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User Manual for SPRINT

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NOTE

Email and telephone support is available during normal UK office hours (08:00 to 17:00).

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AMENDMENT HISTORY

All amendments and additions will be issued with a new copy of this sheet, recording the history of amendments

Issue	Revision	Date	Comments	Section	Page
A	0	Feb 2012	Initial Issue	All	All
A	1	Aug 2012	General updates	All	All
A	2	May 2013	Updated with SPRINT 1.1 changes	All	All
A	3	Oct 2013	ECN 12396: Updated with SPRINT 1.2 changes in Section 6, 9 and E12 General updates	6.3.1, 6.3.11, 6.3.18, 9.2.3 and Appendix E12 All	All

SECTION 1 – INTRODUCTION

1. Introduction

This User Manual describes the safe installation, operation maintenance of the SPRINT System, with Sonardyne Transceivers and Beacons. The information and procedures within this manual are based on Sonardyne's experience and knowledge.

To make sure the safety of the installer and operator is maintained, it is important that all Warnings, Cautions and Safety Section in this manual, and the Warnings, Cautions and Safety Section of any additional manuals are read and understood.

1.1 Related Publications

To make sure the system is operated safely, a Safety Manual is supplied with this User Manual. It is important the Safety Manual is read and understood before proceeding with any activity on the equipment.

The related publications are:

Table 1-1 – Related Publications

Publication	Title
Safety Manual	Safety Manual
UM-8084-101	Lodestar Hardware Manual
UM-8084-107	Lodestar AHRS Manual
UM-8080-109	Lodestar AHRS Messages

SECTION 2 – SAFETY

2. Introduction

Before any activity is carried out on this SPRINT system, it is recommended that the included Safety Manual and all Warnings and Cautions in this manual are read and understood.

It is recommended the operator complies with the Health and Safety Regulations applicable to the vessel and the region before operating this equipment.

Operators and service personnel must be familiar with the normal operating and safety procedures for Subsea Equipment.

Documentation must be consulted whenever a ⚠ Warning symbol is found on the equipment, in order to determine the nature of the potential hazard and any actions which must be taken.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

2.1 Procedures

Before carrying out any procedure on the SPRINT system make sure all the following Warnings and Cautions are read and understood.

WARNINGS

Electric Shock Risk. Make sure the equipment is earthed before using. There is a risk of electric shock if the equipment is not earthed.

Electric Shock Risk. Disconnect power from the equipment before removing the covers. There is a risk of electric shock if the power is not disconnected.

Heavy Equipment. The 1000 metres rated Lodestar weighs 14 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.

Heavy Equipment. The 3000 metres rated Lodestar weighs 22 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.

Heavy Equipment. The 5000 metres rated Lodestar weighs 39 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.

CAUTIONS

⚠ **Incorrect Power Supply. Make sure the Lodestar is supplied with 24 or 48 V DC only. Do not use an AC power supply.**

SECTION 3 – TECHNICAL DESCRIPTION

3. Introduction

Subsea Precision Reference Inertial Navigation Technology (SPRINT) is an acoustically aided inertial navigation system for subsea vehicles. The system extends the operating limits of Ultra-Short Baseline (USBL) and can dramatically improve the operational efficiency of Long Baseline (LBL) by using sparse arrays. SPRINT makes optimal use of acoustic aiding data from acoustic positioning and other sensors such as Doppler velocity log (DVL) and pressure sensors. This improves position accuracy, precision and integrity in any water depth while reducing operational time and vessel costs.

3.1 Lodestar

The core of the system is the Lodestar platform. Lodestar was released to the market in 2007 as a premium quality, survey grade, Attitude and Heading Reference System (AHRS) for surface and subsea applications. Using the same hardware platform, Lodestar is fundamental to SPRINT.

Lodestar makes use of three ring laser gyroscopes that measure the angular rate and three accelerometers that measure the specific force of a moving platform. The highest quality dual use (commercial and military) field proven sensors have been selected for use due to their performance, low mean time between failure (MTBF) and ease of export. These sensors have highly stable error characteristics and are compensated for temperature variation making them ideally suited to subsea applications.

3.2 Inertial Navigation

The INS sensor outputs are combined mathematically to compute the position, velocity and attitude of the vehicle. The output is extremely low noise and very accurate in the short term but slowly degrades over time. Therefore it is necessary to seamlessly aid the INS with complimentary acoustic positioning and other aiding sources.

Acoustic Aiding with Sonardyne’s latest Sixth Generation (6G®) vessel-based transceivers and subsea beacons maximise the benefits of the system by providing the most precise and reliable acoustic aiding input.

Depending on the functionality level of the SPRINT system being used, various aiding options will be available, whilst others may be disabled:

- USBL
- DVL
- Pressure Depth
- Zero Velocity (ZUPT)
- LBL

3.2.1 USBL Aiding

The vessel-mounted USBL transceiver determines the range and bearing to an acoustic beacon fitted to the subsea vehicle. Using vessel DGPS for position and VRU/MRU/AHRS for vessel motion compensation, an absolute position for the vehicle mounted beacon is calculated by the USBL system.

This position is fed into SPRINT as an absolute positioning aiding input. Additionally, the USBL system is synchronised to Coordinated Universal Time (UTC) to provide an accurate timestamp. Whilst the use of Sonardyne USBL provides a tighter acoustic / inertial integration and the best possible USBL positioning performance, SPRINT can accept position aiding from any USBL system that uses correct time-stamped positions in an industry standard telegram. Although SPRINT improves USBL system precision and short term accuracy, it will not resolve any inherent systematic errors that are present. Users must therefore make sure the USBL system they are using is correctly calibrated and recommended operating practices are observed, for example, using regular sound velocity profiles.

3.2.2 Sparse LBL Aiding

In Sparse LBL operations, two or more (instead of four or five) beacons are deployed on the seabed and their positions derived using ‘box-in’ or other top-down calibration techniques. With a known beacon position, the INS can navigate in Sparse LBL mode using the ranges from one or more seabed deployed beacon to acoustically aid the INS and constrain error growth in the absolute position output. In this configuration, the vehicle mounted LBL transceiver (ROVNav 6) communications will be routed to the vessel via the Lodestar for optimal time stamping of acoustic range data.

3.2.3 ZUPT (Zero Velocity) Aiding

In certain operational situations the subsea vehicle will be static (e.g. during average position fixes). In these situations, particularly if there is risk of loss of other aiding, it is beneficial to be able to aid the INS with ‘zero velocity’ updates to estimate inertial sensor errors. This feature is available in SPRINT and is easily activated from the main user interface.

3.2.4 Vehicle-Mounted Sensor Aiding

Lodestar has the ability to use vehicle-mounted aiding sensors such as Doppler velocity logs (DVL) and pressure/depth sensors. The use of these sensors provides further benefits for subsea navigation such as the ability to provide precise and continuous navigation output even if external acoustic positioning is lost for periods of time. SPRINT does not need to be physically co-located with the Doppler Velocity Log or integrated into the same housing. Only ‘coarse’ alignments and offsets from the INS to the DVL are needed from the user. Fine offsets and misalignments are then calculated in the field using a calibration routine. This approach allows for more flexible mounting configurations to be considered.

3.3 Theory of Operation

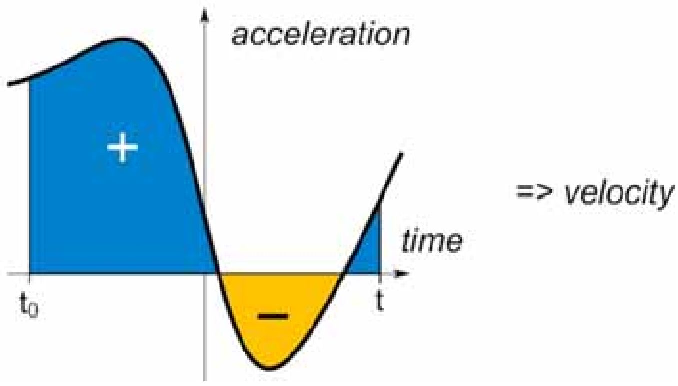
3.3.1 Inertial Navigation

Inertial navigation is the computation of velocity, position and orientation from measurements of acceleration and rotation.

Acceleration (velocity change) is measured by an orthogonal triad of accelerometers. Rotation (angular change) is measured by an equally orthogonal triad of gyroscopes (see **Section 3.3.2**). The composite mechanical structure is called the Inertial Sensor Assembly (ISA). An Inertial Measurement Unit (IMU) is composed of the ISA and a processor that performs various forms of compensation using e.g. factory calibration coefficients. The outputs of an IMU are compensated delta angles and delta velocities typically at a rate of 100-200Hz.

Inertial navigation is based on the dead-reckoning principle. INS velocity is computed from an initial value by integration (see **Figure 3-1**) of acceleration over time. Similarly, position is computed from velocity and orientation (attitude and heading) is computed from integration of measured rotation (angular change).

Figure 3-1 – Computation of Velocity via integration of Acceleration (1D example)**



It can be imagined how a fixed error (bias) in acceleration when integrated will cause an error in velocity that grows proportionally with time giving rise to quadratic with time error in position.

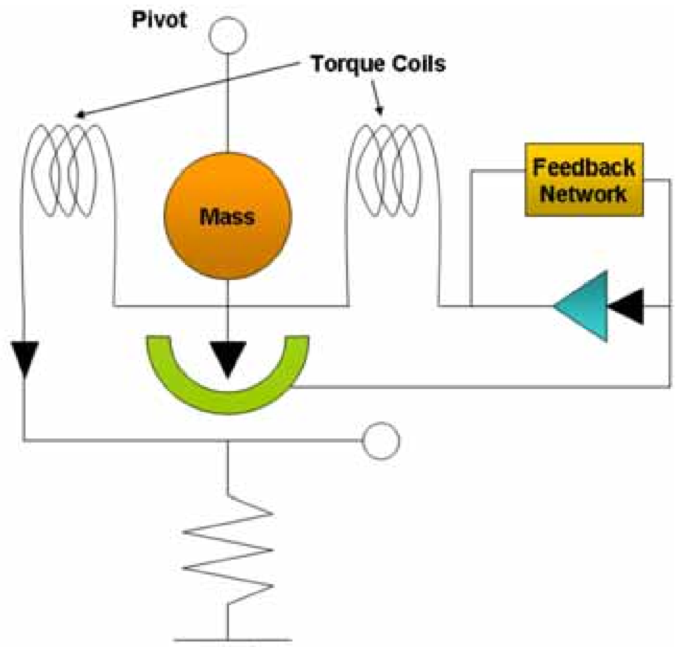
This simplified description of the inertial navigation process match fairly well in the short term especially for stable platform INS where the accelerometers were physically pointed in fixed directions (e.g. North, East and Down). In practise, the 3D vector mathematics are somewhat more involved, especially for modern strap-down INS where the sensors are strapped onto the vehicle body.

** Velocity at time 't' is the sum of the areas under the acceleration curve (yellow counts as negative) plus the initial velocity at time t0.

3.3.2 Inertial Sensors

Accelerometer: Most accelerometers used for inertial navigation are of the force-feedback pendulous type illustrated in **Figure 3-2**. A proof mass at the end of a pivoted or flexible arm is balanced via feedback control keeping its deflection close to zero. The coil current generating the counter acting force is a measure of acceleration along the single axis of free movement.

Figure 3-2 – Force Feedback Pendulous Accelerometer



It is impossible to distinguish between true kinematic acceleration (velocity change relative to the Earth) and gravity. A stationary accelerometer with its sensitive axis pointed up will measure +1g even though it is obviously not moving anywhere. The term specific force is the sum of kinematic acceleration and gravity and has been coined to express what an accelerometer really measures.

Gyroscope: Modern gyroscopes are based on a variety of different physical principles. Most navigation grade gyroscopes are currently based on optics using the “Sagnac” effect to sense rotation, e.g. the Ring Laser Gyro (RLG, see **Figure 3-3**):

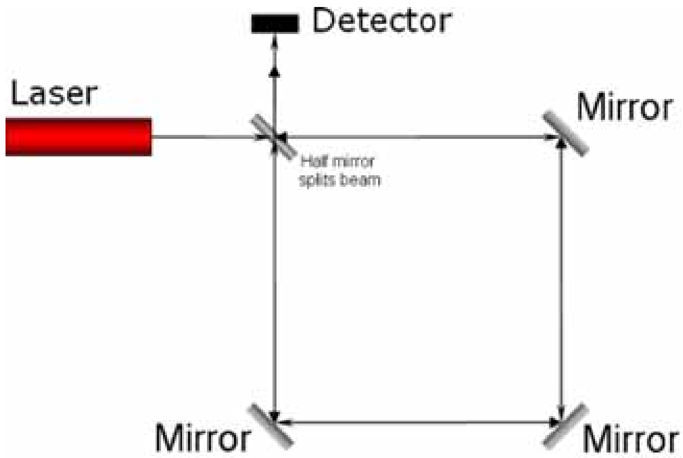
Laser beams are made to travel in both opposite directions within a cavity (“ring”) formed by typically 3 or 4 mirrors. When the cavity rotates relative to inertial space one beam has to travel further than the other. A part of the laser light is allowed to escape via a semi-transparent mirror and is used to form a fringe pattern. Optical sensors count the direction and number of fringes passed which is a precise (digital) measure of how much RLG has rotated relative to inertial space.

In a Fibre Optic Gyroscope (FOG) light travels through loops of optic fibre rather than a closed path. Both RLG’s and FOG’s can achieve very high performance.

Other commonly used gyro technologies are:

- Conventional spinning metal gyroscope
- “Dynamically Tuned Gyro” (DTG). Ingenious compact mechanical strap down device.
- Hemispherical Resonator Gyro (HRG). Resonant device made of very high Q quartz (“Wine glass”) – Coriolis force device
- Micro Electro-Mechanical Devices (MEMS) based gyros (Coriolis force)

Figure 3-3 – Ring Laser Gyroscope Principle of Operation



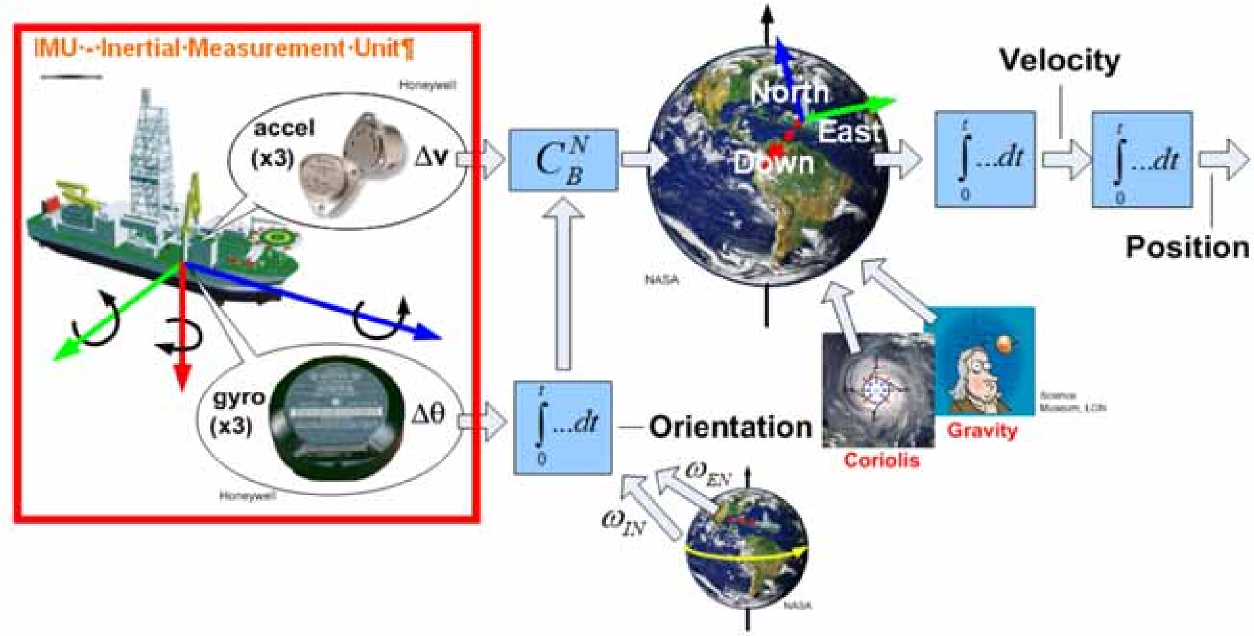
3.3.3 Strap-down Inertial Navigation

The process of strap-down inertial navigation is shown in **Figure 3-4**. Vehicle orientation relative to the Earth is maintained within the navigation computer via integration of measurements from the gyroscope triad and is compensated for Earth rotation and vehicle motion over the surface of the Earth. Known orientation is used to transform accelerometer specific force into a navigation frame (often North-East-Down – NED).

Specific force is compensated for gravity and Coriolis force to obtain kinematic acceleration. Gravity is computed using a mathematical model and is dependent on vehicle position on the Earth, most importantly latitude and depth/height. Coriolis force is a “mathematical artefact” that arises and requires compensations because the navigation frame rotate with the Earth and is therefore not a true inertial frame (fixed relative to the stars). Finally, acceleration is integrated to obtain velocity and velocity is integrated into position.

Typically the strap-down computations are set to execute at 100-200Hz whereas the inertial sensors may be sampled at several kHz. The raw rate is reduced using a coning and sculling algorithm that e.g. very precisely takes into account the non-commutativity of rotations (sequence of rotations matter).

Figure 3-4 – “Strap-Down” Inertial Navigation



3.3.4 Errors in Inertial Navigation

The sources and error propagations in inertial navigation are complex and not always intuitive. The initial part of **Section 3.3.1** describes how a constant error in acceleration would cause error in position to grow with time squared. In a real INS with external aiding (as described in **Section 3.3.7**) a fixed accelerometer bias would primarily cause an error in roll/pitch which would make gravity couple into the horizontal plane by just enough to counteract the position drift.

Simulation techniques and tools are available for accurately predicting INS performance in various scenarios and taking all significant error sources into account. Somewhat counter intuitively, gyroscope errors in general play a more significant role than accelerometer errors.

3.3.5 Reference frames

A number of reference frames are used within inertial navigation.

Vehicle frame: Axes are along the vehicle axis, typically forward, starboard and down. The vehicle frame is typically used for navigation outputs (e.g. roll, pitch and heading) and for defining various sensor lever arms (“offsets”) and mounting angles.

IMU frame: Axes are along the inertial sensor axes as typically marked on the IMU/INS housing. IMU frame is used for many INS internal computations.

Navigation frame: Frame used for the inertial navigation computation of position and velocity (most often local level e.g. North, East and Down).

Inertial frame: Non-rotating frame (relative to inertial space).

NOTE

Definitions of SPRINT (and Lodestar) specific reference frames are provided in Appendix A and Appendix B.

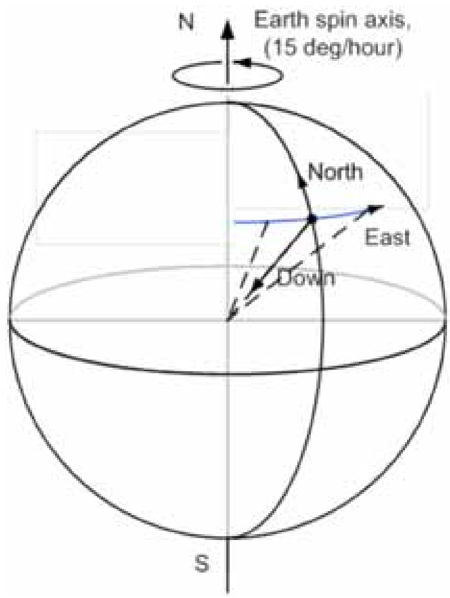
3.3.6 Gyrocompassing – North Finding

An INS can determine its orientation (roll, pitch and heading) relative to the Earth by “gyrocompassing”. Basically the direction of up/down and the Earth spin axis can be sensed using the inertial sensors.

For a slow moving (i.e. marine) vehicle, the measured acceleration (specific force) vector will point “up”, i.e. the measured vector will be parallel with the local gravity vector (down). In practise, measured acceleration is averaged (filtered) to cancel out effect of vehicle motion.

The local gravity vector will follow the rotation of Earth relative to inertial space, see **Figure 3-5**. The direction of East can be determined by tracking the systematic change in the direction of the gravity vector relative to inertial space over time. Knowing the direction of down and East allows the direction of North and full orientation to be determined.

Figure 3-5 – Earth Rotation



The Earth rotates by just 15 deg/hour and the gyroscopes used for tracking the change of direction of gravity must be accurate to considerably better values. Furthermore, it can be shown that the local gravity vector direction changes only by the cosine of Latitude part of Earth rotation, i.e. change is reduced towards the Poles. This explains why heading accuracy is typically specified as x.xxx degrees * Secant Lat (secant = 1 / cosine).

Vehicle position change in the N/E direction (from, e.g. steaming) will cause the gravity vector to change in this direction also and not be pure E/W. This will bias the gyro-compassing determined heading if not compensated for by e.g. measurements from a GPS receiver.

An inertial based Attitude and Heading Reference System use the described principles to generate robust roll, pitch and heading.

3.3.7 Aided INS

The drift of a typical commercial airplane inertial system is on the order of 1NMPH (Nautical Mile Per Hour). This is adequate for guidance from one airport to another and e.g. crossing the Atlantic but hardly useful for navigation of slow moving marine vehicles intended to do e.g. seabed mapping.

Improved performance can be achieved by Aiding the INS with measurements from one or more external sensors; see **Figure 3-6**. IMU data feeds into two separate algorithms: AHRS and AINS. The AHRS is used as a convenience for providing the AINS with initial estimates of attitude/heading thereby simplifying its design.

The INS block was described in **Section 3.3.3** and provides the position, orientation and velocity output. The role of the error state Kalman filter is to estimate and compensate errors in the inertial navigation and thereby constantly keep the INS on track, while monitoring the correction feed.

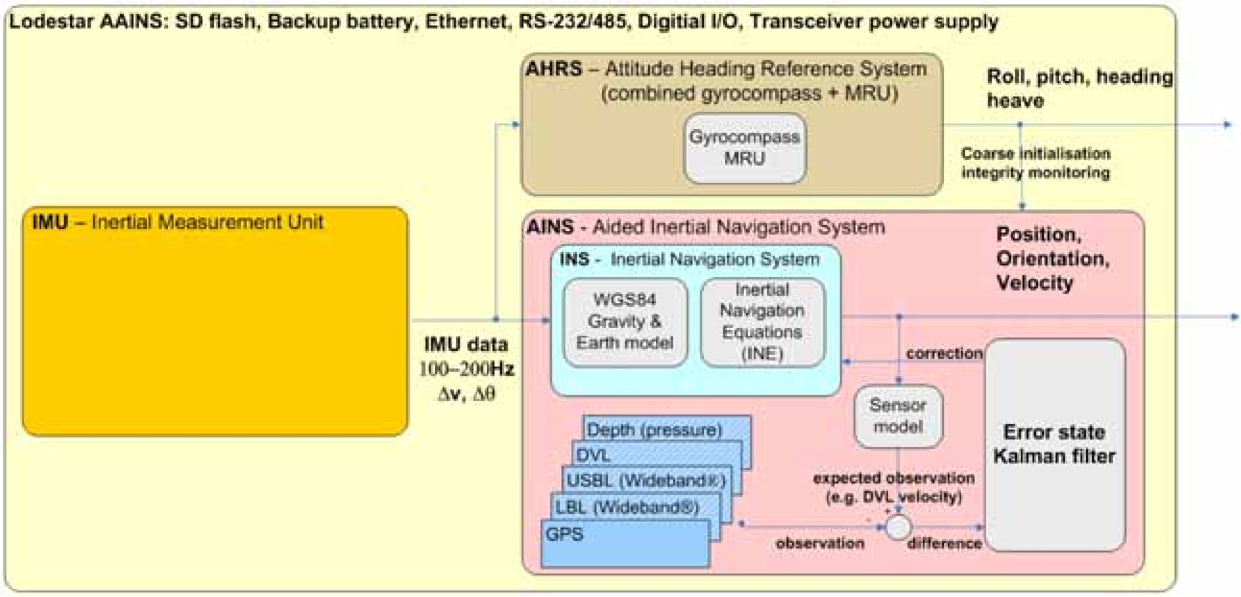
The Kalman filter determines INS errors from external sensor measurements. The difference between a measurement (observation) and its expected value (based on the INS) is fed into the Kalman filter and is used to refine its state vector and covariance matrix. The state vector is composed of INS errors in position, orientation and velocity and often also key inertial sensor errors such as gyroscope and accelerometer bias. Errors in external sensors can also be modelled for improved performance.

The covariance matrix is the “memory” of the Kalman filter and it holds the uncertainty of each state and the correlation between states. Useful performance metrics such as expected positioning accuracy is extracted directly from the covariance matrix.

The Kalman filter will manage asynchronous data and the considerable latency often found in acoustic observations. An Aided INS is often referred to as a “hybrid inertial system”.

The combination of a DVL and INS provides accurate heading/attitude and the ability to perform dead-reckoning to an accuracy of just a few meters per hour. This functionality is extremely useful for subsea navigation. Further combination with USBL or (sparse) LBL provides absolute positioning that is considerably more accurate and robust than acoustic positioning by itself.

Figure 3-6 – Sonardyne "Lodestar" Acoustically Aided INS functional block diagram



The INS aiding options available in SPRINT are listed in **Table 3-1**. Only certain position aiding inputs, such as USBL can be used to initialise Inertial Navigation and that these aiding inputs must be UTC time synchronised.

Table 3-1 – SPRINT INS Aiding Options

Aiding Source	Aiding Type			Aiding Considerations	
	Position Aiding (Horizontal)	Velocity Aiding	Depth Aiding (Vertical)	Time Sync Required?	Can be used to Initialise INS?
USBL	✓	×	×	✓	✓
LBL	✓	×	×	×	×
DVL	×	✓	×	×	×
Zero Velocity	×	✓	×	×	×
Pressure Depth	×	×	✓	×	×

NOTE

Pease note and follow the operational considerations provided below:

*** LBL aiding must be used in conjunction with DVL Aiding.**

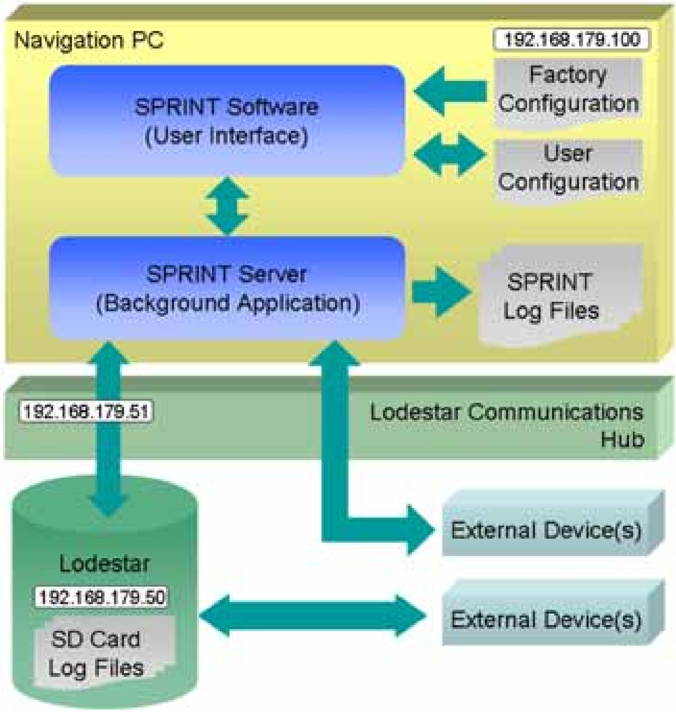
*** LBL and Zero Velocity (ZUPT) aiding are only available in the full version of SPRINT.**

3.4 System Architecture

3.4.1 Architecture

The architecture of the SPRINT system is shown in **Figure 3-7**.

Figure 3-7 – Logical SPRINT Architecture



The Navigation PC runs the SPRINT software which comprises two components:

- User Interface, which provides configuration, control and monitoring of the Lodestar and SPRINT system.
- SPRINT Server, which routes all communications between the Lodestar, User Interface and any other topside external devices. The SPRINT server also logs all data from the Lodestar on the Navigation PC, including raw sensor feeds.

The Lodestar Communications Hub (LCH) is a serial device server and Ethernet hub used by the Navigation PC. An Ethernet link is provided between the Navigation PC and the LCH (ports). For this reason IP Addresses and Ports are used to specify serial as well as Ethernet devices connected to the LCH. The IP addresses of each of the main system components are shown above but note that the Lodestar IP address will only be used if the Lodestar is to be connected to the topside components using an Ethernet connection.

External devices may be connected directly to the Lodestar as well as to the LCH.

The SPRINT system stores the configuration of the Lodestar and Software/Server. A Factory (default) Configuration is provided as a starting point for setup. Thereafter a User Configuration is stored by the software every time a configuration change is made or by user request. If the Lodestar used by the SPRINT system is swapped, the software will prompt the user to re-apply the User Configuration to the new Lodestar to continue operation as before.

As well as storing the log files in real time on the Navigation PC, the Lodestar also stores a rolling backup of all the log files on its onboard SD card. The size of the log data is variable depending on the number/update rate of aiding sensors and also the number of outputs specified. Typically for a USBL/DVL/Depth aided system, the log files are populated at the rate of 0.5mb per minute, which will provide over 10 days continuous onboard storage. The log files on the Lodestar SD card can be retrieved offline using the Lodestar PC Utility (see Lodestar AHRS Manual UM-8084-107 for instructions).

SECTION 4 – PLANNING

4. Planning

4.1 Navigation Scenario

Prior to installation it is important to consider the navigation scenario to determine the optimum system configuration and interfaces. Typically the scenario is defined by the positioning (or attitude) accuracy specifications of a mission or project but equally important is the timeliness (or latency) of positioning or attitude provided by SPRINT system.

Two common navigation scenarios are explained below. The recommended configuration for each navigation scenario is explained in the installation and configuration sections. If there is uncertainty as to which scenario is to be supported it is recommended that 'Dynamic Survey' is selected.

4.1.1 Construction Survey

In this scenario the SPRINT ROV will be used to position subsea structures or pipelines that are slow moving. The positioning and attitude accuracy tolerances can be high but the timeliness requirements of the outputs is relatively low (<~ 0.5 seconds) as ROV is often moving very slowly or performing static fixes during critical positioning phases.

4.1.2 Dynamic Survey

In this scenario the SPRINT ROV will be used to perform dynamic, high accuracy surveys such as multibeam pipeline out-of-straightness. The positioning and attitude accuracy tolerances are high and so is the timeliness of the outputs as the ROV motion must be compensated correctly when processing multibeam data. Any significant latency in ROV position or attitude will result in errors or artefacts in the final multibeam terrain model. In this scenario accurate alignment and instrument offsets will be more critical than in the 'construction' survey.

4.2 Interfaces

Prior to installation the following interfaces should be planned according to the SPRINT navigation scenario (✓indicates a supported interface, ✘ indicates a non supported interface):

		Navigation Scenario	
Interface*		Construction	Dynamic
Lodestar Connection	Either:		
Ethernet (100mbit only)		✓	✓
Serial RS232 115,200 baud		✓	✓
Time Synchronisation**	Either:		
GPZDA UTC message with configurable latency to 1 PPS		✓	✘
GPZDA UTC message & 1PPS sent to Lodestar		✓	✓
USBL Aiding***	Either:		
PSIMSSB message (UTC time, WGS 84 Lat/Long Radians)		✓	✓
USBL GGA message (UTC time, WGS 84 Lat/Long Degrees)		✓	✓
DVL Aiding****	Either:		
RDI Binary PD4/5 Message (Recommended)		✓	✓
RDI Binary PD0 Message		✓	✓
Pressure Depth Aiding	One Of:		
DigiQuartz kPA/PSI/Metres		✓	✓
Valeport Midas SVX2		✓	✓
NMEA DPT message		✓	✘
Sonardyne SONDEP message		✓	✘
Tritech Winson (processed) message)		✓	✘
LBL Aiding			
Fusion 6G LBL 1.11.04 (or later) with appropriate dongle		✓	✓
INS Position Output (with UTC timestamp)	Either:		
From SPRINT topside (LCH)		✓	✓
From Lodestar (ROV)		✓	✓
AHRS Attitude Output (No UTC timestamp)	Either		
From SPRINT topside (LCH)		✓	✘
From Lodestar (ROV)		✓	✓

NOTES

***See Appendix E for all message formats.**

**** It is assumed that in either mode of time synchronisation that the GPZDA message is received no faster than 1Hz (once a second) otherwise the system may not be able to synchronise.**

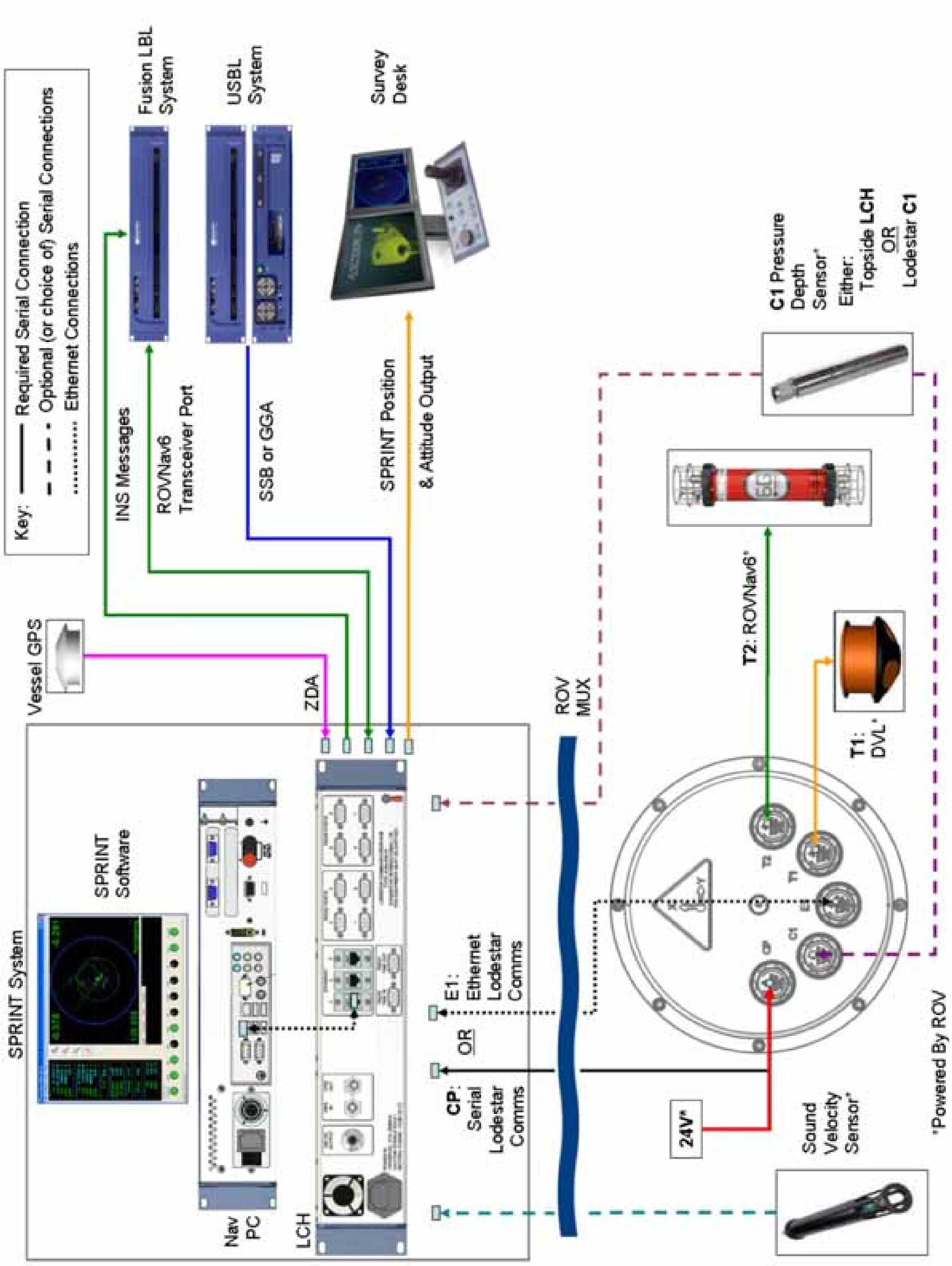
***** All USBL aiding inputs must be raw / measured and should not be subject to any filtering.**

****** See Appendix D for supported DVL configurations.**

4.3 Connections

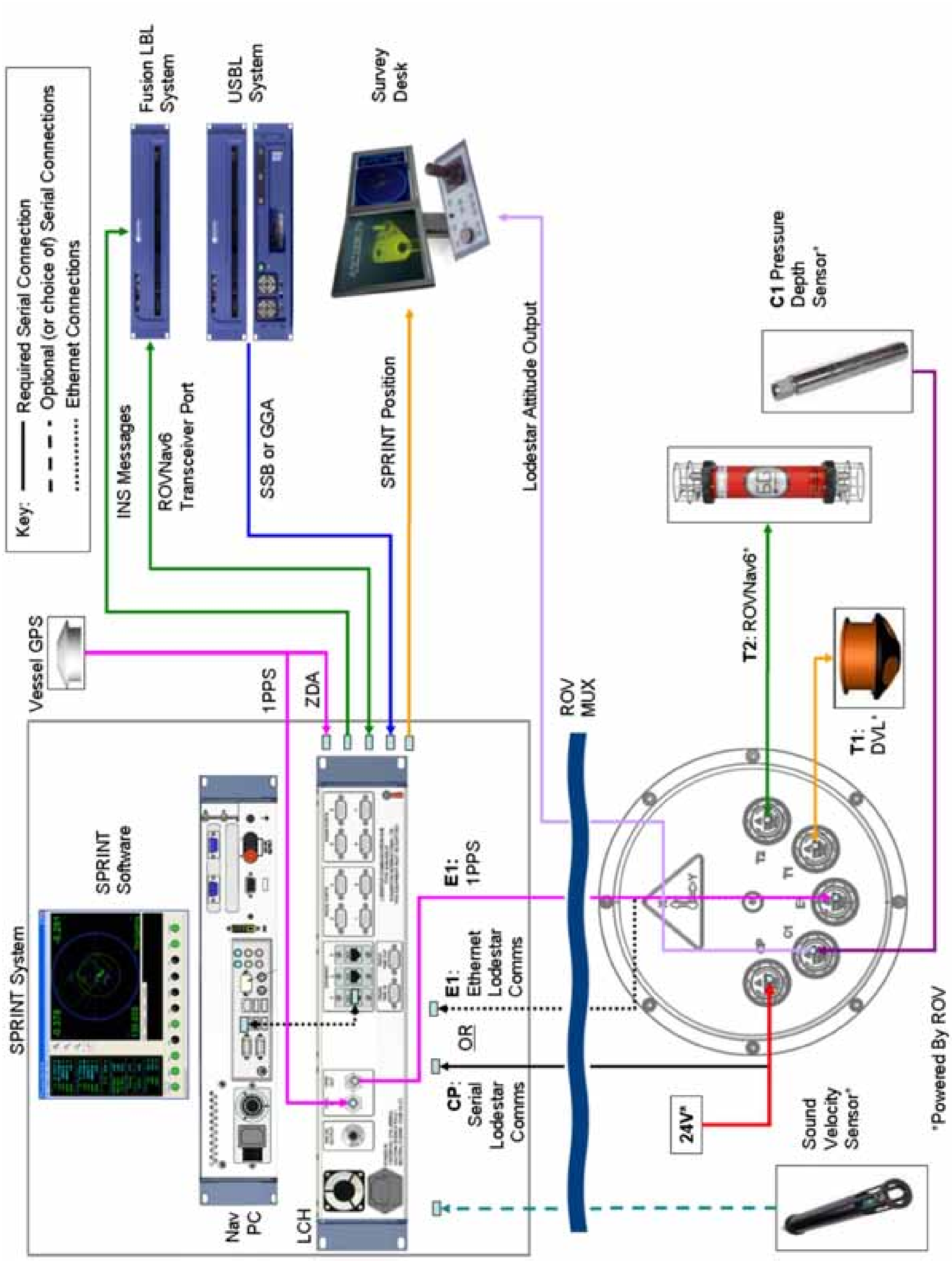
To guarantee the successful operation of the SPRINT system, the system connectivity must be considered at the installation planning stage. A suggested system connectivity diagram for the ‘construction survey’ configuration is shown in **Figure 4-1.**

Figure 4-1 – Construction Survey Interface Diagram



A suggested system connectivity diagram for the 'dynamic survey' configuration is shown in **Figure 4-2.**

Figure 4-2 – Dynamic Survey Interface Diagram



4.4 Cabling

The system cabling must be carefully planned prior to installation to avoid issues. Subsea cables can be costly and time consuming to correct or replace during the installation phase.

4.4.1 Topside

The majority of topside interfaces will be serial. Consideration should be given for any serial cable run length, as this could lead to data corruption if the length is excessive, particularly the serial connection between the SPRINT LCH and the Lodestar (if used). If the distance between the SPRINT LCH and the ROV (de) multiplexer is excessive for an 115,200 baud rate RS232 serial link then alternate interfaces should be planned to make sure the data is not corrupted, such as Serial to Ethernet or RS232 to RS422/485 converters. Alternatively an Ethernet connection to the Lodestar could be considered.

4.4.2 Subsea

A typical cabling diagram for all the required subsea connections to and from the Lodestar on the vehicle is provided in **Appendix F**. This diagram should be used to produce vehicle and sensor specific SPRINT cables prior to installation. If required, there are also individual cable pin-outs for each specific Lodestar port available in the Lodestar Hardware Manual UM-8084-101.

4.5 Time Synchronisation

The SPRINT Lodestar will be time synchronised to UTC by receiving a ZDA message and optionally a 1PPS timing pulse from a GNSS receiver. The SPRINT system will be interfaced to other systems, such as USBL, Survey Software or Multibeam that are also time synchronised to UTC using connections to GNSS receivers. A common source of perceived INS position error is inconsistent time synchronisation across the various systems interfaced with the SPRINT system.

There are three fundamentally different types of GNSS ZDA/1PPS time synchronisation:

- ZDA arrives before its associated 1PPS
- ZDA arrives after its associated 1PPS (most common)
- 1PPS and ZDA are asynchronous (seen with many modern GNSS systems)

Different models and configurations of GNSS receiver may use any of the three types listed above.

It is very important that the type of synchronisation used by each GNSS receiver is understood prior to SPRINT installation to avoid timing issues. This may require consultation with the GNSS manufacturer. If possible, the use of a common GNSS receiver for time synchronising all systems will greatly reduce the risk of issues.

4.6 Depth

The SPRINT system supports either pressure or depth aiding input to determine the depth of the INS. There are several factors that should be considered during the planning phase.

4.6.1 Pressure to Depth Conversion

In the case of a pressure aiding input the Lodestar performs a simple pressure to depth (metres) conversion. The pressure to depth conversion scale factors are provided in **Appendix G**.

If there is a requirement for a different pressure to depth conversion calculation to be used, the operator can either:

- Convert the pressure sensor data to metres using the required conversion and pass this to the Lodestar as a depth (m) aiding message.
- Apply a pressure depth offset to the SPRINT system at operating depth so the INS depth is consistent with the intended depth datum.
- Convert the INS depth output from the system to another datum using the provided conversion calculations.

4.6.2 Surface Pressure

Most pressure sensors will measure ambient air pressure at the surface. This is the equivalent of approximately 10 metres of water depth. SPRINT allows the operator to measure the surface pressure on deck and remove it from any subsequent depth calculation. Depending on project requirements surface pressure may be removed as described above or the INS depth could also include surface pressure – this should be decided at the planning strange.

4.6.3 LBL References

Whichever method or configuration of SPRINT pressure depth is used, the INS depth should always be consistent and relatively accurate to any LBL reference depths.

4.7 (Sparse) LBL Array Planning

4.7.1 Features and Operational Guidelines

The INS can be aided by LBL range observations from a Fusion 6G system.

Due to its DVL-inertial dead-reckoning capability, the INS can manage with less than the 4 or 5 beacons traditionally required for acoustic LBL tracking, hence the term ‘Sparse’ LBL.

Please consider the following features and operational guidelines for sparse LBL:

a. The minimum number of beacons at one site is two. Use of three beacons will support loss of acoustics to any single beacon and INS integrity if there is an error with aiding from any single beacon. For this reason the recommended number of beacons for a sparse array is three.

b. In specific scenarios with favourable vehicle dynamics / trajectory the INS can be aided with range observations from just a single beacon. Additional operational guidelines should be considered – contact Sonardyne for advice.

c. The INS can be actively aided by up to 6 beacons but can record LBL aiding observations for up to 10 beacons for analysis and post processing.

d. Acoustic update rate to each beacon should be faster than 10 seconds – this is primarily for screening of observations prior to INS use.

e. Pressure depth provided to the INS and beacon depths should be consistent. Relative depth errors will cause error in INS positioning if line of sight is not horizontal.

f. Sound velocity in Fusion must be correct. Make regular updates if change is expected (> 0.5m/s).

g. LBL (range) aiding must be used in conjunction with DVL aiding, particularly in very sparse arrays. Contact Sonardyne for specific guidance if DVL is not available.

h. Make sure placement of LBL aiding beacons provides adequate acoustic line of sight and good geometry to the LBL transceiver during planned operations.

4.7.2 Sparse Array Geometry

The reference beacons in the sparse array should be placed so the line of sight to at least two of the beacons is approximately orthogonal to reduce the error in opposing directions.

An example of good geometry is shown below in **Figure 4-3** and examples of poor array geometry are shown below in **Figure 4-4**.

Figure 4-3 – Example of Good Sparse Array Geometry

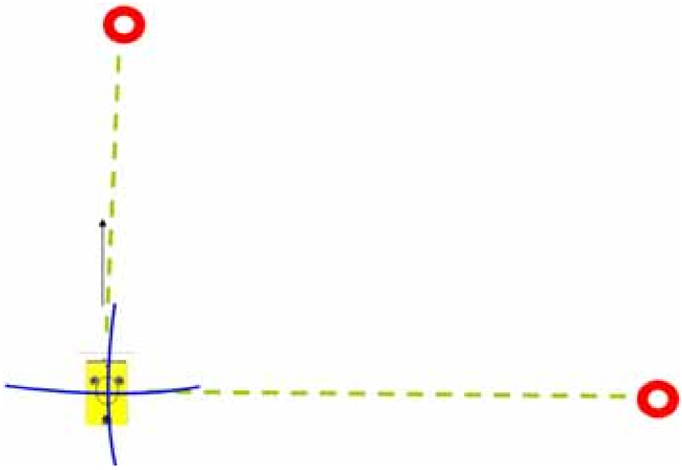
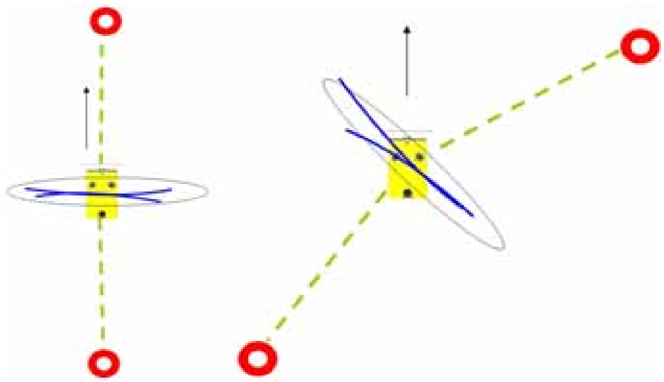


Figure 4-4 – Examples of Poor Sparse Array Geometry



4.7.3 First Use of 'Sparse' LBL Aided INS

It is recommended that with first use of 'Sparse LBL Aiding', full LBL array navigation is also available to provide an independent position reference. Refer to the procedure detailed below:

1. Deploy a full LBL array.
2. Run full LBL acoustic tracking in Fusion.
3. Use SPRINT with LBL aiding from two or more of the array beacons (depending on operational requirements).
4. Compare the positioning performance of SPRINT sparse LBL against full acoustic LBL.

Gross difference between the two positions will indicate an issue for investigation/resolution; see **Section 12.9** for troubleshooting advice.

4.8 Check List

Use the list below to assist in making sure the planning for the SPRINT system is complete prior to system installation:

	Action	Manual Section	Checked
1	Plan navigation scenario	4.1	
2	Plan (and prepare) required interfaces	4.2	
3	Plan system connections	4.3	
4	Plan system cabling	4.4	
5	Plan system time synchronisation	4.5	
6	Plan system depth	4.6	
7	Plan sparse LBL array(s) if required	4.7	

Sign: ………………………………………………………..	Date: …………………………………………………..

SECTION 5 – INSTALLATION

5. Installation

5.1 SPRINT System Kit

The SPRINT system kit should comprise the following items:

Figure 5-1 – SPRINT Installation Kit

1	Lodestar	4	Lodestar Cable Tails
2	Navigation PC	5	Lodestar Test Cables
3	Lodestar Communications Hub (LCH)	6	Lodestar Mounting Plate (not shown)

5.2 Mounting Lodestar

The Lodestar should be installed on the vehicle as per the instructions below.

WARNINGS

⚠ **Electric Shock Risk. Make sure the equipment is earthed before using. There is a risk of electric shock if the equipment is not earthed.**

⚠ **Electric Shock Risk. Disconnect power from the equipment before removing the covers. There is a risk of electric shock if the power is not disconnected.**

⚠ **Heavy Equipment. The 1000 metres rated Lodestar weighs 14 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.**

WARNINGS

Heavy Equipment. The 3000 metres rated Lodestar weighs 22 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.

Heavy Equipment. The 5000 metres rated Lodestar weighs 39 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.

CAUTION

Incorrect Power Supply. Make sure the Lodestar is supplied with 24 or 48 V DC only. Do not use an AC power supply.

NOTES

It is not necessary to mount the Lodestar at the vehicle centre of rotation/gravity.

The Lodestar should be mounted very securely to the vehicle in a rigid location. It should not be mounted on a moveable tray or in locations with excessive mechanical noise (e.g. directly next to hydraulic pumps).

The default mounting for the Lodestar is in the **vertical** position – refer to **Figure 5-2.**

Figure 5-2 – Lodestar Nominal Mounting

In this arrangement the X-axis indicator on the top of the Lodestar is aligned with the forward direction of the vehicle reference frame and the Y-axis indicator is aligned with the starboard direction of the vehicle reference frame (refer to **Figure 5-3**).

Figure 5-3 – Lodestar Axis Indicators

A mounting plate is supplied with the SPRINT system kit to support the mounting arrangement.

The Lodestar can also be mounted in other orientations if required. A common alternative mounting is with the Lodestar orientated **horizontally** as shown below in **Figure 5-4.**

Figure 5-4 – Lodestar Horizontal Mounting

The standard SPRINT system kit does not include mounting brackets or plates to support this orientation but optional mounting brackets can be ordered from Sonardyne on request. Please contact Sonardyne Support for further details.

Additional Lodestar power, maintenance and installation guidelines are provided in **Lodestar Hardware Manual UM-8084-101**.

5.2.1 Alignment

For the Lodestar and SPRINT system to provide accurate attitude and positions with respect to the vehicles reference frame, any misalignment between the Lodestar and vehicle reference frame must be corrected by determining and applying Lodestar mounting angles in the SPRINT system. A definition for the Lodestar reference frame including mounting angle convention is described in **Appendix B.** Typically there are two stages in determining the Lodestar Mounting angles.

First determine the initial 'coarse' mounting angles. If the Lodestar mounting is default as described in **Section 5.2** then the Lodestar mounting angles will all be zero. If the Lodestar mounting is non-default (e.g. the Lodestar is mounted horizontally) then the mounting angles must be applied in the SPRINT system. A selection of Lodestar mounting orientations and related mounting angles are provided in **Appendix C**.

Once the (coarse) mounting angles of the Lodestar have been determined using the guidance provided above, the angles can be refined using existing methods for 'Gyro to ROV' calibration.

These methods may include:

- Manual calculation using traditional survey methods such as a dimensional control survey (usually performed in a static environment onshore).
- Automated calculation provided by Survey software using comparison of ROV gyro against vessel reference gyro (can be performed offshore in a dynamic environment).

Make sure the results of any additional mounting angle calculation match the conventions listed in **Appendix B** before they are applied to the SPRINT system.

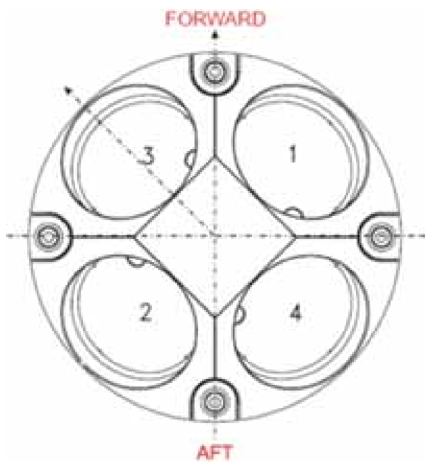
5.3 Mounting Aiding Sensors

All aiding sensors must be mounted very securely to the vehicle in a rigid location. They should not be mounted on moveable arms or trays as this may seriously degrade SPRINT performance by providing inaccurate or imprecise aiding data.

5.3.1 Doppler Velocity Log (DVL)

The SPRINT system is provided with a software utility that will calculate the mounting angles of the DVL used with the system. Therefore a variety of mounting angles can be supported but the SPRINT default DVL configuration (See **Appendix C**) will assume the DVL is mounted with the transducers facing towards the seabed and the alignment mark (also referred to as navigational groove) aligned to the forward direction of the vehicle reference frame.

Figure 5-5 – DVL Alignment



5.4 Measuring Lever Arms

Typically a vehicle has a central reference point or CRP and position calculations for a vehicle should be made with respect to this point. SPRINT will automatically provide the INS position for the defined vehicle CRP (and up to two additional remote positions if required).

The lever arms from the vehicle CRP to the Lodestar and any aiding sensors such as DVL, Pressure Depth and USBL beacon must be measured.

NOTES

One of the most common sources of error in INS positioning is incorrect lever arms.

It is recommended that all measurements are carried out by at least two (ideally three) individuals and the results compared.

Lever arms must be measured to the point of reference on each aiding sensor. If the point of reference is unknown, consult the relevant product manual.

5.4.1 Lodestar Lever Arm

The Lodestar lever arms must be measured from the vehicle CRP to the Lodestar 'centre of axis'. The location of the 'centre of axis' for each of the three subsea housing types are shown below (all dimensions are in millimetres).

Figure 5-6 – 1000 m Lodestar Centre of Axis Location

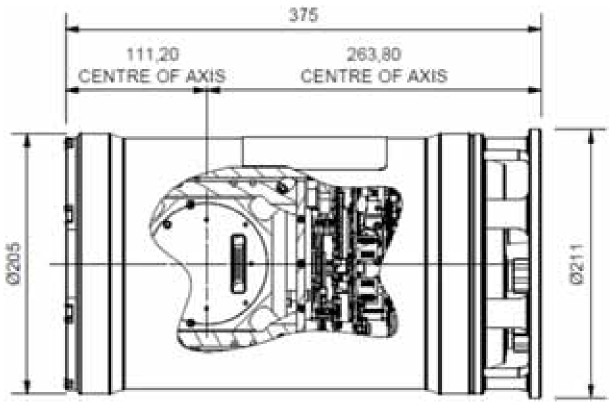


Figure 5-7 – 3000 m Lodestar Centre of Axis Location

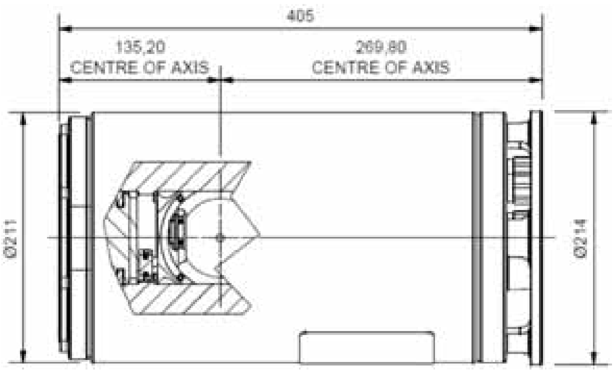
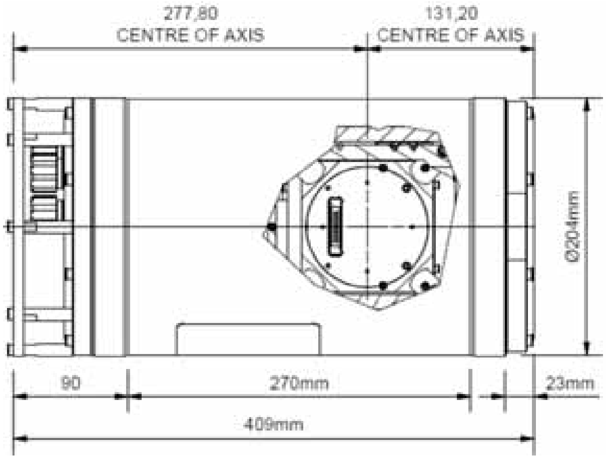


Figure 5-8 – 5000 m Lodestar Centre of Axis Location

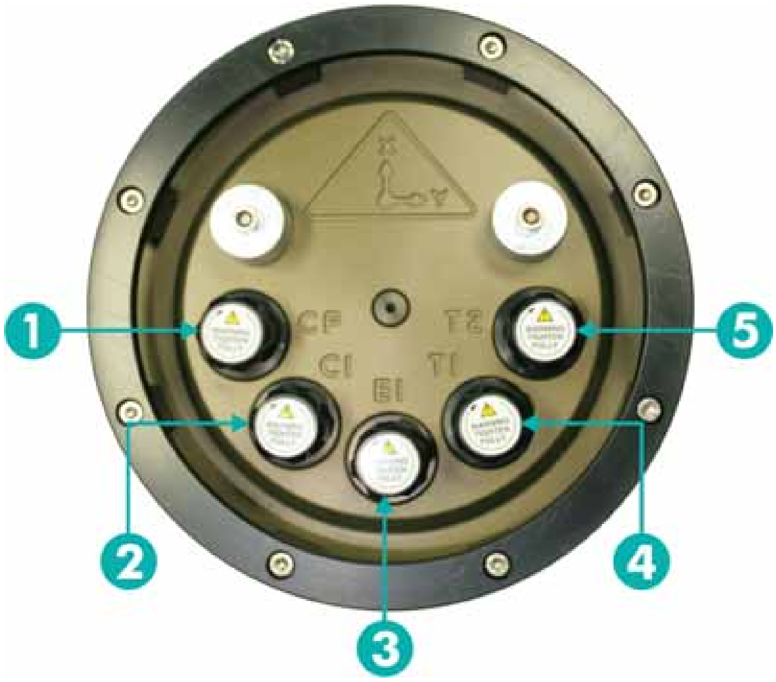


5.5 Connecting the Equipment

Before proceeding with any action make sure all Warnings and Cautions, and the Safety section in this manual are read and fully understood. The equipment interfaces should have been defined during **Interface Planning**, **Section 4.2**. A full set of Lodestar test cables and cable tails are supplied with the SPRINT system. It is assumed that vehicle and instrument specific interface cables have already been made using guidance provided in **Planning**, **Section 4.4.2, Subsea.** Use the following procedure to connect the equipment.

1. Refer to **Figure 5-9**. Connect the vehicle power cable to the Console Port (CP) connection 1 on the top of the Lodestar.

Figure 5-9 – Lodestar Connection Points



1 Console Port (**CP**)	4 Port (**T1**)
2 Port (**C1**)	5 Port (**T2**)
3 Port (**E1**)	

2. If a Pressure Depth Sensor is to be connected to the Lodestar, connect to Port **C1** ❷.

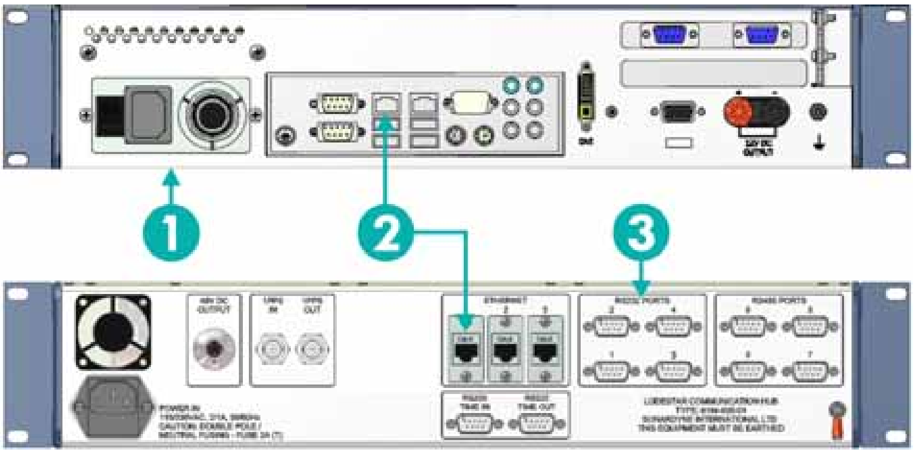
3. For Ethernet communications and/or a 1PPS pulse, connect the vehicle to the Lodestar Port **E1** ❸.

4. If a Doppler Velocity Log is to be connected to the Lodestar, connect to Port **T1** ❹.

5. If an LBL Transceiver is to be connected to the Lodestar, connect to Port **T2** ❺.

6. Refer to **Figure 5-10**. Connect the Navigation PC ❶ to the LCH ❸ using the Ethernet Cable ❷. A label on the Navigation PC will indicate which Ethernet port to use.

Figure 5-10 – Connecting the Navigation PC to the LCH



❶ Navigation PC ❸ LCH
❷ Ethernet Cable

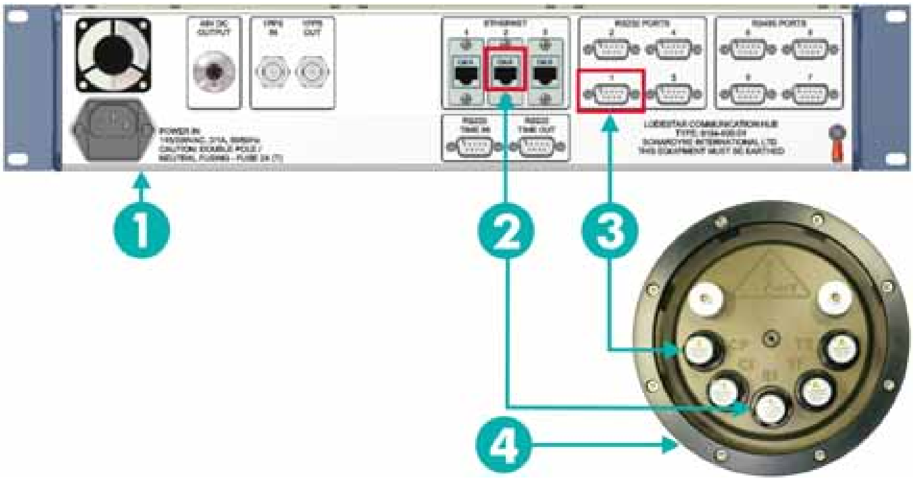
7. Refer to **Figure 5-11**. The Lodestar ❹ can be connected to the LCH ❶ by two methods:

NOTE

If the Lodestar serial connection length is excessive, data may be corrupted, see Section 4.4.1 for guidance.

- An Ethernet cable ❷ connected to the Ethernet connection point **2** on the LCH and connection **C2** on the Lodestar.
- A serial port cable ❸ connected to serial port **1** on the LCH and connection **CP** on the Lodestar.

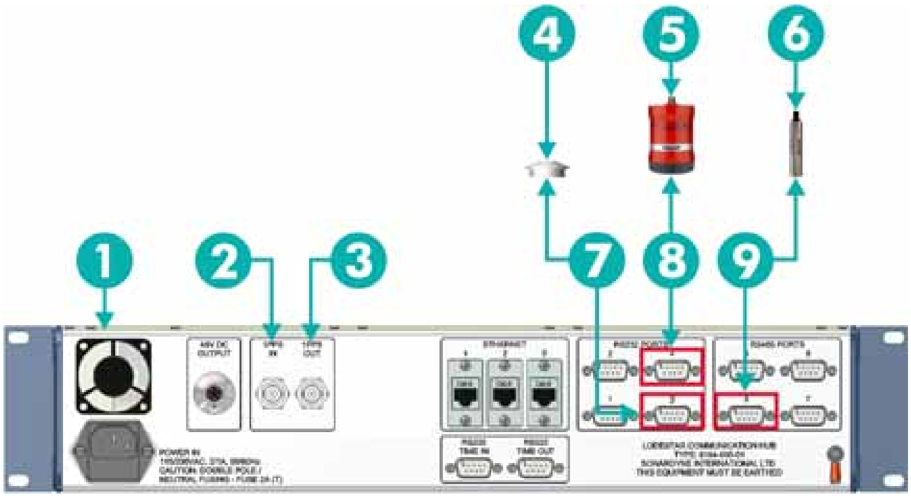
Figure 5-11 – Connecting the Lodestar to the LCH



(1)	LCH	(3)	Serial Port Connection
(2)	Ethernet Cable connection	(4)	Lodestar

8. Refer to **Figure 5-12**. Additional equipment can be connected to the serial points at the rear of the LCH (1).
   - To add a GPZDA feed (4) from the vessel GPS, connect to serial port 3 (7) on the LCH.
   - To add a USBL position feed (5) from the vessel USBL system, connect to serial port 4 (8) on the LCH (1).
   - To add a Pressure Depth (6) input to the topside, connect to serial port 5 (9) on the LCH (1).
   - To add a 1PPS timing pulse from the vessel GPS, connect to 1PPS In Port (2) on the LCH. Then send the pulse to the Lodestar by connecting to 1PPS Out Port (3).

Figure 5-12 – Adding Additional Equipment to the LCH



1	LCH	4	GPZDA feed	7	Serial Port 3
2	1PPS In Port	5	USBL position feed	8	Serial Port 4
3	1PPS Out Port	6	Pressure Depth Input	9	Serial Port 5

5.6 SPRINT Software

The Navigation PC is supplied pre-installed with the SPRINT software; if the software is not installed instructions for installation and updates are supplied below:

1. Log into the PC administrator user account.
2. Insert the SPRINT software CD into the CD drive of the Navigation PC.
3. Run Setup.EXE from the CD drive.
4. Follow the instructions provided by the software installation tool.

5.7 Lodestar Firmware

The Lodestar supplied with the SPRINT system will be pre-configured with the correct firmware for operation with the SPRINT system. See **UM-8084-101 Lodestar Hardware Manual** for detailed instructions on the method for firmware upgrade. If you are unsure if your Lodestar is running the correct firmware version for use with SPRINT contact Sonardyne Support.

5.8 Check List

Use the list below to assist in the system installation, prior to the configuration:

	Action	**Manual Section**	**Checked**
1	Check system kit contents	5.1	
2	Install Lodestar	5.2	
3	Determine equipment alignment	5.3	
4	Measure instrument offsets	5.4	
5	Connect equipment interfaces	5.5	
Sign: …………………………………………………………..		**Date:** …………………………………………………….	

NOTE

See Appendix H for a full step-by-step installation and setup checklist that can be printed and used as a hard copy reference.

SECTION 6 – CONFIGURATION

6. Configuration

6.1 Changing the Lodestar Console Port (CP) Baud Rate

If the Lodestar is to be connected using a serial interface, the baud rate for the console port must be 115200. Lodestars shipped as part of a SPRINT system will be pre-configured with this baud rate. If the Lodestar has not been pre-configured for this baud rate, the Lodestar PC utility software can be used to configure the console port baud rate, see **UM-8084-107 Lodestar AHRS Manual** for instructions.

6.2 Configuring Lodestar Communication Hub (LCH)

The LCH provides an 8-port serial device server interface for the SPRINT system.

Figure 6-1 – LCH front face

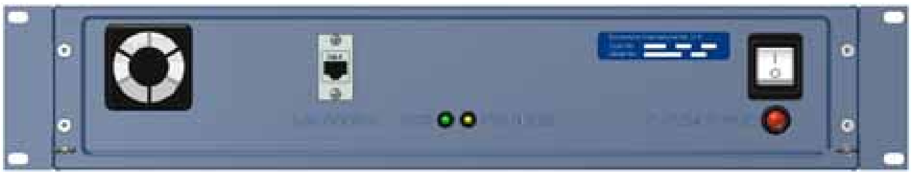
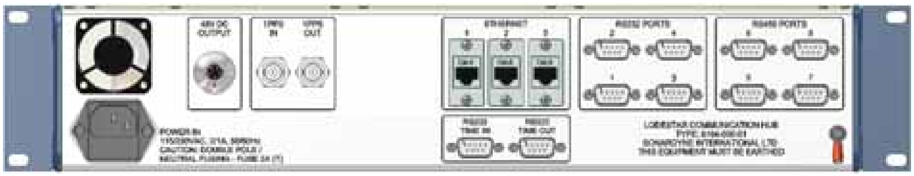


Figure 6-2 – LCH rear face



The LCH can provide a variety of configurable serial settings for each serial input device or output port required topside, such as:

- Baud rates from 50 to 921,600.
- RS-232, RS-422, RS-485 Half Duplex or RS-485 Full Duplex.
- Data bits, Stop bits, parity, flow control and FIFO.

The LCH also contains a 1PPS conditioner that can be used to condition and boost the 1PPS signal before it is sent to the Lodestar.

The LCH is supplied pre-configured with the following settings for serial input/output interfaces:

Table 6-1 – Serial Input / Output Interfaces

LCH Port	Local TCP Port	Purpose	Baud Rate	Data Bits	Stop Bits	Parity	FIFO	Flow Control	Interface
Port 1	5001	Lodestar Console Port	115200	8	1	None	Enable	None	RS-232
Port 2	5002	GPS Input	9600	8	1	None	Enable	None	RS-232
Port 3	5003	ZDA Input	9600	8	1	None	Enable	None	RS-232
Port 4	5004	USBL Input	9600	8	1	None	Enable	None	RS-232
Port 5	5005	Depth or S.V. Input	9600	8	1	None	Enable	None	RS-232
Port 6	5006	Primary Output	9600	8	1	None	Enable	None	RS-232
Port 7	5007	Secondary Output	9600	8	1	None	Enable	None	RS-232
Port 8	5008	DO NOT USE							

If it is necessary to modify any setting for system operation, follow the procedure below:

NOTE

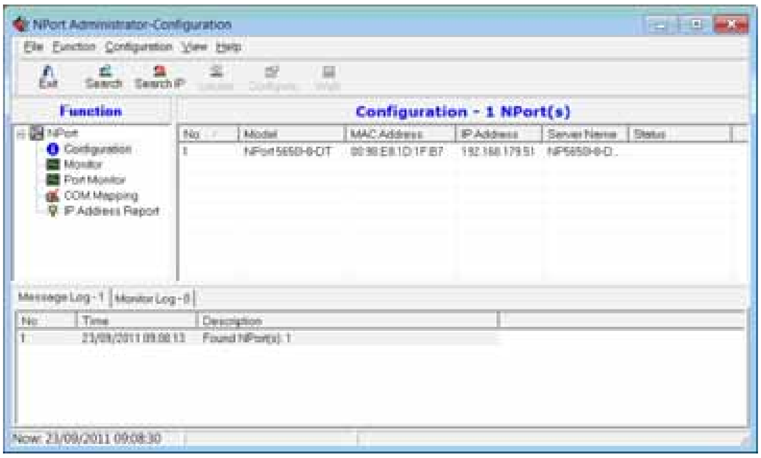
The LCH Port 1 is pre-configured to match the default serial connection configuration of Lodestars used with SPRINT systems. If this Port needs to be modified, the default Lodestar connection configuration will need to be changed. It is advised that Sonardyne Support are contacted for further instructions.

It is necessary to know the IP address of the LCH unit. At the time of manufacture the IP address is set to 192.168.179.51. The IP address can be discovered as follows:

1. Open NPort Administrator by navigating from the start menu: **Programs** > **NPort Administration Suite** > **NPort Administrator**.

2. Refer to **Figure 6-3**. Click the **Search** button on the toolbar and wait 5 seconds for the search to complete. The model and IP address of the LCH comms unit will appear. In the example below the IP address is 192.168.179.51.

Figure 6-3 – LCH Comms IP Address



NOTE

The LCH factory default IP address is 192.168.179.51.

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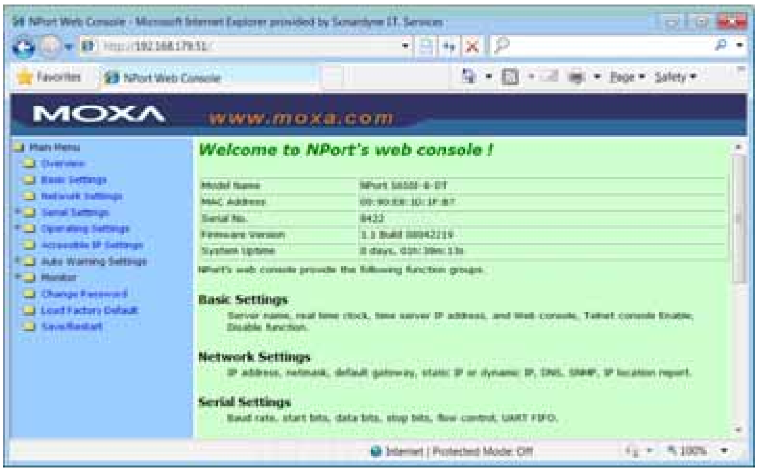
3. Once the IP address is known, open **Internet Explorer**.

4. Enter the LCH IP address into the address bar e.g. **http://192.168.179.51**.

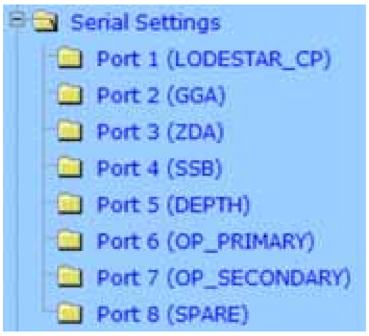
5. Refer to **Figure 6-4**. A web configuration page will be shown.

Figure 6-4 – Web Configuration Page



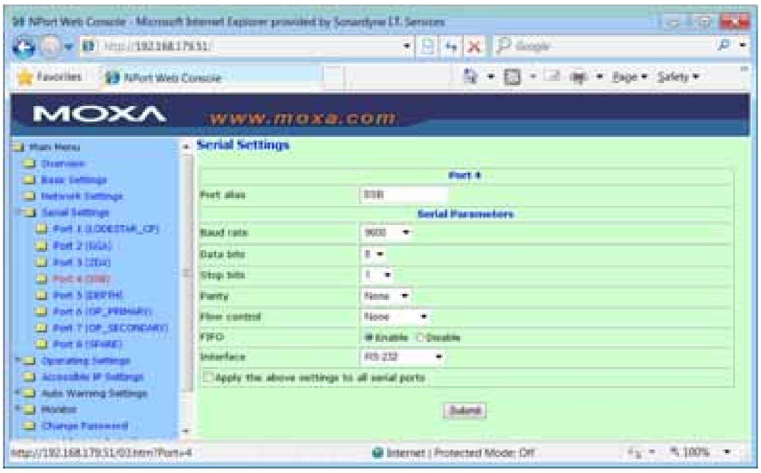
6. Refer to **Figure 6-5**. To change any of the port settings, expand the **Serial Settings** item in the left hand pane.

Figure 6-5 – Port Serial Settings



7. Refer to **Figure 6-6**. Select the port to be configured; the current settings will be shown in the right hand pane.

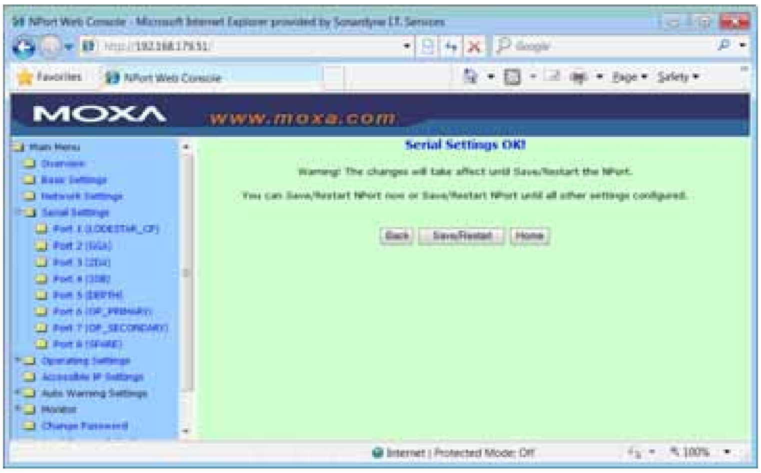
Figure 6-6 – Serial Settings



8. Change the settings as required and then click **Submit** to save the settings.

9. Refer to **Figure 6-7**. Click **Save**/**Restart** and wait approximately 30 seconds for the changes to be applied and the LCH to restart. The LCH will beep twice when it is ready.

Figure 6-7 – Save Serial Settings



10. When all changes have been made close **Internet Explorer**.

6.3 SPRINT Software Configuration

Refer to Figure 6-8. Insert the security dongle into the Navigation PC then open the **SPRINT** software by double clicking on the **SPRINT** application desktop icon:

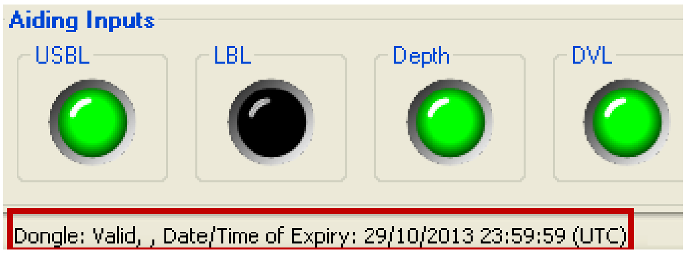
Figure 6-8 – SPRINT Software icon

6.3.1 SPRINT Security Dongle

The security dongle sets the SPRINT aiding options (S5 or S10 system).
The SPRINT S5 and S10 aiding options are shown in **Figure 6-11** and **Figure 6-12**.

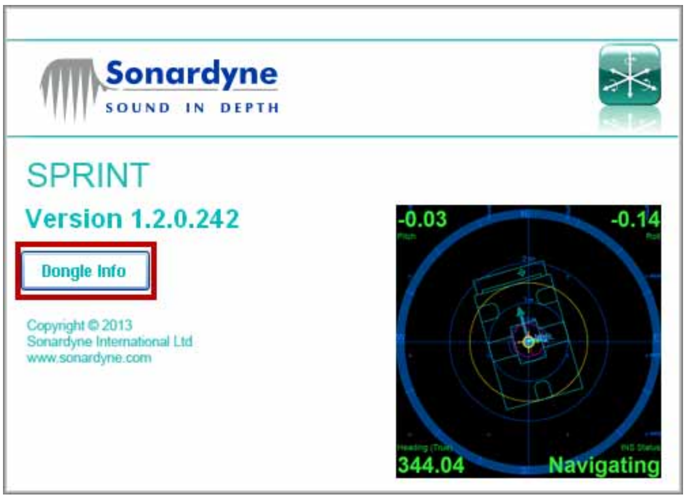
1. Refer to **Figure 6-9**. The dongle validity and date/time of expiry information is displayed within the SPRINT information bar.

Figure 6-9 – Dongle Info Bar



2. Refer to **Figure 6-10**. The SPRINT aiding options (S5 or S10) can be viewed by selecting **Help** > **About** > **Dongle Info** from the SPRINT Menu bar.

Figure 6-10 – Dongle information



3. Refer to **Figure 6-11** and **Figure 6-12**. SPRINT aiding options for S5 and S10 systems are displayed along with dongle validity, type of expiry and date/time of expiry.

Figure 6-11 – SPRINT S5 Settings

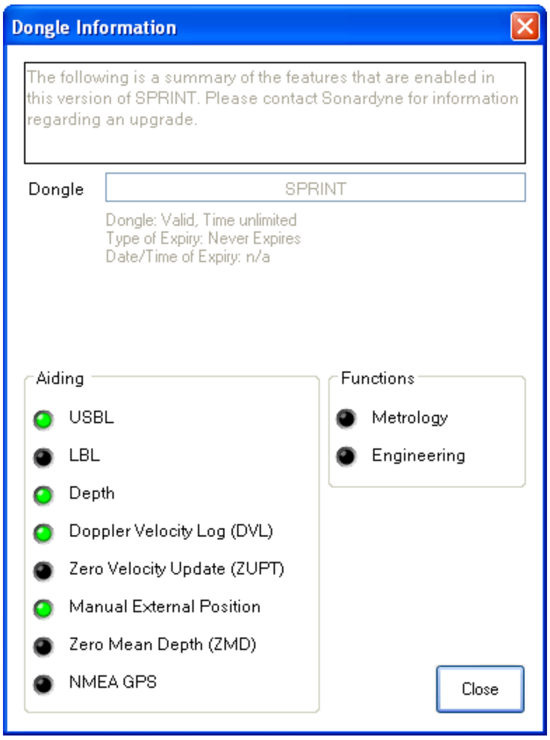
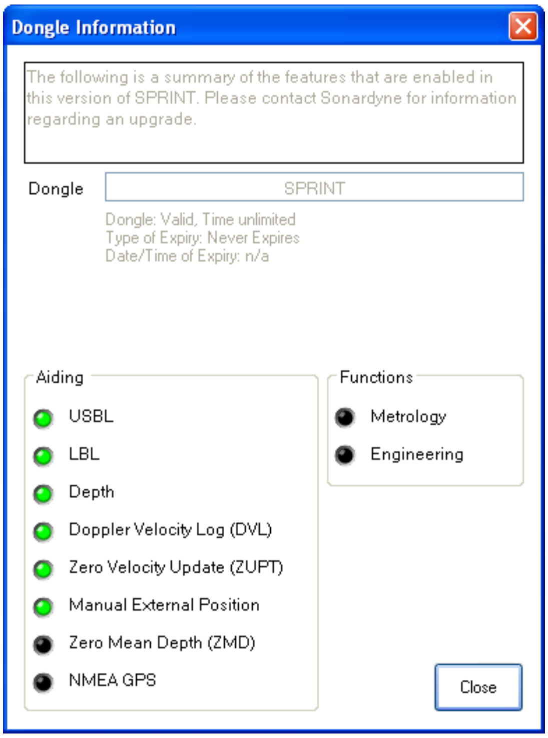


Figure 6-12 – SPRINT S10 Settings



6.3.2 Lodestar Connection

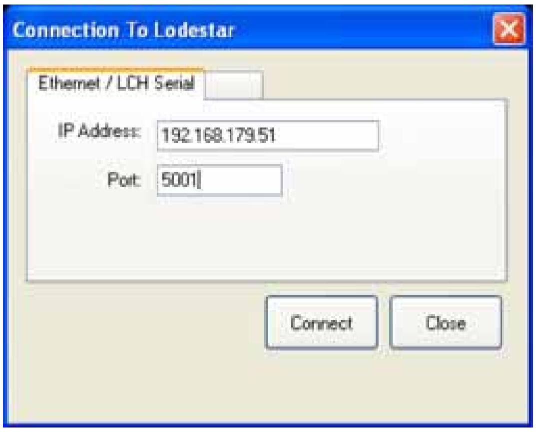
To connect the Lodestar to the SPRINT system, follow the instructions below:

1. If this is the first time the software has been connected to the Lodestar or the connection is not active, the connection window should automatically be displayed. If the connection window does not appear, open it by selecting **Configure** > **Lodestar** > **Connections** from the software menu.

2. In the **Connection to Lodestar** screen, select the **Ethernet/LCH** tab and enter the **IP Address** and **Port**:

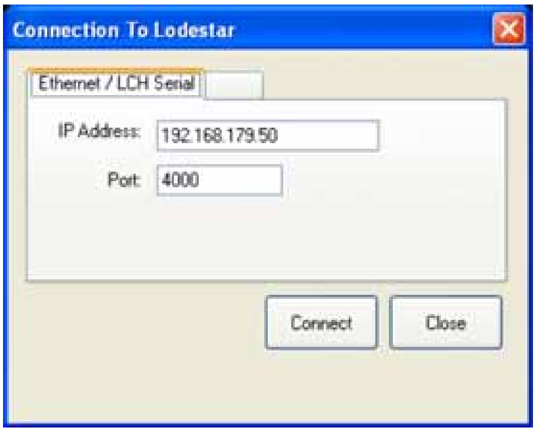
   - Refer to **Figure 6-13**. If the Lodestar is connected by means of a **serial connection** to the LCH, enter **IP Address: 192.168.179.51** and **Port 5001**.

Figure 6-13 – Serial Connection to Lodestar



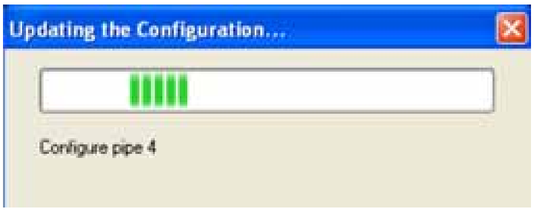
   - Refer to **Figure 6-14**. If the Lodestar is connected directly by means of an Ethernet connection to the LCH, enter **IP Address: 192.168.179.50** and **Port 4000**.

Figure 6-14 – Ethernet Connection to Lodestar



3. Refer to **Figure 6-15**. Click **Connect**. If this is the first time the system has been run and connected to the Lodestar it will then configure communications routing and 'pipes'. It may take several minutes for this process to complete; a progress indicator will be displayed.

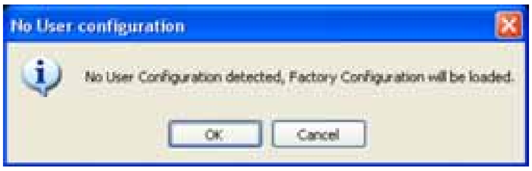
Figure 6-15 – Updating Port Configuration



4. Once connected, the SPRINT software will check the settings of the Lodestar and may prompt the user to apply a stored configuration.

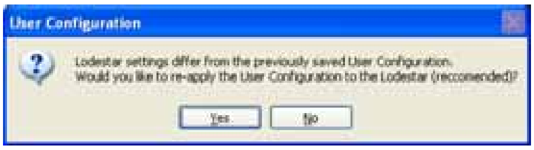
   - Refer to **Figure 6-16**. If this is the first time the system has been run, the user may be prompted to apply the Factory (Default) Configuration.

Figure 6-16 – Apply Factory Configuration



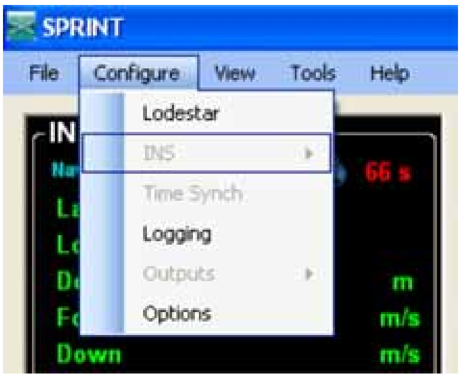
   - Refer to **Figure 6-17**. If the system has been run before but the Lodestar settings are different than the last used (e.g. a different Lodestar is being used), the user may be prompted to re-apply the User Configuration.

Figure 6-17 – Apply User Configuration



5. Refer to **Figure 6-18**.If the Lodestar is not connected the software will prevent the user accessing any windows to retrieve or configure Lodestar settings.

Figure 6-18 – No Lodestar Connection for Configuration



6. In addition, the system status LEDs at the bottom of the main application window will indicate that there is no Lodestar connection, as shown below in **Figure 6-19**:

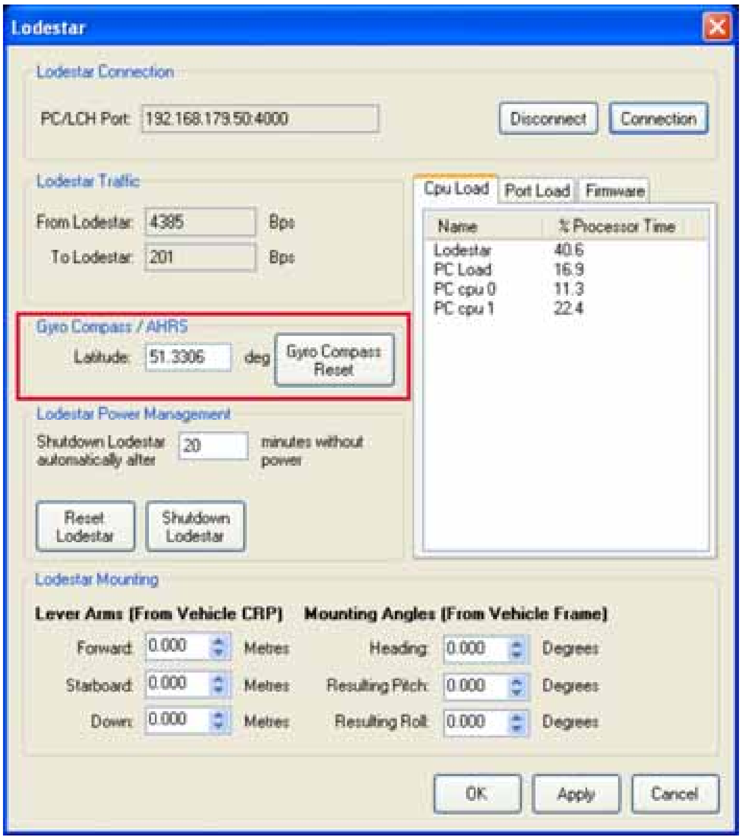
Figure 6-19 – Lodestar not Connected Status

6.3.3 Lodestar Settings

To configure the Lodestar settings, proceed as follows:

1. Select **Configure** > **Lodestar** from the software menu.
2. Refer to **Figure 6-20**. Enter a default **Latitude** value. After any manual change of the default latitude the Gyrocompass algorithm will be automatically reset. The Gyrocompass algorithm can be manually reset at any time by clicking the **Gyro Compass Reset** button.

Figure 6-20 – Lodestar Settings



NOTE

Failure to update the default Latitude to match the current working area could result in poor Lodestar gyrocompass and inertial performance. After any change of default Latitude the Lodestar Gyro Compass algorithm is reset. During INS operations the Lodestar Latitude value will be automatically updated by position aiding messages (USBL).

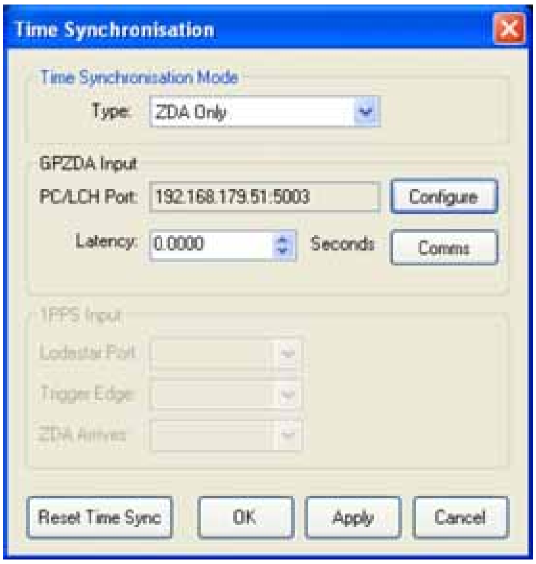
3. Set the **Lodestar Power Management** time period. The Lodestar will run on its internal battery for the selected time period (default period is 20 minutes) after the external power supply has been stopped.
4. Enter the **Lever Arms** (**From Vehicle CRP**) offset values. After changing these values, the Gyrocompass/AHRS and INS algorithms will be automatically reset to use the new settings.
5. Enter the **Mounting Angles** (**From Vehicle Frame**) offset values. After changing these values, the Gyrocompass/AHRS and INS algorithms will be automatically reset to use the new settings.
6. The Lodestar can be manually shutdown at any time by pressing the **Shutdown Lodestar** button, after which the SPRINT software will also close.
7. The Lodestar (firmware) can be manually reset at any time by pressing the **Reset Lodestar** button.
8. Click **OK** to close and save all entered settings.

6.3.4 Lodestar Time Synchronisation

To configure the Lodestar Time Synchronisation, proceed as follows:

1. Refer to **Figure 6-21**. Select **Configure** > **Time Synchronisation** from the software menu:

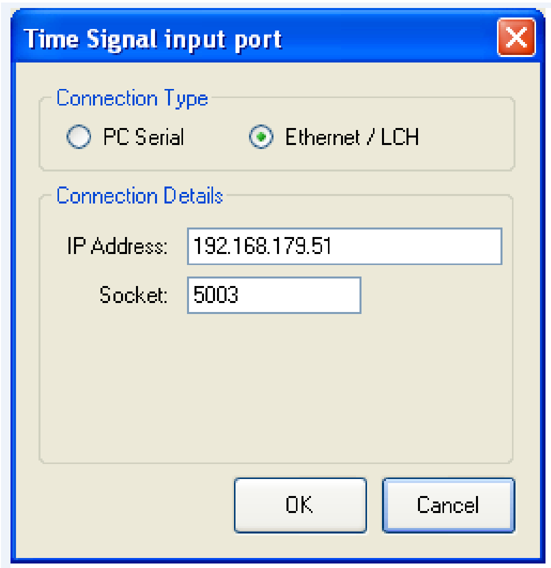
Figure 6-21 – Lodestar Time Synchronisation



2. In the **Time Synchronisation** screen, select **Type: ZDA Only** (default) or **GPZDA** and **1PPS**.

3. Refer to **Figure 6-22**. Click **Configure** and enter the PC Port Serial **IP Address 192.168.179.51**, **Socket 5003** via the LCH.

Figure 6-22 – Adding IP Address



4. Click OK to return to the **Time Synchronisation** screen and enter the ZDA **Latency** value.

NOTE

The Time Synchronisation can be reset at any time by selecting Reset Time Synch.

5. If **GPZDA** and **1PPS** is selected then configure the **1PPS Input** settings. The default Lodestar Input setting for **1PPS** is Lodestar Port **C2**.

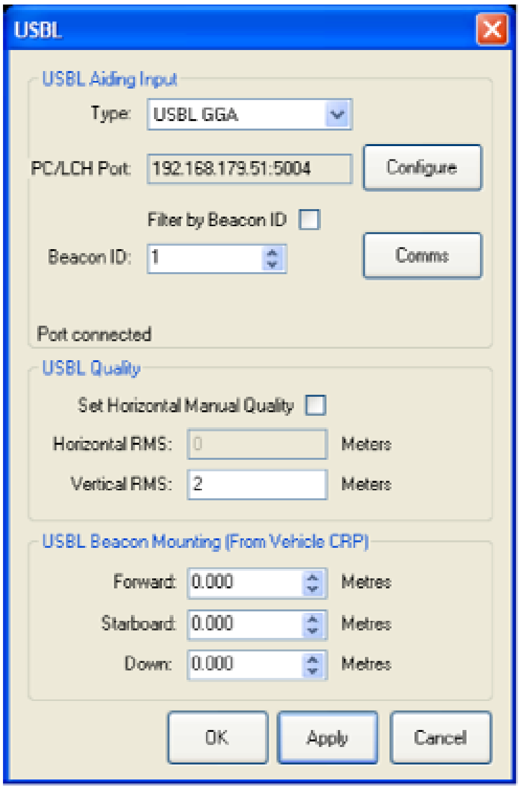
6. Click **OK** to close and save all entered settings.

6.3.5 USBL Aiding

To configure the USBL Aiding, proceed as follows:

1. Select **Configure** > **INS** > **USBL Input** from the software menu.

Figure 6-23 – USBL Aiding



2. Refer to **Figure 6-23**. Select a **USBL Aiding Input Type**: **PSIMSSB** (Default) or **USBL GGA** (**Acoustic)**. Typical USBL aiding inputs are as follows:

   - Sonardyne Ranger/Fusion USBL or EIVA NaviPac: **Acoustic GGA**.
   - Sonardyne Marksman/Ranger 2 or Kongsberg HiPAP: **PSIMSSB**.

3. In the **PC/LCH Port** enter the IP Address for the serial input via the LCH (**192.168.179.51:5004**) by clicking **Configure** (as shown in **Figure 6-22**).

4. If required specify a **Beacon ID** filter, see Appendix E for details of the beacon ID field of the different USBL aiding messages.

5. Horizontal USBL quality:

   i) The default setting is for SPRINT to use the quality value provided by the USBL system in the aiding message, see **Appendix E** for details. In this case the **Set Horizontal Manual Quality** checkbox will be unchecked.

   ii) In some cases, it may be required to set a manual horizontal quality value:

      - If using Sonardyne Ranger, Fusion USBL or other USBL systems where no quality value is provided.

      - The quality value provided by the USBL system is overly optimistic.

   iii) To set the Horizontal Manual Quality, set the check box and enter a **Horizontal RMS** value.

6. Vertical USBL quality:

   i) If USBL depth aiding is to be used by SPRINT, the configured **Vertical RMS** value will be used by the INS. The value should be set according to the method of depth measurement:

      - Acoustic

      - Sensor Measurement

7. In the **USBL Beacon Mounting** (**from Vehicle CRP**) enter the Lever Arm offsets from the ROV CRP to the USBL beacon. After changing the lever arms the INS algorithm will be automatically reset to use the new settings.

8. Click **OK** to close and save all entered settings.

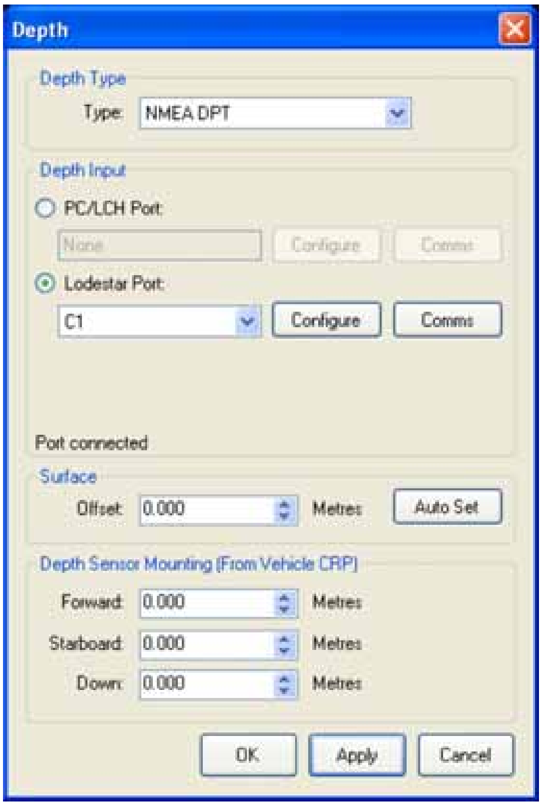
9. If Sonardyne Marksman or Ranger 2 is being used for USBL aiding, configuration instructions are provided in **Section 7.2**.

6.3.6 Depth Aiding

To configure the **Depth** aiding, proceed as follows:

1. Select **Configure** > **INS** > **Depth Input** from the software menu.

Figure 6-24 – Depth Aiding



2. Refer to **Figure 6-24**. From the **Depth Type** drop down menu, select the **Type**: **DigiQuartz** (kPa, PSI or Metres); **NMEA DPT** or **Son Depth**.

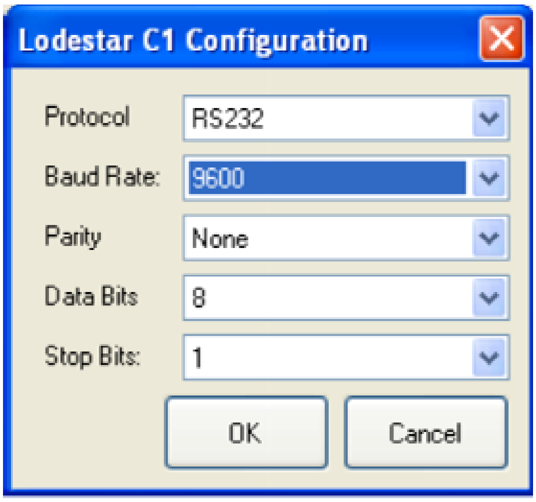
3. Select a **Depth Input by selecting either PC/LCH Port** or **Lodestar Port**.

4. If the sensor is connected via a serial connection, select the **PC/LCH Port and** enter the IP Address for the serial input via the LCH (**192.168.179.51:5005**) by clicking **Configure** (as shown in **Figure 6-22**).

5. If the sensor is connected directly to the Lodestar, select **Lodestar Port** and the relevant connection point (**C1, T1, T2**).

6. Refer to **Figure 6-25**. Click **Configure** and enter the Lodestar Configuration settings.

Figure 6-25 – Lodestar Configuration



7. Click **OK** to save all entered settings and return to the **Depth** window.

8. Enter the **Surface** Depth **Offset** value in metres if required. If the ROV is on deck and the ambient surface pressure is to be removed from raw pressure depth value, click **Auto Set**.

9. Enter the **Depth Sensor Mounting** (**from Vehicle CRP**) Lever Arm offset from ROV CRP to Sensor. After changing the lever arms the INS algorithm will be automatically reset to use the new settings.

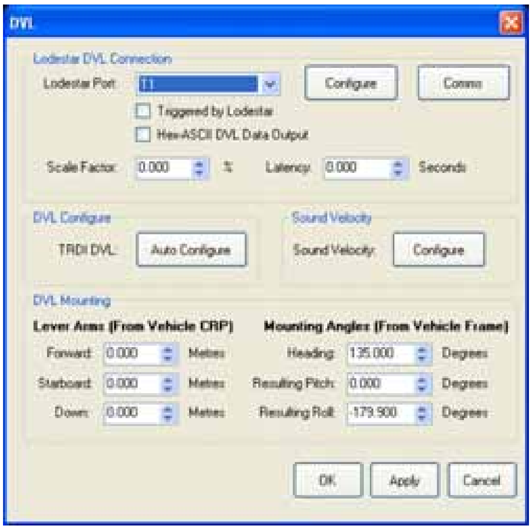
10. Click **OK** to close and save all entered settings.

6.3.7 DVL Aiding

To configure the **DVL** aiding, proceed as follows:

1. Select **Configure** > **INS** > **DVL Input** from the software menu.

Figure 6-26 – DVL Aiding



2. Refer to **Figure 6-26**. Select the **Lodestar DVL Connection** port from the drop down menu, click **Apply** to set the port before continuing.

3. Select **Triggered by Lodestar** checkbox if required.

4. Select the **Hex-ASCII DVL Data Output** checkbox if the DVL will be outputting ASCII data; if left unchecked the Lodestar will expect binary data (default).

NOTE

The DVL mounting angles, scale factor and latency can be calculated using the calibration routine explained in Appendix C. If the DVL input is being configured on deck prior to the calibration, it is recommended that the default mounting angles, scale factor and latency values are used.

5. Enter the **Scale Factor** and **Latency** values from the DVL calibration.

6. Enter the **Lever Arm** offsets from the ROV CRP to DVL; enter the **Mounting Angles** from the ROV frame to the DVL. After changing the mounting angles or lever arms the INS algorithm will be automatically reset to use the new settings.

7. Refer to **Figure 6-27**. If the DVL connected to Lodestar is a Teledyne RDI unit the SPRINT software can automatically program it for use with SPRINT. To configure the DVL click the **Auto Configure** button. The DVL configuration dialog will open.

Figure 6-27 – DVL Auto Configuration

NOTE

Make sure the Teledyne RDI DVL is connected to the Lodestar and powered before trying to configure it.

8. **DVL Mode**: If the DVL cabling will allow the Lodestar to send a trigger to the selected DVL , select **Triggered**, otherwise select **Free Running**.

9. **Data Format**: The data format output of the DVL will be set to **Binary** by default. If Hex-ASCII is required, select **Hex-ASCII**.

10. **Select Data Stream**: The data stream message output of the DVL will be set to **PD4** by default. If PD5 is required, select **PD5**.

11. Click the **Configure** button to configure the DVL; the software will display the progress of the configuration process.

12. If the DVL is already configured, the **Deploy** button will command the DVL to start making measurements.

13. When the DVL has been configured return to the **DVL** dialog.

14. Click **OK** or **Apply** to save the settings.

6.3.8 Sound Velocity

To configure the Sound Velocity, proceed as follow:

1. Select **Configure** > **INS** > **DVL Input** from the software menu and click the **Sound Velocity** button.

Figure 6-28 – Sound Velocity Configuration

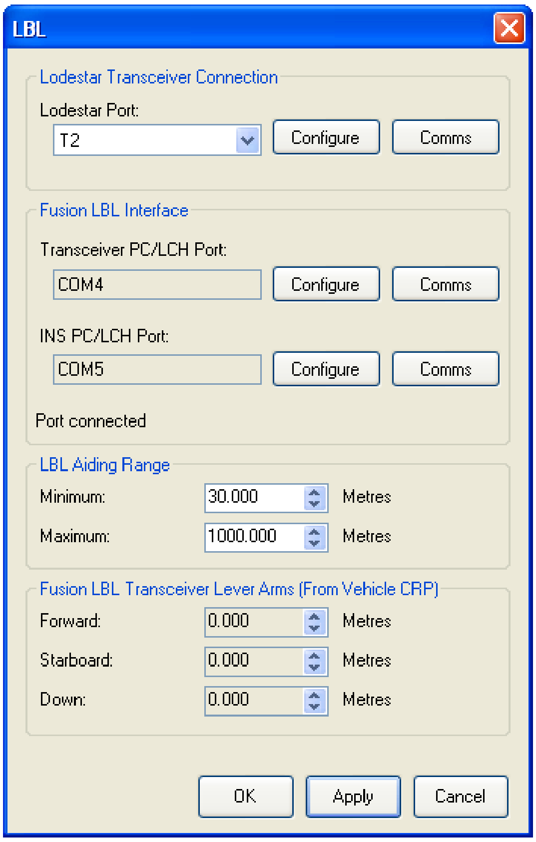
2. Refer to **Figure 6-28**. Select **Sound Velocity Type**. Available options include:
   - DVL Derived which is valid for most ocean conditions; in this method the sound velocity is automatically calculated using the salinity value and measurements from other aiding sensors such as DVL (Temperature) and Pressure/Depth (Pressure).
   - Various options for receiving sound velocity measurement messages from a sensor or other sources, such as a Valeport Mini-SVS.
   - Manual Sound Velocity.
3. If Sound Velocity messages will be received from a sensor or other source specify and configure either:
   - The Lodestar port which will receive the Sound Velocity message (on the vehicle).
   - The LCH or PC port which will receive the Sound Velocity message (topside).
4. If the Manual Sound Velocity type has been selected a value can be entered in the Manual Sound Velocity text box.
5. Click **OK** to close and save all entered settings.

6.3.9 LBL

To configure LBL aiding, proceed as follows:

1. Select **Configure** > **INS** > **LBL Input** from the software menu.

Figure 6-29 – LBL Aiding Configuration



2. Refer to **Figure 6-29**. **Lodestar Transceiver Connection**: Select the **Lodestar port** that the LBL transceiver is physically connected to (usually T2) and configure the baud rate as required by clicking **Configure (**as shown in **Figure 6-25**).

3. **Fusion LBL Interface**: Specify the PC port that will be used to provide LBL transceiver communications to the Fusion LBL software.

4. Click **OK** to close and save all entered settings.

5. Configure Fusion LBL for use with SPRINT by following the instructions provided in **Section 7.1**.

NOTE

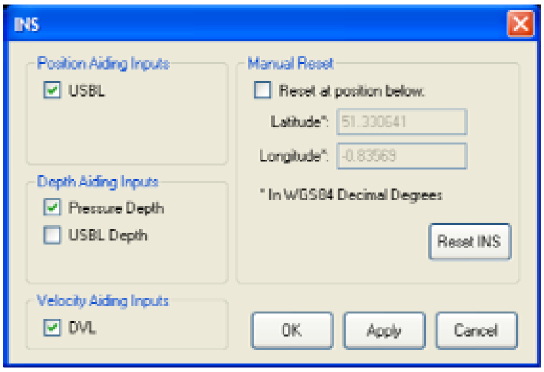
Depending on the SPRINT version, LBL aiding may not be available.

6.3.10 INS

To configure the INS, proceed as follows:

1. Refer to **Figure 6-30**. Select **Configure** > **INS** from the software menu.

Figure 6-30 – INS Configuration



2. Select the INS Aiding Inputs; **USBL**, **Pressure Depth and DVL** are selected by default.

NOTE

The INS can be reset at any time by selecting Reset INS.

3. Even without any external aiding the INS can be reset at a specific position by selecting **Reset at position below** and entering a WGS84 Latitude and Longitude then clicking the **Reset INS** button.

4. Click **OK** to close and save all entered settings.

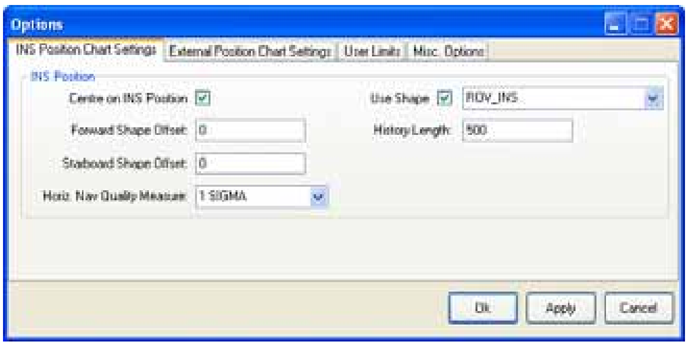
6.3.11 Options

To configure software options proceed as follows:

1. Refer to **Figure 6-31**. Select **Configure** > **Options** from the software menu.

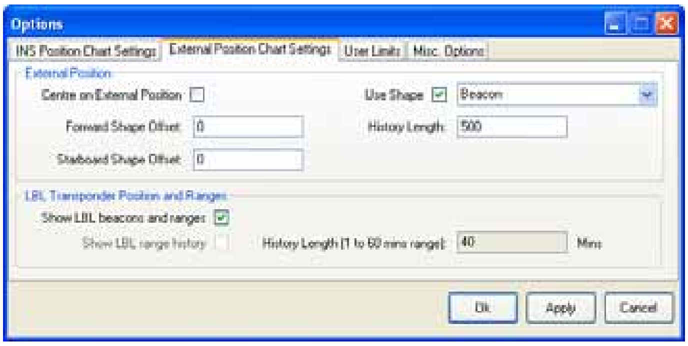
2. Select the **INS Position Chart Settings** tab to configure preferences for the software INS chart display.

Figure 6-31 – INS Position Chart Settings



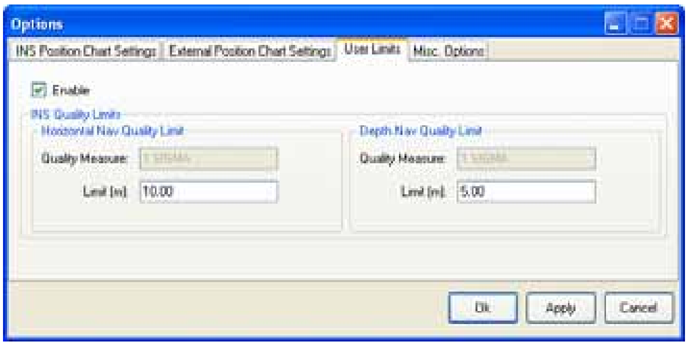
3. Refer to **Figure 6-32**. Select the **External Position Chart Settings** tab to configure preferences for the software external chart display. If using Windows 7, double click on either the USBL, INS or Transponder chart shapes to centre in the main chart.

Figure 6-32 – External Position Chart Settings



4. Refer to **Figure 6-33**. Select the **User Limits** tab to configure navigation horizontal and depth quality limits. If the limits are enabled the software will alert the user if the limits are exceeded, see **Section 9.1.7** for more details.

Figure 6-33 – User Limits



5. Refer to Figure 6-34. Select the **Misc. Options** tab to configure the position text type and history length of the time series plots. It is recommended to select the **Automatically Start with Windows** option.

Figure 6-34 – Misc. Options

6. Click **OK** to close and save all entered settings.

NOTE

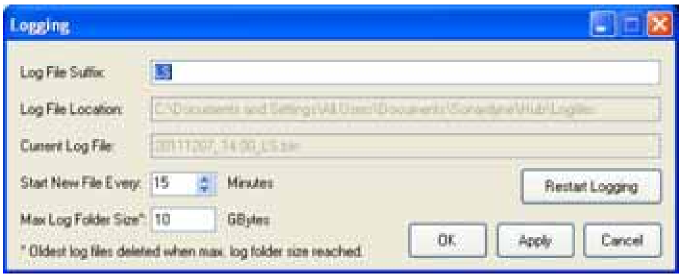
The Show LBL beacons and range history option within the External Position Chart Settings tab can only be enabled when using Windows 7 PC.

6.3.12 Logging

To configure the Logging process, proceed as follows:

1. Refer to **Figure 6-35**. Select **Configure** > **Logging** from the software menu.

Figure 6-35 – Logging Configuration



2. Default settings for logging are already defined but may be changed as required.

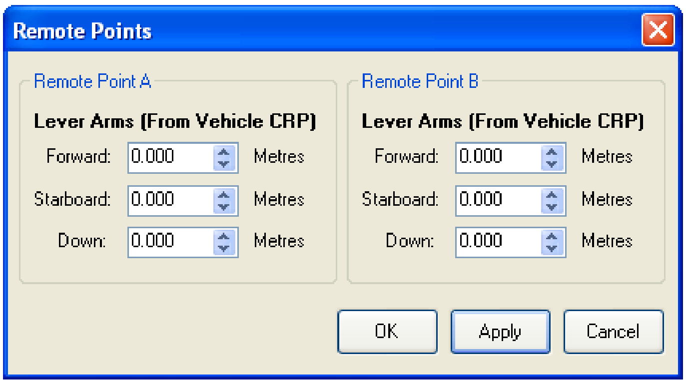
3. Clicking the **Restart Logging** button will close the current log file and open a new one.

6.3.13 Remote Output Points

To configure the Remote Output Points, proceed as follows:

1. Refer to **Figure 6-36**. Select **Configure** > **Outputs** > **Remote Points** from the software menu.

Figure 6-36 – Remote Output Points Configuration



2. The system can support navigation and attitude outputs with respect to two remote points on the vehicle.

NOTE

By default all outputs will be with respect to the CRP of the vehicle.

3. Enter any lever arms for the remote points from the CRP to the remote point specified.

4. Click **OK** to close and save all entered settings.

6.3.14 Lodestar Output

To configure outputs from the Lodestar ports, proceed as follows:

1. Refer to **Figure 6-37**. Select **Configure** > **Outputs** > **Lodestar Port Outputs** from the software menu. Lodestar ports that are not currently in use (connected to the topside system or to an ROV sensor) will be available to configure as an output.

Figure 6-37 – Lodestar Output Configuration

2. Select the tab for the required port to configure.

3. Select the message type, output rate and if a remote output point is to be used (the default output will be with respect to the vehicle CRP). For some outputs (such as a raw sensor feed) an output rate cannot be specified as this is defined by the sensor itself.

4. Click **Apply** to configure the output.

5. If further outputs are required, click **Add** and repeat the configuration steps outlined above.

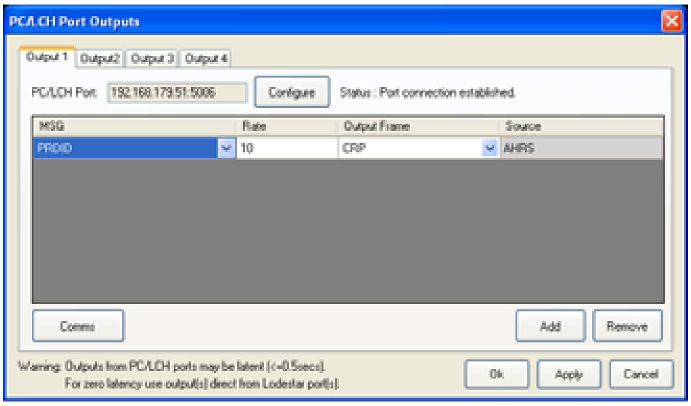
6. After configuration, click **OK** to close and save all entered settings.

6.3.15 PC Port Outputs

The system supports two local output ports (primary and secondary). To configure outputs from the local PC or LCH ports, proceed as follows:

1. Refer to **Figure 6-38**. Select **Configure** > **Outputs** > **PCA CH Port Outputs** from the software menu.

Figure 6-38 – PC Output Configuration



2. Select the tab for the required port to configure.

3. **Configure** the **PC/LCH Port**; enter the IP Address for the serial input via the LCH by clicking **Configure** (as shown in **Figure 6-22**).

4. Select the message type, output rate and if a remote output point is to be used (the default output will be with respect to the vehicle CRP). For some outputs (such as a raw sensor feed) an output rate cannot be specified as this is defined by the sensor itself.

5. Click **Apply** to configure the output.

6. If further outputs are required, click **Add** and repeat the configuration steps outlined above.

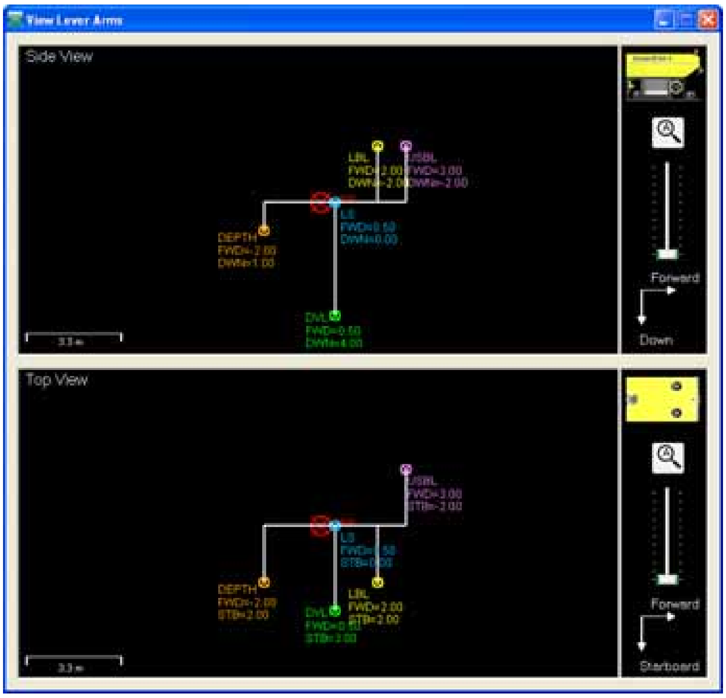
7. After configuration, click **OK** to close and save all entered settings.

6.3.16 View Lever Arms

To view a 3D representation of the configured sensor offsets, proceed as follows:

1. Refer to **Figure 6-39**. Select **View** > **Lever Arms** from the software menu.

Figure 6-39 – View Lever Arms



2. The resulting window will display side and top views of all offsets. Note that scale is dependent on the level of zoom applied. Use this view to check that all offsets are correct and no errors are present.

6.3.17 Main Software Window

To configure outputs from the local PC or LCH ports, proceed as follows:

1. Refer to **Figure 6-40**. Pressing the '**Zoom All**' button will auto zoom the chart on the main software window to keep all chart shapes visible at all times.

Figure 6-40 – Zoom All

2. Refer to **Figure 6-41**. Pressing the '**Zoom In**' button will zoom in the chart display.

Figure 6-41 – Zoom In

3. Refer to **Figure 6-42**. Pressing the '**Zoom Out**' button will zoom out the chart display.

Figure 6-42 – Zoom Out

4. Refer to **Figure 6-43**. Pressing the '**Erase History**' button will erase any position history trails on the chart display.

Figure 6-43 – Erase History

5. Refer to **Figure 6-44**. Pressing the '**ZUPT**' button will enable or disable ZUPT (Zero Velocity) aiding, see **Section 8.3** for more details.

Figure 6-44 – ZUPT

6. Refer to **Figure 6-45**. Pressing the '**INS reset**' button will reset the INS.

Figure 6-45 – INS Reset

7. Refer to **Figure 6-46**. All aiding inputs can be enabled/disabled for INS use or configured by right clicking on the appropriate aiding input LED and selecting the required option.

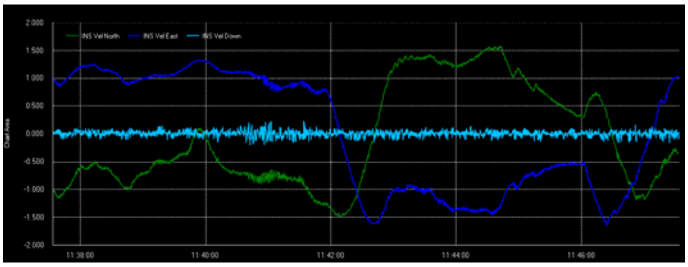
Figure 6-46 – Enable / Configure Aiding Input

6.3.18 Time Series Plots

Navigation and quality data displayed on the user interface can be graphically displayed on a chart as Time Series Plots. Examples of plotted charts are shown in **Figure 6-47** and **Figure 6-48**.

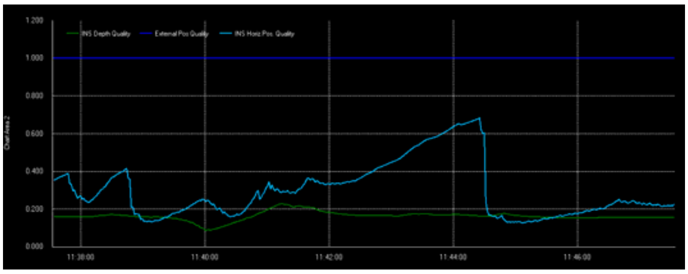
1. Refer to **Figure 6-47**. This time series plot shows INS Velocities North/East/Down.

Figure 6-47 – Time Series Plot



2. Refer to **Figure 6-48**. This time series plot shows INS Depth, External position and INS horizontal position qualities.

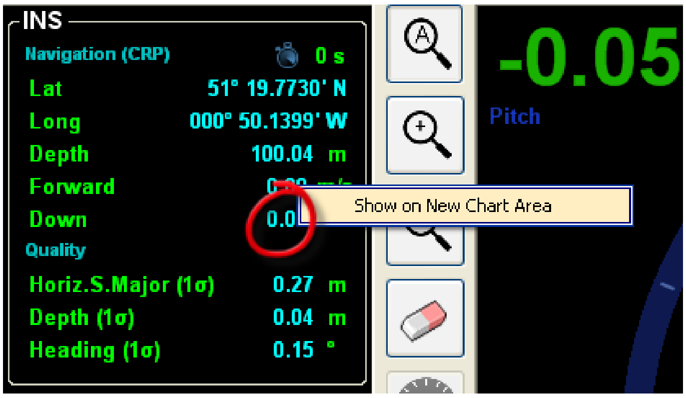
Figure 6-48 – Time Series Plot



The following steps describe how to display data as single and multiple plots.

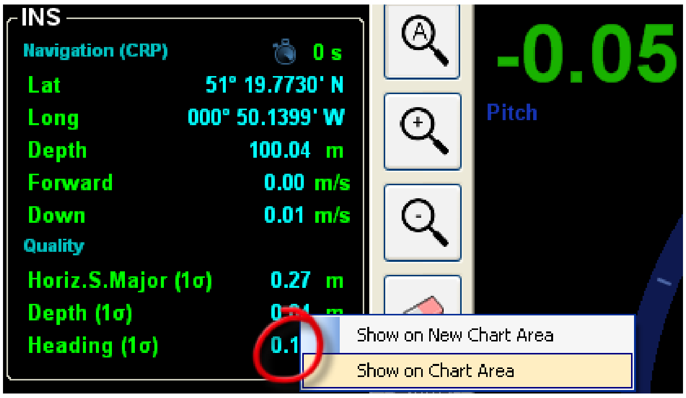
1. Refer to **Figure 6-49**. To display navigation measurements (apart from Lat and Long), quality and INS statistics, right-click a value on the navigation text panel and select **Show on New Chart Area**.

Figure 6-49 – Show on New Chart Area



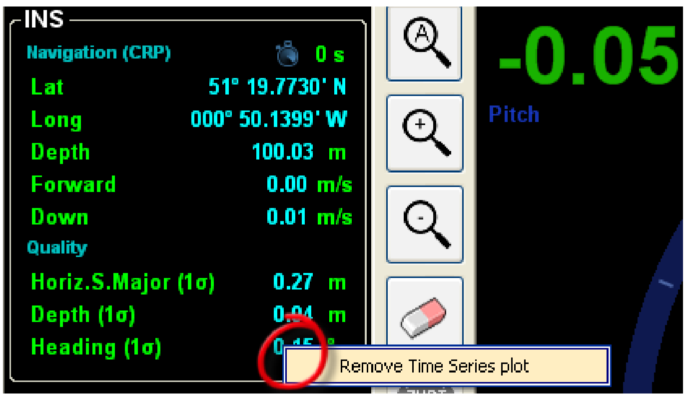
2. Refer to **Figure 6-50**. To display additional plots on the same chart, right-click a value on the navigation text panel and select **Show on Chart Area**.

Figure 6-50 – Show on Chart Area



3. Refer to **Figure 6-51**. To remove data from a chart, right-click the value on the navigation text panel and select **Remove Time Series Plot**.

Figure 6-51 – Remove Time Series Plot



NOTE

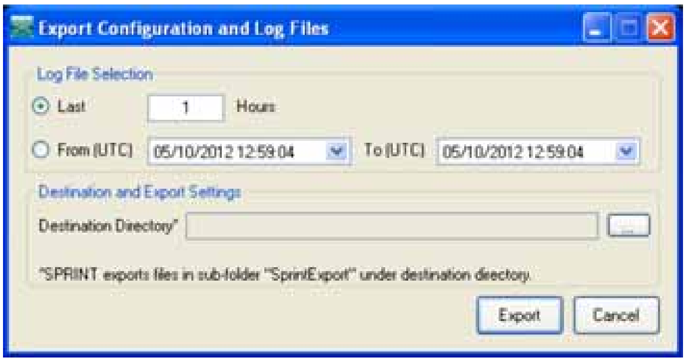
There is a limitation of three sensor inputs per plot and a maximum of four Time Series Plots displayed simultaneously, plus the LBL Aiding Plot.

6.3.19 Exporting Configuration and Log Files

To export system configuration and log files, proceed as follows:

1. Refer to **Figure 6-52**. Select **File** > **Export Configuration** from the software menu.

Figure 6-52 – Export configuration and log files



2. Specify either the **Last** number of hours to export or a date/time range.
3. Specify a destination directory for the exported file.
4. Click the **Export** button to create the export file.

6.4 Check List

Use the summary list below to assist in the system configuration, prior to operation:

	Action	Manual Section	Checked
1	Configure the LCH	6.2	
2	Check Dongle is Valid	6.3.1	
3	Configure the Lodestar Connection	6.3.2	
4	Configure Lodestar	6.3.3	
5	Configure Time Synchronisation	6.3.4	
6	Configure USBL Aiding	6.3.5	
7	Configure Depth Aiding	6.3.6	
8	Configure DVL Aiding	6.3.7	
9	Configure Sound Velocity	6.3.8	
10	Configure LBL Aiding	6.3.9	
11	Configure INS Aiding	6.3.10	
12	Configure Options	6.3.11	
13	Configure Logging	6.3.12	
14	Configure Outputs	6.3.13, 6.3.14 and 6.3.15	

Sign: …………………………………………………………..	**Date:** …………………………………………………….

NOTE

See Appendix H for a full step-by-step installation and setup checklist that can be printed and used as a hard copy reference.

SECTION 7 – CONFIGURING ACOUSTIC AIDING

7. Configuring Acoustic Aiding from Sonardyne Systems

7.1 Fusion LBL Aiding

To interface Fusion LBL to SPRINT for aiding, follow the steps below (for further information on operation of Fusion, refer to the **Fusion Manual OM-8025-000-01**). The instructions assume the following connections have already been configured:

i) A Lodestar is running and connected to the SPRINT software.

ii) LBL Transceiver is physically connected to Lodestar T1 or T2 port and is powered.

iii) The Fusion LBL interface ports have been configured in SPRINT (see **Section 6.3.9**):

- Transceiver PC Port
- INS PC Port

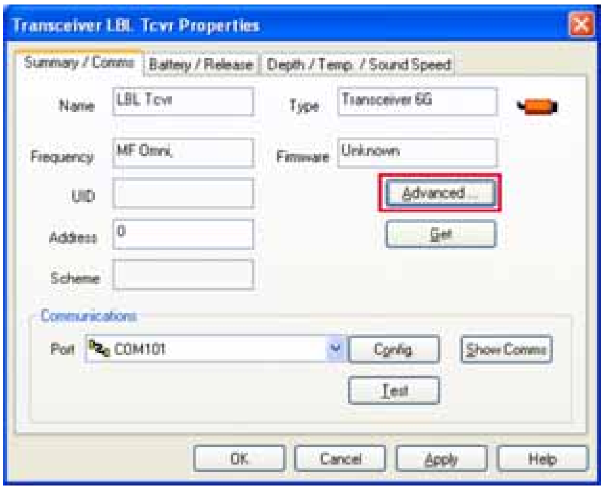
1. Open Fusion LBL and add an LBL Transceiver from the acoustic instruments group in the job tree.

Figure 7-1 – Adding an LBL Transceiver

2. After adding an LBL transceiver, specify the PC COM port configured in SPRINT.

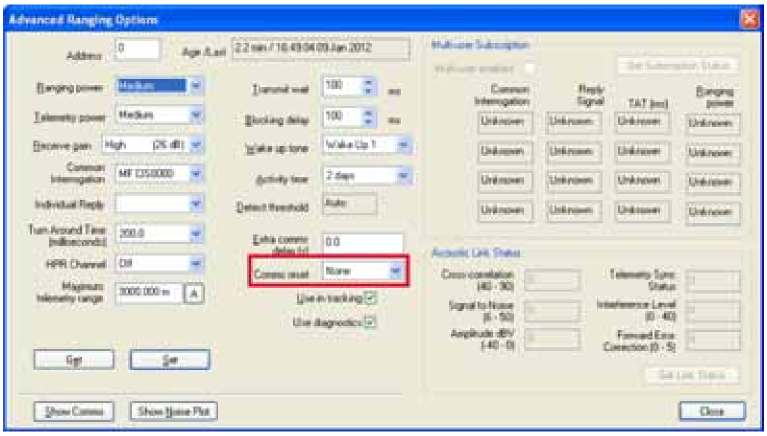
3. Refer to **Figure 7-2**. On the LBL Transceiver properties page, click the **Advanced** button to open the advanced transceiver options page.

Figure 7-2 – LBL Transceiver Properties



4. Refer to **Figure 7-3**. In the **Comms reset** option select **None**, then click **Close**.

Figure 7-3 – LBL Transceiver Advanced Ranging Options

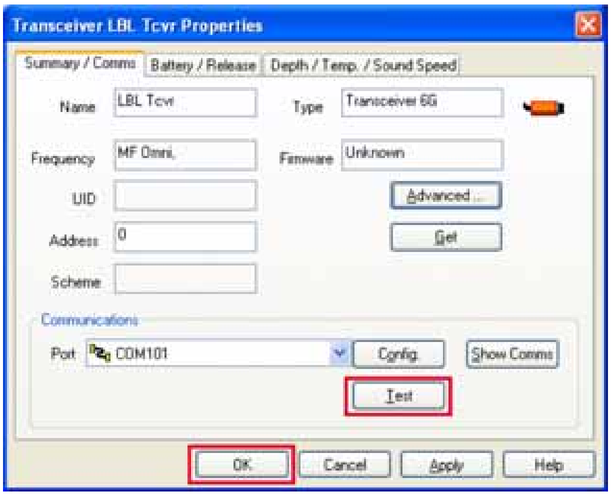


NOTE

In later versions of Fusion, the baud rate of the transceiver may be automatically changed when it is added. In this case the baud rate of the transceiver must be manually changed in the SPRINT software to match Fusion and the new baud rate of the Transceiver.

5. Refer to **Figure 7-4**. On the LBL Transceiver Properties **Summary/Comms** tab, click **Test** to check connection and communications to the Transceiver. Once connection is established the Fusion software will confirm that the instrument is working.

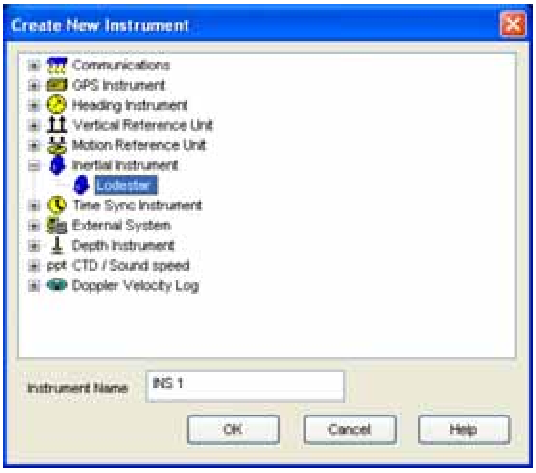
Figure 7-4 – Check connection and communication



6. Click **OK** to close the Transceiver LBL Tcvr Properties page.

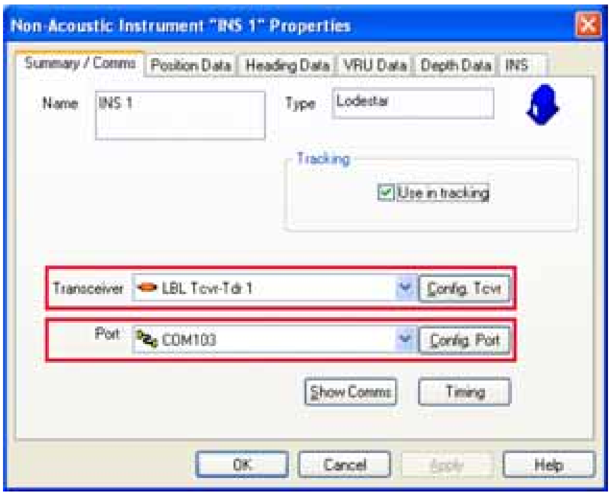
7. Refer to **Figure 7-5**. Add a Lodestar from the non-acoustic INS instruments group in the job tree:

Figure 7-5 – Adding a Lodestar



8. Refer to **Figure 7-6**. After adding the Lodestar, specify the PC COM port that has been configured in SPRINT.

Figure 7-6 – Non-Acoustic Instrument INS Properties



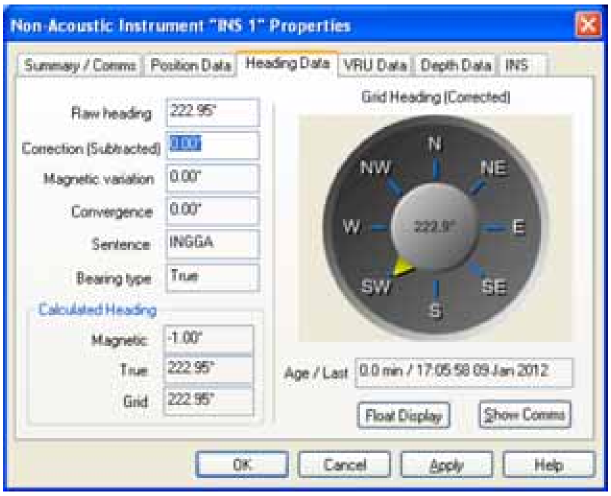
9. The PC port may be a physical COM port of a virtual serial port pair if Fusion is running on the same PC as SPRINT.

10. Select the transceiver connected to the Lodestar from the **Transceiver** drop-down list.

11. Refer to **Figure 7-7**. To check the Lodestar's output to Fusion, select either the **Heading**, **VRU**, **Depth** or **Position** tabs. The data displayed will be sourced from the Lodestar.

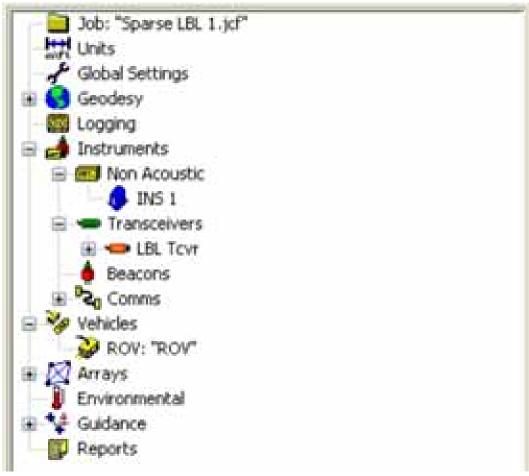
12. Click **OK** to close and save enetered settings.

Figure 7-7 – Checking Lodestar Heading Output to Fusion



13. Refer to **Figure 7-8**. After adding the INS (Lodestar) and Transceiver, they should be listed in the Fusion LBL Job Tree.

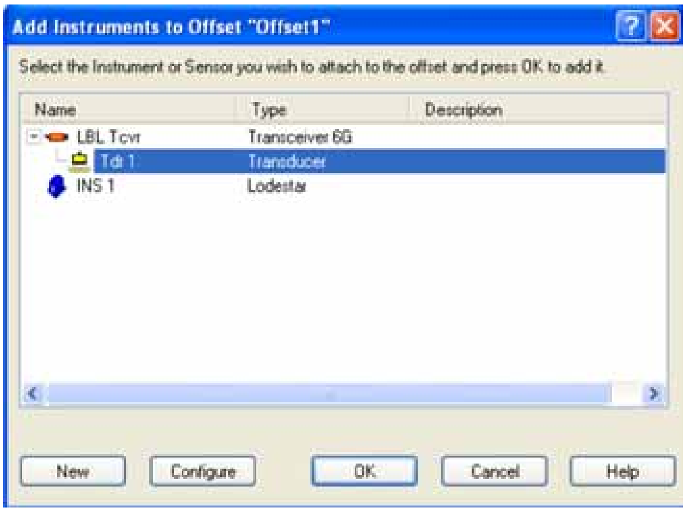
Figure 7-8 – Fusion LBL Job Tree



14. The instruments must now be added to an ROV. Select the ROV from the job tree, then open the **Instruments** tab on the ROV properties page.

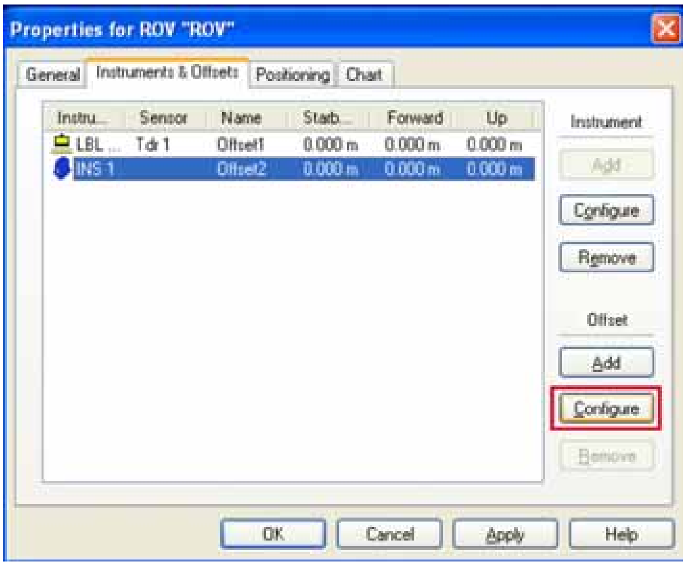
15. Refer to **Figure 7-9**. Add the INS (Lodestar) and the appropriate Transducer by clicking the **Add** button and selecting from the list of available instruments.

Figure 7-9 – Adding Instruments to the ROV



16. Refer to **Figure 7-10**. Adding each instrument, click the **Offset Configure** to enter the instrument offsets:

Figure 7-10 – ROV Instruments Configure

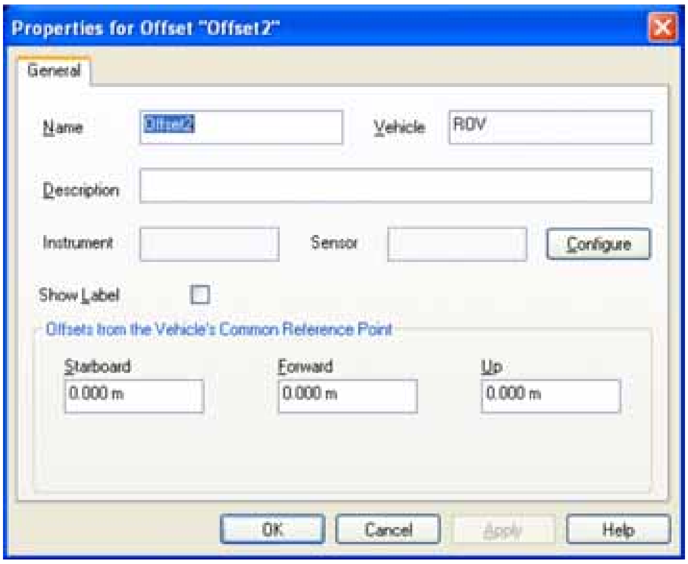


17. Enter the offsets for both instruments with respect to the vehicle CRP.

NOTE

The convention for the instruments may differ from the SPRINT system. These values only require entry at this point as they will automatically be sent to the SPRINT system and the Lodestar.

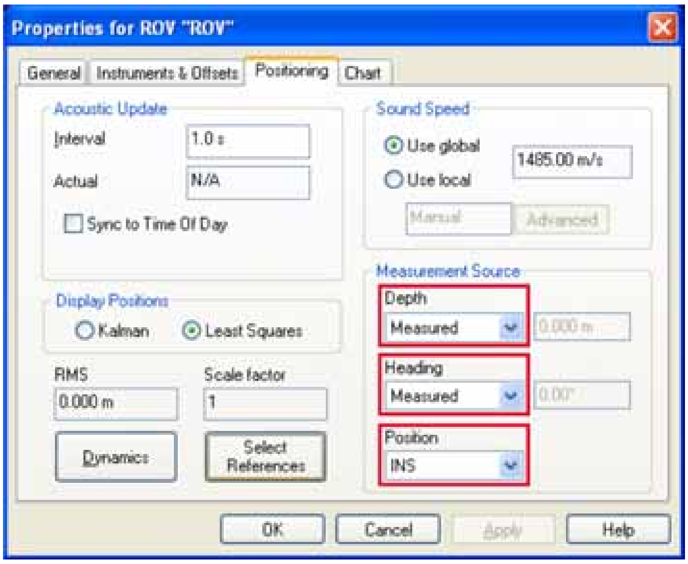
Figure 7-11 – Configure ROV Offsets



18. Click **OK** to close and save all entered settings.

19. Refer to **Figure 7-12**. In the **Properties for ROV** window, select the **Positioning** tab:

Figure 7-12 – ROV Positioning Properties



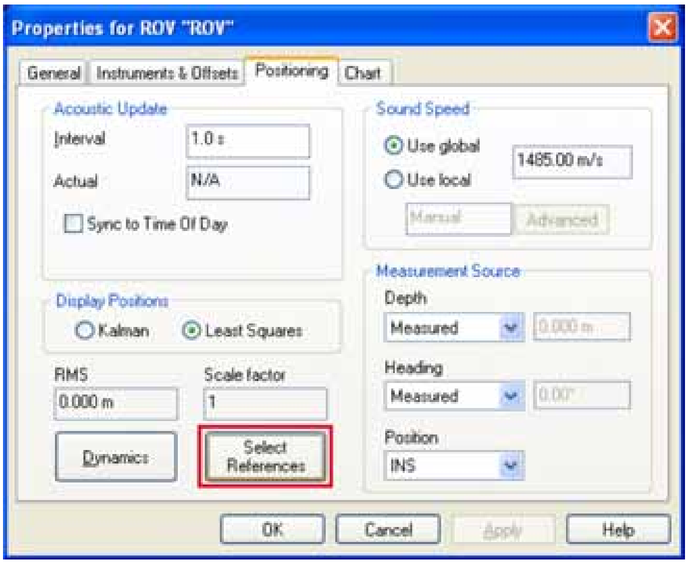
20. To use the depth output from the Lodestar select **Measured** as the **Depth** measurement source.

21. To use the heading output from the Lodestar select **Measured** as the **Heading** measurement source.

22. To use the INS position output from the Lodestar select **INS** as the **Position** measurement source. Alternatively, for LBL acoustic solution, select **Acoustic** as the **Position** measurement source.

23. Refer to **Figure 7-13**. To specify the reference beacons for this ROV, click **Select References**:

Figure 7-13 – ROV Positioning Properties Select References

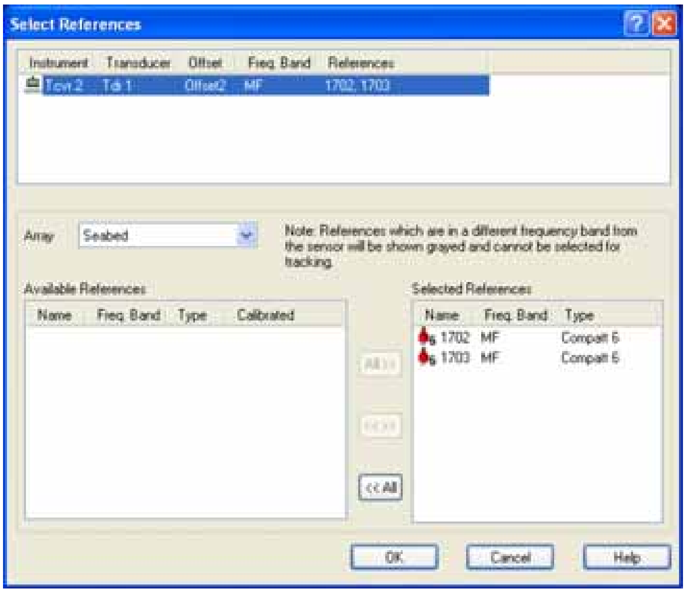


NOTE

Not all reference beacons specified need to be used for INS LBL aiding but must be specified if the SPRINT system is to record the observations for other purposes, such as post processing in Janus.

24. Refer to **Figure 7-14**. After adding the references, click **OK** to close the **Select References** page.

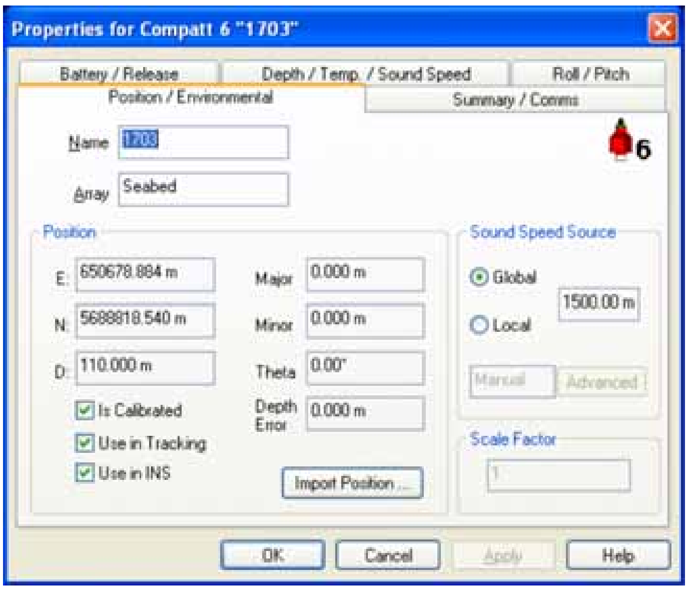
Figure 7-14 – Select ROV References



25. Click **OK** to close the ROV properties page. By default, all reference beacons added as references will be used for INS aiding.

26. Refer to **Figure 7-15**. To disable a beacon for INS aiding but to still record LBL data in SPRINT (for use offline) open the properties page for the Compatt and deselect **Use in INS**.

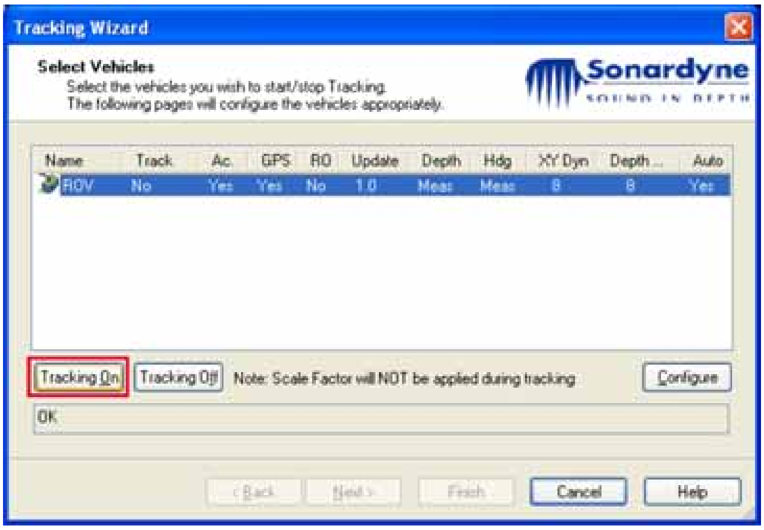
Figure 7-15 – Compatt Properties



27. The ROV can now be tracked using INS with LBL aiding. Click the green **Go** button to start the tracking wizard.

28. Refer to **Figure 7-16**. Select the correct ROV for tracking, then click **Tracking On**.

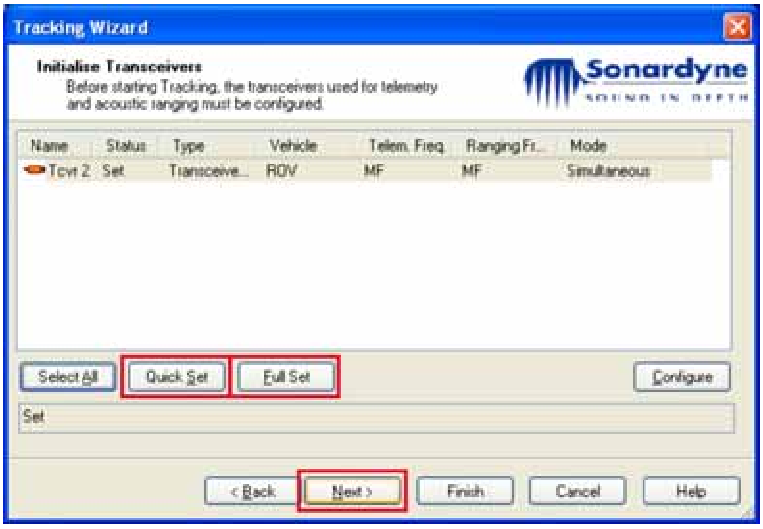
Figure 7-16 – Tracking Wizard Vehicle Selection



29. Click **Next** to proceed.

30. Refer to **Figure 7-17**. If prompted, the transceiver may need to be set by clicking either the **Quick Set** or **Full Set** button.

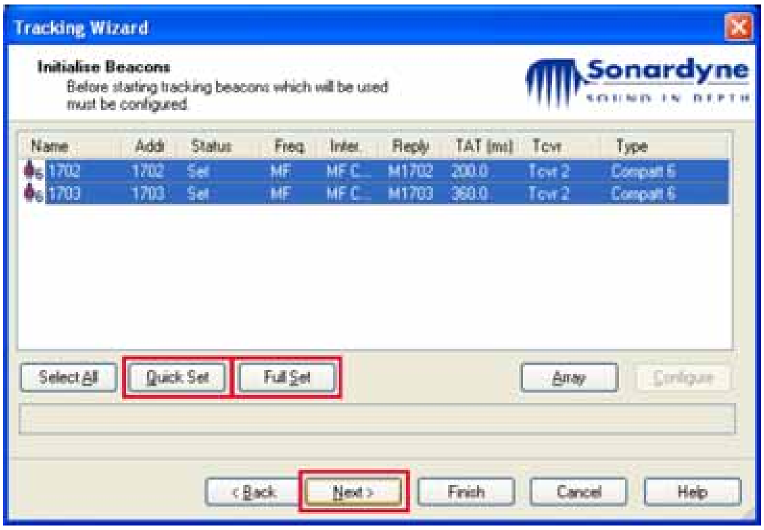
Figure 7-17 – Tracking Wizard Initialise Transceivers



31. Click **Next** to proceed.

32. Refer to **Figure 7-18**. If prompted, the beacons may need to be set using either the **Quick Set** or **Full Set** button:

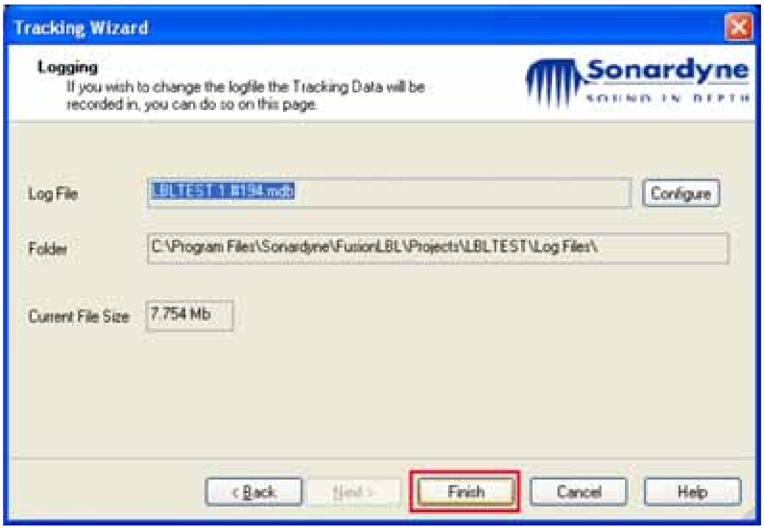
Figure 7-18 – Tracking Wizard Initialise Beacons



33. Click **Next** to proceed.

34. Refer to **Figure 7-19**. Click **Finish** to start tracking and configure any specific Fusion log files:

Figure 7-19 – Tracking Wizard Logging and Finish



7.2 Marksman & Ranger 2 USBL Aiding

To interface Marksman or Ranger 2 USBL to SPRINT for aiding, follow the steps below. The instructions assume the USBL system has already been configured as follows:

i) Calibrated and compensated for vessel movement with a high grade MRU/AHRS.

ii) UC time synchronised.

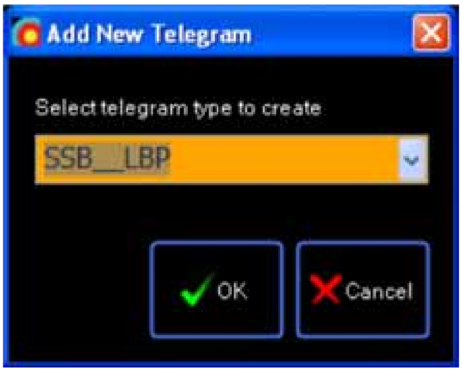
iii) Is using GPS (WGS84) to provide absolute positions.

iv) Using correct sound velocity.

v) Is configured to track the ROV USBL beacon as a mobile beacon.

1. Refer to **Figure 7-20**. Add a new SSB telegram output:

Figure 7-20 – Adding a New Telegram



2. In the **Report Properties**, select **9600** as the baud rate and select an appropriate port to output the message to SPRINT.

3. Refer to **Figure 7-21**. Specify the following telegram options.

- **Frame of Reference**: select **World**
- **Orientation**: select **Lat/Long**
- **Source**: select **Raw**

Figure 7-21 – Telegram Options

SECTION 8 – OPERATION

8. Operation

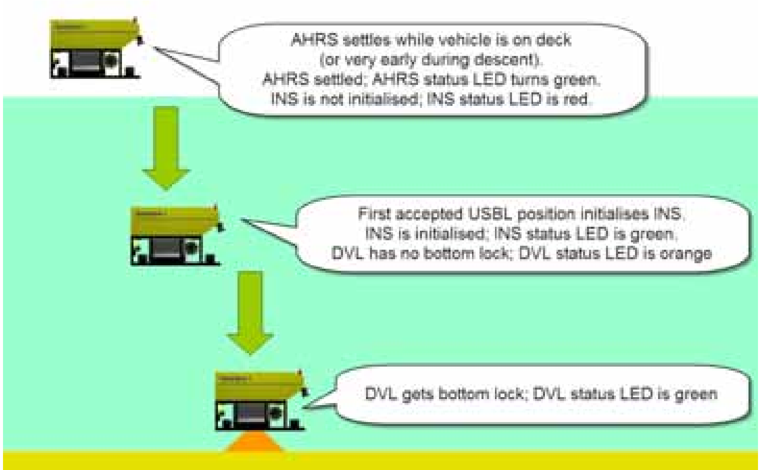
8.1 INS

8.1.1 Initialisation

Refer to **Figure 8-1** for a typical descent and INS initialisation sequence. The INS will require the following to initialise:

1. The AHRS algorithm should be settled. This will take 10 minutes from Lodestar start-up in the default SPRINT configuration. The ROV can be moving. On the main software window the AHRS status LED will be green when the AHRS is settled, see **Section 9.1.2 System and Aiding Status**.
2. The Lodestar should be time synchronised. On the main software window the Time Synch status LED will be green when the Lodestar is Time Synchronised, see **Section 9.1.2 System and Aiding Status**.
3. A starting position for the INS algorithm. In normal operation this will be provided by the first accepted USBL position for the vehicle during descent.

Figure 8-1 – Descent and INS Initialisation Sequence



8.2 Fusion LBL Aiding

8.2.1 Transition from USBL to LBL aided INS

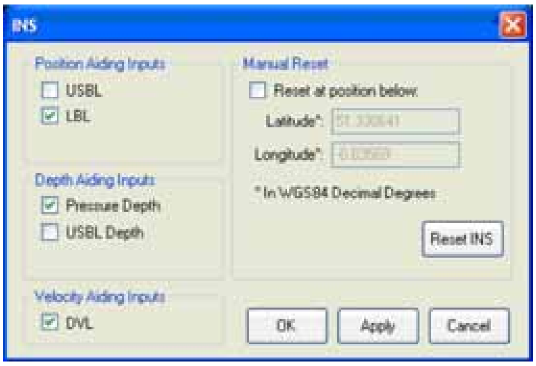
To transition from USBL aided INS to LBL follow the steps below:

1. Make sure SPRINT has good USBL and DVL aiding (e.g. bottom lock). The ROV should continue with some dynamics during the following steps.

2. Check Fusion is tracking and that ranges are being received in the Fusion measurements panel.

3. Refer to **Figure 8-2**. Click the **DVL** and **LBL Aiding checkboxes**.

Figure 8-2 – INS Aiding with LBL Aiding



4. LBL aiding can then be monitored in operation as described in **Section 9.1.5**.

8.3 Zero Velocity (ZUPT) Aiding

8.3.1 Features and Operational Guidelines

Zero velocity aiding feeds ‘zero’ velocities in to the INS (with an amount of error) to help the INS estimate sensor bias errors when a vehicle is not moving. It can be used to:

- Stop INS position drift if DVL, USBL or LBL aiding is lost
- Provide better static fix results if aiding data is poor (e.g. USBL)

Rules for Zero Velocity (ZUPT) Aiding:

NOTE

If Zero Velocity (ZUPT) aiding is used when the vehicle is moving the INS integrity and performance could be affected

- Must ONLY be used when the ROV is truly static
- Must NEVER be used when the ROV is moving
- Switching between USBL and LBL aiding must NOT be carried out when the INS is ZUPT aided as it will not be allowed to move between the two positioning sources.

8.3.2 Enabling Zero Velocity (ZUPT) aiding

Zero Velocity Aiding can be enabled by clicking the **ZUPT** button on the main SPRINT window, see **Figure 8-3**. It can disabled by pressing the **ZUPT** button again. When active the INS status on the navigation chart will display **Navigating** (**ZERO VELOCITY**).

Figure 8-3 – Enabling ‘ZUPT’ Aiding

8.3.3 Static Fixes with Zero Velocity (ZUPT) Aiding

Follow the steps below if **Zero Velocity Aiding** (**ZUPT**) is to be used while taking a static fix.

1. SPRINT should be ‘healthy’ with green LEDs before taking a static ZUPT fix.
2. Manoeuvre the vehicle in to position for the static fix.
3. Once the vehicle is static enable ZUPT mode.
4. Record the static fix using 3rd party software.
5. Turn off ZUPT mode.
6. The vehicle can now move away from the static fix position.

NOTE

ZUPT aiding may not be available depending on the SPRINT version

Pre-Dive Checklist

Use the list below to assist in making sure the SPRINT system is ready before a dive.

	Action	Checked
1	Check the Lodestar is powered.	
2	Check all aiding sensors (Depth, DVL, Sound Velocity, and LBL Transceiver) are powered.	
3	Check the default Latitude in the SPRINT software.	
4	Check the Lodestar, AHRS, Logging and Time Synch status LED's are green (OK).	
5	Check the Depth status LED is blue (not used). A red (critical) status could indicate there is no data being received.	
6	If a DVL is being used, check the DVL status LED is blue (not used). A red (critical) status could indicate there is no data being received.	
7	If an SV feed is being used, check the SV status LED is blue (not used). A red (critical) status could indicate there is no data being received.	
8	If connected to an LBL transceiver, open the Fusion software and check the Transceiver connection by performing a 'Get' or 'Test' on the transceiver instrument page.	
9	Check or set the (surface) pressure offset on the depth aiding page of the SPRINT software.	

Sign: …………………………………………………………..	**Date:** …………………………………………………….

SECTION 9 – MAINTENANCE & MONITORING

9. Maintenance & Monitoring

9.1 Monitoring the System

9.1.1 Main Application Window

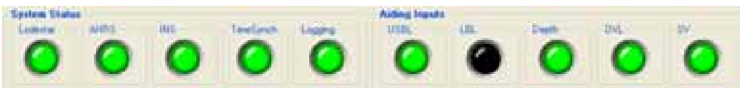
The main software window, with USBL, DVL and Depth aiding active, with key features highlighted is shown below in **Figure 9-1**.

Figure 9-1 – Main Application Window

9.1.2 System and Aiding Status

Refer to Figure 9-2. All the major system components and aiding inputs can be monitored via ‘traffic lights’ at the bottom of the main software window:

Figure 9-2 – System and Aiding Status



The following system components are always monitored:

- Lodestar (Hardware)
- AHRS (Attitude Heading Reference System)
- INS (Inertial Navigation System)
- Time (Synchronisation)
- (Local PC) Logging

Aiding inputs are monitored if they are specified for INS aiding in the INS Settings configuration. The colour of the monitoring 'traffic lights' is explained below:

Table 9-1 – System and Aiding Status 'Traffic Light' Colours

Status	'Traffic Light' Colour	Example States
Critical	Red	Communications Failure to Component Hardware Issue Component not Initialised or running correctly Timeout for Critical Instrument (typically 30 second limit)
Warning	Orange / Amber	Aiding Sensor Data Rejected AHRS Algorithm Settling
OK	Green	Data Received within Time Limit Data Accepted and Used
Not Used or Disabled	Blue	Aiding data is received but as the INS is not initialised it is not yet being used.

A text description for each component status is provided in the status list and can also be seen by placing a mouse over the appropriate LED, as shown in **Figure 9-3** (with the example of the INS being unable to initialise as it is not receiving position). If there is an issue, the status text will provide guidance to resolve it.

Figure 9-3 – Component Status Popup

9.1.3 Navigation Text Panel

Real time navigation data is displayed in the navigation text panel. All positions can either be displayed in WGS 84 decimal degrees or UTM Eastings and Northings. Various quality metrics are also displayed in the panel for both the INS and the Lodestar time synchronisation status.

Figure 9-4 – Navigation Text Panel

NOTE

The displayed USBL beacon position and external depth are with respect to the vehicle CRP to allow for direct comparison with the INS position, which is also with respect to the vehicle CRP.

9.1.4 INS Statistics

Refer to **Figure 9-5.** To view detailed INS performance statistics, from the menu select **View** > **INS Statistics**:

Figure 9-5 – INS Statistics

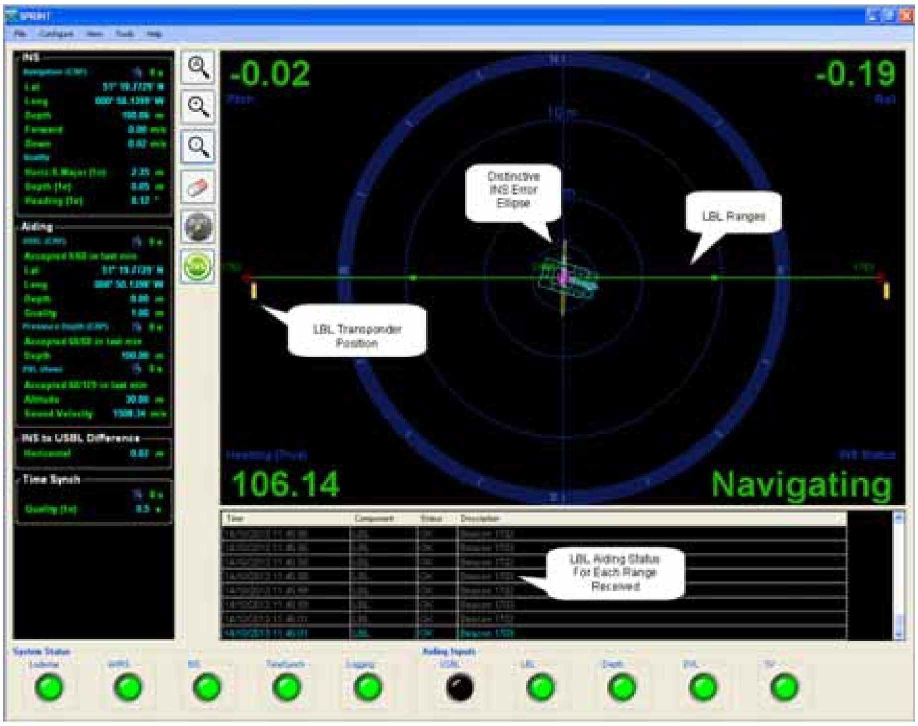
NOTE

If the INS Statistics display is closed while in use as Time Series Plots, the plots will be deleted.

9.1.5 INS with Fusion LBL Aiding

When LBL is selected and used as an aiding source in SPRINT, there are some features that should be noted in the SPRINT software. See the LBL aiding example in Figure 9-6. When LBL aiding is active the USBL position is still displayed for comparison but is not used for aiding. Additionally the INS error ellipse may take a distinctive shape that is representative of the geometry of the vehicle with respect to the reference beacons used for aiding.

Figure 9-6 – SPRINT with Fusion LBL Aiding



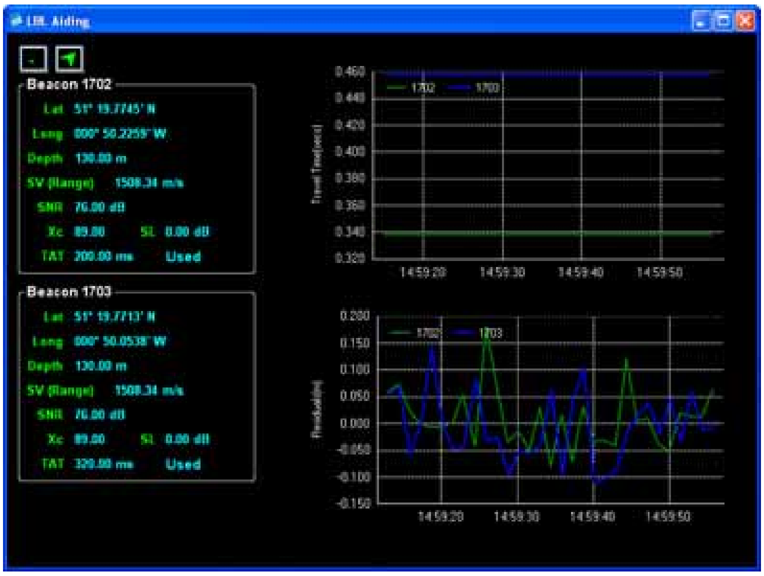
If any LBL ranges are rejected, the LBL aiding ‘traffic light’ will change to amber/orange and the beacon address and reason for rejection will be displayed. Examples showing reasons of LBL rejection are shown in **Figure 9-7**.

Figure 9-7 – LBL Aiding Rejection

OK	Beacon 1703
Warning	Beacon 1703 Rejected (Range Prediction Exceeded: Bad Range Received), Rejected (Range Rate Exceeded: Bad Range Received)
Warning	Beacon 1703 Rejected (Outside INS Prediction)

Select **View** > **LBL Aiding** from the software menu to see additional LBL aiding information as shown in **Figure 9-8**.

Figure 9-8 – LBL Aiding Window



The LBL aiding window will display aiding information for all LBL beacons which are currently being tracked while SPRINT is LBL aided.

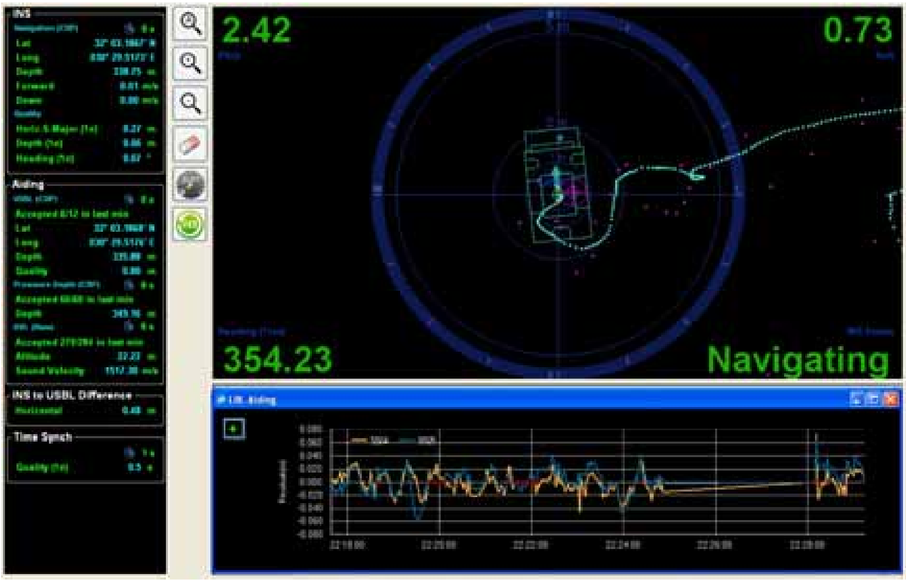
The upper graph displays travel time for all tracked beacons while the lower graph displays the LBL aiding range residuals. The residuals displayed are the differences between the INS estimated and the actual received LBL ranges and are therefore an extremely useful indication of LBL aiding health. The residuals should typically be low (<10cm) and centred around zero.

To edit the LBL aiding chart contents:

1. Press the minus sign −. on the keyboard to hide the beacon text.
2. Right-click on the charts to enable options to:
   - Maximise or hide one of the charts
   - Show or hide data from individual beacons
   - Copy and save the charts
3. Dragging the mouse over a section of the chart will zoom into the area selected.

It is recommended that during critical INS positioning with LBL aiding, the LBL aiding window is kept open to monitor the aiding, as shown below in **Figure 9-9**.

Figure 9-9 – Monitoring LBL Aiding

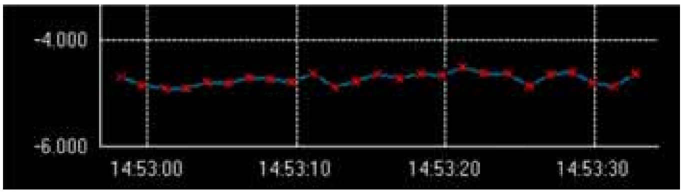


If the residuals are not centred around zero, this would indicate that there is a systematic error with LBL aiding, such as:

- Sound velocity
- Beacon to INS relative depth

If LBL aiding observations are rejected, it will be indicated by a red cross on the residuals display, as shown in **Figure 9-10**.

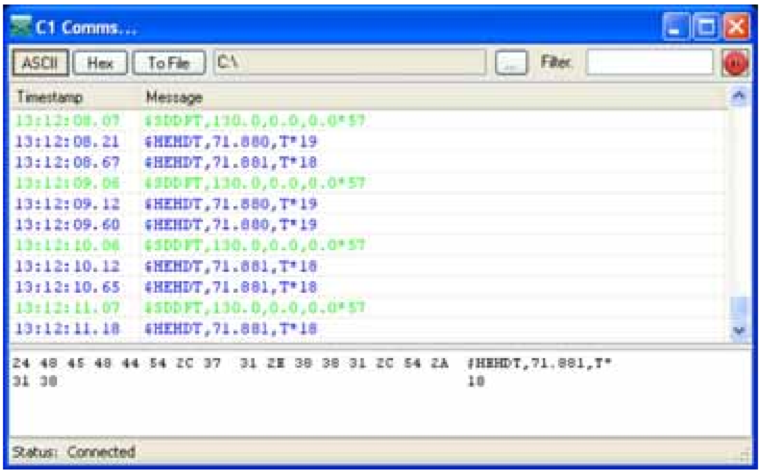
Figure 9-10 – LBL Aiding Rejection in Residuals Graph



9.1.6 Communications Monitor

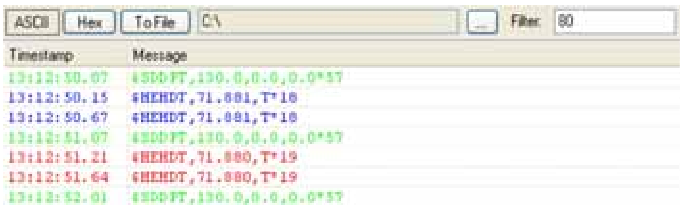
From any of the dialogs in the SPRINT software that allow the configuration of input or output communication, a comms monitoring function is provided. When the **Comms** button is clicked, a new window is displayed showing the received or sent data on the configured port – see **Figure 9-11**. The actual message contents are provided in the **Message** column.

Figure 9-11 – Communications Monitor



The data received on the port is displayed green and the data sent on the port displayed blue as shown in **Figure 9-11**. The communications can be saved to a file by selecting a location and clicking the **To File** button. The communications can be filtered by entering Filter text. Any communication containing the filter text is displayed red as shown in **Figure 9-12.**

Figure 9-12 – Communications Monitor Filter



The communications stream can be paused by pressing the **Pause** button.

9.1.7 Navigation Quality Limits

Navigation quality limits can be enabled and configured in the SPRINT software (see **Section 6.3.11)**. If enabled, the horizontal navigational quality limit will be displayed on the chart as a red circle (NB: INS horizontal quality is displayed as a yellow circle or ellipse). If either the vertical or horizontal quality limits are exceeded, the software will alert the user as shown in **Figure 9-13**:

- The ‘Compass Ring’ on the navigation chart will flash red.
- The INS status on the navigation chart will read ‘Quality Exceeds Limit’.
- The relevant quality value in the navigation text panel will flash red.

Figure 9-13 – Navigation Quality Limits Exceeded

9.2 Maintaining the System

9.2.1 Logging

The system is configured to log all sensor data and internal state messages to allow for offline analysis, post processing and QC of real time SPRINT navigation.

Data is logged automatically onto a local PC directory as configured previously. An automatic background process will make sure that the Navigation PC hard drive does not become full by deleting the logs in date order.

The same data is also logged internally within the Lodestar on an 8GB SD card. The SD card data can be retrieved using the Lodestar Configuration software – see **Lodestar Manual 8084-107** for instructions.

9.2.2 Lodestar Firmware

The Lodestar firmware can be upgraded using a direct serial connection (not via the LCH), see **Lodestar Manual 8084-107** for instructions.

9.2.3 SPRINT Dongle Update

The SPRINT dongle can be updated using the following procedure:

1. Refer to **Figure 9-14 and Figure 9-15**. Select **All Programs** > **Sonardyne** > **SPRINT** > **Security Tool** from the Windows Start menu.
2. Select **Request Update** > email **reference code** to support@sonardyne.com with the dongle request update.
3. To activate the dongle update: **Apply Update** > select the **.DUP** (Dongle Update Packet) file received from Sonardyne Support.

Figure 9-14 – SPRINT S5 Settings

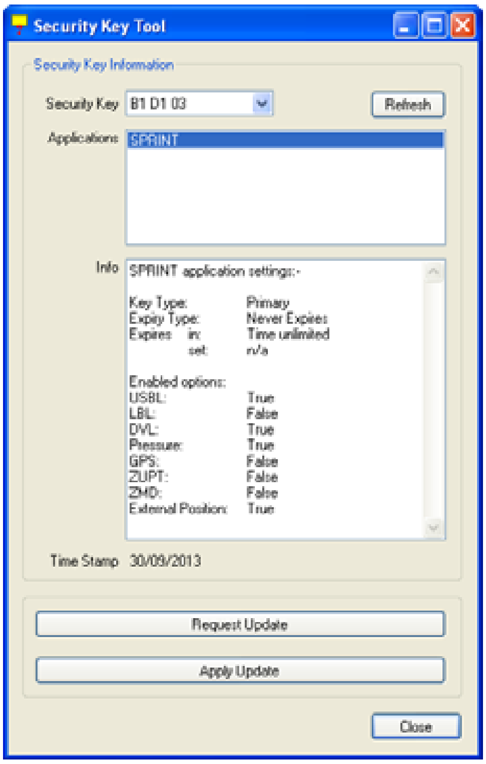
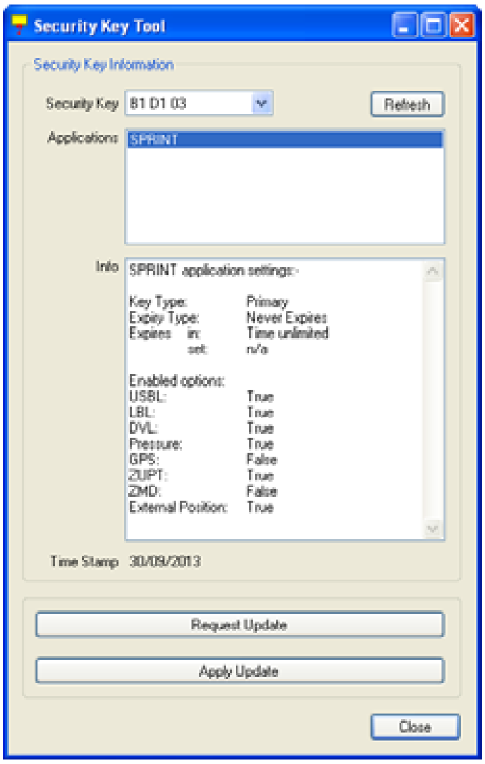


Figure 9-15 – SPRINT S10 Settings



SECTION 10 – FUNCTIONAL TEST

10. Testing

It is strongly recommended the SPRINT system kit is assembled, tested and operated prior to installation on the subsea vehicle. A full set of Lodestar test cables is supplied with each SPRINT kit for that purpose.

NOTE

The Lodestar Communications Hub and associated power cable can be used to provide 48v power to the Lodestar during this test.

The functional test will check that:

1. A connection can be made between the Lodestar and Lodestar Communications Hub prior to it being routed through any interfaces between the subsea vehicle and the vessel.
2. The Lodestar has the correct firmware and is enabled for use with SPRINT.
3. Basic inertial navigation can be initialised.
4. To undertake the test follow the operational steps listed in **Section 6** prior to vehicle installation.

SECTION 11 – DVL CALIBRATION PROCEDURE

11. Calibration

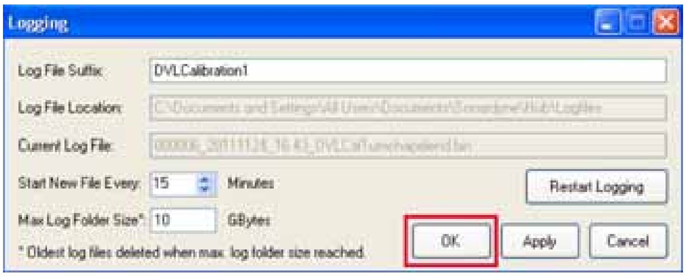
An accurate calibration will typically require ~15-20 minutes of manoeuvring at the seabed. A quick calibration can be done in just a few minutes. Follow the instructions below to undertake a DVL calibration.

Prior to the start of the calibration, make sure the following conditions apply:

- The subsea vehicle must be within DVL range of the seabed with good bottom lock.
- The subsea vehicle is being tracked with USBL and SPRINT is receiving USBL aiding.
- The Pressure Depth input is active and SPRINT is receiving Pressure Depth aiding.
- The correct sound velocity is being used by SPRINT.

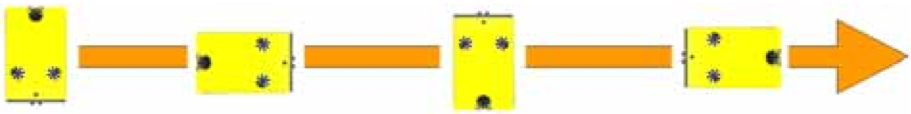
1. It is recommended to start a new log file with a suffix that will be clearly identifiable as DVL calibration data.
2. Refer to **Figure 11-1**. Open the **Logging** dialog and enter the required log file suffix (e.g. DVLCalibration).

Figure 11-1 – DVL Calibration Logging Configuration



3. Click **OK** to close and save all entered settings
4. The subsea vehicle can now undertake some specific manoeuvres. A suggested and efficient approach would be to travel along an approximate linear path whilst performing:
   - Accelerations along various axes including up/down.
   - Heading changes +/- 90°, i.e. sideways movement maintained for a few minutes.
   - **Random** high dynamic manoeuvres
5. A total position change of ~500 metres is sufficient. For deep water, make the trajectory/duration longer for optimum performance.

Figure 11-2 – DVL Calibration ROV Manoeuvres



6. When the calibration manoeuvres have been completed the subsea vehicle can continue with other operations.
7. Open the **Logging** dialog and enter a log file suffix to indicate the log files no longer contain any DVL calibration data, the default log file suffix is **LS**.
8. Create a working folder on the hard drive for the DVL calibration log files; e.g. **My Documents\DVLCal**. Create a subfolder in the working folder called **LogFiles**.

NOTE

SPRINT binary log files have a .BIN extension

---

9. Copy the relevant log files from the SPRINT logging location into the **LogFiles** folder; e.g. 'My Documents\DVLCal\LogFiles'. SPRINT.

NOTE

It is important to only copy the log files covering the time period of the DVL calibration manoeuvres as time taken to process the log files will increase with the amount of data used.

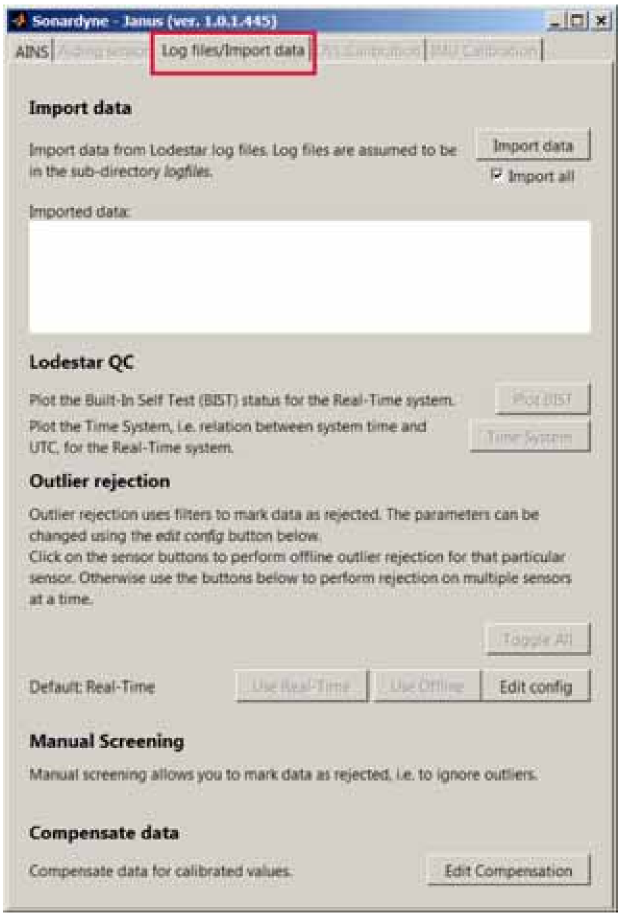
---

10. Run the DVL Calibration tool by double-clicking the icon on the desktop (it may be necessary to wait up to 10 seconds for the application to run):
11. The DVL calibration application will open on the **AINS** tab.
12. Refer to **Figure 11-3**. Click the **Choose job/root directory** button and select the parent working folder, e.g. 'My Documents\DVLCal', and click **OK**.

Figure 11-3 – DVL Calibration Folder Selection

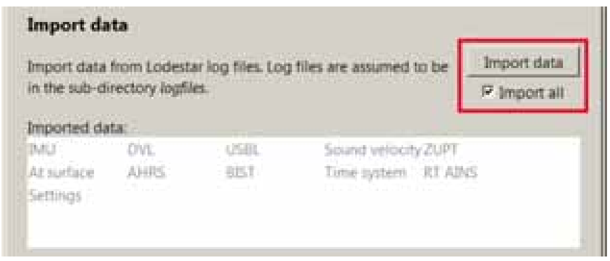
13. Refer to **Figure 11-4**. Select the **Log file/Import data** tab.

Figure 11-4 – DVL Calibration Import Data



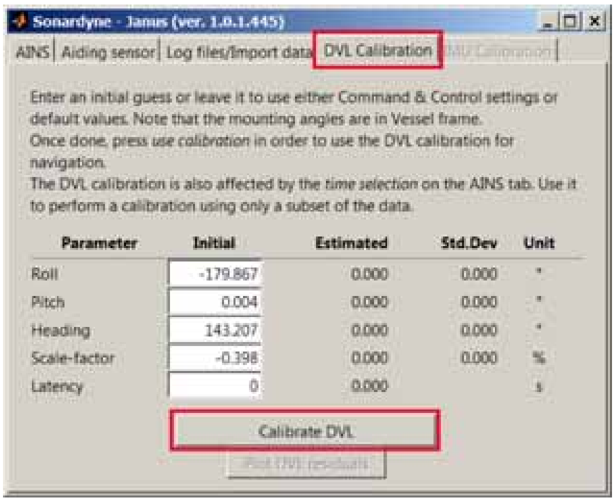
14. Refer to **Figure 11-5**. Click **Import data** to import the data from the LogFiles, this may take several minutes. When the import is completed a list of imported data is displayed:

Figure 11-5 – DVL Calibration Import Data



15. Refer to **Figure 11-6**. Select the **DVL Calibration** tab.

Figure 11-6 – DVL Calibration Calibrate DVL



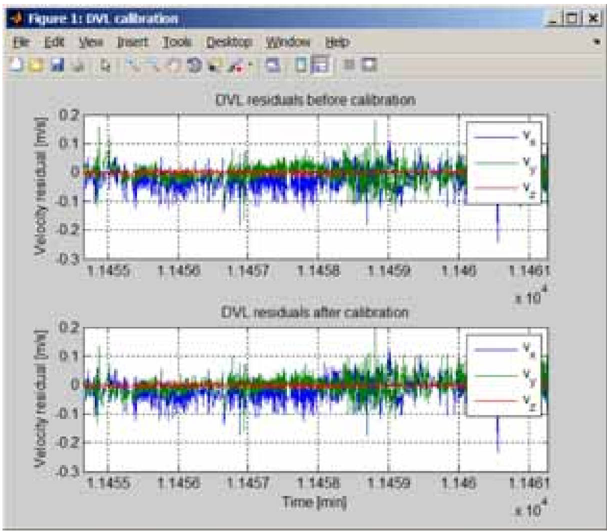
16. The initial (default) values will be displayed. They do not need to be modified.

17. Refer to **Figure 11-7**. Click the **Calibrate DVL** button. A progress indicator will show the processing status.

Figure 11-7 – DVL Calibration Calibrate Progress

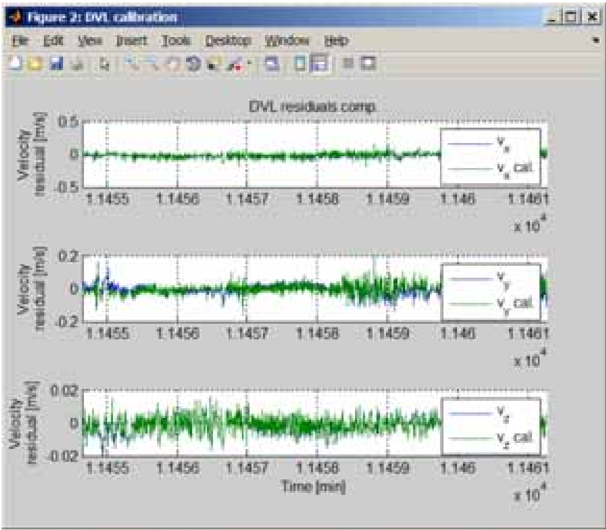
18. Refer to **Figure 11-8**. When completed, two figures will be displayed. **Figure 1: DVL Calibration** displays the DVL velocity residuals for all axes before and after calibration.

Figure 11-8 – DVL Calibration All Axes Residual Results



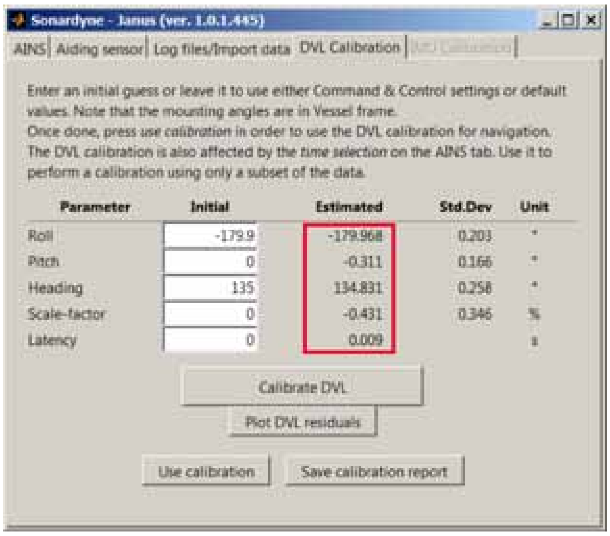
19. Refer to **Figure 11-9**. **Figure 2 DVL Calibration** displays the DVL velocity residuals for each axes before and after calibration.

Figure 11-9 – DVL Calibration X, Y and Z Axes Residual Results



20. Refer to **Figure 11-10**. On the **DVL Calibration** tab the estimated calibration values are displayed.

Figure 11-10 – DVL Calibration Computed Results



21. It is recommended a (PDF) copy of the DVL calibration report is saved by pressing the **Save calibration report** button and specifying an appropriate location.

22. Refer to **Figure 11-11**. Open the report to retrieve the results (they are also available directly from the **DVL Calibration** tab):

Figure 11-11 – DVL Calibration Results Report

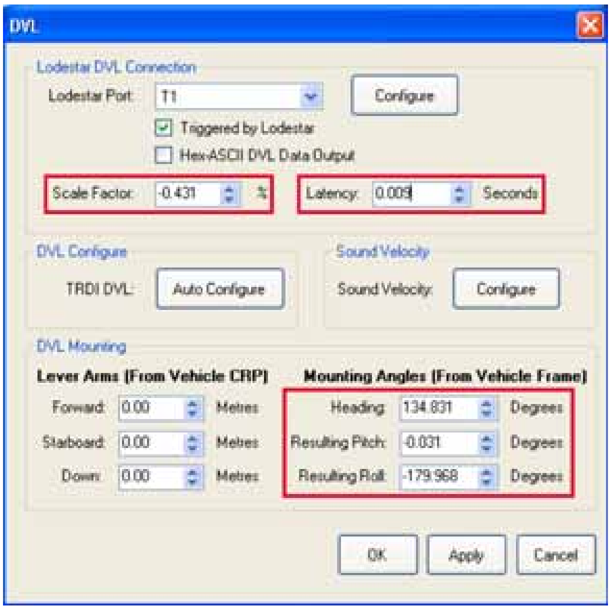
Results:

DVL params	Roll [°]	Pitch [°]	Heading [°]	Scale factor error [%]	Latency [s]
Before	-179.900	0	135.000	0	0
Calculated	-179.968	-0.211	134.831	-0.431	0.009
Calculated Accuracy	0.203	0.106	0.258	0.340	NaN

23. Refer to **Figure 11-12**. In the SPRINT software, navigate to the DVL dialog (**Configure** > **INS** > **DVL Input**).

24. Enter the calculated values in the dialog and click **Apply** or **OK** to save the changes:

Figure 11-12 – DVL Entering Results in SPRINT



SECTION 12 – FAULT DIAGNOSIS

12. Introduction

The following sections suggest possible causes and/or solutions for problems that may be experienced for each system component. If, after checking the causes and solutions listed below the problem is still occurring please contact Sonardyne Support. You may be requested to provide a system configuration export as described in **Section 6.3.19**.

12.1 Lodestar Connection

When connecting the Lodestar, carry out the following:

1. ALWAYS configure and check Lodestar connection prior to mounting on subsea vehicle.
2. Make sure the Lodestar is fully charged (2-3 hours) prior to vehicle connection tests to eliminate any communication failures due to intermittent connections and power loss.
3. Once the Lodestar is mounted on the vehicle, connect a laptop using test cables to verify Lodestar operation and sensor communications.
4. Ethernet – check vehicle supports 100 megabit.
5. Serial – check 232 485 cable select for console port connection issues.

12.2 Attitude Heading Reference System (AHRS)

When using the AHRS, make sure:

1. The default Latitude is set.
2. There is a constant bias noted. If so, check Lodestar mounting angles, lever arms and remote output points if configured.

12.3 Inertial Navigation System (INS)

When using the INS, make sure:

1. Generally, INS will always reject for a valid reason. Rejection indicates issues for investigation on the aiding sensor.
2. The most common reason for rejection of time stamped data (GPS / USBL) is an incorrectly configured time synchronisation.
3. If bad aiding data is accepted as good then INS may report Bias, Accelerometer or Heading warnings.
4. Following other troubleshooting steps first (INS is last port of call for issues/errors).

12.4 Time Synchronisation

When using the Time Synchronisation process, make sure:

1. If ZDA only is used, latency MUST be set.
2. The ideal method is ZDA and 1PPS.
3. Make sure any time stamped aiding (GPS/USBL) is also UTC time synched; check in comms viewer.
4. If Lodestar is synchronised to difference time base than GPS/USBL the behaviour to notice is:
   - Lodestar accepts position data while static
   - Lodestar rejects position data as soon as it moves

NOTE

Rejection reason might be 'outside INS estimate' rather than indicating a time synch issue, an INS cannot tell the difference.

12.5 Aiding Inputs (All)

When using Aiding Inputs, make sure to:

1. Check input using:
   - Comms Monitor
   - Lodestar Port Traffic
2. Check lever arms and mounting angles.

12.6 USBL Aiding

When using USBL Aiding:

1. Make sure the USBL system is UTC time synched.
2. Check UTC time stamp in telegram is correct.
3. Make sure the Radians Lat/Long are selected for PSIMSSB message.
4. Check that **measured** rather than **filtered** is selected (raw position is required).
5. Make sure beacon ID is correct.
6. Check USBL setup:
   - Lever arms and angular corrections (calibration)
   - Sound velocity

12.7 Depth Aiding

When using Depth Aiding make sure:

1. The correct units are selected.
2. To check surface correction.

12.8 Doppler Velocity Log (DVL) Aiding

When using a Doppler Velocity Log Aiding system, make sure:

1. The DVL is configured correctly.
2. The sound velocity is correct.
3. The latency and scale factor are configured correctly.

12.9 LBL Aiding

When using LBL Aiding:

1. Is Fusion sound velocity correct?
2. Is ROV to Beacon(s) relative depths correct?:
    - Tide
    - Absolute->Corrected
3. Has INS had time to move between USBL and LBL?
4. How does this beacon fit into array?
5. Can the acoustic LBL position be used for comparison?
6. Are the minimum/maximum range settings correct?

SECTION 13 – REMOVAL

13. Introduction

It is recommended that any packaging supplied with the SPRINT system is retained for future use.

13.1 Dismantling

If the system is to be returned to Sonardyne International, it must be dismantled as follows:

WARNINGS

⚠ **Heavy Equipment. The 1000 metres rated Lodestar weighs 14 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.**

⚠ **Heavy Equipment. The 3000 metres rated Lodestar weighs 22 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.**

⚠ **Heavy Equipment. The 5000 metres rated Lodestar weighs 39 kg. Manual Handling Equipment (MHE) must be used to move the Lodestar. If MHE is not available, then a manual handling assessment must be carried out prior to carrying out manual lifting / handling. Personal Protective Equipment such as protective footwear and gloves must be worn when lifting this equipment.**

1. Make sure the SPRINT software is stopped and closed.
2. Make sure the power to the LCH is switched **OFF**.
3. Make sure the power to the NAV PC is switched **OFF**.
4. Rinse all subsea equipment with clean fresh water. Dry with lint free cloth.
5. Disconnect all connections at the rear of the LCH.
6. Disconnect all connections at the rear of the NAV PC.
7. Disconnect all connections to the top of the Lodestar.
8. Check all the equipment for signs of damage or corrosion.
9. Make sure all equipment is clean and dry before inserting into the packing cases.
10. Any problems encountered then please contact your nearest Sonardyne office.

SECTION 14 – SPARES

14. Introduction

There are no spares supplied with this system.

14.1 Component Identification Table

Refer to the list below when contacting Sonardyne International or your local office to identify any required component.

Table 14-1 – Component Identification Table

Stock Code	Description	Quantity
620-0080	NAV Computer CORE 2 DUO - 8026-000-05-A6	1
610-2362	OEM WIN XP PRO for embedded	1
272-0345	Cable Mains Plug to straight	2
272-0352	Cable Euro Plug to straight	2
272-036C	Cable USA Plug to straight IEC	2
222-6004	SCR SL PAN HTS Chemi BLK M6X16	8
205-0832	Schroff 21100-015 F/Panel plastic washer	8
790-0931	Fusion packing box cardboard	2
610-2393	OEM Norton Ghost 2005 V9	1
820-6592	Earth Strap Eyelet Type - 8020-075-A1	2
280-4001	Cable CAT.5e UTP patch 5M - RoHS	1
272-0793	Video DVI-DVI Interface Cable - RoHS	1
280-4714	Serial Data Cable 9 pin SUBD M/F 5M	8
610-0048	OEM Norton net Security 2011 - Symantec 21076753	1
272-0291	Cable CAT.6a SSTP patch 0.3m - RoHS	1
620-0142	LCH assembly - 8184-000-01-A3	1
280-4198	Cable BNC to BNC 3 m - RoHS	1
820-0216	LCH 48V Power Test Cable Assy - 8184-015-A1	1
820-0072	Subsea Lodestar Comms Ethernet - 8084-138-04-A3	1

Stock Code	Description	Quantity
820-0078	Subsea Lodestar TCVR Test - 8084-139-04-A2	2
620-0203	SPRINT Software - 8253-006-A	1
8084-3110	Lodestar 3K 5-CONN - 8084-000-3110-B1	1
317-5404	CON U/W 6W I/L MP MICRO	2
790-1135	Subsea Lodestar Transit Case	1
317-5383	Con U/W 8W I/L FS Micro	1
317-5384	Con U/W 8W I/L MP Micro	2
317-5385	Con impulse locking sleeve	5
820-0067	Lodestar Subsea Console Test - 8084-136-04-A2a	1
820-0070	Subsea Lodestar comms C1 TEST - 8084-137-04-A2a	1
998-0137	Subsea Gyro drilling template - 8146-200-A2	1
620-7214	Lodestar-2 software CD - 8084-114-C1	1

APPENDIX A – LODESTAR ANGLE DEFINITIONS

A 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:

1. Rotation by the gamma angle about Zref.
2. Rotation by the beta angle about the resulting Y axis.
3. Rotation by the alpha angle about the resulting X axis.

A.1 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].

A.2 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].

A.3 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].

A.4 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:

A.5 Pitch

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

A.6 Roll

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

A.7 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 – REFERENCE FRAMES AND ANGULAR CONVENTIONS

B Reference Frames and Angular Conventions

B.1 Lodestar Frame

The Lodestar frame is a fixed right-hand coordinate frame X Y Z. Typically Lodestar is mounted so that 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**).

Lodestar angular outputs are defined in Gravity (or Datawell) angles; see **Appendix A** for further details.

Figure B–1 – Lodestar Reference Frame

1	Y Axis Positive (+) Starboard	3	X Axis Positive (+) Forward
2	Orientation Marks (Forward)	4	Z Axis Positive (+) Down

B.2 Vehicle Reference Frame

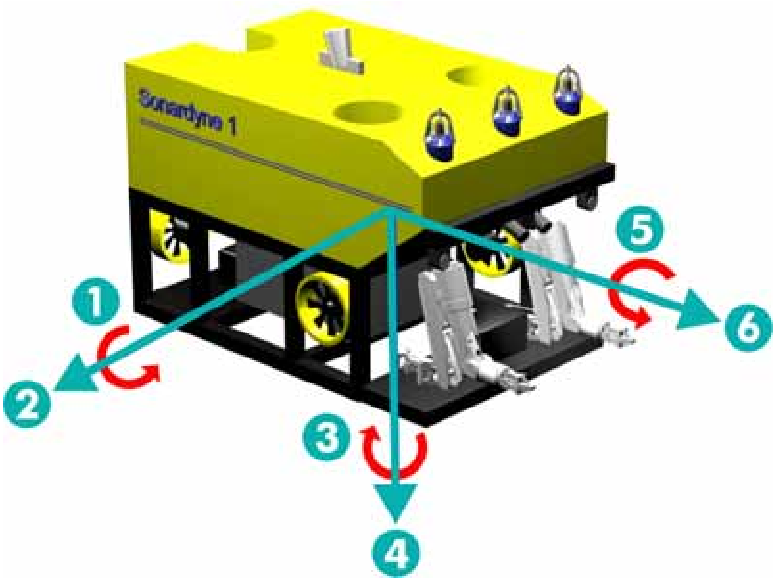
For most applications, measurements are required with respect to the vehicle's reference frame. The definition of the vehicle reference frame is shown below.

Unless otherwise stated for a particular output telegram, the Lodestar will output measurements with respect to this frame.

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 CRP or central reference point.

In a typical installation, the Lodestar may not be perfectly aligned to the installation vehicle reference frame.

Figure B–2 – Vehicle Reference Frame



1	Positive Pitch (Bow up)	4	Down (Z)
2	Starboard (Y)	5	Positive Roll (Starboard Down)
3	Positive Heading Change	6	Forward (X)

B.3 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 C (Heading) angle about the Z axis of the reference frame.
2. Rotation by the B (Pitch) angle about the resulting Y axis.
3. Rotation by the A (Roll) angle about the resulting X axis.

NOTE

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

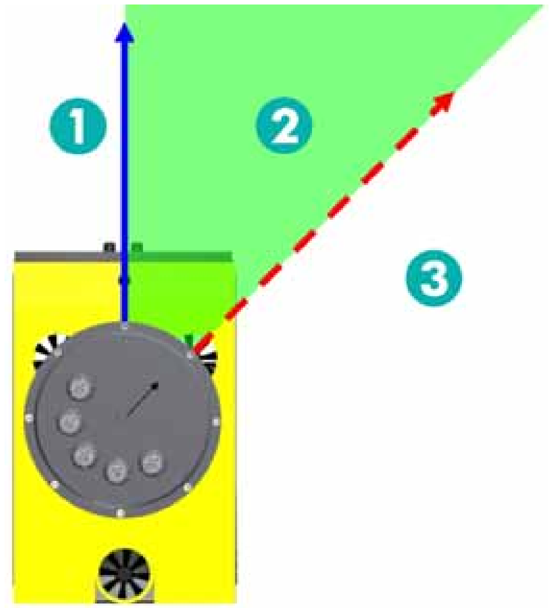
Mounting angles are specified as Euler angles; see **Appendix A** for further details.

The convention for measuring each mounting angle is shown below.

NOTE

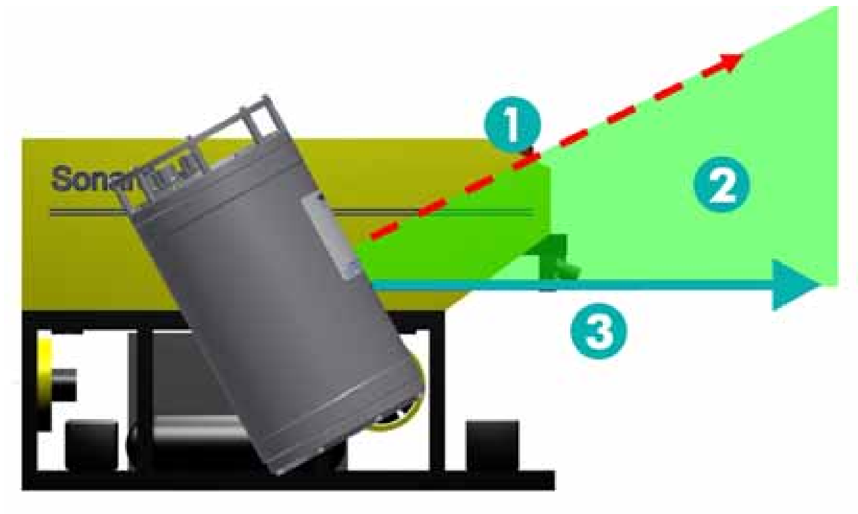
To simplify the definition and convention of each mounting angle, each angle is depicted independently but in practice they are non-commutative and must be measured in the order defined previously.

Figure B–3 – Lodestar Heading Mounting Angle Example



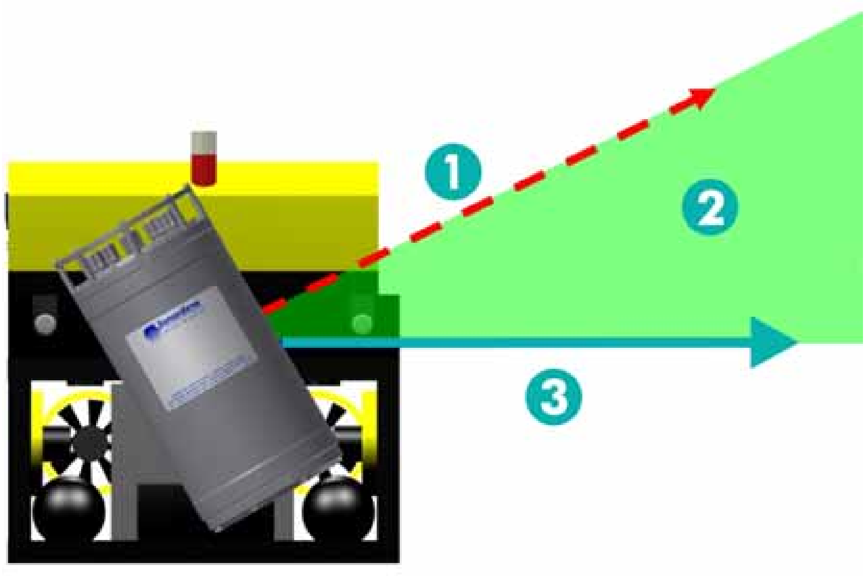
1 Heading Output (Mounting Angle +40°)
2 Positive (+) Mounting Angle Applied
3 Heading Output (Mounting Angle 0°)

Figure B– 4 – Lodestar Pitch Mounting Angle Example



1 Pitch Output (Mounting Angle 0°)
2 Positive (+) Mounting Angle Applied
3 Pitch Output (Mounting Angle +30°)

Figure B– 5 – Lodestar Roll Mounting Angle Example *



1 Roll Output (Mounting Angle 0°)
2 Positive (+) Mounting Angle Applied
3 Roll Output (Mounting Angle +30°)

*Vehicle view is bow-on.

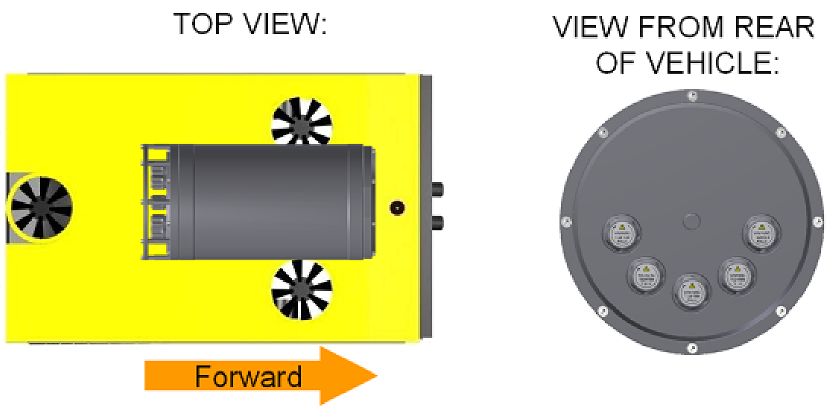
APPENDIX C – LODESTAR MOUNTING ANGLE EXAMPLES

C Lodestar Mounting Angle Examples

This section provides some examples of alternate Lodestar mountings and the associated “coarse” mounting angles that should be used in the system configuration.

Configuration A

If the Lodestar is mounted in the following configuration:



Then use the following mounting angles on the Lodestar configuration page:

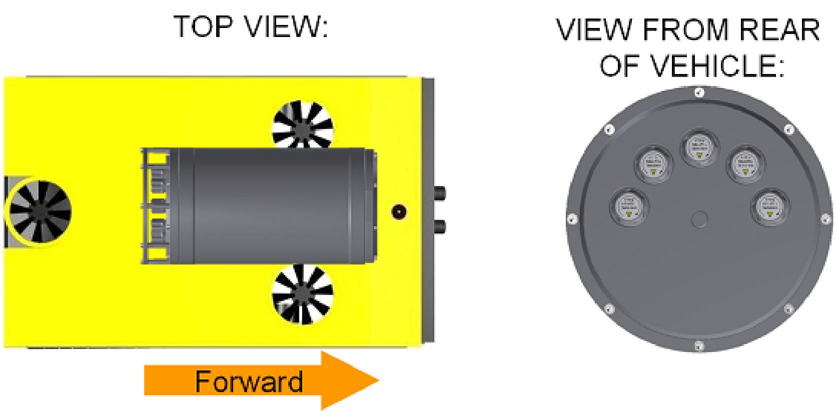
Heading: 0

Resulting Pitch: 90

Resulting Roll: 0

Configuration B

If the Lodestar is mounted in the following configuration:



Then use the following mounting angles on the Lodestar configuration page:

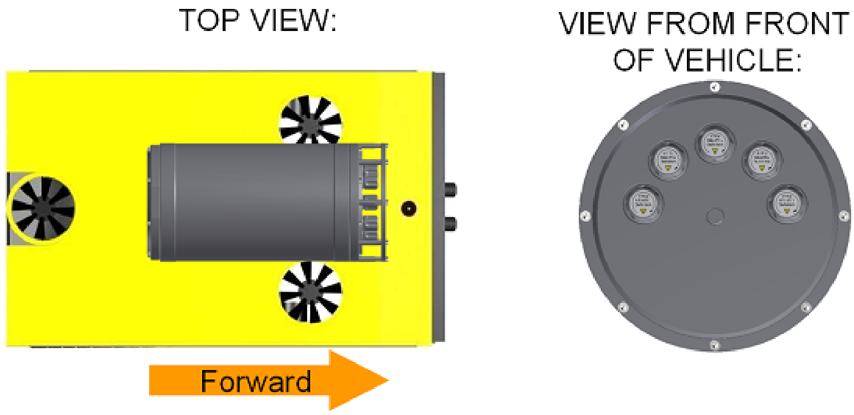
Heading: 180

Resulting Pitch: -90

Resulting Roll: 0

Configuration C

If the Lodestar is mounted in the following configuration:

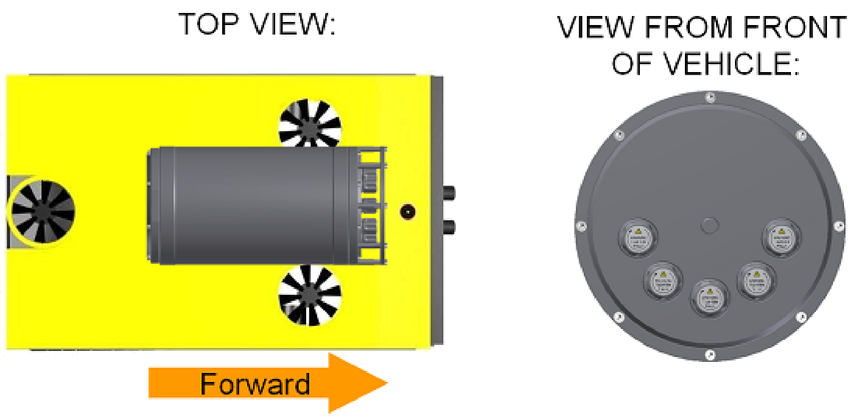


Then use the following mounting angles on the Lodestar configuration page:

Heading:	0
Resulting Pitch:	-90
Resulting Roll:	0

Configuration D

If the Lodestar is mounted in the following configuration:



Then use the following mounting angles on the Lodestar configuration page:

Heading:	180
Resulting Pitch:	90
Resulting Roll:	0

APPENDIX D – RECOMMENDED DVL CONFIGURATIONS

D Recommended DVL Configuration

Please contact Sonardyne Support if your DVL configuration is not listed (e.g. PD0).

D.1 RDI DVL PD4/5 (Triggered)

- CR1
- CB811
- CF11110
- CX1
- CT1
- BK0
- EX01010
- EZ0000001
- PD4 *(or PD5)*
- TE00:00:00.00
- TP00:00.00
- CK
- CS

D.2 RDI DVL PD4/5 (Non-Triggered)

- CR1
- CB811
- CF11110
- CX0
- CT1
- BK0
- EX01010
- EZ0000001
- PD4 *(or PD5)*
- TE00:00:00.00
- TP00:00.00
- CK
- CS

APPENDIX E – SPRINT MESSAGE DEFINITIONS

E Introduction

This section lists messages that are specific to the SPRINT (INS) system input and output. Other messages are available for output, such as Lodestar AHRS output messages. These are listed manual 8084-109 AHRS Messages.

Table E-1 – SPRINT Input & Output Messages

Message	INS Input	INS Output
GGA	✓ GPGGA NPGGA	✓ INGGA
PSIMSSB	✓	×
DVL PD4	✓	×
DVL PD5	✓	×
DigiQuartz Pressure Depth	✓	×
Valeport Midas SVX2 Depth	✓	×
PSONDEP Depth	✓	×
NMEA DPT Depth	✓	×
ZDA	✓	×
Valeport Sound Velocity	✓	×
PSONSS Sound Velocity	✓	×
INS Navigation	×	✓
INS Navigation Quality	×	✓
Time System	×	✓

E.1 Simrad SSB – SSBL Position Report ($PSIMSSB)

Reference: Kongsberg APOS Release 4.2.2 Manual (29.April. 2005)

E.1.1. Description

The PSIMSSB sentence contains the position of a SSBL beacon which is sent after each USBL measurement. The operator may define various parameters.

E.1.2. Format

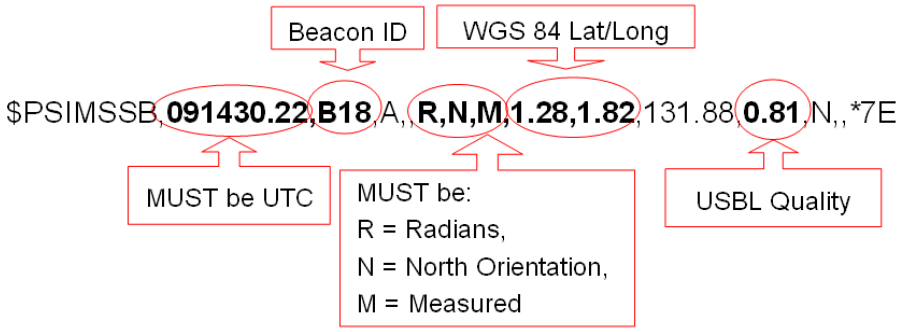
$PSIMSSB,hhmmss.ss,cc__,A,cc__,a,a,a,x.x,x.x,x.x,x.x,a,x.x,x.x*hh <cr><lf>

Table E-2 – PSIMSSB Formatting

Field	Description
$	Start character
PSIM	Proprietary Simrad code
SSB	Sentence Formatter
,hhmmss.ss	Empty or UTC time of reception
,cc_	Beacon code, Examples: B01, B33, B47
,A	Status, A for OK, V for not OK
,cc_	Error_code, Empty or 3 character error code
,aa_	C for Cartesian, P for polar, U for UTM coordinates, R for radians
,aa_	Orientation, H vessel head up; N for north; E for East:
,aa_	Software filter, M=Measured, F=Filtered, P=Predicted
,x.x	x coordinate
,x.x	y coordinate
,x.x	Depth in metres
,x.x	Expected accuracy of the position
*,aa_*	Additional info, N=none,C= compass, I=inclinometer, T=Time from Beacon to Transceiver
,x.x	First add value, empty or Tp compass or Tp x inclination
,x.x	Second add value, empty or Tp y inclination.
**hh*	Terminator and checksum (or empty ?)
<CR><LF>	return plus linefeed

E.1.3. Supported Input Format

Sonardyne Marksman/Ranger 2 and Kongsberg HiPAP:



E.2 Proprietary $PSONDEP Report

E.2.1. Description

The purpose of this proprietary string is to support depth input into Sonardyne software and instruments from a non-specific source. This string is already used in several subsea positioning applications with both Ranger and Fusion software.

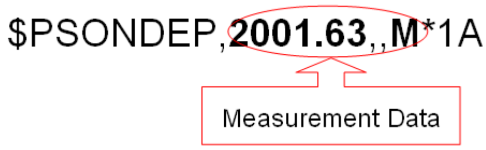
E.2.2. Format

$PSONDEP,x.xx,y.y,c*hh*<CR><LF>*

Table E-3 – PSONDEP Formatting

Field	Description
$	Start_character
PSONDEP	Address
,x.xx	Depth
,y.y	Observation Error
,c	Units (M=metres)
*hh	Terminator and Checksum
<cr><lf>	Termination (0x0D 0x0A)

E.2.3. Supported Input Format



E.3 Proprietary $PSONSS Report

E.3.1. Description

The purpose of this proprietary string is to support sound speed input into Sonardyne software and instruments from a non-specific source. This string is already used in several subsea positioning applications with both Ranger and Fusion software.

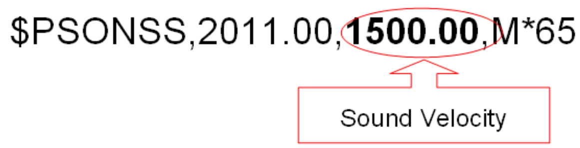
E.3.2. Format

$PSONSS,x.x,y.y,c*hh<CR><LF>

Table E-4 – PSONSS Formatting

Field	Description
$	Start_character
PSONSS	Address
,x.x	Depth
,y.y	Sound Speed in Units per second
,c	Units
*hh	Terminator and Checksum
<cr><lf>	Termination (0x0D 0x0A)

E.3.3. Supported Input Format



E.4 Digiquartz Pressure Sensor Report

E.4.1. Description

Pressure depth output from Paroscientific Digiquartz intelligent pressure depth sensor.

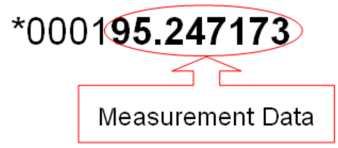
E.4.2. Format

*0001nnn__<CR><LF>

Table E-5 – Digiquartz Formatting

Field	Description
*	Start character
00	Destination ID (00 is ID of serial host)
01	Source ID (01 is ID of sender device)
nnn___	Measurement Data **(units=Metres H2O / KPA / PSI)**
<CR><LF>	return plus linefeed

E.4.3. Supported Input Format



E.5 $__DPT Report

E.5.1. Description

This is NMEA string outputs water depth.

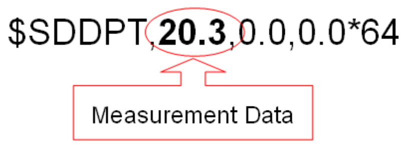
E.5.2. Format

$__DPT,x.x,y.y,z.z*hh<*CR*><*LF*>

Table E-6 – DPT Formatting

Field	Description
$	Start_character
__DPT	Address
,x.x	Water depth relative to the transducer, in metres
,y.y	Offset from transducer, in metres. (NOT USED)
,z.z	Maximum range scale in use
*hh	Terminator and Checksum
<*cr*><*lf*>	Termination (0x0D 0x0A)

E.5.3. Supported Input Format



E.6 Valeport Sensor Telegram

E.6.1. Description

This simple string outputs the data from the Valeport Mini SVS sensor. Sound Velocity only m/sec supported.

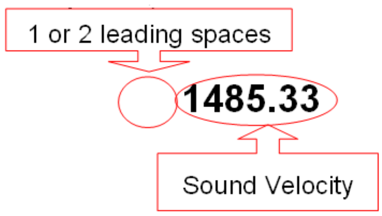
E.6.2. Format

<space>1234.567<*CR*><*LF*>

Table E-7 – Valeport Sensor Telegram Formatting

Field	Description
<space>	A space character
x.x	Sound Speed in metres per second
<cr><lf>	Termination (0x0D 0x0A)

E.6.3. Supported Input Format



E.7 $__GGA Report

E.7.1. Description

This NMEA string outputs longitude and latitude at a UTC time.

E.7.2. Format

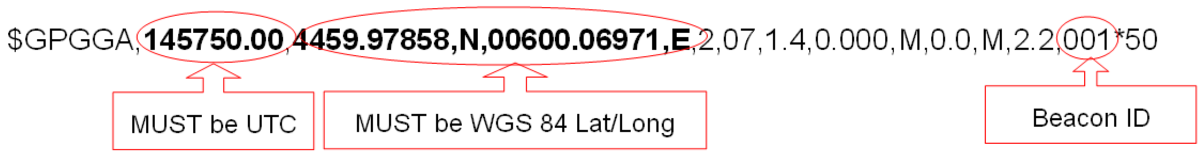
$--GGA, hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.xxx,M,x.x,M,x.x,xxxx*hh<CR><LF>

Table E-8 – GGA Formatting

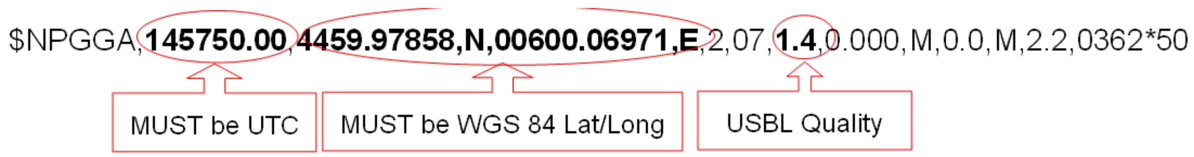
Field	Description
$	Start character
--	Sender Code (IN ? or GP)
GGA	Sentence Formatter
hhmmss.ss	UTC
llll.ll,a	Latitude, N/S 2 fixed digits degrees, 2 fixed digits minutes, variable digits of decimal minutes.
yyyyy.yy,a	Longitude, E/W 3 fixed digits degrees, 2 fixed digits minutes, variable digits of decimal minutes.
x	GPS quality Indicator 0-8
xx	Number of satellites
x.x	Horizontal dilution of precision
x.xxx,M	Antenna altitude above/below mean sea level (geoid), Metres (units of antenna altitude)
x.x,M	Geoidal Separation, Metres
x.x	Age of Differential data, not relevant.
xxxx	Differential Reference Station ID
**hh*	Terminator and checksum
<CR><LF>	Terminator, return plus linefeed

E.7.3. Supported Input Formats

Sonardyne Ranger:



EIVA NaviPac:



E.8 $__ZDA Report

E.8.1. Description

This NMEA string outputs UTC,day,month,year and local time zone.

E.8.2. Format

$--ZDA,hhmmss.sss,xx,xx,xxxx,xx,xx*hh <cr><lf>

Table E-9 – ZDA Formatting

Field	Description
$	Start character
--	Sender Code
ZDA	Sentence Formatter
,hhmmss.sss	Hours, minutes, seconds, and decimal seconds
,xx	Day, 0 to 31
,xx	Month, 01 to 12
,xxxx	Year
,xx	Local Zone hours 00 to ±13
,xx	Local Zone minutes 00 to 59
**hh*	Terminator and checksum
<CR><LF>	return plus linefeed

E.8.3. Supported Input Format

$GPZDA,**162408.00**,02,04,2007,,*6C

MUST be UTC

E.9 Navigation (Nav) Data

The navigation (Nav) data message is the *generic* navigation output from Lodestar AINS and is closely related the navigation quality message (NavQual), refer to **Table E-8** – GGA Formatting.

NOTE

Nav and NavQual are intended for advanced users including internal (Sonardyne) and external system integrators. Nav values are valid for vehicle CRP / frame, except acceleration which is valid for the IMU zero point but expressed in vehicle frame. For best accuracy it is recommended to use CRP=IMU zero point. AINS algorithm is the only source for the NAV message.

Table E-10 – Navigation Data

Byte#	Field name	Unit (LSB)	Data type	Note
0-5 / 6	timeTag	1e-6 sec	Uint48	System time
6-9 / 4	lat	2^-31*90 x° [-90;90]	Int32	+North (LSB ~= 0.5cm)
10-13 / 4	lon	2^-31*180° [-180; 180]	Int32	+East (LSB ~= 1cm @ Equator)
14-17 / 4	depth	1e-3 m	Int32	
18-19 / 2	altitude	1e-2 m	Uint16	Height above seabed (from DVL)
20-21 / 2	roll	2^-15*180° [-180; 180]	Int16	Angle between y and horizontal. Roll is positive when y is pointed below the horizontal (starboard down)
22-23 / 2	pitch	2^-15*180° [-90;90]	Int16	Angle between x and horizontal. Pitch is positive when x is pointed above the horizontal (bow up)
24-25 / 2	heading	2^-15*180° [0;360]	Uint16	Angle between North and projection of X onto the horizontal (measured about down).
26-27 / 2	vx	1e-3 m/s	Int16	X-velocity (max ~32m/s)
28-29 / 2	vy	-	-	-
30-31 / 2	vz	-	-	-
32-33 / 2	wx	1e-2°/s	Int16	Angular rate about x axis (max ~327°/s)
34-35 / 2	wy	-	-	-
36-37 / 2	wz	-	-	-
38-39 / 2	ax	1e-3 m/s^2	Int16	X-acceleration (max ~ 3.2 G)
40-41 / 2	ay		-	-
42-43 / 2	az		-	-
44-45 / 2	mode	N/A	Bit16	Logical. Bit# 0: data valid 1:INS initialised 2: INS application not enable 3-14: Reserved 15: System failure

NOTE

Altitude = 0 imply invalid.

E.10 Navigation Quality Estimate (NavQual)

The navigation quality message reports the expected accuracy of the data given in the “nav” message.

NOTES

Horizontal position 1DRMS = sqrt(posMajor^2 + posMinor^2).

CEP(50%) ~= 0.589 * (posMajor + posMinor).

Error ellipse (1 sigma) is 39.4% probability (i.e. 39.4% likelihood that true value is within ellipse).

95% percent probability error ellipse is 2.447 * 1 sigma error ellipse.

Roll, pitch 1 sigma ~= max(stdLevN,stdLevE) for roll, pitch << 45deg.

Velocity rms = sqrt(velMajor^2+ velMinor^2).

Table E-11 – Navigation Quality Estimate – Rate: 1 Hz

Byte#	Field name	Unit (LSB) / range	Data type	Note
0-5 / 6	timeTag	1e-6 sec	Uint48	System time
6-9 / 4	posMajor	m	Float32	Position (horizontal) error ellipse: - semi-major axis (1 sigma)
10-13/ 4	posMinor	-	Float32	- semi-minor axis (1 sigma)
14-17 / 4	dirPMajor	deg [0;360[	Float32	- direction of semi-major axis
18-21 / 4	stdDepth	m	Float32	Depth (1 sigma)
22-25 / 4	stdLevN	deg	Float32	Level error about North (1 sigma)
26-29 / 4	stdLevE	deg	Float32	Level error about East (1 sigma)
30-33 / 4	stdHeading	deg	Float32	Heading (1 sigma)
34-37 / 4	velMajor	m/s	Float32	Velocity (horizontal) error ellipse: - semi-major axis (1 sigma)
38-41 / 4	velMinor	m/s	Float32	- semi-minor axis (1 sigma)
42-45 / 4	dirVMajor	deg [0;360[	Float32	- direction of semi-major axis
46-49 / 4	velDown	m/s	Float32	Down velocity (1 sigma)

E.11 Time System Data

The Time System data format is defined below.

NOTES

Source of RTC to UTC update; 0 = NO SOURCE; 1 = LODESTAR RTC; 2 = Standalone GPZDA; 3 = Standalone GPGGA; 4 = GPZDA 1PPS.

Fields in *italic* are for advanced users only and are subject to change.

Table E-12 – Time System Data

Field #	Byte# (from 0)	Size (bytes)	Field name	Unit/LSB	Data type	Notes
1	0-5	6	sysTime	1e-6 sec	Uint48	System time (and message timeTag)
2	6-13	8	utcTime	1e-6 sec	Uint64	UTC time – seconds since midnight 1970.01.01
3	14-19	6	timeSinceUpdate	1e-6 sec	Uint48	Time since last accepted UTC time update, e.g. from ZDA/PPS
4	20-23	4	stdDev	sec	Float32	Expected standard deviation of UTC time field
5	24	1	Source	logical	Uint8	Currently used source of UTC sync
6	*25*	*1*	*ppsRising*	*logical*	*Uint8*	*0: PPS valid on falling edge (low to high voltage). 1: PPS valid on rising edge.*
7	*26*	*1*	*zdaCount*	*#*	*Uint8*	*LS byte of ZDA message count*
8	*27*	*1*	*ppsCount*	*#*	*Uint8*	*LS byte of PPS message count*
9	*28*	*1*	*zdaRejCount*	*#*	*Uint8*	*LS byte of ZDA message rejection count*
10	*29*	*1*	*ppsRejCount*	*#*	*Uint8*	*LS byte of PPS signal rejection count*
11	*30*	*1*	*ppsZdaProcCount*	*#*	*Uint8*	*LS byte of accepted PPS/ZDA pairs*
12	*31*	*1*	*filtResetCount*	*#*	*Uint8*	*LS byte of UTC filter reset count*

Example: Converting IMU time tag from [sys] to [utc]

imu.timeTag[sys] = 1234567890 usec

Get the preceding time system message:

timeSys.sysTime = 1234101010 usec

timeSys.utcTime = 1254273030984001 usec

timeSys.stdDev = 0.0000124 sec low std.dev. => UTC can be trusted

imu.timeTag [utc] = imu.timeTag[sys] + (timeSys.utcTime - timeSys.sysTime)

= 1234567890 + (1254273030984001 - 1234101010) usec

= 1254273031450881 usec = 20090930T011031 (ISO 8601) = **2009-09-30 01:10:31**

E.12 Midas SVX2 Depth

E.12.1. Description

This message is tab delimited and provides Sound Velocity, Depth, Temperature and conductivity.

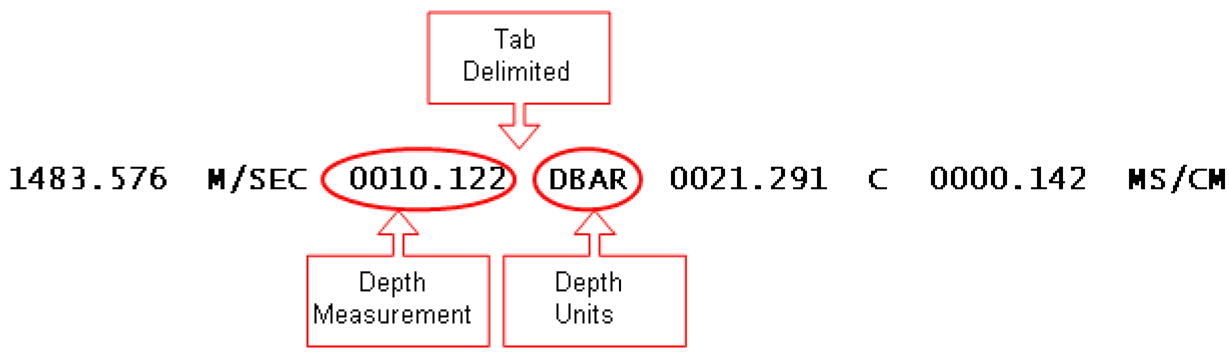
E.12.2. Format

ssss.sss<tab>uuuu<tab>dddd.ddd<tab>xxxx<tab>tttt.ttt<tab>xxxx<tab>cccc.ccc<tab>zzzz<cr><lf>

E.12.3. Table

Field	Description
ssss.sss	Sound Velocity in metres per second
uuuu	Sound Velocity Units (M/SEC)
dddd.ddd	Depth
xxxx	Depth Units (DBAR)
tttt.ttt	Temperature
xxxx	Temperature Units (C)
cccc.ccc	Conductivity
zzzz	Conductivity Units (MS/CM)
<CR><LF>	return plus linefeed

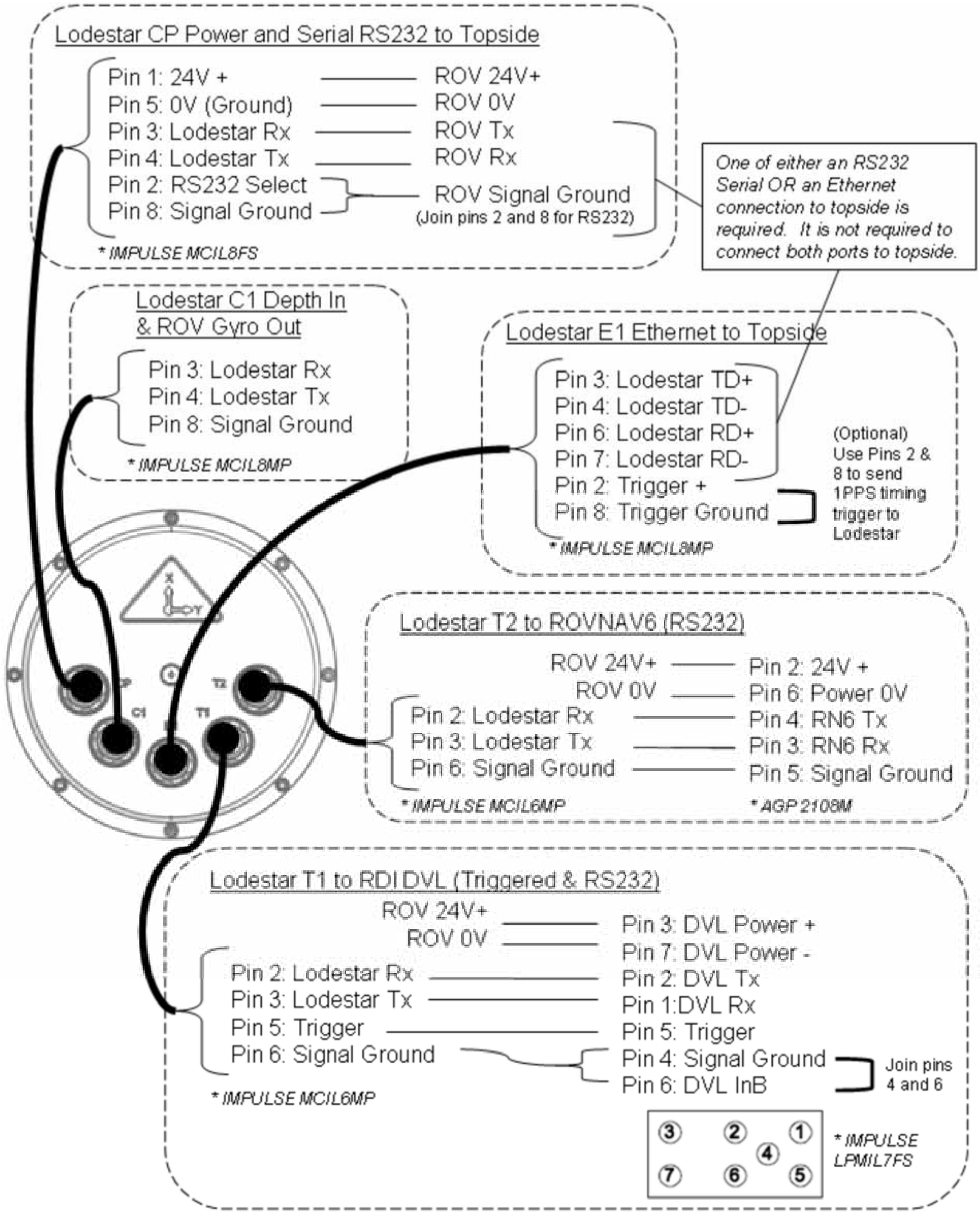
E.12.4. Supported Input Format



APPENDIX F – SPRINT WIRING DIAGRAM

F Typical Wiring Diagram

Figure F–1 – Typical SPRINT Wiring Diagram

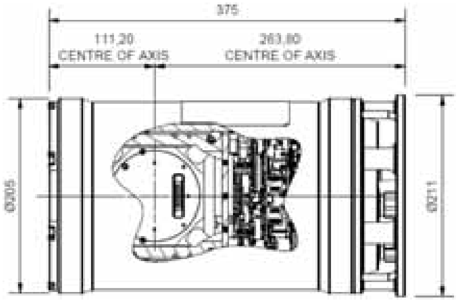
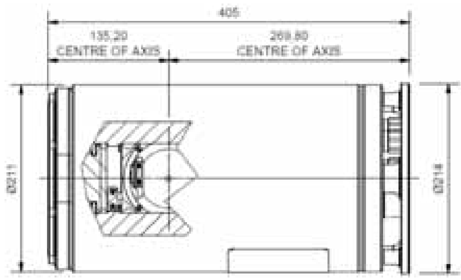
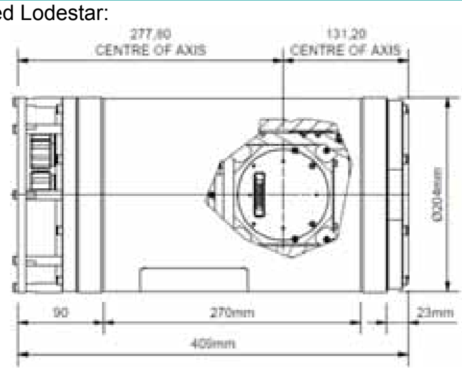


APPENDIX G – PRESSURE TO DEPTH CONVERSION

Pascal to Metres: 0.00009938710

PSI to Pascals: 6894.757293168361

APPENDIX H – SPRINT INSTALL & SETUP CHECKLIST

Post-Transit Checks		**Yes**	**No**	**Notes**
	Prior to installation on the vehicle has the Lodestar been powered and connected to the SPRINT topside (PC & LCH) to check operation and basic communication?			
Vehicle Checks		**Yes**	**No**	**Notes**
Vehicle	Vehicle CRP defined and identifiable?			
	Is Lodestar mounted rigidly and away from any source of vibration or (non-vehicle frame) independent movement?			
	[Serial] Vehicle MUX connection configured/available @ 115,200 baud rate?			
	[Ethernet] Vehicle MUX connection configured/available @ 100 Mbit?			
	Cable connection wired as per system wiring diagram?			
	[Serial] 232/485 select pin wired correctly?			
	Powered by either 24 or 48 V?			
	Offsets **from** vehicle CRP **to** Lodestar 'Centre of Axis' measured (Metres)?			Forward:___________ Starboard:__________ Down:_____________
	1000 m Rated Lodestar: 			
	3000 m Rated Lodestar: 			
	5000 m Rated Lodestar: 			

	Mounting Angles from vehicle frame to Lodestar frame measured (Degrees)?*NB: Not required if Lodestar mounted nominally: Connectors are uppermost on Lodestar and 'X' orientation mark is aligned with forward direction of vehicle body*			Heading:___________ Pitch:_____________ Roll:______________
USBL	Offsets **from** vehicle CRP **to** USBL beacon (centre of transducer) measured (Metres)?			Forward:___________ Starboard:_________ Down:_____________
	If multiple USBL beacons present, has acoustic check been run on the SPRINT aiding beacon to confirm correct address and offsets?			
	If SPRINT aiding beacon is responder, has responder trigger been checked?			
Depth	Offsets **from** vehicle CRP **to** depth sensor (point of measurement) measured (Metres)?			Forward:___________ Starboard:_________ Down:_____________
	Cable connection wired as per system wiring diagram?			
	Sensor powered?			
	If multiple depth sensors present, has check been run on the SPRINT aiding sensor to confirm correct offsets?			
	Has output format been checked (for compatibility) prior to connection with Lodestar or SPRINT?			Format:____________ Units:______________
	Have serial settings been checked?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
LBL	Offsets **from** vehicle CRP **to** the LBL Transducer measured (Metres)?			Forward:___________ Starboard:_________ Down:_____________
	Cable connection wired as per system wiring diagram?			
	Sensor powered?			
	If LBL transducers present, has check been run on the SPRINT aiding sensor to confirm correct offsets?			
DVL	Offsets **from** vehicle CRP **to** DVL (centre of transducer faces) measured (Metres)?			Forward:___________ Starboard:_________ Down:_____________
	Cable connection wired as per system wiring diagram?			
	DVL facing down with alignment mark facing forward on the vehicle? *NB: Misalignments can be calculated by the DVL calibration procedure*			
	Is DVL triggered by Lodestar? (If no then DVL will be free-running / untriggered)			
	DVL powered?			
	If multiple DVLs present, has check been run on the SPRINT aiding DVLto confirm correct offsets?			
	Can DVL be auto-configured by SPRINT (customer does have a specific output requirement?)			
	If No:			
	• Has configuration been checked (for compatibility) prior to connection with Lodestar?			Format:____________ Units:______________

	• Have serial settings been checked?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
Remote Output Points	Is position output from SPRINT required from a point other than the vehicle CRP?			
	If Yes:			
	Offsets **from** vehicle CRP **to** remote point(s) measured (Metres)?			Forward:___________ Starboard:__________ Down:_____________
Topside Checks		**Yes**	**No**	**Notes**
LCH	Is LCH powered?			
	Is LCH connected to the SPRINT PC?			
	Can the LCH Admin Page be opened?			
Lodestar	[Serial] Is Lodestar connected to serial port 1 on the LCH?			
	[Ethernet] Is Lodestar connected to Ethernet port 2 on the LCH?			
	Has the default/work site Latitude been set in the SPRINT software (Lodestar)?			
	Has the Lodestar shutdown delay been checked in the SPRINT Software (Lodestar)?			
	Have the Lodestar offsets been configured in the SPRINT Software (Lodestar)?			
	Have the Lodestar mounting angles been configured in the SPRINT Software (Lodestar)?			
Time Synch	Has output format been checked (for compatibility) prior to connection with SPRINT?			Format (GPZDA):__________
	Have serial settings been checked?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
	Has the LCH ZDA serial port been checked/configured with the correct serial settings?			
	Is GPZDA output @ 1Hz?			
	Does GPZDA message contain UTC time and date?			
	Is the latency between the GPZDA and the actual UTC time known?			
	Has the Time Synch been configured in the SPRINT software (Time Synch)?			
USBL	Has output format been checked (for compatibility) prior to connection with SPRINT?			Format:____________
	Have serial settings been checked?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
	Has the LCH USBL serial port been checked/configured with the correct serial settings?			
	Is USBL position in WGS84 Latitude Longitude?			
	Is the USBL position the 'raw' USBL position and not corrected for offsets or filtered/smoothed?			
	Does USBL message contain UTC timestamp?			
	Does USBL message contain USBL quality? *NB: Quality field in PSIMSSB message or in certain applications HDOP field in USBL GGA message is populated with USBL quality*			
	If No:			

	Has the manual USBL quality value been configured in the SPRINT Software (USBL Input)?			
	Does USBL feed contain messages for multiple beacons identified by beacon ID? *NB: Beacon ID field in PSIMSSB message or in certain applications reference station ID in USBL GGA message is populated with beacon ID*			
	If Yes:			
	Has the USBL beacon ID filter been configured in the SPRINT Software (USBL Input)?			
	Have the USBL beacon offsets been configured in the SPRINT Software (USBL Input)?			
	Has the USBL type been configured in the SPRINT Software (USBL Input)?			
Depth	Has output format been checked (for compatibility) prior to connection with Lodestar or SPRINT?			Format:____________ Units:______________
	If Depth sensor feed is connected to Topside (not Lodestar):			
	Have serial settings been checked?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
	Has the LCH USBL serial port been checked/configured with the correct serial settings?			
	Has the correct port been specified and configured if depth sensor is connected directly to the Lodestar?			
	Does a surface correction need to be applied?			
	Have the depth sensor offsets been configured in the SPRINT Software (Depth Input)?			
	Has the Depth type and units been configured in the SPRINT Software (Depth Input)?			
DVL	Has the correct Lodestar port been specified in the SPRINT software (DVL)			
	Has the DVL been auto-configured by the SPRINT software?			
	Yes			
	Has the DVL been 'deployed' after the auto-configuration?			
	No			
	Have the Lodestar port settings been configured to match the DVL serial settings?			
	Has the correct 'triggered by Lodestar' setting been configured in the SPRINT Software (DVL)			
	Has the correct 'Binary or Hex ASCII' setting been configured in the SPRINT Software (DVL)			
	If a new installation, have the default DVL mounting angles been configured in the SPRINT software (DVL)			Heading:________135 Pitch:___________0.0 Roll:_________-179.9
	If a new installation have the latency and scale factor values been set to zero (default) in the SPRINT software (DVL)			
	Have the DVL offsets been configured in the SPRINT Software (DVL)?			
Sound Velocity	Has the correct Sound Velocity type been specified in the SPRINT software (Sound Velocity)?			
	Yes (automatic DVL derived to be used)			
	Has the salinity value been checked/set in the SPRINT software (Sound Velocity)?			
	Yes (Manual)			
	Has the manual sound velocity be set in the SPRINT software (Sound Velocity)?			

	Yes (Sound velocity message feed to be used)			
	Has input format been checked (for compatibility) prior to connection with SPRINT?			Format:___________
	Have serial settings been checked?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
	Has the LCH serial port been checked/configured with the correct serial settings?			
	Sound Velocity sensor offsets are optional - have they been configured in the SPRINT Software (Sound Velocity)?			
LBL	Have the serial settings for the INS port been checked in the Fusion software?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
	Have the serial settings for the Fusion INS port been checked in the SPRINT software?			As above
	Have the serial settings for the LBL port been checked in the Fusion software?			Baud Rate:_________ Data Bits:__________ Stop Bits:__________ Parity:_____________
	Have the serial settings for the Fusion LBL port been checked in the SPRINT software?			As above
	Have the LBL transceiver AND Lodestar offsets been configured in the Fusion Software?			
	Has the transceiver Comms Reset been set to "None" in the Fusion software (Transceiver Advanced)?			
	Has the transceiver connection been tested in Fusion (Get or Get All)?			
Remote Output Points	Is position output from SPRINT required from a point other than vehicle the CRP?			
	If Yes:			
	Have remote point(s) offsets been configured in the SPRINT software (Remote Points)?			
Outputs	Have Lodestar (direct) outputs been configured in the SPRINT software (Lodestar Outputs)?			
	Have PC/LCH outputs been configured in the SPRINT software (PC/LCH Outputs)?			
INS	Have the correct INS aiding options been specified in the SPRINT software (INS Aiding)?			

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SPECIAL CONDITIONS

The user is allowed to modify data files, as described in the operating instructions, to suit his own custom test routines.

GLOSSARY OF TERMS

Term	Definition
Attitude and Heading Reference System (AHRS)	An inertial sensor that provides outputs of heading, pitch and roll.
Doppler Velocity Log (DVL)	A DVL bounces sound off the bottom (or a reference layer of water) and can determine the velocity vector of a subsea vehicle (or surface vessel) moving across the sea floor
Global Positioning System (GPS)	A multi-user, 24-hour, worldwide radio navigation system using the NAVSTAR constellation of satellites. GPS receivers are capable of tracking and decoding data from the satellites and using it to compute the position and velocity of a vehicle.
Inertial Navigation System (INS)	A navigation aid that uses a computer, motion sensors and rotation sensors to continuously calculate the position, orientation and velocity of a moving object without the need for external references.
Long Base Line Positioning System (LBL)	A system where two or more beacons are on the seabed. The positions of the beacons are established by a calibration process in a seabed frame. The distances from a transducer to each beacon are measured using a transceiver. The position of the transducer can be computed in the seabed frame. The name comes from the “baselines” joining each beacon.
Subsea Precision Reference Inertial Navigation Technology (SPRINT)	An acoustically aided inertial navigation system for subsea vehicles. The system extends the operating limits of USBL and improves the operational efficiency of LBL by using sparse arrays.
Ultra Short Base Line Positioning System (USBL)	A system similar to an SBL system except the system uses three or more elements in a single transducer array. The measurements it makes are the differences in “time-phase” of the signals from each element. The co-ordinate frame is fixed to the transducer array which must be oriented in the vessel frame to be equivalent to the SBL.

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