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UM-8084-107
Lodestar AHRS Operation Manual

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1 U.S. Department of Commerce License

This product contains US Department of Commerce controlled items. As such the Lodestar, or Lodestar portion of the product, must not be removed from the housing, be disassembled or repaired outside of the terms and conditions detailed in the US Department of Commerce Re-Export Licence under which the product was sold. If any servicing or repair of the Lodestar, or Lodestar portion of the product is required consult your nearest Sonardyne office for the best current advice.

2 Lodestar AHRS Operation Manual

2.1 Introduction

This Installation Manual is intended to accompany the Lodestar training courses run by Sonardyne International Limited, but it can also be used in isolation or as a source of reference information. It has been written primarily as a guide for field engineers who have been given the task of installing either a surface or a sub-sea Lodestar AHRS on board a vehicle.

Note: - Please pay particular attention to section 4. Make sure the latest manuals and Lodestar Configuration Software are used.

Purpose of this manual

The purpose of this Installation Manual is to introduce the Lodestar Configuration Software and to guide through a typical Lodestar set-up. The text and instructions in this manual assume the Lodestar Configuration Software is installed on a PC.

The instructions in this manual help to:

- Configure the outputs from the Lodestar
- Confirm the Lodestar is decoding input from a GPS receiver successfully
- Set the default operating Latitude for the Lodestar
- Set the offset distances,
- Compensate for any mounting angles between the Lodestar and the vessel

2.2 What is the Lodestar AHRS?

The Lodestar Attitude and Heading Reference System (AHRS) is an inertial sensor that provides outputs of roll, pitch, heading, surge, sway and heave through serial communication links at update rates up to 100 Hz.

The Lodestar AHRS is a robust gyrocompass and, unlike some north-seeking aided inertial navigation systems, a real-time input of position is NOT a prerequisite for basic operation. However, Sonardyne strongly recommends the Lodestar is supplied with real-time Latitude and velocity compensation data from a GPS in circumstances where significant changes in Latitude or velocity can occur.

3 Output and Alignment

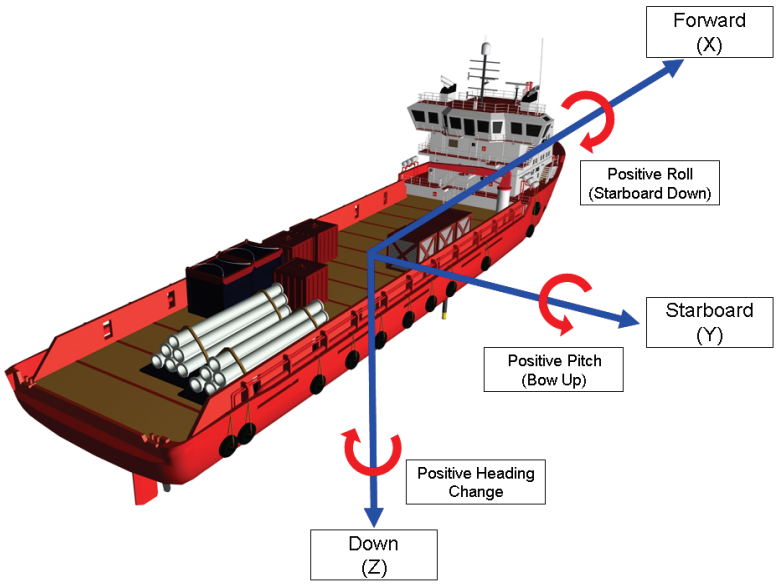
3.1 Lodestar Output and Alignment

The Lodestar frame convention is described in Figure 1. Unless otherwise stated for a particular output telegram (see AHRS Messages Specification UM-8084-109 A1 for further details). The Lodestar will output measurements with respect to this frame. Lodestar angular outputs are defined in Gravity (or Datawell) angles; see Appendix A for further details.

Before installing the Lodestar it is important to understand the concept of the vehicle reference frame. Often the chosen centre of a vehicle's reference frame is its centre of motion or mass and is usually defined and documented prior to the installation of equipment such as the Lodestar. The centre of the vehicle's reference frame is often referred to as the central reference point (CRP).

For most applications measurements are required with respect to the vehicle's reference frame. The definition of the Lodestar reference frame with respect to a vehicle is shown in Figure 1.

Figure 1 – Lodestar Reference Frame



The Lodestar frame is a fixed right-hand coordinate frame X Y Z. Typically Lodestar is mounted so the X axis is approximately coincident with vehicle forward; the Y axis is coincident with vehicle starboard; and the Z axis is coincident with vehicle down. Lodestar has the X and Y directions displayed on the top of the unit as an orientation aid during installation. Additionally, all measurements involving the Lodestar should be made with respect to the unit's centre of axis (see Lodestar Hardware Manual UM-8084-101).

In a typical installation, the Lodestar may not be perfectly aligned to the installation vehicle reference frame. In certain scenarios, this misalignment may not need to be corrected within the Lodestar, such as when using Sonardyne's CASIUS procedure which will calibrate external sensors used for USBL positioning.

Detailed explanations of the effect of misalignment are described in Appendix B. Methods for measuring fine misalignments of the Lodestar are described in Appendix C.

Should there be a need; the Lodestar can be configured to compensate small or large mechanical misalignments as described below.

Mounting angles

In some cases, for the Lodestar to output measurements that are correct for the vehicle reference frame, mounting angles in the three axes must be carefully measured and configured

The rotation sequence from a reference frame (vehicle) to the actual Lodestar frame is:

1. Rotation by the gamma (heading) angle about the Z axis of the reference frame.
2. Rotation by the beta (pitch) angle about the resulting Y axis.
3. Rotation by the alpha (roll) angle about the resulting X axis.

CAUTION	Only the misalignment for angle C (heading) can be measured independently. As explained above, the misalignments for angles B (pitch) and A (roll) are the resultant misalignments after the preceding misalignments have been applied.

Misalignment angles are specified as Euler angles; see Appendix A for further details.

The convention for measuring each misalignment angle is shown in Figure 2, Figure 3 and Figure 4.

Note: - To simplify the definition and convention of each misalignment angle, each angle is depicted independently but in practice they are non-commutative and must be measured in the order defined previously.

Figure 2 – Lodestar Mounting Angle Gamma (Heading) Example

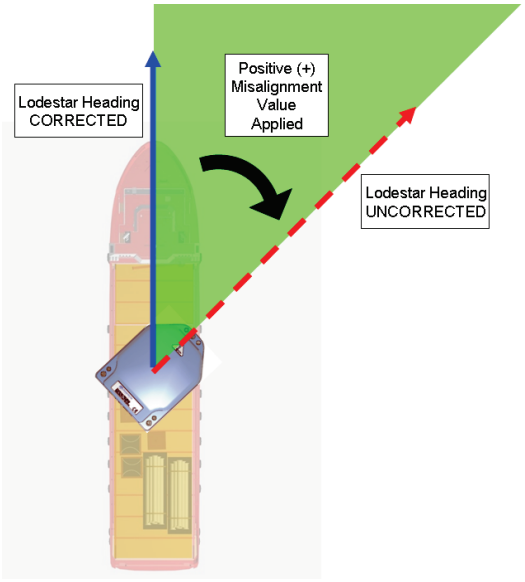


Figure 3 – Lodestar Mounting Angle Beta (Pitch) Example

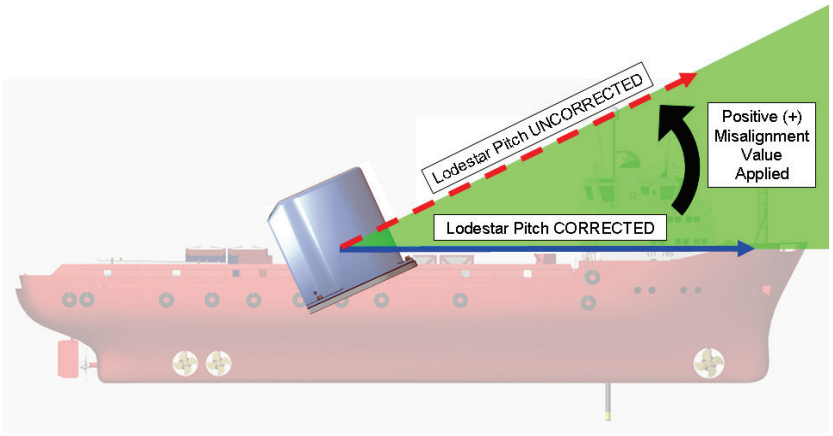
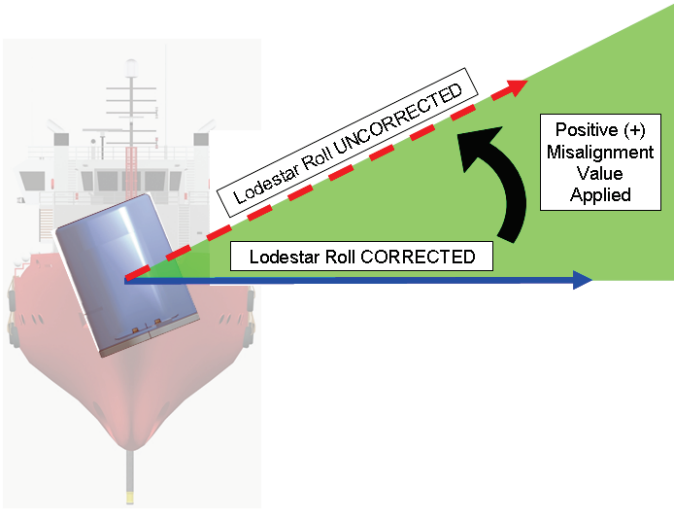


Figure 4 – Lodestar Mounting Angle Alpha (Roll) Example[1]



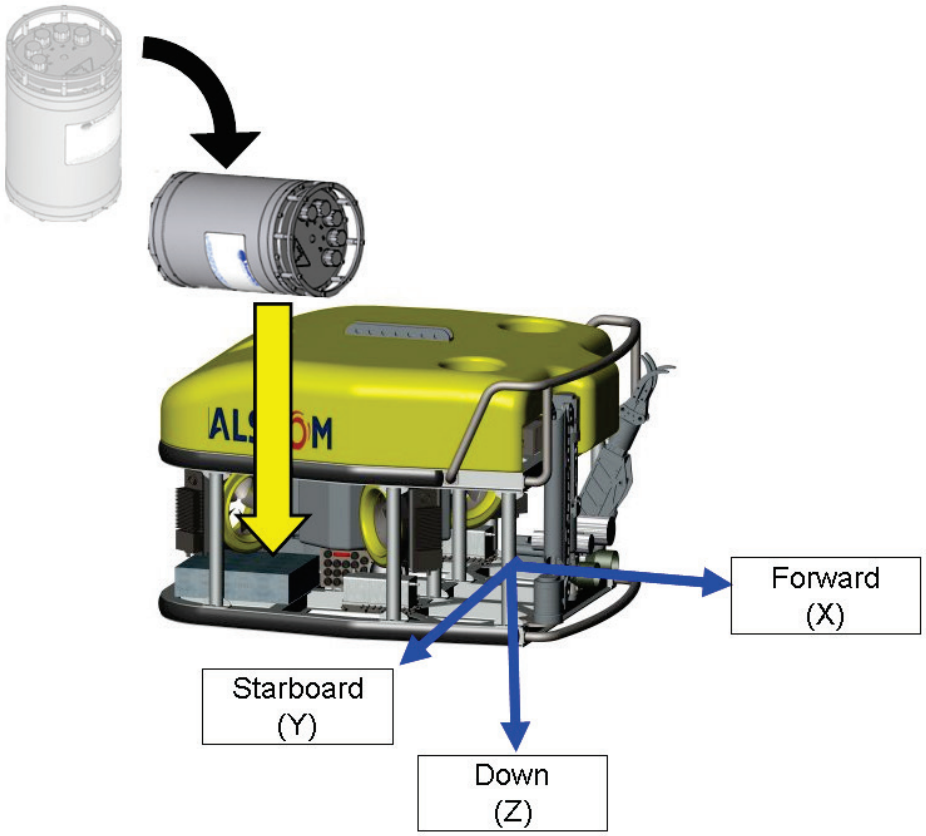
[1] Vessel view is 'bow-on'

Large Mounting Angles

In some cases, the Lodestar may be mounted with a large misalignment, e.g. horizontally.

In the example shown in Figure 5 the Lodestar is to be mounted horizontally on an ROV. The Lodestar has been pitched forward 90 degrees to be mounted horizontally; the X axis marking on the top of the Subsea Lodestar is now coincident with the Z axis of the vehicle's frame, pointing in the down direction. If no other rotations have been applied the resulting misalignment is -90° for misalignment angle **B**.

Figure 5 – Example ROV mounting of Subsea Lodestar

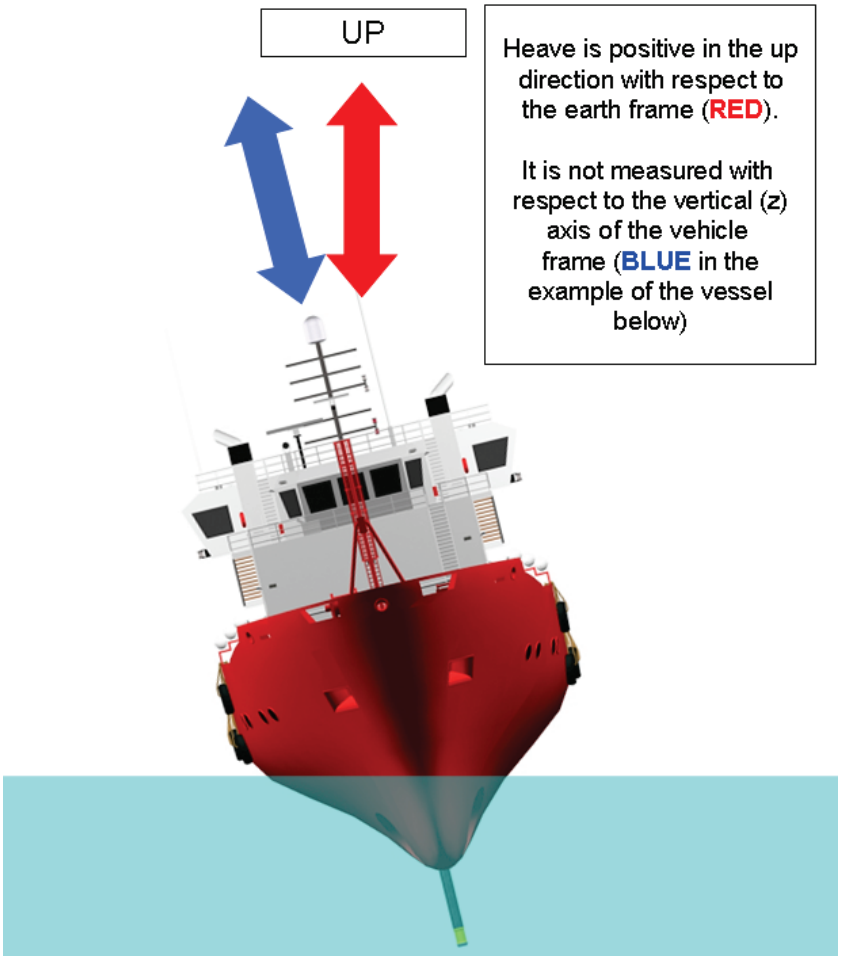


Heave, Surge and Sway

The heave, or vertical motion of the vehicle in the Earth up direction, is determined by the double integration of the vertical acceleration. A high pass filter is used to zero the systematic biases of the vertical position, which are a characteristic of the internal sensors. Similarly, the horizontal motions of the vehicle with zero mean in the X and Y axes respectively are surge and sway.

Heave is output with respect to the earth frame, rather than the vehicle frame, see Figure 6.

Figure 6 – Lodestar Heave Definition



Remote Heave

Some instruments on the vehicle may require heave compensation. It is likely that few, if any, of these instruments are installed very close to the centre of the vehicle frame, and so measurements of heave with respect to the vehicle CRP or the Lodestar may not be valid for those instruments.

If the Lodestar has information about the offset distances to a remote instrument, then it can calculate and supply measurements of remote heave for that instrument using remote vectors. The remote output will resemble what would be output if the Lodestar was installed in the remote location. Note that the closer to the remote location the Lodestar is situated, the more accurate the output will be.

The location of the remote point relative to the CRP must be measured in the vehicle axes pictured in Figure 1.

Remote Outputs

As with remote heave output the Lodestar can support other measurement outputs for remote points for selected telegrams.

A remote point can be specified as offset distances and angular misalignments with respect to the centre of the vehicle reference frame (CRP) in the following order.

1. Offset distances (X, Y and Z)
2. Misalignment Angles (A, B and C)

GPS Antenna

The GPS antenna offset must be measured from the centre of the vehicle reference frame (CRP) to the phase centre of the antenna.

Settling

Measurements of heading require the Lodestar firmware to identify the earth rotation, which it uses to determine the true north direction. This process does not happen instantaneously and the Lodestar's heading output does not achieve the accuracy quoted for it until the necessary settling time has elapsed.

Note: - The vessel does not need to be stationary during the short settling time.

4 Installation Preparation

4.1 Installation Preparation

Supplied items

Shipments of the surface Lodestar include the following items as standard:
☐ 1 × Console test cable CPN 820-0057
☐ 1 × Comms test cable CPN 820-0061
☐ 1 × Console cable tail CPN 820-0054
☐ 2 × Comms cable tails CPN 820-0096
☐ 2 × Transceiver cable tails CPN 820-0062
☐ 1 × Drilling template CPN 998-0138
☐ 1 × Laminated quick start guide sheet
☐ 1 × Installation disk with Lodestar Configuration Software and manuals CPN 620-7214

Shipments of the Subsea Lodestar include the following items as standard:
☐ 1 × Console test cable CPN 820-0067
☐ 1 × Comms (C1) test cable CPN 820-0070
☐ 1 × Console cable tail CPN 317-5383
☐ 2 × Comms cable tails CPN 317-5384
☐ 2 × Transceiver cable tails CPN 317-5404
☐ 1 × Drilling template CPN 998-0137
☐ 1 × Laminated quick start guide sheet
☐ 1 × Installation disk with Lodestar Configuration Software and manuals CPN 620-7214

Configuration requirements

The following items are required to help configure the Lodestar AHRS:

- A computer with two serial ports running windows XP
- The Lodestar Hardware manual (UM-8084-101)
- The Lodestar AHRS Messages Specification (UM-8084-109)
- The Lodestar Configuration Software
- Lodestar test cables

Configuration requirements

The following information will be required to complete the installation of Lodestar

- Lodestar mounting angles with respect to the vehicle frame
- Output requirements
- Remote heave offsets or output points with respect to the vehicle frame
- GPS input (optional in some scenarios, see below)
- GPS offsets with respect to the vehicle frame

GPS Input

The Lodestar requires real-time NMEA 0183 telegrams, derived from GPS, to compensate for changes in Latitude and velocity.

The NMEA GPGGA and GPVTG sentence formats provide the necessary information and should be supplied to Lodestar through an IEC 61162 compliant RS232 serial link, using an update rate of at least 1 Hz and preferably more than 5 Hz.

Note: - In some scenarios it may not be possible to supply a GPS input to Lodestar (e.g. mounting on a Subsea vehicle). In this case, it is important that the operating Latitude is

set manually. The process for configuring the Latitude is described later in this document.

GPS Offset

The GPS offset is the distance from the centre of the reference frame to the phase centre of the GPS antenna. The offset consists of three measurements taken in the vessel's forward, starboard and up frames, with the distances measured from vehicle CRP to the GPS antenna.

A survey of the vehicle should generate accurate drawings of the vessel with reference points clearly visible.

- If a survey has been scheduled for the near future, it should include the Lodestar and the information concerning the Lodestar's location in the vessel should be made available to the installation engineer.
- If a survey has already taken place and does not include Lodestar, then the most up-to-date drawings available will be required.

5 Installation and Physical Configuration

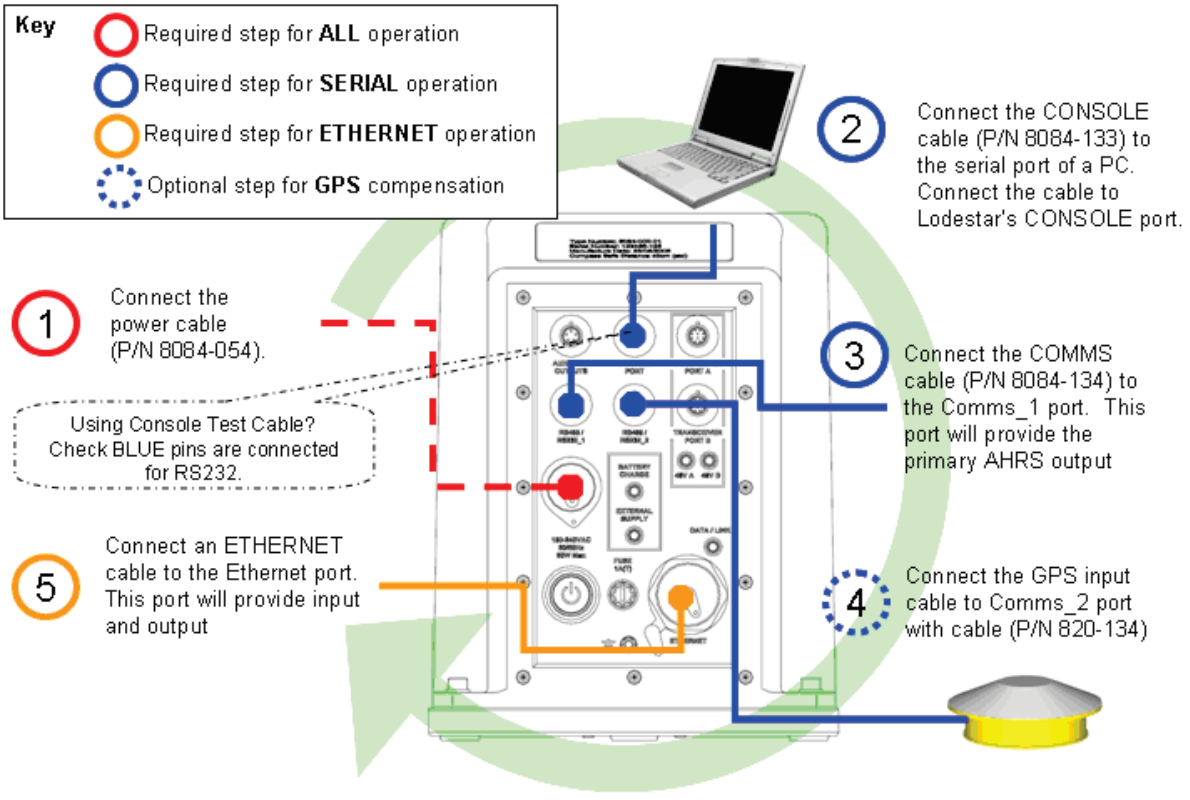
5.1 Typical Lodestar AHRS configuration

This Installation Manual is intended to accompany the Lodestar training courses run by Sonardyne International Limited, but it can also be used in isolation or as a source of reference information. It has been written primarily as a guide for field engineers who have been given the task of installing either a surface or a subsea version of the Lodestar AHRS on board a vessel.

Surface Lodestar

Figure 7 shows an example of a typical installation for the surface Lodestar.

Figure 7 – Typical Installation of the surface Lodestar



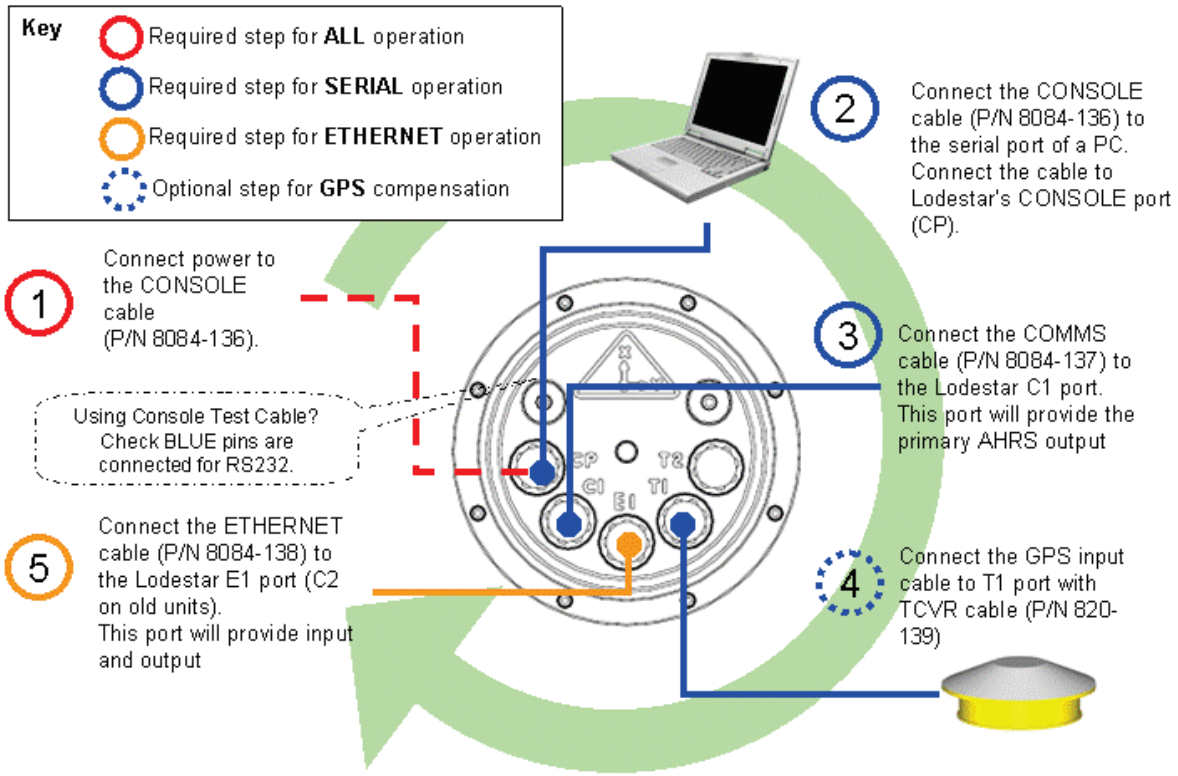
In the example shown:

- Console Port is the command port and has its output communication parameters fixed on 9600-8-N-1. This port is connected to a PC running the Lodestar Configuration Software.
- RSXXX_1 is the primary output port on the surface variant. This port is connected to the navigation system.
- RSXXX_2 is connected to a GPS receiver.
- Ethernet connection is optional but can be used to configure and send/receive data to or from the Lodestar.

Subsea Lodestar

Figure 8 shows an example of a typical installation for the subsea Lodestar.

Figure 8 – Typical Installation of the subsea Lodestar



In the example shown:

- Console Port is the command port and has its output communication parameters fixed on 9600-8-N-1. This port is connected to a PC running the Lodestar Configuration Software.
- C1 Port is the primary output port on the Subsea variant. This port is connected to the navigation system.
- T1 Port can be connected to a GPS receiver if possible (for example when using the system with a multi-beam or USBL when the Subsea Lodestar is not at depth).
- T2 is another output port RS232 or RS485, and is not used in the example shown.
- E1 (C2 on old units) Port provides Ethernet connection, which is optional but can be used to configure and send/receive data to or from the Lodestar

5.2 Installation

Important:

- The unit must be secured.
- A Surface Lodestar must be connected to Earth.

Physical installation

The Lodestar mounting bracket has reference dowels to make sure the Lodestar mounting position is repeatable.

If the Lodestar mounting bracket is not used for some reason, do not disturb or remove the Lodestar from its installed location after measuring the mounting angles and offsets. If removed or disturbed then the misalignment is void.

Connect all the cables to be used for the installation. Note the Console cable is different from the communications and transceiver cables. Do not mix these cables. The cables are keyed differently and colour coded. For Subsea and Surface units, a Red cable is for the console port, Yellow is for comms ports and Blue is for Transceiver ports. For the Subsea unit, the Ethernet cable is colour coded green.

Further guidance on Lodestar installation and physical configuration can be found in Lodestar Hardware manual (UM-8084-101)

6 Configuration using Lodestar PC Utility

6.1 Installation and Connection

Installation

1. Close all applications running on the PC and insert the Lodestar Software CD into the CD/DVD drive.
2. Browse to the drive using Windows Explorer and use the left mouse button to double-click the drive.
3. The disk installs the Lodestar Software and manuals automatically, follow the on-screen instructions.
4. Once installed, the Lodestar PC Utility runs.

Connection to PC

1. Connect the PC to the Lodestar via a serial port on the PC or alternatively an Ethernet connection and switch on Lodestar.

Note: - Connection to the Lodestar can be made via serial or Ethernet ports.

Serial Port:

The software will default to COM 1 on the PC

Ethernet Port:

The Lodestar default Ethernet properties are:

- IP Address: 192.168.179.50
- Subnet Mask: 255.255.255.0
- Command port/socket: 4000

The software will default to these values if the Ethernet options is chosen. Make sure the PC Ethernet port is configured correctly to allow communication with the Lodestar's default settings. The method for changing the Lodestar Ethernet's settings is explained later in this manual.

2. If Lodestar is being used as a stand alone AHRS then connect GPS to the Lodestar using a spare IO port and arrange to supply the NMEA 0183 $GPGGA and $GPVTG sentences to the Lodestar.

Note: - See section 5.1 for some example connection configurations.

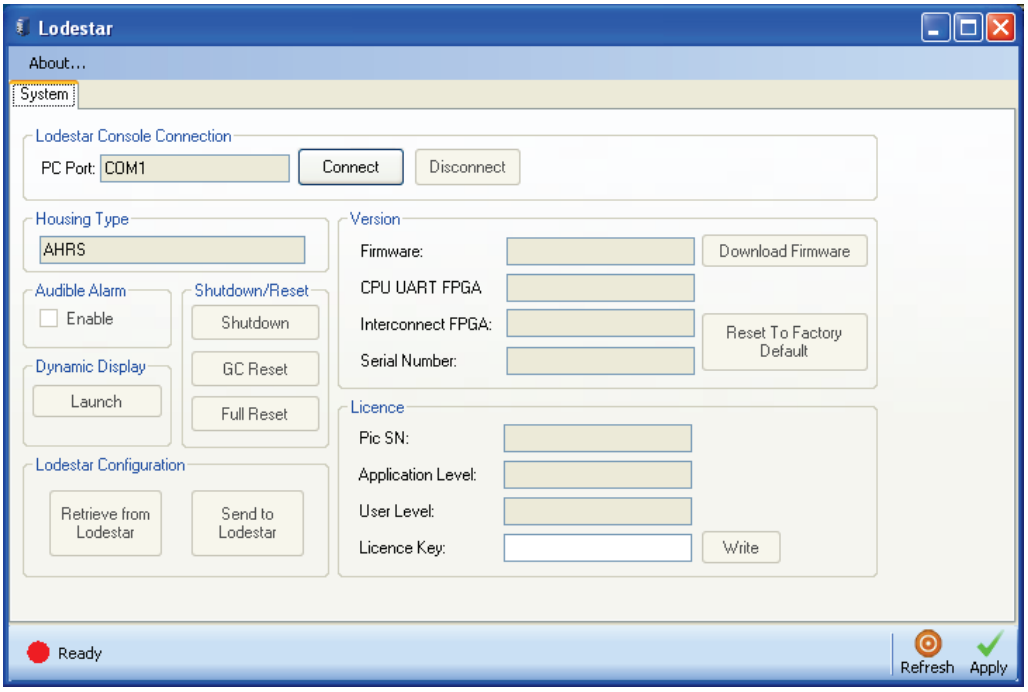
3. Connect the Lodestar's IO ports to the external instrumentation as required.
4. Start the Lodestar Configuration Software if it is not already running by double clicking the program's icon on the PC's desktop.

6.2 System

Connect to the Lodestar

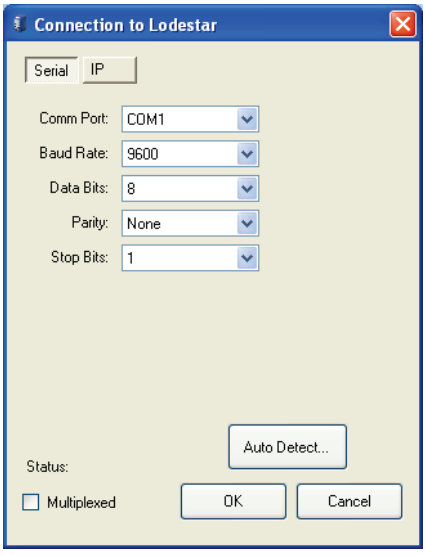
Once a physical connection has been made it is necessary to tell the PC Utility to communicate with Lodestar; see Figure 9.

Figure 9 – Configuration Software Main Window (not connected)



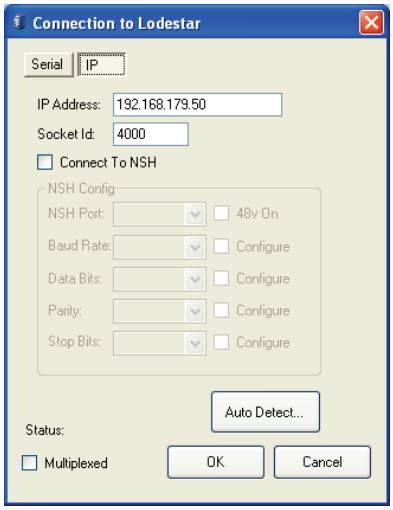
Configure the connection to the Lodestar by pressing the 'Connect' button. The application will default to a serial connection on PC port COM 1 as shown in Figure 10.

Figure 10 – Lodestar Serial Connection Settings



To configure an Ethernet or NSH connection, press the 'IP' button and the default Lodestar Ethernet connection parameters are displayed, as shown in Figure 11.

Figure 11 – Lodestar Ethernet Connection Settings

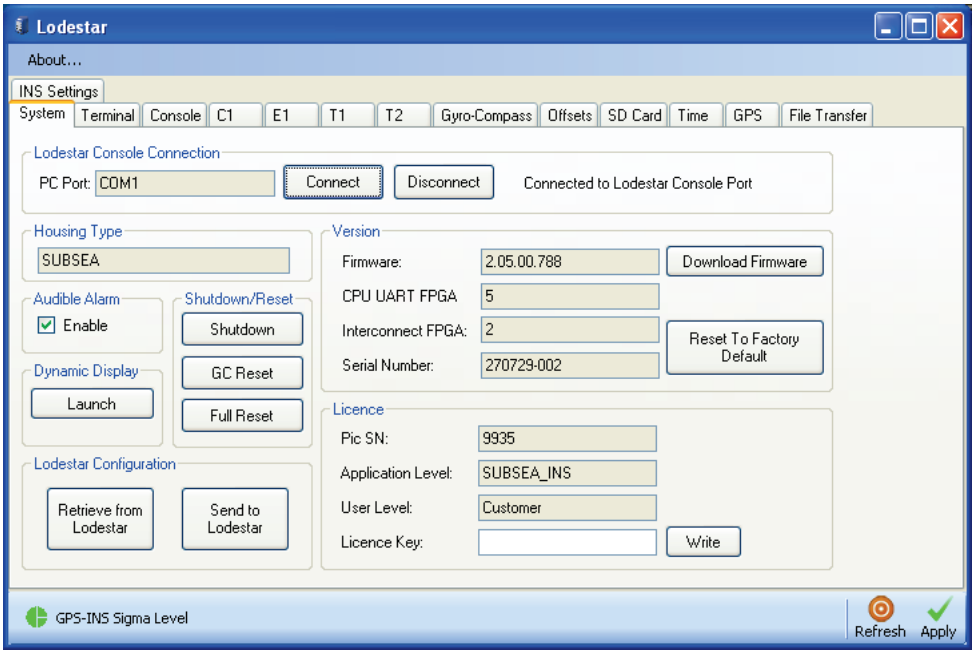


Note: - Before proceeding make sure the Lodestar has been running for at least 1 minute before trying to connect via the configuration software. This allows time for the Lodestar to start up and receive commands (see Lodestar Hardware Manual UM-8084-101 for more details)

Once the connection parameters match the physical connection between the Lodestar and the PC, press the 'OK' button.

A window will appear indicating communication status with the Lodestar.
Once connected, the software will populate with the Lodestar configuration and the status indicator circle on the bottom left hand side of the application will turn green, indicating a good communication link with the Lodestar; see Figure 12.

Figure 12 – Configuration Software Main Window (connected)



Note: - If the status indicator remains red and the Lodestar configuration is not updated the software was unable to connect to the Lodestar. Check the Lodestar is powered, all cables are connected to the correct ports and the settings entered on the 'configure connection' window are correct and then retry connecting. If this is not successful see Hardware Manual UM-8084-101 for further troubleshooting assistance.

Shutdown and Reset

The Lodestar can be commanded to shutdown or reset from the configuration software using the buttons in the 'Shutdown/Reset' panel:

- **Shutdown** will shutdown and turn off the Lodestar
- **GC Reset** will restart the Lodestars Gyro Compass and Attitude algorithms.
- **Full Reset** will re-boot Lodestar completely resetting it.

Audible Alarm

This setting will either enable or disable the audible alarm installed in the Surface Lodestar. Note the surface Lodestar will always emit an audible alarm if external power is lost even if this setting is disabled.

Note: - The Subsea Lodestar does not have an audible alarm installed.

See section 7 on page 39 of this manual for further details on Lodestar alarms and the trigger states.

Steps to Configure Lodestar

The configuration process for the Lodestar includes the following stages:

1. Configure the Gyro-Compass configuration:
   - Set the default Latitude
   - Configure GPS input
   - Configure Heave Filter
2. Configure the Lodestar offsets:
   - Configure Lodestar mounting angles and offsets
   - Configure offsets for remote output points
3. Port Configuration:
   - Port Settings
   - AHRS Outputs
4. Configure time settings:
   - Set the Lodestar clock
   - Configure automatic time updates
5. Output check

These stages and how to complete them using the configuration software are described below.

6.3 Gyro-Compass

Select the Gyro-Compass tab on the Configuration Software.

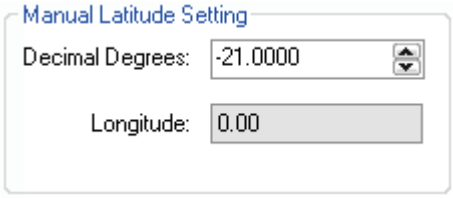
Default Latitude

It is essential to set the default Latitude if Lodestar is operated without a GPS input. It is also important to set this parameter even when the Lodestar is used with a GPS input, because the Lodestar can revert to using the default Latitude if the GPS input fails for any reason.

Note: - If the Lodestar receives telegrams from a GPS receiver, these will automatically update the default Latitude. However, if the GPS input fails, then the Lodestar will revert back to using the default Latitude. Make sure the default Latitude setting is kept up to date in case the GPS input fails or is not available.

The default Latitude can be set by entering the operating Latitude in the 'Manual Latitude Setting' panel, see Figure 13. After setting the Latitude the user must press the 'Apply' button on the main application window.

Figure 13 – Manual Latitude Setting Panel



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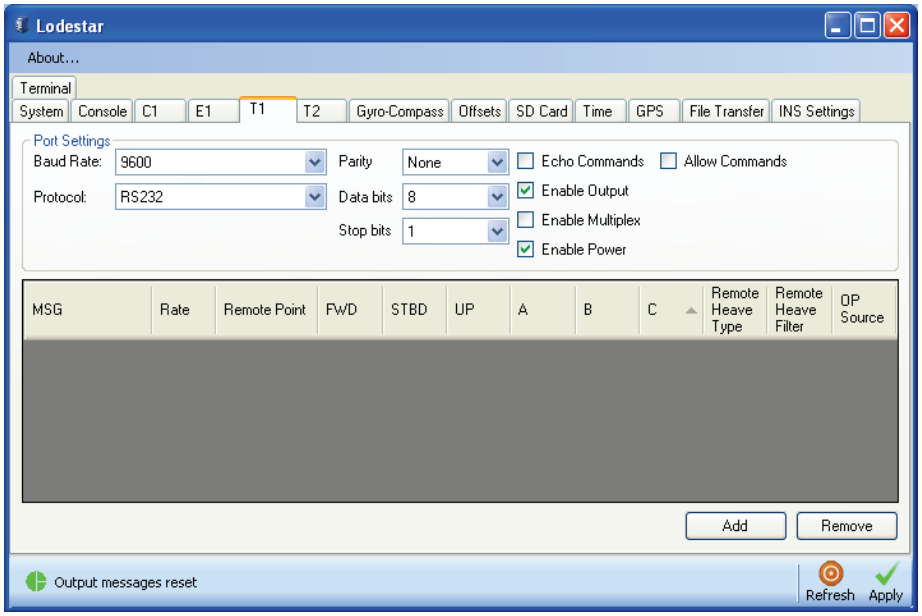
GPS Input

Where possible it is strongly recommended to connect a GPS receiver supplying the necessary NMEA 0183 GPGGA and GPVTG sentences to Lodestar.

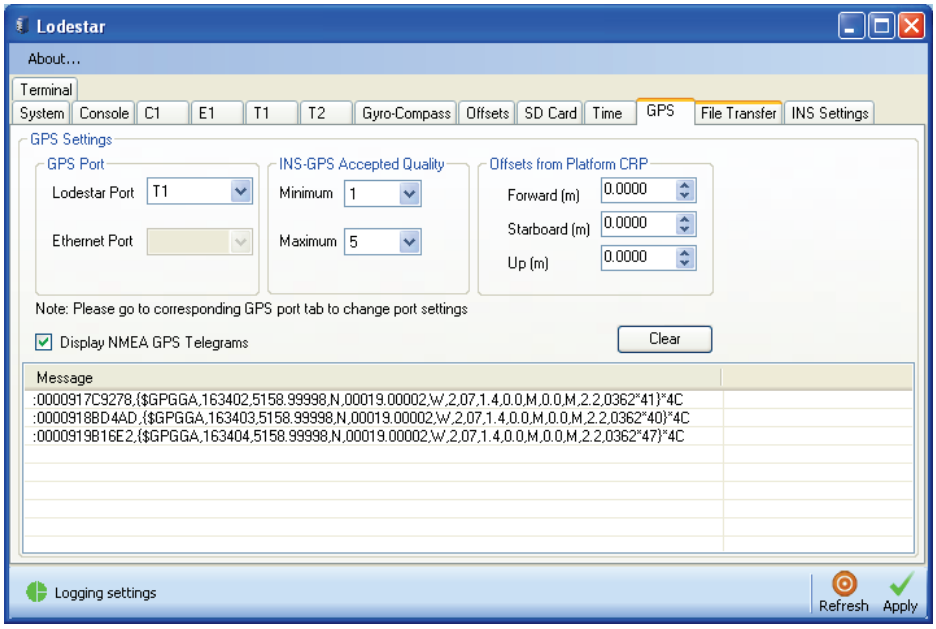
First click on the tab that corresponds to the GPS input which in this case was T1. Configure the baud rate and protocol. Make sure the Output is Enabled and that Power is Enabled and press the Apply button at the bottom right.



Now click on the GPS tab. Configure the GPS port to be the port the GPS is connected to which in this case was T1. Enter the offsets from the vessel CRP to the GPS antenna and press apply to send the changes to Lodestar.

Finally click on the Display NMEA GPS Telegrams to show any GGA telegrams that are being correctly received and decoded.

Figure 14 – Automatic GPS Compensation Panel



Heave Filter

If required, the Heave output from the Lodestar can be configured for the anticipated surface wave period experienced by the vehicle. This can be set on the 'Heave Filter' panel, see Figure 15.

Figure 15 – Heave Filter Panel

6.4 Offsets

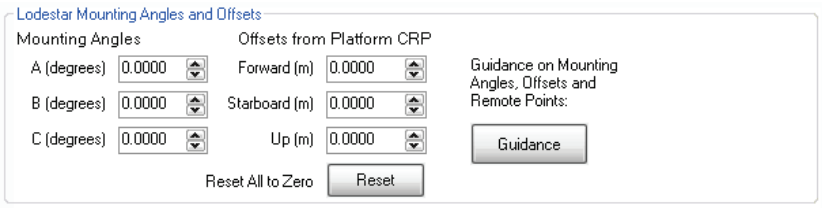
Select the Offsets tab on the Configuration Software.

Lodestar Mounting Angles and Offsets

If mounting angles for the Lodestar need to be configured this can be done by entering the appropriate values in the A, B and C mounting angle entry boxes, as shown in Figure 16. Similarly if there are any offsets that need to be applied for the Lodestar with respect to the vehicle CRP these can be applied in the Forward, Starboard and Up entry boxes. See section 3.1 Lodestar Output and Alignment on page 7 for definitions and an example of the Lodestar mounting angles and offsets.

CAUTION It is strongly recommended the Lodestar mounting angles are not modified while the Lodestar is in operation as an AHRS device. When any changes are applied the user will be prompted to reset the Lodestar AHRS algorithm and it will be several minutes before the Lodestar output is settled.

Figure 16 – Mounting Angles and Offsets Panel



All mounting angles can be reset to zero using the button available.

Remote Output Points

Lodestar measurements may be required for vehicle sensors that are not located near to the vehicle CRP, such as remote heave.

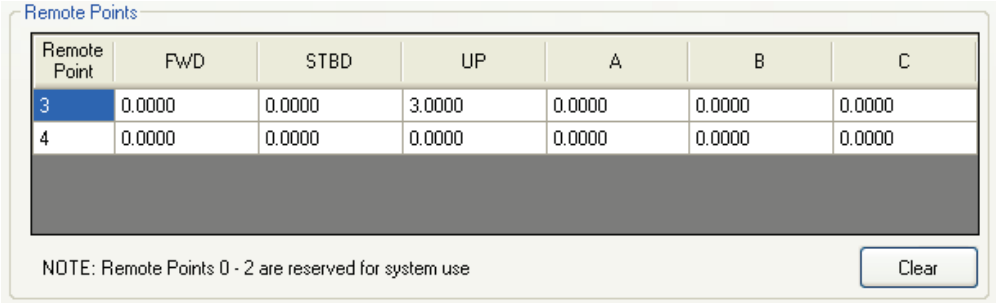
For the Lodestar to be able to supply these systems with measurements, offset distances must be measured and applied in the Lodestar configuration.

The Lodestar supports up to two remote outputs (extendable on request) and these are listed in the 'Remote Points' list; see Figure 17. The remote points are numbered 3 and 4 (remote points 0 to 2 are reserved for system use).

The offsets can be entered in the X, Y and Z columns and then saved in the Lodestar by pressing the 'Apply' button on the main application window.

Additionally, angular adjustments can be entered in the A, B and C columns and also saved by pressing the 'Apply' button on the main application window.

Figure 17 – Remote Points List



Guidance on Offsets

Further information on Lodestar offsets, angles and frames can be found in section 3 on page 7 of this manual. If a copy of the manual is not available, the user can view a summary guidance page explaining the Lodestar angles and offsets by pressing the 'Guidance' button on the Offsets tab.

6.5 Console, C1, C2, E1, T1 and T2 Ports

Port and output settings

The settings for each Lodestar port are available by selecting the appropriate tab in the main C application window as listed below.

Table 1 – Lodestar ports to Software tab mapping

Lodestar Type	Lodestar Port	Software Tab
Surface	Console	Console
	RS485 / RS232_1	C1
	RS485 / RS232_2	C2
	Ethernet	Ethernet
	Transceiver Port A	T1
	Transceiver Port B	T2
	Auxiliary Outputs	Analogue Pins
Subsea	Console	Console
	C1	C1
	E1 (C2 on old units)	Ethernet (E1)
	T1	T1
	T2	T2

The configuration application window will automatically enable the correct port tabs for the type of Lodestar connected. These tabs allow the setup of data formats, update rates and communication parameters for the Lodestar serial output ports.

Serial port settings

The settings for the port can be viewed or modified in the 'Port Settings' Panel, see Figure 18.

Figure 18 – Port Settings Panel

The baud rate, protocol, parity, data and stop bits can be configured by selecting the appropriate value from the drop down lists and pressing the 'Apply' button on the main application window.

Note: - Several settings on the Console port are fixed to make sure the user can always communicate with the Lodestar. Protocol is selected by the protocol select pin on the console cable and cannot be set in the configuration software. Also, the power to the console port cannot be turned off.

Further settings can be modified using the check boxes in the Port Settings Panel:

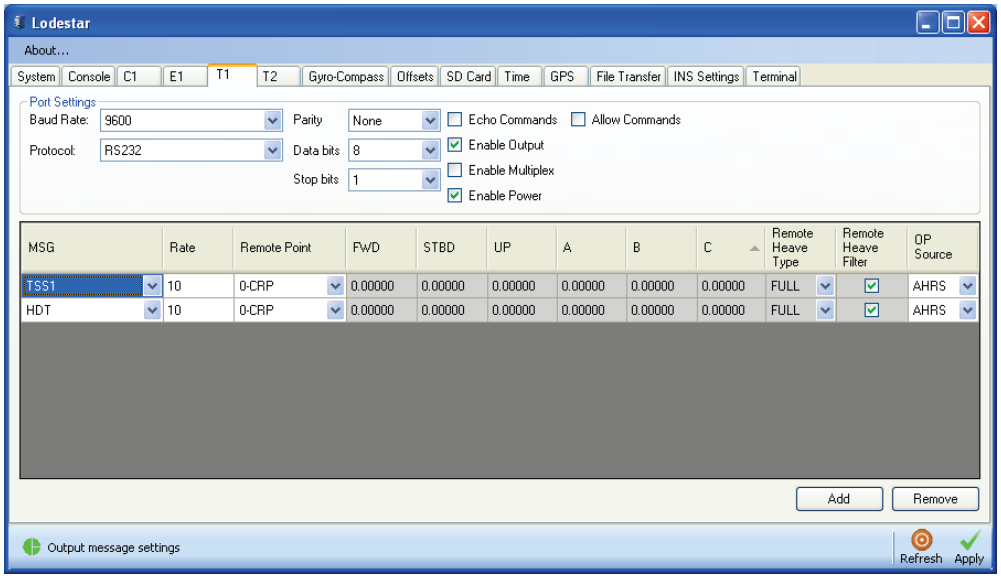
- **Echo Commands** will output any commands received by the Lodestar on this port
- **Enable Output** will turn the message output ON/OFF on this port
- **Enable Multiplex** will enable/disable multiplex communications on this port
- **Enable Power** will enable/disable power to this port

Note: - The Enable Power setting does not activate external power for the selected port; it allows a user to turn off a communication port completely to lower power consumption. If the power for a port is turned off it can no longer send or receive data.

Serial output messages

The output messages for the appropriate port can be viewed or modified in the output message table, see Figure 19.

Figure 19 – Output Message Table



To add a message output press the ‘Add’ button and similarly to remove an output, select the ‘Remove’ button.

Select the required output message by selecting a message type from the dropdown list in the ‘MSG’ column. Select an output rate (up to 100Hz) by entering the required value in the ‘Rate’ column.

If this message is to be output with respect to a remote point on the vehicle, select the appropriate remote point (already setup on the ‘Offset’ tab) from the list in the ‘Remote Point’ column. After selecting the Remote Point the appropriate offsets and angles are displayed in the table.

Lodestar output messages are described in Lodestar AHRS Messages UM-8084-109 specification.

If this message is to be output with respect to the vehicle CRP, leave ‘None’ selected in the ‘Remote Point’ column.

After all settings have been updated on the tab, press the ‘Apply’ button on the main application window to make sure the configuration is saved to the Lodestar.

6.6 Ethernet and Ethernet (E1) Ports

These tabs allow the user to set the data format, update rate and communication parameters for the Lodestar's Ethernet output ports.

Ethernet port settings

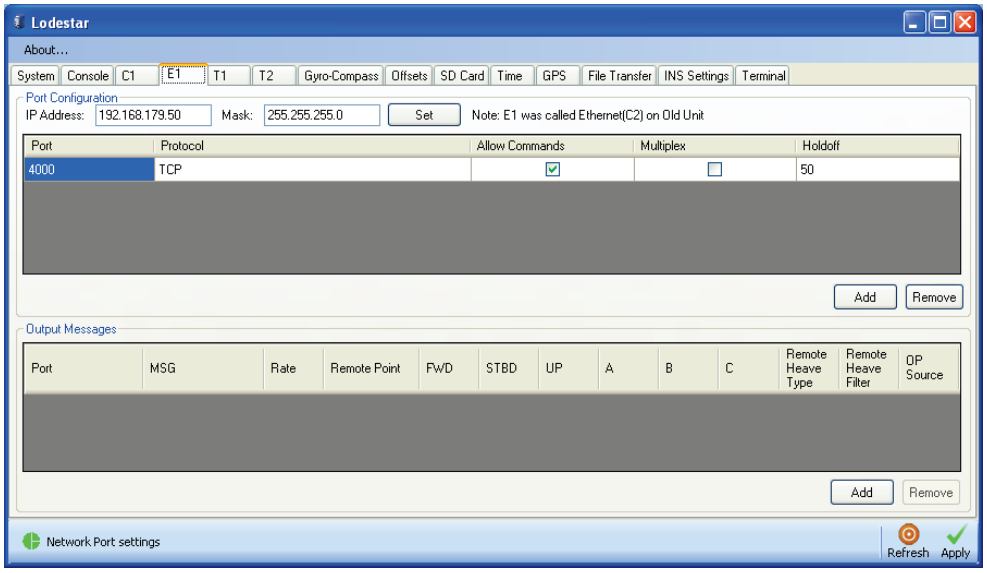
The default IP settings of the Lodestar are listed below:

- IP Address: 192.168.179.50
- Subnet Mask: 255.255.255.0
- Command port/socket: 4000

Note: - The command port 4000 is always available to make sure the user can always communicate with the Lodestar via an Ethernet connection. This port is not shown or listed in the configuration application as it should never be removed or modified.

The IP port settings can be viewed and modified on the 'Port Configuration' panel, see Figure 20.

Figure 20 – IP Port Configuration Panel



The IP address and subnet mask can be modified by changing the value then pressing the 'Set' button.

CAUTION If connected to the Lodestar via the Ethernet port and wish to change the IP address or subnet mask, it is strongly recommended that after changing the values the configuration application is closed. The user should reconnect using the new IP address by setting it in the 'configure connection' window before pressing 'connect'. It also recommended the Lodestar is restarted.

To add an Ethernet port (also referred to as a socket) press the 'Add' button and similarly to remove a port, press the 'Remove' button. The Ethernet port settings available are:

- **Protocol** can be TCP/IP (secure but slow) or UDP (broadcast fire and forget).

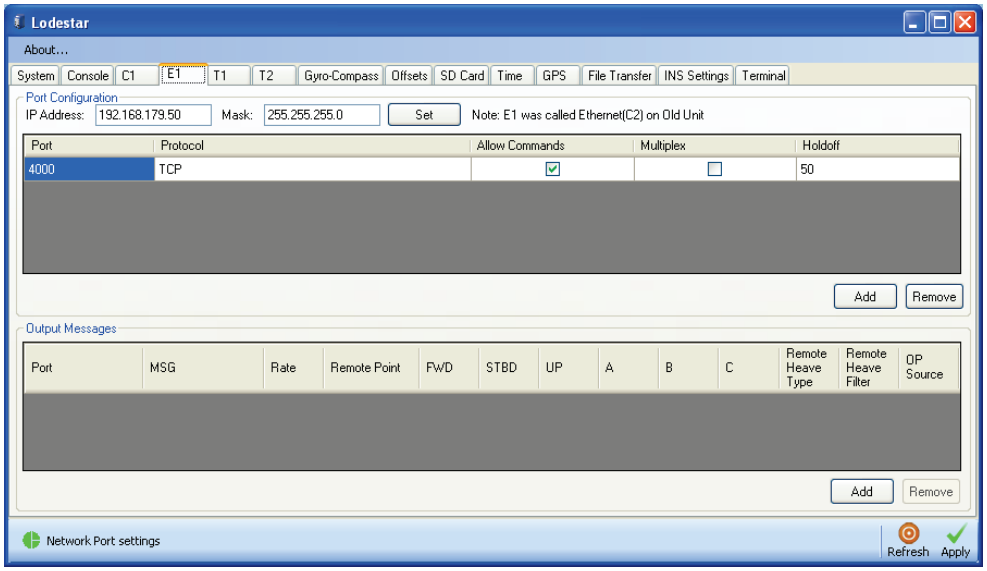
- **Allow Commands** will enable the Lodestar to be commanded on this port.
- **Multiplex** will enable/disable multiplex communications on this ethernet port.
- **Holdoff** is the timeout in milliseconds for data to be output on a network port in the event there isn't enough data to be output within that time.

After all port settings have been updated on the tab, press the 'Apply' button on the main application window to make sure the configuration is saved to the Lodestar.

Ethernet output messages

The Ethernet output messages can be viewed or modified in the output message table, see Figure 21.

Figure 21 – Ethernet Output Message Table



To add a message output press the 'Add' button and similarly to remove an output, press the 'Remove' button.

Select the ethernet port from which this message will be output using the dropdown list in the 'Port' column.

Then select the required output message by selecting a message type from the dropdown list in the 'MSG' column. Select an output rate (up to 100Hz depending on other outputs on this port) by entering the required value in the 'Rate' column. If this message is to be output with respect to a remote point on the vehicle, select the appropriate remote point (already setup on the 'Offset' tab) from the list in the 'Remote Point' column. After selecting the Remote Point the appropriate offsets and angles are displayed in the table.

Lodestar output messages are described in the Lodestar AHRS Messages UM-8084-109 specification.

If this message is to be output with respect to the vehicle CRP, leave 'None' selected in the 'Remote Point' column.

After all settings have been updated on the tab, press the 'Apply' button on the main application window to make sure the configuration is saved to the Lodestar.

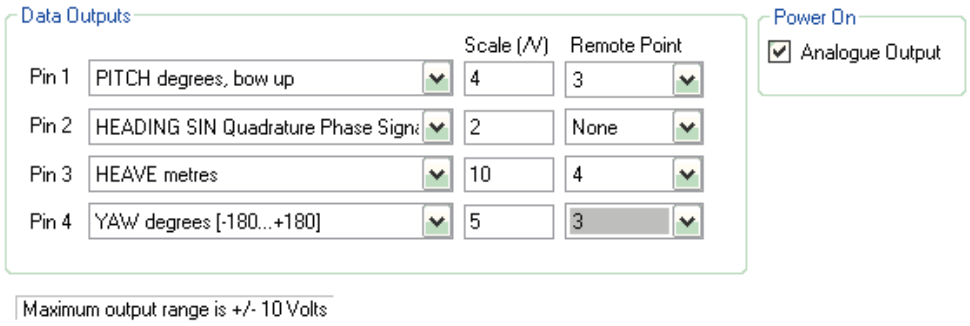
6.7 Analogue Output Tab

This tab allows the configuration of analogue outputs from the Lodestar.

Analogue port settings

The output for each pin in the analogue port can be configured on the analogue port tab, as shown in Figure 22.

Figure 22 – Analogue Port Tab



The analogue output can be enabled or disabled using the 'Analogue Output' check box.

The options available for output on each analogue pin are as follows:

Table 2 – Analogue Port output options

Option	Purpose
PITCH	degrees, bow up
ROLL	degrees, starboard down
YAW	[-180... +180] degrees
HDG	Quadrature Phase Signal SIN|COS
HEAVE	Heave, metres
VZ	Velocity in the Navigation Frame, m/s

The voltage scale for each pin can be set from 0-10 volts. A remote point can be specified for each analogue output pin.

After setting the analogue output, press the 'Apply' button on the main application window to save the configuration to the Lodestar.

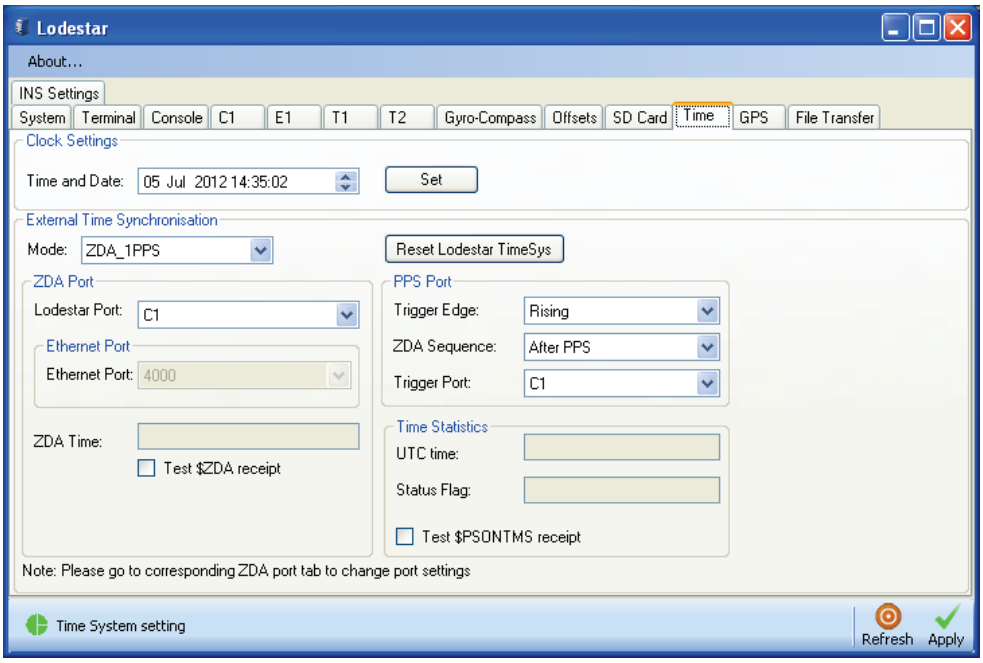
6.8 Time

This tab allows configuration of Lodestar's time settings.

Time and Date

The time and date configured in the Lodestar is displayed in the 'Clock Settings' panel on the Time tab, see Figure 23.

Figure 23 – Clock Settings panel



The time and date can be modified by clicking on the value to change and using the up and down button to the right of the time and date value. When the value is correct, press the 'Set' button to update the Lodestar time and date.

ZDA Port

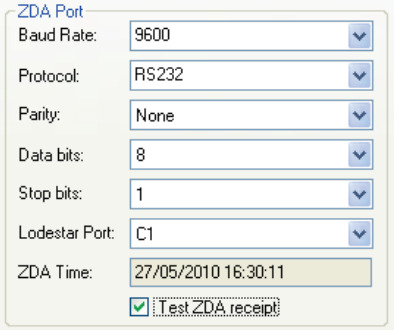
If GPS input is available and a GPS receiver is not already supplying the necessary NMEA 0183 GPZDA sentences to the Lodestar, make sure the input is connected now.

The GPZDA input can be configured in the 'ZDA Port' panel, see Figure 24.

Select the Lodestar port the GPS is connected to from the drop-down list. The settings for the selected port are displayed and can be changed if required.

Press the 'Apply' button on the main application window to save this configuration on the Lodestar.

Figure 24 – ZDA Port Panel



The GPZDA input (if available) can be checked by clicking 'Test ZDA receipt' as shown in Figure 24.

PPS Port

If the PPS input is available and is not already connected to Lodestar, connect it now. Lodestar can accept an input trigger on the following ports:

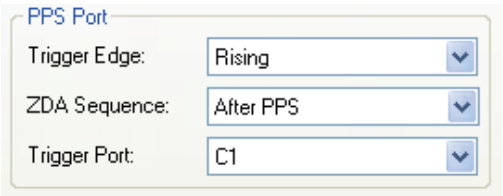
Table 3 – PPS Input Ports

Lodestar Type	Lodestar Port
Surface	RS485 / RS232_1
	RS485 / RS232_2
	Transceiver Port A
	Transceiver Port B
Subsea	C1
	E1 (Ethernet)
	T1
	T2

Note: - The test cables supplied with the Lodestar have BNC connectors that can be used to input the PPS pulse to the Lodestar.

The PPS input pulse can be configured in the 'PPS Port' panel, see Figure 25.

Figure 25 – PPS Port panel



The 'Trigger Edge' setting specifies whether the timing pulse should be measured on the rising (high) or falling (low) of the input signal.

The 'ZDA Sequence' specifies when the ZDA message arrives with respect to the PPS timing pulse.

- 'After PPS' should be selected if the ZDA arrives shortly after the PPS pulse
- 'Before PPS' should be selected if the ZDA arrives shortly before the PPS pulse
- 'Time of Arrival' should be selected is the ZDA arrives at the same time as the PPS pulse

From the 'Trigger Port' drop-down list, select the Lodestar port that is receiving the 1PPS signal.

Press the 'Apply' button on the main application window to save this configuration on the Lodestar.

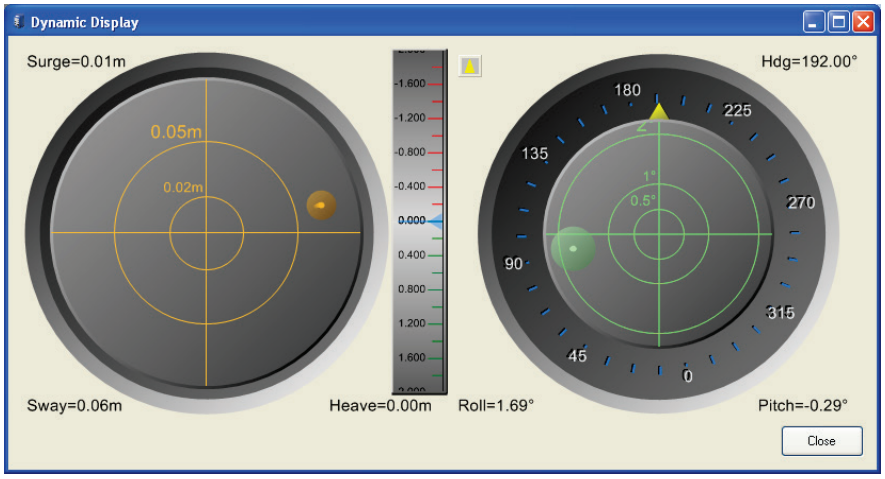
6.9 Output Check

There are several methods that can be used to check the output from the Lodestar, these are explained below.

Dynamic Display

A dynamic display can be viewed that allows the user to view the real time output from the Lodestar. This can be launched by pressing the 'Dynamic Display' button on the 'System' tab. The display shows heading, roll, pitch, heave, surge and sway measurements with respect to the CRP of the vehicle, see Figure 26.

Figure 26 – Dynamic Display



Note: If the output is incorrect, check the following settings are correct:

Mounting angles and offsets

Default Latitude or automatic GPS compensation

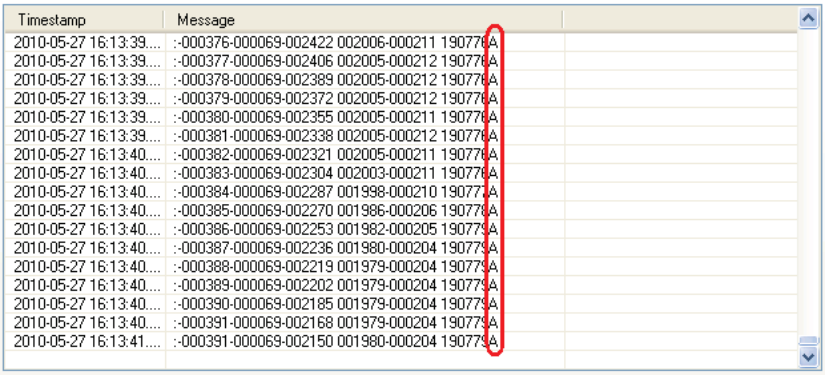
The method for checking the automatic GPS compensation in detail is explained below.

GPS Compensation Checks

While the 'Dynamic Display' window is open, navigate to the 'Terminal' tab on the main application window.

The 'Terminal' tab will be displaying the output from the Lodestar, which in this case is the Sonardyne proprietary SON1 telegram. The last character of each received message is a status flag that indicates the type of GPS compensation received by the Lodestar, as shown in Figure 27.

Figure 27 – Terminal check of GPS compensation



The status flag should be 'A' indicating the Lodestar is receiving full GPS compensation and is also fully settled. Descriptions of all possible states are listed below:

An upper case character indicates the Lodestar is settled whereas a lower case character indicates the unit is still settling.

- 'a' or 'A' means the Lodestar is receiving and decoding valid GPGGA and GPVTG telegrams successfully.
- 'g' or 'G' means the Lodestar is receiving and decoding only valid GPGGA telegrams.
- 'v' or 'V' means the Lodestar is receiving and decoding only valid GPVTG telegrams.
- 'u' or 'U' means the Lodestar is not receiving or decoding any valid GPGGA and GPVTG telegrams.

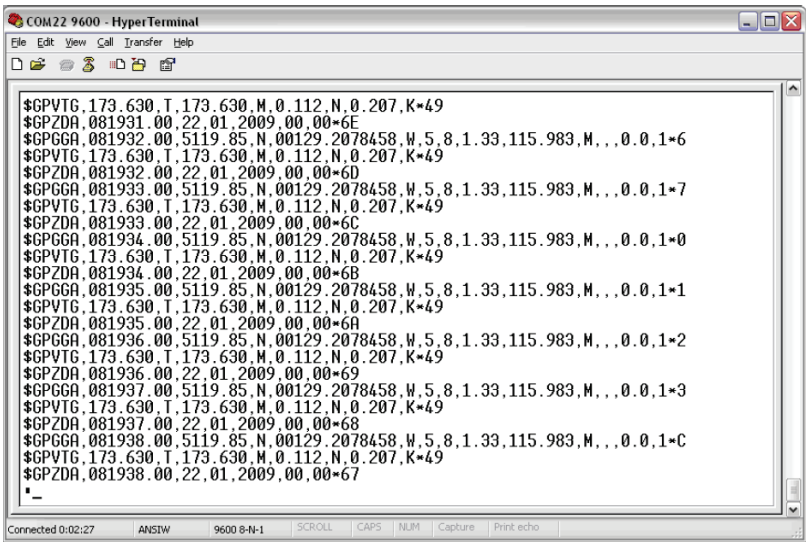
Troubleshooting

Try the following remedies if the GPS input flag is NOT 'A'.

Check GPS telegram using terminal

Make sure the GPS receiver is sending the correct telegrams by connecting a terminal application, such as HyperTerminal, to the GPS receiver's output as shown in Figure 28.

Figure 28 – Example GPS output in HyperTerminal



6.10 File Transfer

The File Transfer tab allows data to be retrieved from the Lodestar's internal SD card.

Lodestar Connection

Files can be transferred from the Lodestar's SD card to PC using either a Ethernet (E1 or C2 on older units) or a serial port connection (C1). It is recommended that file transfers for all applications of Lodestar use the Lodestar Ethernet port 4000 or C1 port with the exception of a SPRINT configuration which uses Ethernet port 4001.

For Lodestar Ethernet port connection use **Lodestar Subsea Ethernet test cable 8084-138-04**

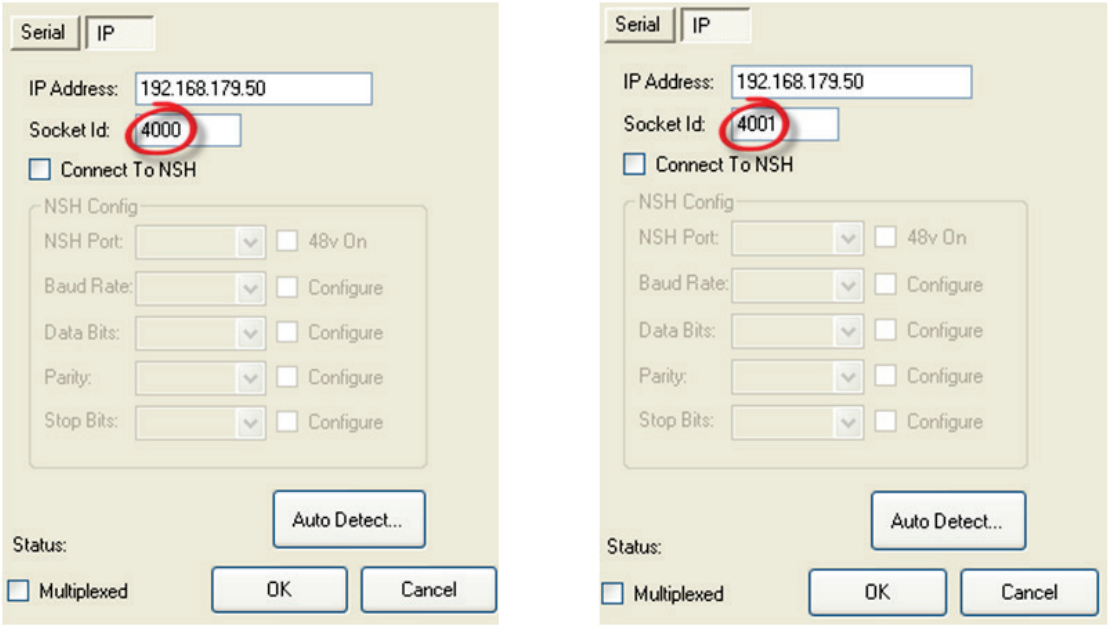
For Lodestar C1 port connection use **Lodestar Subsea C1 test cable 8084-137-04**.

Connect to the Lodestar as described in section **6.2 System**.

Ethernet port configuration

Connect to Ethernet port 4000 or 4001 (if using the Lodestar in a SPRINT application), refer to figure 29.

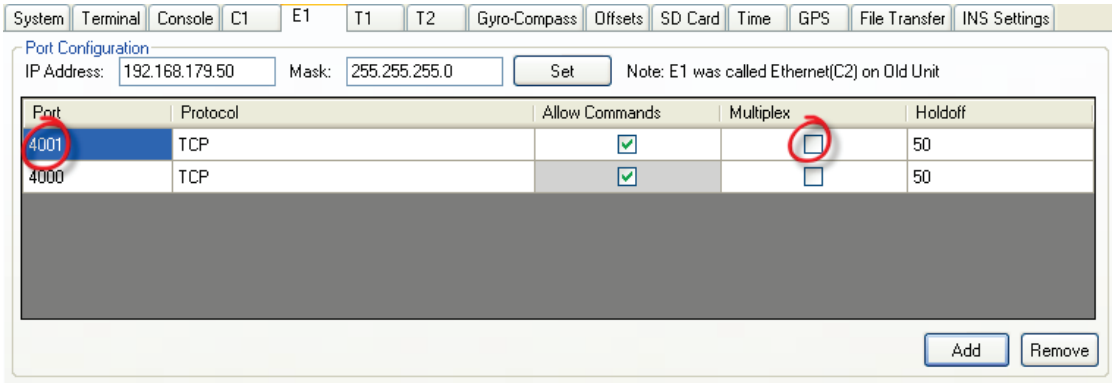
Figure 29 – Lodestar Ethernet Connection



Once the connection has been established, navigate to the E1 tab and ensure multiplex is disabled, refer to figures 30 and 31. Apply changes and wait for progress bar to complete prior to navigation to a new tab.

Figure 30 – Lodestar Ethernet Port 4000 Configuration

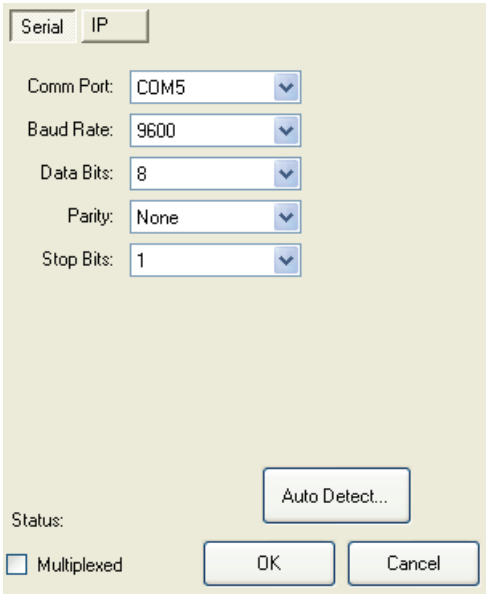
Figure 31 – Lodestar Ethernet Port 4001 Configuration



Serial port configuration

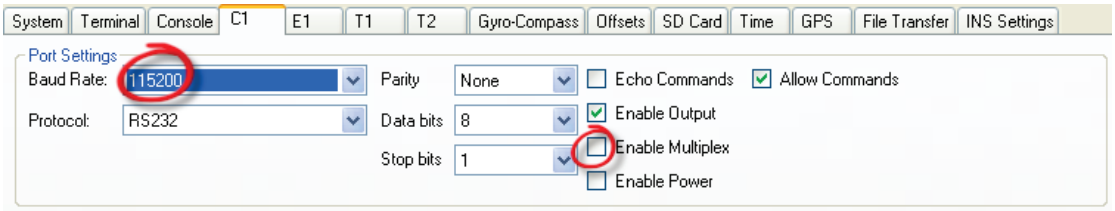
Connect to the Lodestar C1 port (use Auto Detect if unsure of C1 settings), refer to figure 32.

Figure 32 – Lodestar C1 Port Connection



Once the connection has been established, navigate to the C1 tab and set the baud rate to 115200 and disable multiplex, refer to figure 33. Apply changes and wait for progress bar to complete prior to navigation to a new tab.

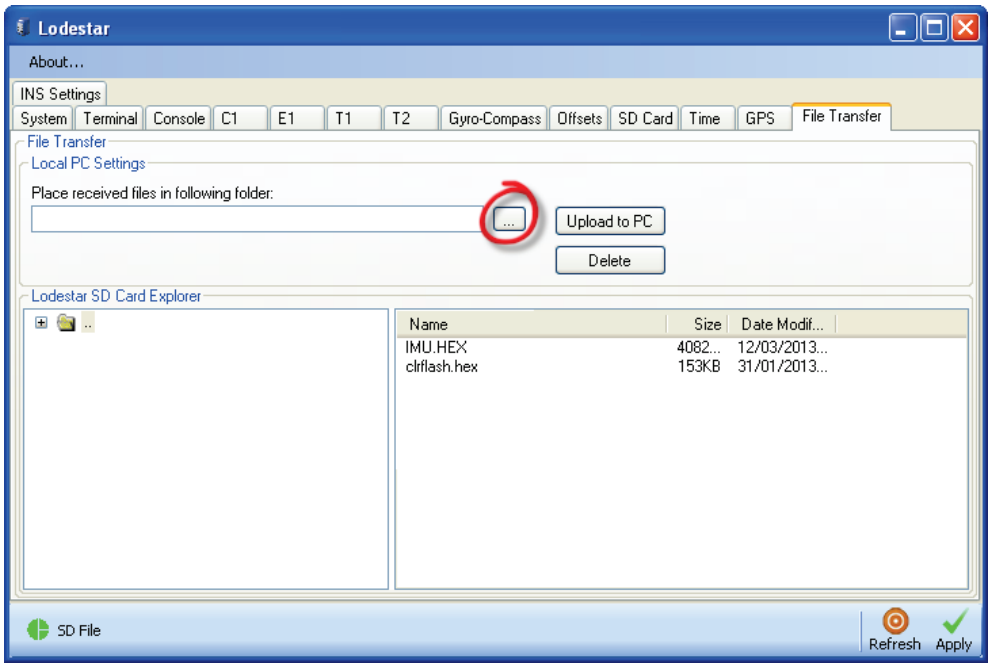
Figure 33 – Lodestar C1 Port Configuration



SD File Transfer

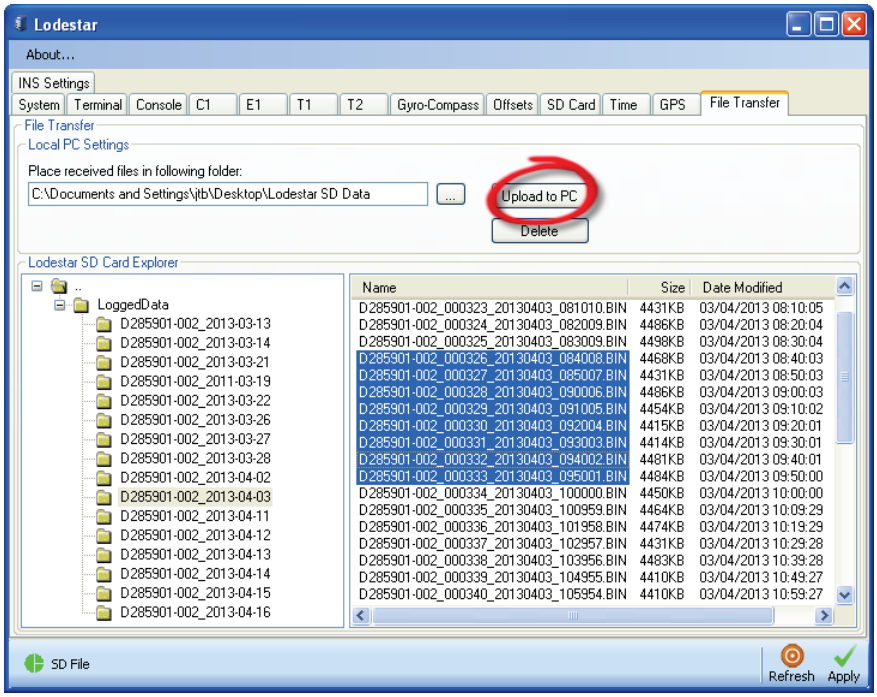
Navigate to the file transfer tab and select the data destination file, as shown in figure 34.

Figure 34 – SD files destination folder



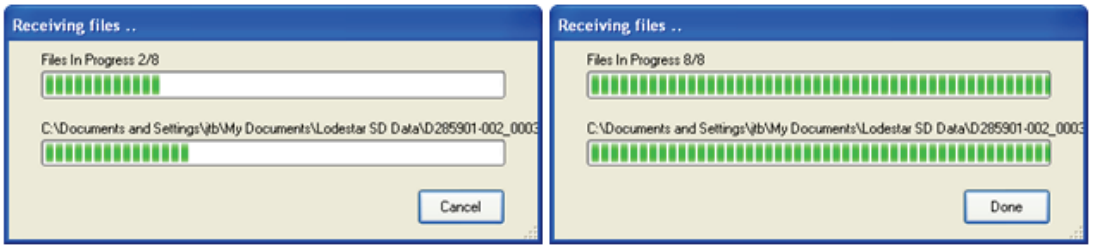
The destination folder link will appear in Local PC Settings once the folder is chosen.
Expand the folders **..** and **LoggedData** by clicking on the cross within **Lodestar SD Card Explorer**, refer to figure 35.
The SD logfiles and folders are named as: **D/serial number/year/month/day** with the logfiles named with the addition of **hours/mins/secs**.
Select the logfile(s) for retrieval and click upload to PC, refer to figure 35.

Figure 35 – Logfile Upload



A progress bar will displayed during the data upload and wait for the upload progress bar to complete, refer to figure 36.

Figure 36 – Data upload progress bar



After file transfer completion, navigate to the system tab and disconnect prior to removing the test cable connect to the Lodestar.

7 Alarms

7.1 Introduction

Alarm Process

Lodestar outputs an alarm message ($__ALR) when a threshold is exceeded. The alarm recipient will send an acknowledge message ($__ACK). The Lodestar continues to send the alarm message until an acknowledgement is received from the alarm recipient. The Lodestar will then send another alarm message acknowledging receipt of the acknowledgement.

The Lodestar also sends an alarm message if the threshold is not exceeded anymore, to be acknowledged and counter acknowledged in the same manner

The alarm and acknowledgement formats are described in the Lodestar AHRS Messages UM-8084-109 specification.

Alarm States

An alarm message will be generated by the Lodestar for the following events or states:

- Shutdown Imminent
- Battery voltage low
- No external power
- No Gyro power
- SD card file deletion problem
- Sensor temperature alarm
- GPS unavailable / not used by AHRS
- Default settings used (indicating loss of the stored settings)
- Accelerometer overloaded

These alarms will remain active until they are automatically cleared by the Lodestar or are acknowledged.

Appendix A - Lodestar Angle Definitions

Euler angles (Tate Bryan rotations)

The "Tate Bryan" rotations given hereafter are commonly and henceforward referred to as the Euler angles even though they are formally just a specific sequence of a larger set of possible Euler angle rotation sequences. The Euler angle rotation sequence from NED (Earth Frame; x-North, y-East, z-Down) to body frame is:

1. Rotation by the heading angle φ (phi) about Zned.
2. Rotation by the pitch angle θ (theta) about the resulting Y axis.
3. Rotation by the roll angle ψ (psi) about the resulting X axis.

Similarly, the rotation sequence from a reference frame (ROV) to a sensor frame (IMU, USBL, DVL) is:

4. Rotation by the gamma angle about Zref.
5. Rotation by the beta angle about the resulting Y axis.
6. Rotation by the alpha angle about the resulting X axis.

Heading (Azimuth, Yaw)
Heading is the angle between Xned and the projection of Xb into the horizontal plane (XYned) measured about Zned. Heading is in the interval [0º ... 359.999º], Yaw is in the interval [-179.999º ... +180.000º].

Pitch
Pitch is the angle between Xb and the horizontal plane (XYned). Pitch is positive when Xb is pointed above the horizontal plane. Pitch angle lies in the interval [-90º ... +90º].

Roll
Roll is the angle between Yb and the horizontal plane measured in the ZYb plane. Roll is positive when Yb is pointed below the horizontal plane. Roll angle lies in the interval [-180º ... +180º]..

Gravity (Datawell) angles

Gravity angles are typically returned by a gyro and traditional VRUs measuring the angle of the gravity vector using 2 independent orthogonally mounted tilt sensors e.g. Datawell, TSS or Watson VRUs. These are generally defined as follows:

Pitch
Angle between the vessel forward axis and the horizontal, positive when bow is pointed above horizontal.

Roll
Angle between the vessel starboard axis and the horizontal, positive when starboard is pointed below horizontal.

Heading
Angle from the North axis to the vertical projection of the vessel forward axis onto the horizontal, measured about the down axis.

Appendix B - Effect of Misalignment Errors

Effects of error

It is important to note that Lodestar measures heading, roll and pitch in its own IMU body frame. For these measurements to be valid for the vessel or vehicle on which it is mounted, then the Lodestar's IMU body frame must align precisely with the vessel's body frame, or the Lodestar's misalignment angles must be compensated completely in software. Any uncompensated misalignment between the Lodestar and the vessel body frames will cause the following effects:

- There will be a fixed error between the vessel's true heading and the heading reported by the Lodestar.
- There will be an element of the vessel's rolling motion appearing on the Lodestar's pitch and heading output.
- There will be an element of the vessel's pitching motion appearing on the Lodestar's roll and heading output.

The size of the error depends on the misalignment angle between the Lodestar and the vessel, and on the amplitude of the roll and pitch motion.

Note: It is important to note that this error arises wholly from the misalignment between the Lodestar and the vessel. It is NOT caused by the Lodestar.

From the above, it is clear that care is needed when installing and aligning the Lodestar to avoid degrading the attitude measurement accuracy delivered by the Lodestar.

Appendix C - Fine Alignment Methods

Fine alignment

There are several methods that can be used to complete a fine alignment between the Lodestar AHRS and the vessel. These all rely on adjusting the alignment angles in software, the adjustments are too fine to rely on making physical changes to the Lodestar's mounting angle.

After one or more of these methods has been used to estimate the misalignment in the Lodestar heading measurements, the remaining angular misalignments can be calculated.

CASIUS alignment

CASIUS is an acronym that stands for Calibration of Attitude Sensors In the USBL System. It is software created by Sonardyne International Limited.

When used with Sonardyne's USBL acoustic navigation systems, CASIUS determines the offset distances between a GPS antenna and the acoustic transceiver. However, in addition to these measurements, CASIUS can also calculate the misalignment angles that apply to roll, pitch and heading outputs from the Lodestar. Note that this method calculates the misalignments and offsets between the Lodestar, GPS antenna and transceiver, independent of the vessel frame. However, it can be used to define the vessel frame.

This method involves deploying a reference acoustic beacon on the sea bed and making simultaneous observations using the GPS receiver, Lodestar, and the USBL transceiver at defined positions and orientations on the surface.

Contact Sonardyne for information and instructions.

Transfer alignment

This method of fine alignment relies on there being another attitude measurement instrument on board the same vessel where the Lodestar is installed. This instrument must already have been surveyed into the vessel's body frame and must be capable of measuring the vessel's attitude and heading to the same degree of accuracy as the Lodestar.

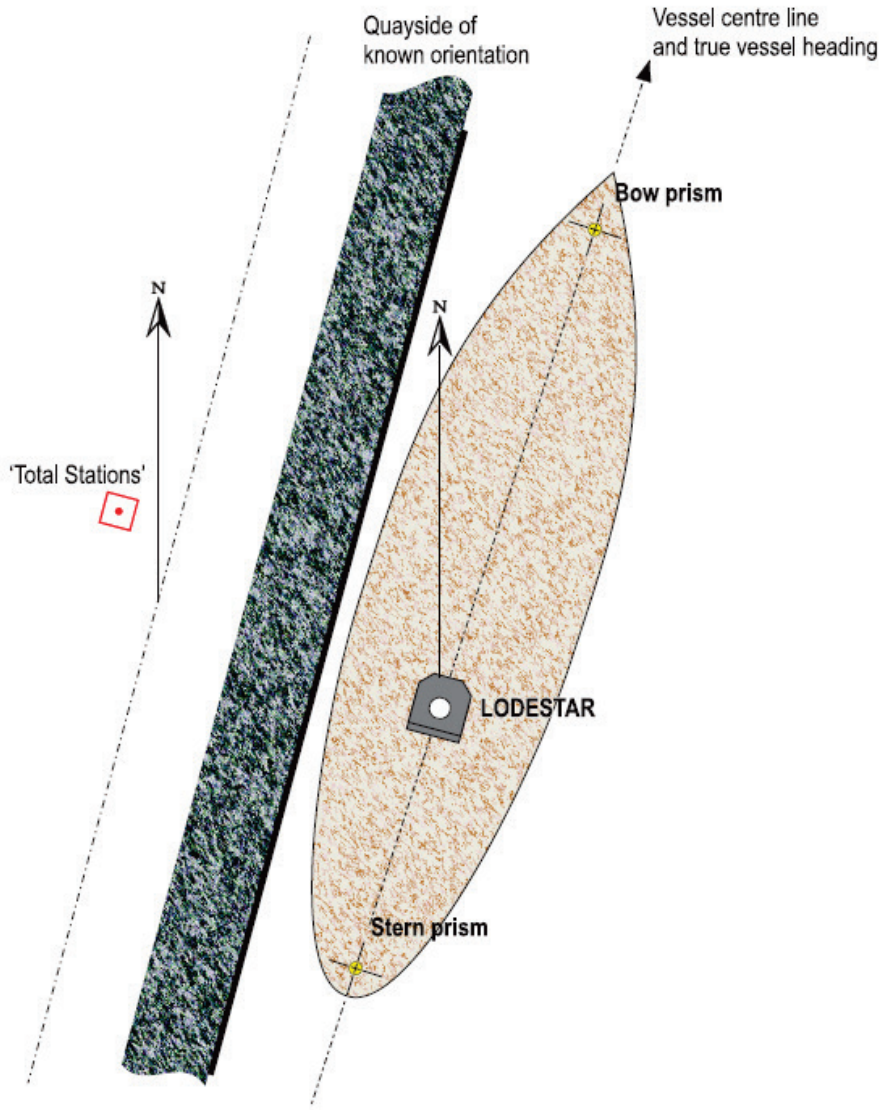
If such an instrument exists on the vessel, compare its measurements with those of the Lodestar, either simultaneously or through time-stamped log files, and apply mount angle corrections to the Lodestar so the two sets of measurements coincide.

Port or shore-based alignment

This method of fine alignment relies on there being another attitude measurement instrument on board the same vessel where the Lodestar is installed. This instrument must already have been surveyed into the vessel's body frame and must be capable of measuring the vessel's attitude and heading to the same degree of accuracy as Lodestar.

If such an instrument exists on the vessel, its measurements can be compared with those of Lodestar, either simultaneously or through time-stamped log files. The mounting angle corrections can be applied to the Lodestar so that the two sets of measurements coincide.

Figure 37 – Port or shore-based alignment

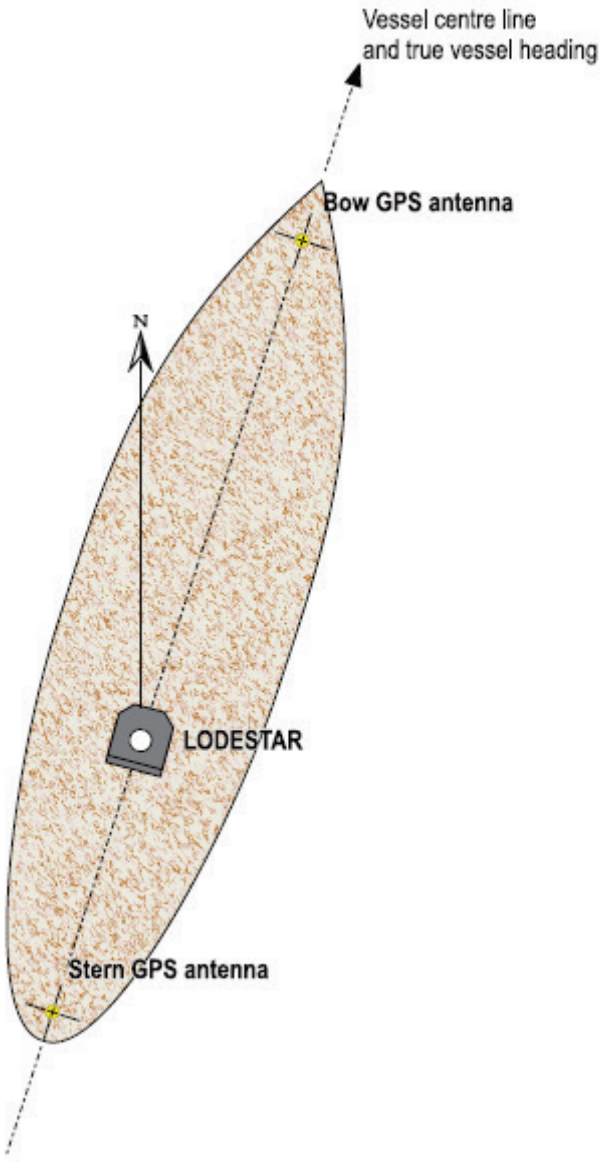


The Total Stations laser survey system must take a series of measurements on two prisms mounted on the vessel's centre line at the bow and the stern. These measurements allow a close estimation of the vessel's heading. This information is compared with a log of heading data taken from the Lodestar AHRS on the vessel, which is averaged over the relevant period. This comparison then allows the determination of heading error as measured by the Lodestar.

Heading alignment at sea

This method relies on two GPS antennas placed on the vessel's centre line at the bow and the stern. It is most effective when performed in sheltered waters where there is a good quality differential GPS service available.

Figure 38 – Heading alignment at sea



By post-processing data logged from both GPS systems and from the Lodestar, the vessel's true heading can be estimated at specific times as determined by the GPS time stamp. This comparison allows a good estimation of the error included in the heading measurements from Lodestar, which can then be compensated for in software.