Sonardyne
SOUND IN DEPTH

SPRINT
INERTIAL NAVIGATION FOR SUBSEA VEHICLES

SPRINT is an acoustically aided inertial navigation system for subsea vehicles. SPRINT makes optimal use of acoustic aiding data from acoustic USBL and LBL positioning and other sensors such as Doppler Velocity Log (DVL) and pressure sensors. This improves position accuracy, precision, reliability and integrity while reducing operational time and vessel costs. The system extends the operating limits of Ultra-Short BaseLine (USBL) and can dramatically improve the operational efficiency of Long BaseLine (LBL).

Lodestar

The core of the system is the vehicle-mounted subsea Lodestar unit. Lodestar is a combined AHRS (Attitude Heading Reference System) and AAINS (Acoustically Aided Inertial Navigation System). Running both the AHRS and INS algorithms concurrently allows inertial navigation to start or restart instantaneously on receipt of a position update as the AHRS seamlessly provides orientation to the INS on start-up. This avoids the lengthy 'alignment' period common to other INS systems. Thereafter, the separate AHRS and INS computed attitudes are autonomously monitored as an indication of system health.

All AHRS and AAINS computations are performed within the Lodestar, making the system robust and resilient to communications issues. Lodestar maintains a rolling 15 day backup of all real time navigation and raw data on an onboard SD card which can be retrieved if required. Coupled with concurrent logging of all data by the topside software, data integrity is ensured.

Acoustically Aided INS

Inertial navigation is inherently self-contained, robust with very good short term accuracy but can drift over time. Therefore the INS is aided with complementary acoustic positioning to provide long term accuracy and robustness. The additional

Applications

6G 2 Sonardyne Wideband

- ROV and Towfish Positioning
- Hydrographic Survey
- Offshore Construction
- Trenching
- As-Laid and Out of Straightness
- Multibeam Survey
- ROV DP including mid water station keeping
- Touchdown Monitoring
- Cut To Length
- Structure Placement

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integrity offered by inertial integration significantly reduces operational delays during periods of challenging subsea acoustic conditions such as aeration and noise. The precision and update rate of the output allows greater subsea vehicle control and is suitable for ROV station keeping.

USBL aiding is vendor independent using a standard, absolute USBL position message. It can be further optimised with integration to a Sonardyne Marksman LUSBL or Ranger 2 USBL system. Alternatively, tightly coupled LBL aiding from Fusion 6G can be used with either full or sparse (2 to 3 beacon) arrays. LBL observations are optimally time stamped and the rich quality statistics provided with Wideband 2 are used to provide optimal aiding.

The Lodestar does not need to be physically co-located with the Doppler Velocity Log. Misalignments are calculated in the field using a freely available calibration utility. This approach allows for more flexible mounting configurations to be considered.

A ZUPT (zero velocity) aiding feature is available to provide exceptionally precise positioning during static fixes even if external aiding such as DVL has been lost (e.g. loss of bottom lock).

Flexible and Easy to Use

The Lodestar installed on the subsea vehicle is interfaced using a single serial or Ethernet connection through the vehicle's umbilical. The Lodestar acts as a subsea multiplexer for it's own data and all subsea aiding data. A navigation PC running the SPRINT software is provided to allow easy configuration, monitoring, communications routing and logging for the subsea Lodestar. Also provided with the system is a communications hub providing multiple serial/Ethernet ports for input and output.

The SPRINT software user interface is shown opposite.

Software Features:

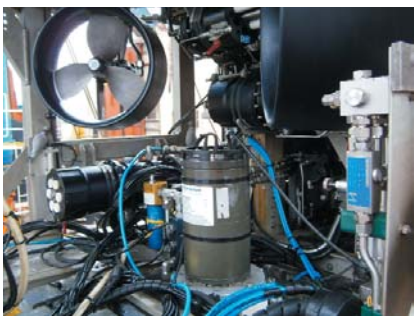
- Virtual LED status indicators for all system components for easy 'one glance' monitoring of system health
- Navigation chart with INS, USBL / LBL aiding and Attitude displays
- INS and raw sensor data display (including age and aiding rejection status)
- Logging of all INS and raw sensor data
- Configurable job specific quality limit alarms
- Time series plotting
- Advanced LBL aiding displays including:
  - Range observation residuals
  - Graphical representation of aiding status and history
- Automatic backup of Lodestar configuration
- Graphical representation of configured sensor lever arms
- Automatic DVL discovery and configuration
- Configurable outputs for INS, AHRS or raw sensor data
- Flexible INS aiding option packages with remote upgrade capability

Janus Post Processing

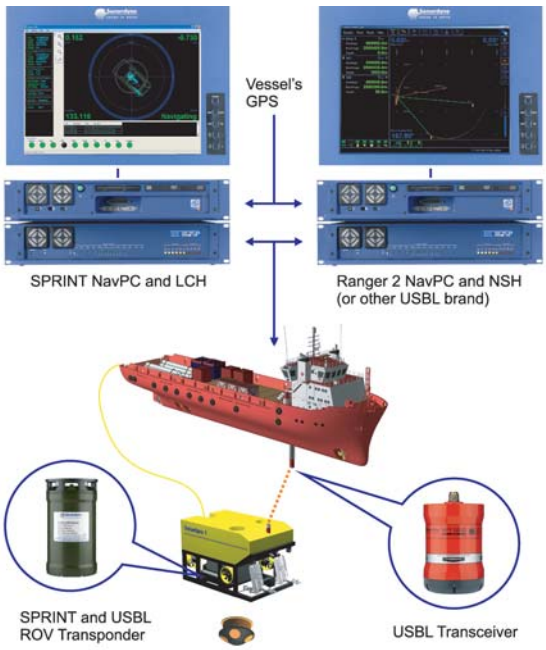
Sonardyne's INS post-processing software package Janus complements SPRINT. It provides Kalman smoothing of Lodestar IMU and aiding sensor data for improved navigation accuracy and integrity. The software provides the ability to replicate real-time results offline and to repair issues experienced in real-time such as the use of an incorrect offset. Also included is the control and screening of aiding sensor data and settings including offsets and mounting angles. Similarly, sensor aiding and Kalman filter settings can be controlled. Navigation data can be exported in selected text formats.

Lodestar Aided INS Platform
The core of the system is the Lodestar platform. The unit is depth rated up to 5,000 metres and has an in-built battery backup that can maintain its inertial and AHRS algorithms for up to two hours if external power is lost. 1,000 metre rated unit shown below.

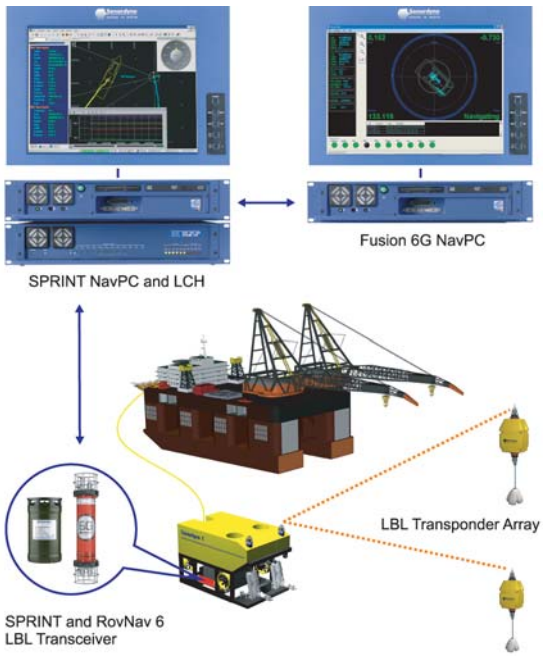
Vehicle Installation
The Lodestar INS unit installed on the subsea vehicle is interfaced to the topside using a single serial or Ethernet connection through the vehicle's umbilical.



External Aiding
Lodestar has the ability to use vehicle-mounted aiding sensors such as Doppler Velocity Logs (DVL) and pressure/depth sensors.



SPRINT: USBL AIDED

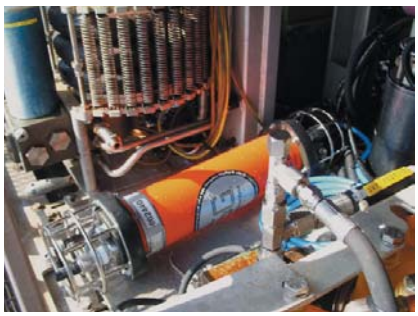


SPRINT: LBL AIDED

SPRINT System

Features and Benefits

- High output rate (100Hz+)
- Precise, low noise for smooth navigation
- Resilience to outliers keeping the system on track
- All computations made inside Lodestar reducing reliance on tethered communications
- Lodestar uses Ring Laser Gyroscopes which are used commercially throughout the world and offer resilience to temperature and vibration
- Topside connection via a single RS232 or Ethernet connection
- AHRS and INS
  - Continuous AHRS always available (regardless of aiding)
  - INS
- Battery backup to ride through brown outs
- Onboard data storage provides redundant storage of log files
- Vendor independent USBL aiding
- Tightly coupled Fusion 6G LBL aiding option
- DVL aiding (user auto configuration)
- Subsea multiplexer (raw sensor feeds available topside)
- Course or fine time synch (ZDA or ZDA+1PPS) options
- Full navigation outputs available:
  - Position / Depth / Attitude
  - Velocity / Accelerations
  - Rotations
- Flexible configuration for all aiding sensors (configurable lever arms, DVL calibration routine).
- ZUPT and Manual Position aiding options



6G® Technology
Sonardyne's latest 6G® LBL (above) and USBL transceivers (below) maximise the benefits of SPRINT by providing the most precise and reliable acoustic aiding input.

SPRINT Software

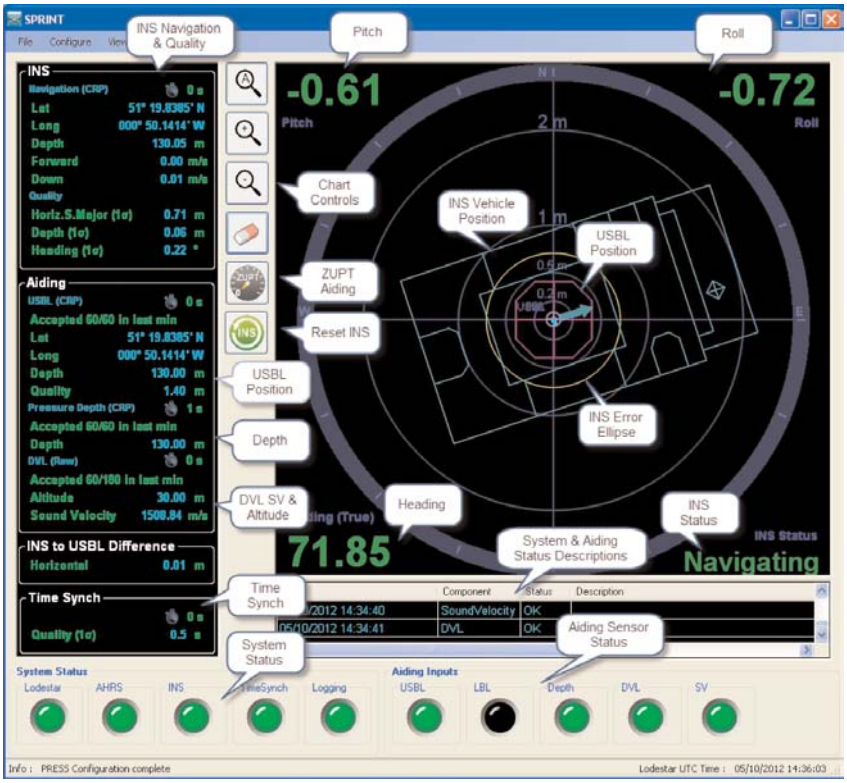


Figure 1
The SPRINT processing software is installed on a Sonardyne Navigation PC which is typically located on the vessel's bridge or in a survey room. All sensor position and timing information is interfaced through the INS software which is easy and intuitive to use. Users can configure and control the system whilst logging all inertial navigation data for analysis or post processing. Various displays allow performance of the system to be assessed, including real-time inertial quality indicators, inertial external position comparison and system health.

INS and USBL position fixes with ROV following pipeline

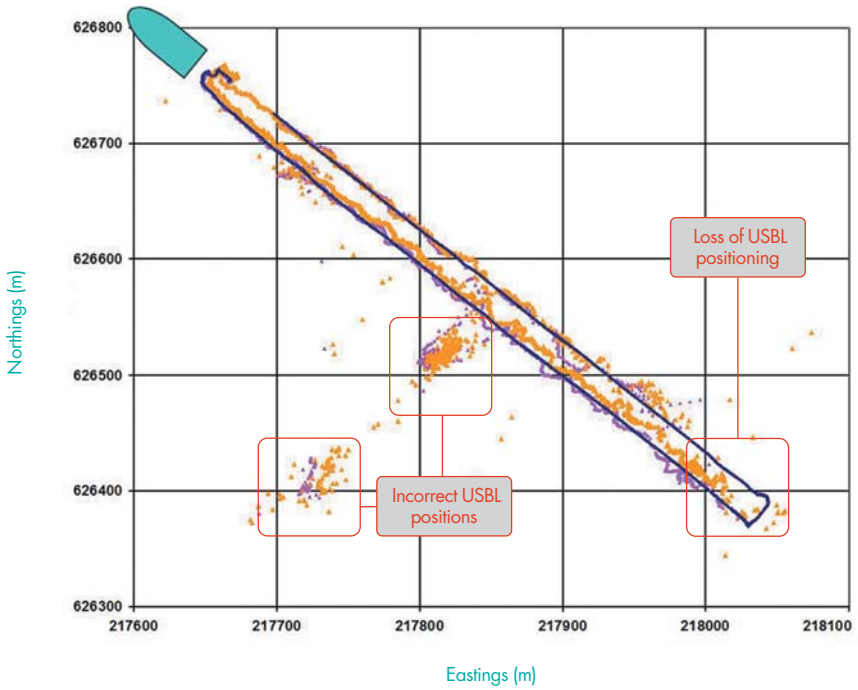


Figure 2
SPRINT's performance is further emphasised in Figure 2. Here, the ROV was running a generally straight south easterly track away from a vessel and in parallel with a pipeline in 130 metres water depth out to distance of up to 1,000 metres behind the vessel.
The positions from SPRINT (blue) can be seen to follow the actual ROV dynamics much more closely than the USBL (orange) positions.

Key to Figures:
● Sonardyne SPRINT INS
▲ 'Brand-X' USBL

SPRINT System Performance

USBL Aided	
Precision	2-3 times improvement in precision over 'raw' USBL*
USBL and DVL Aided	
Precision	4-6 times improvement in precision over 'raw' USBL*
	* INS also provides improvements in short term accuracy through rejection of outliers. INS will not resolve long term inaccuracy of the USBL system (e.g. systematic errors)
DVL Aided	
Accuracy	< 0.1% position error for distance travelled (e.g. <1m error after 1km travelled)
LBL and DVL Aided	
Accuracy with 1 transponder	< 0.2% distance to transponder (**)
Accuracy with 2+ transponders	Centimetre level (dynamic) accuracy similar to the accuracy of conventional (static) LBL but with much enhanced robustness to loss of acoustics. (***)
	** Vehicle dynamics required *** With good geometry and excluding effect introduced by errors in: transponder position/depth and sound speed - with careful operation these can all be minimised

SPRINT Equipment List Key: ● = Required ○ = Optional

● Software
SPRINT User Interface

○ Janus
DVL Calibration only

● Type 8026
Navigation Computer

● Type 8184
Lodestar Comms Hub

● Type 8024
Lodestar Subsea

Additional Requirements (At least one required)

Ranger 2 USBL	3rd Party USBL	Marksman LUSBL	Fusion 6G® LBL
○ System Ranger 1 USBL	○ System 3rd Party USBL	○ System Marksman LUSBL	○ System Fusion 6G® LBL

Other Acoustic and Inertial Systems from Sonardyne

- ● Ranger 2 USBL
- ● DP-INS
- ● Fusion 6G® LBL

SPRINT Key Technology

6G®

Sonardyne's new sixth generation (6G®) technology platform provides robust performance, ease of use, greater functionality, equipment flexibility and compatibility with aided inertial technologies. Its features reduce operational risk, deliver more efficient operations and lower the cost of ownership.

Acoustically Aided INS

Seamlessly integrates Sonardyne LBL, USBL and Lodestar INS technologies to offer a combined acoustic and inertial navigation solution suitable for the most demanding subsea tracking and vessel positioning applications.

Wideband 2®

Sonardyne Wideband® 2 is an ultra-wide bandwidth signal architecture exclusively developed for 6G® hardware. Delivering seamless acoustic navigation and telemetry of subsea data, the technology offers a host of benefits; fast and robust transmission of data, precise ranging, wide area coverage, mitigation from multipath signals and greater immunity to noise from vessels and other acoustic systems.

Global Headquarters
T. +44 (0) 1252 872288
F. +44 (0) 1252 876100
sales@sonardyne.com

Aberdeen, UK
T. +44 (0) 1224 707875
F. +44 (0) 1224 707876
sales@sonardyne.com

Houston, USA
T. +1 281 890 2120
F. +1 281 890 7047
usa.sales@sonardyne.com

Singapore
T. +65 6542 1911
F. +65 6542 6937
asia.sales@sonardyne.com

Rio das Ostras, Brasil
T. +55 22 2123 4950
F. +55 22 2123 4951
brasil.sales@sonardyne.com