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SeaTrac X110 / X150 User Guide

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seatrac



X100 Series
Micro-USBL Tracking, Data Modem & AHRS Acoustic Beacons

User Manual

P/N: BP00918.6

UM-140-P00918-06

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1. Introduction

Before proceeding, we recommend that you read the safety, deployment and operation guidelines in this user manual, in order to get full benefit from the features of the SeaTrac system.

Throughout this document the following symbols are used to indicate special precautions or procedures you should note…



WARNING!
This symbol indicates a warning you should follow of to avoid bodily injury and damage to your equipment.



CAUTION
This symbol denotes precautions and procedures you should follow to ensure correct operation to your equipment, and in some situations (where noted) possible damage.



NOTE
This symbol denotes special instructions or tips that should help you get the best performance from your beacons.

The SeaTrac X100 series of Micro-USBL tracking and data modems are suite of complimentary products built around a robust broadband spread spectrum signalling scheme. These multi-purpose acoustic transponder beacons are capable of simultaneously tracking asset positions and undertaking bi-directional data exchange, making them ideal for use in a wide range of applications including…

- Remote monitoring and control of sensors and equipment,
- Re-location and retrieval of sub-sea assets,
- ROV positioning and navigation tasks,
- AUV navigation, telemetry, mission adjustments and real-time position monitoring,
- Diver buddy and surface-vessel/dive-bell tracking and re-location,
- Remote and local depth, water temperature, attitude and heading reference (AHRS) information.

Data Modems

In a modem application, either X110 or X150 beacons are mounted at either end of the required data link and addressable packets of data are exchanged between the Acoustic Communication Stacks using protocols that ensure integrity of data, buffering and (optionally) reattempting transmission in event of packet loss.

Each beacon is configured by the user with a unique identification-code that allows up to 15 beacons to exchange acoustic data messages or broadcast to all other beacons in the network.
Messages are exchanged by a request/response process and when complete the sending beacon is able to obtain a range measurement to the remotely interrogated beacon.
Additionally, the X150 USBL beacon allows the interrogating end of the link to obtain a relative position 'fix' of the remote modem during data exchange.

Integrated beacon sensors such as depth, temperature, pitch, roll, yaw and supply voltage, may also be remotely queried by the interrogating modem.

USBL Position Tracking

As well as the features offered by the X110 data modem and transponder beacon, the X150 beacon includes an Ultra-Short Baseline (USBL) receiver array capable of calculating the azimuth and elevation of incoming data messages.

In a tracking or navigation application, one X150 is mounted from the supervisor vessel, and connected to a PC running the SeaTrac PinPoint display and logging software. All positions are computed by the X150 beacon, so no additional PC hardware is required.

Sub-surface assets to be tracked (including Divers, ROV's, AUV's etc) are fitted with an X110 beacon, and optionally may use the data port to provide periodic acoustic communications with other systems and sensors.
In this mode up to 14 beacons may be tracked at ranges up to and in excess of 1km from the supervisor[1], with the position of each being optionally broadcast to others in the network.

[1] Please refer to the "Acoustic Limitations" in the Notices section on page 53 for factors that govern the actual achievable operational range of the modem and tracking functionality.

AHRS

Each beacon is fitted with a 9 Degrees-of-Freedom (9-DOF) Attitude and Heading Reference System, processing data from the onboard MEMS gyroscope, accelerometer and magnetometer to compute pitch, roll and yaw information that is made available to external applications via the communications port.

The X150 series beacons make use of this information to convert the remote beacons range and computed azimuth and elevation angles into relative real-world coordinates.

Pressure & Temperature Sensors

Each beacon is fitted with an environmental pressure and temperature sensor that allow the depth of each beacon to be calculated and monitored.

When used as part of a tracking system, the remote beacon's depth information can be transmitted and used as part of the position solution, improving vertical accuracy.

Additionally, the pressure and temperature information can be used to automatically update the local velocity-of-sound value at each beacon, ensuring ranging calculations have the least possible error.

Software Applications

To compliment the product family, a range of software applications is also available…

- **SeaTrac Tools** – Supplied with all beacons, this utility provides a configuration interface for the hardware's operating parameters and allows performance and diagnostic tests to be performed when setting up for a new job.

- **SeaTrac PinPoint** – A navigation application for Microsoft Windows that can display position, depth, attitude and course history for each beacon to the user via a simple graphical display, for a network of up to 14 remote beacons from a central USBL X150 beacon.

- **SeaTrac Programmer** – Supplied with all beacons, this utility allows beacons to be remotely upgraded in the field to new firmware releases as they become available.

For OEM's, system integrators and developers wishing to integrate SeaTrac beacons into their own applications, a software Developers Kit (SDK) is available documenting the ASCII serial command interface from the Application level (i.e. tracking or bi-directional data-exchange) down to individual protocols within the Acoustic Communication Stack for more specialist requirements.

1.1. System Contents

Before proceeding, please check that your system contains the following items…

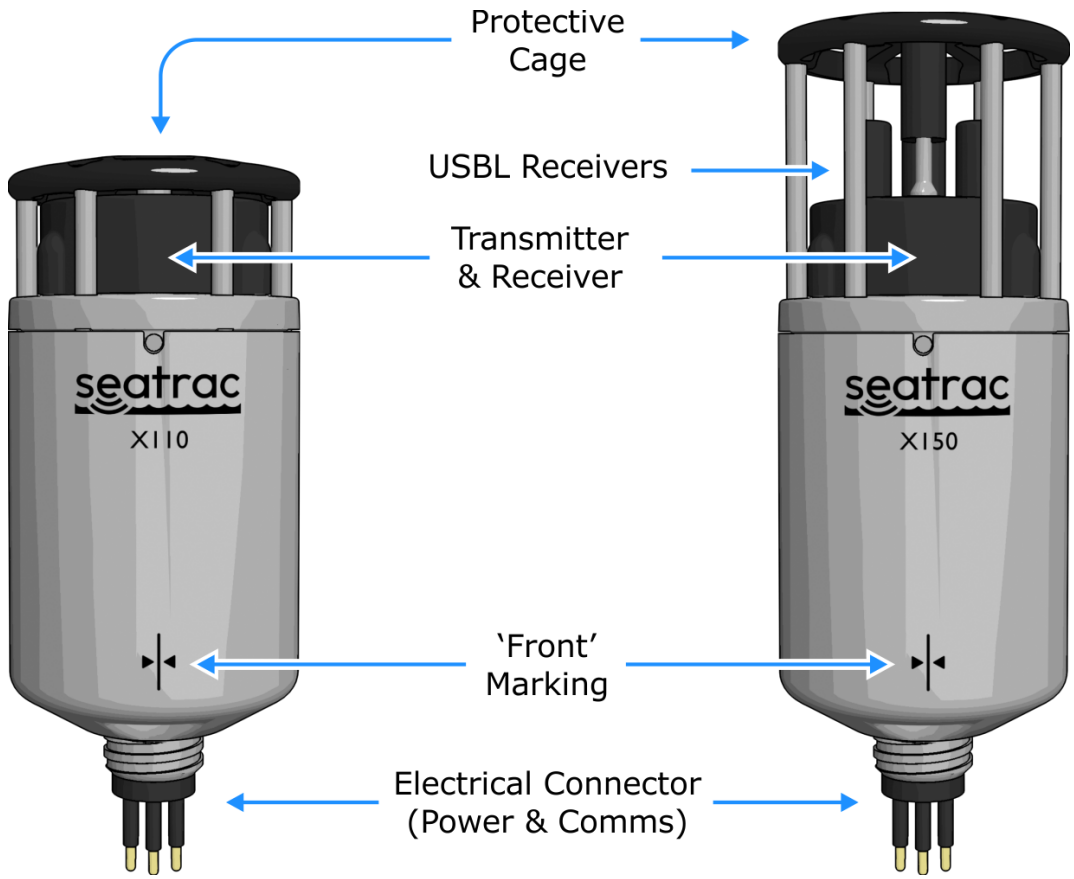
- X110 modem and/or X150 USBL Beacon (quantity and configured specified at time of ordering)
- Cables…
  - For X150 beacons, a Teledyne Impulse MCBH series socket and 20m deck-lead, cable.
  - For X110 beacons, a Teledyne Impulse MCBH series socket and 600mm bare-ended cable-whip.
- Pole mounting bracket.
- Bag of sundries including…
  - M4 x 8mm cap-head screws - for securing the beacon to the pole mounting bracket.
  - Rare-earth Neodymium magnet - for magnetic reset-to-defaults function).
- SeaTrac Software CD.
- User Manual.
- Transit Case

You will also need…

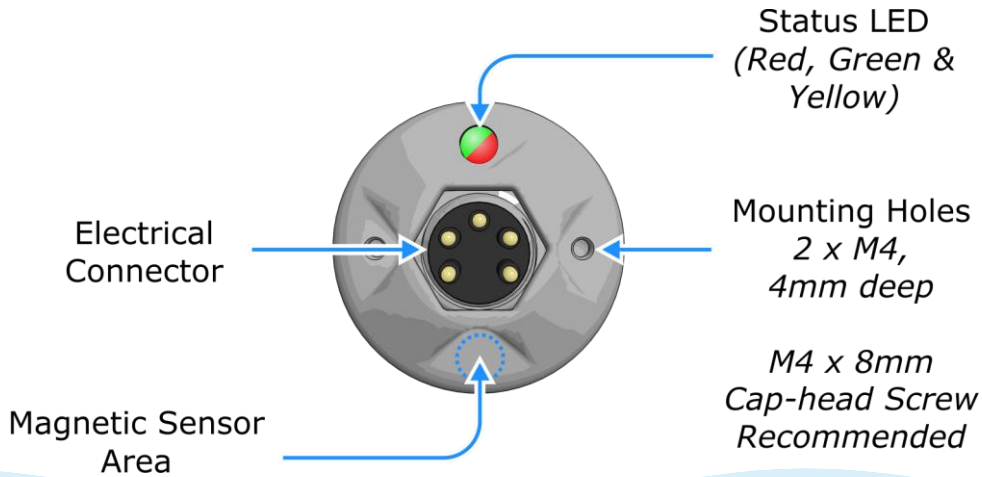
- Microsoft "Windows XP / Vista / 7 / 8" compatible computer, with…
  - 1 free serial port for connection to Beacons – alternately a serial-to-USB adapter may be required if no serial port is available (not supplied with system).
  - CD-ROM drive (or internet connection) for software installation.

1.2. Beacon Features

X110 Transceiver Beacon **X150 USBL Beacon**



(NB: Beacons are shown in the 'upright' position, as referenced in the following sections)



1.2.1. Status LED

When powered up, the current operating state of the beacon is shown by the colour and flashing style of the Status LED positioned on the bottom end of the beacon housing…



- Green 2s flash followed by short pulses and 2s off period

Beacon is operating normally. After the 2 second on period, the Beacon Identification code is flashed on the LED by a sequence of short 0.25 second pulses (i.e. 5 short flashes means beacon is configured as Id 5).



- Red Slow Flashing

Beacon is in 'bootloader mode' and will only respond to basic status request and firmware update commands.



- Red Fast Flashing

A reset magnet is over the magnetic sensor, after 5 seconds the LED will become continuous and defaults applied.



- Red Continuous

Beacon settings will be restored to factory default values when the reset magnet is removed.

- Yellow Continuous

Firmware update is in progress – typically takes 5-10 seconds.

1.2.2. Mounting holes

The base of the beacon housing has two 4mm deep M4 threaded holes. These allow the beacon to be easily attached to the supplied pole-mounting bracket or other asset attachment points.

1.2.3. Magnetic Sensor Area

The magnetic 'reset' sensor is situated below the flat area on the bottom bulkhead of the beacon housing. When the south pole of a magnet is placed against the housing, the status LED should flash red quickly turning to continuous red after 5 seconds, and at this time factory default settings will be restored when the magnet is removed.

1.2.4. Front Marking

The front marking indicates the reference position on the beacon from which incoming signal angles and headings are computed. When the front marking is pointing to magnetic north, the yaw angle reported by the AHRS sensors will be 0°.

Incoming USBL signals arriving at the front marking will have a reported azimuth

of 0°, increasing in value as the beacon is rotated anticlockwise (in the upright position) – i.e. as the signal source moves clockwise around the beacon.

1.2.5. Acoustic Transducers

Both the X110 and X150 transmit and receive data messages using the large 40mm diameter ring transducer mounted on the upper bulkhead of the beacon housing.
The beacon is designed to allow the ring area to free-flood, enabling maximum transfer of acoustic energy from the transducer into the surrounding water. However, for best performance, when submerging the beacon ensure that no large air bubble remain trapped in this area otherwise operating range may be impacted.

Additionally, the X150 USBL beacons feature 4 additional small receiver elements mounted above the main transmitter ring. The position and spacing between each receiver element is critical for the accurate operation of the USBL system.

To achieve optimal performance, the acoustic transceiver elements are manufactured from a ceramic material and encapsulated by a thin rubber coating. The elements may be damaged by sharp impacts or sustained point-pressure loads if care is not taken when handling or mounting beacons correctly. Avoid mounting the beacons in situations where impacts in the transducer area may be likely, otherwise damage may occur.

1.2.6. Pressure and Temperature sensor

The pressure transducer is mounted on the upper bulkhead of the beacon within the area of the main transducer ring. It is slightly recessed and has a corrugated surface from with the water temperature is also measured.
The beacon depth reading (in metres) is computed from the measured pressure (in Bar), and this value combined with the water temperature and user specified salinity can be used to auto-compute the current velocity-of-sound value, constantly calibrating the measure ranges to other interrogated beacons.

Do not touch or attempt to depress the diaphragm of the pressure transducer as it may be marked and permanently damaged, causing inaccurate readings.

The pressure transducer is temperature compensated over the 0° to 50° Celsius range. Within this range its output is specified to be within ±0.5% of it's full scale reading at any given value.

1.3. Important Considerations

Before using your SeaTrac product, please read and follow these safety considerations…
If you have any other safety or operational queries, please contact SeaTrac technical support (see page 5252).

1.3.1. Operation

- Do not rely on this product or its sensors as a primary means of life-support. SeaTrac products are designed as a survey tools, and not as an alternative or replacement for dive-computers or similar apparatus.
- Do not use this product if any housings or cabling appear to be damaged or compromised for the ingress of water (where required to be watertight).
- Do not attempt to disassemble or service this product yourself (outside the scope described in this manual). Contact Artemis technical support for any maintenance, spares or repair work required.
- Ensure the acoustic transducers are protected from image and damage during use but a protective cage or other suitable means.
- SeaTrac Beacons are designed for use in water. Where possible avoid periods of prolonged transmitter use in air (i.e. greater than 10 to 15 minutes) as the main transmitter transducer ring will be un-damped with un-dissipated acoustic energy causing internal heating and possible long-term damage. Larger current consumption and current surges may also be observed on switch-mode power supplies during transmission in such situations.

1.3.2. Maintenance and Cleaning

When you have finished using your SeaTrac product, you should…

- Wash the housing in fresh water if it has been used in salt-water, to prevent corrosion and degradation of rubber mouldings.
- Remove any weed, or other detritus, that may have been collected during its operation.

Additionally please observe the following precautions for cleaning and maintenance…

- Do not clean with solvents, and only use a damp cloth on the exterior surfaces of the unit.
- Do not undertake maintenance of the unit, outside the scope of that defined within this manual, unless instructed to do so by technical support.
- Do not insert extraneous objects (metal or otherwise) into the unit or any of its connector apertures.
- Take care when cleaning the pressure sensor diaphragm to ensure it is not damaged or marker.

1.3.3. Storage

When storing or shipping SeaTrac products, please observe the following…

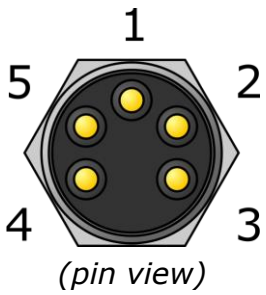
- Do not store the unit in direct or strong sunlight, as this may cause surfaces or transparent windows to discolour, perish cable insulation and other rubber mouldings.
- To prevent corrosion, remove any salt or other residues from the product before storage.
- Store in the recommended temperature range (see Specification section), and avoid excessive and large fluctuations in temperature.
- Store in a well ventilated enclosure after use, to allow any moisture on system components to evaporate naturally.
- Do not store battery packs in a discharged state, as this may reduce operational life or cause premature ageing of the cell. When storing batteries for more than one year, charge at least once a year to prevent leakage and deterioration of performance due to self-discharging.
- Do not leave battery packs in the battery housing for long periods of storage, and cells may leak and damage the seals and interior of the housing.

2. Operation

2.1. Electrical Connections

2.1.1. Connector Pin-out

Power and digital communications with the Beacon are connected through a Teledyne Impulse MCBH series plug that uses the following pin-out…



(pin view)

	600mm Whip Colour	*20m Deck-Lead Colour*
1. Power Positive	BLACK	SCREEN
2. Power Ground	WHITE	GREEN
3. Serial RS232 Transmit	RED	YELLOW
4. Serial RS232 Receive	GREEN	BROWN
5. Not Used	BLUE	-

Serial Communications directions are specified with respect to the SeaTrac Beacon.

2.1.2. Power Supply

For correct operation, SeaTrac Beacons require DC power from a regulated and electrically noise free power supply, capable of supplying a constant voltage between 9V and 28V with a peak load of up to 10W during an acoustic transmission (standby load is approximately 0.6W).

The Beacon is internally fitted with a 2A quick-blow fuse (non-user serviceable), supply filtering, transient protection and reverse current protection circuitry.

2.1.3. Serial Communications

The Serial Communications (Comms) port allows SeaTrac Beacons to be connected to a PC or other control system, and provides a means of configuring the beacons operational parameters, monitoring its status, triggering actions and receiving event notifications (such as data reception, ranges, positional fixes and diagnostics).

SeaTrac Beacons use the RS232 serial communications specification, with signal levels of ±5V achieving baud rates of 115200 bits-per-second over a

20m screened twisted-pair (STP) cable length.

Cables of grater length can be used with reduced baud-rates depending on electrical and environmental conditions. Basic beacon communications do not require significant serial bandwidth, but the frequency and content of status messages may need to be reduced in such circumstances (through the use of the SeaTrac Tools application).

For computers without an integrated serial port, the SeaTrac beacons have been tested for use with a variety of Serial-To-USB converters. For further details please contact your sales representative or the SeaTrac support team.

By default the Beacon requires the host systems serial port to be configured for operation with the following settings…

- 115200 baud
- 8 data bits
- 1 start and stop bit
- No parity
- No handshaking or flow-control

When used as a remote transponder (for interrogation by a navigation/tracking system), the serial communications interface is not required during normal operation - although status and diagnostic information is made available for external systems to monitor and use.
However, for initial setup and configuration provision should be made to allow connection of the Beacon to a PC running the SeaTrac Tools software application.

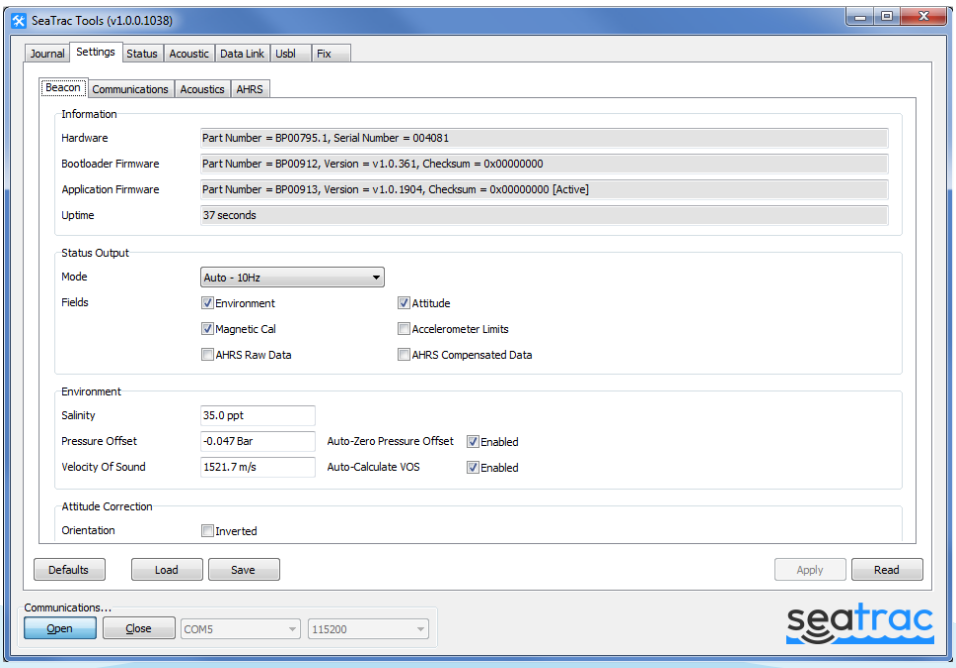
2.2. Configuring Settings

SeaTrac Beacons can be configured prior-to and during use with "SeaTrac Tools" software application (part of the SeaTrac Utilities installer on the software CD supplied with each Beacon, or the latest version is available for download from the Technical Support website).

Settings are stored in permanent Flash memory within the Beacon, applied on power up (or via software command) and can be reset back to the factory default values at any time by following the "Resetting to Defaults" procedure described in section 2.6 on page 32.

To configure the beacon settings…

- First, physically connect the Beacon to the serial port of a PC with the SeaTrac Tools application installed and power up.
- Run the SeaTrac Tools application, and use the "Communications" controls to establish a serial link with the Beacon.
- Switch to the "Settings" tab and make the necessary adjustments required.
- Click the "Apply" button to store the new settings in the Beacon.
- Alternately, click the "Defaults" button to reset the settings back to factory values – the new settings will be re-read into the application.



The SeaTrac Tools application is periodically updated to reflect changes and new features made to the Beacon firmware, and can be downloaded from the Technical Support website. Please refer to the SeaTrac Tools User Manual for further details on specific settings

For details of specific Beacon Settings, please refer to the "Beacon Settings" section on page 36, and to the SeaTrac Tools application user manual.

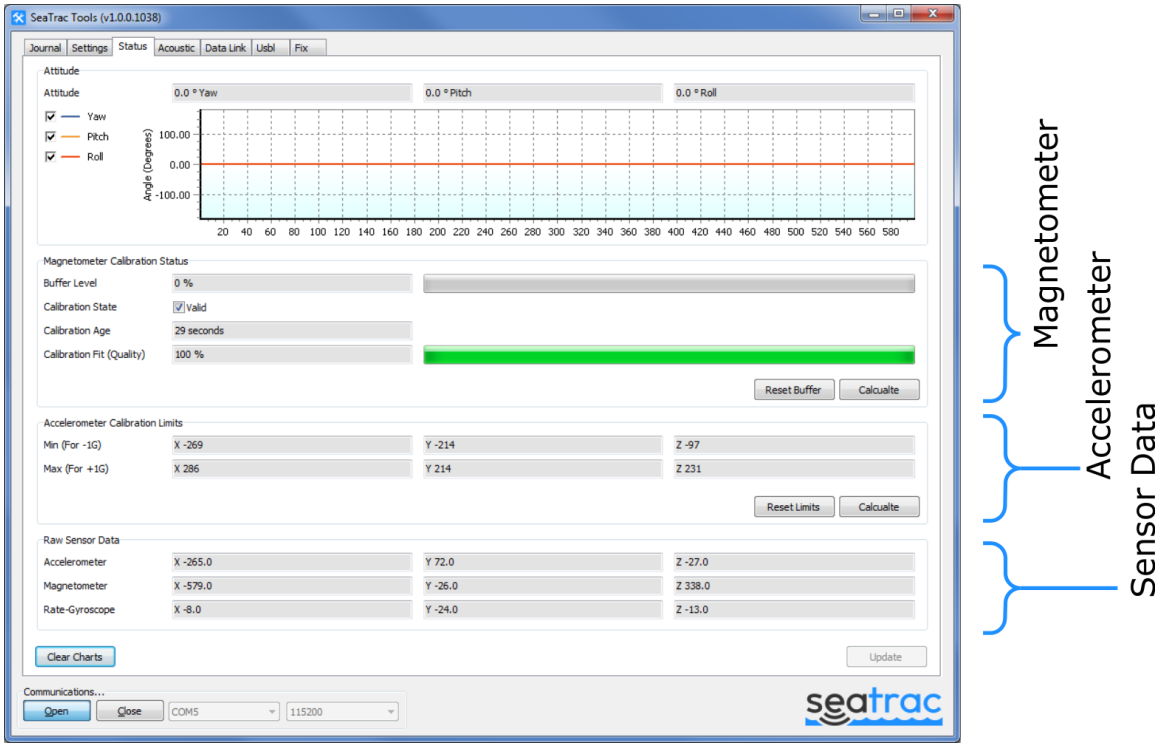
2.3. Calibrating the AHRS

The Attitude and Heading Reference System (AHRS) monitors the on-board sensors (comprising accelerometers, magnetometers and rotational rate gyroscopes) to compute the yaw, pitch and roll angles of the Beacon relative to the direction of gravity and the magnetic north direction.

Additionally, on the X150 series Beacons, the AHRS system also updates the Acoustic Transceiver module with orientation, that in turn is used to resolve incoming USBL signal directions into relative Northing/Easting/Depth coordinates.

The simplest way to calibrate the AHRS system is via the "SeaTrac Tools" software following the steps below…

- Run the SeaTrac Tools software application and connect to the Beacon.
- Select the main "Settings" tab.
- On the "Beacon" sub-tab, under the "Status Output" heading, configure the following settings…
    - Mode = "Auto – 10Hz"
    - Fields = Attitude, Magnetic Cal, Accelerometer Limits, AHRS Raw Data
- Click the "Apply" button to update the Beacon settings. This causes Status Output messages to be generated 10 times a second with the necessary information to check a calibration is being performed correctly.
- Switch to the main "Status" tab. The display should look similar to the image below…



Follow the instructions in the sections below to calibrate the Magnetometer and/or Accelerometer as needed…

2.3.1. Calibrating the Accelerometer

The accelerometer is responsible for measuring the pitch and roll orientation by determining the direction of gravitational force relative to the Beacons local frame of reference (see the section on page 65 for definitions).

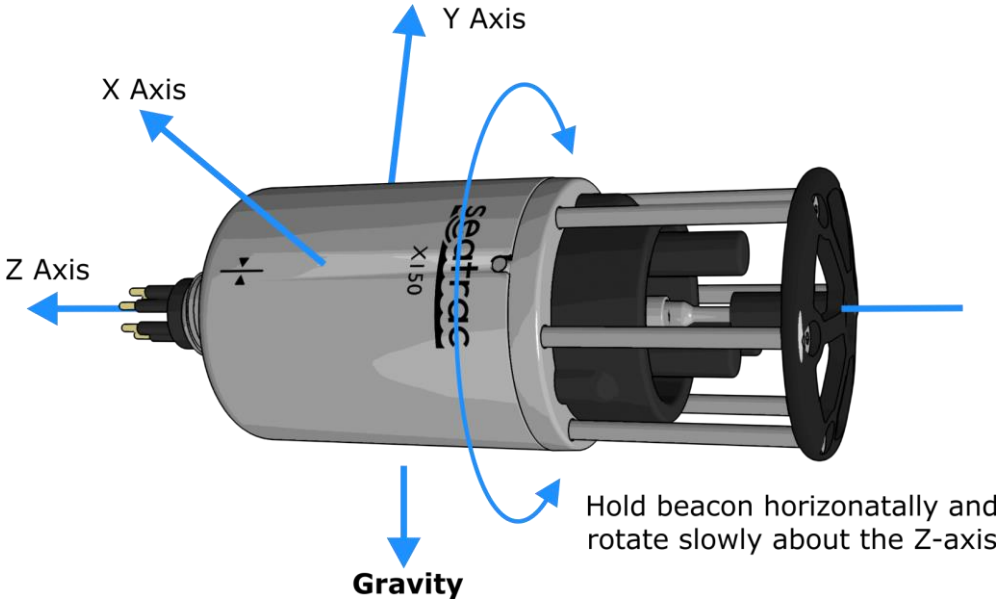
To operate correctly, each accelerometer axis needs to store the raw sensor readings for a force of +1G and -1G being applied to it (referred to as the 'limits'), such that readings in between can be determined, and acceleration due to motion discounted.

These values are set by the factory prior to shipping, and will normally not require recalibration unless extremes of environmental temperature are seen or default settings are applied.

Having started the SeaTrac Tools application and configured it using the procedure described above, follow the steps below to calibrate the Accelerometer…

- On the main "Status" page in SeaTrac Tools, under the Accelerometer group, click the "Reset Limits" button. This will reset all values back to zero ready for a new calibration.

- Very slowly (so as not to introduce any significant acceleration forces) orient the beacon horizontally and start to roll it around its Z-axis so that the X and Y axis sequentially rotate towards and away from the direction of gravity – see the diagram below…



- As the beacon is rotated you should notice that the X and Y minimum values start to approach their limits.

  These values are filtered to remove erroneous noise values so slow down as the minimum and maximum values are approached (these can be seen in the "Raw Sensor Data" values) until the limit values become stable.

  Slowly oscillating the beacon back-and-forth past the minimum and maximum positions for the X and Y axis will help settle these values.

- Once the X and Y limits have been found, slowly rotate the beacon into the upright position (so gravity is acting downwards through it), as you do so the minimum Z-axis limit should start to change.
- As with the X and Y limits, the Z limits are filtered, so slowly oscillate the beacon through a few degrees either side of vertical in all directions to ensure the limit value stabilises.
- Slowly invert the beacon so its now points down towards gravity and repeat the above step again to obtain the maximum Z-axis limit.



- Finally, once you are happy with that all 6 limit values have been obtained, click the "Calculate" button (under the Accelerometer group) to compute the calibration and store the values into permanent Flash memory. This completes the Accelerometer calibration for pitch and roll.

2.3.2. Calibrating the Magnetometer

The magnetometer is responsible for measuring the direction of the Earth's magnetic field lines, and determining the direction of magnetic north relative to the Beacons local frame of reference (see the section on page 65 for definitions).

The magnetometer readings can be significantly affected by the presence of ferrous materials (such as Iron, Nickel, Cobalt and some alloys involving those materials) in the proximity of the Beacon, so it is important that it is correctly calibrated before use to ensure that yaw readings are aligned to magnetic north and update correctly as the beacon rotates.

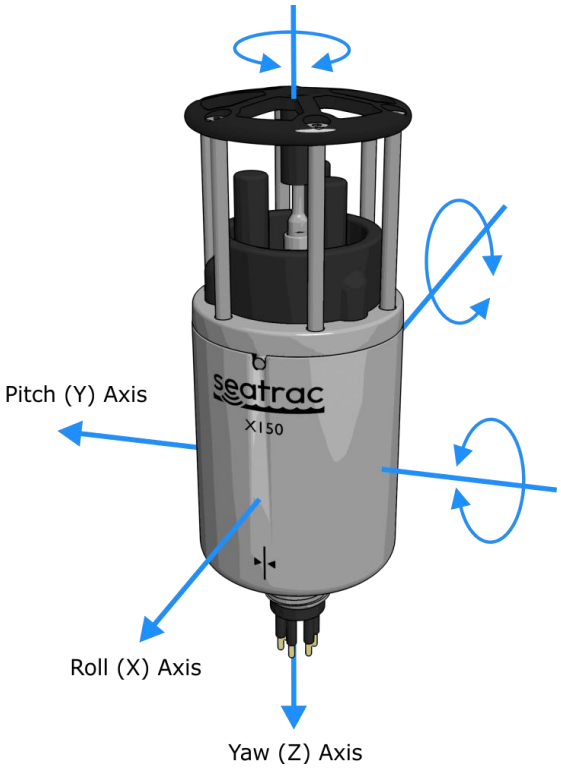
Having started the SeaTrac Tools application and configured it using the procedure described above, follow the steps below to calibrate the Magnetometer. Important note: This process will also calibrate the Gyroscope in the beacon.

- On the main "Status" page in SeaTrac Tools, under the Magnetometer group, click the "Reset Buffer" button. This will clear all previous magnetic reading and should reset the "Buffer Level" value back to 0%.

- Start rotating the beacon around its three axis (yaw, pitch and roll). It helps if you imagine the beacon to be inside a sphere, and during rotation the top of beacon is painting the inside of the sphere as you move it around.

  The aim is to rotate and roll the beacon through as many orientations as possible in three-dimensional space, and as you do so the magnetometer is attempting to measure the magnetic field for each orientation.

  The figure below give an indication as to the types of movements you should make around the axes, and this should be done in as many combinations of orientations as possible (i.e. horizontally, vertically, upside down etc)…



- As you rotate the beacon, the "Buffer Level" value in SeaTrac tools will slowly increase. Keep rotating the beacon until the Buffer Level reaches 100%.

- Once at 100%, place the beacon onto a flat steady surface and allow it to settle for around 10 seconds. This is to allow the Gyroscope to settle

before confirming the calibration.

- Finally, with the Buffer Level at 100%, click the "Calculate" button (under the Magnetometer group) to compute the calibration and store the values into permanent Flash memory. This completes the Magnetometer calibration for pitch and roll.

Mounting on a Platform

Beacons can be attached to platforms in a variety of different ways. However, regardless of mounting method, please ensure the following points are observed…

- Always ensure the transducer are suitable protected, and will not be damaged by contract or impact with other objects and structures.
- Ensure there is good "acoustic visibility" around the transducers. Like light, all objects can cast acoustic shadows, and the closer objects are to the transducer arrays the more pronounced this effect will be. For best performance ensure each beacon has good all round visibility and line-of-sight clearance to other beacons it will communicate with.
- If using the AHRS, mount the beacon as far away from sources of magnetic interference as possible (i.e. ferrous materials), and perform a calibration if necessary.

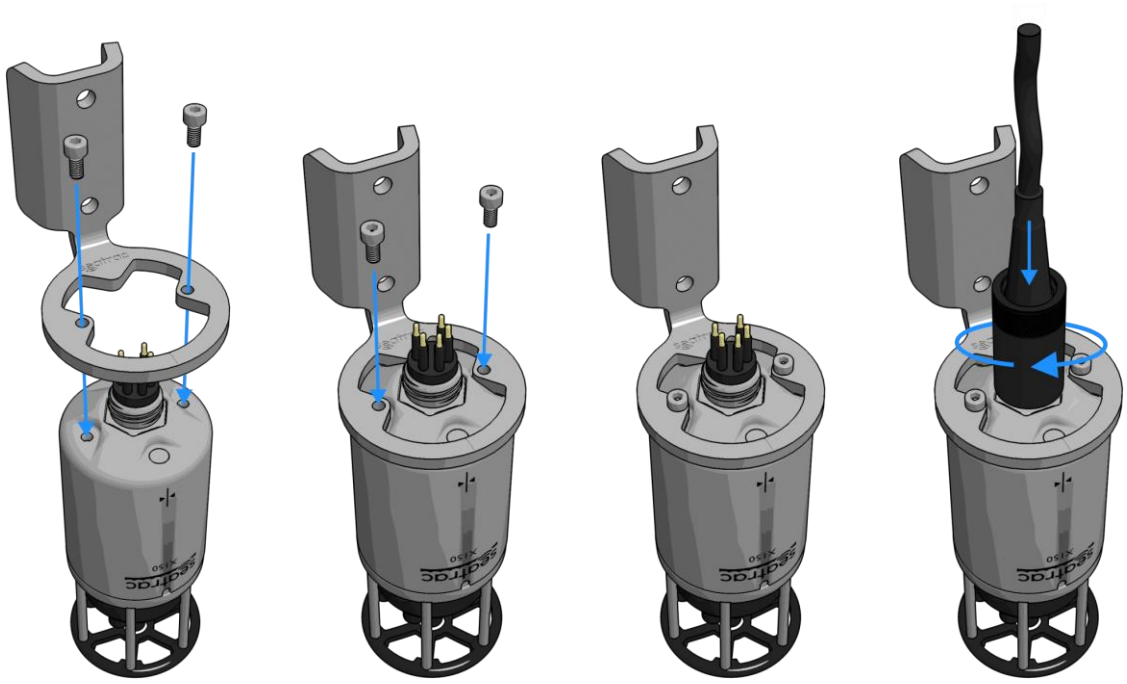
2.3.3. Pole Mounting Bracket

The pole mounting bracket allows the beacon to be rigidly attached to its operating platform.

Typically this may involve mounting the X110 modem beacon onto an ROV, AUV or equipment platform ready for USBL interrogation by an X150 beacon, or data exchange with another X110 modem.

To attach the bracket…

- Orient the bracket such that the two holes align with the M4 threaded holes in the beacon housing and the Status LED is visible through the bracket.
- Use M4 × 8mm cap-head screws to secure the bracket onto the beacon.
- Plug the external cable loom onto the beacon connector and tighten the securing collar.



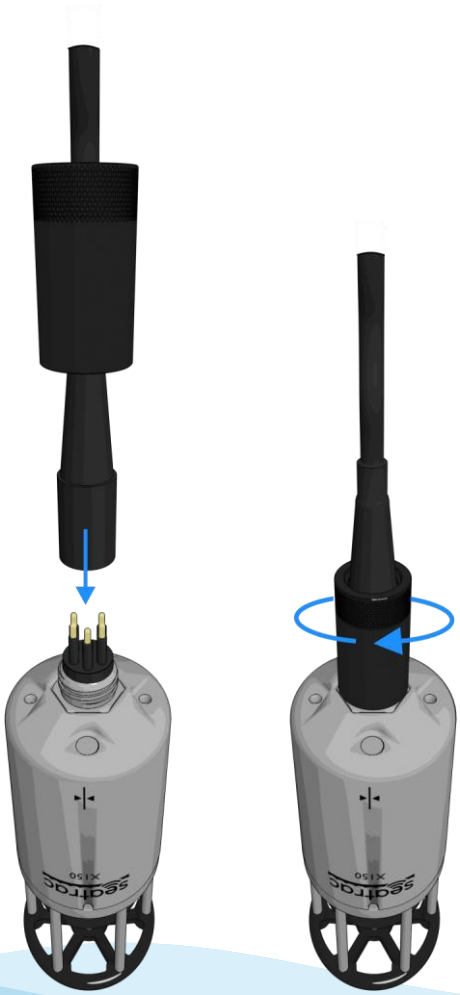
2.3.4. Cable Mounting

For the X150 USBL system, it may be desirable to hang the beacon over the side of the surface vessel by the supplied cable alone.

This has the advantage of allowing the beacon to be mechanically decoupled from the vessel and less susceptible to position measurement errors introduced when small movements and vibrations are amplified down a pole-mount.

To mount the beacon on the cable…

- Plug external cable loom onto the beacon connector and tighten the securing collar.
- Ensure the other end of the cable is securely fastened to the vessel in a way that will not damage the outer cable insulation, or damage the inner conductors if the bend radius is too small.



When using the X150 USBL beacon from a cable in the above manor, it is recommended that the "USBL uses AHRS" option is enabled to allow the beacon to continuously compensate for any swinging or rotational movement on the cable.
For further details on this setting, refer to section 3.6.5 on page 46.

2.4. Pre-Use Checklist

Before using your SeaTrac Beacon(s), it is recommended to work through the following list to ensure all settings and hardware are properly configured and ready for use…

Connect each beacon as required to the PC and use the SeaTrac Tools application to modify it settings, or perform calibration and diagnostic procedures…

2.4.1. All Beacons (Local and Remote)

Setup Beacon ID codes

Each beacon should be assigned its own unique identification value to allow it to send and receive messages.
The beacon ID can be quickly checked by applying power and counting the green flash sequence on its Status LED.
See section 3.6.1 on page 43 for further details.

Check the Acoustic Response Times for all beacons are set to the same value

All beacons must be configured with the same response time to ensure correct operation – by default this should be 10ms.
To improve performance, this time can be increased for environments that have high reverberation levels (such as tanks, docks and harbours).
See section 3.6.3 on page 45 for further details.

2.4.2. Local Beacons (for Ranging or USBL applications)

In addition to the above…

Choose the Status Output message mode and content fields

If using SeaTrac Tools to monitor beacon activity or perform diagnostic tests, enable automatic generation of the Status Output message, and choose the data content fields you would like to monitor (i.e. depth, temperature, attitude, supply voltage etc).
See section 3.3 on page 37 for further details.

Setup the Salinity and VOS settings

Manually specify a velocity-of-sound, or enter the water salinity and enable automatic calculation of VOS from depth and temperature.
VOS must be correct in order to obtain accurate range readings when communicating with other beacons.

Setup the Pressure sensor offset

Manually zero the pressure sensor with the beacon at the water surface, or enable automatic calculation of the offset.
See section 3.4.4 and 3.4.5 on page 40 for further details.

Setup the Timeout Range

Specify the maximum time (relating to range) a beacon should wait for before reporting a Response Timeout error. Smaller values speed up operation but limit the maximum operating range.
See section 3.6.2 on page 44 for further details.

Setup Acoustic Transceiver activity messages (if required)

If using SeaTrac Tools to monitor beacon activity or perform diagnostic tests, enable the output messages to allow required data to be collected.
See section 3.6.4 on page 45 for further details.

2.4.3. Local Beacons (for USBL applications)

In addition to the above…

Enable the USBL to use the AHRS attitude, or enter a preset attitude offset if not using the AHRS.

If using an X150 USBL modem, enable the "USBL uses AHRS" settings to allow real-world coordinates relative to the beacon to be computed, otherwise enter the fixed platform attitude offsets.
See section 3.6.5 on page 46 for further details.

Calibrate the AHRS (if required)

If using the AHRS to compute USBL positions, ensure the AHRS is properly calibrated and not affected by any local magnetic distortions.
See section 2.3 on page 18 and section 3.5 on page 41 for further details.

2.5. Acoustic Communication Diagnostics

Once installed on their respective platforms, the SeaTrac Tools application can be used to test if communications between beacons are functioning correctly.

To test communications, first configure the beacons to output Transceiver diagnostic information…

- Start the SeaTrac Tools application and establish serial communications with the beacon.
- Switch to the main "Settings" tab, and on the "Acoustics" sub-tab ensure the transceiver "Fix", "Tx/Rx" and "USBL" (X150 only) activity outputs are enabled.
- Click "Apply" to update the settings if required.

Further details on using SeaTrac Tools can be found its user documentation.

2.5.1. Receiver Noise Analysis

The first step in diagnosing communication issues is to examine the surrounding background noise levels the beacon receiver is experiencing.

SeaTrac beacons operate at frequencies between 24KHz and 32KHz, and any large sources of noise in this band from external sources (vessels passing by, other acoustic instruments etc) may affect the operation.

To perform a Receiver Noise Analysis…

- Start SeaTrac Tools as described above, and switch to the main "Acoustics" tab.
- Ensure all beacon transmission activity is stopped both locally and from remote beacons (as this may affect the computed noise levels).
- Click the "Rx Analyse" button at the bottom of the window. This will sample of background noise data and compute noise levels.
- After a short period, the results window will be display – the significant values to understand are…
    - **RX Level (RMS)** The average background signal level observed. Under normal operations this should be between 80dB and 88dB.

Electrical power supply noise or nearby vessels with continuous acoustic noise output (engines, pumps, propellers etc) may be a cause of this value being larger than expected.

- **RX Level (Pk-Pk)**

  This is the peak background level observed During the receiver analysis. Typically this value should lie between 88dB and 96dB.

  Higher values seen (when the RMS noise level is low) may be caused by the presence of other acoustic instruments transmitting bursts of sound in the same band.

If the Receiver Noise levels are higher than expected then investigate and attempt to eliminate interfering factors such as…

- Acoustic noise from surrounding vessels or equipment/plant installations (engines, propellers, pumps etc).
- Interference from other acoustic sensors operating nearby (echo-sounds, sonars etc).
- Electrical noise present on the beacons power supply.

2.5.2. Received Signal Strength Indication (RSSI) with PING and ECHO

The main "Acoustics" tab of the SeaTrac Tools application provides means to test communications between beacons using the "PING" and "ECHO" protocols.

- **PING**

  The PING protocol forms the simplest and shortest acoustic message possible addressed to the required beacon, and requests a USBL response is made.

- **ECHO**

  The ECHO protocol forms a data message addressed to the required beacon, and with a user specified payload of up to 30 characters. The message is sent and upon successful reception, retransmitted as a response back to the beacon.
  Due to their data payload, Echo messages are significantly longer (in time) than PING messages, and so are useful for testing the integrity of an acoustic communication channel.

On the "Acoustics" tab, the table shows each addressable beacon, along with its transceiver status, the last range and USBL position fix obtained, the received signal level for the last message and command to initiate PING and ECHO transmissions.

Each beacon also has an "enable" checkbox used for batch operations. By selecting the required beacons, continuous PING or ECHO messages can be sent allowing repeatability to communications to be tests, or Ranging and USBL Positioning information validated.

To obtain an RSSI for a beacon…

- Start SeaTrac Tools as described above, and switch to the main "Acoustics" tab.
- Either click the appropriate PING or ECHO button in the row corresponding to the Beacon's ID you wish to test. This will start a transmission.
- After a short time a response will be received, or an error such as checksum (indicating data corruption) or timeout (indication no reception) will be displayed.
- If a valid response is received, the range to the remote beacon (and its USBL position fix if using an X150 beacon) will be displayed along with the RSSI level.

  Invalid responses will not clear down the last range, position and RSSI, but instead display bracket "()" symbols around their values to show they are no longer valid.

When a response is received from the remote beacon, the Received Signal Strength Indication (RSSI) is displayed in the corresponding table row, with values shown as decibels referenced to 1 micro-Pascal (dB re 1μPa).

RSSI levels are calibrated against the transmitter strength (Source Pressure Level – SPL) of 173dB.

Due to receiver hardware limitations, the RSSI value is clipped at a maximum 135db, although in practice the actual signal level may be stronger.

Signal levels below the Rx Noise floor (approx 90dB) may start to experience

communication problems.

The exact communications limits obtainable on any given day can depend heavily on…

- Local environmental conditions (with factors including water temperature, dissolved oxygen content, presence of marine plant life and man-made acoustic noise from passing vessels or submerged equipment).
- Geographical conditions (such as depth of channel, acoustic reverberation nearby structures and obstacles that may block the acoustic transmission).
- Beacon mounting method (orientation and position of the beacon of each operating platform, acoustic shadowing, lack of line-of-sight between beacons).

The RSSI level can be used in conjunction with a simplified form of the "sonar equation" to determine if the received signal level is below that expected for the range between beacons…

$$RSSI = SL - \left(20 \cdot Log_{10}(r) + \alpha r\right)$$

Where…

- 'SL' is the source level = 173dB
- 'r' is the range to the remote beacon in metres
- 'α' is the acoustic absorption coefficient of water, with suitable values being found in the table below…

Water Temp (°C)	Fresh Water (Salinity 0 ppt)	Sea Water (Salinity 35 ppt)
5	4.0×10^{-4}E	2.2×10^{-3}
10	3.7×10^{-4}	1.4×10^{-3}
15	3.4×10^{-4}	1.0×10^{-3}
20	3.3×10^{-4}	8.5×10^{-4}
25	3.2×10^{-4}	7.5×10^{-4}

Pre-computed values for expected RSSI levels versus communications range, water temperature and salinity are available in section 6.7 on page 69.

These calculated values can be compared against the measured RSSI level to determine correct operation.
If the measured level is significantly less than the expected level then

this is an indication of signal being lost through environmental conditions (such as high surface water temperature).

2.5.3. USBL Signal Level

On X150 beacons, the received USBL signals can be analysed in a manor similar to that discussed in the previous section.

This feature is particularly useful if the communications continue to function but computed positions start to become inaccurate due to signal loss.

To monitor the USBL signal levels…

- Start SeaTrac Tools as described above, and switch to the main "Acoustics" tab.
- Use the checkboxes to enable the single beacon you with to interrogate and click the "Batch Ping" button to start continuous repeated communication with them.

  It is advisable to only "Batch Ping" a single beacon, other alternating signal levels for each beacon will be display, confusing the analysis process.
- When acoustic communications is working, switch to the main "USBL" tab in the SeaTrac Tools display.
- USBL responses will be received and displayed on the screen, with the main chart showing the decoded signal level. On the right hand side of the display, the RSSI for the 4 USBL channels will be displayed in dB.

The 4 USBL channel RSSI levels are calibrated against the transmitter strength (Source Pressure Level – SPL) of 173dB, and give an indication as to weather the USBL elements are receiving a signal that can be processed successfully.

Pre-computed values for expected RSSI levels versus communications range, water temperature and salinity are available in section 6.7 on page 69.
These calculated values can be compared against the measured RSSI level to determine correct operation.
If the measured level is significantly less than the expected level then this is an indication of signal being lost through environmental conditions (such as high surface water temperature).

2.6. Resetting to Defaults

2.6.1. Hardware Reset

If you are having trouble connecting the programmer to the beacon, and you are sure the Beacon has power and is connected to the correct serial port, it may be that you have changed the Beacon's serial communication baud rate (speed) setting.

This setting is stored within the Beacons Flash memory, and can be reset to the factory default value of 115200 baud by the following procedure…

Please note that resetting the Beacon to default will loose all user settings and calibration data. Please refer to the "Calibrating the AHRS" section on page 18 for details on how to recalibrate the hardware.

To reset the Beacon to factory defaults…

- Turn off, then turn on the power to the Beacon and check it has booted into the main application – the status LED on the base of the Beacon housing should be flashing Green.
- Hold the "reset magnet" (south pole) over the magnetic sensor at the base of the Beacon (see Beacon user manual for details).
- As the magnet is moved into place, the Green status LED should start quickly flashing Red to show the presence of the magnet.
- Hold the magnet in place for 5 seconds until the status LED stops flashing, and become permanently illuminated red. At this point the defaults have been applied.
- Cycle the power to the beacon to ensure the new communications and some of the calibration settings are re-applied to hardware.

To save power, and prevent accidental activation, the magnetic reset sensor is disabled after the Beacon has been powered up for 2 minutes. After this period the sensor will no longer function until the power is cycled to the Beacon.

2.6.2. Software Reset

Beacon settings can be restored to factory default values through the serial

interface, by programs such as SeaTrac Tools.

To reset the settings, start SeaTrac Tools and connect to the Beacon, then from the "Settings" page, click the "Defaults" button.

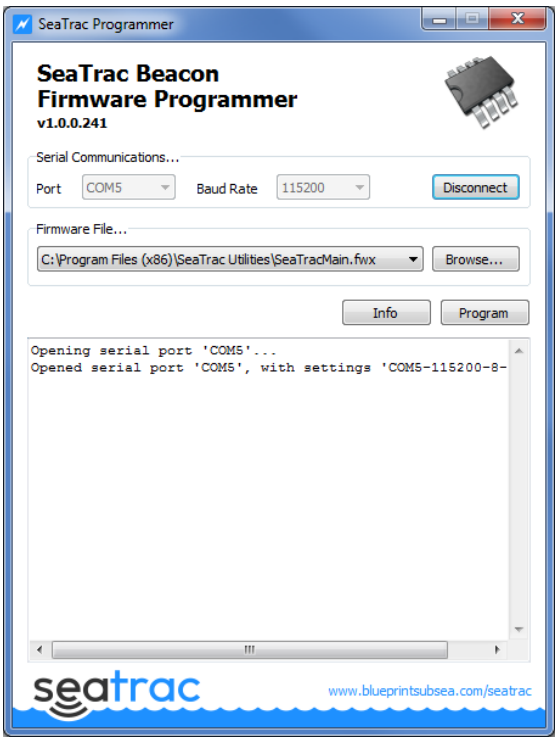
2.7. Updating Firmware

Periodically, new firmware releases will be made available for SeaTrac Beacons via the support website (see page 52), that add new features or correct reported bugs.

These updates can be programmed into the Beacon using the "SeaTrac Programmer" software application (part of the SeaTrac Utilities installer on the software CD supplied with each Beacon, or the latest version is available for download from the support website).

To run the SeaTrac Programmer application…

- First open, the Windows Start Menu and find the "SeaTrac Utilities" folder.
- Click on the icon for "SeaTrac Programmer". A window similar to the image opposite will appear…
- Follow the detailed instructions on download firmware updates and using the programmer application found in the "SeaTrac Programmer User Manual"[2] (installed as part of the SeaTrac Utilities suite).



Once the firmware has updated, there may be situations where settings require resetting to factory defaults to ensure correct operation.

[2] Document reference UM140-D00221.

2.8. Entering Bootloader Mode

On power-up the Beacon will start its Bootloader application firmware, initialise hardware then start the main application firmware running.
However, if power was interrupted during the 'update' stage of the programming procedure, or another issue has caused this firmware become corrupt, then the main application may fail causing the beacon to freeze and become unresponsive.

Activating 'Bootloader Mode', prevents the Bootloader firmware from starting the main application, and as the Bootloader application is stored in a separate part of memory to the main firmware, it is unlikely it will have been corrupted.

To activate Bootloader mode…

- Turn off the power to the beacon,
- Hold the "reset magnet" over the magnetic sensor at the base of the Beacon (see Beacon user manual for details).
- Power up the beacon keeping the magnet in place. The Beacon's status LED should stay quickly flashing red.
- After a couple of seconds the magnet can be removed, and the Beacon status LED should flash red at a slower rate to show Bootloader Mode has been activated.

Once activated, Bootloader mode only provides support for reprogramming the application firmware.

To leave Bootloader mode, remove the magnet and cycle the power to the beacon. The Status LED should flash Green to show the main application has started.

In Bootloader mode, the serial port data rate is fixed at 115200 baud, and cannot be altered by the user.

If you have been experiencing problems connecting the programmer software to the beacon. Try reconnecting using the above setting once Bootloader mode is active and see if this resolves the issue.

Bootloader mode only activates a small subset of the Beacon's hardware – enough to provide serial communications (for firmware reprogramming), and status indication.

Consequently only the Status and Programming serial command set is implemented, so developers and system integrators using higher-level functions will find these no longer work while the beacon is in Bootloader mode.



If you are having trouble activating Bootloader mode using the method described above, an alternative method is available that involves making hardware changes – contact the SeaTrac technical support team for further details on this procedure.

3. Beacon Settings

Between sessions, configured settings are stored in non-volatile Flash memory within the Beacon.
On power up, these settings are loaded into working memory (RAM) and applied to the Beacon's systems.

Most settings in RAM will be applied immediately when changed, although some (such as communication settings) are only applied on power up.

When settings are modified with a "Set" command, only the RAM copy is updated. A separate "Save" command should be issued to update the Flash copy with the RAM copy.
Software programs like SeaTrac Tools will do this automatically when the "Apply" button is clicked, but system integrators developing their own interfaces will need to issue "Set" and "Save" command sequences.

The following sections discuss the groups of settings that can be adjusted through applications such as SeaTrac Tools…

3.1. Product Information

In addition to the Settings, information about the SeaTrac product can also be obtained through the serial interface, including…

- Hardware part number, revision and serial number.
- Bootloader firmware type, version, release and checksum details.
- Main application firmware type, version, release and checksum details.
- Uptime – the number of seconds since the Beacon was powered up.

The above information can be used to help ensure that correct hardware is attached to a PC by operating software, or determining if firmware updates need to be applied.

3.2. Communications

To allow connection to a variety of external platforms, or to operate over longer cable length, the baud-rate of the Beacons serial port hardware can be selected from one of the following settings…

- 4800 baud
- 9600 baud
- 14400 baud
- 19200 baud
- 38400 baud
- 57600 baud
- 115200 baud

Please note, when adjusting the serial baud-rate settings, the new values are only applied when the Beacon power up, so a power re-cycle will be required, after which the current software communications settings should then be also adjusted to reflect the changes.

Should the current baud-rate settings be, the Beacon can be reset back to the factory default value of 115200 baud by following the "Resetting to Defaults" procedure described in section 2.6 on page 32.

3.3. Status Output

To allow simple integration with third party applications, SeaTrac Beacons produce a Status Output message that can be configured to contain a variety of information fields, and generated either on request or at a specified frequency.

Information fields are requested by setting the appropriate content 'bit masks' when either configuring the Status Output setting, or making a manual Status Output request.

3.3.1. Output Mode

The Status Output mode setting allows the frequency to be specified at which Status Output messages are sent from the Beacons serial port. Valid values are…

- Manual — Messages are only sent in response to a "Get Status Output" command, which may specify the information fields required on a case-by-case basis.
- 1Hz, 2.5Hz, 5Hz, 10Hz — Messages are generated at the specified frequency, using the pre-configured information field's settings.

3.3.2. Environment Fields

The Environment Fields group contains the following parameters…

- Beacon supply voltage (in volts)
- External water temperature (in degrees Celsius)
- External pressure (in Bar)
- Computed Depth (in metres)
- Current Velocity-of-Sound (in metres per second)

3.3.3. Attitude Fields

The Attitude Fields group contains the following parameters…

- Beacon Yaw angle (in degrees)
- Beacon Pitch angle (in degrees)
- Beacon Roll angle (in degrees)

Please refer to section 6.5 on page 65 for definitions of the above.

3.3.4. Magnetic Calibration Fields

The Magnetic Calibration Fields group contains the following parameters…

- Calibration Buffer Level (in percent)
- Current Calibration Valid flag
- Calibration Age (in seconds)
- Calibration Fit/Quality (in percent)

These fields are useful to monitor the process and results obtained when performing a calibration of the AHRS – see section 2.3 on page 18 for further details.

3.3.5. Accelerometer Limits Fields

The Accelerometer Limits Fields group contains the following parameters…

- Sensor minimum values for X, Y and Z axes representing -1G force along the axis.
- Sensor maximum values for X, Y and Z axes representing +1G force along the axis.

These fields are useful to monitor the process and results obtained when performing a calibration of the AHRS – see section 2.3 on page 18 for further details.

3.3.6. AHRS Raw Data Fields

The AHRS Raw Data Fields group contains the following parameters…

- Accelerometer sensor current X, Y and Z axis readings.
- Magnetometer sensor current X, Y and Z axis readings.
- Rate-Gyroscope sensor current X, Y and Z axis readings.

The raw data fields are useful for diagnosing correct operation of the AHRS hardware, or performing calibrations by external means.

3.3.7. AHRS Compensated Data Fields

The AHRS Compensated Data Fields group contains the following parameters…

- Accelerometer sensor X, Y and Z axis readings with calibration data applied.
- Magnetometer sensor X, Y and Z axis readings with calibration data applied.
- Rate-Gyroscope sensor X, Y and Z axis readings with calibration data applied.

The compensated data fields are only used for diagnosing correct operation of the AHRS hardware.

3.4. Environment Monitoring

It is important that the Velocity-Of-Sound (VOS) through water is correctly defined to ensure the measured ranges between Beacons are correctly calibrated and have minimum error.

3.4.1. Manual Velocity of Sound

VOS can be manually specified as a constant when obtained from a third party sensor, such as CTD probe or Velocimeter.

Section 6.6 on page 68 contains pre-computed fresh and sea water VOS values for a variety of temperatures and depths.

3.4.2. Auto-Calculate Velocity of Sound

As an alternative to manual constant VOS, the current value can be computed automatically (at the sampling rate of the pressure sensor – typically 10Hz) based on the current water temperature, water pressure and user specified salinity constant.

3.4.3. Salinity

If VOS is computed automatically, the user should manually configure a value for salinity, entered as a value defined in "parts per thousand" – typically 0ppt is fresh water, and 35ppt represents the value for seawater.
If VOS is specified manually then no salinity value is required to be entered.

3.4.4. Manual Pressure Offset

The pressure sensor, used to monitor submerged depth and water temperature is factory calibrated and temperature compensated over the range from 0°C to 50°C – reported values at any time lie within ±0.5 of its full scale reading.

To compensate for atmospheric fluctuations, a manual pressure offset can be specified by the user (in Bar) to zero the depth reading to the waters surface.

3.4.5. Auto-Calculate Pressure Offset

Alternately, the pressure offset can be automatically calculated, in which case the minimum measured pressure (when the pressure sensor reads less than 0.3 Bar) will be used as the offset to zero the depth sensor.

This approach allows Beacons to be powered up on a vessels deck, or at the waters surface, and the depth reading automatically zeroed.
Should the Beacon's power be cycled when submerged below approximately

3m (0.3 Bar), the previous pressure offset value will be used ensuring the depth sensor is not reset.

3.5. AHRS

The Attitude and Heading Reference System (AHRS) monitors the on-board sensors (comprising accelerometers, magnetometers and rotational rate gyroscopes) to compute the yaw, pitch and roll angles of the Beacon relative to the direction of gravity and the magnetic north direction.

The Beacon can be manually interrogated for its current AHRS state via the previously discussed Status Output fields (see page 37), or configured to automatically output values as part of the status message (see section 0 above) at user specified intervals (1Hz, 2.5Hz, 5Hz, 10Hz).

On the X150 series Beacons, the AHRS system also updates the Acoustic Transceiver module with new orientation information as the Beacon rotates, which in-turn is used to resolve incoming USBL signal directions into relative Northing/Easting/Depth coordinates – options for this are discussed in section 3.6.5 on page 46.

3.5.1. Accelerometer Calibration Constants

The accelerometer is responsible for measuring the pitch and roll orientation by determining the direction of gravitational force relative to the Beacons local frame of reference (see the section on page 65 for definitions).

Each accelerometer axis needs to store the raw sensor reading for a force of +1G and -1G being applied to it, such that readings in between can be determined, and acceleration due to motion discounted.



There are 6 settings in total for the minimum (-1G) and maximum (+1G) values the accelerometer will measure in the X, Y and Z local axis.
These values are set by the factory prior to shipping, and will normally not require recalibration unless extremes of environmental temperature are seen or default settings are applied. However, should these value need recomputing, they can be automatically obtained through the calibration procedures discussed in section 2.3 on page 18.

3.5.2. Magnetometer Calibration Constants

The magnetometer is responsible for measuring the direction of the Earth's

magnetic field lines, and determining the direction of magnetic north relative to the Beacons local frame of reference (see the section on page 65 for definitions).

The magnetometer readings can be significantly affected by the presence of ferrous materials (such as Iron, Nickel, Cobalt and some alloys involving those materials) in the proximity of the Beacon, and such distortions are classified into two groups called "Hard Iron" and "Soft Iron" effects.

Magnetic calibration theory is a complex subject with many texts available for download from the internet, but simply put…

- Hard Iron materials can be permanently magnetised and will retain a residual magnetic field when the magnetising field is removed. Typically this effect can be seen as a heading deflection when moving steel object passed a compass needle. Normally all other ferrous materials that are mounted in the same frame of reference as the Beacon (i.e. the ROV of Vessel it is mounted on) will have an offsetting effect on the measured magnetic heading.

- Soft Iron materials are those materials that can have a magnetic field generated within them, but will not retain their field when the magnetising field is removed (i.e. transformer cores, electromagnets, wiring looms/loops with current flowing etc.), these presence of these materials can also distort the magnetic field around them.

In an ideal world, as a 3-axis magnetometer is rotated through space the combined measured magnetic field of all axis should equal the Earths magnetic field, and if orientation were plotted on a 3D polar-chart against field strength, a sphere cantered around the chart origin should be seen.
However, Hard Iron has the effect of shifting the centre of the sphere on the plot, while Soft Iron has the effect of distorting is shape to produce an ellipsoid.

The six Hard and Soft Iron corrections in the X, Y and Z axis are offset and scalar values that are used to re-map the magnetometer readings back into the 'ideal sphere' discussed above.
These values are obtained by rotating the Beacon (and its mounting platform) through as many orientations possible in 3D space to determine the distorting effect of the surroundings, from this a Fit-Error (i.e. how well the results match the ideal sphere) is computed.

For further details on automatically obtaining these values through the calibration procedure, please refer to section 2.3 on page 18.

3.5.3. Rotational Rate-Gyroscope Calibration Constants

The rotational rate-gyroscope is responsible for measuring how fast the beacon is being rotated around each axis relative to its local frame of reference (see the section on page 65 for definitions).

The gyroscope values are used to minimise the AHRS response time and provide rapid updates to the yaw, pitch and roll readings.

Temperature and time dependant drift corrections are removed by the magnetometer and accelerometer sensors, but three sensor offset value are provided for diagnostic purposes.

Normally the 3 offsets for the X, Y and Z axis should be set to a value of zero (0).

3.5.4. Dynamic Magnetic Calibration

In addition to initial static calibration, the AHRS system also features the ability to perform ongoing dynamic magnetic calibration, by continuously analysing the magnetic field around the beacon as it is rotated, and determining if better calibrations can be applied than the current calibration in use (by examining Fit-Error and Field-Scalar values).

Normally on mobile platforms, it is recommend to leave dynamic calibration enabled (the default setting), but if a beacon is remaining stationery for long periods of time it may be beneficial to disable this option.

3.6. Acoustic Transceiver

The Acoustic Transceiver module is responsible for undertaking all aspects of acoustic data communications, ranging and position computation from USBL signals (X150 beacons only).

3.6.1. Beacon Identification (ID)

To allow messages to be exchanged between Beacons, each unit's Acoustic Transponder module must be assigned a unique Identification value (ID) between 1 and 15.

Care should be taken to avoid allocating the same ID value to more than one beacon, otherwise during acoustic communications multiple beacon responses will be triggered simultaneously and messages corrupted.

To simplify setup and aid identification, the ID code currently used by each Beacon will be displayed by a series of short green flashes on the Status LED (situated on the base of the housing).

To read the identification code, power up the beacon and wait for a 2-second-long green flash to indicate the start of the sequence, then count the number of short green flashes that follow until the 2 second pause when the LED is off.

From beacon firmware version 3.2.8 onwards, you may also see an orange flash if the ID is greater than 9. The orange flash indicates a value of 10, and any green flashes that follow indicate a value of 1 as before. Combinations of colours can be added up to get the final ID value. For example, 1 orange flash followed by 5 greens would mean ID = 15.

The following are some examples of reading the Beacon ID code:

- For Beacon ID = 3



- For Beacon ID = 5



- For Beacon ID = 10 (FW 3.2.8 onwards)



3.6.2. Timeout Range

As the Acoustic Transceiver uses a "Request / Response" scheme to determine the range to remote beacons, and bi-directionally transfer data, it needs some mechanism to determine at which point it should stop waiting for a response to be returned and signal a Timeout Error has occurred.

To achieve this, the Timeout Range settings specified the maximum range at which beacons can be interrogated and a response expected. When beacons pass beyond this range boundary (relative to the transmitting beacon) their responses will be discarded.

Setting a larger Timeout Range value will allow beacons to operate further away from the interrogating beacon (within their acoustic limitations), but will also increase the maximum time it may take for navigation and tracking systems to poll round the network of beacons if communications are intermittent due to poor conditions.
Allow approximately 133ms of delay per 100m of range, i.e. for 1000m the range timeout will be 1.3 seconds of inactivity while waiting for a response.

3.6.3. Response Time

When a remote beacon is interrogated by a Request message it must generate the Response within a set constant period of time, that can be accounted for when computed the range.

By default, this "Response Time" is set to be 10ms (the minimum value allowed), but can be increased to improve receiver reliability in situations where there is significant amounts of acoustic reverberation, as more time is allowed for echoes to die away - i.e. test tanks, swimming pools, enclosed docks and harbours.

Each remote beacon and the local beacon used within the network must be configured with the same Response Time, otherwise reported Range values will be inconsistent and inaccurate.

3.6.4. Activity Output

For applications that wish to monitor the status of the Acoustic Transceiver, or not implement support for the more complex Acoustic Communication Protocols, the Activity Output settings provide a means to enable the generation of simple serial communications messages in response to transceiver events…

- Tx/Rx Messages

  When enabled, messages are produced when the Acoustic Transceiver transmits a message, receives a message, requests a response, receives a response to a request, or encounters an error (checksum failure, timeout etc).

  Generated messages typically contain the source and destination Beacon ID codes, the message contents and any other relevant status information, as well as a Received Signal Strength Indication (RSSI) in decibels.

- **Fix Messages**

  Fix messages are generated when the Acoustic Transceiver receives either…

  1) a response from which ranging information can be determined (X110 and X150), and/or

  2) a valid USBL signal (X150 only) from which it can determine the position of the remote beacon.

  Fix messages contain details of the remote beacons ID, range, depth, position (X150), current VOS and signal angles.

- **USBL Messages**

  USBL messages are only generated by the Acoustic Transceiver modules on X150 series beacons in response to receiving a valid USBL signal form the remote beacon.

  These messages contain decoded signal waveforms and information on detection, channel decoding, baseline phase angles, resolved signal angles and signal strength for diagnostic analysis. As such, these messages are typically large in size (up to 500 bytes), and should be disabled when slower serial communication speeds are used, or the diagnostic information is not required.

3.6.5. USBL Attitude

On X150 series beacons, the Acoustic Transceiver uses the in-built AHRS to resolve positions in its local frame-of-reference to the world frame-of-reference (as Northing's, Easting's and Depth's from the surface).

When the "USBL uses AHRS" option is enabled, orientation information is internally passed between the AHRS and Acoustic Transceiver when new USBL messages are received.



However, this feature can be disabled if the Beacon is mounted on a fixed installation and instead constant attitude offsets for yaw, pitch and roll are instead applied to align local to world coordinates.

If values of zero are used for yaw, pitch and roll, then coordinates in the beacons local frame-of-reference will be reported.

4. Troubleshooting

4.1. Hardware Issues

• When I power up the beacon, there is no activity on the status LED.	Check the power supply is connected with the correct polarity. Check the power supply is at the correct levels, noise and glitch free as this may be resetting the beacon unexpectedly. Check power is reaching the beacon connector through any external wiring loom. Check if the beacon response to serial communication, or attempt to put the beacon into "Bootloader Mode" – see section 2.8.
• When powered up the beacon status LED flashes Red (slowly).	A slow flashing red LED indicates the beacon has entered "Bootloader mode". This may be because a magnet is present over the magnetic sensor causing the beacon to stay in Bootloader mode, or the main application firmware may be corrupt or not present (preventing the beacon from starting it). Remove any strong magnet from around the beacon and cycle the power. If this fails, attempt to re-program the main application firmware.
• When powered up the beacon status LED flashes Red (quickly).	A quick flashing red LED indicates the magnetic sensor is active. To clear the fault, check there is no magnet (or strong magnetic field) present by the beacon.
• The beacon has unpredictable or incorrect operation.	Check the power supply is at the correct levels, noise and glitch free as this may be resetting the beacon unexpectedly. The non-volatile memory that holds the application firmware may have become corrupt (due to the presence of a large electro-magnetic spike, etc). Attempt to put the beacon into Bootloader mode (see section 2.8) and apply new firmware (see section 2.7).
• Settings appear changed or corrupt after firmware update.	Some firmware update may add new features and settings that require the reconfiguration of the internal non-volatile Flash memory where settings are stored. In these cases, the beacon will attempt to apply default settings where possible, but there may be occasions where sensor calibrations and values are lost. It is always advisable to use SeaTrac tools to backup settings before performing a Firmware Upgrade.
• The magnetic reset to details (or enter Bootloader mode) function does not work.	The magnetic sensor is disabled 2 minutes after the beacon is powered up (to save power and prevent accidental operation while in the field). Cycle the beacons power and try the operation again.

4.2. Serial Communications Issues

• I get no serial communications from the beacon.	Start by checking the beacon power supply is at the correct levels, noise and glitch free. If there is not status LED activity, it is likely the processor is not running and the beacon's internal fuse may have gone open-circuit. Alternately, the firmware may be corrupt and need reprogramming. The beacon processor is running if the status LED is flashing the beacon ID code in green. If the Reset-Magnet is placed over the magnetic sensor it should quickly flash red. If the LED is slowly flashing red, the beacon may be stuck in Bootloader mode. Check the beacons serial baud-rate hasn't been changed : either use the magnet to reset the beacon to defaults (115200 baud), or try connecting with other baud rate values in the software application. If connection is possible with the beacon, use the SeaTrac Tools application to check the required output and status settings have been enabled.
• The serial communication output seems either slow, intermittent or misses messages.	The beacon may be configured to send more information over the serial link than can be handled by the current baud rate setting. Either increase the speed of the serial link, by increasing the beacons configured baud-rate value, or disable some of the required information output (i.e. turn off Status Output message field groups, and disable Acoustic Transceiver USBL activity messages – very large!). See sections 3.2, 3.3 and 3.6.4 for further details.

4.3. Inaccurate Output Issues

• The beacons AHRS produces an inaccurate attitude reading (yaw, pitch or roll).	The AHRS system uses a magnetometer to measure the surrounding magnetic field, and an accelerometer to measure the direction of gravity – from these it can determine yaw, pitch and roll. For errors in yaw, changes in the surrounding magnetic field may require the magnetometer to be recalibrated – see sections 2.3.2, 3.5.2 and 3.5.4 for further details. For errors in pitch and roll, extreme temperature changes may require the accelerometer to be recalibrated – see sections 2.3.1 and 3.5.1 for further details.
• The depth sensor reading is inaccurate.	Ensure the pressure offset has been set to zero the depth sensor reading to the surface of the water, and does not contain a large or erroneous reading – or ensure that the "Auto-Calculate Pressure Offset" option has been enabled.

	The depth sensor if specified to produce readings accurate to 0.5% of its full-scale output over the temperature range form 0°C to 50°C. Therefore, if a depth sensor with large range is specified (i.e. 200bar) then all reading will have a tolerance of ±1bar (or approx ±10m). See sections 3.4.4 and 3.4.5 for further details.
• The beacon produces inaccurate Range readings.	The range between beacons is calculated by timing how long it takes for the remote beacon to receive, generate and return a response. From this time, the velocity-of-sound value is used to compute a range. Check the specified VOS value is correct, or salinity is correct (0 for fresh water, approx 35 for sea water) if Auto-Calculate VOS is enabled – see sections 3.4.1, 3.4.2 and 3.4.3 for further details. Check all beacons use the same "Response Time" value, as differing values will introduce timing errors – see section 3.6.3 for further details.
• I get a significant error in the USBL 'fix' position	The resolved position of a USBL fix is the cumulative output of a series of calculations, from ranging the remote beacon, examining the direction of received signals, calculating a relative position and compensating this with the local beacons attitude to obtain world coordinates. Each of these stages has the potential to introduce errors, and the net result of several inaccuracies may be combined together. For ranging, ensure the Velocity-Of-Sound value is specified (or computed) correctly (see section 3.4), and all beacons use the same "Response Time" setting. Ensure the AHRS system is correctly calibrated (see section 2.3), or rigidly mount the beacon to the platform and specify the attitude offsets used by the USBL system. Ensure the depth sensors "pressure offset" reading has been zeroed correctly. Ensure there are no obstacles blocking the acoustic path between beacons, and they are mounted far enough below the water surface and away from reflecting structure to avoid multi-path effects degrading the signal. Use SeaTrac Tools to perform acoustic tests with the PING and ECHO commands to validate ranges, test the background receiver noise levels, examine received RSSI levels and examine the USBL signal for multi-path effects.

4.4. Acoustic Communication Issues

• The beacon does not receive messages – I get "Response Timeout" errors	Response Timeouts occur either when the remote beacon hasn't received a request, or the local beacon hasn't received the sent response. Both or these situations are usually due to the acoustic

	conditions present in the local water environment. A simple source of this problem is two beacons have the same Beacon ID code and are attempting to response at the same time – check each beacon has a unique code, see section 3.6.1. Initially it is worth checking that the remote beacon does not lie further away than the local beacons "Range Timeout" settings, as ranges beyond this will be ignored. If settings look correct, to resolve which end of the link is failing, connect a PC running the SeaTrac tools application to beacons at both end of the link (if possible) and use the PING command to interrogate the other beacon. If the Acoustic Transcevier "Activity Output" settings are enabled, signal levels for the Data and USBL transmissions can be analysed. SeaTrac Tools can also be used to carry out other tests – use the "Rx Analysis" function on the Acoustics tab to perform a background noise test and check the levels are below the RSSI levels observed (generally less than 95 dB) Section 2.5 details how to perform these diagnostic tests. See the section below for "Rx Checksum" errors for further possible causes.
• The beacon produces "Rx Checksum" errors.	A checksum error occurs when the beacon's receiver has been triggered by the decoded data content does not match the checksum sent at the end of the message. A simple source of this problem is two beacons have the same Beacon ID code and are attempting to response at the same time – check each beacon has a unique code, see section 3.6.1. This problem usually occurs in environments where multi-path effects and reverberating echoes degrade the current signal (i.e. enclosed environments with hard reflective sides or bottoms – i.e. tanks, lock chambers, pipes etc), and is hard to solve. Attempt to place the beacons in open clear water away from reflecting surfaces of the water surface. Slow down the ping/generation rate of acoustic messages, and investigate increasing the "Response Time" setting for all beacons (see section 3.6.3) to allow more time for echoes to die down. Use SeaTrac Tools to help diagnose communications and the USBL signals – see section 2.5.

5. Technical Support

5.1. Website

For the latest software and firmware updates, as well as production information, manuals and datasheets, visit…

www.blueprintsubsea.com/seatrac/support.php

We welcome any feedback you may have about SeaTrac products, from bug reports to ideas for new features or hardware to support – please use the contact details on the website (or shown below) to get in touch.

5.2. Technical Support

If your SeaTrac product is not operating properly, please consult the 'Troubleshooting' section of this manual and further information on the above website to see if the problem can be easily remedied.

However, if you need further support, you can contact us at…



- Web — www.blueprintsubsea.com (for access to on-line resources and technical support)



- Email — support@blueprintsubsea.com



- Call us — +44 (0)1539 531536 (9:00am to 5:00pm, Monday to Friday, GMT/BST)

For all of the above please provide the following information, where appropriate and if possible, to help us with your technical support request…

- Part and Serial Numbers of the system components. These are located on the labels of each item, and are in the form "BPxxxxx.xxxxxx".
- Version numbers of the software and firmware you are using.
- The operating system name, version, type (32 bit or 64 bit) and service pack upgrade your computer is using.
- Brand and model of your computer (processor type and memory configuration is also useful if known).

- Name of the distributor where the system was purchased from.

If you have to return your SeaTrac product for servicing, please…

- Contact us (using the details above) for a "Returned Materials Authorisation" (RMA) number, and shipping details.
- Pack your SeaTrac system back in the original packaging (or other suitable container), and include written documentation including your contact details (including contact phone number), the RMA number and a description of the problem and any symptoms occurring.
- If your product is still under warranty, please include a copy of your receipt (showing proof and date of purchase).
- Please return the product back to Blueprint Design Engineering Ltd, using an insured courier and delivery confirmation.

6. Appendix

6.1. Notices

Copyright

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All information in this document is believed to be correct at the time of going to press, Blueprint Design Engineering Ltd cannot be held responsible for any inaccuracies or omissions. If you find an error or feel we have missed important or useful information, please contact us. The latest version of the manual is always available to download from the website.

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Acoustic Limitations

Please note, the actual operation ranges achieved between acoustic beacons depends heavily on environmental factors (including water temperature, dissolved oxygen content, marine plant life and man-made acoustic noise from passing vessels and submerged equipment), geographical conditions (such as depth of channel, acoustic reverberation nearby structures and obstacles that may block the acoustic transmission) and the mounting method, orientation and position of the beacon of each operating platform. Acoustic performance values stated in the documentation describe achievable results obtained in favourable conditions.



Handling Recommendations

SeaTrac products contain sensitive electronic components that may be damaged by an Electrostatic Discharge (ESD) if handled incorrectly. To minimise risk, avoid dismantling the unit, touching any exposed electrical contacts on external connector, or inserting anything other than the recommended cabling into the connectors.



Waste Electrical & Electronic Equipment Statement

Under the European Union (EU) directive on 'Waste Electrical & Electronic Equipment' (Directive 2002/96/EC), from August 13, 2005, products categorised as electrical or electronic equipment cannot be discarded as municipal waste by placing in landfill, dumping in the sea or incineration. SEPARATE collection is mandatory.

At the end of its life, you should either return this system and its associated leads & accessories (if appropriate) to Blueprint Design Engineering Ltd with a certificate of decontamination (we reserve the right to protect our staff from the effects of any contamination) or it should be sent to an appropriate treatment or recycling agency.



Restriction of Hazardous Substances Statement

Under the European Union (EU) directive on the 'Restriction of Hazardous Substances' (Directive 2002/95/EC), from July 1, 2006, electrical and electronic equipment cannot contain lead ("lead free"), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

All components of the this system, sold by Blueprint Design Engineering Ltd, fully comply with this legislation where applicable.

6.2. Limited Warranty Policy

The manufacturer, Blueprint Design Engineering Ltd (herein after referred to as Blueprint), warrants that at the time of shipment all products shall be free from defects in material and workmanship and suitable for the purpose specified in the product literature.

The system warranty commences immediately from the date of customer acceptance and runs for a period of 365 days. Customer acceptance will always be deemed to have occurred within 72 hours of delivery.

Conditions

These include, but are not limited to, the following…

1. The warranty is only deemed to be valid if the equipment was sold through Blueprint or one of its approved distributors.
2. The equipment must have been installed and commissioned in strict accordance with approved technical standards and specifications and for the purpose that the system was designed.
3. The warranty is not transferable.
4. Blueprint must be notified immediately (in writing) of any suspected defect and if advised by Blueprint, the equipment subject to the defect shall be returned by the customer to Blueprint, via a suitable mode of transportation and shall be freight paid.
5. The warranty does not apply to defects that have been caused by failure to follow the recommended installation or maintenance procedures, or defects resulting from normal wear & tear, incorrect operation, fire, water ingress, lightning damage or fluctuations in vehicles supply voltages, or from any other circumstances that may arise after delivery that is out with the control of Blueprint. (Note: The warranty does not apply in the event where a defect has been caused by isolation incompatibilities.)
6. The warranty does not cover the transportation of personnel and per diem allowances relating to any repair or replacement.
7. The warranty does not cover any direct, indirect, punitive, special consequential damages or any damages whatsoever arising out of or connected with misuse of this product.
8. Any equipment or parts returned under warranty provisions will be

returned to the customer freight prepaid by Blueprint

9. The warranty shall become invalid if the customer attempts to repair or modify the equipment without appropriate written authority being first received from Blueprint.

10. Blueprint retains the sole right to accept or reject any warranty claim.

11. Each product is carefully examined and checked before it is shipped. It should therefore be visually and operationally checked as soon as it is received. If it is damaged in anyway, a claim should be filed with the courier and Blueprint notified of the damage.



If the system is not covered by warranty, or if it is determined that the fault is caused by misuse, repair will be billed to the customer, and an estimate submitted for customer approval before the commencement of repairs.

Any customer acceptance testing (if applicable) must be performed at either Blueprint premises or at one of their approved distributors unless mutually agreed in writing prior to despatch.

6.3. Glossary of Terms

• Absolute Positions	In the SeaTrac system Absolute positions are coordinates that are specified with respect to the earth, not a local beacon – usually as a latitude and longitude pair.
• Acoustic Stack	The SeaTrac Acoustic Stack refers to the implementation of the acoustic specifications and communication protocols that define the operation and function of the modem and navigation beacons. Further details of the Acoustic Stack and its layers and protocols can be found in the SeaTrac Beacon Software Development Kit (SDK) documentation.
• Attitude	Attitude refers to the orientation of one object with respect to another – typically the SeaTrac Beacon with respect to the world frame of reference. Attitude is described by three compound rotation angles – yaw, pitch and roll. See section 6.5.1 on page 65 for further details.
• Attitude and Heading Reference System (AHRS)	An Attitude and Heading Reference System (AHRS) usually consists of an accelerometer, magnetometer and gyroscope sensor that each monitor 3 orthogonal axis (X, Y and Z) to provide attitude information for a body, described by yaw, pitch and roll values.
• Azimuth	Azimuth is the angle (measured in degrees) in a spherical coordinate system that defines a horizontal projection angle measured clockwise from a north base line or meridian reference (i.e. front of the Beacon).
• Baud Rate	Baud rate is a term used in telecommunications to describe the number of bits or symbols per second being sent over a communications link (be it acoustic or electrical).
• Beacon	In the SeaTrac system, Beacons are the hardware devices used to transmit and receive acoustic information and provide an interface to digital hardware devices (such as computers or embedded controls systems) forming the backbone of a navigation or communications network. The X110 device is described as a Modem & Transponder Beacon, while the X150 device is a Modem & USBL Beacon.
• Beam Pattern	Acoustic transducers transmit a sound wave that varies in intensity in different directions because of constructive and destructive interference patterns, where the overall shape of the intensity/angle function is referred to as Beam Pattern. Typically a beam pattern with have angle of maximum intensity referred to as the “main lobe”, whose width (or angle) is defined as the points where the intensity if half (-3dB) of the maximum intensity. Additionally further “side lobes” may be present as lower intensities depending on the design of the transducer. Acoustic received also have a defined beam pattern that refers to the transducer sensitivity function versus angle.

• Decibel (dB)	The decibel (dB) is a logarithmic unit used to express the ratio between two values of a physical quantity. In acoustic terms, one of these quantities is a reference value of 1 micro-Pascal (written fully as 'dB re 1μPa'), allowing it to express the absolute intensity level of the transmitted or received signals. Every 6dB intensity increase represents a doubling of signal strength, and conversely a 6dB reduction in signal strength represents a halving of signal. Similarly, a 20dB increase represents a gain of 10.
• Degrees of Freedom (DOF)	Degrees of freedom (DOF) in a mechanical system specify the number of independent parameters that define its configuration. In SeaTrac Beacons, the AHRS is described as a 9 DOF system, as it contains 3 sensors (accelerometer, magnetometer and gyroscope) each measuring data on 3 axes (X, Y and Z).
• Depth	Depth is defined as the distance vertically downwards from the surface of a body of water. Depth can be specified as an absolute or relative value – an absolute terms, positive values of depth describe a distance underwater from the surface, while negative values describe a distance above the water surface. Relative values describe a vertical translation from a reference depth in either a positive downwards, or negative upwards, direction.
• Easting	Eastings are one of the terms describing a geographic Cartesian coordinates for a point, where an easting refers to the eastward-measured distance (or the x-coordinate) usually measured in metres from a horizontal datum. A 3-dimensional coordinate comprising Nortings, Eastings and Depths is sometimes referred to as an NED coordinate.
• Elevation	Elevation is the angle (measured in degrees) in a spherical coordinate system that defines the vertical projection angle of a vector above or below a horizontal reference plane, with +90° representing vertically up and -90° representing vertically down.
• Fix	Within the scope of the SeaTrac system, "Fix" is the term applied to the process of acoustically interrogating a remote beacon and receiving a response from which ranging and/or positioning information is computed, resulting in a "fix".
• Frame-of-Reference	A frame of reference to refers to either a coordinate system, set of axes or is used to represent and measure properties of objects, such as their position or orientation. Frames of reference must be defined with respect to some origin or reference. In the SeaTrac system, local frames of reference are defined with respect to the Beacon's housing, while world frames of reference are defined with respect to gravity and magnetic north. See section 6.5 on page 65 for further details.
• Modem	A modem (or modulator-demodulator) is a device that modulates an analogue carrier signal to encode digital information and demodulates the signal to decode the transmitted information content.

• NED Coordinates	NED is the abbreviation used to describe an absolute 3-dimensional Cartesian coordinate, or position offset relative to a horizontal datum. NED can either mean "Northing, Easting and Depth" or "North East down" where the 3-dimensions represent the position along the northern axis (Y), one along the eastern axis (X), and one represents vertical position (Z). Down is chosen as opposed to up in order to comply with the right-hand rule for axes rotational directions.
• Northing	Northings are one of the terms describing a geographic Cartesian coordinates for a point, where a northing refers to the northward-measured distance (or the y-coordinate) usually measured in metres from a horizontal datum. A 3-dimensional coordinate comprising Nortings, Eastings and Depths is sometimes referred to as an NED coordinate.
• Platform	In the SeaTrac system, Platform is the term used to describe the structure onto which a beacon is mounted or operated from. For example an X110 modem beacon may be mounted onto an ROV, AUV, Scuba Diver or sub-sea installation, while an X150 USBL beacon may be mounted onto (or suspended from) a vessel, quay-side or pontoon.
• Received Signal Strength Indication (RSSI)	Received Signal Strength Indication (RSSI) is a measure of the strength of the received signal compared to the transmitted signal strength (nominally 173dB), and is quoted in decibels. For SeaTrac Beacons, every 6dB intensity reduction in RSSI represents a halving of the received signal strength (while 20dB represents a 10-fold reduction). RSSI values can be obtained via serial port command following an acoustic reception.
• Relative Positions	Relative positions are those specified with respect to a specified origin. In the SeaTrac system, X150 USBL beacons compute the positions of remote beacons with respect to the local USBL beacon as an NED coordinate – these positions are referred to as relative positions.
• RS-232	RS-232 is a telecommunications standard for digital serial communication transmission of data, formally defining the signals connecting between a DTE (data terminal equipment) such as a PC and a DCE (data communication equipment) such as a SeaTrac Beacon. The RS-232 standard in its simplest form requires 3 electrical signals, Transmit (TX), Receive (RX) and Ground (GND) and on SeaTrac systems these are specified with respect to the Beacon (DCE) end of the link. Electrical signals can be in the range of ±5 to ±15V, and on SeaTrac Beacons these typically are +6V representing a logical '0' and -6V representing a logical '1'. RS-232 communications can be quickly and simply connected directly to most embedded systems, and to modern PCs (that don't natively feature a serial port) via and RS232-to-Usb converter module.
• Salinity	The acoustic properties of water will vary depending the quantity of dissolved salts it contains. This is referred to as Salinity and is specified in "parts per thousand" (ppt).

	Fresh water has a salinity of 0ppt while the average salinity of the worlds oceans is approximately 35ppt.
• Spherical Angle	When the USBL system received a valid positioning signal, it computes a spherical angle indicating its direction of origin. Spherical angles are specified by an Azimuth and Elevation value. See section 6.5.2 on page 66 for further details.
• Transceiver (XCVR)	A transceiver (XCVR) is a device capable of both transmitting and receiving signals. Transceivers are the key functional module within a transponder beacon.
• Transducer (XDCR)	A transducer (XDCR) is a device that is capable of converting on form of energy into another. In the case of the SeaTrac beacons the transmission (TX) and reception (RX) transducers convert electrical energy to acoustic waves and back again.
• Transponder (XPDR)	Transponders (XPDR) are acoustic devices capable of performing a transmission and responding to one (transponder being a portmanteau of transmitter-responder). Both the X110 and X150 SeaTrac beacons are transponders.
• Ultra Short Base Line (USBL)	USBL is a method of underwater positioning consisting of a local transceiver transmitting acoustic pulses to a remote transponder and receiving signals back. An array of receiver elements (usually spaced within the wavelength of the acoustic frequency in use) determines the incoming angle of the signal by measuring phase differences in acoustic paths, while ranging is computed from the transmission-to-reception time (based on the current VOS).
• Velocity-of-Sound (VOS)	The speed at which acoustic waves propagate through the medium of water is referred to a VOS (Velocity of Sound). The exact speed is dependant on the water temperature, salinity content and the depth at which the sound waves are travelling. Accurate specification of VOS is important is ranging applications to minimise the computed error range error from acoustic timings. Specific values for VOS can be found in section 6.6 on page 68.

6.4. Technical Data

6.4.1. Specifications

	SeaTrac X150	SeaTrac X110
Part Number	BP00795	BP00843

Mechanical

Length	130mm (5.2”) excluding connector 159mm (6.3”) including connector	107mm (4.2”) excluding connector 136mm (5.3”) including connector
Diameter	54mm	
Weight	710g in air, 510g in water	680g in air, 485g in water
Depth Rating	2000m (other depths available)	
Construction	316 Stainless Steel	
Mounting Holes	2 × M4 at 37mm centres, 4mm deep	
Operating Temp Range	-5°C to +40°C (23°F to 104°F)	

Electrical

Connector	Teledyne Impulse MCBH-5-MP (5-way bulkhead plug)
Communications	Options from RS232 (x2, Main and Aux), RS485, Ethernet / USB (available Q4 2014)
Supply Voltage	9V to 28V DC
Power Consumption	Peak load up to 10W when transmitting, approximately 0.6W in standby
Integrated Sensors	Pressure, Temperature, 9-DOF AHRS, Supply Voltage Monitor
Indicators	Red/Green visual status LED

Acoustic

Remote Ranging	Yes	Yes
Remote Positioning (USBL)	Yes	No
Transmit Level	173dB re 1μPa	
Receiver Sensitivity	Ring Receiver -190dB re 1μPa, USBL Receivers -230dB re 1μPa	
Acoustic Range	1km radius horizontal, 1km vertical (TBC)	
Ranging Resolution (1)	50mm (dependant on VOS accuracy)	
Angular Resolution (1)	0.5°	N/A
Velocity-of-Sound Range	1300ms-1 to 1700ms-1	
Beacon Velocity	Active Doppler compensation, up to 15kts (28kph)	
Communications	Broadband spread spectrum encoding, 24-32kHz, 100 baud. Multi-tiered Acoustic Protocol Stack.	
Message Addressing	15 unique beacon identifiers, and broadcast to all capability.	

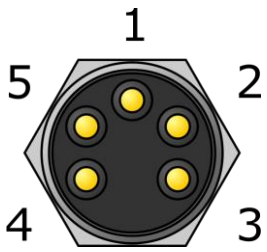
Applications

Supported Software Platforms	SeaTrac PinPoint Software, SeaTrac Tools Management Utility, SeaTrac Programmer Utility
Developers/Integrators	SDK, including ASCII based serial command interface with Application level and Acoustic Protocol Stack level commands for third party integration.

Notes…

1) Acoustic range resolution and angular resolution depend on accurate specification of Velocity-of-Sound.

6.4.2. Connector Pin-out



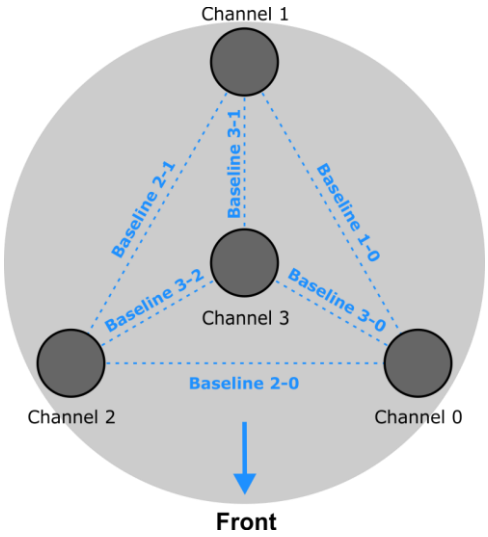
(pin view)

1. Power Supply, Positive
2. Power Supply, Ground
3. Serial Communications, RS232 Transmit
4. Serial Communications, RS232 Receive
5. Not Used

6.4.3. USBL Transducer Identification

On the X150 beacon, for reference and diagnostic purposes, the diagram opposite shows the identification scheme used for USBL transducers and the baselines they form for phase angle analysis.

These channel and baseline identifiers are used on the SeaTrac Tools application and throughout technical documentation…

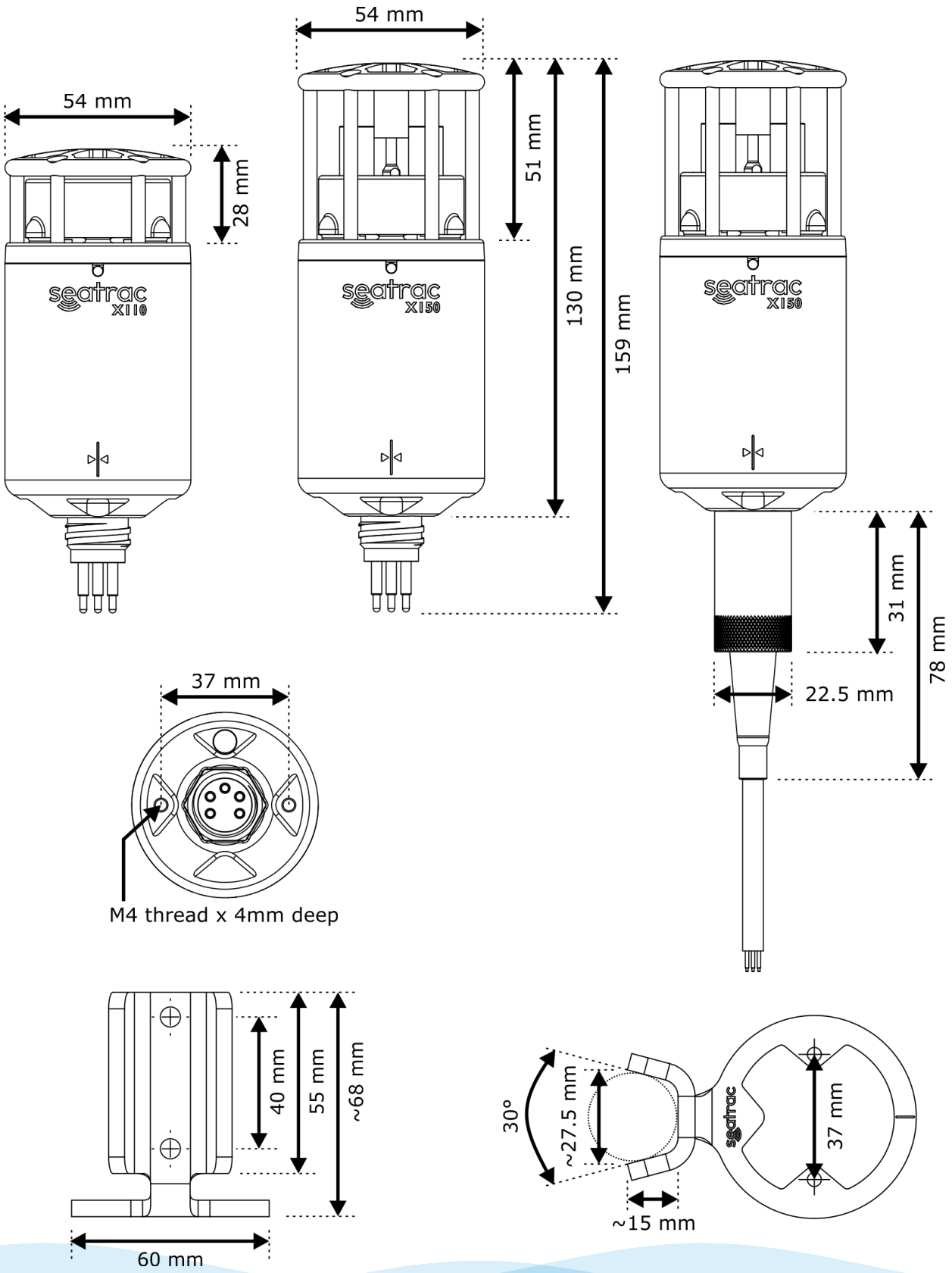


(USBL Transducers, Top Down View)

When USBL data is output via the serial communications port, the following array index scheme is used…

- Index 0 = Baseline 1-0
- Index 1 = Baseline 2-0
- Index 2 = Baseline 2-1
- Index 3 = Baseline 3-0
- Index 4 = Baseline 3-1
- Index 5 = Baseline 3-2

6.4.4. Mechanical Drawings



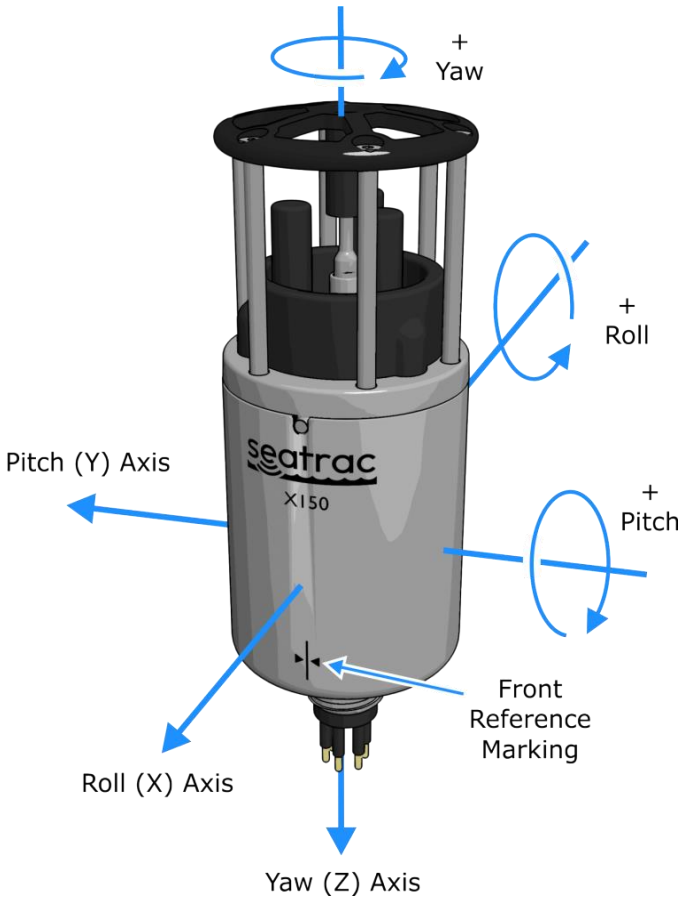
6.5. Frames Of Reference

The diagrams below show the definitions of the SeaTrac Beacon's frames-of-reference…

6.5.1. Attitudes (Yaw, Pitch and Roll)

For rotation and orientation, the beacon uses the following axis definitions.
These follow the same standard as those used to define aircraft attitudes and rotations, allowing the "right-hand-rule" to be applied to each axis.

By orienting the positive Z-axis downwards, positive Yaw angles also match compass headings, with 0° Yaw occurring when the housing "front" marking aligns with magnetic north.
Pitch and Roll angles are 0° when gravity is perpendicular to (and below) the horizontal plane, defined by the XY axis pair.

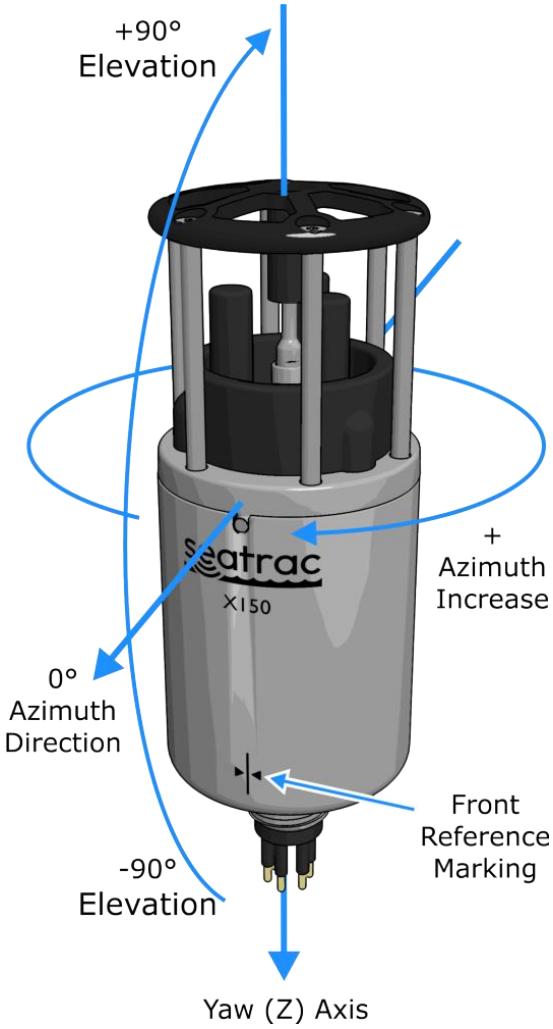


Attitudes are valid where…

- 0° ≤ Yaw < 360°
- -90° ≤ Pitch ≤ +90°
- -180° ≤ Roll < +180°

6.5.2. USBL Spherical Angles (Azimuth and Elevation)

On X150 beacons, for resolving incoming USBL signals, positive azimuths are defined as being a positive rotation around the yaw axis (complying with the right-hand-rule). Positive elevations are defined as being above the beacons horizontal plane (defined by the XY axis pair), while negative elevations are defined as being below it.

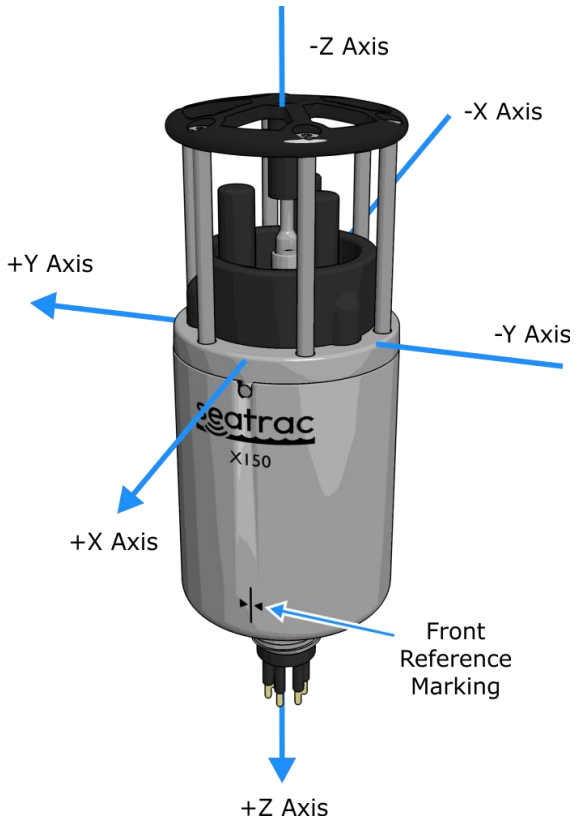


Spherical angles are valid where…

- 0° ≤ Azimuth < 360°
- -90° ≤ Elevation ≤ +90°

6.5.3. USBL Local Relative Position Coordinates

On X150 beacons, having resolved the range and incoming USBL signal angle (as an azimuth and elevation), the position of the remote beacon in the beacon's local frame of reference is computed (in metres) and defined in the coordinate frame shown below…



Coordinates are relative to the beacon's position, with the origin being the defined as the centre of the upper beacon housing bulkhead.

Please note that to comply to the earlier 'attitude' definition, positive Z axis directions are defined as "down" (towards the seabed) when the beacon is mounted in the upright position shown above.

6.5.4. USBL World Relative Position Coordinates

On X150 beacons, once a local frame-of-reference position is computed, it is transformed into the world frame-of-reference using the attitude from the AHRS (or user specified setting).

World coordinates are provided in a Cartesian Northing, Easting and Depth (NED) triplet, with values stated in metres. Positive values of depth represent a translation towards the seabed, while negative values represent a translation towards the surface.

6.6. Velocity-Of-Sound Values

SeaTrac Beacons use the Coppens (1981) equations for computing the velocity of sound in water, which provides valid results for temperatures from 0° to 35°C, salinities of 0 to 45 parts per thousand, and depths from 0 to 4000m.

For manual and constant entry, typical values of VOS are…

6.6.1. Fresh Water

Fresh water specified as 0 ppt salinity…

		Temperature (°C)					
		0	**5**	**10**	**15**	**20**	**25**
Depth (m)	**0**	1402.4	1426.1	1447.2	1465.9	1482.4	1496.7
	100	1404.0	1427.7	1448.8	1467.5	1484.0	1498.3
	500	1410.6	1434.2	1455.3	1474.0	1490.4	1504.8
	1000	1418.8	1442.5	1463.5	1482.1	1498.5	1512.8
	1500	1427.2	1450.8	1471.7	1490.3	1506.5	1520.8
	2000	1435.7	1459.1	1480.0	1498.4	1514.6	1528.7
	2500	1444.3	1467.6	1488.3	1506.6	1522.7	1536.7
	3000	1453.0	1476.2	1496.7	1514.9	1530.8	1544.6
	3500	1461.8	1484.8	1505.2	1523.2	1538.9	1552.5
	4000	1470.7	1493.5	1513.7	1531.5	1547.0	1560.4

6.6.2. Sea Water

Fresh water specified as 35 ppt salinity…

		Temperature (°C)					
		0	**5**	**10**	**15**	**20**	**25**
Depth (m)	**0**	1449.1	1470.6	1489.8	1506.7	1521.5	1534.3
	100	1450.7	1472.3	1491.4	1508.3	1523.1	1536.0
	500	1457.2	1478.8	1498.0	1515.0	1529.8	1542.8
	1000	1465.5	1487.1	1506.4	1523.3	1538.2	1551.2
	1500	1473.9	1495.5	1514.7	1531.7	1546.6	1559.5
	2000	1482.4	1504.0	1523.2	1540.1	1555.0	1567.9
	2500	1491.0	1512.5	1531.7	1548.6	1563.4	1576.3
	3000	1499.7	1521.2	1540.2	1557.0	1571.8	1584.6
	3500	1508.5	1529.9	1548.8	1565.6	1580.2	1592.9
	4000	1517.4	1538.7	1557.5	1574.1	1588.6	1601.2

6.7. Expected RSSI versus range

The table below shows expected RSSI levels for beacon returns at the specified range and water temperature, and can be used to help diagnose acoustic communication issues.

Signal levels in dB re 1µPa	Range(m)	Fresh Water (Salinity 0 ppt) Temperature (°C)						Sea Water (Salinity 35 ppt) Temperature (°C)					
		0	5	10	15	20	25	0	5	10	15	20	25
	1	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0
	5	159.0	159.0	159.0	159.0	159.0	159.0	159.0	159.0	159.0	159.0	159.0	159.0
	10	153.0	153.0	153.0	153.0	153.0	153.0	152.9	153.0	153.0	153.0	153.0	153.0
	20	147.0	147.0	147.0	147.0	147.0	147.0	146.8	146.9	147.0	147.0	147.0	147.0
	30	143.4	143.4	143.4	143.4	143.4	143.4	143.2	143.4	143.4	143.4	143.4	143.4
	40	140.9	140.9	140.9	140.9	140.9	140.9	140.6	140.9	140.9	140.9	140.9	140.9
	50	139.0	139.0	139.0	139.0	139.0	139.0	138.6	138.9	139.0	139.0	139.0	139.0
	60	137.4	137.4	137.4	137.4	137.4	137.4	136.9	137.3	137.4	137.4	137.4	137.4
	70	136.1	136.1	136.1	136.1	136.1	136.1	135.5	135.9	136.0	136.0	136.0	136.0
	80	134.9	134.9	134.9	134.9	134.9	134.9	134.2	134.8	134.8	134.9	134.9	134.9
	90	133.9	133.9	133.9	133.9	133.9	133.9	133.1	133.7	133.8	133.8	133.8	133.8
	100	133.0	133.0	133.0	133.0	133.0	133.0	132.1	132.8	132.9	132.9	132.9	132.9
	150	129.4	129.4	129.4	129.4	129.4	129.4	128.2	129.1	129.3	129.3	129.4	129.4
	200	126.9	126.9	126.9	126.9	126.9	126.9	125.2	126.5	126.7	126.8	126.8	126.8
	250	124.9	124.9	124.9	125.0	125.0	125.0	122.8	124.5	124.7	124.8	124.8	124.9
	300	123.3	123.3	123.3	123.4	123.4	123.4	120.8	122.8	123.0	123.1	123.2	123.2
	350	122.0	122.0	122.0	122.0	122.0	122.0	119.0	121.3	121.6	121.8	121.8	121.9
	400	120.8	120.8	120.8	120.8	120.8	120.8	117.4	120.1	120.4	120.5	120.6	120.7
	450	119.7	119.8	119.8	119.8	119.8	119.8	116.0	118.9	119.3	119.5	119.6	119.6
	500	118.8	118.8	118.8	118.8	118.9	118.9	114.6	117.9	118.3	118.5	118.6	118.6
	550	117.9	118.0	118.0	118.0	118.0	118.0	113.4	117.0	117.4	117.6	117.7	117.8
	600	117.2	117.2	117.2	117.2	117.2	117.2	112.2	116.1	116.6	116.8	116.9	117.0
	650	116.4	116.5	116.5	116.5	116.5	116.5	111.0	115.3	115.9	116.1	116.2	116.3
	700	115.8	115.8	115.8	115.9	115.9	115.9	109.9	114.5	115.1	115.4	115.5	115.6
	750	115.2	115.2	115.2	115.2	115.3	115.3	108.9	113.8	114.5	114.7	114.9	114.9
	800	114.6	114.6	114.6	114.7	114.7	114.7	107.9	113.2	113.8	114.1	114.3	114.3
	850	114.0	114.1	114.1	114.1	114.1	114.1	106.9	112.5	113.3	113.5	113.7	113.8
	900	113.5	113.6	113.6	113.6	113.6	113.6	106.0	111.9	112.7	113.0	113.1	113.2
	950	113.0	113.1	113.1	113.1	113.1	113.1	105.1	111.3	112.1	112.5	112.6	112.7
	1000	112.6	112.6	112.6	112.7	112.7	112.7	104.2	110.8	111.6	112.0	112.1	112.3
	1100	111.7	111.7	111.8	111.8	111.8	111.8	102.5	109.7	110.7	111.0	111.2	111.4
	1200	110.9	110.9	111.0	111.0	111.0	111.0	100.9	108.8	109.8	110.2	110.4	110.5
	1300	110.1	110.2	110.2	110.3	110.3	110.3	99.3	107.8	108.9	109.4	109.6	109.8
	1400	109.4	109.5	109.6	109.6	109.6	109.6	97.8	107.0	108.2	108.6	108.9	109.0
	1500	108.8	108.9	108.9	109.0	109.0	109.0	96.3	106.2	107.4	107.9	108.2	108.4
	1600	108.2	108.3	108.3	108.4	108.4	108.4	94.8	105.4	106.7	107.3	107.6	107.7
	1700	107.6	107.7	107.8	107.8	107.8	107.8	93.4	104.6	106.1	106.6	106.9	107.1
	1800	107.1	107.2	107.2	107.3	107.3	107.3	92.0	103.9	105.4	106.0	106.4	106.6
	1900	106.6	106.7	106.7	106.8	106.8	106.8	90.7	103.2	104.8	105.5	105.8	106.0
	2000	106.1	106.2	106.2	106.3	106.3	106.3	89.4	102.5	104.3	104.9	105.3	105.5



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