IM-8084 A1 Lodestar Integration Guide – LBL UTC Addendum

Contents

Acoustic Positioning ● Inertial Navigation ● Wireless Communication ● Sonar Imaging

1.1 Embedded LBL aiding of Sonardyne SPRINT

LBL aiding a SPRINT product is not outlined in the previous sections of the integration guide. This section describes how to aid a SPRINT system with acoustic range measurements from an LBL acoustic transceiver.

Sonardyne LBL acoustic positioning can provide absolute and relative (static) positioning accuracy to centimetre level accuracy (subject to transponder array calibration and geometry). The combination of a SPRINT INS and LBL range aiding provides the same level of accuracy even for highly dynamic vehicles, less (“sparse”) transponders, increased robustness, zero latency and a user configurable fixed high update rate.

Acoustic ranges are collected using an LBL acoustic transceiver operated by the user (vehicle). Measured ranges are time tagged against a UTC reference before being provided to SPRINT. SPRINT and the LBL ranges should be time synchronised off the same UTC source.
NOTE: SPRINT can provide a UTC output (1PPS/ZDA) and act as a time server.

Whilst manging LBL ranging in this manner is powerful and flexible it will require a testing period for the operator to be confident it is working as intended. Sonardyne will support the Integrator through this integration process by reviewing configuration setup and trials data.

1.1.1 Scenario

This addendum to the integration guide will be scenario based and will have the following components:

- SPRINT-NAV Hybrid navigation system
- Sonardyne AvTrak6 transceiver – physically connected to AUV PC
- Sonardyne 6g seabed mounted transponders
- AUV control system (management layer)
    - Including accurate knowledge of UTC time
- AUV operating using sparse LBL, not full array.

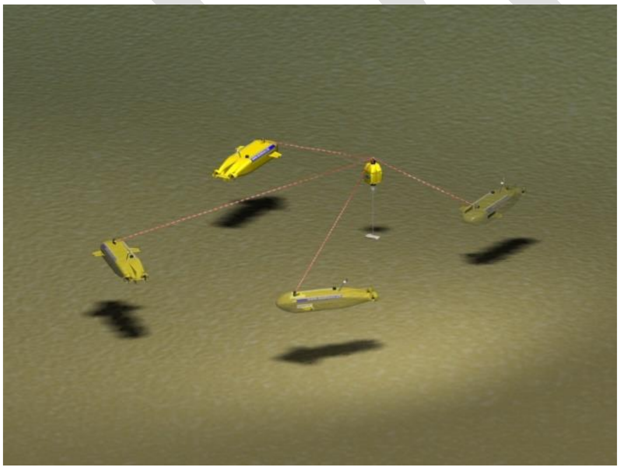

Figure 1 - Sparse LBL

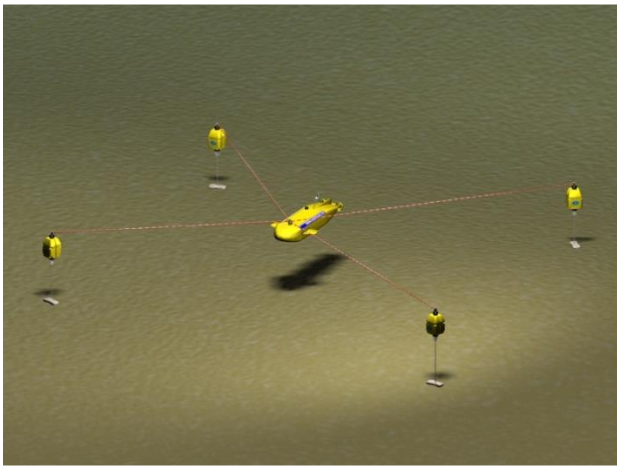

Figure 2 - LBL array

Note

AvTrak transceiver must have the correct functionality level to allow MR ranging functionality, contact Sonardyne if this is not the case. SPRINT should be running FW versions later than 3.04.02.1099

This document assumes the operator has an understanding of the fundemental principles of LBL and sparse LBL positioning, contact Sonardyne if this is not the case.

Any UTC timing mismatch errors between the SPRINT-Nav time and the vehicle UTC time (used to timetag ranges) will result in positioning error directly tied to the speed of the vehicle and the difference between time references.

1.1.2 System Architecture

As shown in Figure 3 there is a required set of messages that need to be passed between the AUV control system, SPRINT-Nav, AvTrak6 and Sonardyne 6G seabed transponder to enable embedded LBL. It is fundamental that these messages are time tagged correctly in SPRINT time to allow the inertial algorithms to process LBL ranges correctly.

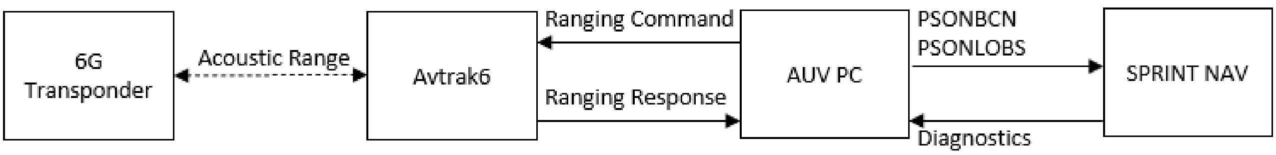

Figure 3 –Sprint – LBL System Architecture

Note

Although an AvTrak6 has dual port functionality only one command can be actioned at once. As such if using one AvTrak port for INS aiding and the other AvTrak port for telemetry/modem operations this scheduling must be managed so it does not overlap.

1.1.3 General configuration tips

- Table **3** should be referred to for example power, gain, blanking and receive wait times based upon expected range to remote 6G transponder.
- The LBL tracking update rate (defined by rate of sending the MR) should not be the same or less than the defined receive wait.
- If ranging to more than one 6G transponder it is recommended to use Common Interrogate, however this adds complexities. For Sparse LBL, only reference beacon is required at any one time.

1.2 Adding LBL Transponder

In order to configure a SPRINT to accept LBL observations, the following parameters must be set and understood:

Firstly LBL and the PSONLBLBCN macro family must be added as inputs on the control port (Port 0), enabling the SPRINT to expect LBL messages through the control port.

```
IN 0 MSG + LBL
IN 0 MSG + PSONLBLBCN
```

LBL parameters can be configured using the below default parameters detailed in Appendix A – LBL configuration:

```
LBL LA 0.00000 0.00000 0.00000
LBL SIGNAL -5.00000 10.0000 -30.0000 10.0000 30.0000 50.0000
LBL PASTOBSCNT 2.00000
LBL MAXTSINCEPASTTWT 30.0000
LBL RANGE 25.0000 500.000 1.00000 2.00000
```

Note

The above parameters should be a good starting set for AUV operation. LBL Lever Arms should be set and LBL Range min/max may need to be modified based upon desired operating range from 6G transponder. If other parameters are to be modified Sonardyne should be contacted.

1.3 Using AvTrak6 to LBL aid into SPRINT

When using an AvTrak6 via the AUV PC, send the measure range command MR:****;W1 where **** is the beacons address. This uses a fixed Turn-Around-Time (TAT) of 320. A UTC timestamp, synced to <20ms will require appending on receipt of the MR response. Note, to use UTC instead of Lodestar System Time, UTC timestamp is number of seconds since midnight with a negative sign to indicate UTC.
e.g. 10:53:21.186643UTC should be sent as '-39201.186643'.

To manage individually ranging to multiple transponders the below methodologies are recommended:

- The boxed in positions can be programmed into the AUV to determine which beacon should be used to range to when within 1100m for example
- Alternatively, the AUV could send the Discovery (DISC) command periodically to see what beacons are within the area and then send the MR to the responding beacons.

For Sparse LBL only 1 beacon is required to be interrogated at a time, however if more seabed transponders can be ranged to this will improve the accuracy of the solution.

Note

The operator should be confident managing acoustics in an embedded environment

1.4 Managing Acoustics

1.4.1 Scheduling acoustics

To schedule LBL acoustics Sonardyne Navigation Commands are used, this allows the operator to define; transmitted and received signals as well as manage scheduling, the full protocol definition can be found in .

Figure 4 - 6G range scheduling architecture

Figure 4 highlights the architecture required to schedule acoustic range updates in the format required for LBL range aiding.

Table 1 shows an example ranging interaction on start-up of an embedded LBL system, as described below:

1. VS (Volatile Status) messages are sent to check AvTrak6 settings
2. CS (Configurable Status) configuration messages are sent to check AvTrak6 settings.
3. Diagnostics (DIAG) are then turned on to enable filtering based upon acoustic quality metrics.
4. MR command is sent to get range information.

Order	Tx/Rx	Command
1	Tx	`<VS`
1	Rx	`>VS:2601,WKT1,HPR45,BT1;LI;VLT13.8;IDC-14.0;CAP100.0/75;T4.0`
2	Tx	`<CS`
2	Rx	`>CS:2601,TAT200,BLK100,RXW1600,TXW100,NPL181,TPL181,LG14,CIS0,AT8,EC1,EU0,ME0,RSP0,PPR0`
3	Tx	`<DIAG:XC,CRP,TEL,DBV,FEC,SNR,MOD1`
3	Rx	`>DIAG:2601,CRP,FEC,TEL,DBV,SNR,XC,P0,DEV0,SYS0,MOD1,RX0,TX0,ERR0`
4	Tx	`<MR:2302;W1`
4	Rx	`>MR:2302;R322425[XC92,SNR57,DBV-20,CRP0;0,TEL;NONE]`

Table 1 - Scheduled acoustics example

1.5 Aiding SPRINT-Nav with LBL

In order for SPRINT to use the LBL ranges the MR response (with appended UTC time) must be reformatted into two aiding messages; PSONLOBS & PSONBCN. This exchange is highlighted in green in Figure 5.

Figure 5 - Aiding SPRINT-Nav with LBL

Below is a range measured from an Avtrak6:

>MR:2302;R322425[XC92,SNR57,DBV-20,CRP0;0,TEL;NONE]

The time stamp appended should be valid for when the response is received.

10:53:21.186643UTC MR:2302;R322425[XC92,SNR57,DBV-20,CRP0;0,TEL;NONE] should be sent as '-39201.186643' in the PSONLOBS.

Note

Relavent sections of the above MR reply are shown in different colours. These colours can be used to trace the building of messages in the following sections. SPRINT will also augment the comms with heading, pitch and roll however these values are not required for LBL.

1.5.1 Populating PSONBCN message

The PSONBCN message is used to tell the SPRINT transponder specific parameters, such as; address, 3D position and TAT and should be passed to the SPRINT (with MID 160 if multiplexing). Transponder positions and TAT should be fixed for the entire job, Transponder positions will need to have reliable known WGS84 latitude/longitude positions. Position error should always be zero.

$PSONBCN,,2302,51.33072814,-0.83554238,100.000,80.000,0,0.0,0.0*7C

Note

If using MR to measure ranges TAT is always 320ms

8.2.14 PSONLBLBCN

Description

This proprietary string contains the real world position of a calibrated (fixed) beacon. It is sent to Lodestar along with an associated $PSONLOBS message. These messages provide acoustic aiding to the INS algorithm.

Format

$PSONBCN,ttttttt.tttttt,dddd,d.ddddddd,d.ddddddd,d.ddd,d.ddd,ddddd,dd.d,d.d*hh<cr><lf>

Fields

Field	Description	Units
$PSONBCN	Start character and format identifier	
ttttttt.tttttt	INS timestamp (Note 1)	Seconds
dddd	Beacon address	
d.ddddddd	Latitude	Degrees
d.ddddddd	Longitude	Degrees
d.ddd	Depth	Metres
d.ddd	TAT (Turn Around Time)	ms
ddddd	Carrier frequency	Hz
dd.d	Horizontal error radius	Metres
d.d	Depth error	Metres
*hh	Terminator and checksum	
<cr><lf>	Return plus linefeed	

Example

$PSONBCN,922.672222,2306,28.2236437,-88.5303721,1693.373,200.000,25500,0.0,

0.0*59<cr><lf>

Notes

1. Timestamp can be omitted (empty) or set to zero. Time of arrival of message will be used in either case.
2. The Latitude and Longitude fields can contain up to 7 decimal places for a resolution of approximately 1 cm at the Equator.
3. The $PSONBCN message will normally be expected before the $PSONLOBS message. If the $PSONBCN message is missing then the preceding message will be used. If the most recent PSONBCN is older than 180s then the observation is not used.

Note

Although the message specification is that PSONBCN should be passed to the SPRINT a minimum of once every 180s it is best/common practice to pass the PSONBCN to SPRINT with every PSONLOBS update cycle.

Carrier frequency and uncertainties should be left as 0 as in above messages unless transponders are to be put into a SLAM mode, if this is required Sonardyne should be contacted.

1.5.2 Populating PSONLOBS message

This proprietary string is used for inputting LBL observations into SPRINT and should be generated with an associated $PSONBCN message. If multiplexing, the PSONLOBS should be tagged with **MID163**.

$PSONLOBS,-39201.186643,2302,322425.000,1485.000,1485.000,57,-20,92,A*72

8.2.13 PSONLOBS

This proprietary string is used for inputting LBL observations to Lodestar/SPRINT. It should be generated with an associated $PSONBCN message. These messages provide acoustic aiding to the INS algorithm.

Format

$PSONLOBS,tttttt.ttttt,ddd,ddd.ddd,dddd.ddd,dddd.ddd,dd.d,dd.d,d,c*hh<cr><lf>

Fields

Field	Description	Units
$PSONLOBS	Start character and format identifier	
tttttt.ttttt	INS system timestamp (Note 1)	Seconds
ddd	Beacon address	
ddd.ddd	Travel time (Note 2)	µSecond
dddd.ddd	Sound speed at beacon, as determined by acoustic system	m/s
dddd.ddd	Sound speed for range, as determined/used by acoustic system	m/s
dd.d	Signal to noise	dB
dd.d	Signal level (dB relative to full scale voltage [DBV-12])	dB
d	Cross correlation (Note 3)	
c	Status flag (A = accept, V = invalid)	
*hh	Terminator and checksum	
<cr><lf>	Return plus linefeed	

Example

$PSONLOBS,20138.186643,1706,444750.000,1485.000,1485.000,71.0,-2.0,89.0,A*7B
<cr><lf>

Notes

1. Time stamp is time of transceiver reception of the acoustic response signal (beginning). This can be expressed in the INS system time base, or in UTC. UTC timestamp is number of seconds since midnight with a negative sign to indicate UTC rather than Lodestar system time.

   e.g. 10:53:21.186643UTC should be sent as '-39201.186643'.

   The acoustic system can either determine INS system time from the INS augmented TCVR comms or get it via other means (in case TCVR comms is not augmented by INS).
2. Two way travel time including TAT.
3. Depending on the implementation the cross correlation may or may not be present.

   The $PSONBCN message will normally be expected before the $PSONLOBS message. If the $PSONBCN message is missing then the preceding message will be used. If the most recent PSONBCN is older than 180s then the observation is not used.

Note

Sound velocity (SV) values should be kept up to date using values from a direct read SVS. In deep water operations with known stable SV it is often acceptable to assume that the local SV is the same as the remote SV.

1.6 Diagnostics

1.6.1 LBL INS Diagnostics

The OBSTLBL message should be monitored for low level LBL acceptance metrics with the BIST and LNAVUTC messages monitored for high level acceptance metrics. The PSONLBLBCN and OBSTLBL messages should also be logged to the SD card or AUV control binary logfile for offline analysis.

LOG SD MSG + OBSTLBL

LOG SD MSG + PSONLBLBCN

1.6.2 Acoustic Diagnostics

Managing the quality of the acoustic signal at the AvTrak is fundamental to both receiving robust and precise LBL ranges. Table 2 highlights a typical ‘traffic light’ scheme for acoustics. With the aim to always ensure that the signal metrics are in the ‘good’ section. Cross Correlation (XC) Signal Level (db relative to full scale voltage DBV) and Signal to Noise Ratio (SNR) should all be passed to the SPRINT by the operator. The operator should aim to manage the acoustics and set the LBL parameters in the LBL SIGNAL command, so ranges are correctly rejected/accepted by the SPRINT.

Parameter	Good	Okay	Difficult
XC	>60	>45	<45
DBV	-3 to -26	>-36	<-36 or >-3
SNR	>20	>12	<12
IFL	<20	<40	>40
FEC	<2	<4	<5

Table 2 - Signal diagnostic traffic light

Table **3** provides suggested AvTrak6 settings for an Omni-directional AvTrak 6 at certain ranges. Note that these proposed settings assume ambient background noise, so may be conservative.

Range	NPL	SPL	TPL	LG	BLK	RXW (ms)
25	166	166	166	6	100	800
50	166	166	166	14	100	800
100	181	181	181	6	100	800
500	181	181	181	14	100	1600
1000	181	181	181	20	100	2000
2000	187	187	181	26	100	3600
3000	187	187	181	34	500	5000

Table 3 **- Suggested range dependent acoustic settings**

Appendix A – LBL configuration

LBL SIGNAL

LBL SIGNAL <d.d> <d.d> <d.d> <d.d> <d.d> [<d.d>]
The six numbers represent:
minimum SNR,
maximum reduced SNR relative low pass filter,
minimum SignalLevel,
maximum reduced SignalLevel relative low pass filter,
tau respectively. These are the limits which the AINS uses to accept or reject LBL messages. Tau is a time constant used in the low pass filtering.
Minimum allowable XC – optional value to indicate the value that the XC field must exceed to be considered for use by the INS algorithm
INS uses the LBL if all the following is true (in addition to other checks):

SNR in the PSONLOBS msg is > the minimum SNR
SignalLevel in the PSONLOBS msg is > the minimum SignalLevel
SNR – filtered SNR > -maximum reduced SNR relative LPF
SignalLevel – filtered SignalLevel > -maximum reduced SignalLevel relative LPF
XC > Min Level Configured

Default: LBL SIGNAL -10.0000 2.00000 -10.0000 3.00000 30.0000 50.0000

LBL RANGE

LBL RANGE <d.d> <d.d> <d.d> <d.d>
The four numbers represent:
minimum range,
maximum range,
maximum range rate,
maximum range prediction error
respectively. These are the limits which the AINS uses to accept or reject LBL messages.
INS uses the LBL if all the following is true (in addition to other checks):

Range in the PSONLOBS msg is > the minimum range
Range in the PSONLOBS msg is < maximum range
Range rate in the PSONLOBS msg is < maximum range rate
Predicted range is < maximum range prediction

Default: LBL RANGE 40.0 350.0 2.0 0.5

LBL PASTOBSCNT

LBL PASTOBSCNT <d>
This is the number of observations for a beacon to be required within the previous time specified by LBL MAXTSINCEPASTTWT.
INS uses the LBL if this is true.

Default: LBL PASTOBSCNT 2

LBL MAXTSINCEPASTTWT

LBL MAXTSINCEPASTTWT <d>
This is the time in seconds prior to the current observation during which LBL PASTOBSCNT observations are required.

Default: LBL MAXTSINCEPASTTWT 21.0

Please refer to the main integration guide for details of the below messages:

- PSONLOBS
- PSONBCN

- Diagnostics (OBSTLBL, LNAVUTC, BIST)