS heading will be in 5 degrees resolution, indicating no valid calibration. After a new successful deviation calibration, heading is output in full resolution.

NOTE: In order to verify that a subsequent deviation calibration has succeeded, see *Verify a subsequent deviation calibration* on page 24.

Verify a subsequent deviation calibration

There are three ways to verify a sub-sequent deviation calibration:

- After a successful deviation calibration (the new deviation calibration is stored in the unit), the LT-500 AHRS will suspend the heading output for 15 seconds. The suspension of the heading output should be possible to see on navigation heading displays, which are connected to the LT-500 AHRS.

- Use the LT-500 AHRS MMI interface (MMI: Status->Deviation cal) to check for deviation calibration status. When no calibration is available in the LT-500 AHRS, the unit will display 'None'. After a successful deviation calibration, the LT-500 AHRS will display 'Ok (1)', which indicate that one successful calibration has been stored. Subsequent deviation calibrations will be presented as 'Ok (2)', etc.

- Use the following LT-Service Tool command: "status". The status command will display the latest deviation calibration with a timestamp. If the LT-500 AHRS did not receive GPS time from external source at the time of calibration, the timestamp will be time passed between calibration and last power cycle.

FIGURE 26: THE **LT-SERVICE TOOL** COMMAND 'STATUS' SHOWING THE NUMBER OF DEVIATION CALIBRATIONS (~MAGNETIC) SUCCESSFULLY COMPLETED.

MMI Description

The LT-500 AHRS has a built-in MMI interface, which is illustrated in Figure 27. The MMI interface consists of LEDs, five push buttons, and a display. All relevant functions to be used under installation, calibration, and operation can be accessed and controlled via this MMI interface.
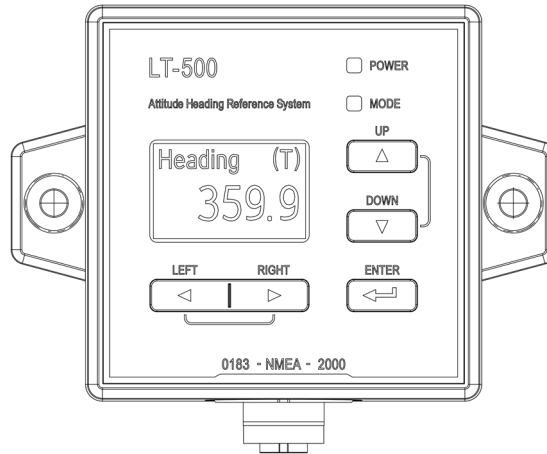
FIGURE 27: LT-500 AHRS ILLUSTRATING THE BUILT-IN MMI

LEDs

The color code and description of the LEDs are illustrated in Table 19.

LT-500 AHRS LEDs Color Description		
Power LED	**Mode LED**	**Description**
On	Off	Power on unit.
On	On	Power on Unit. Error present. Check *Troubleshooting* on page 30 to resolve the problem. Connect the LT-Service Tool to read-out details from the LT-500 AHRS, see *Connecting LT-Service Tool* on page 15.
Off	NA	No power on unit (check whether the Green LED has been turned off)

TABLE 19: LT-500 AHRS LED COLOR CODE AND DESCRIPTION

Buttons

The push buttons have two modes: Navigation and Edit mode, which is illustrated in Figure 28. A description of the push buttons is available in Table 20.
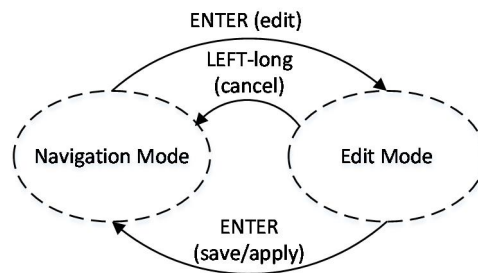
FIGURE 28: PUSH BUTTONS MODES

Push Buttons Description		
Buttons	**Modes**	
	Navigation	**Edit**
LEFT	Back to previous menu. (long press: back to start menu)	Left (long press: cancel)
RIGHT	Select sub-menu	Right
ENTER	Enter 'Edit' mode	Save or apply changes
UP	Navigate up in current menu	Increase number
DOWN	Navigate down in current menu	Decrease number

TABLE 20: LT-500 AHRS PUSH BUTTONS DESCRIPTION.

Display and Menu Layout

The display content can be divided into the following sub-menus:

- Output data   view of navigation output data
- Settings   user settings
- Setup   installation options
- Status   calibration and SW version

NOTE: Auto dim is per default enabled and the backlight will be removed after 60 seconds of inactivity in the display. If the light from the green LED (power) is disturbing, then it is possible to turn it off. The red LED (mode) cannot be switched off. Brightness of the display and LEDs can manually be adjusted in the settings menu.

The LT-500 AHRS menu layout is illustrated in Figure 29.

LT-500 AHRS Menu Layout

1: Output data 'position' is only available in the menu, if position and time is received on either NMEA 0183 or NMEA 2000. For further details, see *App. F – Variation Modes* on page 39.

FIGURE 29: LT-500 AHRS MENU LAYOUT.

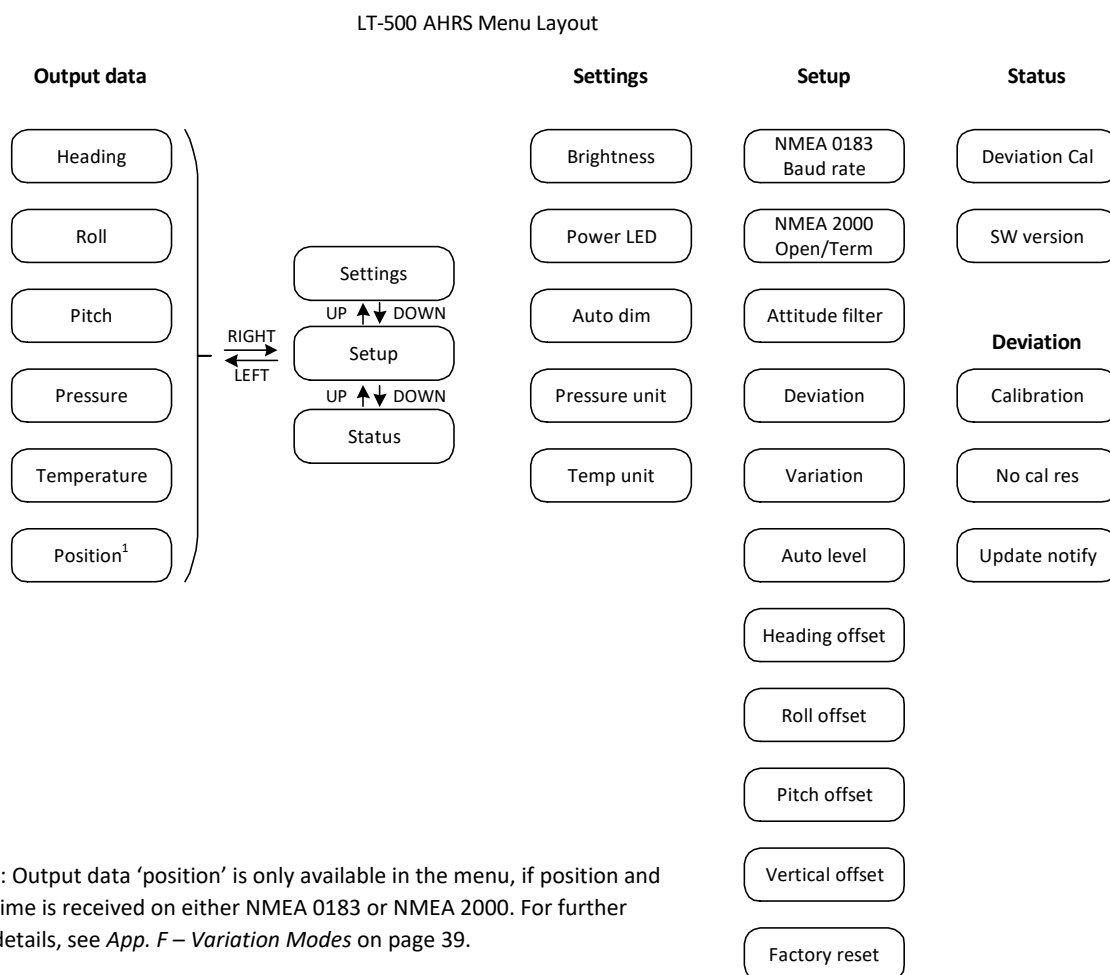**IMPORTANT**: The information 'Reboot Required' will be shown in the display, when a user action is required. The user will have to switch the power off and on before the changed configuration will be activated in the LT-500 AHRS.

Each of the functions in the settings, setup and status menus are described in details in Table 21.

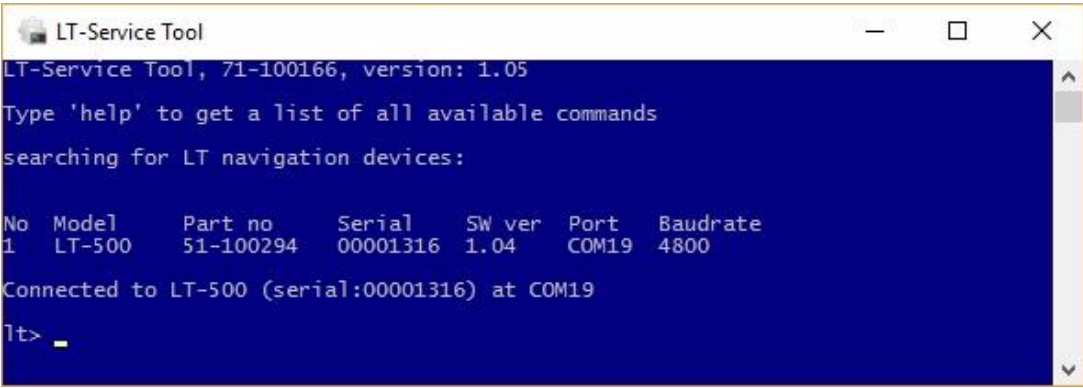| LT-500 AHRS – Settings & Setup Description			
Settings	**Options**	**Default**	**Notes**
Brightness	1 to 9	9	Adjustment of display and LED brightness.
Power LED	On / Off	On	The Power LED can be switch off, if the light from the LED is disturbing.
Auto dim	On / Off	On	Backlight can be configured to be constant on. Per default the backlight and LEDs will dim after 60 seconds.
Pressure unit	hPa / inHg	hPa	Display pressure unit can be changed between hPa and inHg.
Temp unit	°C / °F	°C	Display temp unit can be changed between °C and °F.
Setup	**Options**	**Default**	**Notes**
NMEA 0183 baud rate	4800 / 38400	4800	See *NMEA 0183 Baud rate* on page 17.
NMEA 2000 termination	Open / Term	Open	See *NMEA 2000 Termination* on page 17.
Attitude filter	0.0 to 9.9 s.	0.0	See *Attitude filter* on page 17.
Deviation			
Calibration	On / Off / Reset	On	See *Deviation* on page 18.
No cal res	5° / 0.1°	5°	See *Deviation* on page 18.
Update notify	Yes / No	Yes	See *Deviation* on page 18.
Variation	Off / Auto / User	Off	See *Variation* on page 19.
Auto level	Run / Reset	NA	See *Auto level* on page 19.
Heading offset	±180.0°	+000.0°	See *Heading offset* on page 19.
Roll offset	±10.0°	+00.0°	See *Roll offset* on page 19.
Pitch offset	±10.0°	+00.0°	See *Pitch offset* on page 20.
Vertical offset	±99.9 m. / ft.	+00.0 m.	See *Vertical offset* on page 20.
Factory reset	No / Yes	NA	Factory reset will reset all configuration values to default (deviation calibration will be reset as well).
Status	**Options**	**Default**	**Notes**
Deviation cal	NA	NA	Displays the number of successful deviation calibrations e.g., Ok (3). In this example 3 calibrations have been completed.
SW version	NA	NA	Displays the SW version e.g., 1.04R ('R' is indicating an official release candidate).

TABLE 21: LT-500 AHRS MMI MENU SETTINGS & SETUP DESCRIPTION.

LT-Service Tool

The LT-Service Tool is a PC program interfacing and communicating with LT-Navigation devices. The LT-Service Tool is communicating via the NMEA 0183 serial interface. The newest available LT-Service Tool will be available from the local dealer or distributor, see www.thrane.eu (Dealers & Distributors).

File name: LT-Service_vX.XX.exe

NOTE: The LT-Service Tool is an optional PC program, which can be used together with the LT-500 AHRS. It is possible to install the LT-500 AHRS and use it for navigational purposes, without configuration by the LT-Service Tool. Many of the LT-Service Tool settings and setup features can also be configured via the built-in MMI, see *MMI Description* on page 25. The LT-Service Tool is intended for installation and service by trained personnel.

FIGURE 30: THE LT-SERVICE TOOL WILL AUTOMATICALLY SEARCH FOR LT-NAVIGATION DEVICES, WHICH ARE CONNECTED TO THE PC. A MANUAL CONNECTION MODE IS ALSO AVAILABLE.

Identify a LT-Navigation device

The LT-Service Tool requires a bi-directional RS-422 balanced or RS-232 unbalanced serial interface in order to communicate with the LT-Navigation devices. The baud rate is either: 4800 or 38400 baud (configured in the LT-500 AHRS MMI interface, see *MMI Description* on page 25.

NOTE: It is recommended to use a 'USB to RS-422 converter' for easy interfacing in-between the PC (LT-Service Tool) and the LT-500 AHRS. Interconnection diagrams are illustrated in *Connecting LT-Service Tool* on page 15.

Automatic mode:

Step 1:   Double click on the LT-Service_vX.XX.exe file to start the program

Step 2:   The LT-Service Tool will automatically search all COM ports on the PC to identify potential LT-Navigation devices connected to the PC. Devices found, will be shown in a list, as illustrated in Figure 30.

Step 3:   If the LT-Service Tool finds more than one LT-Navigation device, then type the number of the device in the list to be connected with, e.g. "1" and "Return". If only one device is found, then the LT-Navigation device will automatically connect.

<u>Manual mode:</u>

Step 1:   Start cmd.exe (Windows command prompt).

Step 2:   Navigate to the directory where the LT-Service Tool is stored.

Step 3:   In the cmd prompt write: "LT-Service_vX.XX.exe –p COM25 –b 4800" to launch the program
                 (depends on the version of the LT-Service Tool (X.XX = 1.01), PC COM port, and the baud rate
                 for which the LT-500 AHRS is configured).

LT-Service Tool functions
The LT-Service Tool functions and commands are divided into three main groups:

- SETUP   The setup commands can be used for configuration of installation parameters
                       (most of these configuration options are also available from the MMI). The
                       configurations are described in *Configuration* on page 17.

- UTILITIES   The utilities commands are related to the navigation status of the unit,
                       especially verification of NMEA 0183 sentences.

- SYSTEM   The system commands are supporting general support related issues e.g.
                       upload of firmware, configuration status, health status of unit, etc.

LT-Service Tool commands
All available commands in the LT-Service Tool are listed when using the "help" command, see *App. H – LT-Service Tool (commands) on page* 41.

Some of the most used commands are listed here:

"help"   Lists all commands supported by the LT-Service Tool and the LT-500 AHRS

"deviation calibration"   set mode to On, Off or Reset

"autolevel"   Levelling pitch and roll to zero (auto level function)

"heading <actual heading>" Calculates heading offset and compensate

"vertical offset <offset>" Compensate barometer to sea level

"nmea0183 sentences"   Configuration of NMEA 0183 sentences (enable/disable, talker ID, output rate)

"diag"   Generate a Diagnostic Report

"upload <filename>"   Upload a new application image (absolute or relative file path)

"reboot"   Reboot device (for configuration to take affect)

"post", "event" & "status" Prints Power On Self-Tests (POST), events (CM) and status

Troubleshooting

Before contacting the distributor or dealer for support, please check the following troubleshooting guide.

Troubleshooting guide:

1) Power cycle the unit to verify that the problem still exists

2) Is the communication cable properly connected?
   For more information on connecting cables, see *Connecting* on page 11.

3) Check the status of the LEDs.
   If everything is correct, the green LED shall lit and the red LED shall non-lit (check that the green LED has not been turned off). For further details on the LEDs, see *MMI Description* on page 25.

4) If using NMEA 0183:
   a. Check configuration of the NMEA 0183 baud rate.
      NMEA 0183: 4800 or 38400 baud (factory default: 4800 baud)
      For further details on the baud rate, see *MMI Description* on page 25.

   b. Check your navigation equipment for correct baud rate. Check that the LT-500 AHRS is supporting the expected NMEA 0183 Sentences; see *App. D - NMEA 0183* on page 36.

   c. Verify the NMEA 0183 sentences configuration (enable/disable, talker ID, output rate). The configuration of NMEA 0183 sentences are described in *NMEA 0183 Sentences* on page 20.

5) If using NMEA 2000:
   a. Check the configuration of the NMEA 2000 termination.
      NMEA 2000: 'Open' or 'Terminated' (factory default: 'Open')
      For further details on the NMEA 2000 termination, see *MMI Description on* page 25.

   b. Check your navigational equipment for correct selection of the LT-500 AHRS as preferred source (Heading, Environmental). Check that the LT-500 AHRS is supporting the expected NMEA 2000 PGNs; see *App. E - NMEA 2000* on 38.

6) If using the MMI interface:
      If any configurations has been applied in the MMI interface and the message 'Reboot Required' has been shown, then make sure that the power to the LT-500 AHRS has been switch off and on again for the configuration to be activated.

7) If using the LT-Service Tool:
      If any configuration has been applied in the LT-Service Tool, make sure that you have used the "reboot" command and check that the new configuration is properly configured after the LT-500 AHRS has power up again.

8) Connect the LT-Service Tool, see *Connecting LT-Service Tool* on page 15 and *LT-Service Tool on page 28*). Check and record the following commands in the LT-Service Tool:
   a. Write "status" and check for errors and warnings
   b. Write "nav" and verify navigation data is as expected
   c. Write "mon" to monitor NMEA 0183 output
   d. Write "stat" to evaluate the NMEA 0183 output

9) Use the "factory reset" command, to reset any configurations back to default. This command can be activated from the MMI interface, see *MMI Description* on page 25 (or from the LT-Service Tool).

If none of these troubleshooting steps have re-solved the problem, please contact your local distributor or dealer for further action and support.

NOTE: It is recommended, that the end-user makes contact to the local distributor or dealer for technical support on the product, as they have information and experience with the product.

Service and repair

This section describes what the end-user must do in case of required service or repair.

NOTE: The LT-500 AHRS does not require any scheduled maintenance or service. Make sure that the product is installed, as described in this manual, before making contact to the distributor or dealer for further assistance.

For troubleshooting the LT-500 AHRS, see *Troubleshooting* on page 30.

If the LT-500 AHRS for some reason does not work as described in this manual, make contact with the distributor or dealer, from where the product was originally bought. The distributor or dealer will have experience and know-how to assist with further technical support and troubleshooting.

Contacting the distributor/dealer:

1) Make sure to have the product name (LT-500 AHRS), Part Number (P/N: 51-100294), and the unit serial number (S/N: XXXXXXXX) identified. The unit serial number is mounted on the bottom of the device. Alternatively, use the LT-Service Tool to read-out the S/N.
2) Write a technical report about the observation or error. If possible, attach a picture of the installed product and include a wiring diagram. If possible, make a diagnostic report with the LT-Service Tool (see *LT-Service Tool* on page 28).
3) Send all information to the local distributor or dealer.

IMPORTANT: Unless otherwise agreed, the end-user shall always coordinate service and repair issues directly with the distributor or dealer. This practice also applies for returning of products for service and repair.

All information that will get back to Lars Thrane A/S, either directly or indirectly, will be handled with confidentiality. End-user sensitive data will not be shared with any third party without prior written acceptance from the involved parties.
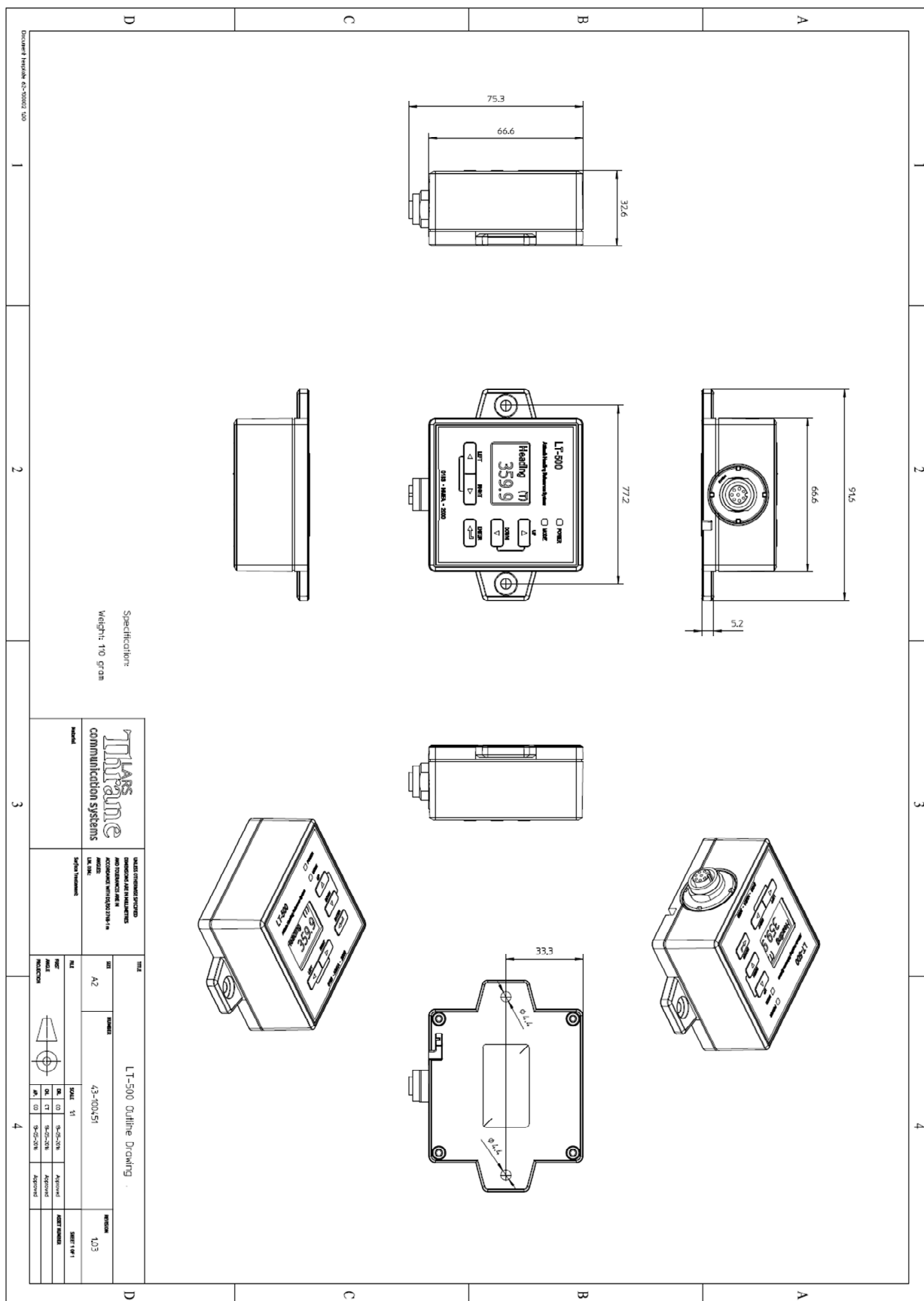
App. A - Outline Drawing

LT-500 AHRS

FIGURE 31: LT-500 AHRS LAYOUT DRAWING

App. B – Performance

LT-500 AHRS Performance[1]			
Data	**Accuracy**	**Resolution**	**Range/Comments**
Heading[2]	Static: < 0.5° (rms) Dynamic: < 1.5° (rms)	0.1°	Heading is calculated with input from Sensor-fusion technology and Kalman filtering
Roll	Static: < 0.5° (rms)	0.1°	± 180°
Pitch	Static: < 0.5° (rms)	0.1°	± 90°
Rate of turn	< 1°/s	0.1°/s	0 to 45°/s
Air Pressure	1 hPa	0.1 hPa	800 to 1100 hPa
Temperature[3]	1°C (1.8°F) 2°C (3.6°F)	0.1°C (0.1°F)	0°C to +55°C (32°F to +131°F) -25°C to 0°C (-13°F to +32°F)

1: The LT-500 AHRS performance may be subject to degradation caused by an improper installation. For best performance, the LT-500 AHRS shall be mounted in the horizontal plane (if the LT-500 AHRS is not mounted in the horizontal plane, a little degradation can be seen in the temperature min and max areas).

2: The dynamic heading accuracy is specified with roll/pitch less than ± 45° and ROT ≤ 45°/s.

3: Environmental conditions will affect the measured air temperature (accuracy is specified as on-board sensor performance)

App. C – Specifications

<table>
<tr><td colspan="2" align="center">LT-500 AHRS Specifications</td></tr>
<tr><td>Certification and standards</td><td>CE, IEC 60945, IEC 60950-1,
FCC, IC, RCM (C-Tick), RoHS,
NMEA 0183, NMEA 2000</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Equipment class</td><td>Protected, according to IEC 60945</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Weight</td><td>104 g (0.23 lbs)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Dimensions</td><td>91.6 x 75.3 x 32.7 mm (3.61 x 2.96 x 1.29 in)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Temperature, operational (ambient)</td><td>-25°C to +55°C (-13°F to +131°F)</td></tr>
<tr><td>Temperature, storage (ambient)</td><td>-30°C to +85°C (-22°F to +185°F)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Vibration, operational</td><td>IEC 60945 (sine) & Proprietary Maritime Random profile (240 h)</td></tr>
<tr><td>Vibration, survival</td><td>Properitary Maritime Random profile (100 h)</td></tr>
<tr><td>Vibration, shock</td><td>Proprietary Maritime profile (100 g pk, 11 ms)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Waterproof rating</td><td>IP42</td></tr>
<tr><td>Humidity</td><td>95% non-condensing @ 40°C</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Communication interface</td><td>8-pin female connector for NMEA 0183, NMEA 2000, and power</td></tr>
<tr><td>Input voltage</td><td>9-40 VDC</td></tr>
<tr><td>Power consumption</td><td>< 1 W (@ 12 VDC)</td></tr>
<tr><td>Load Equivalent Number (LEN)</td><td>2</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Compass safe distance standard</td><td>0.3 m (1 ft)</td></tr>
<tr><td>Compass safe distance steering</td><td>0.3 m (1 ft)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Warranty</td><td>2 year</td></tr>
<tr><td>Maintenence</td><td>None</td></tr>
</table>

App. D - NMEA 0183 Sentences

The LT-500 AHRS is compliant with version 4.00 of the NMEA 0183 standard. The following table lists the supported sentences.

NMEA 0183 Sentences		
Sentence	**Description**	**Rate**
4800 baud		
HCHDG[1]	Heading and Magnetic Heading Variation	1 Hz
HCHDM[1]	Magnetic Heading	1 Hz
HCHDT[1]	True Heading	10 Hz
HCROT	Rate of Turn	1 Hz
PFEC,GPatt[1]	Attitude	1 Hz
WIMDA[2]	Meteorogical Composite	0.5 Hz
38400 baud		
HCHDG[1]	Heading and Magnetic Heading Variation	10 Hz
HCHDM[1]	Magnetic Heading	10 Hz
HCHDT[1]	True Heading	10 Hz
HCROT	Rate of Turn	10 Hz
HCTHS[1]	True Heading and Status	10 Hz
PFEC,GPatt[1]	Attitude	10 Hz
WIMDA[2]	Meteorological Composite	2 Hz
WIXDR[3]	Transducer Measurements	2 Hz

1: The LT-500 AHRS can be configured to different variation modes, which affects the heading output. The variation modes are described in details in *App. F – Variation Modes* on page 39. This table represents the variation mode 'User' and 'Auto'. Factory default setting is variation mode 'Off'.
2: Pressure (inHg, Bar) and Air Temperature (°C) only
3: Pressure (Pa) and Temperature (C)

MDA sentence

The Meteorological Composite (MDA) sentence can convey more information about the environment than the LT-500 AHRS supports. In compliance with the NMEA 0183 standard, data fields for which LT-500 AHRS has no data will be null fields.

Here is an example of an MDA sentence outputted from an LT-500 AHRS containing air pressure and air temperature:

$WIMDA,29.29,I,0.9918,B,19.8,C,,C,,,,C,,T,,M,,N,,M*23

XDR sentence

The XDR sentence Transducer ID field is not standardized by the NMEA 0183 standard and is thus proprietary. Lars Thrane A/S has defined the following proprietary Transducer IDs:

XDR Proprietary Transducer ID's		
Transducer ID	**Transducer**	**Unit**
ATMO	Pressure (P)	Pascal (P)
TEMP	Temperature (C)	Celcius (C)

TABLE 22: XDR TRANSDUCER ID'S

Here is an example of an XDR sentence outputted from an LT-500 AHRS containing air pressure and air temperature:

$WIXDR,P,99178,P,ATMO,C,19.8,C,TEMP*6B

App. E - NMEA 2000 PGNs

The LT-500 AHRS is compliant with version 2.000 of the NMEA 2000 standard and version 2.000 of the NMEA Network Database. The following table lists the supported PGNs.

NMEA 2000 PGNs		
PGN	**Description**	**Rate**
Periodic PGNs		
126993	Heartbeat	< 0.1 Hz
127250[1]	Vessel Heading	10 Hz
127251	Rate of Turn	10 Hz
127257	Attitude	10 Hz
127258[1]	Magnetic Variation	1 Hz
130311[2]	Environmental Parameters	2 Hz
130312[2]	Temperature	0.5 Hz
130314	Actual Pressure	0.5 Hz
130316[2]	Temperature, Extended range	0.5 Hz
Requestable PGNs		
126464	PGN List (Transmit and Receive)	-
126996	Product Information	-
Oher PGNs		
059392	ISO Acknowledgement	-
059904	ISO Request	-
060928	ISO Address Claim	-
126208	NMEA Request/Command/Acknowledge	-

1: The LT-500 AHRS can be configured to different variation modes, which affects the heading output. The variation modes are described in details in *App. F – Variation Modes* on page 39. This table represents the variation mode 'Auto', where Magnetic Variation is transmitted. Factory default setting is variation mode 'Off'.
2: Temperature is reported as "Inside" temperature.

App. F – Variation Modes

The LT-500 AHRS can be configured to the following variation modes: 'Off' (factory default), 'User', and 'Auto'. The three different variation modes are further described in Table 23, with respect to heading output. In 'Off' mode only magnetic heading will be outputted. In 'User' & 'Auto' modes, both true heading and magnetic heading will be outputted.

Variation Modes and Heading Output					
Mode	**NMEA 0183**			**NMEA 2000**	
	Sentence	**4800 baud**	**38400 baud**	**PGN**	**Data**
Off	HDG	1 Hz (no variation data)	10 Hz (no variation data)	127250 (Vessel Heading)	10 Hz (magnetic heading)
	HDM	10 Hz	10 Hz	127258 (Magnetic Variation)	not transmitted
	HDT	not transmitted	not transmitted		
	THS	not transmitted	not transmitted		
	PFEC,GPatt	1 Hz (no yaw data)	10 Hz (no yaw data)		
User	HDG	1 Hz (variation data)	10 Hz (variation data)	127250 (Vessel Heading)	10 Hz (true heading)
	HDM	1 Hz	10 Hz	127258 (Magnetic Variation)	not transmitted
	HDT	10 Hz	10 Hz		
	THS	not transmitted	10 Hz		
	PFEC,GPatt	1 Hz (yaw data)	10 Hz (yaw data)		
Auto	HDG	1 Hz (variation data)	10 Hz (variation data)	127250 (Vessel Heading)	10 Hz (true heading)
	HDM	1 Hz	10 Hz	127258 (Magnetic Variation)	1 Hz
	HDT	10 Hz	10 Hz		
	THS	not transmitted	10 Hz		
	PFEC,GPatt	1 Hz (yaw data)	10 Hz (yaw data)		

TABLE 23: LT-500 AHRS VARIATION MODE AND HEADING OUTPUT.

NOTE: The variation modes can be configured from the LT-500 AHRS MMI interface (see *MMI Description* on page 25).

If the variation mode is configured to 'Auto', then requirements for receiving position and time data on NMEA 0183 and NMEA 2000 is listed in Table 24 and Table 25. The LT-500 AHRS will calculate the variation based on the WMM model, with input from position and time data.

NMEA 0183 Data Input		
Sentence	**Description**	**Rate**
RMC	Recommended Minimum Specific GNSS Data	≥ 0.5 Hz

TABLE 24: NMEA 0183 POSITION AND TIME DATA.

NMEA 2000 Data Input		
PGN	**Description**	**Rate**
129029	GNSS Position Data	≥ 0.5 Hz

TABLE 25: NMEA 2000 POSITION AND TIME DATA.

NOTE: The LT-500 AHRS must be configured to variation 'Auto' in order to read position and time data from either NMEA 0183 or NMEA 2000. Position data will be available in the LT-500 AHRS MMI, if position and time data is received correctly.

App. G – Auto Level

In order for the LT-500 AHRS to be mounted in any position, it is required to align the physically installed unit with the ships horizontal plane and bow. This can be done by using the built-in 'auto-level' function and 'heading offset' function.

Auto level

The purpose of the auto-level function is to level out pitch and roll. Figure 32 is illustrating the Auto level function. By applying, the Auto level function, the LT-500 AHRS will transform the internal coordinate system to adapt to the horizontal plane of the ship. Pitch and roll should be equal to zero after using the Auto level function. The Auto level function is available from the MMI interface, see *MMI Description* on page 25.
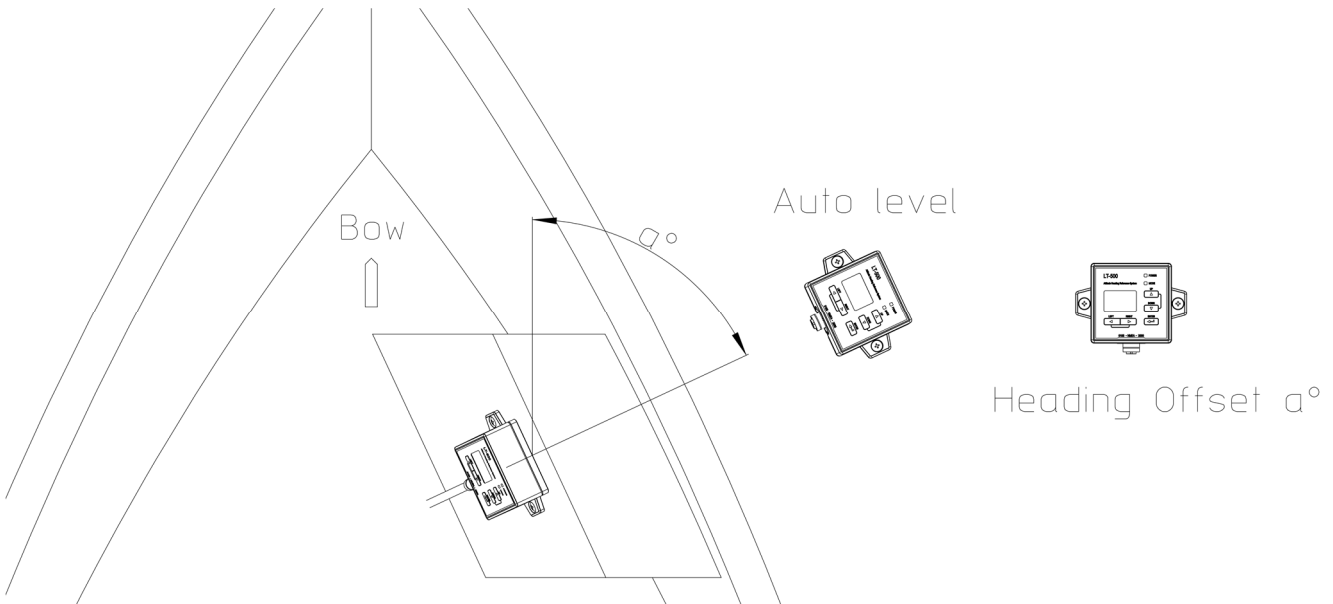
FIGURE 32: ILLUSTRATION OF 'AUTO-LEVEL' AND 'HEADING OFFSET' ADJUSTMENTS.

NOTE: The purpose of the auto level function is to level pitch and roll to zero. The LT-500 AHRS can be mounted up-side-down, or any other position and still provide valid output; in which case it is possible to configure a heading offset (a°).

Heading offset

After applying the Auto level function a heading offset might be present for the installed LT-500 AHRS. The purpose of the heading offset function is to align the LT-500 AHRS with the bow of the ship (direction of sailing). The heading offset function can be applied before or after completing the deviation calibration. The heading offset function is supported from the MMI interface, see *MMI Description* on page 25.

NOTE: The LT-500 AHRS Auto level and heading offset functions are graphically illustrated in Figure 32. After fastening the LT-500 AHRS, the unit shall not be un-screwed. The Auto level and heading offset functions are built-in software features.

IMPORTANT: If the auto level function has been applied, a new deviation calibration is always required. The deviation calibration procedure is described in details in *Deviation calibration* on page 22.

App. H – LT-Service Tool (commands)

FIGURE 33: LT-SERVICE TOOL SCREEN DUMP (HELP COMMAND OUTPUT).

App. I - Declaration of Conformity

68-100430 Rev. 1.00

LARS Thrane
communication systems

Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer

Manufacturer: Lars Thrane A/S

Address: Stubbeled 2, 2950 Vedbæk, Denmark

Product Identification: LT-500   Attitude Heading Reference System (AHRS) PN = 51-100294

Product Description

The LT-500 AHRS is a small, compact, and very advanced unit with 11 precision sensors (magnetometers, gyros, accelerometers, barometer, and thermometer). With the use of sensor-fusion and Kalman filtering, the LT-500 AHRS outputs: true-heading, magnetic heading, roll, pitch, air pressure, and temperature real-time, with high precision and resolution.

The LT-500 AHRS is designed and built for the demanding and rough environment at sea and with an operational temperature (ambient) range from -40^{0}C to +55^{0}C (-40^{0}F and +131^{0}F).

Declaration

We as manufacturer declare that the above listed product complies with the specification of the EC directive 1999/5/EC. The conformity has been assessed according to the procedure detailed in Annex IV of the R&TTE Directive. The following harmonized standards were applied:

EMC: EN 301 489-1, v1.9.2 / EN 301 489-3, v1.6.1

Safety: EN 60950-1:2006+AC:2011+A11:2009+A1:2010+A12:2011+A2:2013 / EN 60945:2002

Tested by Cetecom GmbH (Germany)

Year of affixing the CE mark: 2016

Place and Date

Vedbæk, 28. April 2016

Peter Thrane, CEO
Lars Thrane A/S

CE

Lars Thrane A/S   www.thrane.eu

FIGURE 34: LT-500 AHRS DECLARATION OF CONFORMITY