AM-7707

Applications Manual for Type 7707 USBL / LUSBL Systems (Version 6)

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AM-7707

APPLICATIONS MANUAL

FOR

VERSION 6 OF THE USBL/LUSBL SYSTEM

ISSUE B

REVISION 2

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AMENDMENT RECORD

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

Issue	Revision	Date	Comments	Section	Page
A	0	19.11.99	Initial Issue	All	All
A	1	16.12.99	Miscellaneous small corrections. Appendix F (DP Telegram Formats Introduced)	2,3,4,5, 8,9, A,C,E,F	
B	0	13.06.05	Manual upgrade	All	All
B	1	08.12.05	Support operation with both tone and wideband signals	All	All
B	2	19.05.06	Update ATS ASCII telegram in Appendix F CN 8999	All	All

SECTION 1

1. INTRODUCTION

This manual brings together a set of procedures covering the most commonly utilised applications of an L/USBL system. The procedures are aimed at systems running Version 6 of the system software, up to and including release 6.06 which supports operation with both tone and wideband signals. USBL, L/USBL and Dual-redundant L/USBL versions are all covered. Version 6 systems are different from earlier versions of Sonardyne's USBL/LUSBL in a very significant way - they are designed to manage communications between multiple Transceivers and multiple Objects. This yields much improved operational flexibility when the system is being used in a complex configuration.

Section 2 contains a System Description plus some general description of acoustic positioning principles and the operational modes of Sonardyne beacons supported by an L/USBL system. Earlier Version 6 systems were supplied with analogue transceivers identified by their white housings. Systems supplied since 2002 use digital transceivers identified by yellow housings that provide higher measurement precision and the additional features described in this manual, which includes support of both tone and wideband signals when running firmware version 8 and above.

In many cases, experienced operators will need to refer only to Sections 3 and 4. Installation check procedures common to all applications are included in Section 3. Once these common procedures have been carried out, the procedure for each application, included in Section 4, is written so as to be self-contained. It should not be necessary to refer to any other section of the manual unless a user chooses to explore any procedural point in more detail. A Reference Section is included as Section 9 and contains detailed descriptions of how to use the menu system and how to make changes to the system configuration to suit the job in hand.

In most cases, the default settings for the Beacons employed on a job will suffice (and Section 4 is based on this assumption). However, in the event that Beacon settings do need to be changed to suit a particular scenario, Section 9 covers the procedures involved.

Section 5 contains details of error and information messages.

Section 6 describes how to set up the system display to suit the job in hand and Section 7 covers a range of common calibration procedures.

Basic fault finding procedures are given in Section 8.

Installation and maintenance procedures are given in a separate manual.

SECTION 2

2. SYSTEM DESCRIPTION

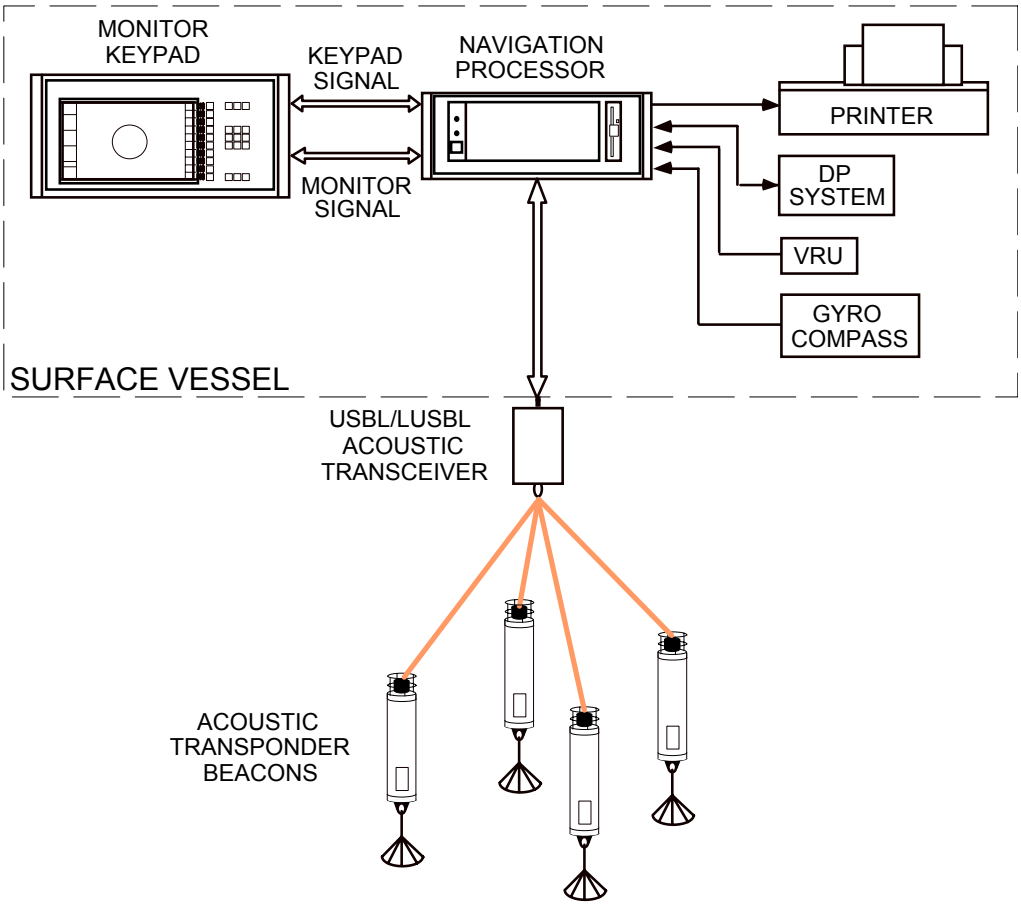
2.1 OVERALL SYSTEM

The components comprising a typical L/USBL system are illustrated in Fig 2.1 which follows.

The key difference between USBL and L/USBL systems is that the basic USBL system utilises only one Transponder Beacon on the seabed (or on an ROV, etc.) and has less accuracy and more limited functionality as a result. The L/USBL system communicates with an array of seabed Reference Transponders and is able to use statistical filtering principles to achieve higher accuracy. In addition to this, Version 6 of the system is designed to manage communications between multiple Transceivers and multiple Objects. This yields much improved operational flexibility when the system is being used in a complex configuration. Earlier L/USBL systems were supplied with analogue transceivers identified by their white housings. Systems supplied since 2002 use digital transceivers identified by yellow housings that provide higher measurement precision and the additional features listed in this manual. Digital transceivers running firmware version 8 and above can be used with transponders that support operation with wideband signals, which provide the additional benefits described in this manual.

The dual redundant version of the system incorporates a second set of Navigation Processor, Monitor/Keypad and Transceiver. These two sub-systems are cross-linked in such a way that, in the event of a failure of any major element, system operation will continue without the need for operator intervention.

FIG 2.1 SCHEMATIC DIAGRAM – BASE LUSBL SYSTEM



Operation of the system is controlled by the Navigation Processor once it has been set up and initialised by the operator. The operator uses either the key board or Keypad unit(s) as his Man / Machine Interface. The Processor commands the Transceiver (or Transceivers) to emit acoustic signals to the Beacon(s) and then interprets the responses received by the Transceiver(s).

In a typical basic USBL system, the Processor receives reference information from a VRU and a Gyro Compass and produces outputs to a DP system and a survey computer. In other system configurations, the vessel's absolute position in WGS 84 UTM co-ordinates may be derived by reference to a DGPS system.

The system measures the range and direction of a Beacon relative to the known location and orientation of the Transceiver(s) housing:-

- Beacon range is calculated by measuring the elapsed time between the interrogation signal and the detection of the Beacon reply.

- Beacon bearing is calculated by measuring the difference in "time-phases" between signals in a number of pairs of acoustic receiving elements on the front face of the Transceiver(s). (This is sometimes referred to as the Interferometer method).

In the case of an L/USBL system, where a number of Beacons are in use, greater accuracy of position fixing is possible than with a basic USBL system because the larger volume of data being gathered enables a greater degree of statistical filtering to be carried out.

In a typical navigation cycle:-

- The Navigation Processor commands the Transceiver to transmit an interrogation signal.

- The Beacon reply (or replies in the case of L/USBL) is detected by the Transceiver(s), which measures the elapsed time(s) and the time-phases. The data is reported to the Navigation Processor. Simultaneously, the Navigation Processor will have received the vessel's attitude (roll, pitch) and, possibly, heading data.

- The Navigation Processor computes the position of the Beacon relative to the vessel and, if required, reports the data to the DP system or a survey computer.

If heading data is present, the processor can compute the position of the vessel in a North-referenced grid relative to a Beacon fixed to the seabed. Without heading data, vessel position would only be known in terms of range, bearing and elevation from the Beacon.

Subsequent navigation cycles may be used to position other Beacons up to a maximum of 10 Beacons in total. If the positions of the Beacons in an array on the seabed (ie relative to each other) have previously been calibrated, the position of the vessel (relative to the array) may be calculated to a high degree of accuracy.

2.2 ACOUSTIC POSITIONING METHODS

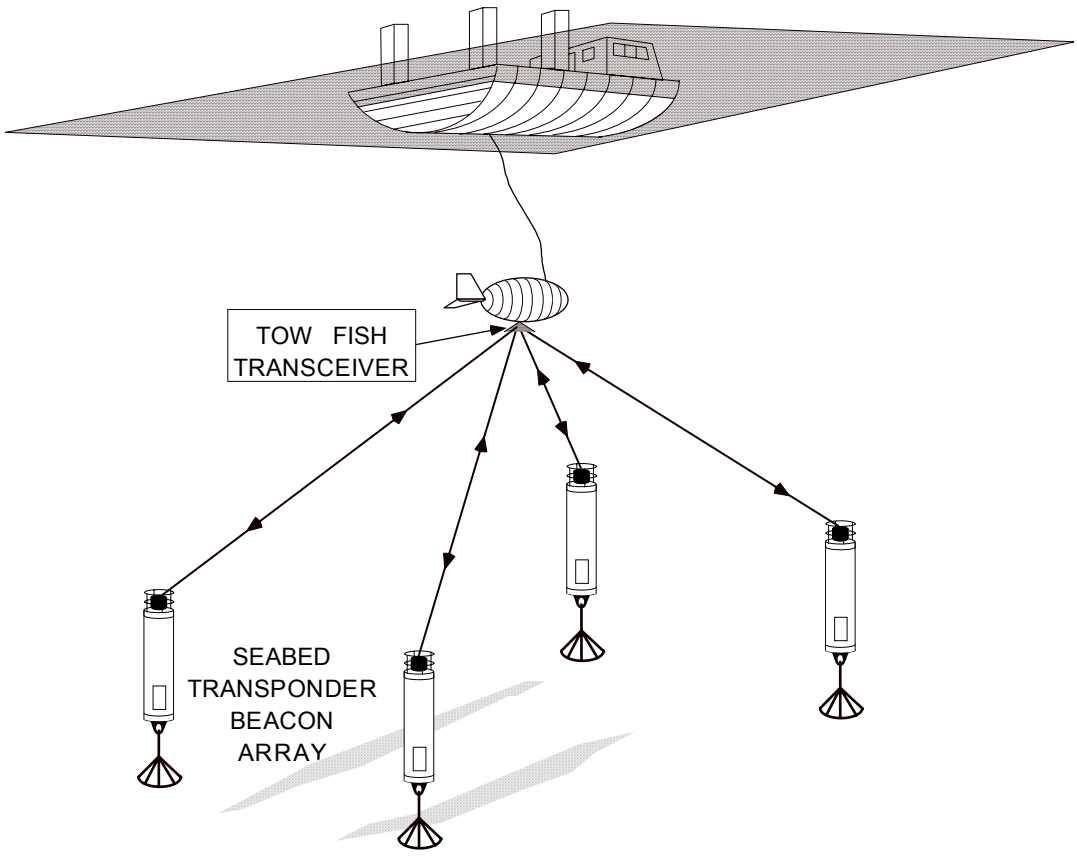
2.2.1 LBL

A "Long-Base-Line" system has two parts or segments.

The first segment comprises a number of acoustic Transponder Beacons moored in fixed locations on the seabed - see Fig 2.2. The positions of the Beacons are described in a co-ordinate frame fixed to the seabed. The distances between them form the “baselines” used by the system.

The second segment comprises an acoustic transducer on a Transceiver which is normally installed on the vessel - or on a Tow Fish in the example shown in Fig 2.2. The distance from the transducer to a Transponder Beacon can be measured by causing the transducer to transmit an acoustic signal which the Transponder detects and causes it to transmit an acoustic signal in response. The time from the transmission of the first signal to the reception of the second is measured. As sound travels through the water at a known speed, the distance between the transducer and the Beacon can be estimated. The process is repeated for the remaining Beacons and the position of the vessel relative to the array of Beacons is then calculated or estimated.

FIG 2.2 A CLASSICAL LBL SYSTEM



In principle, navigation can be achieved using just two seabed Transponder Beacons but in this case there is a possible ambiguity as to which side of the baseline (a line drawn between the Beacons) the vessel may be. In addition, the depth or height of the transducer has to be assumed. Three Transponder Beacons is the minimum required for unambiguous navigation in three dimensions; four is the minimum number required for some degree of redundancy - which is useful for checks on the quality of navigation.

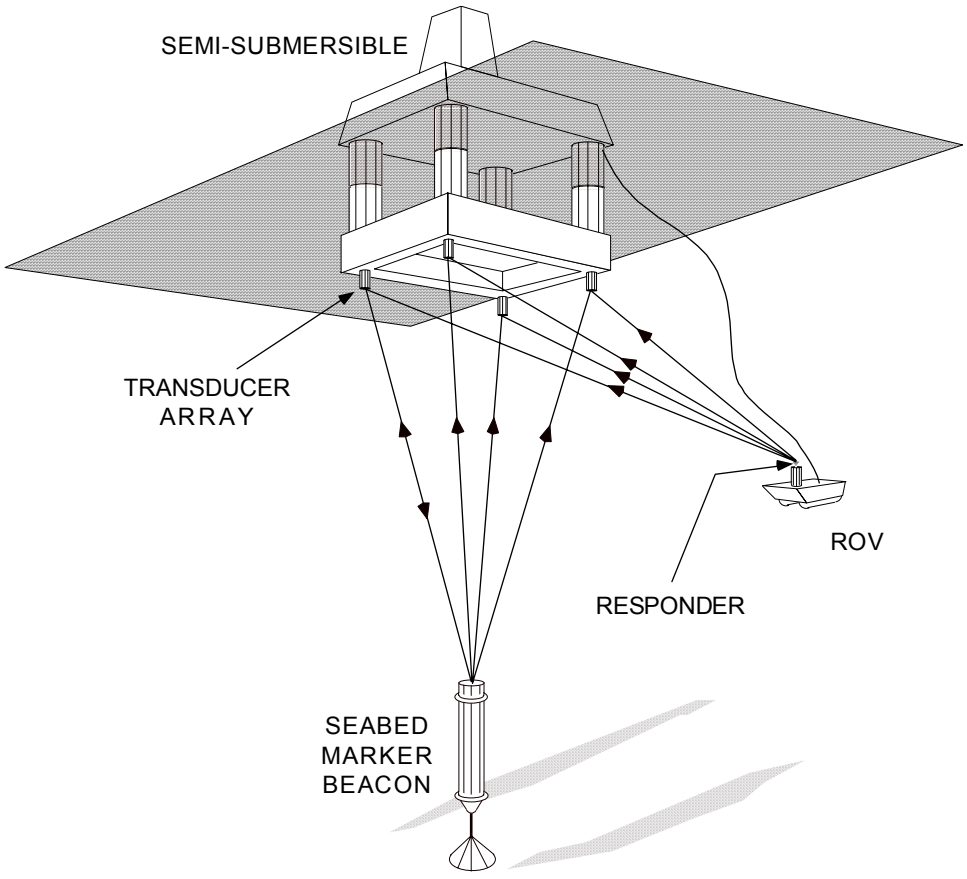
The term "Long-Base-Line" is used because in general the baseline distances are much greater for LBL than for SBL (Short Base-Line) and certainly for USBL (Ultra Short Base-Line)! Because the baselines are much larger, an LBL system is very accurate compared with the SBL and USBL versions and also has the advantage of positioning the vessel (or any other object) directly in a "fixed" or an inertial frame. This removes most of the problems associated with vessel motion.

The array of seabed Beacons needs to be calibrated and there are several techniques available for achieving this. The most appropriate technique depends on the requirements of the task or job in hand and the available hardware. With the continuing integration of LBL, SBL and USBL systems with intelligent Transponder Beacons (that measure baselines directly) and satellite navigation systems, the calibration of seabed arrays is becoming a quick and simple operation. The operator will be free to choose the techniques appropriate to the requirements and the task. (Section 7.3 describes simple array calibration in V6).

2.2.2 SBL

A "Short-Base-Line" system is normally fitted to a vessel such as a barge, semi-submersible or a large drilling vessel - see Fig 2.3. A number of (at least three but typically four) acoustic transducers are fitted in a triangle or a rectangle on the lower part of the vessel. The distances between the transducers (the "baselines") are made as large as is practical, typically they are at least 10 metres long. The position of each transducer within a co-ordinate frame fixed to the vessel is determined by conventional survey techniques or from the "as built" survey of the vessel.

FIG 2.3 A CLASSICAL SBL SYSTEM



The term "Short" is used as a comparison with "Long-Base-Line" techniques. If the distances from the transducers to an acoustic Beacon are measured as described for LBL, then the position of the Beacon within the vessel co-ordinate frame can be computed. Moreover, if redundant measurements are made, a best estimate can be determined which is, statistically, more accurate than the basic position calculation.

SBL systems transmit from one but receive on all transducers. The result is one distance (or range) measurement and a number of range (or time) differences.

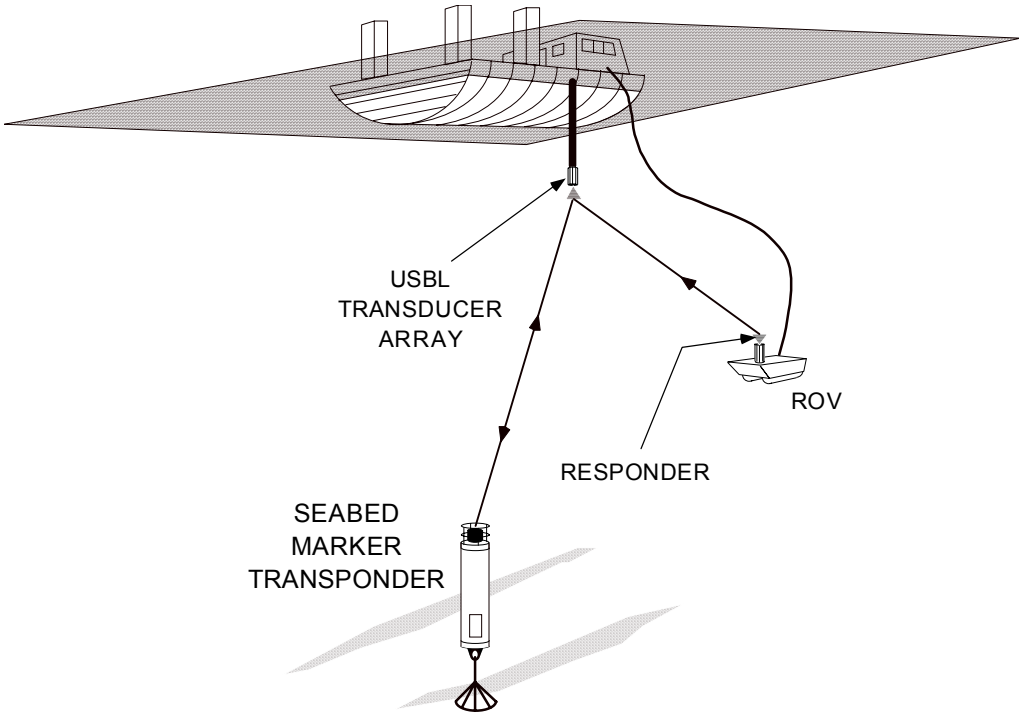
With an SBL system, the co-ordinate frame is fixed to the vessel - which is subject to roll (change in list), pitch (change in trim) and yaw (change in heading) motion. This "disadvantage" can be overcome by using additional equipment such as a VRU (Vertical Reference Unit - see glossary) to measure roll and pitch and a Gyro-compass to measure heading. The co-ordinates of the Beacon can then be transformed mathematically to remove the effect of these rotational motions.

If the requirement is to estimate the position of the vessel in some "fixed" or "inertial" frame such as one fixed to the seabed, then at least one Beacon should be placed in a fixed position on the seabed and used as a reference point. It is this principle that is used for "DP" vessels. Fig 2.3 illustrates a system having a Transponder Beacon fixed to the seabed and a Responder Beacon located on an ROV (Remotely Operated Vehicle). In such a case, the system can calculate the position of both the vessel and the ROV in a seabed-fixed frame.

2.2.3 USBL

USBL (Ultra-Short-Base-Line, which is also known as a SSBL or Super-Short-Base-Line) principles are very similar to SBL (Short-Base-Line) principles (in which an array of acoustic transducers is deployed on the surface vessel), except that the transducers are all built into a single transceiver assembly - or the array of transducers is replaced by an array of transducer elements in a single transceiver assembly - see Fig 2.4, which follows.

FIG 2.4 A CLASSICAL USBL SYSTEM



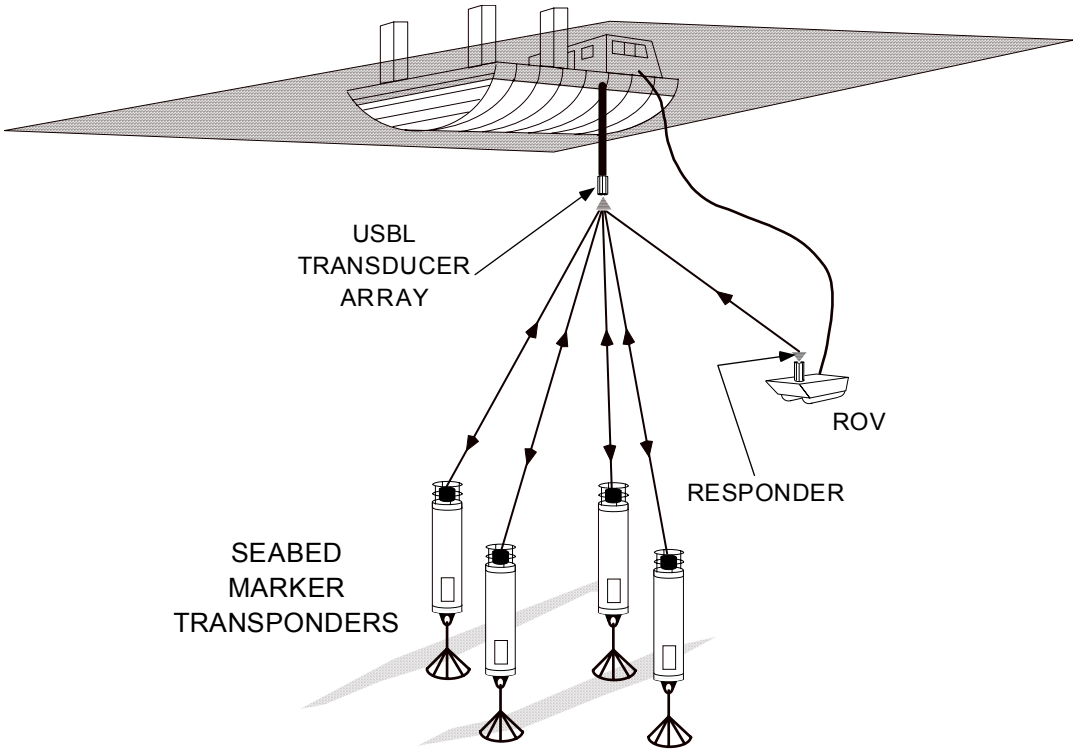
The distances or ranges are measured as they are in an SBL system but the time differences are now much less. Systems using sinusoidal signals measure the "time-phase" of the signal in each element with respect to a reference in the receiver. The "time-phase differences" between transducer elements are computed by subtraction and then the system is equivalent to an SBL system.

Another practical difference is that the transducer elements are in a Transceiver assembly that is placed somewhere in the vessel frame. The attitude of the assembly in the vessel frame must be measured during installation. It should be remembered that, intrinsically, a USBL system positions a Beacon in a frame fixed to the Transceiver assembly, not directly in a vessel-fixed frame as in the SBL case.

2.2.4 L/USBL

The L/USBL system is a special case of a USBL system. It utilises USBL hardware in a configuration similar to the one described for the LBL system - see Fig 2.5 which follows.

FIG 2.5 A CLASSICAL L/USBL SYSTEM



Range and bearing in an L/USBL system are still measured as described for a basic USBL system. However, because a larger number of Beacons is deployed on the seabed, a considerable improvement in accuracy may be achieved.

If a basic L/USBL system is not to be used for accurate survey work, the L/USBL system as illustrated in Fig 2.5, will automatically carry out a “Top Down” calibration as soon as the system is placed in Navigation mode with the array beacons declared as References. This calibration technique relies on multiple range and time phase difference measurements between the USBL Transducer and each seabed Transponder in turn. Over a period of time, provided an accurate measure of sound velocity through the water column has been entered, the system will calculate highly repeatable positions for the seabed array relative to the USBL Transducer.

If the L/USBL system is to be used for survey work, the seabed array must be calibrated separately or using baseline measurements (see next paragraph). If a satellite navigation input is available to the L/USBL system, it is feasible to locate each seabed Beacon directly in an earth-referenced frame to an accuracy determined by the accuracy of the satellite navigation system.

Similarly, if 'intelligent' Beacons of the COMPATT type (see Section 2.3 and the Glossary) are used on the seabed, the potential exists for the seabed array, under command from the L/USBL system, to be self-calibrating. Using COMPATT Beacons has the advantage also of affording the system considerably more flexibility in that they can be commanded to be interrogated and respond on any of a variety of acoustic signals and with any desired turnaround delay time. Thus, from the operator's point of view, the COMPATT version of the system becomes simpler and faster to set up and use.

Two complete sets of L/USBL equipment [each set comprising Navigation Processor, Monitor/Keypad and Transceiver(s)] may be operated in tandem to form a Dual-Redundant version of the System. The two sub-systems are cross-linked in such a way that, in the event of a failure of any major element, system operation will continue without the need for operator intervention. From the operator's point of view, operation of the Dual-Redundant version is essentially identical to that of the standard version.

In operation, one sub-system or the other operates as the "Master" and performs all normal system functions. The second, "Slave", sub-system monitors the function of the "Master" and will commandeer system operation if it detects that the erstwhile "Master" is not functioning.

2.2.5 L/S/USBL

If four or more USBL transceivers are deployed below the vessel as shown for simple transceivers in Fig 2.3 and four or more Beacons are deployed as shown in Fig 2.5, the system is able to operate in a L/S/USBL mode.

L/S/USBL mode is a combination of USBL, LBL and SBL. The reference array is interrogated from one transceiver and the replies from all of the Beacons are collected at all the transceivers. One solution of the position of the vessel is computed from all the measurements. This single solution comprises SBL, USBL and LBL components.

Ranges to each Beacon are collected at all the transceivers giving an SBL component to the solution. The Ranges having been collected to three or more Beacons constitute an LBL solution. Directions are collected from one of the transceivers and used with the Ranges from this transceiver to provide the USBL component.

L/S/USBL uses the same equipment and set up as L/USBL; it just uses data from more transceivers. It is therefore not specifically described in this manual. The description for L/USBL should be used, except that the additional transceivers should be entered.

2.3 COMPATT OPERATIONAL MODES

2.3.1 COMPATT Commands

A COMPATT is a type of intelligent Transponder Beacon that is managed by a micro-controller. It can decode acoustic telemetered commands from a Transceiver and can send telemetered data to the Transceiver. It can measure the distance between itself and other Transponder Beacons and then telemeter the data to a Transceiver.

Usually the instrument is capable of measuring its depth and the temperature of the water and may be used to measure a variety of underwater parameters and telemeter these back to the surface. Very often it is fitted with a release mechanism enabling it to be returned, on command, back to the surface at the end of a mission (or if battery power is low).

The COMPATT may also be used as an acoustically operated remote Transceiver.

Mk5 Compatt versions supplied since 2005 support operation with both tone and wideband signals when operated in conjunction with digital transceivers running firmware version 8 and above.

The acoustic command set used by the L/USBL system to control a COMPATT that incorporated in the Version 6 software is set out in Appendix B.

2.3.2 COMPATT Telemetry

When a command is actioned to Mk4 Compatt and earlier versions of Mk5 Compatts, the reply is in the form of a data telemetry string consisting of a Start frequency and then a combination of '1's and '0's, either 24 or 48 bits long. The data contains an echo of the address to which the command was sent, and an echo of the command number to be actioned, followed by a simple acknowledgement (24 bit) or data (48 bit) word (which ends with a number of checksum bits). Some commands return more than one 48 bit data word - in which case each new word starts with a Start frequency bit.

Mk5 Compatts supplied since 2005 can also transmit reply strings using a Wideband Telemetry technique at a faster baud rate when operated in conjunction with digital transceivers running firmware version 8 and above.

2.3.3 Common Interrogation Ranging

In this mode, the Transceiver transmits on a common interrogation signal, and receives an individual reply signal. All Transponders with their common interrogation receiver enabled will reply on their own individual reply signal. In this way, provided that replies at the Transceiver do not conflict in time, the Transceiver can receive replies from multiple transponders to a single interrogation without ambiguity. The Turn-Around Times (TAT) of the Transponders can be set to ensure that the replies do not conflict. In tone mode, the signals are referred to as the Common Interrogation Frequency (CIF) and Individual Reply Frequency (IRF), and in wideband mode the signals are referred to as the Common Interrogation Signal (CIS), and Individual Reply Signal (IRS). (See Appendix H for more details on wideband signals).

If the Transponder is a COMPATT, any potential problem with reply overlap can be eliminated by commanding the COMPATT to change its turn-around time - thus delaying the time at which it transmits its reply back to the Transceiver, although this is less critical when using wideband signals.

Similarly, the IRF frequency or IRS signal for a COMPATT can be changed from the surface by issuing the appropriate command (see Appendix B). The default IRF frequency and TAT may be restored using the COMPATT Reset command.

Later COMPATTs are able to respond to other interrogation channels (nominated to the COMPATT by the system) as though they were "Alternative – CIFs or CISs" - thus enabling operation with multiple vessels / multiple arrays to overcome acoustic interference problems, although this is less critical when using wideband signals.

2.3.4 Common Reply Ranging

In this mode, the Transceiver transmits on an individual interrogation signal, and receives a common reply signal. An individual Transponder with its individual interrogation receiver enabled will reply on the common reply signal. The Transceiver associates the received common reply signal as being from the interrogated Transponder. In this scheme, there is only a single reply signal in the water at a time, and so it is not necessary to adjust the Turn-Around Times (TAT) of the Transponders to prevent signals overlapping. In tone mode, the signals are referred to as the Individual Interrogation Frequency (IIF) and Common Reply Frequency (CRF), and in wideband mode the signals are referred to as the Individual Interrogation Signal (IIS), and Common Reply Signal (CRS). (See Appendix H for more details on wideband signals).

2.3.5 Individual Interrogation and Reply Ranging

In an acoustically noisy environment, this mode is the most secure method of communicating between the USBL Transceiver and a COMPATT when using tone signals. In this mode, the Transceiver again transmits to a particular Transponder on the Individual Interrogation Frequency signal (IIF) peculiar to that Transponder. The Transponder will reply on the Individual Reply Frequency signal (IRF) to which it has been set. The commands necessary to set the COMPATT into this mode are described in Appendix B.

2.3.6 HPR Ranging

This refers to the Hydro-acoustic Positioning Reference system developed by SIMRAD. Two standards are available - HPR309 and HPR 418, both of which are supported by current L/USBL systems.

When a COMPATT is used in the HPR mode a default pair of interrogation (SIF) and reply (SRF) frequencies which match the HPR channel on the housing label are used. The commands necessary to set the COMPATT into this mode are described in Appendix B.

2.4 OTHER BEACONS

Version 6 systems being used with digital transceivers support operation with the following beacons:

- 300 series HPR beacons
- 400 series HPR beacons
- Super Sub Mini beacons (SSM)
- Buoy Positioning Transponders (BPT)
- Emergency AODC transponders (Association of Offshore Diving Contractors)
- Programmable Generic Transponders (PGT)
- Wideband Sub Mini Transponder (WSM) – supported by Version 6.06 software

The SSM, BPT and PGT beacons can also be used to monitor the water depth under the control of the Version 6 system software.

SECTION 3

3. COMMON INSTALLATION PROCEDURES

In most cases the common installation procedures for the operator involves simply checking that the installation parameters already set into the system are suitable for the job in hand.

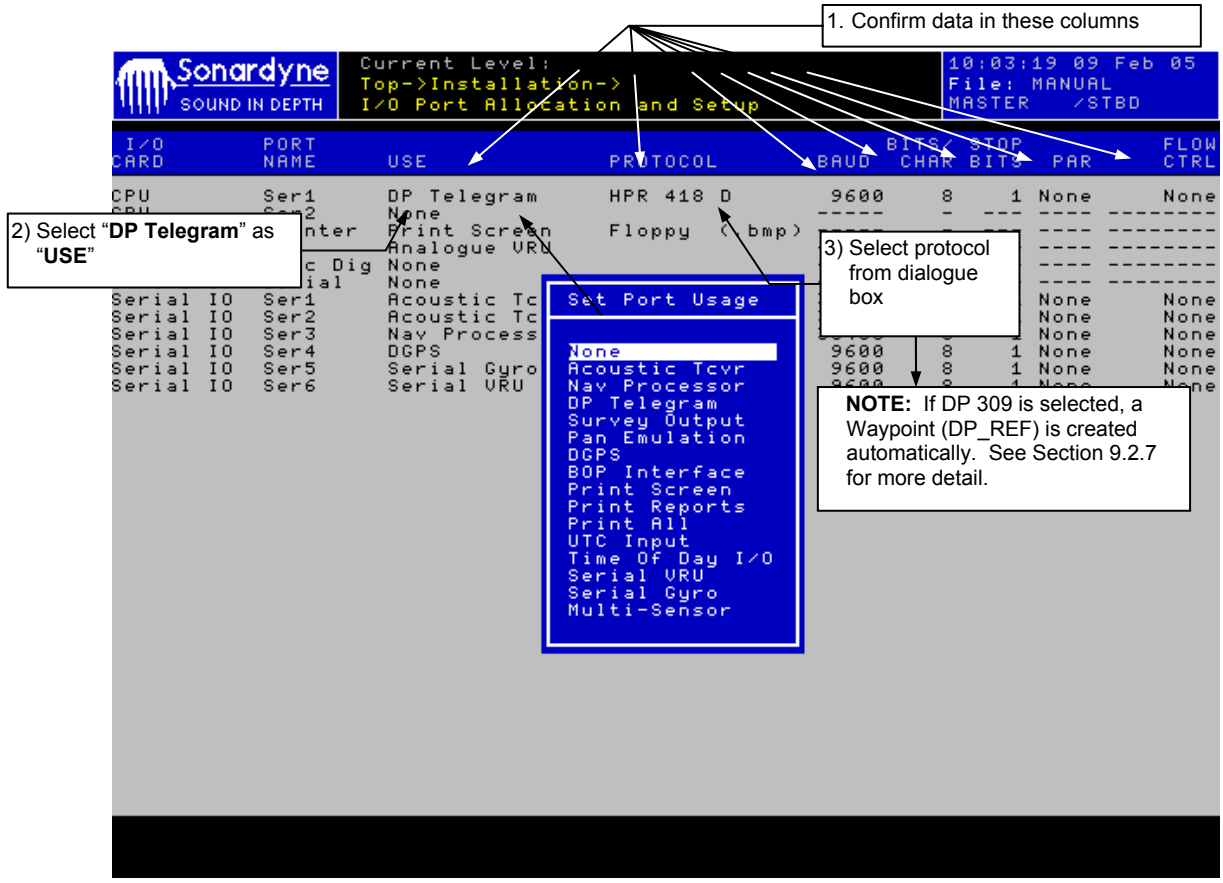
In the following menu illustrations, the procedures are set out in call-out boxes associated with each illustration. Carry out these procedures in the number order of the boxes. The illustrations used apply to general cases and do not necessarily relate to any particular application.

3.1 INSTALLATION MENU

Start by selecting "**Installation**" from the main menu. You may be prompted to enter a password set by the system operator. Then proceed as follows:

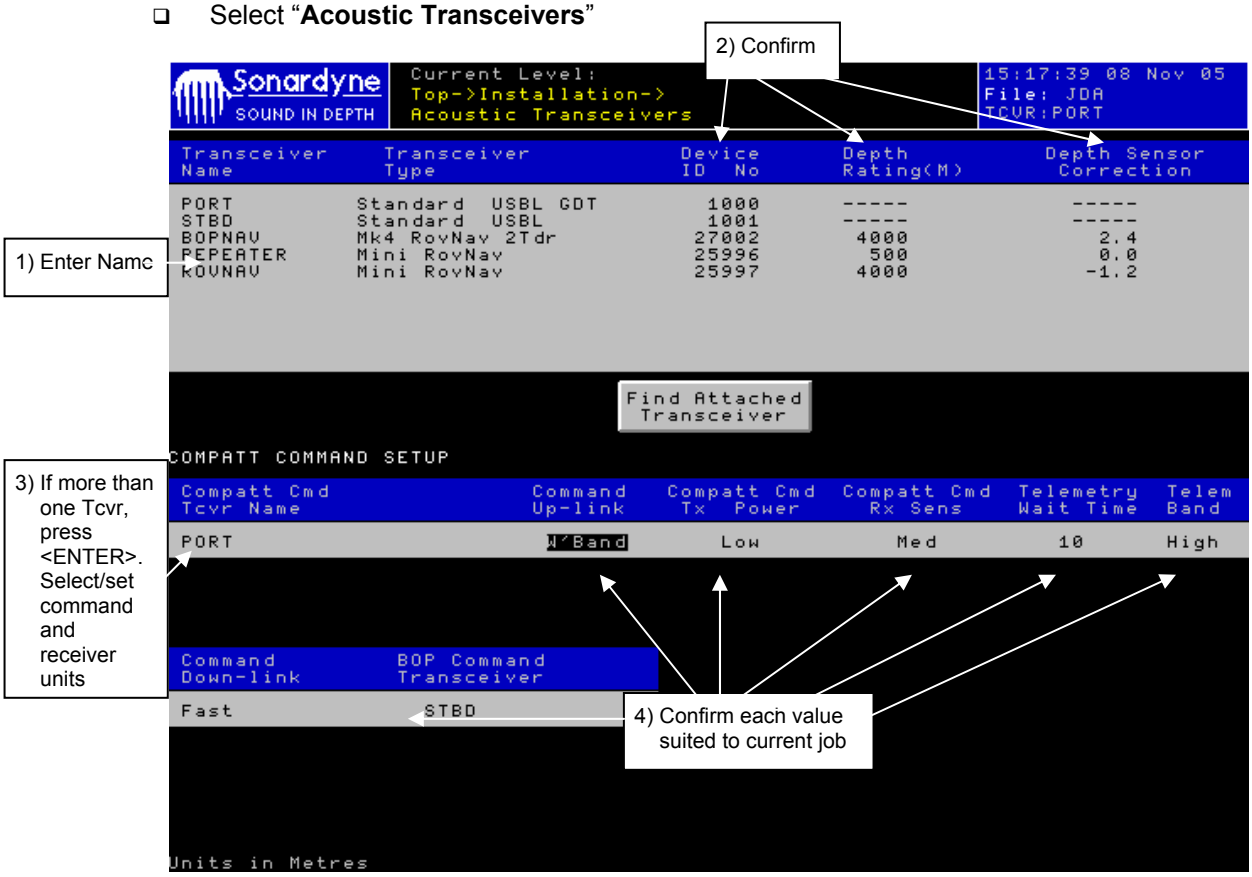
- Select "**I/0 Port Allocation and Setup**"

  If the DP system is to be used in the current job then "**USE**" should be set for DP as indicated below.

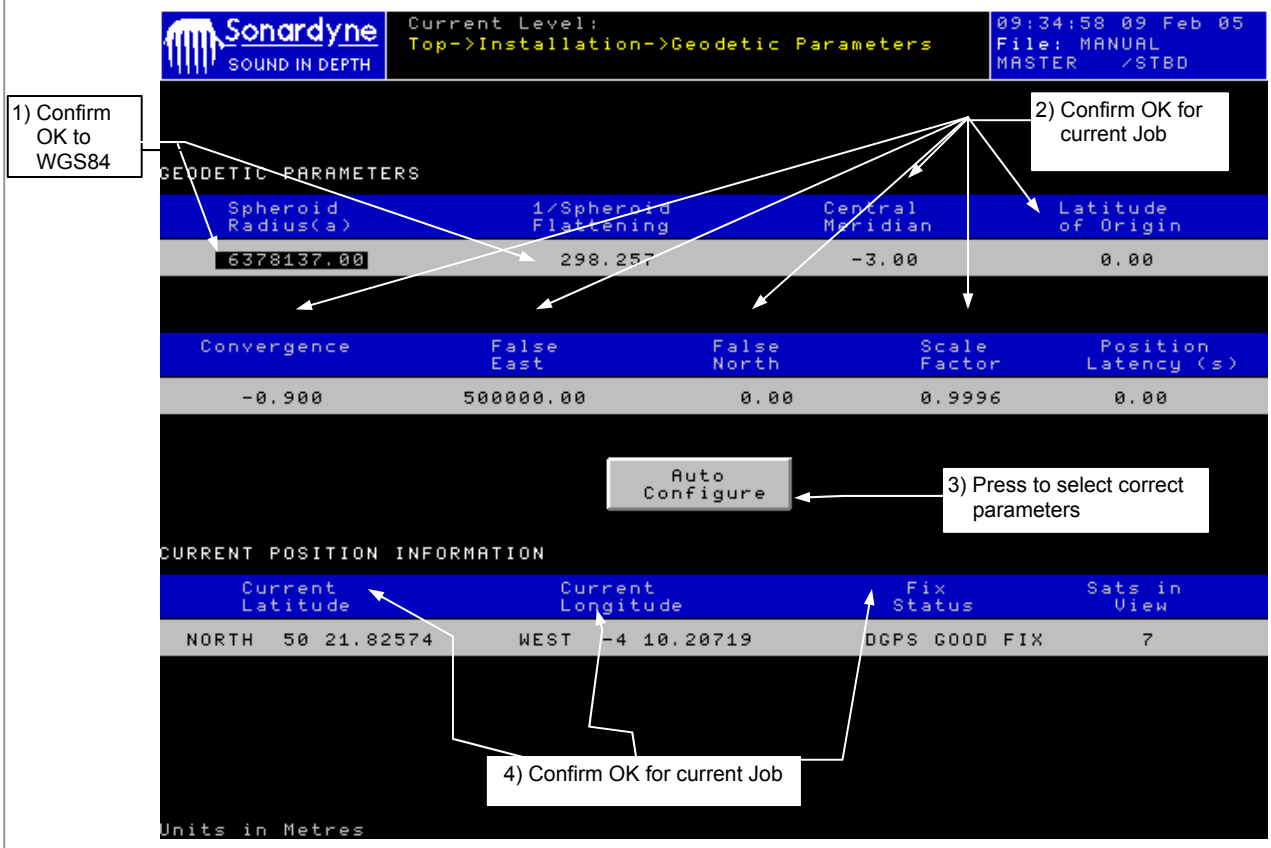


The "**USE**" of the available CPU and Serial card inputs must match the specific vessel installation hardware and data formats (refer to Section 9.44 for technical details).

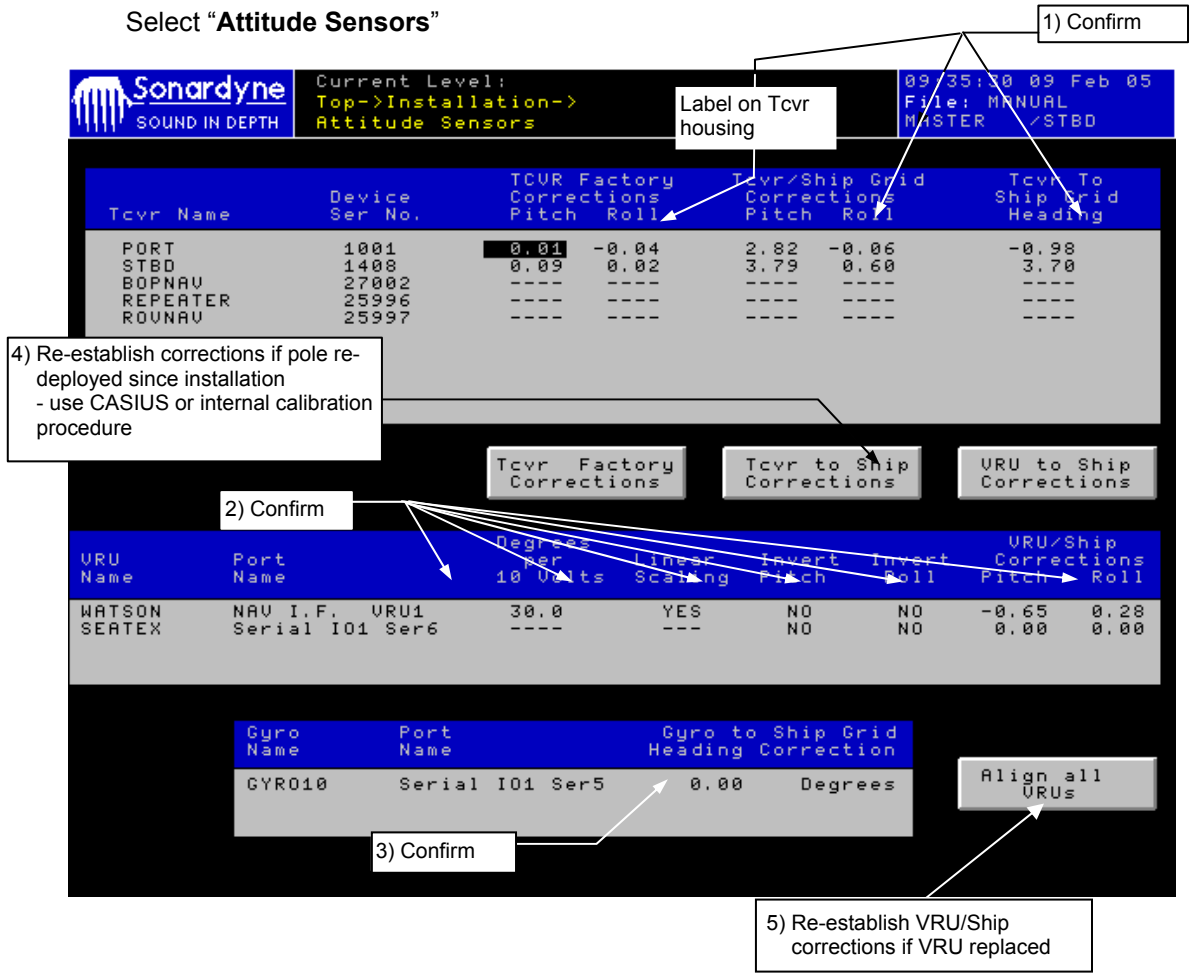
- Select "**Acoustic Transceivers**"



- Select "**Geodetic Parameters**". **WARNING:-** Changes to this page, if any, should only be made by an operator fully conversant with both DGPS and geodetics.



Select "**Attitude Sensors**"



- ❑ Select "**Set/Change Installation Password**"

  - Access this option only if is necessary to change the password. If so, follow on-screen prompts to effect change via dialogue box as illustrated here to the right. Advise all appropriate user personnel of change.

- ❑ Select **"Advanced Options"**

  This utility is available to Sonardyne engineers and used during the initial installation.

- ❑ Select "Download GDT firmware"

  This utility allows digital transceiver firmware to be upgraded from a file received from Sonardyne and would normally be used by Sonardyne engineers during the initial installation or a field visit.

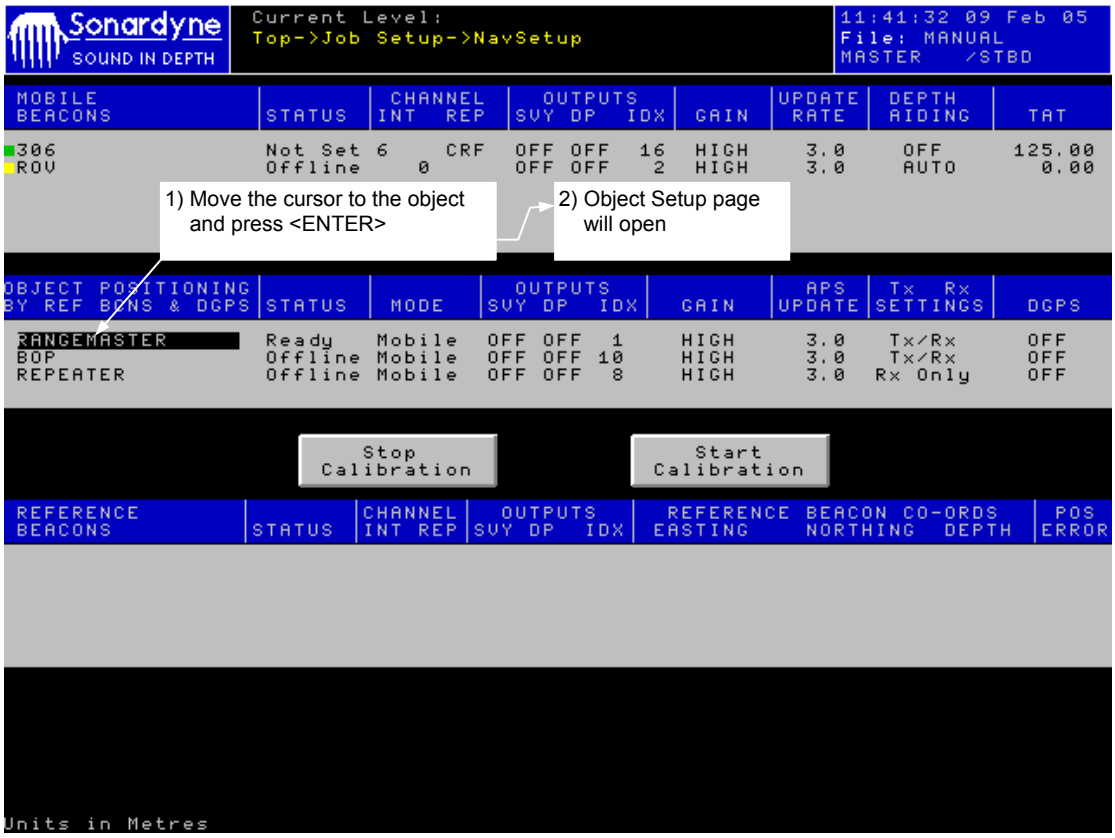
3.2 OBJECT SETUP

Having checked the main installation parameters, it is now necessary to check those 'Object' parameters which have been set during the installation phase. They will need changing only if the job configuration has changed in some significant way since the installation.

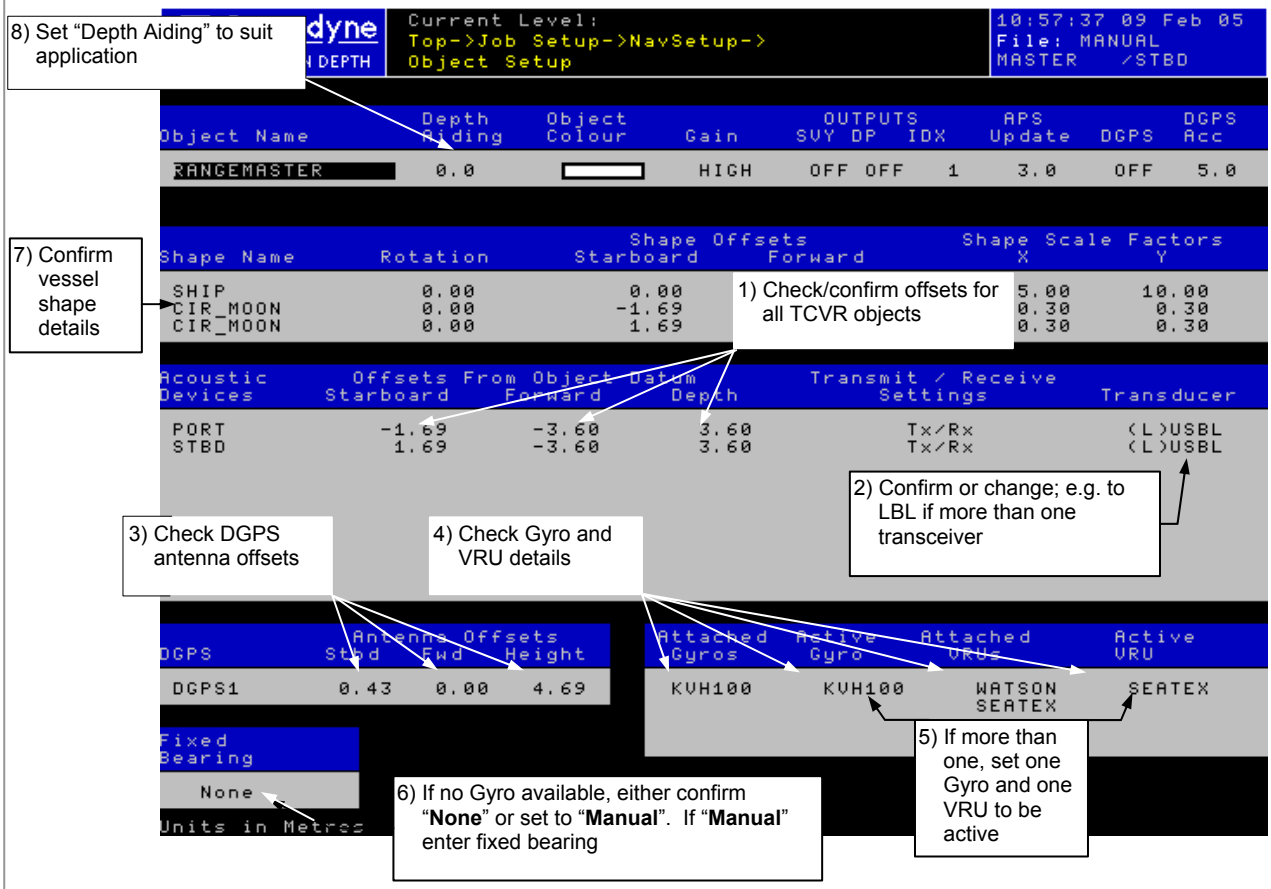
This task is accomplished using the "**Object Setup**" page that is accessed via the "**Navigation Setup**" page under **"Job Setup"**. The 'Object(s)' to be checked will always include at least the Vessel and may include, for example, an ROV and/or a BOP stack.

Note that with Version 6 systems and with the acoustic configuration of both the Vessel and (where appropriate) ROV set to "**Tx/Rx**", the system will transmit from the Vessel and ROV on alternate acoustic cycles. It will receive replies at all transceivers on every cycle. If there is more than one transducer on a Transceiver (e.g. a BOPNav), it is possible to select either transducer or both transducers to be used in the acoustic positioning. If both are chosen, the system will select the transducers alternately and use this information to compute the Object heading.

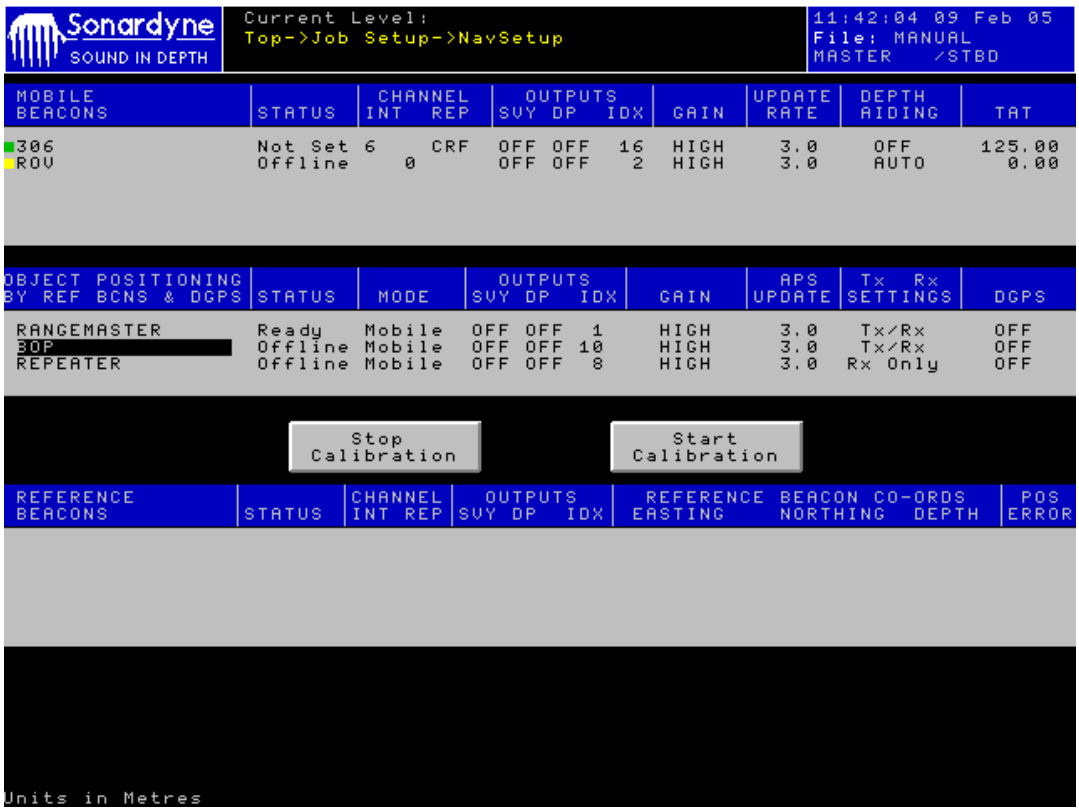
Return to the main menu and select "**Job Setup**" followed by "**Navigation Setup**":-



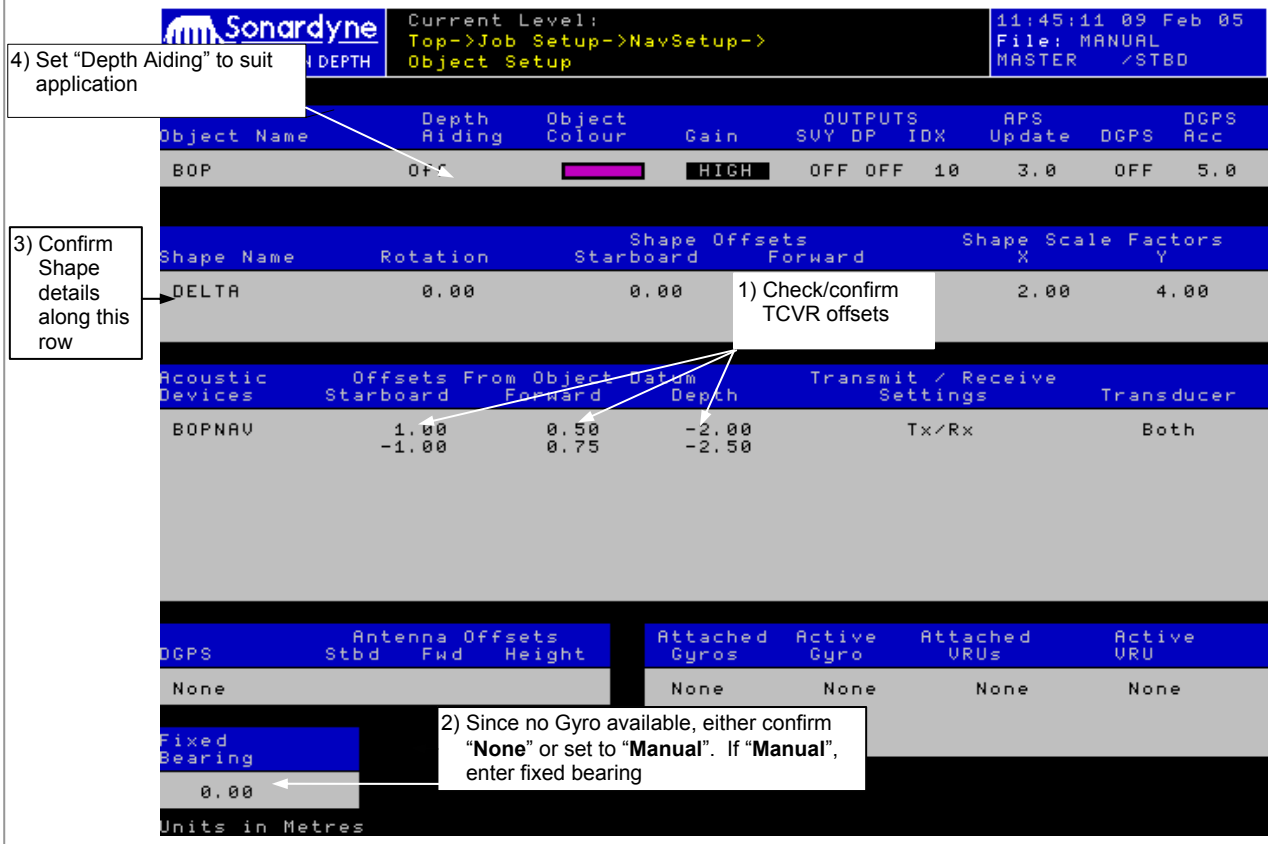
On the "**Object Setup**" page for the object - in this case the vessel:-



If a Mobile Object, say a BOP stack, is included in the system set up, return to the "**Navigation Setup**" page:-



On the "**Object Setup**" page for the BOP Stack:-



3.3 JOB FILE MANAGEMENT MENU

3.3.1 Archiving Installation File

On completion of all installation checks, archive the installation file for this job. (If you are not sure how to do this, refer to Section 9.3).

3.3.2 Job File Setup

If current job is not suitable, select **"File Management**" from main menu. Then either:-

- Select "**Select Job**" - if continuing to work on earlier job.
  - A job file list opens - select required file. This file then becomes current job file.
- Or select "**Copy Job**" - if starting work on a new job which is similar to an old job.
  - A job file list opens - select file to be copied. This option copies one selected Job File on the hard disc to another on the hard disc.
  - Enter a name and description of the new job. This new file then becomes current job file. It can then be modified and re-saved.
- Or select "**Create New Job**" - if starting new job.
  - Enter name of new job and description. This new file then becomes current job file. (If you need more detail on this, please refer to Section 9.3).

This concludes the basic installation checking process.

SECTION 4

4. APPLICATIONS PROCEDURES

4.1 INTRODUCTION

This section contains a set of procedures for carrying out common acoustic positioning tasks which may be performed by USBL and L/USBL systems. Note that Version 6 of the system is designed to manage communications between multiple Transceivers and multiple Objects. This yields much improved operational flexibility when the system is being used in a complex configuration. Some of the procedures described in this Section take advantage of this flexibility. The procedures are also aimed at systems running V6 software release 6.06 that supports operation with both tone and wideband signals.

Each procedure contains both set-up and operating elements. Some parts of the set-up process are common to several different applications and these common set-up steps are contained in Section 3. The remaining part of the set-up process specific to each application plus the operating element, is contained within the sub-section applicable to that application. The common set-up procedure and the application-specific procedure are each self-contained - in the sense that each makes no reference to any other sections of the manual.

Where the user wishes to understand a particular step in more detail, full explanations of each menu page may be found in the Reference Section (Section 9).

All procedures assume that the system has been installed correctly and that the Beacons required by the job have been deployed and all Beacon data has been programmed onto the system database via the "**Navigation Setup**" and "**Beacon Setup**" pages (see paragraph 9.2.1.2 in Section 9). The system must have been switched on and the main menu should be on the display with the system device status listed after polling.

All procedures also assume that the operator is familiar with the rules for selecting menu items, moving the cursor around the pages and activating a dialogue box for any field on a page. If not, these rules are given in the Reference Section (Section 9).

The applications covered in this Section are listed below:-

4.2 Mobile Tracking (p 4)	In this scenario, a USBL system is required simply to report the position of a mobile Beacon (typically installed on an ROV) or the position and orientation of a structure marked by multiple mobile Beacons (such as a Turret buoy). Position is reported in terms of x, y and z or, if a gyro is installed, East, North and Depth relative to the vessel datum. The output may be provided to a DP system and / or a survey package.
4.3 Single Beacon DP (p 11)	In this application, a USBL system is required to report to a DP system the position of the vessel relative to a single seabed beacon – i.e. one whose position has been fixed.
4.4 L/USBL DP (p 14)	This application is an extension of the previous example but involves an array of Reference Beacons calibrated using the 'Top-Down' method. Covers two cases – with and without DGPS inputs to the system.

4.5 L/USBL Ship (DP) and a USBL Mobile (p 22)	This covers a further extension of the Single Beacon DP case in which the L/USBL system will provide DP positioning for the vessel and at the same time position a mobile target, for example an ROV or BOP. The mobile target can be positioned in one of two ways:- ❑ **Transponder**. The mobile target is completely remote, equipped with a Beacon that is interrogated acoustically and replies acoustically. ❑ **Responder**. This is an extension of the previous example where the acoustic interrogation is replaced by an electronic interrogation through a hardwired link OR umbilical. It can take two forms:- • **Beacon**. A Beacon with a responder option is interfaced to the L/USBL system through the Mobile's umbilical. An electrical interrogation is transmitted from the L/USBL through the umbilical to the Beacon which 'responds' with an acoustic signal. • **Transceiver**. A Mini ROVNav, Mk4 ROVNav or BOPNav Transceiver, interfaced through the mobile's umbilical, can be used as described in the previous example.
4.6 LBL Mobile (p 27)	In this application, the system is used to report the position of a mobile transceiver (ROVNav or BOPNav) relative to an array of Reference Beacons with known co-ordinates in an LBL (Long Baseline) mode ONLY – no USBL tracking is involved.
4.7 L/USBL Ship (DP) and an LBL Mobile (p 31)	In this application, an L/USBL system is required to report to a DP system the position of the vessel relative to an array of Reference Beacons. At the same time the system will report the position of a mobile transceiver (such as a Mk4 ROVNav) relative to the same array of Reference Beacons in an LBL (Long Baseline) mode.
4.8 L/USBL Ship (DP) and a Transceiver on a 'Latched' BOP (p 37)	In this application, an L/USBL system is required to report to a DP system the position of the vessel relative to an array of Reference Beacons. The difference between this application and the L/USBL DP case is that the array would be interrogated from the L/USBL Transceiver(s) at the surface, but the Beacon replies would also be received at the BOPNav Transceiver installed on the BOP. This application assumes that the BOP has already been positioned on a well and latched. If it has not, then the application described in Section 4.5 (L/USBL Ship (DP) and a USBL Mobile) may be used to cover the BOP deployment phase.
4.9 Baseline or 'Bottom Up' Array Calibration (p 43)	This procedure covers the setup and operation of the system when using the baselines measured between COMPATTs to determine the accurate relative calibration of an array being used to position a mobile LBL transceiver (such as a Mk4 ROVNav or BOPNav) close to the seabed during survey operations. Two different methods are available – 'Array Baseline Measurement' and 'Incremental Baseline Measurement'.

4.10 MRAMS – Marine Riser Angle Monitoring System (p 56)	This covers setup and operation of the system for reporting the angle of the Riser relative to the BOP on a wellhead system. Covers two cases – as a standalone system and in parallel with a DP operation. The procedure applies only to special purpose Riser Angle COMPATT systems. It is assumed that a Riser Angle COMPATT (RAC) and its External Inclinometer Unit are ready for deployment.
4.11 Dual Redundancy (p 66)	This describes a procedure for using a Dual-Redundant system in the L/USBL DP application. The difference between this and the basic procedure is that two L/USBL systems share all data and a common database. If any part of the 'Master' system should fail then that part of the 'Slave' system would take over.
4.12 PAN Emulation (p 69)	This describes how to use a Navigation Processor to emulate a PAN in conjunction with a survey system (Fusion LBL for example). In this mode COMPATTs can be commanded to carry out any of a variety of specialised tasks – such as tracking a mobile COMPATT using the Simultaneous (SI) or Fast Simultaneous (FS) mode.
4.13 BOP Control System (p 70)	This sets out a procedure for using the L/USBL Navigation Processor to emulate a Transceiver for the acoustic BOP control system.

NOTE: In the following menu illustrations, the procedures are set out in call-out boxes associated with each illustration. Carry out these procedures in the number order of the boxes.

4.2 MOBILE TRACKING

In this scenario, a USBL system is required simply to report the position of a single mobile Beacon (typically installed on an ROV), or the position and orientation of a structure marked by multiple mobile Beacons (such as a Turret buoy). The position is reported in terms of x, y and z or, if a gyro is installed, East, North and Depth relative to the vessel datum. The output may be provided to a DP system and or a survey package. The procedures to be followed for the two different cases are described:-

4.2.1 Single Mobile Beacons

4.2.1.1 Common Installation Procedures

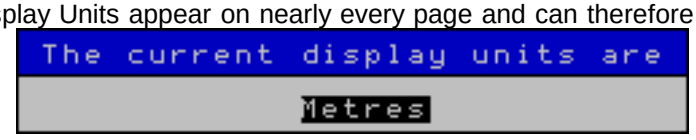
The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.2.1.2 Job Setup Menu

Having assigned a job file (see Section 3.3 if job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

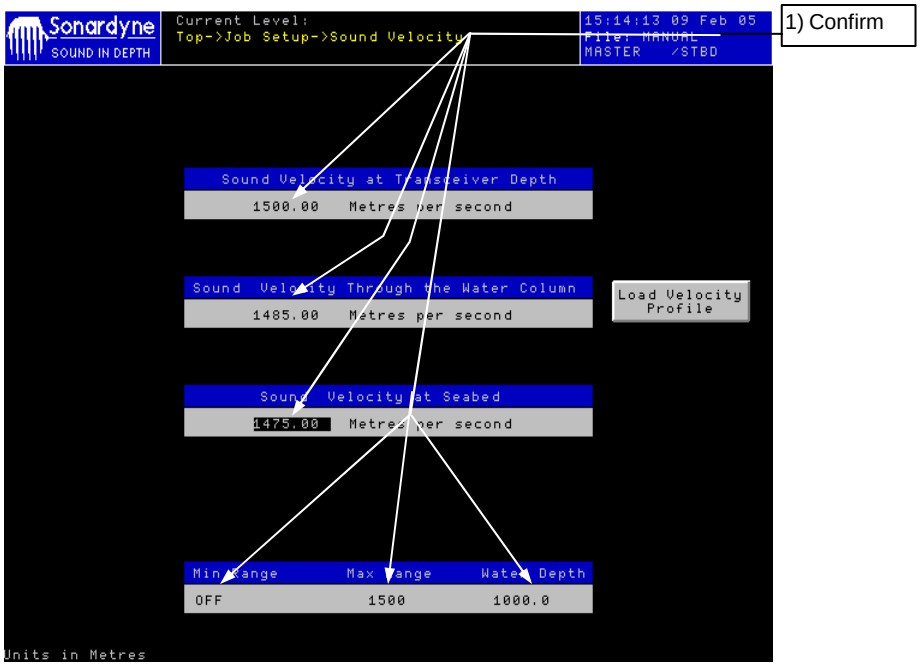
- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.



NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to compute the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

❑ Confirm the fields in the bottom row of the "**Sound Velocity**" dialog box, as follows:-

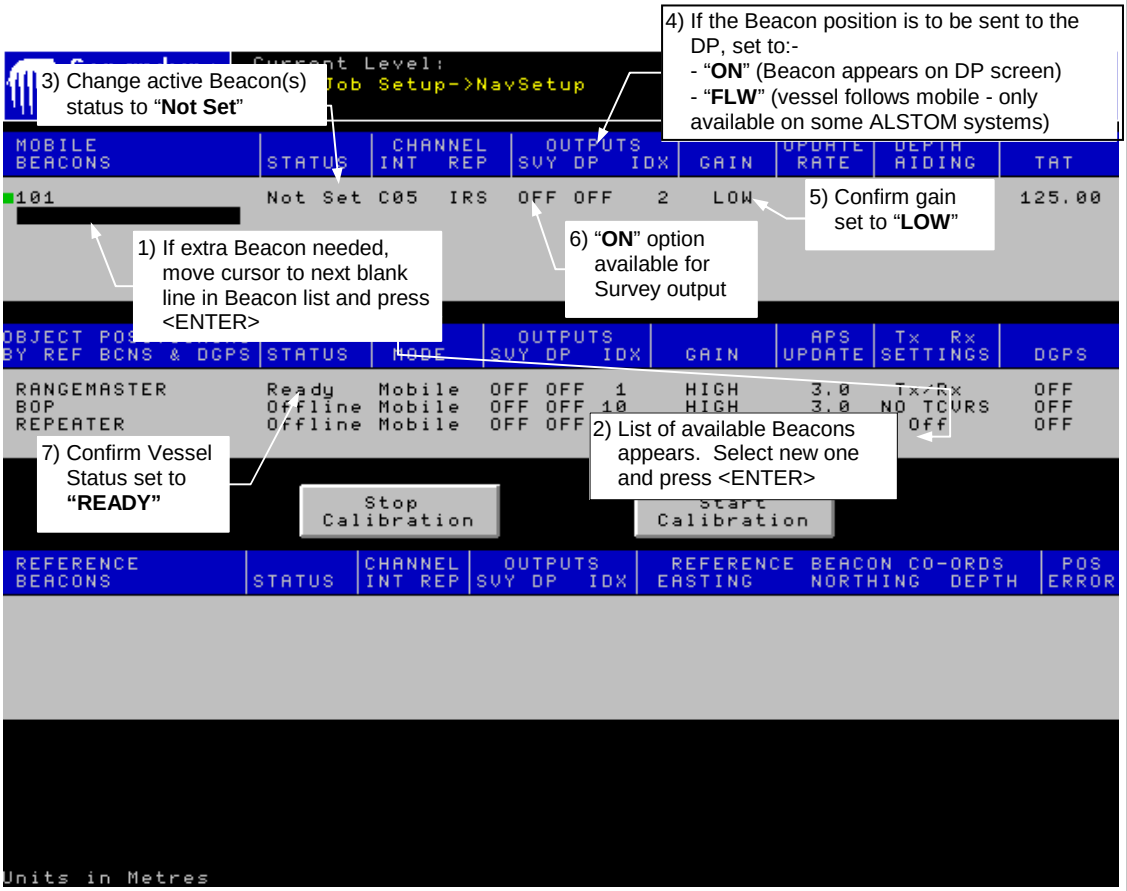
- "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**OFF**".
  - "**Manual**" User input minimum expected range in feet/metres.
  - "**OFF**" No minimum range gating will be implemented.
- "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

❑ Select "**Navigation Setup**"

The following steps describe how to add new Beacons to the job (if required), how to set COMPATT, PGT, SSM and WSM beacon types to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

On the "**Navigation Setup**" page:-



4.2.1.3 Navigate Menu

Having set the job up, return to the Top Level menu and select "**Navigate**".

- COMPATT, PGT, SSM and WSM beacons types that are "**Not Set**" will be automatically configured by the system, with commands being displayed in the message box at the top of the display.

- Set up the Chart Display to suit the job in hand (refer to Section 6 if you need help with this). Set up one of the Position Data Boxes for the mobile Beacon - "**Mobile Beacon Data**" in the "**Data Boxes**" menu. Set up a second Position Data Box to display the "**Range Diags**" for the mobile beacon.

- Check that the system is navigating correctly - there should be no error messages in the message box at the top of the display and the Position Data Box should be confirming sensible replies coming in from the mobile Beacon with Range Diagnostic values generally under 0.3 milliseconds. See Section 5 for a listing and explanation of error messages.

Once the system is setup and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.2.2 Multiple Beacons mounted on a Structure

4.2.2.1 Common Installation Procedures

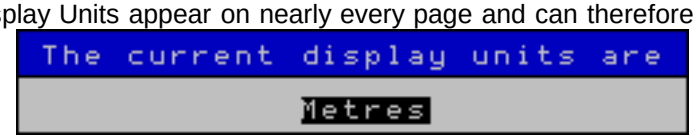
The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.2.2.2 Job Setup Menu

Having assigned a job file (see Section 3.3 if job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

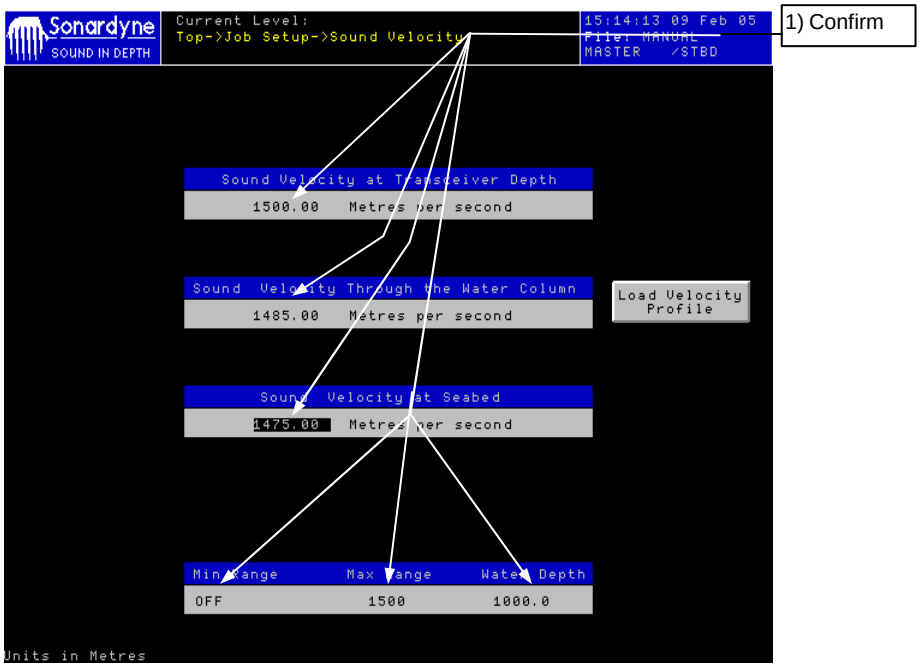
- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.



NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to compute the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

- Confirm the fields in the bottom row of the "**Sound Velocity**" dialog box, as follows:-

  - "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**OFF**".

    - "**Manual**" User input minimum expected range in feet/metres.
    - "**OFF**" No minimum range gating will be implemented.

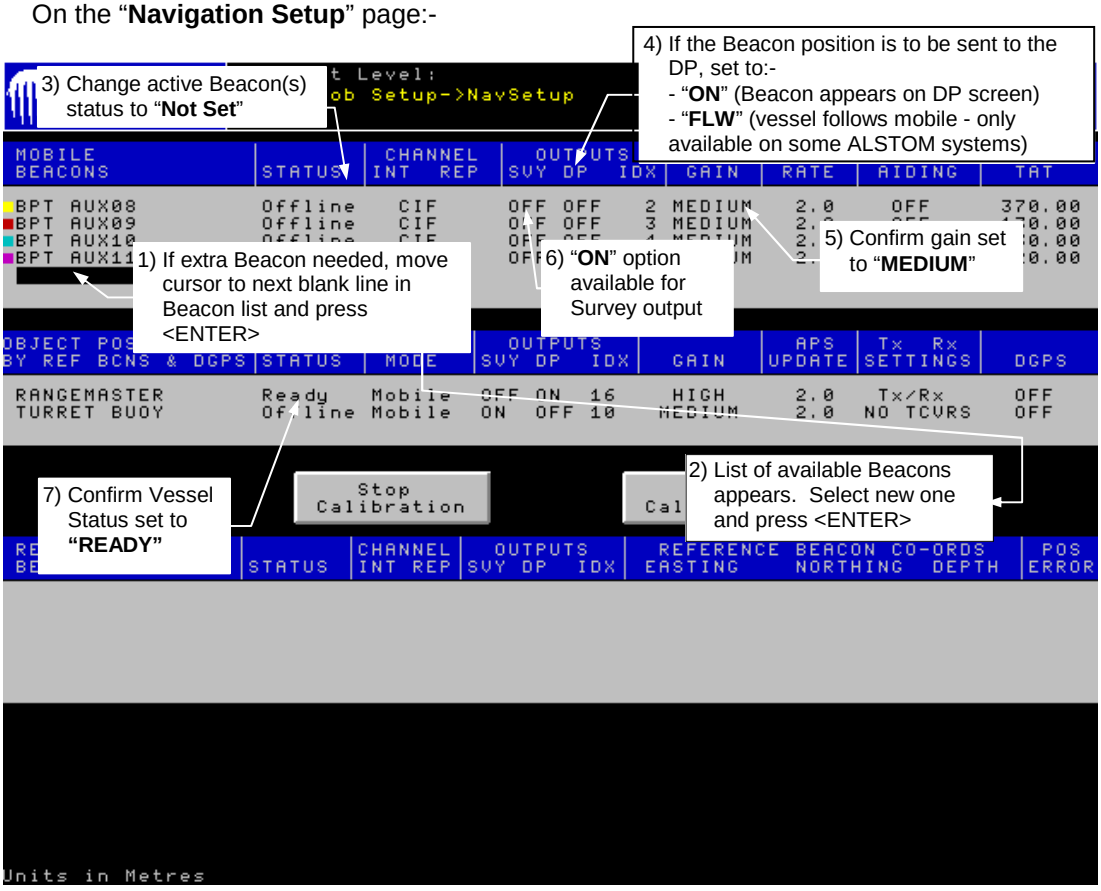
  - "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.

  - "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

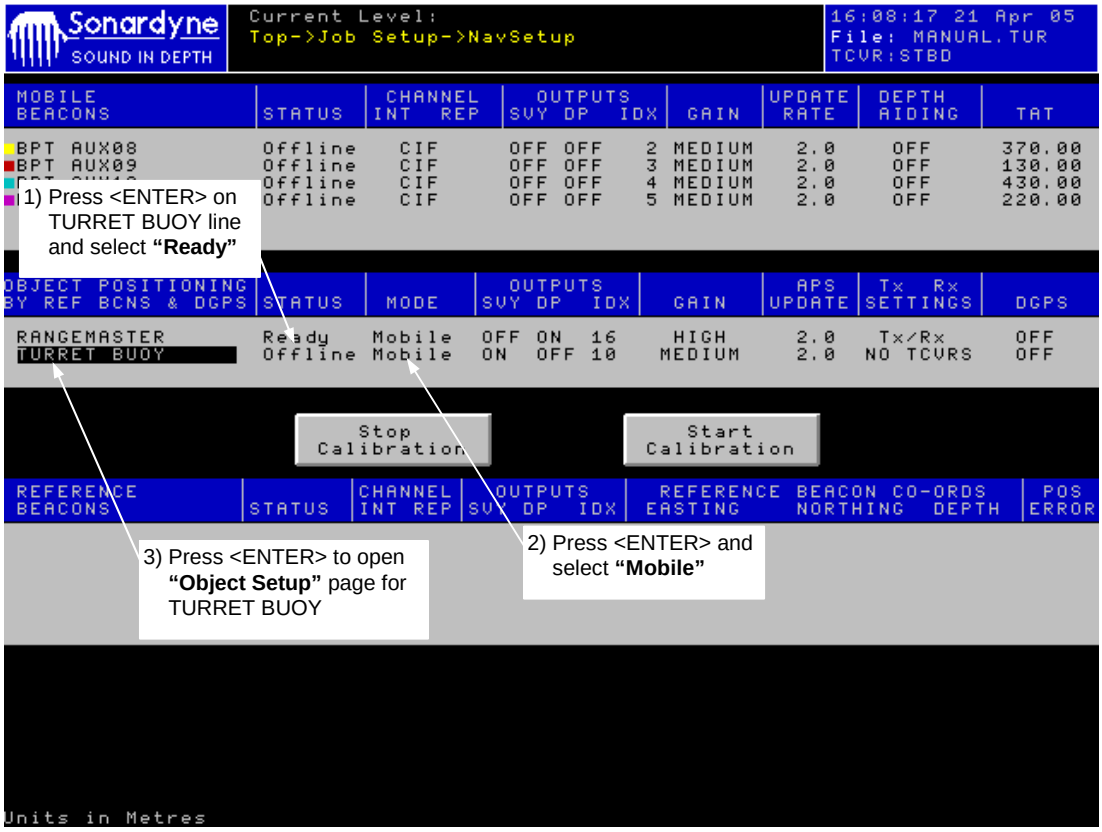
- Select "**Navigation Setup**"

The following steps describe how to add new Beacons such as Buoy Positioning Transponders (BPTs) to the job (if required), how to set COMPATT, PGT, SSM and WSM beacon types to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

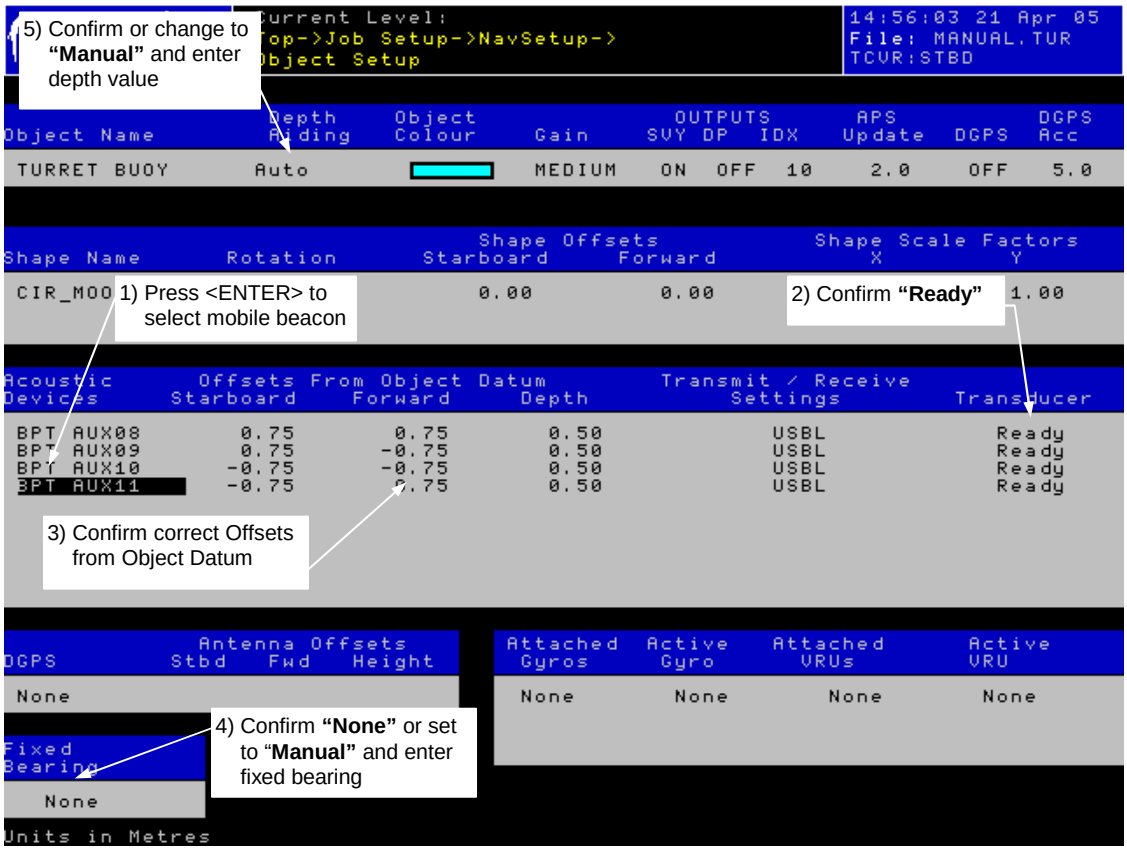
On the "**Navigation Setup**" page:-



While still on the "**Navigation Setup**" page:-



On the "**Object Setup**" page for the TURRET BUOY:-



4.2.2.3 **Navigate Menu**

Having set the job up, return to the Top Level menu and select "**Navigate**".

- COMPATT, PGT, SSM and WSM beacons types that are "**Not Set**" will be automatically configured by the system, with commands being displayed in the message box at the top of the display.

- Set up the Chart Display to suit the job in hand (refer to Section 6 if you need help with this). Set up one of the Position Data Boxes for the mobile Structure - "**OBJECT Position Data**" in the "**Data Boxes**" menu. Set up a second Position Data Box to display the **"Range Diags"** for the mobile beacons.

- Check that the system is navigating correctly - there should be no error messages in the message box at the top of the display and the Position Data Box should be confirming sensible position for the mobile Structure with Range Diagnostic values generally under 0.3 milliseconds for each Beacon. See Section 5 for a listing and explanation of error messages.

Once the system is setup and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.3 SINGLE BEACON DP

In this scenario, a USBL system is required to report to a DP system the position of the vessel relative to a single Beacon whose position has been fixed.

4.3.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.3.2 Job Setup Menu

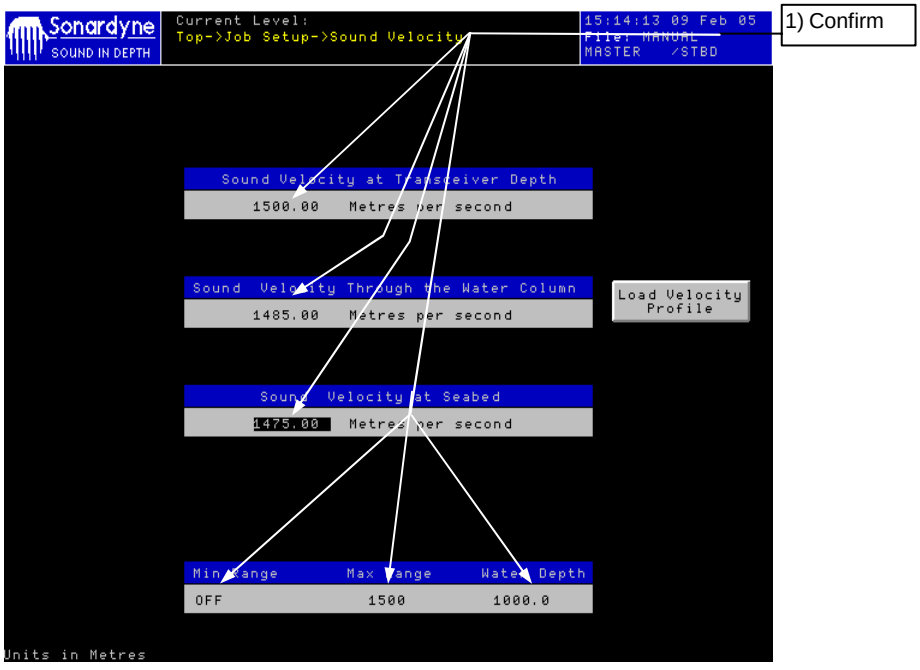
Having assigned a job file (see Section 3.3 if job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

❑ Confirm the fields in the bottom row of the "**Sound Velocity**" dialog box, as follows:

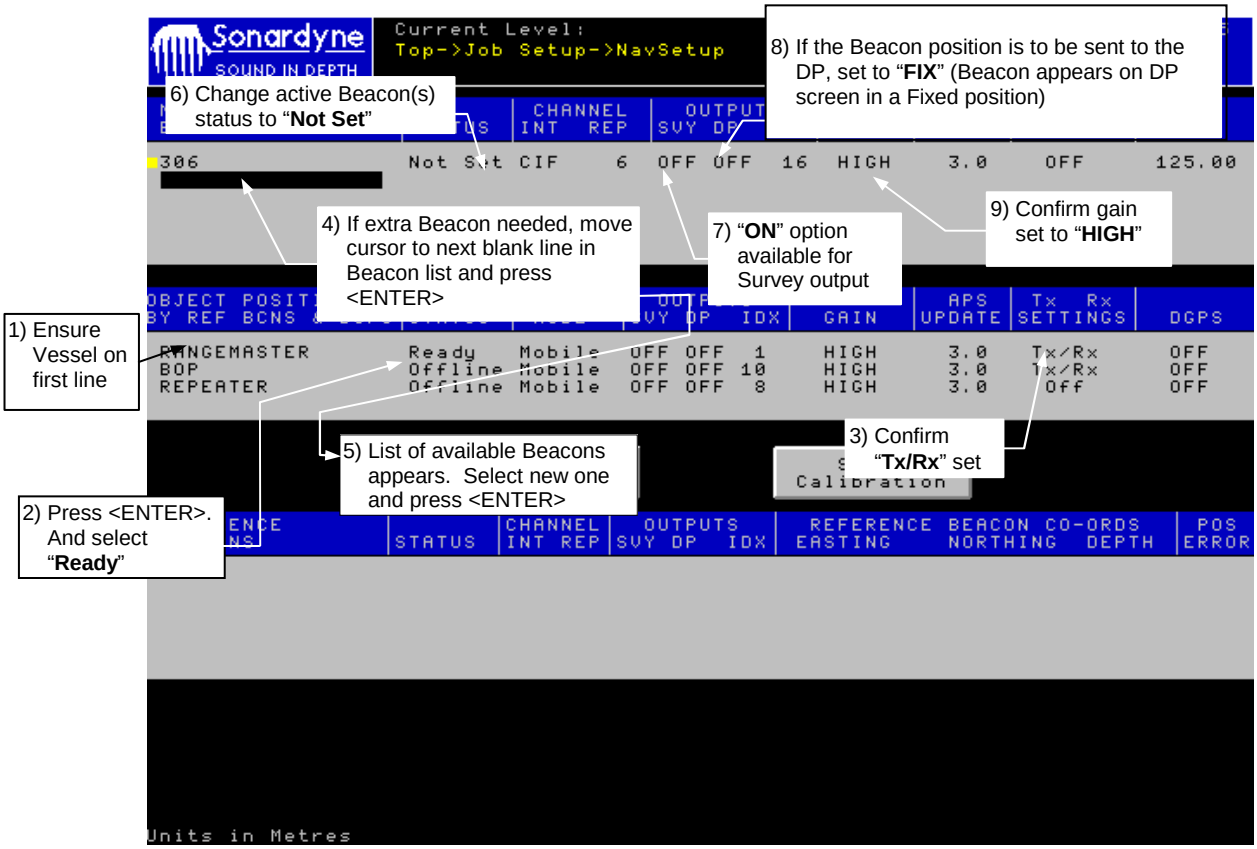
- "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**OFF**".
  - "**Manual**" User input minimum expected range in feet/metres.
  - "**OFF**" No minimum range gating will be implemented.
- "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

❑ Select "**Navigation Setup**"

The following steps describe how to add new Beacons to the job (if required), how to set COMPATT, PGT, SSM or WSM beacon types to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

On the "**Navigation Setup**" page:-



4.3.3 Navigate Menu

Having set the job up, return to the top level menu and select "**Navigate**".

- The system will set up COMPATT, PGT, SSM and WSM beacon types as defined on the Beacon Setup page ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will start to calculate Beacon position with reference to the vessel.

- Set up one of the Position Data Boxes to show Beacon position - "**Mobile Beacon Data**" in the "**Data Boxes**" menu. Set up a second Position Data Box to display the **"Range Diags"** for the mobile beacon to be used as a 'fixed' DP Beacon.

- Check that the system is navigating correctly - no error messages in the message box at the top of the display and the Position Data Box is confirming sensible replies coming in from the mobile Beacon, with Range Diagnostic values generally under 0.3 milliseconds.

- Observe the **"Qual"** value in the Position Data Boxes. A Beacon is ready to be used as a fixed DP Beacon when the quality value is consistently below 1% of slant range on a quiet vessel or greater than this on a noisy vessel.

NOTE: The DGPS must be turned off before using the system as a DP reference.

- Return to the Chart Display

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.4 L/USBL DP

This application is an extension of the previous example but involves an array of Reference Beacons calibrated using the 'Top-Down' method, which is outlined below and covers two cases – with and without DGPS input.

4.4.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.4.2 Job Set-Up Menu

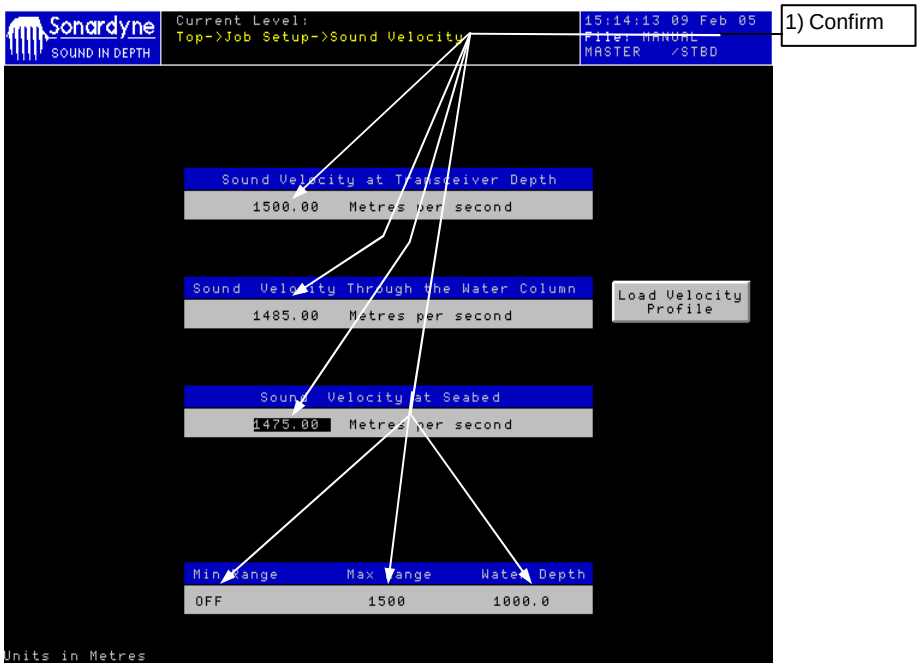
Having assigned a job file (see section 3.3 if the job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

  In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

  NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

❑ Confirm the fields in the bottom row of the "**Sound Velocity**" dialog box, as follows:

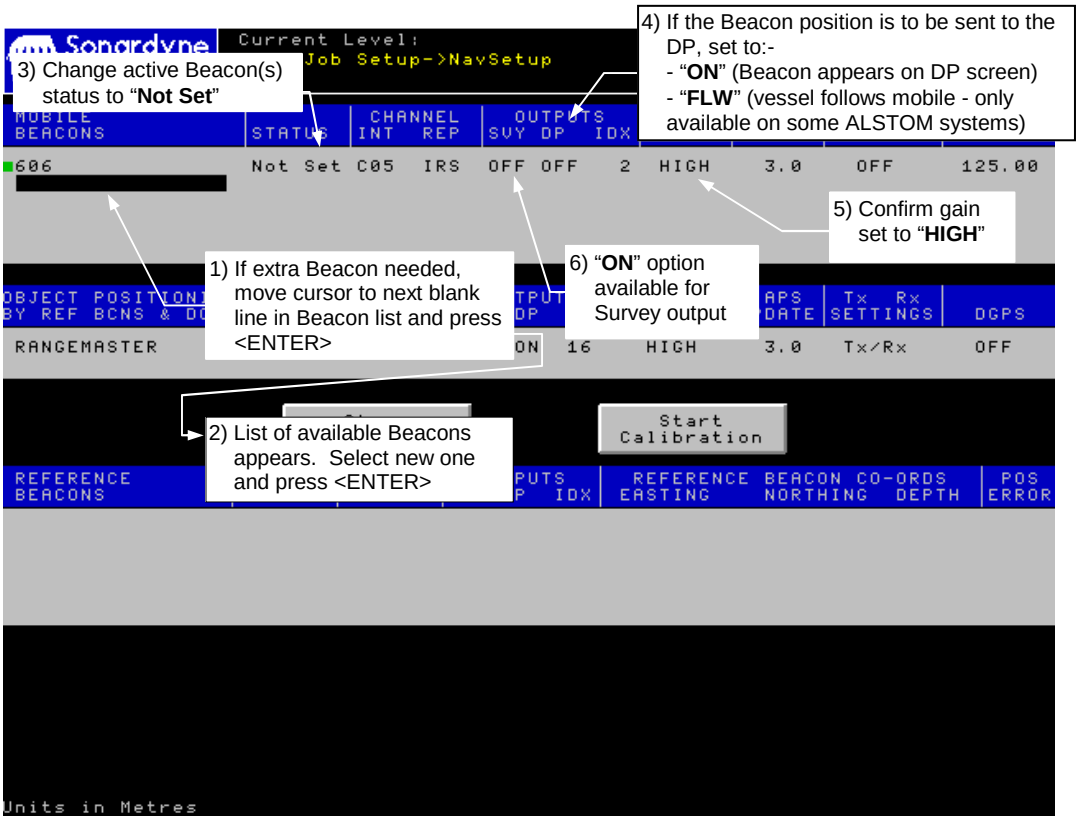
- "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**OFF**".
  - "**Manual**" User input minimum expected range in feet/metres.
  - "**Off**" No minimum range gating will be implemented.
- "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

❑ Select "**Navigation Setup**"

The following steps describe how to add new Beacons to the job (if required), how to set COMPATT, PGT, SSM and WSM types to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

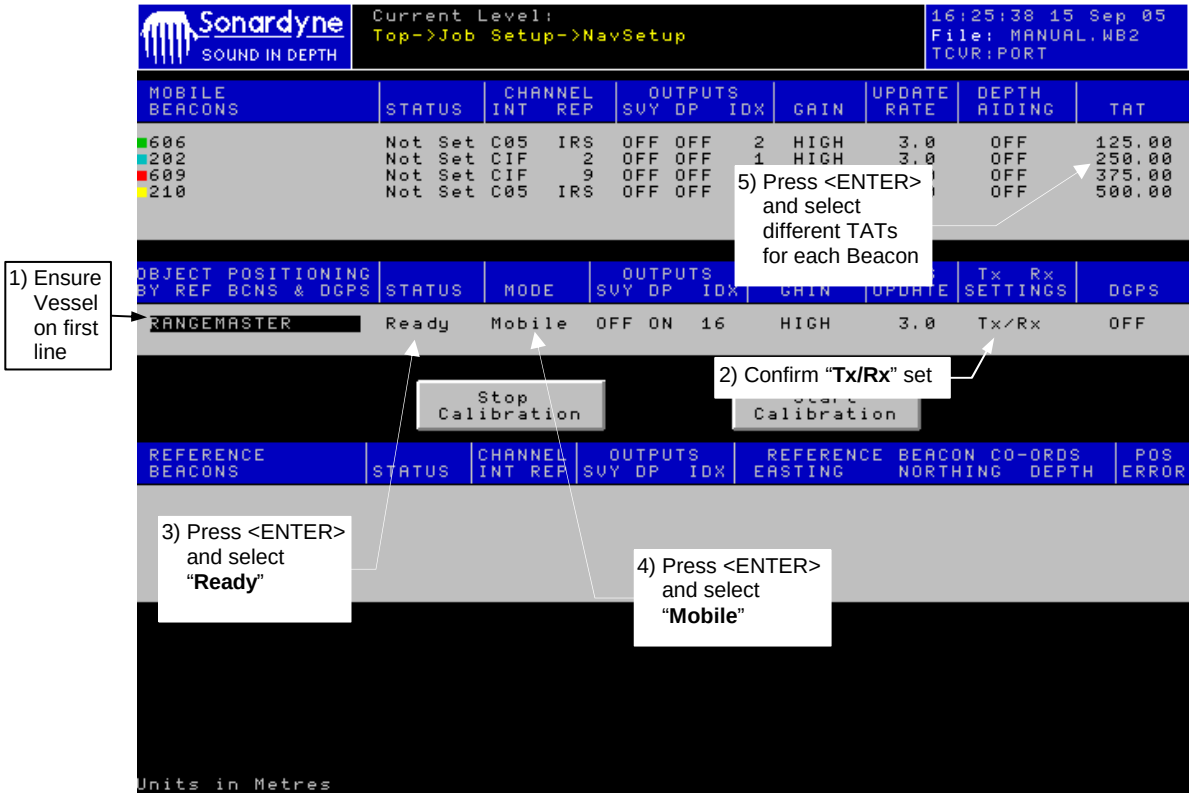
NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

On the "**Navigation Setup**" page:-



4.4.3 Object Set-Up Procedure

While on the **Navigation Setup** page:-



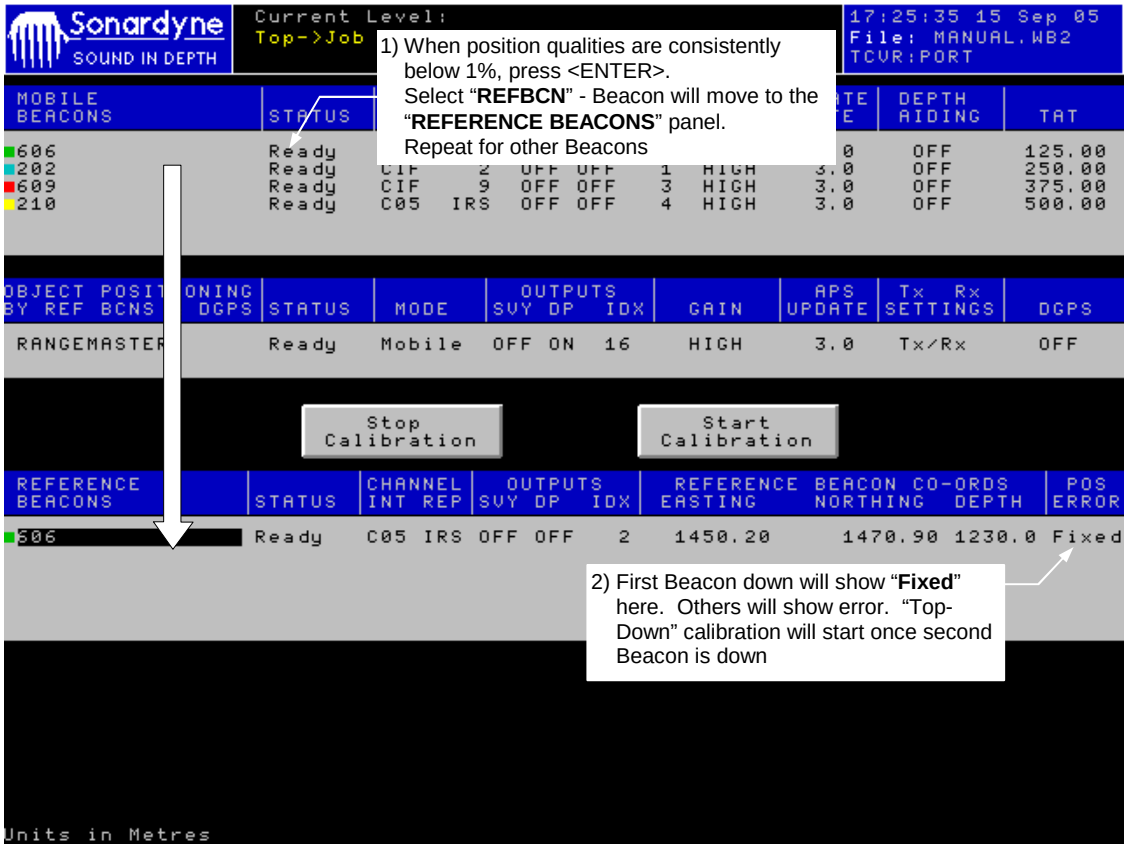
4.4.4 Calibrating the L/USBL Array with no DGPS

A "Top Down" array calibration is achieved by using this procedure. Select the "**Navigation Setup**" page, move the cursor along the Vessel row to the "**DGPS**" column, press <ENTER> and turn DGPS "**OFF**".

Return to the top level menu and select "**Navigate**". The system will set up COMPATT, PGT, SSM and WSM beacon types as previously defined on the Beacon Summary pages ("Status" will change automatically to "**Ready**" on the "**NavSetup**" page when each beacon is set up) and will start to calculate Beacon positions with reference to the vessel. Set up Position Data Boxes and a Range Diagnostics Box for the Beacons.

Return to the Chart Display and observe the "**Qual**" value in the Position Data Boxes. A Beacon is ready to be defined as a Reference Beacon when the position error is consistently below 1% of slant range and the "**Range Diags**" under 0.3 milliseconds on a quiet vessel or greater than this on a noisy vessel.

- Select "**NAV SET-UP**"



Once more than one Beacon is in the "**REFERENCE BEACONS**" panel, the system will automatically start a 'Top Down' calibration - all other Beacons being calibrated with respect to the first. In practice, the Easting and Northing co-ordinates of the first Beacon will be fixed and the depth value will be allowed to vary.

Once the position error of all the Reference Beacons has stabilised at an acceptable value with very small changes being made to each beacon co-ordinate (approximately 1 hour), press the "**Stop Calibration**" button. This will fix all Beacons in Easting, Northing and Depth co-ordinates.

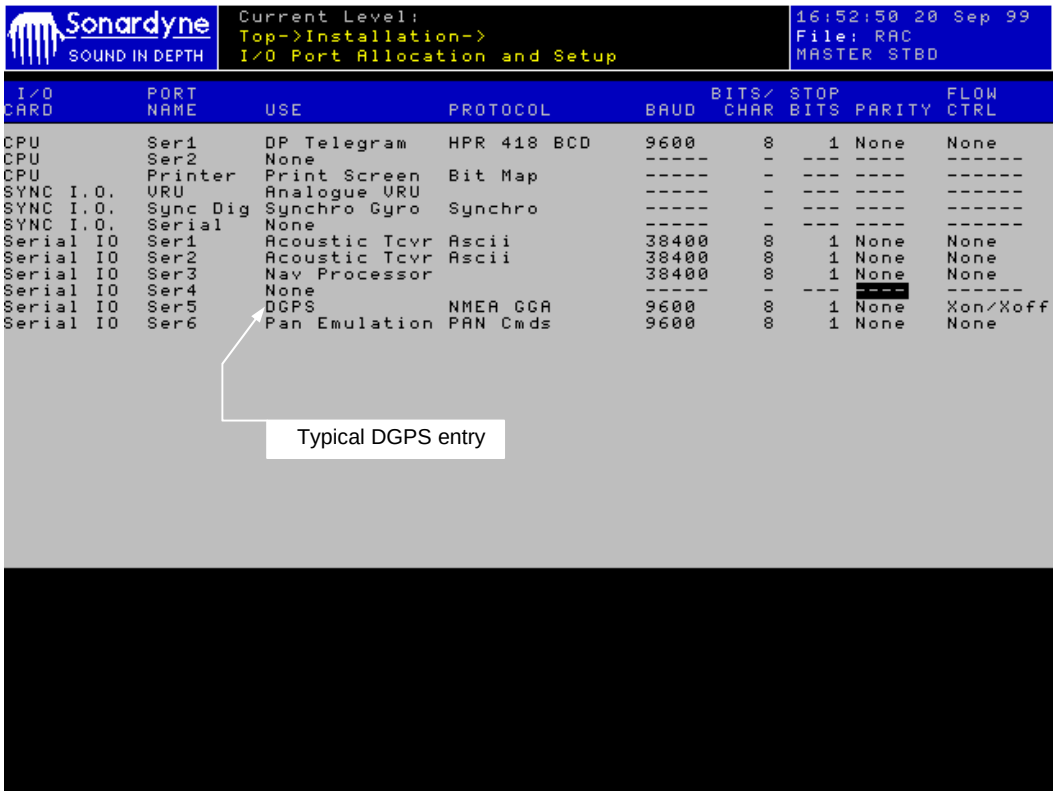
- Return to the Chart Display

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.4.5 Calibrating the L/USBL Array with DGPS

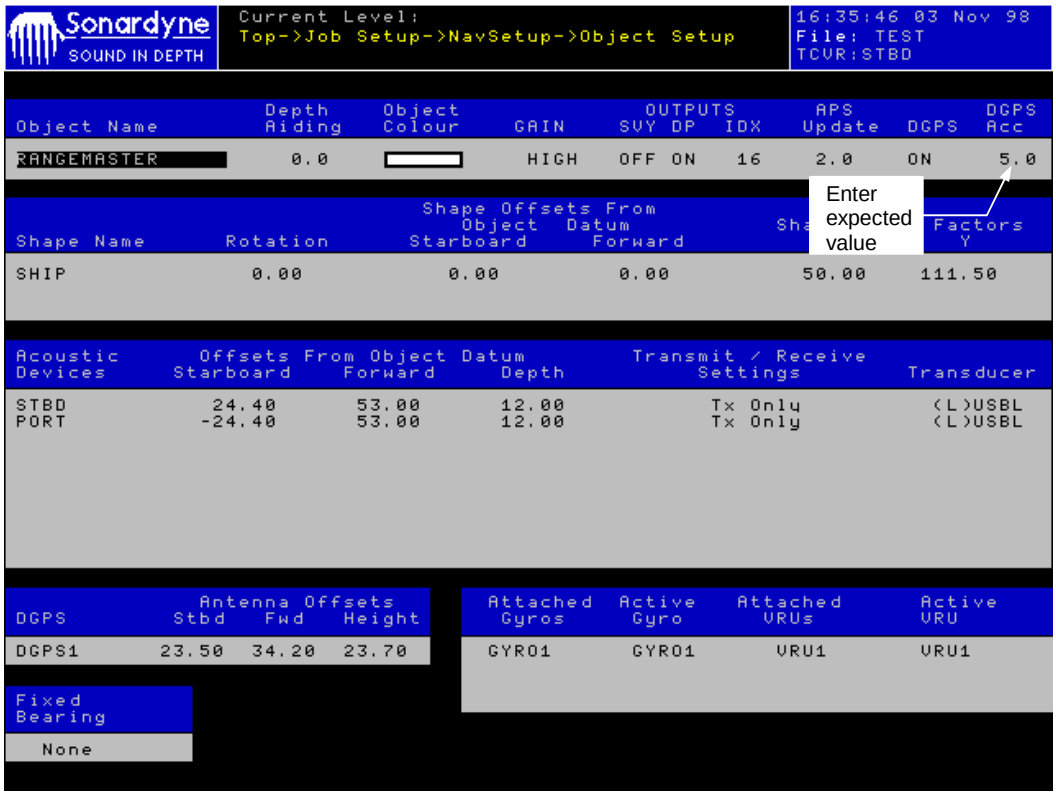
A 'Top Down' calibration is achieved by using this procedure relative to the DGPS fix.

If not already done, select "**I/O Port Allocation and Setup**" from the "**Installation"** menu and set up a DGPS line as illustrated in the following:-



Select the "Navigation Setup" page, move the cursor along the Vessel row to the "**DGPS**" column, press <ENTER> and turn DGPS "**ON**".

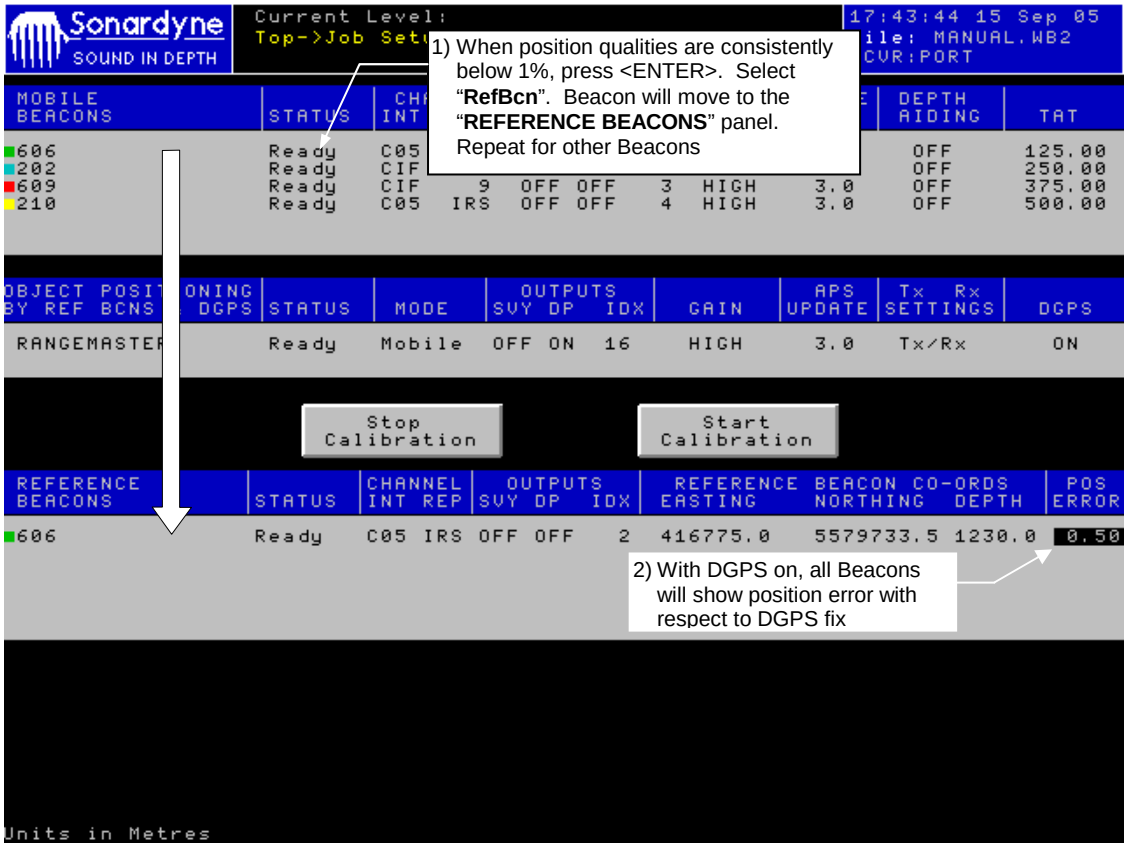
Move the cursor back to the Vessel column and press <ENTER>. The "**Object Setup**" page for the Vessel will open. Move the cursor along to the "**DGPS Acc**" column and enter the expected value in system units - as illustrated below:-



Return to the top level menu and select "**Navigate**". The system will set up COMPATT, PGT, SSM and WSM beacons types as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page when each beacon is set up) and will start to calculate Beacon positions with reference to the vessel. Set up Position Data Boxes and a Range Diagnostics Box for the Beacons.

Return to the Chart Display and observe the "**Qual**" value in the Position Data Boxes. A Beacon is ready to be defined as a Reference Beacon when the position error is consistently below 1% of slant range and the "**Range Diags**" under 0.3 milliseconds on a quiet vessel or greater than this on a noisy vessel.

- Select "**NAV SET-UP**"



Once more than one Beacon is in the "**Reference Beacons**" panel, the system will automatically start a 'Top Down' calibration - all Beacons being calibrated with respect to the DGPS fix.

Once the position error of all the Reference Beacons has stabilised at an acceptable value with very small changes being made to each beacon co-ordinate (approximately 1 hour), press the "**Stop Calibration**" button. This will fix all Beacons.

- Return to Chart Display

NOTE: The DGPS must be turned off before using the system as a DP reference.

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.5 L/USBL SHIP (DP) AND A USBL MOBILE

This covers a further extension of the Single Beacon DP case in which the L/USBL system will provide DP positioning for the vessel using an array of Beacons and at the same time position a mobile USBL target relative to the vessel, for example an ROV. The mobile USBL target can be positioned in one of two ways:-

- **Transponder:** The mobile target is completely remote, equipped with a Beacon that is interrogated acoustically and replies acoustically.

- **Responder:** This is an extension of the previous example where the acoustic interrogation is replaced by an electronic interrogation through a hardwired link OR umbilical. It can take two forms:-

  - **Beacon:** A Beacon with a responder option is interfaced to the L/USBL system through the Mobile's umbilical. An electrical interrogation is transmitted from the L/USBL through the umbilical to the Beacon which 'responds' with an acoustic signal.

  - **Transceiver:** A ROVNav (Mini or Mk4) or BOPNav Transceiver, interfaced through the mobile's umbilical, can be used as described in the previous example.

4.5.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.5.2 Job Set-Up Menu

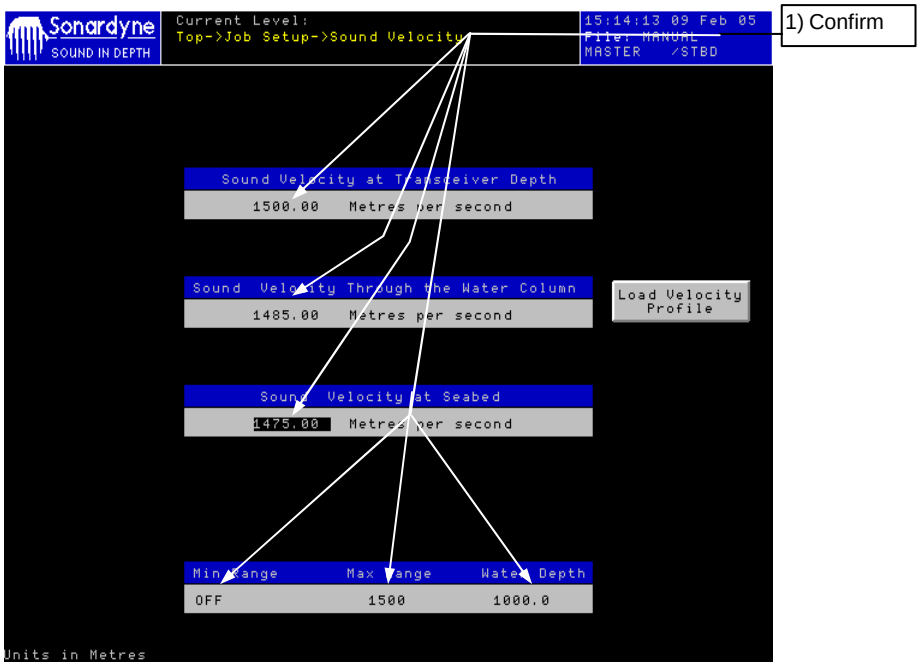
Having assigned a job file (see section 3.3 if the job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

- Confirm fields in bottom row of "**Sound Velocity**" dialog box, as follows:

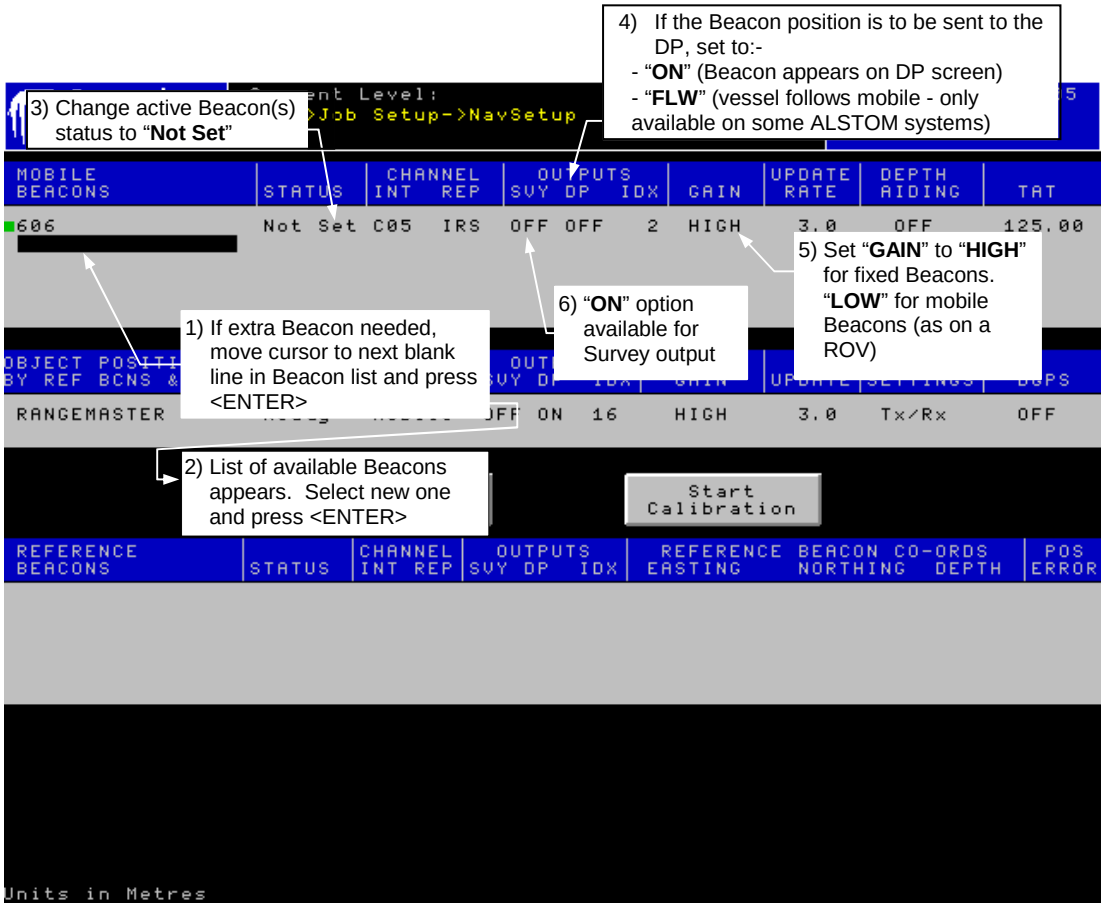
  - "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**OFF**".
    - "**Manual**" User input minimum expected range in feet/metres.
    - "**OFF**" No minimum range gating will be implemented.
  - "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
  - "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

- Select "**Navigation Setup**"

The following steps describe how to add new Beacons to the job (if required), how to set COMPATT, PGT, SSM or WSM beacon types to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

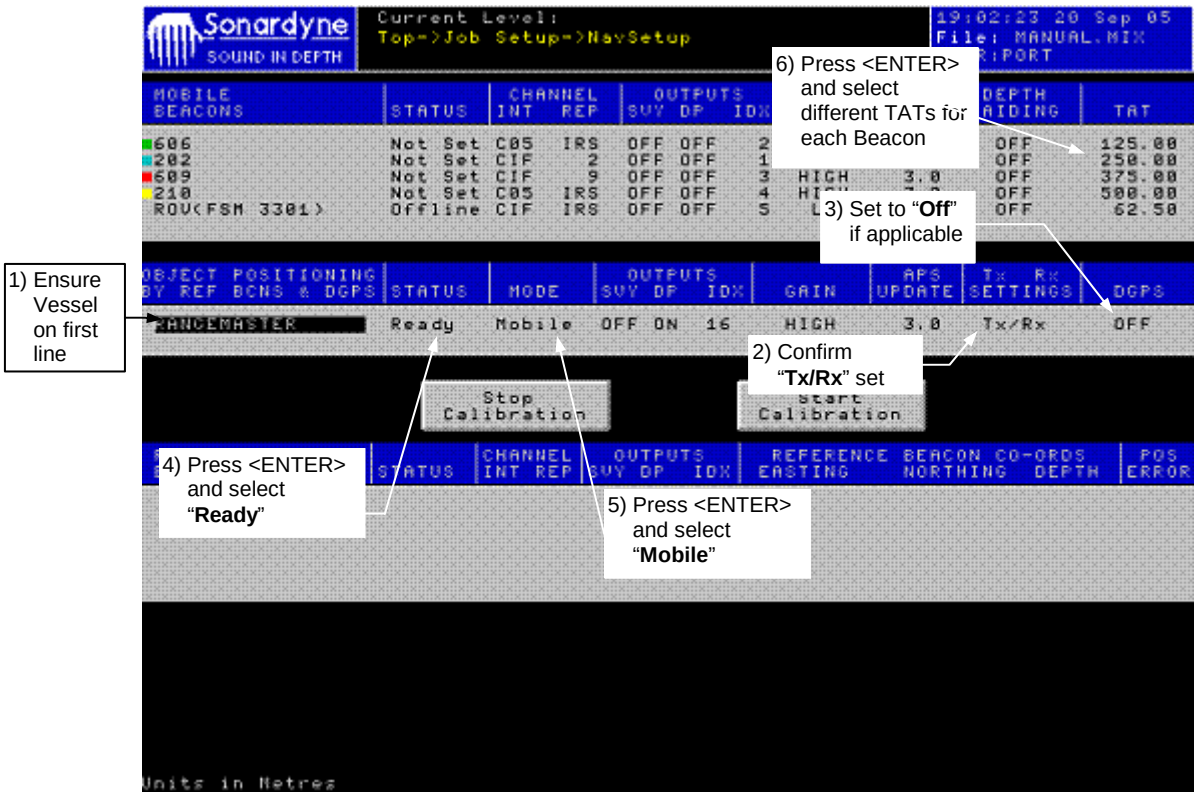
On the "**Navigation Setup**" page:-



As well as adding Beacons which are to become the reference array, add the mobile transponders, responders or transceivers which will be treated as mobile targets into the "**MOBILE BEACONS**" panel, as shown in the following Bit Map for the ROV mobile target marked by a WSM beacon being interrogated by a tone signal (CIF) and set to reply with a wideband signal (IRS). However, in the case of these mobile targets, leave them "**Offline**" initially until the array calibration has been completed.

4.5.3 Object Set-Up Procedure

While on the **Navigation Setup** page:-

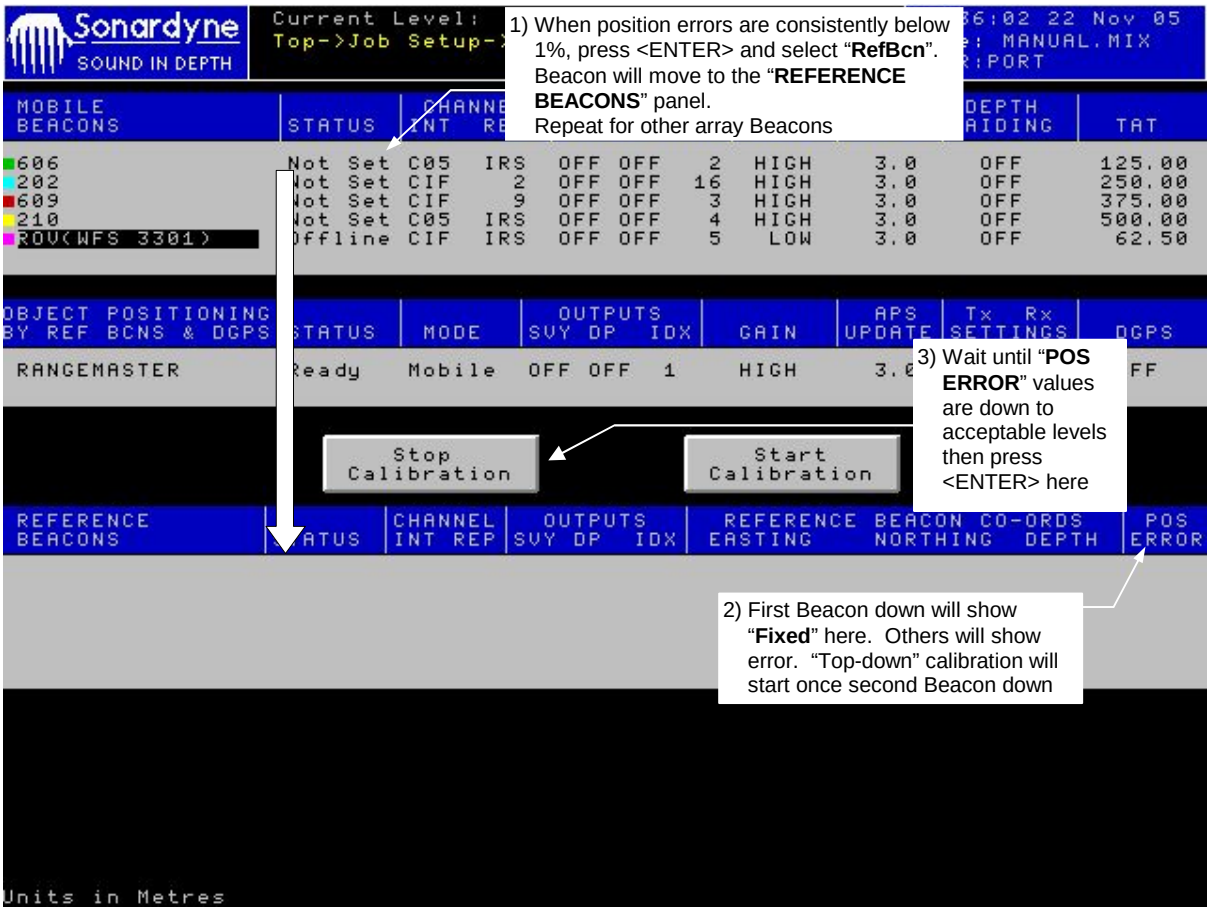


4.5.4 Navigate Menu

Return to the top level menu and select "**Navigate**". The system will set up COMPATT, PGT, SSM and WSM beacons types as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NAV SET-UP**" page) and will start to calculate Beacon positions with reference to the vessel. Set up Position Data Boxes and a Range Diagnostics Box for the Beacons. Allow time for the Beacon positions on the Chart Display to settle down.

Return to the Chart Display and observe the **"Qual**" value in the Position Data Boxes. A Beacon is ready to be defined as a Reference Beacon when the position error is consistently below 1% of slant range and the **"Range Diags"** under 0.3 milliseconds on a quiet vessel or greater than this on a noisy vessel.

Once the position quality of a Beacon has become small enough, select "**NAV SET-UP**" again:-



Once more than one Beacon is in the "**REFERENCE BEACONS**" panel, the system will automatically start a 'Top Down' calibration - all other Beacons being calibrated with respect to the first. In practice, the Easting and Northing co-ordinates of the first Beacon will be fixed and the depth value will be allowed to vary.

Once the position error of all the Reference Beacons has stabilised at an acceptable value with very small changes being made to each beacon co-ordinate (approximately 1 hour), press the "**Stop Calibration**" button. This will fix all Beacons in Easting, Northing and Depth co-ordinates.

Set the **"STATUS"** of the mobile transponder, responder or transceiver to "**Not Set**". If there are any commands to send to set it up, these will be sent and then the system will change the status to "**Ready**".

Set up Position Data Boxes to show the position of the mobile beacon or transceiver and the "**Range Diagnostics**" for the Beacons and confirm that the system is operating correctly.

- ❑ Return to Chart Display to track the vessel and the mobile(s).

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.6 LBL MOBILE

In this application, the system is used to report the position of a mobile transceiver (Mini ROVNav, Mk4 ROVNav or BOPNav) relative to an array of Reference Beacons with known co-ordinates in an LBL (Long Baseline) mode ONLY – no USBL tracking is involved.

Note that for survey work the basic 'Top Down' calibration method will not be accurate enough and a baseline calibration technique must be used. This procedure assumes the Reference Beacon co-ordinates are known and will need an accurate seabed velocity to be input to the system.

The following options can be considered for determining the array co-ordinates:-

- Known Co-ordinates The Reference Beacon co-ordinates have already been determined in a relative or geodetic WGS84/UTM grid and the information provided.

- Using a 'Bottom Up' Calibration The system can be used to determine the accurate relative calibration of an array of Reference COMPATT beacons by measuring the baselines between them, as described in Section 4.9.

4.6.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.6.2 Job Set-Up Menu

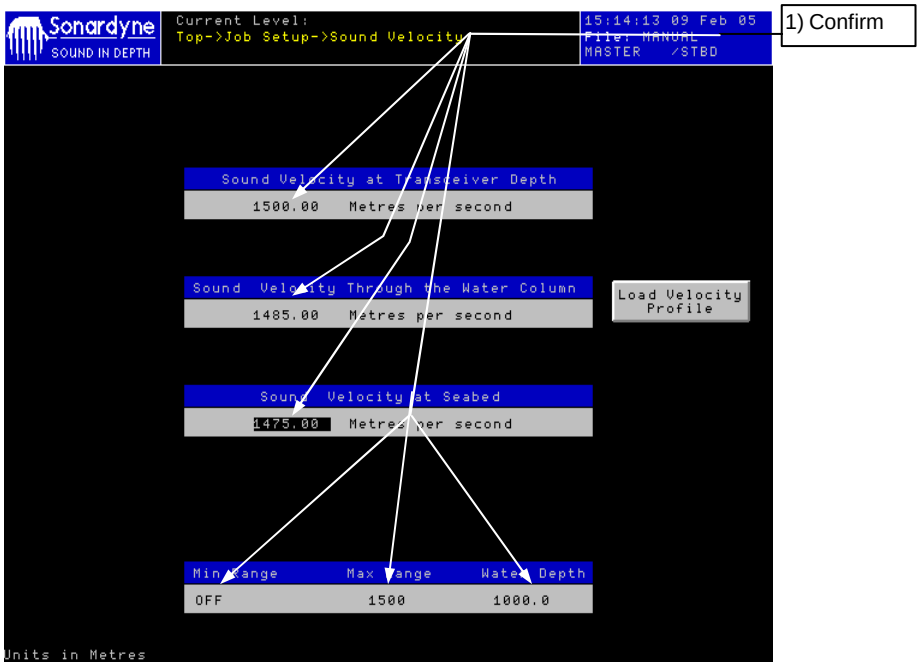
Having assigned a job file (see Section 3.3 if the job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: In this case, the "**Sound Velocity at Seabed**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver (mounted on the Mobile) and the Reference Beacons, the system automatically compensates for ray refraction. There are three ways of determining the "**Sound Velocity at Seabed**" value:-

- (Preferred). Use a Sound Velocity Probe data to calculate the velocity.
- Use COMPATT environmental sensor data to calculate sound velocity - Appendix I has more information on this.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

- Confirm fields in bottom row of the "**Sound Velocity**" dialog box, as follows:-

  - "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**Off**".
    - "**Manual**" User input minimum expected range in feet/metres.
    - "**Off**" No minimum range gating will be implemented.
  - "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.

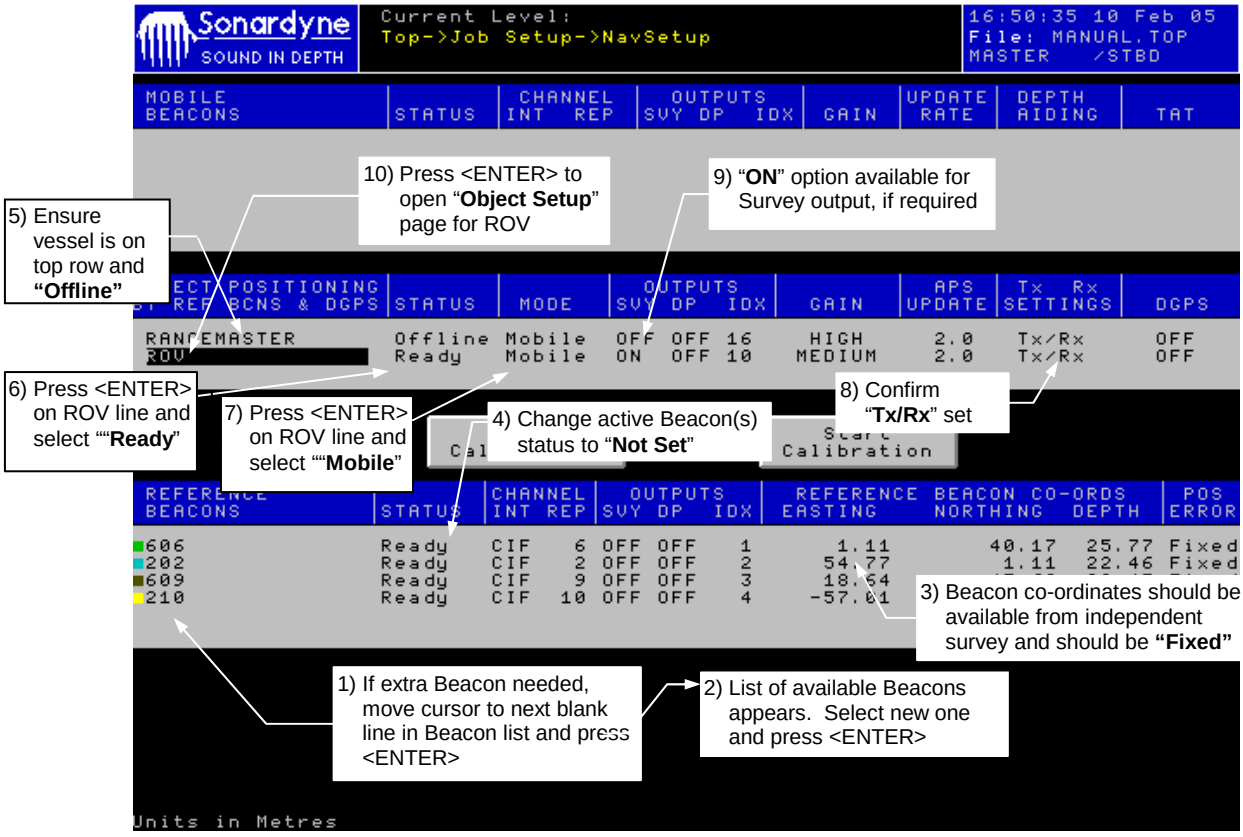
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

❑ Select "**Navigation Setup**"

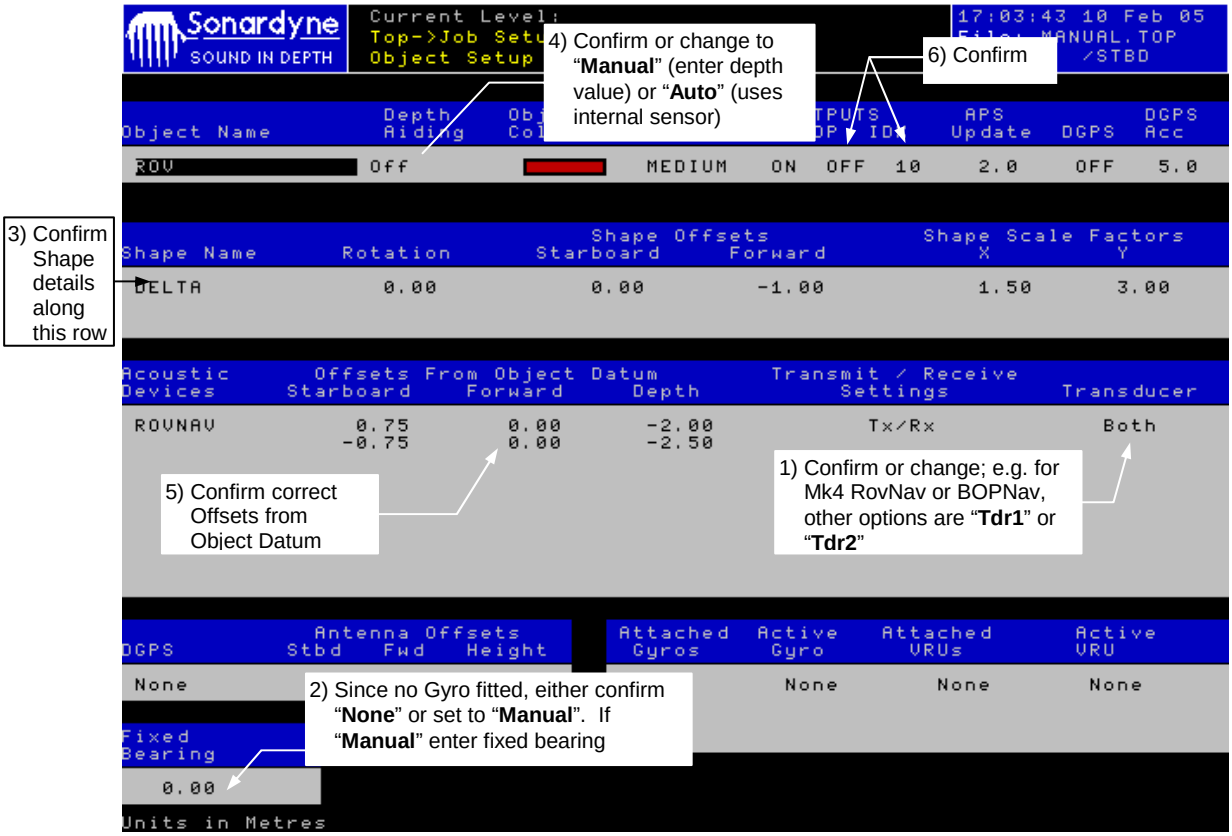
The following steps describe how to add new Reference Beacons with known co-ordinates to the job (if required), how to set COMPATT, PGT, SSM and WSM beacon types to "**Not Set**" prior to starting Navigation and how to turn DP and/or Survey outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

On the "**Navigation Setup**" page:-



- On the "**Object Setup**" page for the ROV:-



4.6.3 Navigate Menu

Return to the top level menu and select "**Navigate**". The system will set up any COMPATT, PGT, SSM and WSM Reference Beacons as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will compute and display the positions of the LBL Mobile. If the LBL transceiver is connected to two separate transducers (frequently the case when tracking a BOP using a BOPNav) the system will compute and display the heading of the LBL Mobile.

Set up Position Data Boxes to show the co-ordinates and heading of the LBL Object and the Range Diagnostics for the Beacons and confirm that the system is operating correctly.

- Return to Chart Display

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.7 L/USBL SHIP (DP) AND AN LBL MOBILE

In this application, an L/USBL system is required to report to a DP system the position of the vessel relative to an array of Reference Beacons. At the same time the system will report the position of a ROVNav transceiver (Mini, or Mk 4) or a BOPNav transceiver relative to the same array of Reference Beacons in an LBL (Long Baseline) mode.

Note that for survey work involving a LBL Mobile the basic L/USBL 'Top Down' calibration method will not be accurate enough and a baseline calibration technique must be used. This will need an accurate seabed velocity to be input to the system.

The following options can be considered for determining the array co-ordinates:-

- Known Co-ordinates The Reference Beacon co-ordinates have already been determined in a relative or geodetic WGS84/UTM grid and the information provided.

- Using a 'Bottom Up' Calibration The system can be used to determine the accurate relative calibration of an array of Reference COMPATT beacons by measuring the baselines between them, as described in Section 4.9.

4.7.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.7.2 Job Set-Up Menu

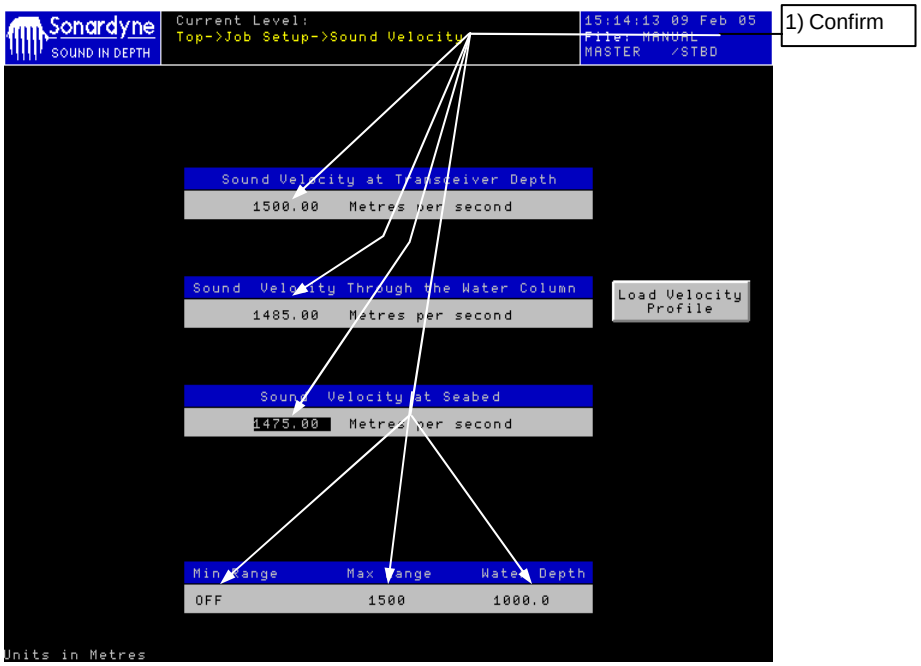
Having assigned a job file (see Section 3.3 if the job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: In this case, both the "**Through the Water Column**" and "**Sound Velocity at Seabed**" values are important. Provided the "**Through the Water Column**" value is set to the average sound velocity in water between the Transceivers and the working depth, the USBL automatically compensates for ray refraction. There are four ways of determining these values:-

- (Preferred). Use a Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- For Seabed Velocity, use COMPATT environmental sensor data to calculate sound velocity - Appendix I has more information on this.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

- Confirm fields in bottom row of "**Sound Velocity**" dialog box, as follows:

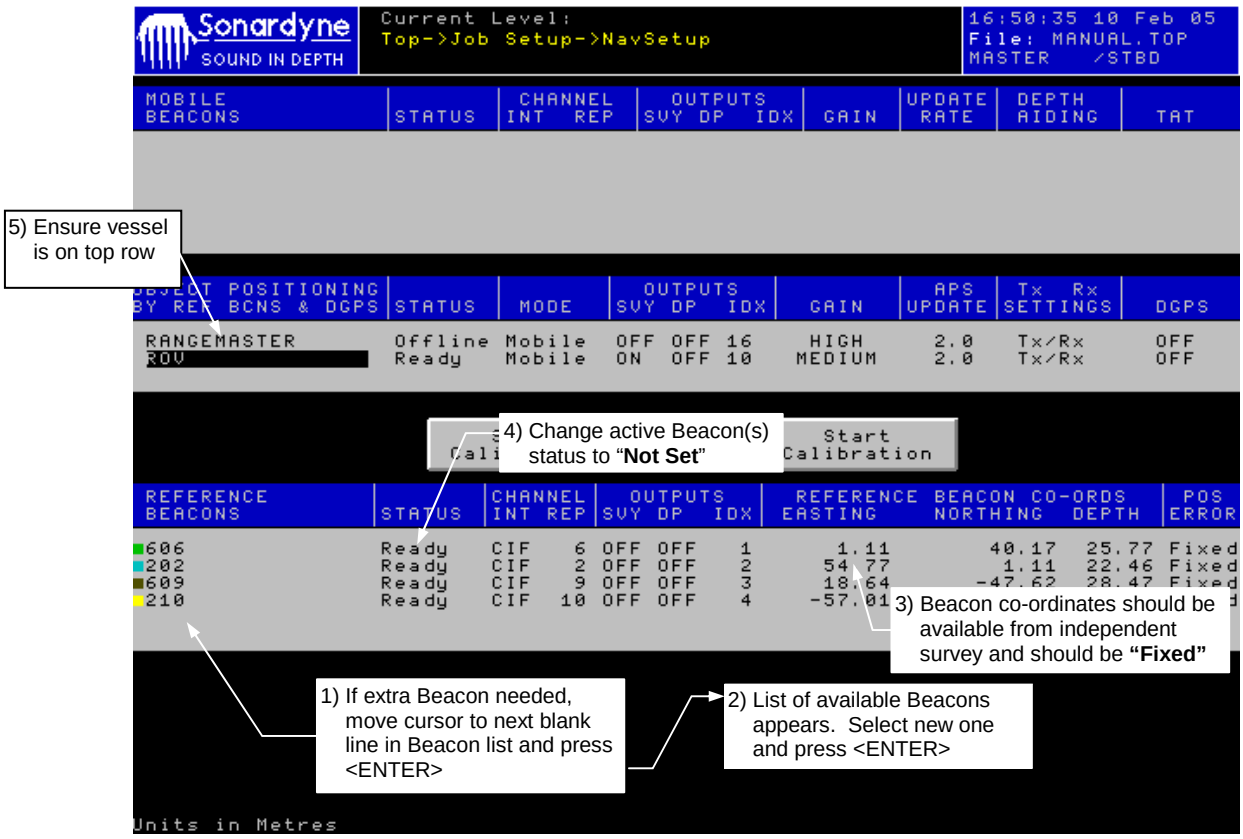
  - "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**Off**".
    - "**Manual**" User input minimum expected range in feet/metres
    - "**Off**" No minimum range gating will be implemented.
  - "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
  - "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

- Select "**Navigation Setup**"

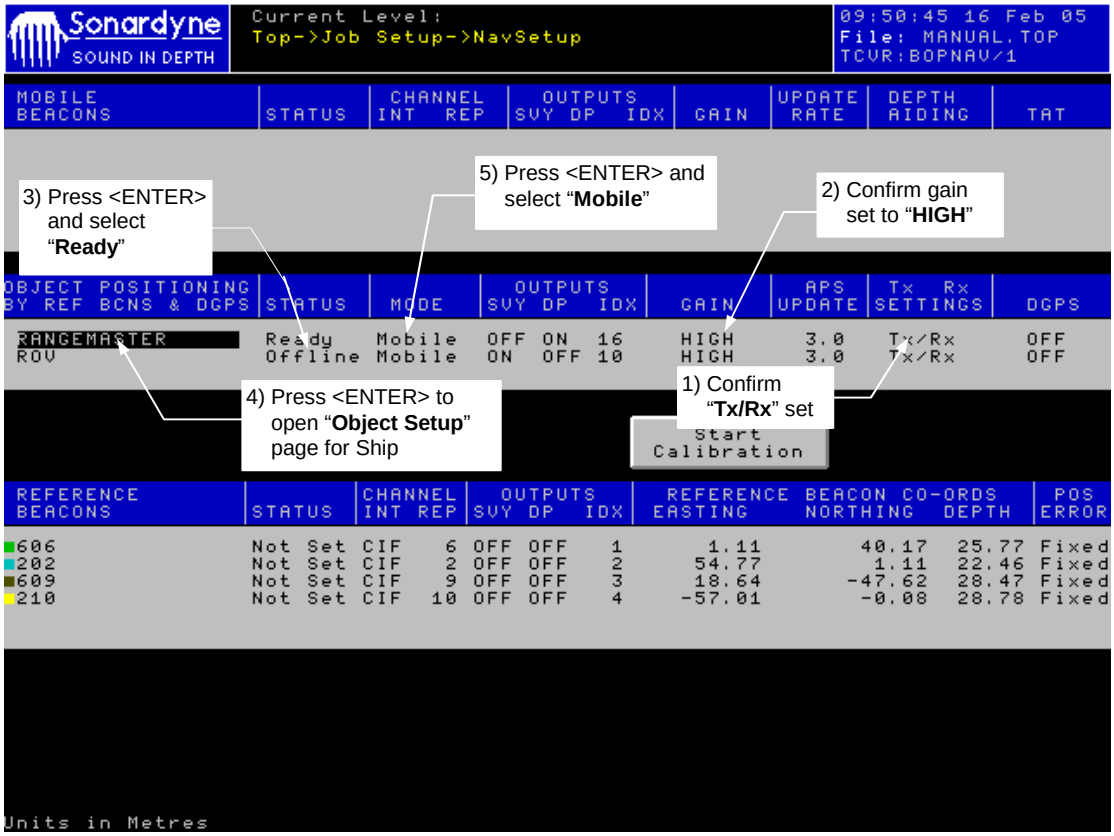
The following steps describe how to add new Reference Beacons with known co-ordinates to the job (if required), how to set COMPATT, PGT, SSM and WSM beacon types to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, refer to paragraph 9.2.1.2 in Section 9.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

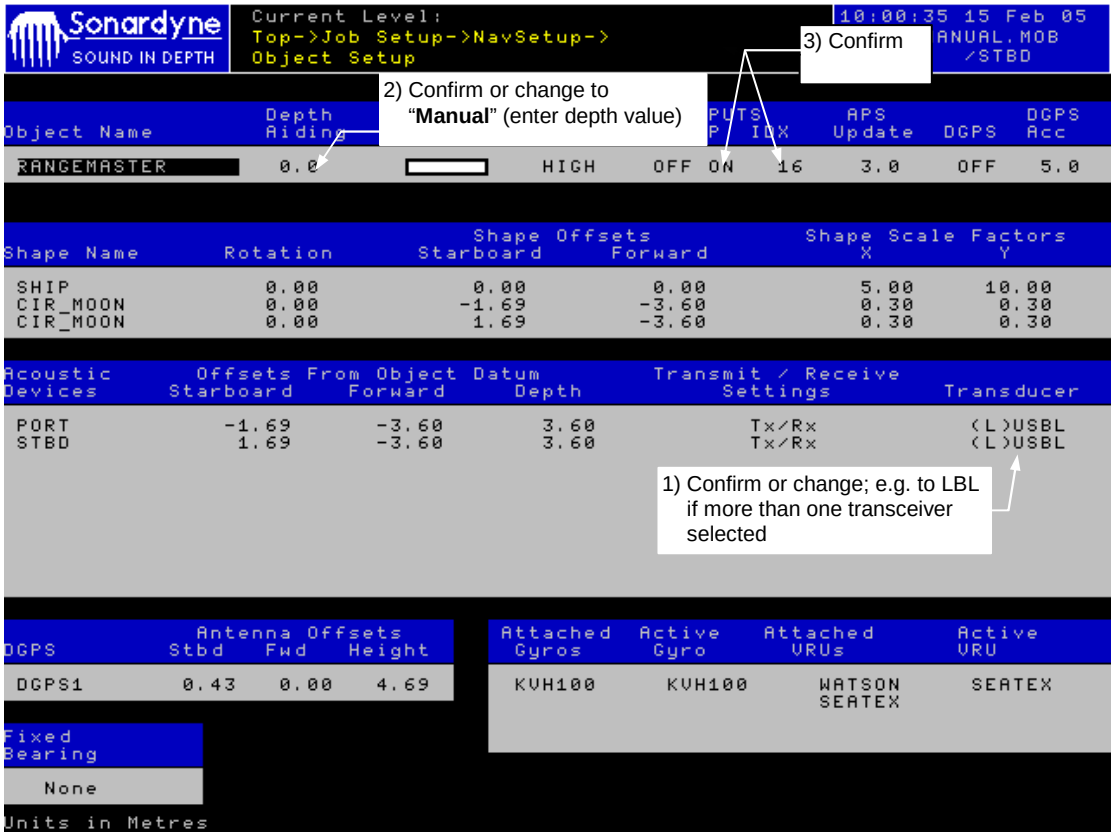
On the "**Navigation Setup**" page:-



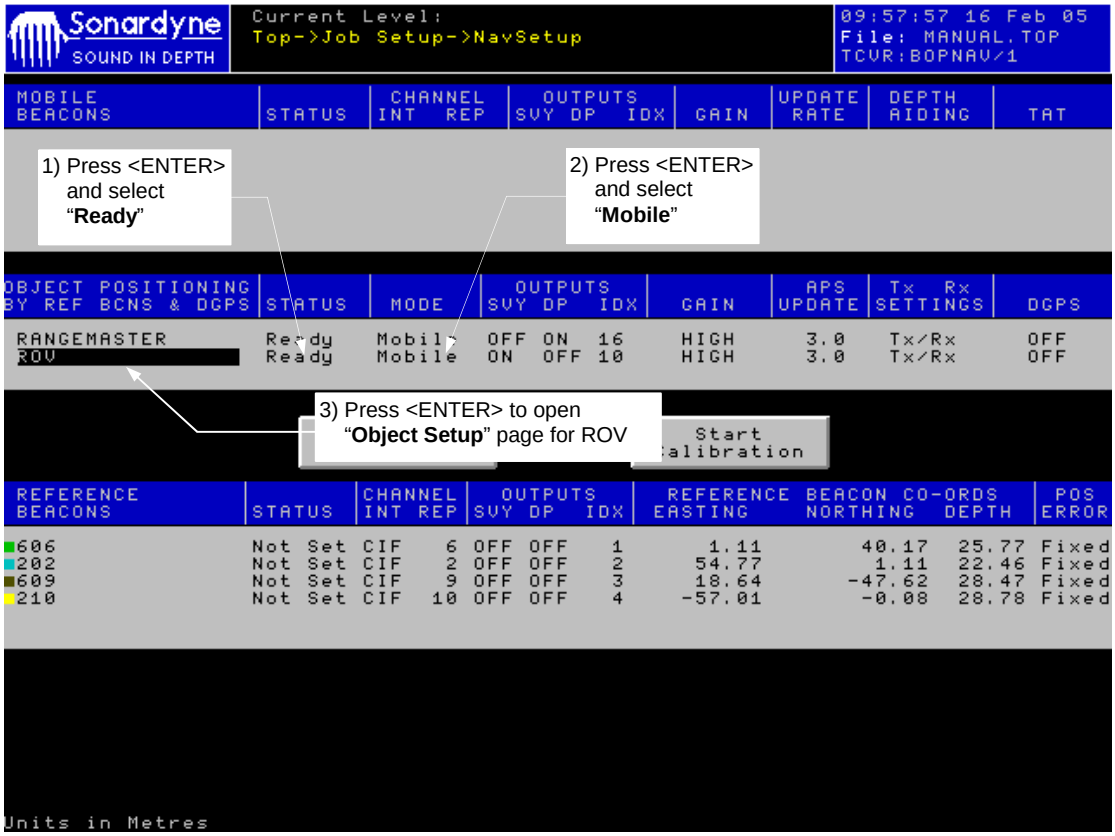
While still on the "**Navigation Setup**" page:-



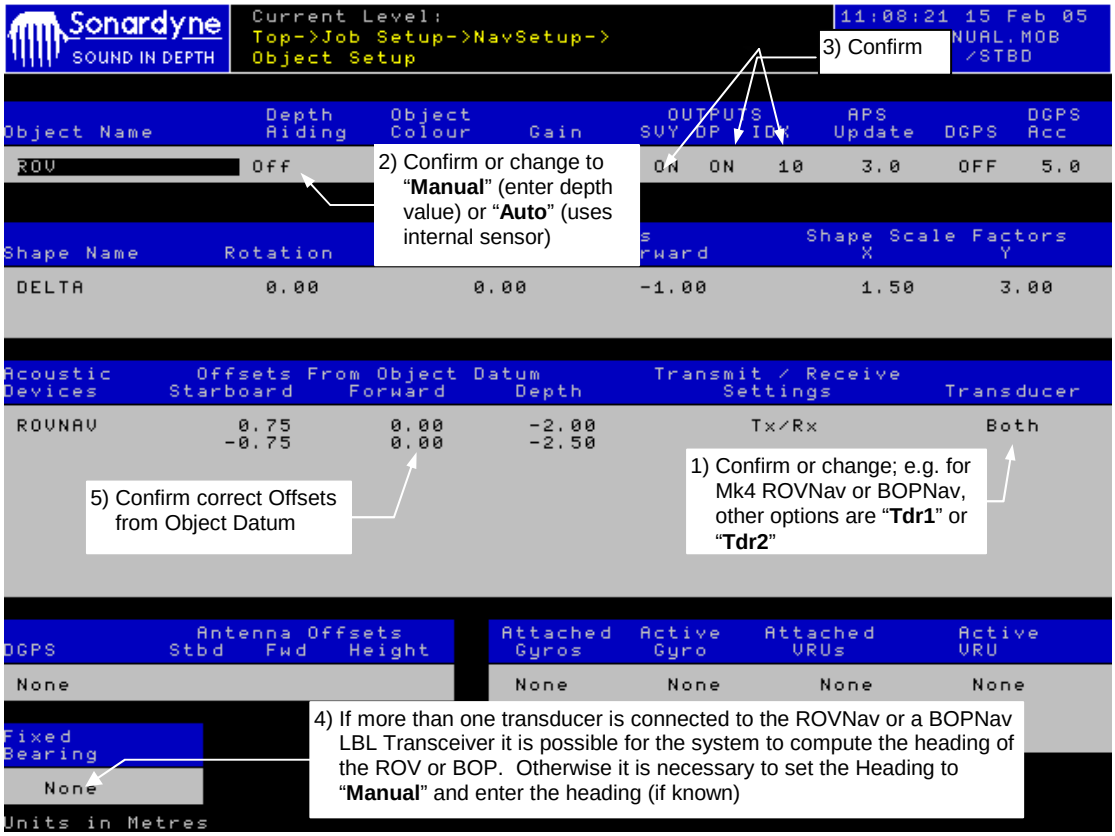
- On the "**Object Setup**" page for the Ship:-



- Return to the "**Navigation Setup**" page:-



- On the "**Object Setup**" page for the ROV:-



NOTE: With Version 6 systems and with the acoustic configuration of both the Vessel and LBL Mobile set to "**Tx/Rx**", the system will transmit from the Vessel and LBL Mobile on alternate acoustic cycles. It will receive at all transceivers on every cycle.

If there is more than one transducer on a Transceiver, it is possible to select either transducer or both transducers to be used in the acoustic positioning. If both are chosen, the system will select the transducers alternately and use this information to compute the object heading.

4.7.3 Navigate Menu

Return to the top level menu and select "**Navigate**". The system will set up COMPATT, PGT, SSM and WSM beacon types as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will compute and display the positions of both the Vessel and the LBL Object.

Set up Position Data Boxes to show the co-ordinates of the Vessel and LBL Objects and the Range Diagnostics for the Beacons and confirm that the system is operating correctly. If the LBL transceiver is connected to two transducers (frequently the case when tracking a BOP using a BOPNav) the system will compute and display the heading of the LBL Object.

- ❑ Return to Chart Display

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.8 L/USBL SHIP (DP) AND A TRANSCEIVER ON A 'LATCHED' BOP

In this application, an L/USBL system is required to report to a DP system the position of the vessel relative to an array of Reference Beacons. The difference between this application and L/USBL DP case is that the array would either be interrogated from the L/USBL Transceiver at the surface or from the BOPNav Transceiver installed on the BOP stack, with the Beacon replies being received at either or both the L/USBL and the BOPNav Transceivers. In practice, there are likely to be two stages involved in working with a BOP:-

- Deploying the BOP The procedure involved during the deployment phase is as described in Section 4.5 (L/USBL Vessel (DP) and a USBL Mobile). The vessel is first positioned in L/USBL mode using the normal 'Top Down' calibration. During deployment, the BOP is treated as a Mobile USBL Beacon with its BOPNav Transceiver selected as a Responder.

- BOP Latched Once the BOP is positioned on the well and latched, then the procedure set out in the following applies.

4.8.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.8.2 Job Set-Up Menu

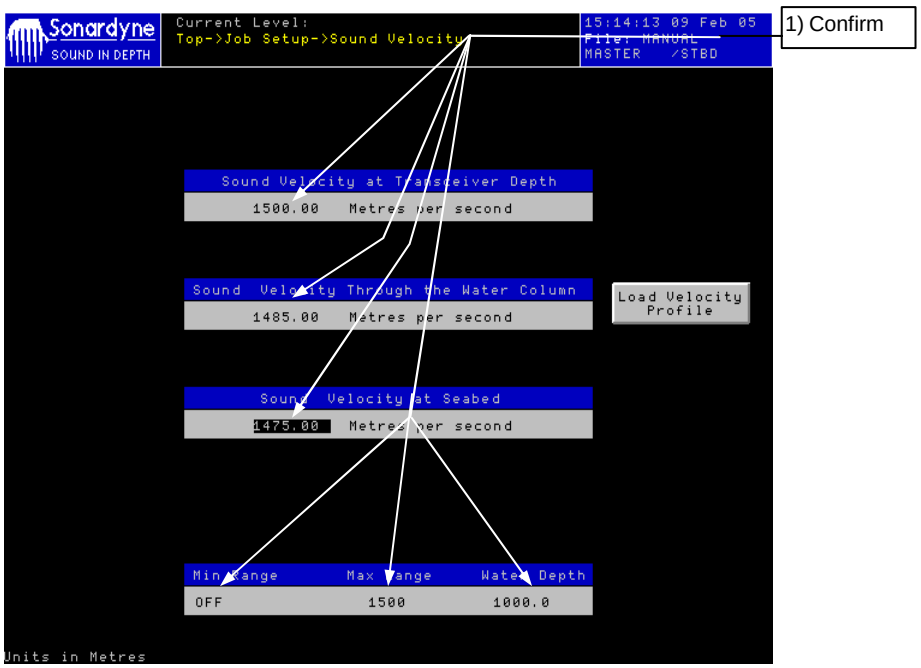
Having assigned a job file (see Section 3.3 if the job file is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: In this case, both the "**Through the Water Column**" and "**Sound Velocity at Seabed**" values are important. Provided the "**Through the Water Column**" value is set to the average sound velocity in water between the Transceivers and the working depth, the USBL automatically compensates for ray refraction. There are four ways of determining these values:-

- (Preferred). Use a Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- For Seabed Velocity, use COMPATT environmental sensor data to calculate sound velocity - Appendix I has more information on this.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

- Confirm fields in bottom row of "**Sound Velocity**" dialog box, as follows:-

  - "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**Off**".

    - "**Manual**" User input minimum expected range in feet/metres.
    - "**Off**" No minimum range gating will be implemented.

  - "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.

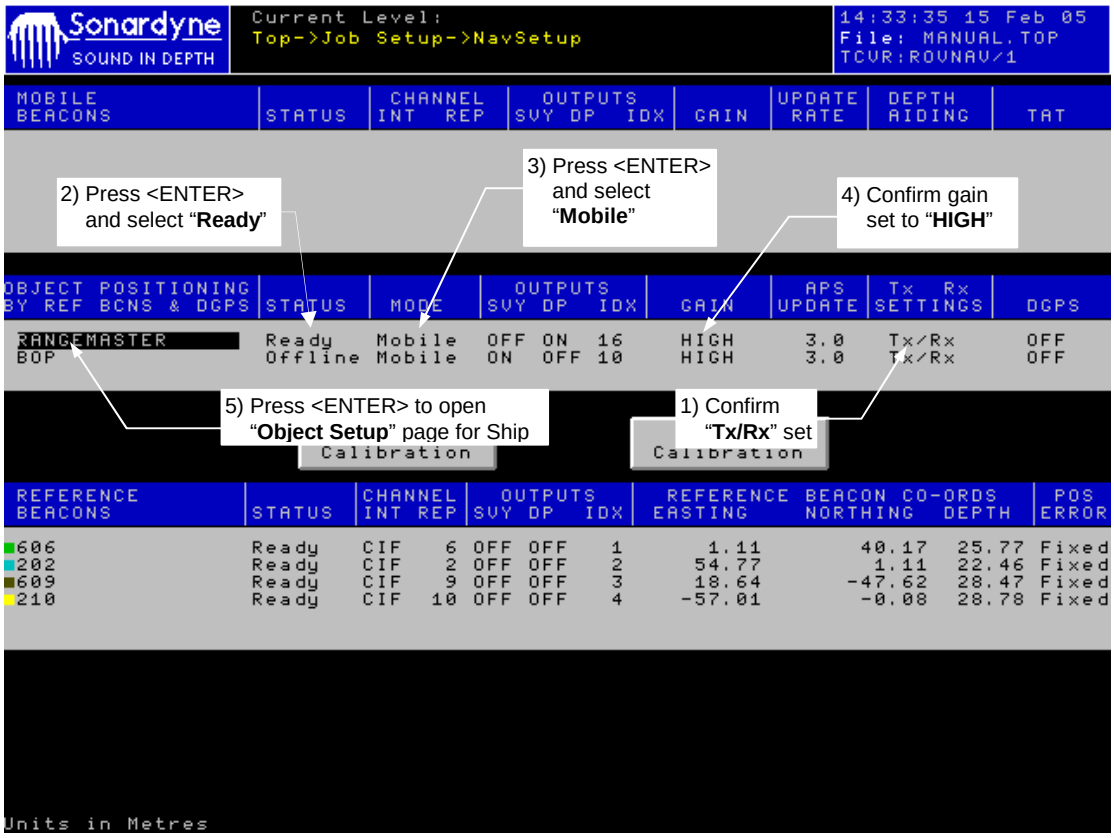
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

❑ Select "**Navigation Setup**"

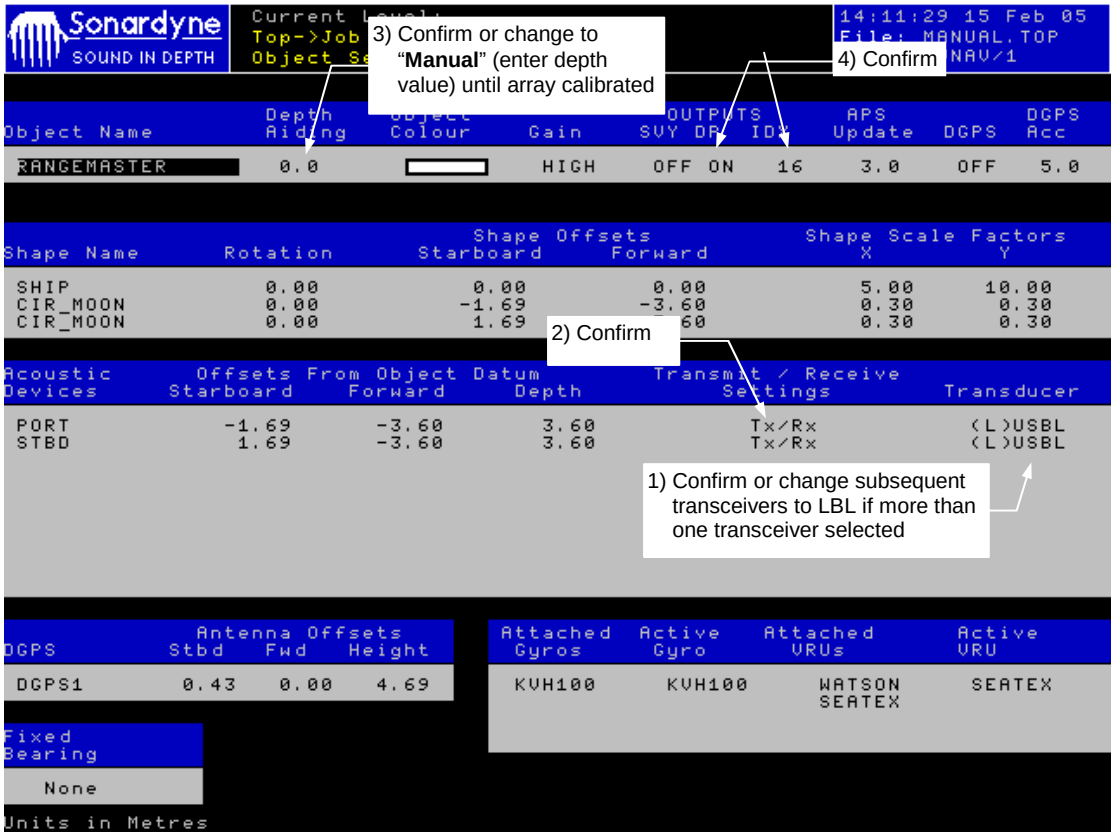
For this procedure, it assumed that the Reference Beacon array has been set up* and calibrated using the 'Top Down' calibration technique before the deployment of the BOP - using the procedure described in Section 4.5.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

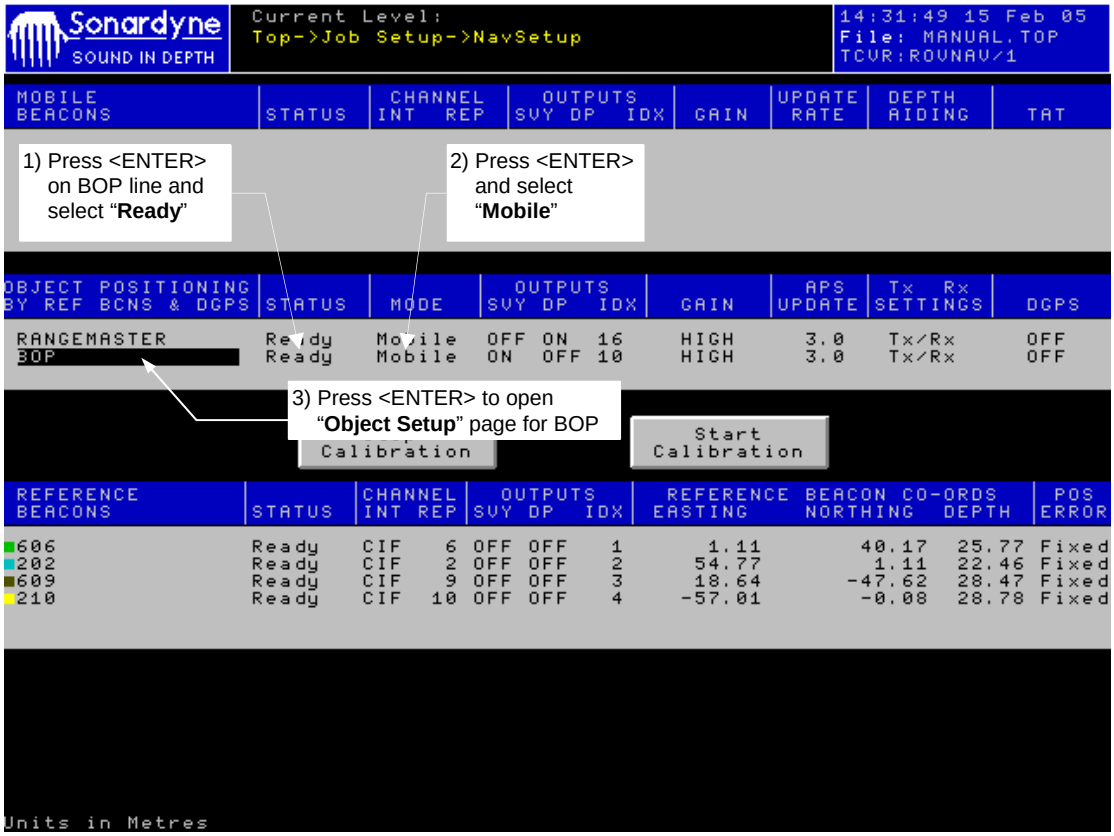
On the "**Navigation Setup**" page:-



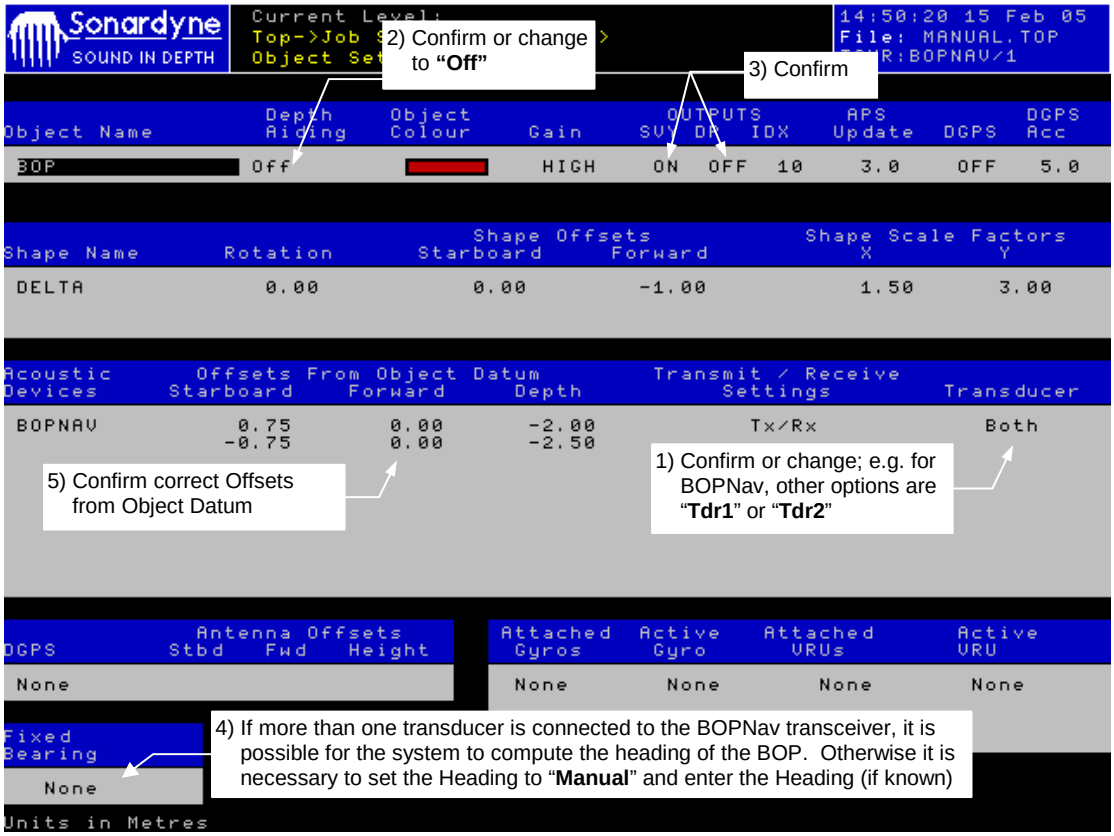
- On the "**Object Setup**" page for the Ship:-



- Return to the "**Navigation Setup**" page:-



- On the "**Object Setup**" page for the BOP:-



NOTE: With the acoustic configuration of both the Vessel and BOP set to "**Tx/Rx**" the system will transmit from the Vessel and BOP on alternate acoustic cycles. It will receive at all transceivers on every cycle (which includes the direct signals between the Vessel and BOP transceivers).

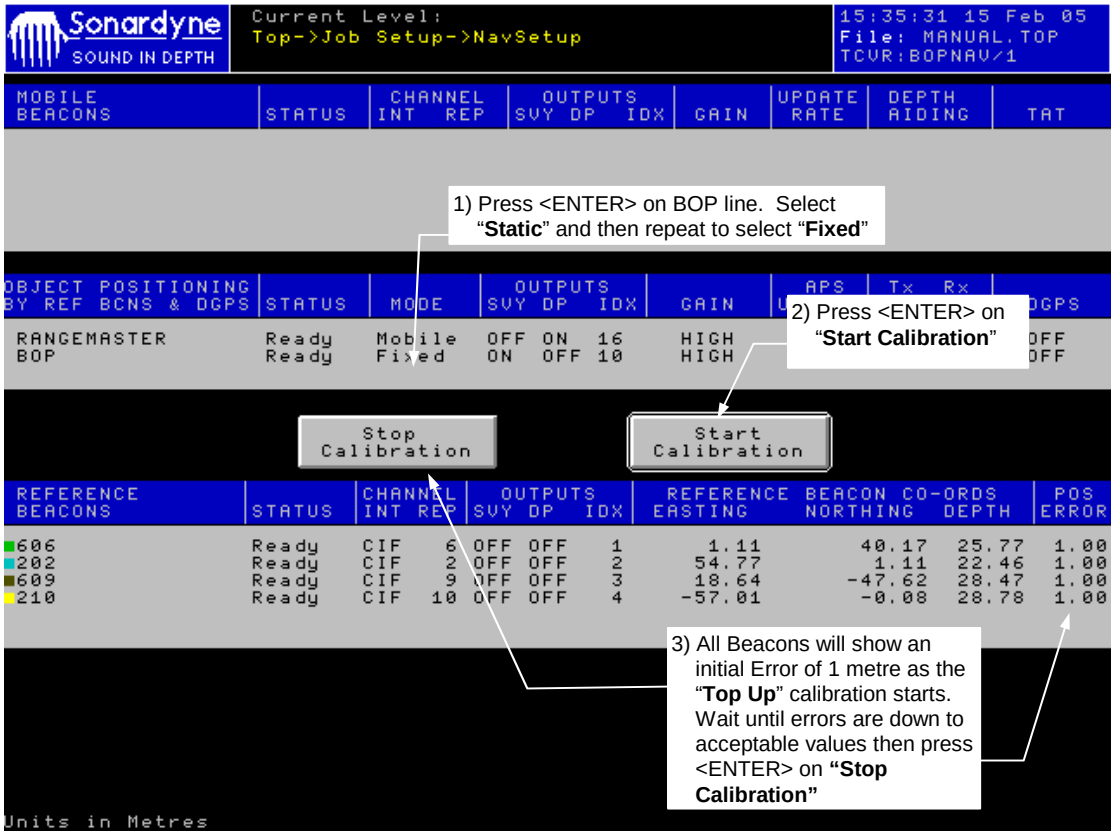
If there is more than one transducer connected to a BOPNav transceiver, it is possible to select either transducer or both transducers to be used in the acoustic positioning. If both are chosen, the system will select the transducers alternately; transmitting and receiving from each transducer in turn, and use this information to compute the BOP heading.

4.8.3 Navigate Menu

Return to the top level menu and select "**Navigate**". The system will track and display the positions of both the Vessel and BOP as LBL Objects relative to the 'Top Down' calibrated array, with a larger Position Quality being reported for the BOP.

Set up Position Data Boxes to show the co-ordinates of the Vessel and BOP and the Range Diagnostics for the Beacons and confirm that the system is operating correctly. If the BOP transceiver is connected to two transducers, the system will compute and display the heading of the BOP.

Once the BOP position, heading and position quality have settled down, set the BOP "**MODE**" to "**Static**". When the BOP position and heading have stabilised, change the "**MODE**" to "**Fixed**" and press the "**Start Calibration**" button:-



With the acoustic configuration of both the BOP and the Vessel "**STATUS**" set to "**Ready**" and the BOP "**MODE**" set to "**Fixed**", the system will automatically run a 'Top Up' calibration in which the ranges of the Reference Beacons to the BOP will be taken into account in the process of refining the positions of the array relative to the Vessel and the BOP. The Reference Beacon co-ordinates (Easting, Northing and Depth) will gradually change and the Position Errors reduce. Monitor the Vessel and BOP positions (using the Data Boxes on the Chart Display) until they settle down to reasonably stable values.

As soon as all of the Reference Beacon position errors have dropped to a sensible value with very small changes being made to each beacon co-ordinate (after approximately one hour), press the "**Stop Calibration**" button. Confirm that the Reference Beacons and the BOP are now "**Fixed**".

The Vessel position update rate can be improved EITHER by changing the "**Tx/Rx SETTINGS**" of the Vessel to "**Tx**" and BOP to "**Rx**", OR changing the "**Tx/Rx SETTINGS**" of the Vessel to "**Rx**" and BOP to "**Tx**".

Once the system is set up and operating correctly, archive the job and installation files. If you are not sure how to do this, refer to Section 9.3.

4.9 BASELINE OR 'BOTTOM UP' ARRAY CALIBRATION

This procedure covers the set-up and operation of the system when using the baselines measured between COMPATTs to determine the accurate relative calibration of an array being used to position a mobile LBL transceiver (such as a Mini ROVNav, Mk4 ROVNav or BOPNav) close to the seabed during survey operations. A 'Top Down' calibration must be carried out first before measuring the baselines between the array beacons.

Two different methods are available – 'Array Baseline Measurement' and 'Incremental Baseline Measurement'. The former method assumes that COMPATT command reception and their telemetry replies can be reliably achieved from the vessel to all the COMPATTs being calibrated from a central location within the array. The system will automatically configure each COMPATT in turn to the correct state for taking baseline measurements, re-setting the COMPATTs back to their Navigation settings after the measurements. The latter method is used when command/telemetry communication is only possible from the vessel to one COMPATT at a time. It assumes that all the COMPATTs have been configured into a mode which can be used either for Navigation or carrying out baseline measurements, which is restricted to Mk4 Compatts set to HPR mode.

4.9.1 Array Baseline Measurement

4.9.1.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

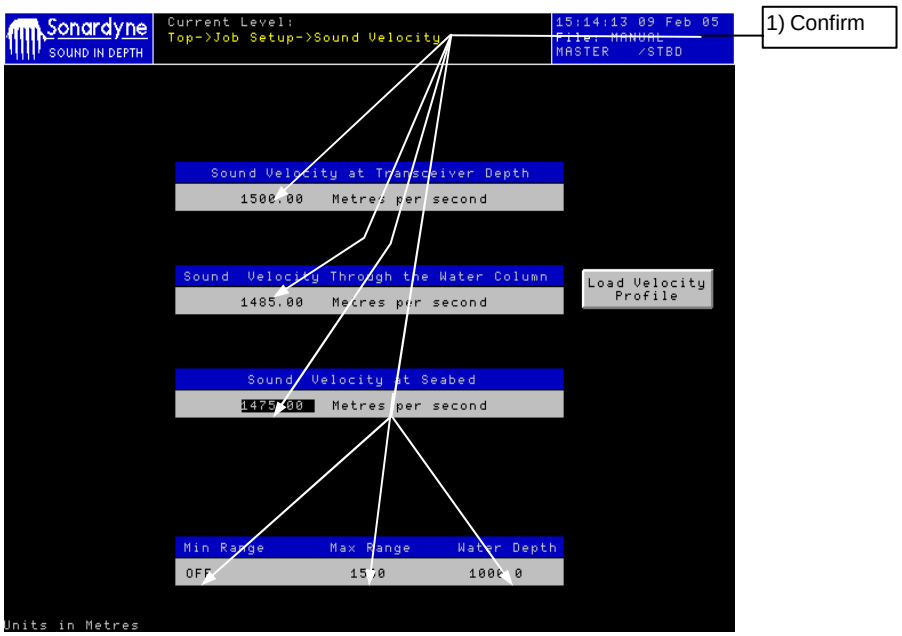
4.9.1.2 Job Set-Up Menu

- Select "**Display Units**"

  In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

  NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: In this case, both the "**Through the Water Column**" and "**Sound Velocity at Seabed**" values are important. Provided the "**Through the Water Column**" value is set to the average sound velocity in water between the Transceivers and the working depth, the system automatically compensates for ray refraction. There are four ways of determining these values:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- For Seabed Velocity, use COMPATT environmental sensor data to calculate sound velocity - Appendix I has more information on this.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

❑ Confirm the fields in the bottom row of the "**Sound Velocity**" dialog box, as follows:

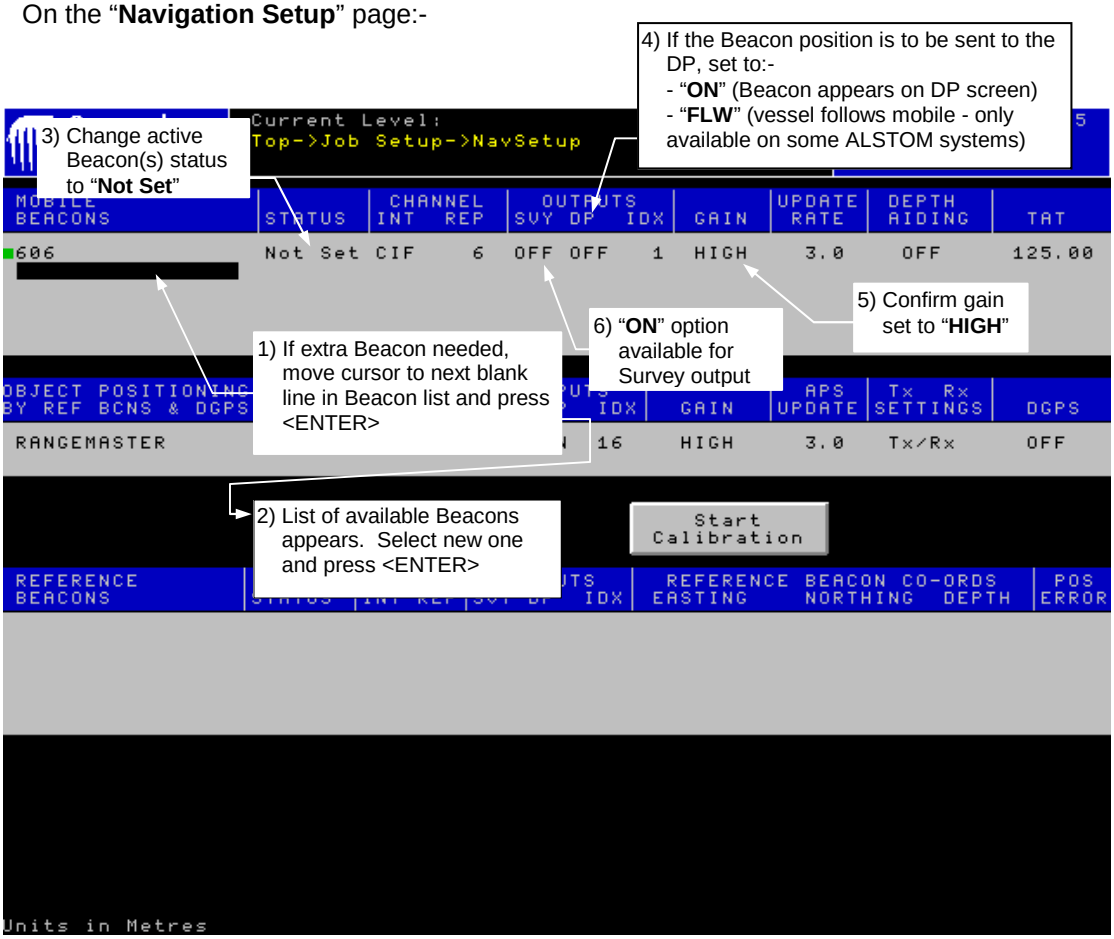
- "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**Off**".
  - "**Manual**" User input minimum expected range in feet/metres.
  - "**Off"** No minimum range gating will be implemented.
- "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTS to prevent re-interrogation of the beacons by multipath transmissions.

❑ Select "**Navigation Setup**"

The following steps describe how to add new COMPATT beacons to the job (if required), how to set them to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

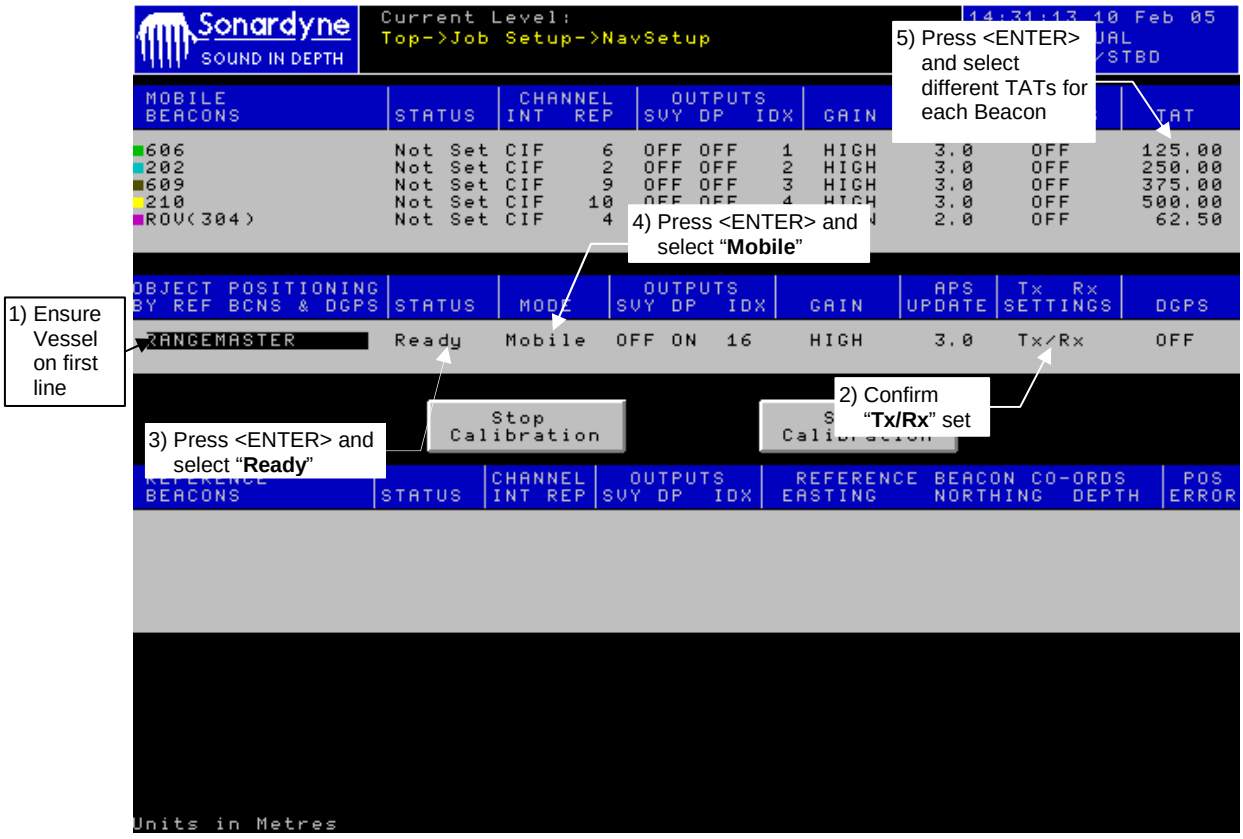
On the "**Navigation Setup**" page:-



As well as adding COMPATT beacons which are to become the Reference array, add any mobile transponders, responders or transceivers which will be treated as Mobile USBL targets into the "**MOBILE BEACON**" panel. However, in the case of these mobile targets, leave them "**Offline**" until after the array calibration has been completed.

4.9.1.3 Object Set-Up Procedure

While on the" **Navigation Setup**" page:-



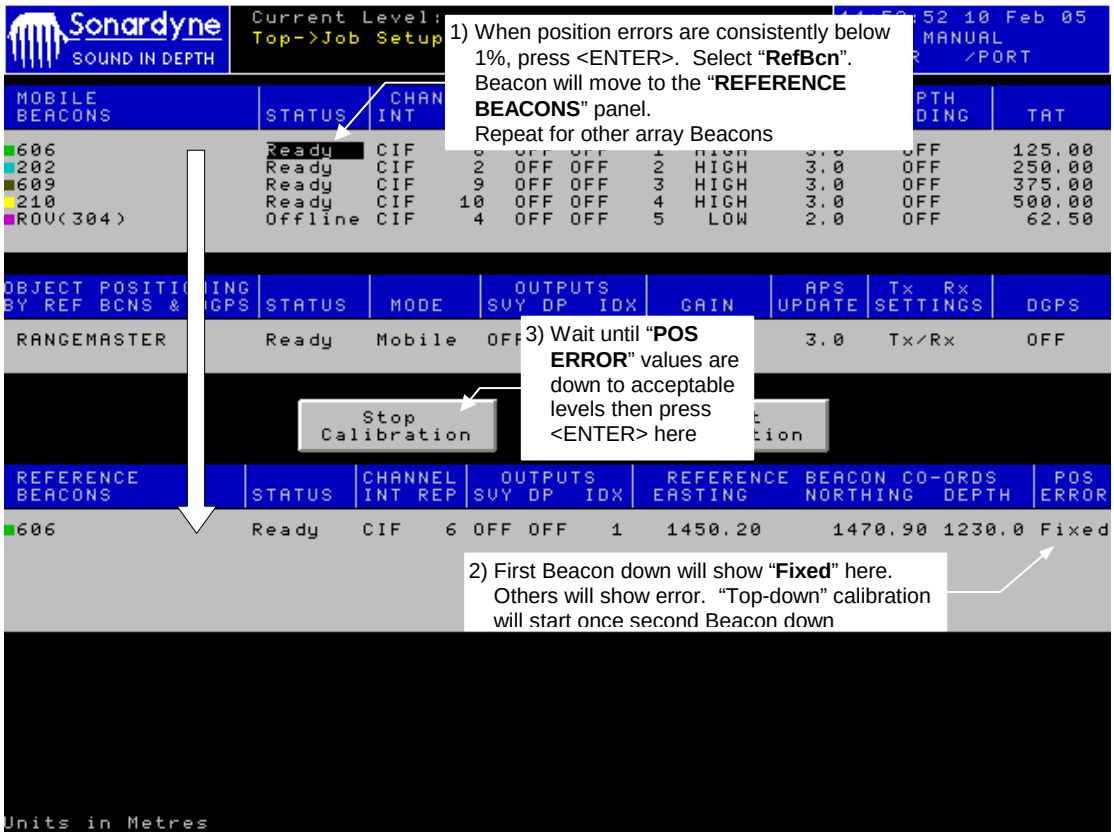
Any COMPATT beacons whose local or UTM co-ordinates are already known, (for example from a CASIUS calibration), should be defined as Reference Beacons using the "**STATUS**" facility and the appropriate co-ordinates entered. The "**POS ERROR**" for one of these beacons should be "**Fixed**" by highlighting the "**POS ERROR**" field and pressing "**F**", with the expected position errors entered for the other beacons.

4.9.1.4 Navigate Menu

Return to the Top Level menu and select "**Navigate**". The system will set up COMPATTs as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will start to calculate Beacon positions with reference to the vessel. Set up Position Data Boxes and a Range Diagnostics Box for the Beacons. Allow time for the Beacon positions on the Chart Display to settle down.

Return to the Chart Display and observe the "**Qual**" value in the Position Data Boxes. A Beacon is ready to be defined as a Reference Beacon when the position error is consistently below 1% of slant range and the "**Range Diags**" under 0.3 milliseconds on a quiet vessel or greater than this on a noisy vessel.

Once the position quality of a Beacon has become small enough, select "**NAV SET-UP**" again:-



Once more than one Beacon is in the "**REFERENCE BEACONS**" panel, the system will automatically start a 'Top Down' calibration - all other Beacons being calibrated with respect to the first. In practice, if no DGPS is enabled, the Easting and Northing co-ordinates of the first Beacon will be fixed and the depth value will be allowed to vary.

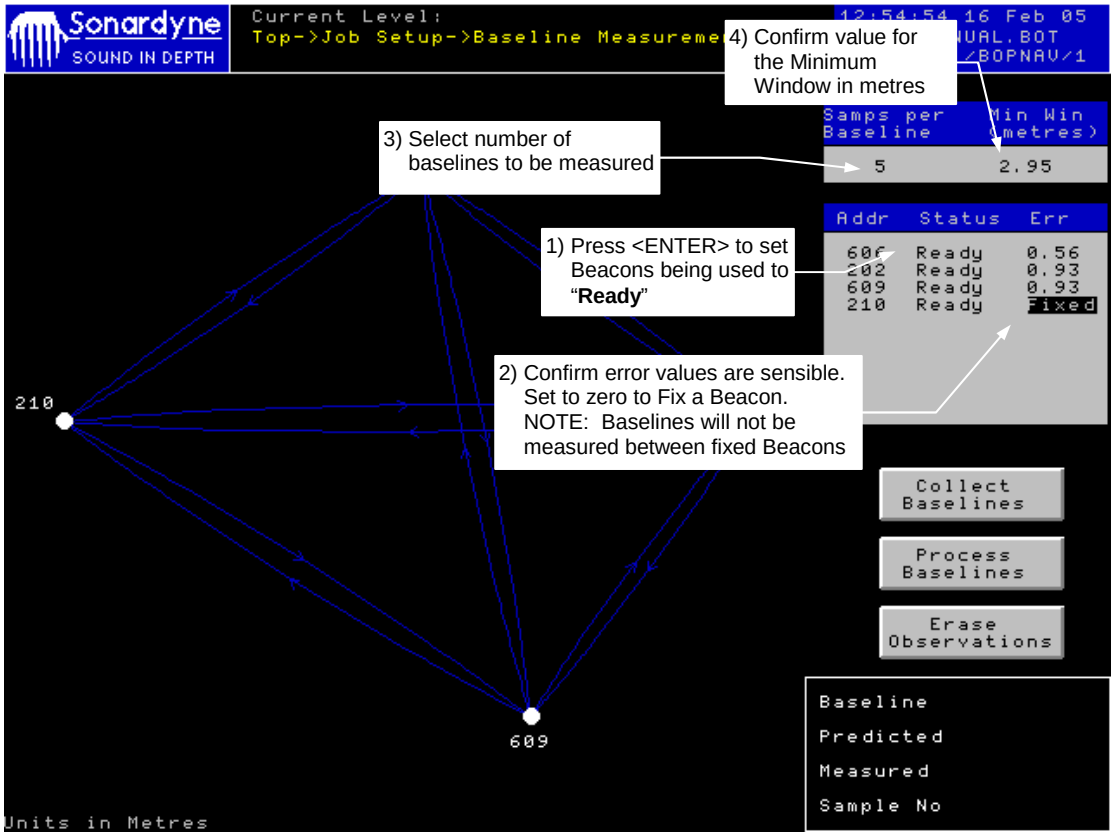
Once the position error of the Reference Beacons have stabilised with all the "**POS ERROR**" figures below 1% of slant range, press the "**Stop Calibration**" button. This will fix all Beacons in Easting, Northing and Depth co-ordinates.

Exit Navigation to return to the Top Level menu and copy the 'Top Down' calibrated Job file to a new file with a different name. If you are not sure how to do this, refer to Section 9.3.

4.9.1.5 Baseline Measurements

Select "**Job Setup**" from the Top Menu and then "**Array Baseline Measurement**". The following steps describe how to select the COMPATTs between which baselines are to be measured (shown in white), the error values to be assigned to each beacon, the number of baselines to be measured and the acceptance window. In the event that these settings do need to be changed, refer to Section 9.2.9 in Section 9.

On the "**Array Baseline Measurement**" page:-



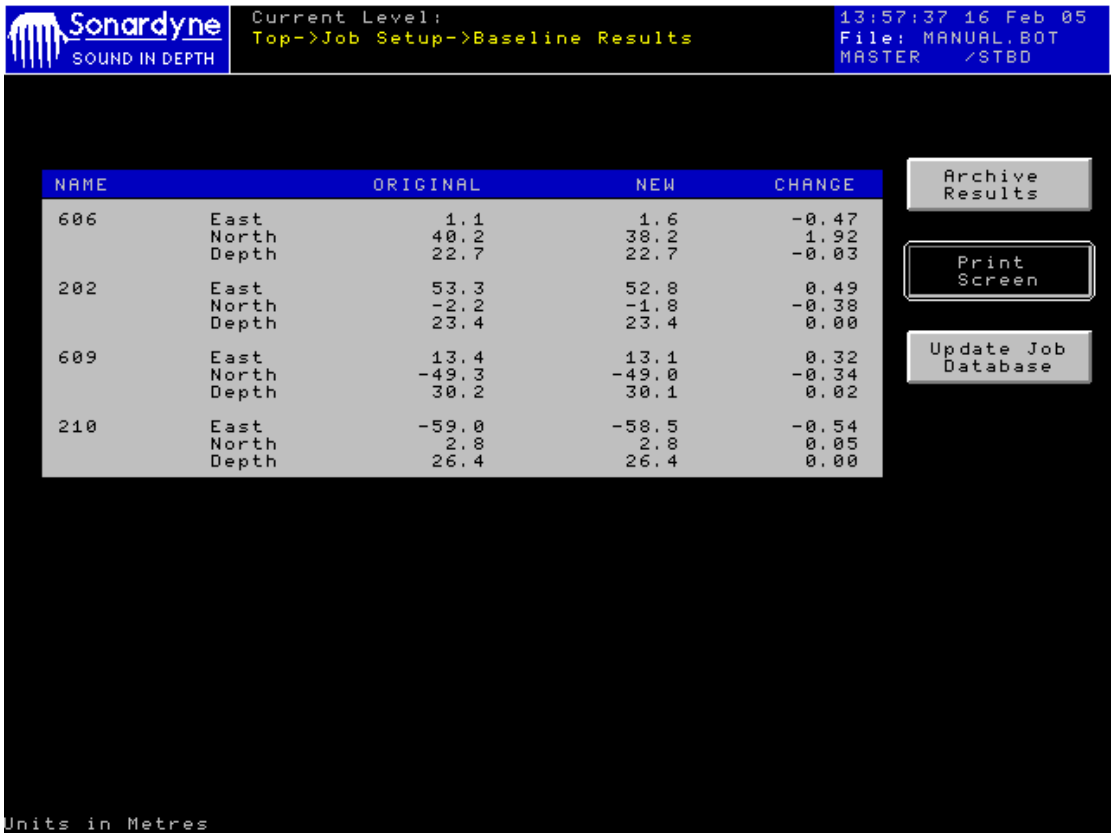
Select "**Collect Baselines**" and press <ENTER>. The system will set up each selected COMPATT Beacon in turn to the correct state for taking baseline measurements to the selected Beacon. The requisite number of baseline measurements will be taken from each of the other selected COMPATTs in turn to that Beacon.

The baseline being measured will be indicated on the display. The "**Baseline**", the "**Predicted**" value calculated from the initial array co-ordinates, the "**Measured**" value and the current "**Sample Number**" will be shown in the summary box.

Baseline measurements will be repeated if the measured value falls outside the minimum window compared with the predicted value or if (a) Telemetry Errors, (b) No Reply or (c) a Zero Baseline measurement is reported. The measurement will be repeated up to three times after which a warning prompt will be displayed. The baseline being measured is displayed in white, failed measurements in red and baseline measurements completed in both directions indicated by a green colour on the display. When all the baselines have been measured to a COMPATT, the system will re-set the COMPATT back to its Navigation configuration before moving onto the next Beacon.

4.9.1.6 Array Calibration

Once all the baselines have been measured, (either one-way or two-way) select "**Process Baselines**" and press <ENTER> to process the data. The results of the array adjustment will be displayed on the "**Baseline Results**" page:-



The system displays the COMPATT Beacon "**Name**", the "**Original**" co-ordinates, the "**New**" co-ordinates using the baseline measurements and the amount by which each co-ordinate has "**Changed**". The following options are available:-

- Select "**Archive Results**"

  All the data can be archived to a floppy disc for inspection using a terminal program. This includes the measured baselines and the output from the least squares adjustment showing any baseline measurements which have been rejected.

- Select "**Print Screen**"

  Allows the operator to copy the results of the baseline adjustment to a Bitmap.

- Select "**Update Job Database**"

  Pressing this button will update the current Job database with the results of the baseline adjustment.

4.9.2 Incremental Baseline Measurement

4.9.2.1 **Common Installation Procedures**

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

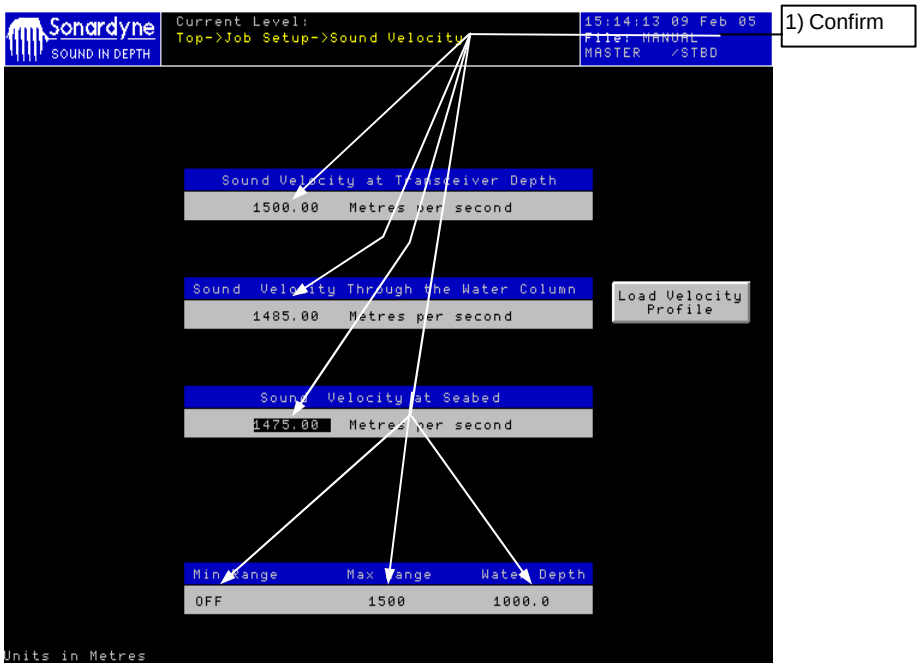
4.9.2.2 **Job Set-Up Menu**

- Select "**Display Units**"

In Version 6, the current units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

- Select "**Sound Velocity**"



NOTE: In this case, both the "**Through the Water Column**" and "**Sound Velocity at Seabed**" values are important. Provided the "**Through the Water Column**" value is set to the average sound velocity in water between the Transceivers and the working depth, the USBL automatically compensates for ray refraction. There are four ways of determining these values:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- For Seabed Velocity, use COMPATT environmental sensor data to calculate sound velocity - Appendix I has more information on this.
- Load a Sound Velocity Profile by selecting the "**Load Velocity Profile**" and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

- ❑ Confirm the fields in the bottom row of the "**Sound Velocity**" dialog box, as follows:-

  - "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual"** and "**Off"**.

    - "**Manual**" User input minimum expected range in feet/metres.
    - "**Off**" No minimum range gating will be implemented.

  - "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.

  - "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

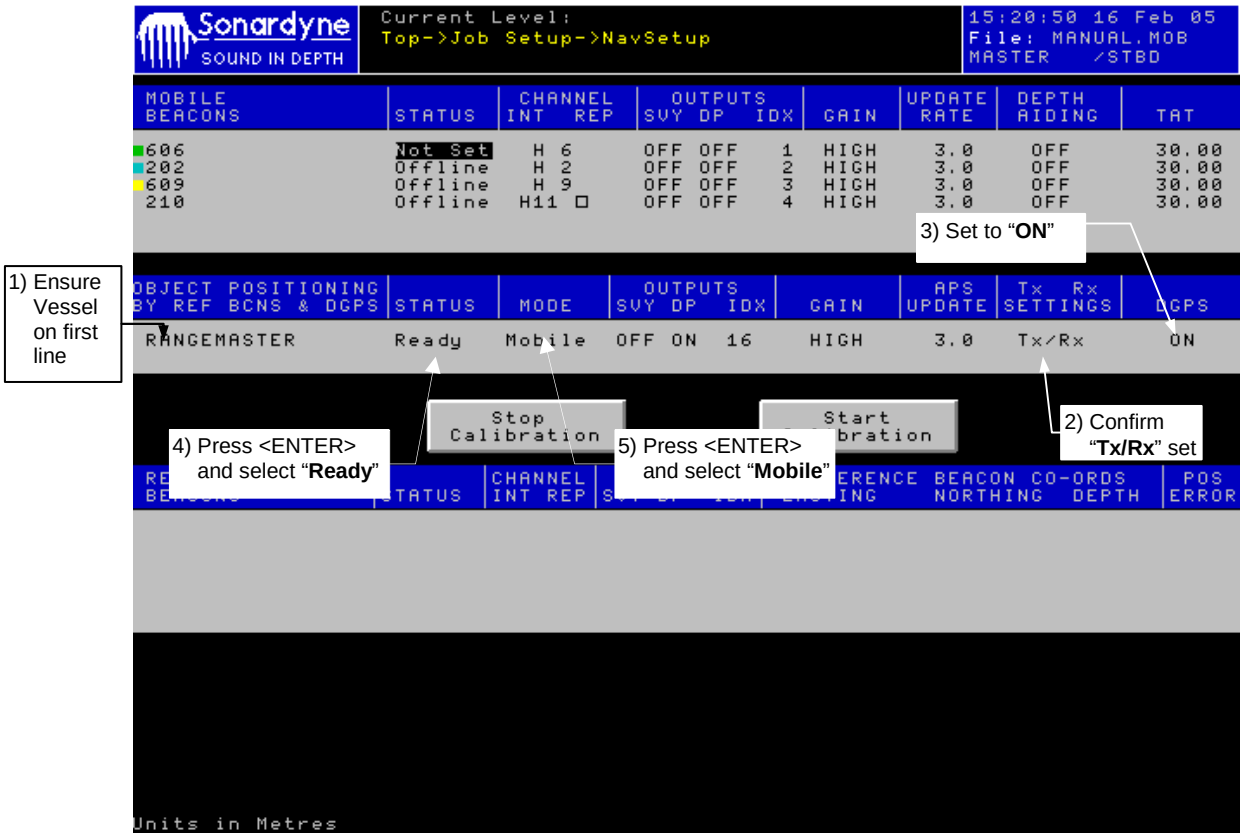
- ❑ Select "**Navigation Setup**"

The following steps describe how to add new COMPATT beacons to the job (if required) and how to set them to "**Not Set**" prior to starting Navigation. These basic steps assume that all the Beacons are Mk4 Compatts with firmware versions later than 7.90, which can be configured to HPR modes.

On the "**Navigation Setup**" page:-

4.9.2.3 Object Set-Up Procedure

While on the **Navigation Setup** page:-



Any COMPATT beacons whose UTM co-ordinates are already known, (for example from a CASIUS calibration), should be defined as Reference Beacons using the "**STATUS**" facility and the appropriate co-ordinates entered. The "**POS ERROR**" for one of these beacons should be "**Fixed**" by highlighting the "**POS ERROR**" field and pressing "**F**", with the expected position errors entered for the other beacons.

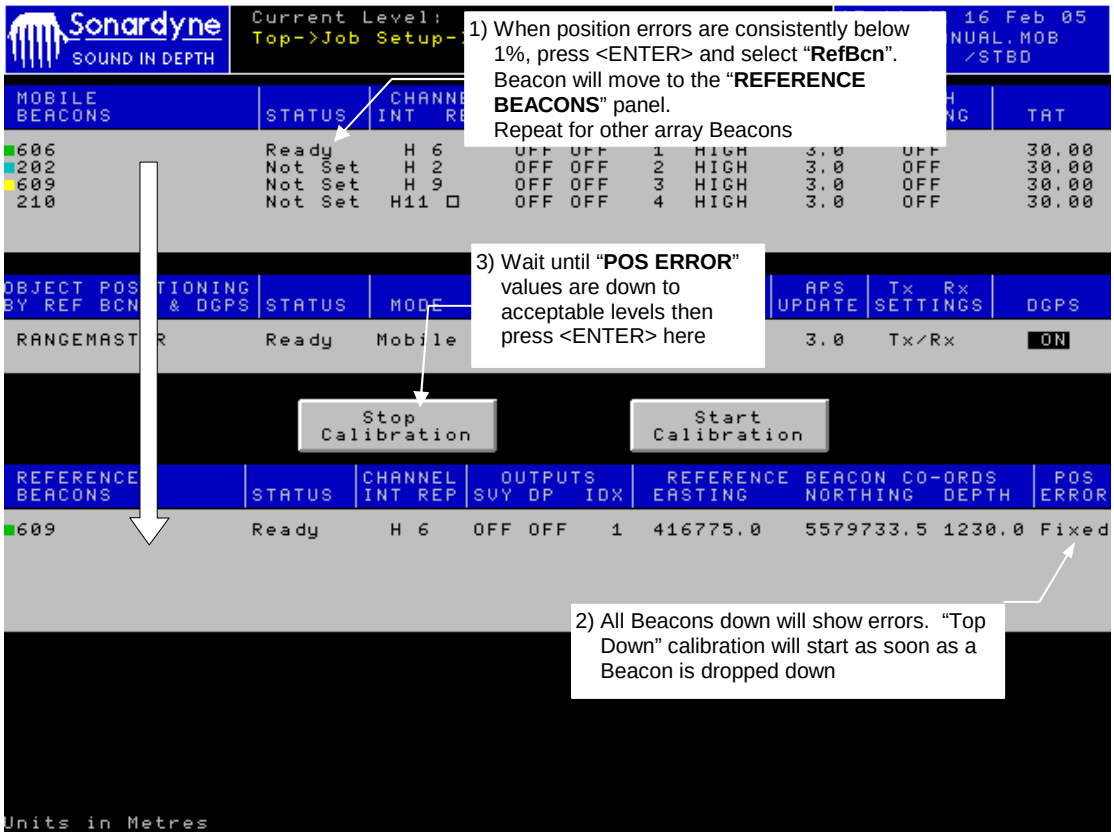
4.9.2.4 Navigate Menu

The following steps assume that each Beacon will be deployed one at time and that their initial drop co-ordinates will be determined (in UTM co-ordinates using the vessel USBL transceiver) before moving onto the next Beacon. Following the deployment of the second and subsequent Beacons, the 'one-way' baselines will be measured from the Beacon being deployed to the previously deployed Beacons.

On the "**Baseline Measurement**" page:-

Set the current COMPATT beacon to "**Not Set**" on the "**Navigation Setup**" page, return to the Top Level menu and select "**Navigate**". The system will set up the Beacon as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**Nav Setup**" page when the Beacon has been correctly set up) and will start to calculate the Beacon position with reference to the vessel in a UTM grid. Set up the Position Data Boxes for the Vessel and Beacon and a Range Diagnostics Box and allow time for the Beacon position on the Chart Display to settle down. Observe the "**Qual**" value in the Position Data Box - a Beacon is ready to be defined as a Reference Beacon when the position error is consistently below 1% of slant range and the "**Range Diags**" under 0.3 milliseconds on a quiet vessel or greater than this on a noisy vessel.

Once the position quality of a Beacon has become small enough, select "**NAV SET-UP**" again:-



Once the Beacon is in the "**REFERENCE BEACONS**" panel, the system will automatically start the 'Top-down' calibration, with the system improving the calibration of the Beacon position in UTM co-ordinates. Once the position error of the Reference Beacon has stabilised with the "**POS ERROR**" below 1% of slant range, press the "**Stop Calibration**" button. This will fix the Beacon Eastings, Northings and Depth co-ordinates, storing the current estimated position error.

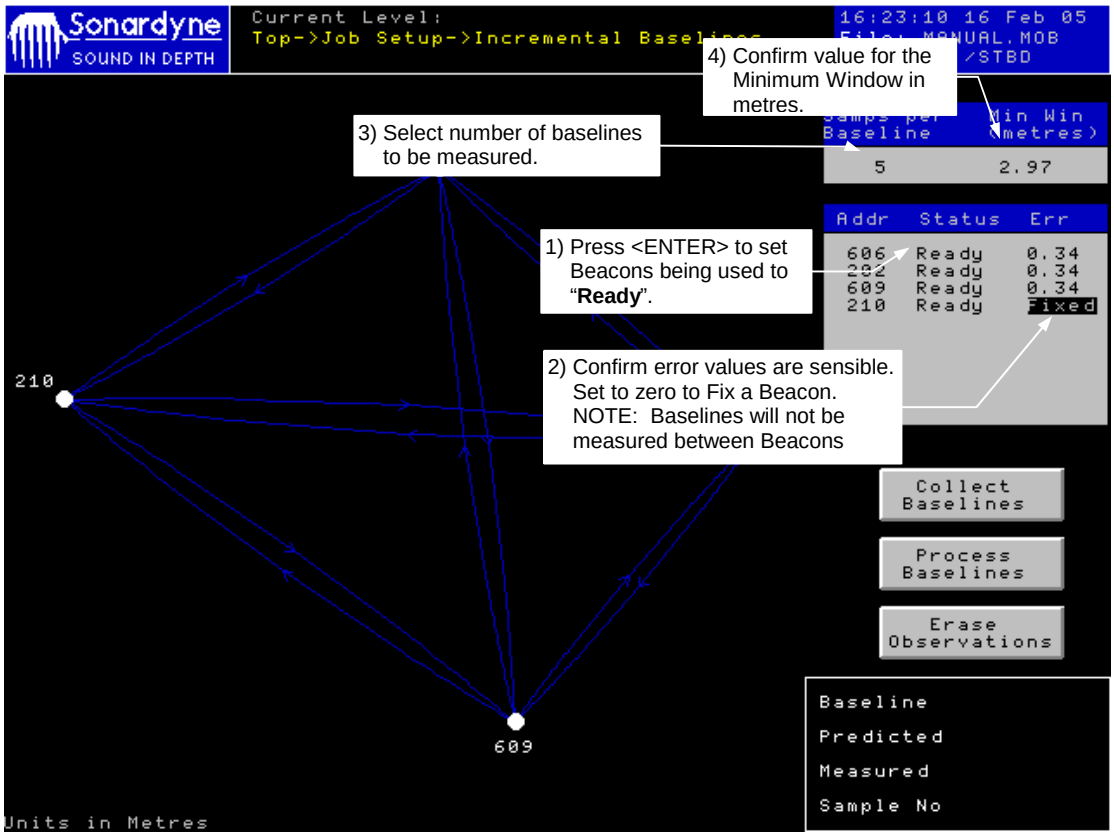
Set the Beacon "**STATUS**" to "**Offline**" and move the vessel to the position where the second Beacon is to be deployed and repeat the steps outlined above.

Exit Navigation to return to the Top Level menu and copy the 'Top Down' calibrated Job file to a new file with a different name. If you are not sure how to do this, refer to Section 9.3.

4.9.2.5 Baseline Measurements

Select "**Job Setup**" from the Top Menu and then "**Incremental Baseline Measurement**". The following steps describe how to select the COMPATTs between which baselines are to be measured (shown in white), the error values to be assigned to each Beacon, the number of baselines to be measured and the acceptance window.

On the "**Incremental Baselines**" page:-



Select "**Collect Baselines**" and press <ENTER>. The system will prompt the operator for the Beacon being used as the "**Interrogator**" - place the cursor on the correct Beacon and press <ENTER>. The system will proceed to measure the requisite number of baselines from the Interrogator to each of the other selected COMPATTs in turn.

The baseline being measured will be indicated in bold white on the display. The "**Baseline**", the "**Predicted**" value calculated from the initial array co-ordinates, the "**Measured**" value and the current "**Sample Number**" will be shown in the summary box.

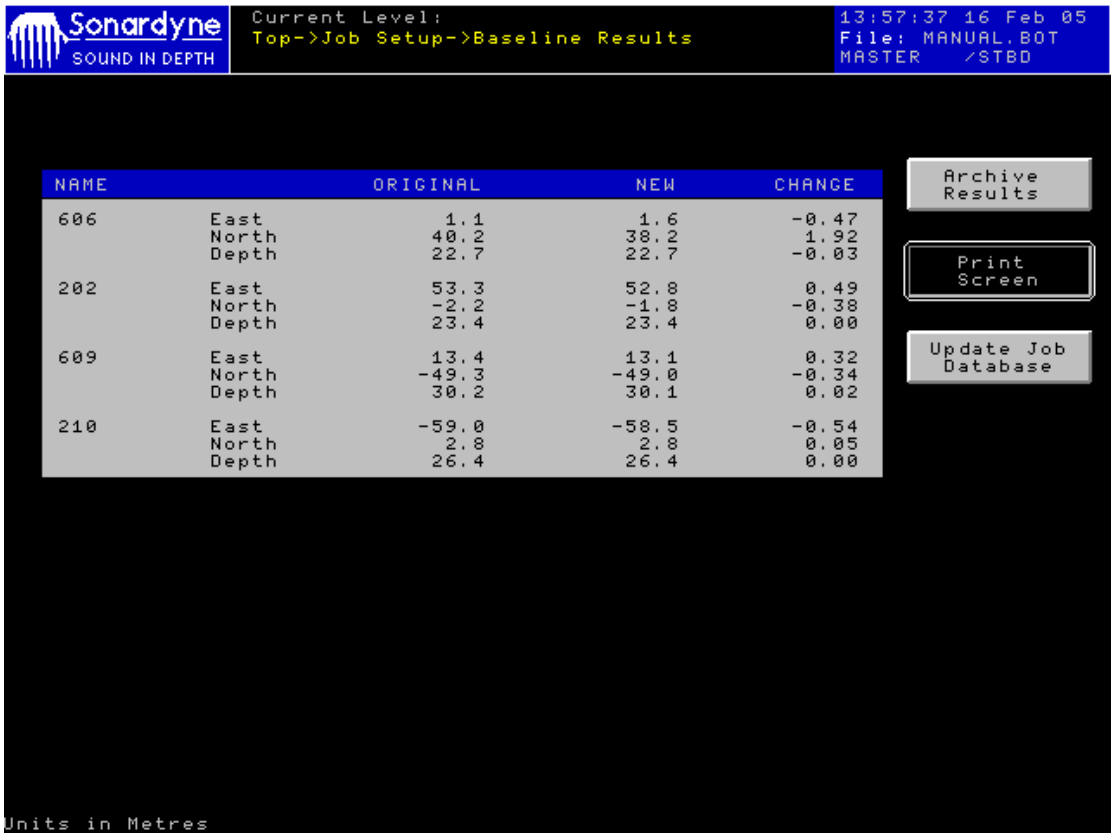
Baseline measurements will be repeated if the measured value falls outside the minimum window compared with the predicted value or if (a) Telemetry Errors, (b) No Reply or (c) a Zero Baseline Measurement is reported. The measurement will be repeated up to three times after which a warning prompt will be displayed. Completed baseline measurements are indicated by a green colour and failed measurements in a red colour on the display. When all the baselines have been measured from the Beacon currently set as the Interrogator to all the other selected Beacons, the system will return to the "**Incremental Baselines**" page, having stored all the baseline measurements to the current Job File.

Exit the "**Incremental Baselines**" page to return to the "**Job Setup**", set the current active Beacons' "**Status**" to "**Offline**" and move the vessel to the position where the next Beacon is to be deployed and repeat all the steps outlined above.

4.9.2.6 Array Calibration

Once all the baselines have been measured (either one-way or two-way), select "**Process Baselines**" on the "**Incremental Baselines**" page and press <ENTER> to process the data.

The results of the array adjustment will be displayed on the "**Baselines Results**" page:-



On the "**Incremental Baseline Results**" page, the system displays the Beacon "**NAME**", the "**ORIGINAL**" co-ordinates, the "**NEW**" co-ordinates using the baseline measurements and the amount by which each co-ordinate has "**CHANGED**". The following options are available:-

- Select "**Archive Results**"

  All the data can be archived to a floppy disc for inspection using a terminal program. This includes the measured baselines and the output from the least squares adjustment showing any baseline measurements which have been rejected.

- Select "**Print Screen**"

  Allows the operator to copy the results of the baseline adjustment to a Bitmap.

- Select "**Update Job Database**"

  Pressing this button will update the current Job database with the results of the baseline adjustment.

Press <ESCAPE> to return to the Top Menu.

4.10 'MRAMS' – MARINE RISER ANGLE MONITORING SYSTEM

This procedure covers setup and operation of the system for reporting the angle of the Riser relative to the BOP stack on a wellhead system. It covers two cases – as a standalone system and in parallel with a DP operation.

The procedure applies only to special purpose Riser Angle COMPATT (RAC) systems designed to make accurate measurements of the Riser Angle. It is assumed that a Riser Angle COMPATT (RAC) and its External Inclinometer Unit are ready for deployment.

4.10.1 Stand-Alone System

4.10.1.1 **Common Installation Procedures**

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.10.1.2 **Job Set-Up Menu**

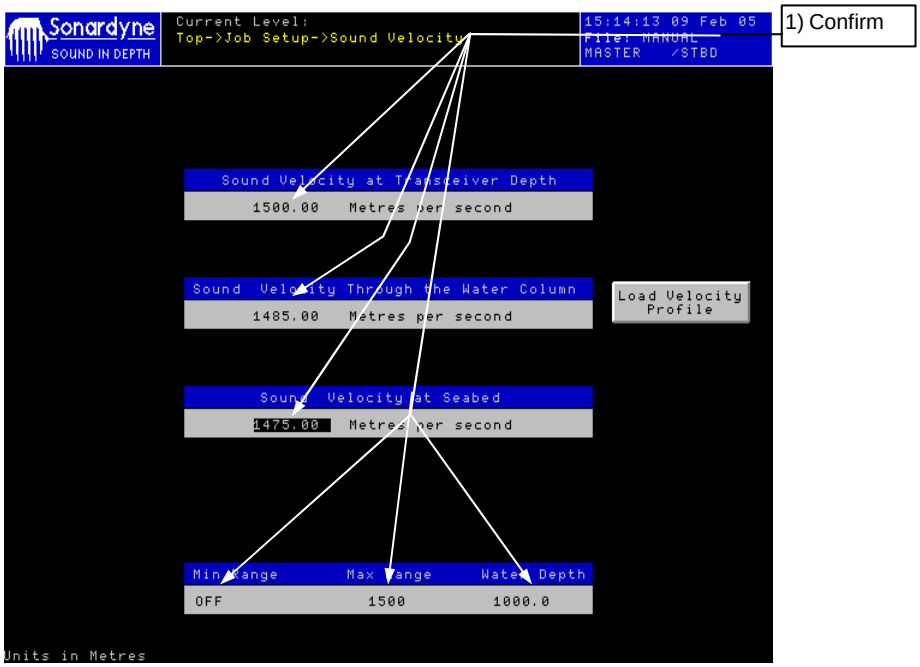
Having assigned a Job File (see Section 3.3 if the Job File is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m)

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

❑ Confirm fields in bottom row of "**Sound Velocity**" dialog box, as follows:-

- "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" and "**Off**".
  - "**Manual**" User input minimum expected range in feet/metres.
  - "**Off**" No minimum range gating will be implemented.
- "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTS to prevent re-interrogation of the beacons by multipath transmissions.

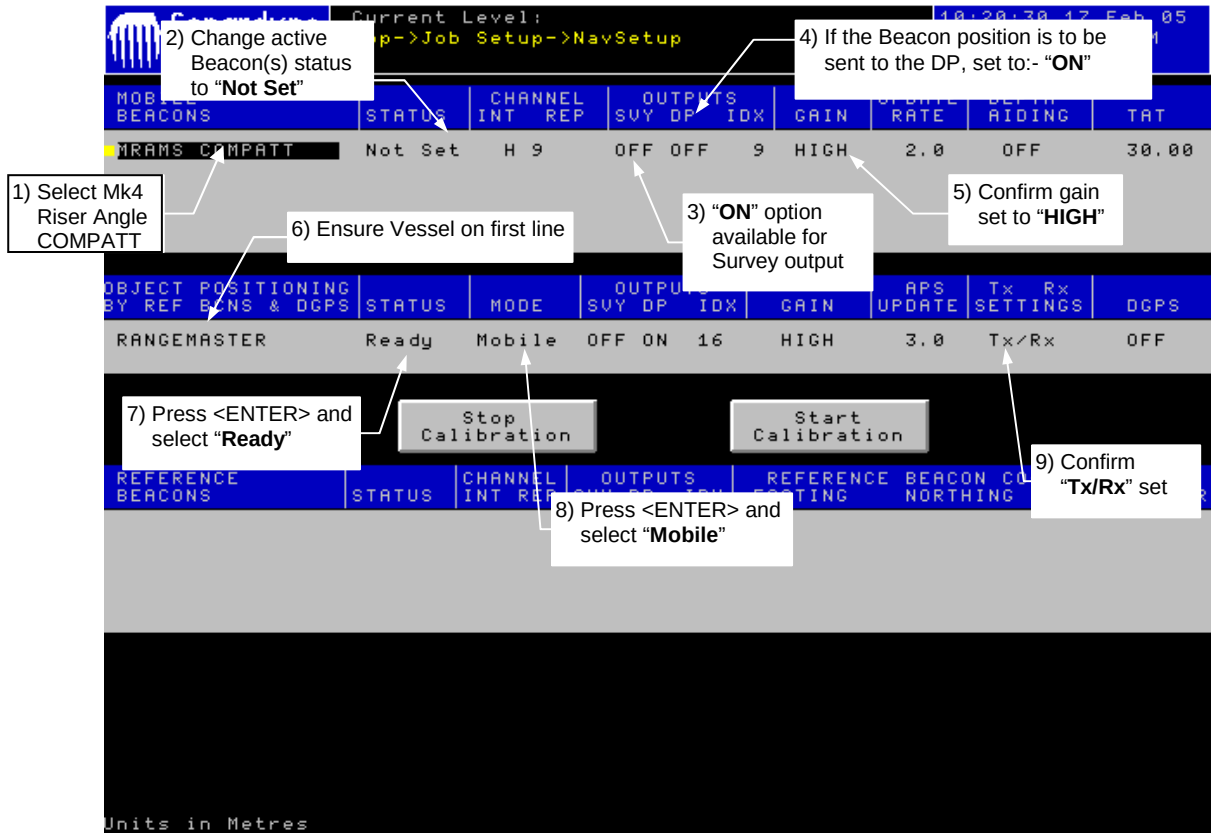
❑ Select "**Navigation Setup**"

The following steps describe how to add a new Riser Angle COMPATT (RAC) to the job (if required), how to set them to "**Not Set**" prior to starting Navigation and how to turn DP outputs on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

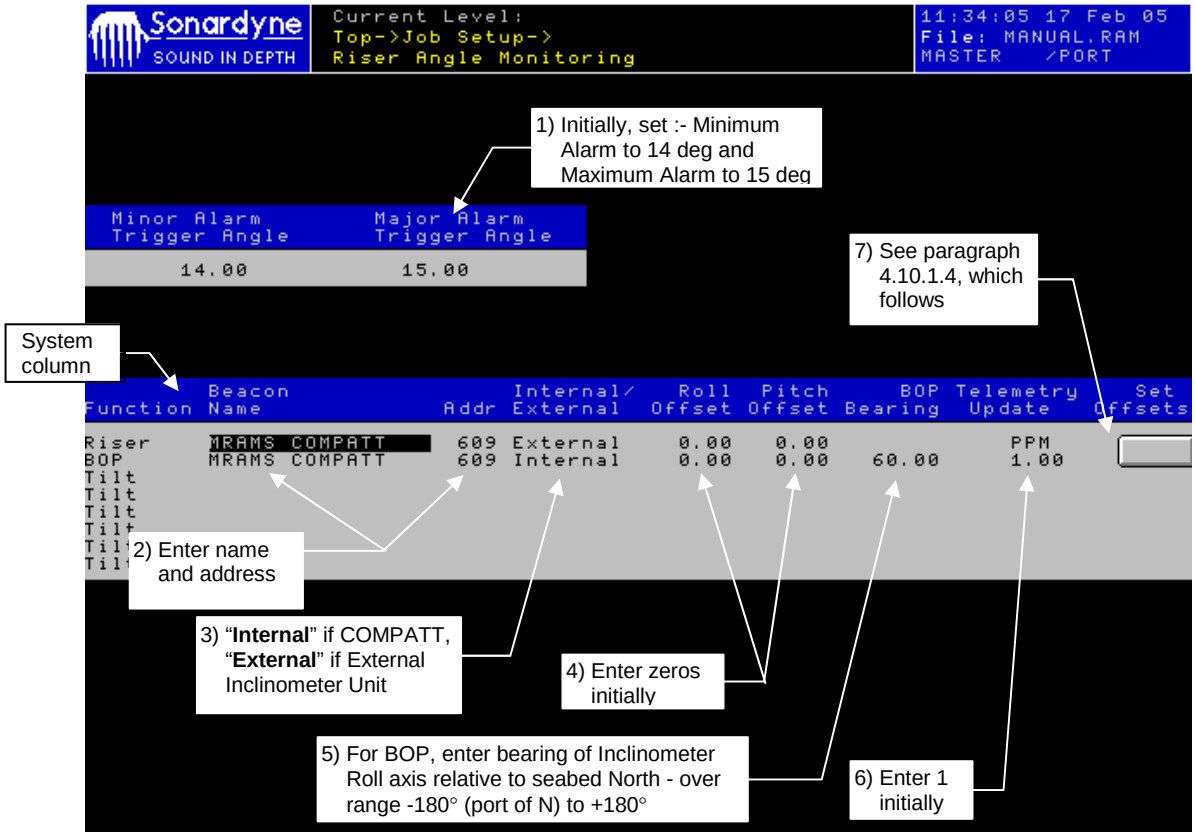
NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

4.10.1.3 **Set-Up Procedure**

Select the "**Navigation Setup**" page:-



- Select "**Riser Angle Monitoring Setup**" from the "**Job Setup**" menu:-



4.10.1.4 Measuring Offsets

The Roll and Pitch offsets are measured by deploying the BOP and Riser at a sufficient depth (say 75 metres / 250 feet) so that it is hanging vertically below the Rig. Once this has been done:-

- Select the "**Set Offsets**" button on the "**Riser Angle Monitoring Setup**" page with the "**Telemetry Update**" initially set to one minute and let the system run for five minutes to stabilise. The system will collect values for the Roll and Pitch for the Riser and the BOP using acoustics. As the Riser and BOP should be hanging vertically, these values are the offset values. The updated offset values will appear in the "**Roll & Pitch Offset**" columns on this page.

- **Note**: It is important to note that before calibrating the Riser angle COMPATT and external inclinometer pair, the system must be hanging freely and not under the influence of tidal and current affects. If necessary the BOP 'bull's eye' should be inspected to insure that no bias exists.

4.10.1.5 Final Set-Up

On the "**Riser Angle Monitoring Setup**" page, make the following entries:-

- Change the "**Alarm Trigger Angles**" to the required values (typically 2° for the Minimum Trigger Alarm and 5° for the Maximum Trigger Alarm).

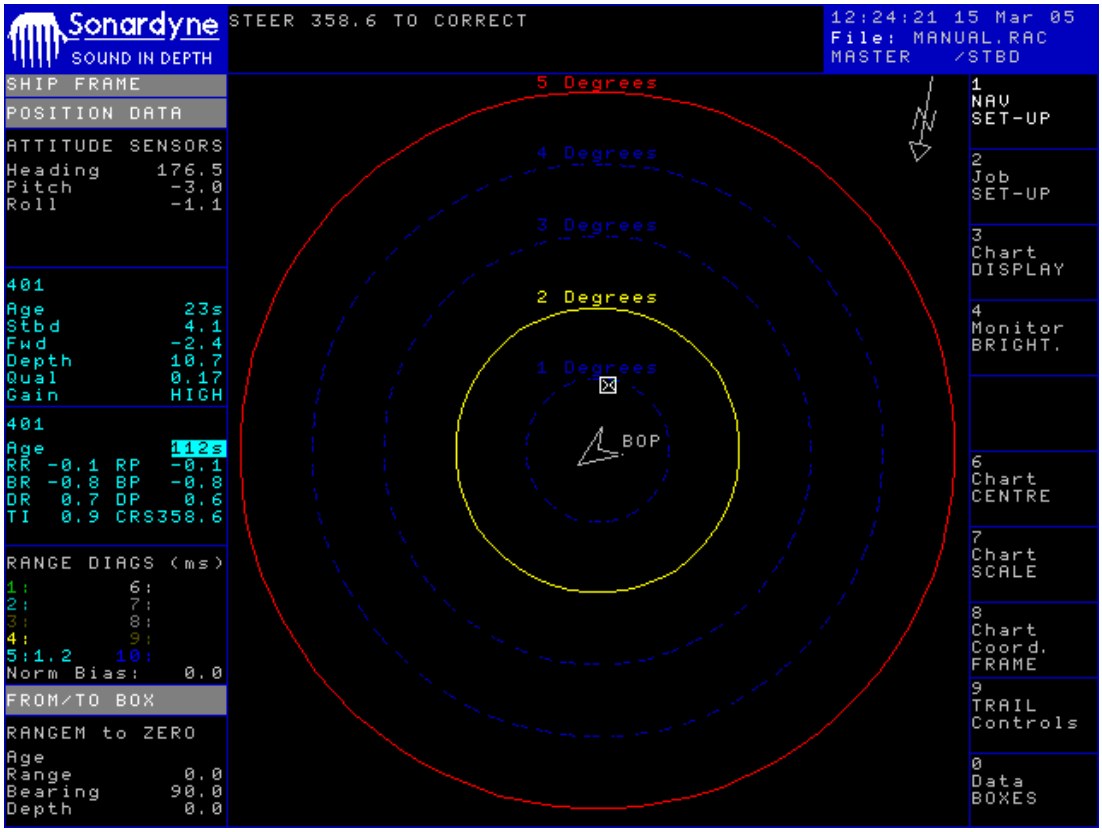
- Enter a "**Telemetry Update**" Once the offsets have been collected, it is recommended this value is increased to at least 60 minutes as a regular check of the BOP attitude.

The system is now set up ready for use once the BOP and Riser have been fully deployed.

4.10.1.6 **Navigate Menu**

Having completed all of the set-up procedures, return to the Top Menu select "**Navigate**". The system will set up the Riser Angle COMPATT (RAC) beacons as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will compute and display the position of the Beacons.

Select "**Chart DISPLAY**" and then "**Display RISER ANGLES**". The system will monitor the differential angle of the Riser with respect to the BOP and will display the result as a Rig position angle on the chart, as illustrated below:-



One of the Data Boxes may be set to "**RISER Angle Data**". This data box will show roll and pitch angles for the Riser (RR & RP), the BOP (BR & BP) and the differential angle between these (DR & DP). It will also show the tilt angle which is the resultant of the differential roll and pitch (TI), and the course to steer to reduce the tilt towards zero (CRS).

By observing the display, it is possible to decide when it is necessary to re-position the rig and in which direction to steer.

Once the system is set up and operating correctly archive the Job and Installation files. If you are not sure how to do this, refer to Section 9.3.

4.10.2 Operating with a L/USBL (DP) System

4.10.2.1 **Common Installation Procedures**

The common installation procedures described in Sections 3.1 and 3.2 should have been completed.

4.10.2.2 **Job Set-Up Menu**

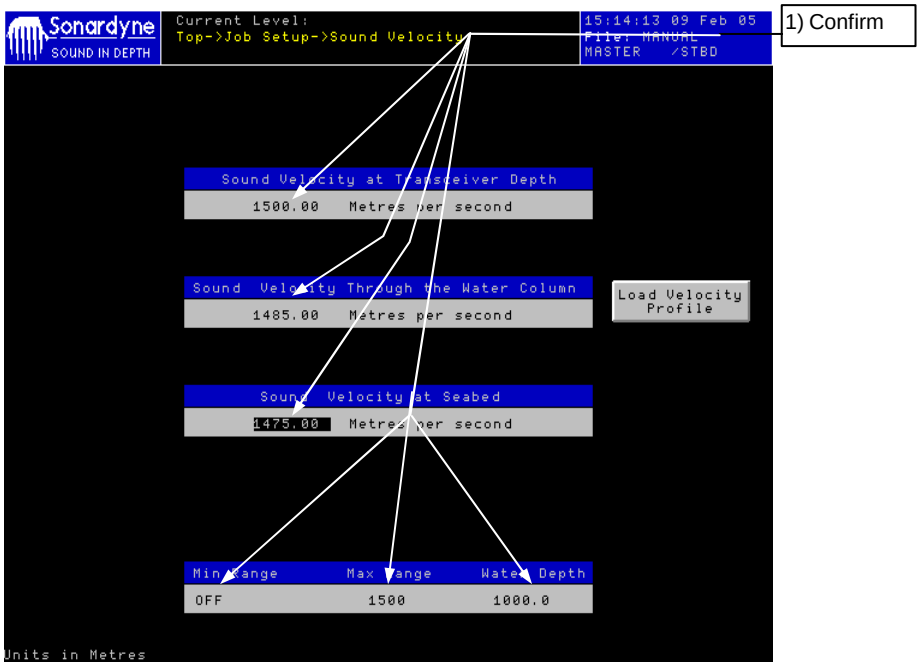
Having assigned a Job File (see Section 3.3 if the Job File is to be changed), the Job Setup menu should be checked to ensure that it is correct for the current job. Select "**Job Setup**" from the main menu and then:-

- Select "**Display Units**"

In Version 6, the current Display Units appear on nearly every page and can therefore be checked without selecting this menu item. If necessary, the units may be changed on this page via the dialogue box illustrated to the right.

NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m)

- Select "**Sound Velocity**"



NOTE: The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

- (Preferred). Use Sound Velocity Probe data to calculate the velocity.
- Compare COMPATT sensor depth with the acoustic measurement.
- Load a Sound Velocity Profile by selecting the **"Load Velocity Profile"** and press <ENTER>. The software will then automatically compensate for ray refraction between the transceiver and any mobile target.

❑ Confirm fields in bottom row of "**Sound Velocity**" dialog box, as follows:-

- "**Min Range**" This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual"** and "**Off"**.
  - "**Manual**" User input minimum expected range in feet/metres.
  - "**Off**" No minimum range gating will be implemented.
- "**Max Range**" This field will limit the time the transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.
- "**Water Depth**" This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTS to prevent re-interrogation of the beacons by multipath transmissions.

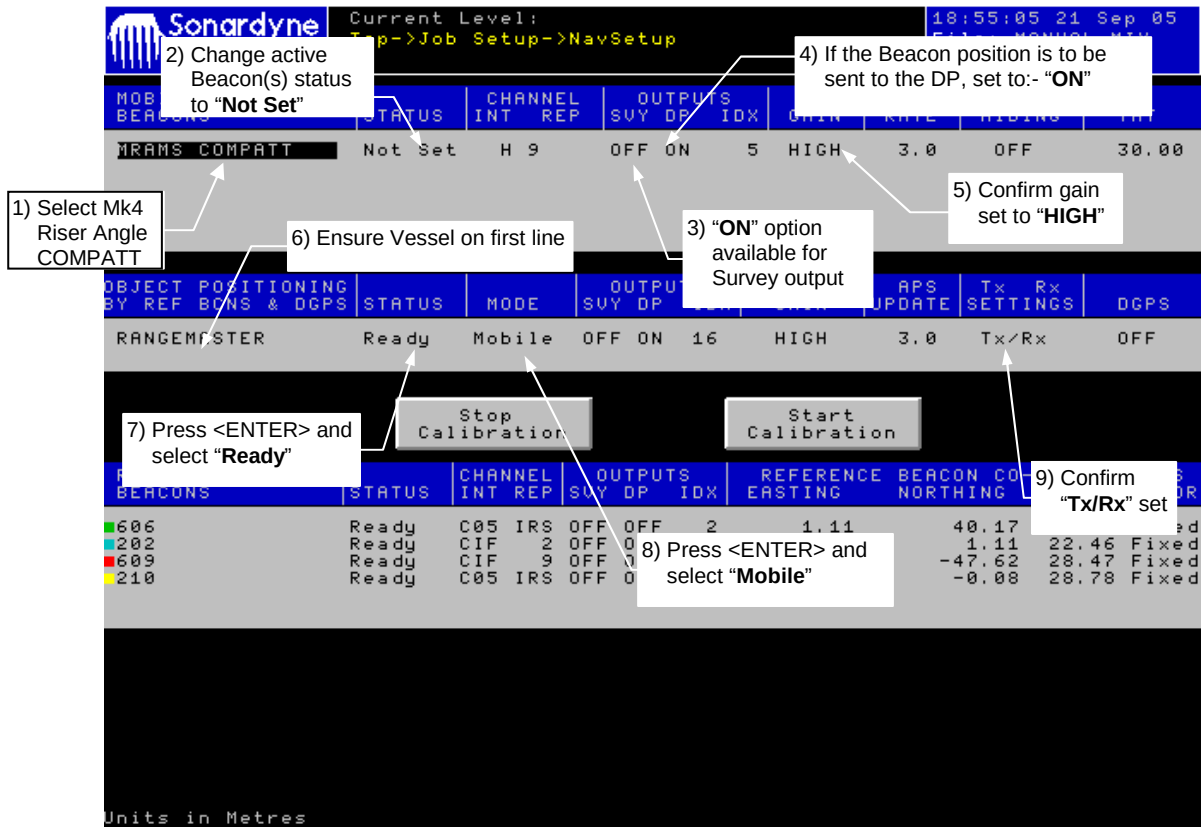
❑ Select "**Navigation Setup**"

For this procedure, it is assumed that the Reference array has been set up and calibrated as part of the BOP deployment process – using the procedure described in Section 4.5. The following steps describe how to add Riser Angle COMPATT beacon(s) (RAC) to the Job, how to set them to "**Not Set**" prior to starting Navigation and how to turn the DP output on. However, these basic steps assume that the default Beacon settings* are acceptable for the current job. In the event that these settings do need to be changed, please refer to paragraph 9.2.1.2 in Section 9.

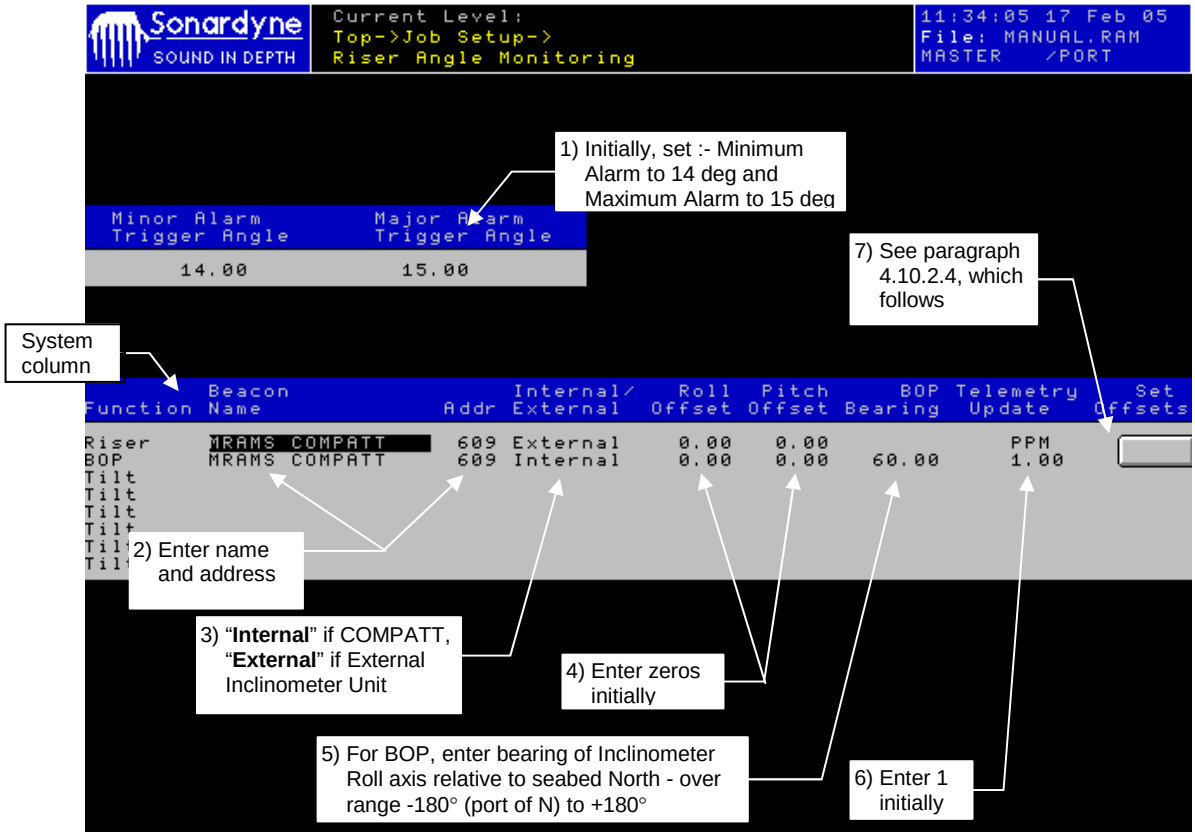
NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, whilst analogue transceivers and beacons are supported in tone mode.

4.10.2.3 Set-Up Procedure

Select the "**Navigation Setup**" page:-



- Select "**Riser Angle Monitoring Setup**" from the "**Job Setup**" menu:-



4.10.2.4 Measuring Offsets

The Roll and Pitch offsets are measured by deploying the BOP and Riser at a sufficient depth (say 75 metres / 250 feet) so that it is hanging vertically below the Rig. Once this has been done:-

- Select the "**Set Offsets**" button on the "**Riser Angle Monitoring Setup**" page with the "**Telemetry Update**" initially set to one minute and let the system run for five minutes to stabilise. The system will collect values for the Roll and Pitch for the Riser and the BOP using acoustics. As the Riser and BOP should be hanging vertically, these values are the offset values. The updated offset values will appear in the "**Roll & Pitch Offset**" columns on this page.

- **Note**: It is important to note that before calibrating the Riser angle COMPATT and external inclinometer pair the system must be hanging freely and not under the influence of tidal and current affects. If necessary the BOP 'bull's eye' should be inspected to insure that no bias exists.

4.10.2.5 Final Set-Up

On the "**Riser Angle Monitoring Setup**" page, make the following entries:-

- Change the "**Alarm Trigger Angles**" to the required values (typically 2° for the Minimum Trigger Alarm and 5° for the Maximum Trigger Alarm).

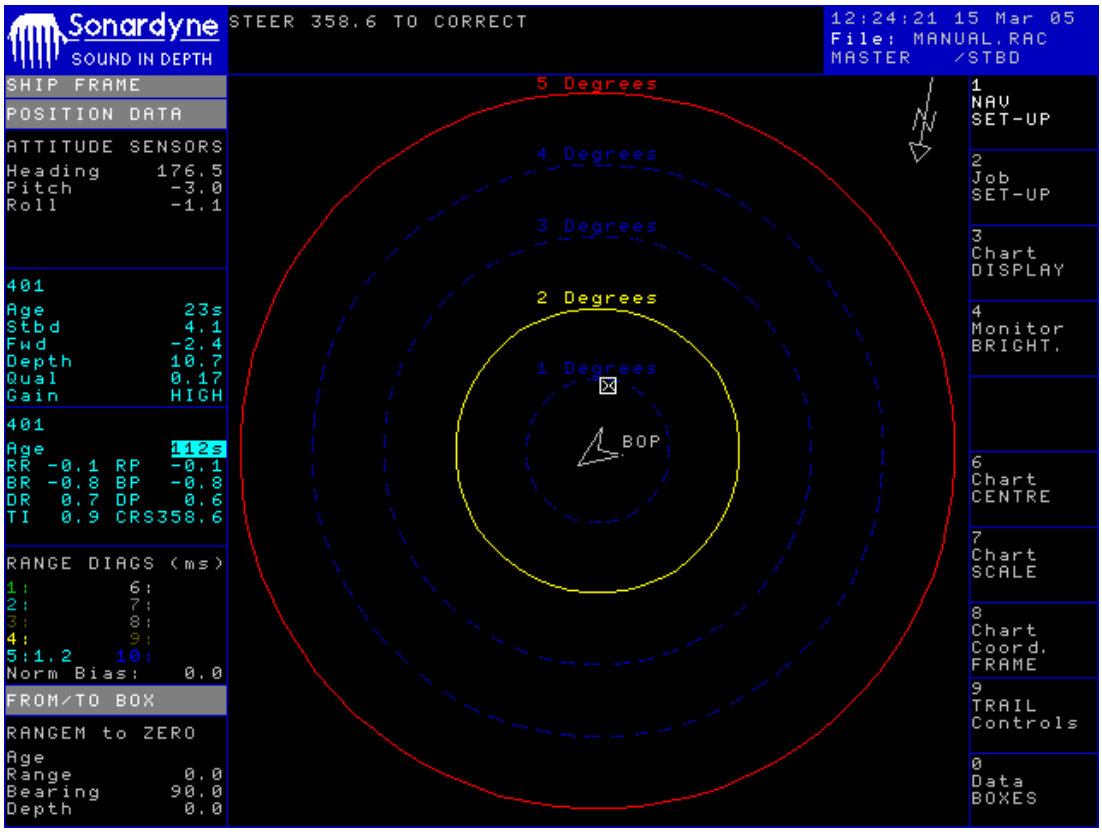
- Enter a "**Telemetry Update**" Once the offsets have been collected, it is recommended this value is increased to at least 60 minutes as a regular check of the BOP attitude.

The system is now set up ready for use once the BOP and Riser have been fully deployed.

4.10.2.6 Navigate Menu

Having completed all of the set-up procedures, return to the Top Menu select "**Navigate**". The system will set up COMPATT, PGT, SSM and WSM beacon types as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will compute and display the position of the Vessel and Riser Angle Beacon(s).

Select "**Chart DISPLAY**" and then "**Display RISER ANGLES**". The system will monitor the differential angle of the Riser with respect to the BOP and will display the result as a Rig position angle on the chart.



A Data Box may be set to "**RISER Angle Data**". This data box will show roll and pitch angles for the Riser (RR & RP), the BOP (BR & BP) and the differential angle between these (DR & DP). It will also show the tilt angle which is the resultant of the differential roll and pitch (TI), and the course to steer to reduce the tilt towards zero (CRS).

By observing the display, it is possible to decide when it is necessary to re-position the rig and in which direction to steer.

Once the system is set up and operating correctly, archive the Job and Installation files. If you are not sure how to do this, refer to Section 9.3.

4.11 DUAL-REDUNDANCY

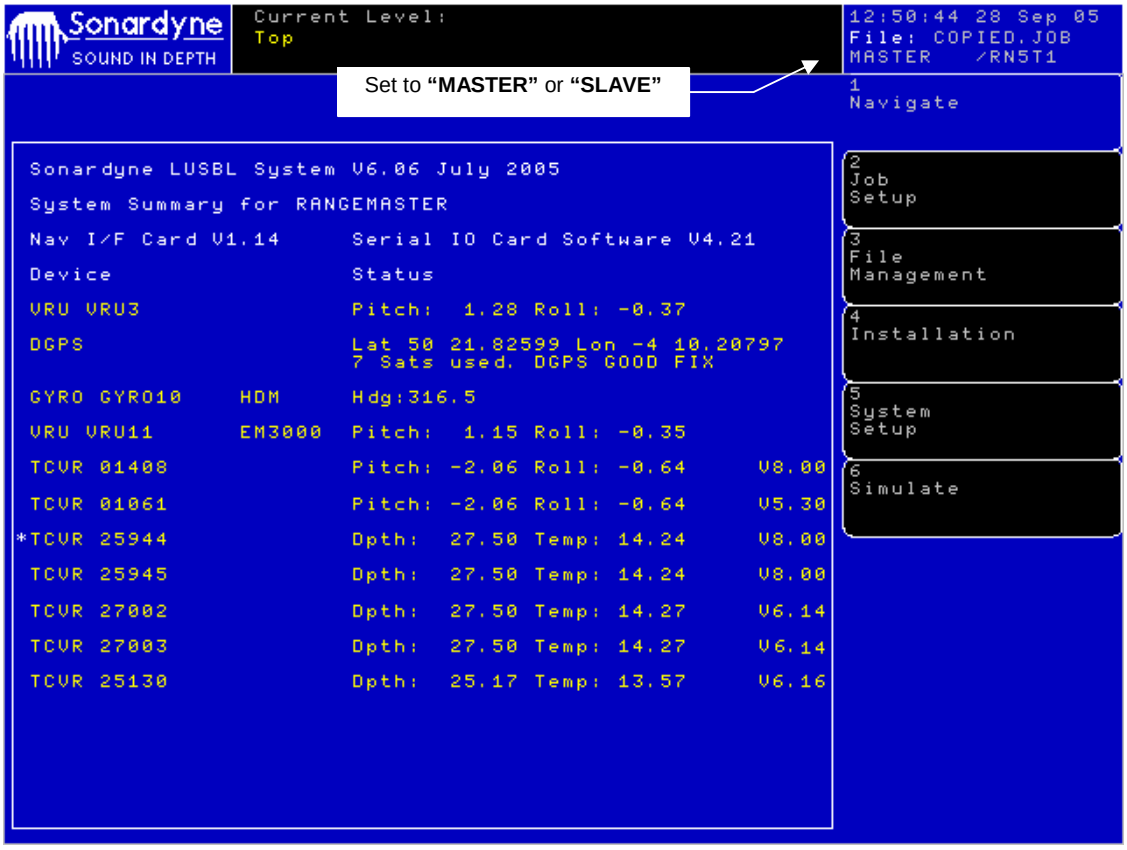
This describes a procedure for using a Dual-Redundant system in the L/USBL DP application. The key difference between this and the basic procedure is that two L/USBL systems share all data and a common database.

In the Dual-Redundant version of the system, two complete sets of L/USBL equipment [Navigation Processor, Monitor/Keypad and Transceiver(s)] are operated in tandem. The two sub-systems are cross-linked in such a way that, in the event of a failure of any major element, system operation will continue without the need for operator intervention. From the operator's point of view, operation of the Dual-Redundant version is essentially identical to that of the standard version.

In operation, one sub-system or the other operates as the 'Master' and performs all normal system functions. The second, 'Slave', sub-system monitors the function of the 'Master' and will commandeer system operation as a new 'Master' if it detects that the erstwhile 'Master' is not functioning.

System start-up is essentially normal - except that two sub-systems have to be powered-up instead of one. The two sub-systems will sort out automatically which of them is to become 'Master' and, thereafter, operation will proceed in much the same way as a standard system.

The operator will be aware at all times, by observing the status display box on the Monitor screen, whether or not his local sub-system is currently 'Master' or 'Slave' and, if system operation is normal, there will be no need to change the 'Master/Slave' situation.



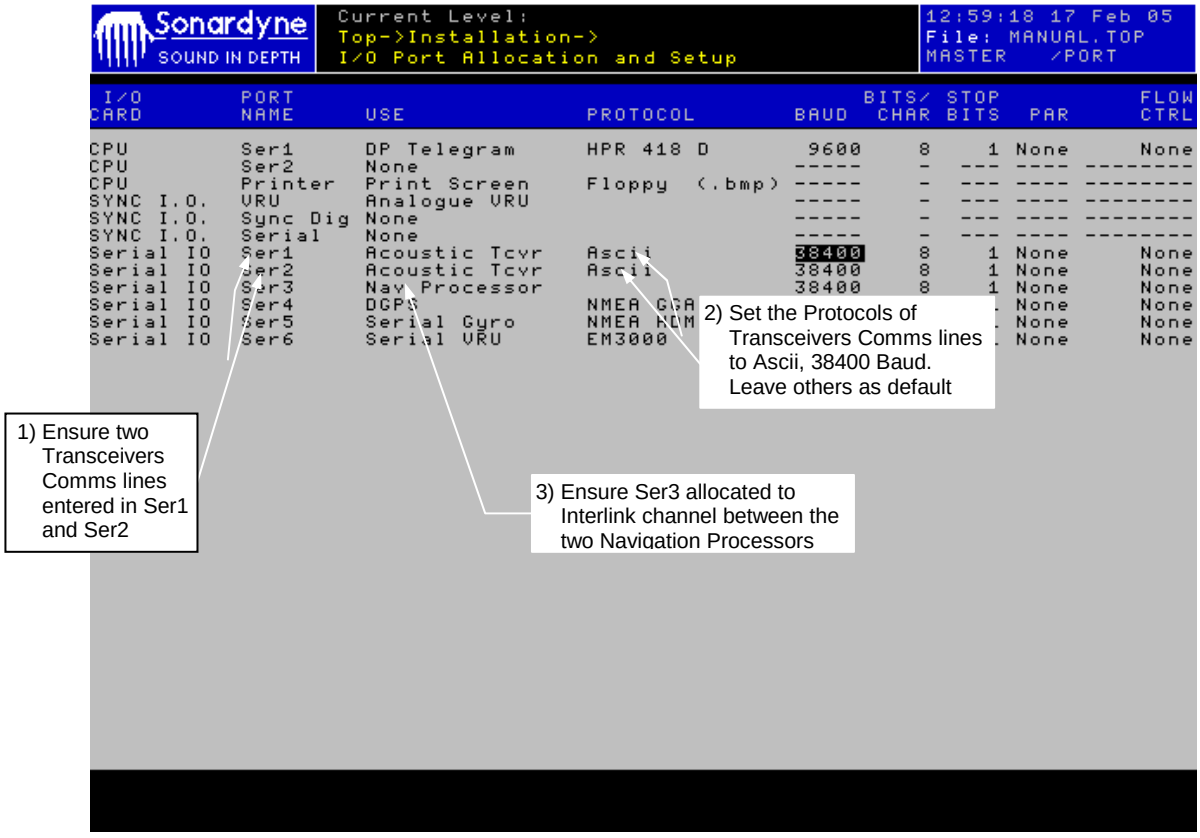
The following procedure describes set-up and operation for a Dual-Redundant LUSBL DP job.

> **NOTE:** Use the "**ARM + MASTER"** keys on a 'Slave' system to make it the 'Master'. [Alternatively, if a keyboard version is being used, "**CONTROL + Y"** achieves the same result].

4.11.1 Common Installation Procedures

The common installation procedures described in Sections 3.1 and 3.2 should have been completed for both Navigation Processors. As well as these, the transceiver communication set up and Navigation Processor interlinking should be set as in the "**Installation**"; "**I/O Port Allocation and Setup**" page shown in the following illustration:-

On the "**I/O Port Allocation and Setup**" page:-



Note that it is only possible to change parameters on the 'Master' system. Also, when a Navigation Processor is turned on or re-booted it collects Installation and Job parameters from the 'Master' if that is already running.

In general, installation data has to be entered separately on each Navigation Processor, but Job data is entered on the 'Master' and passed automatically to the 'Slave'. It is therefore advisable to configure the first Navigation Processor's installation data with the other turned off. The configuration should be archived (see section 9.3) and then the first system should be turned off while the second is turned on. The configuration should be restored from this archive, and the second system can then have its configuration modified if there are any desired differences. The first system should then be re-started for setting up the Job.

Once the system is set up and operating correctly, archive the Job and Installation files. If you are not sure how to do this, refer to Section 9.3.

If a sub-system failure occurs, the system will continue operating normally without operator intervention, although the operator is made aware that a failure has occurred by means of an audible alarm and a warning message on his screen. If such a message does appear, the operator should note the contents of the message and whether his local station is currently 'Master' or 'Slave'. He should then move to the remote station and note the same information on that sub-system - if applicable. The audible alarm may be switched off by pressing the "**ARM**" and "**ALARM**" keys together but the warning message will remain until the fault is cleared.

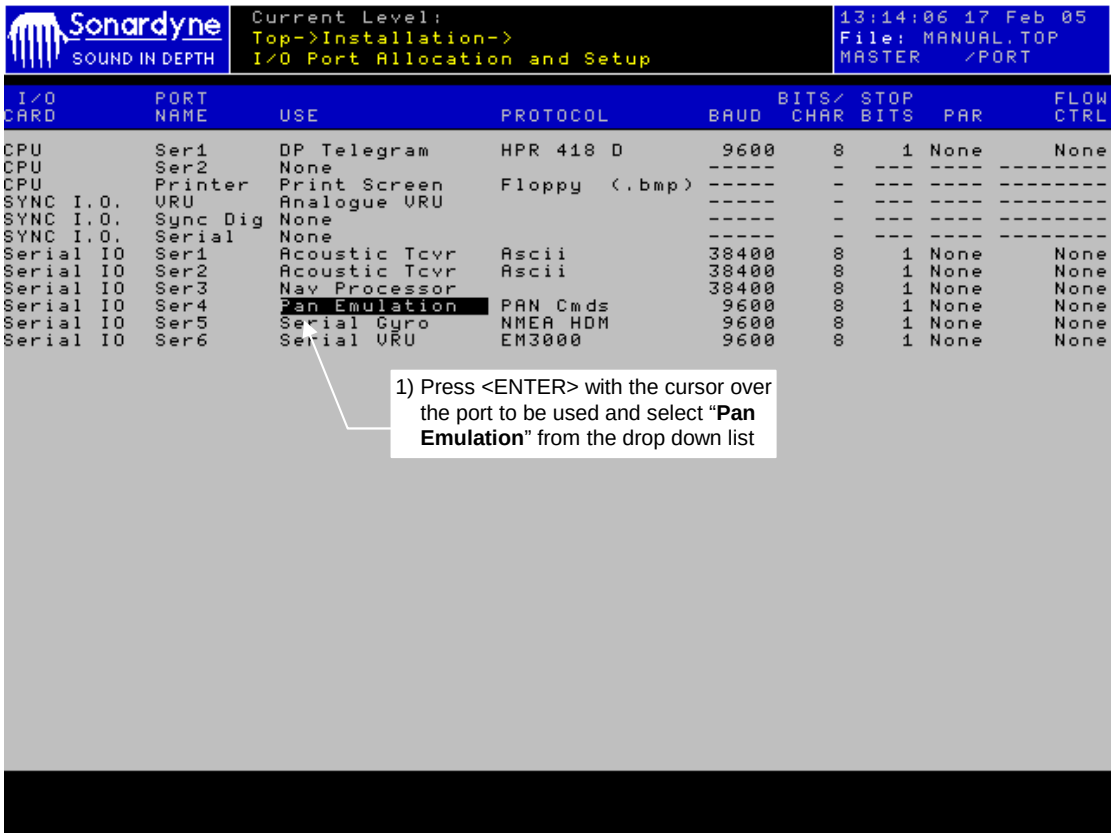
4.12 PAN EMULATION

This describes how to use a Navigation Processor to emulate a PAN and thereby control COMPATTs to carry out any of a variety of specialised tasks – such as tracking a mobile COMPATT using the Simultaneous (SI) mode. An additional survey computer system is required.

4.12.1 Set-Up Procedure

This procedure assumes that an external navigation package capable of PAN operation (Fusion LBL for example) is connected to one of the spare serial ports on the Navigation Processor. The particular example used in this procedure is that of tracking a COMPATT in Simultaneous Interrogation (SI) mode (for example, if the COMPATT was mounted on an ROV).

All that is necessary then is to assign the spare serial port to PAN Emulation. From the Installation menu select "**I/O Port Allocation and Setup**":-



Select "**Acoustic Transceivers**" from the "**Installation**" menu and set the Transceiver to be used for acoustic commands.

Return to the top level menu. There is no need to enter Navigate mode. The Navigation Processor will simply emulate the operation of a PAN: translating all of the commands sent by the external navigation system into PAN format; transmitting them to the COMPATT; receiving all of the replies issued by the COMPATT as would a PAN; returning them to the external system.

NOTE: Not all COMPATT Commands are supported. See Appendix B for explanations of the commands and which ones are supported in PAN Emulation.

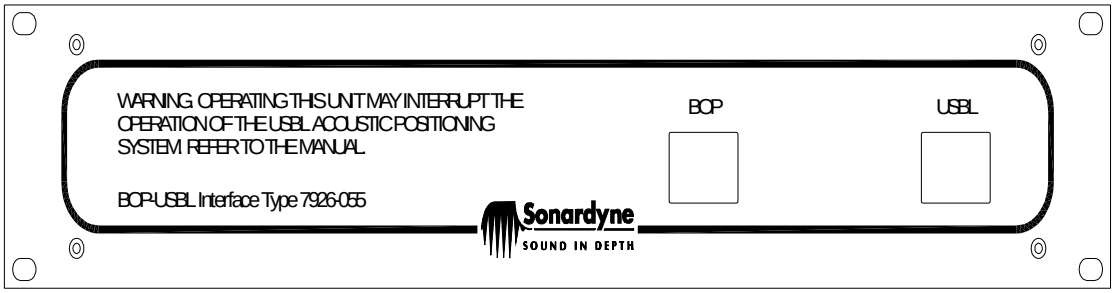
4.13 BOP CONTROL SYSTEM

This sets out procedures for using the L/USBL Navigation Processor in conjunction with an Emergency Acoustic BOP Control system. Two separate cases are covered: (1) Operating with a 'designated' Transceiver and a stand-alone BOP Controller and (2) Operating with a 'shared' Transceiver through the L/USBL Navigation Processor and an integrated BOP Controller.

4.13.1 Using a Designated L/USBL Transceiver

4.13.1.1 **Set-Up Procedure**

This procedure assumes that a stand-alone BOP Controller is being used in conjunction with a Dual Redundant L/USBL system, as described in Section 4.11, with one of the selected L/USBL transceivers being routed via a BOP-USBL Interface unit. When it is required to use the BOP Command Unit to send instructions to its designated transceiver to transmit acoustic commands to the BOP Subsea system, the "**BOP**" push button on the front on the BOP-USBL Interface unit is selected, as illustrated below:-



NOTE: When the BOP Controller is communicating with the Subsea BOP system using a L/USBL transceiver, the L/USBL system will continue to operate and pass acoustic position data to a DP desk, provided another L/USBL transceiver has been selected and configured for transmit and receive. However, the L/USBL system will only be able to send Commands and receive Telemetry replies from seabed array COMPATTs when the BOP Controller and the L/USBL system Command/Telemetry use different frequencies and/or formats.

4.13.1.2 **BOP Controller Operation**

See the BOP Controller Manual for details of how it is operated. (Reference: SM-7926-10).

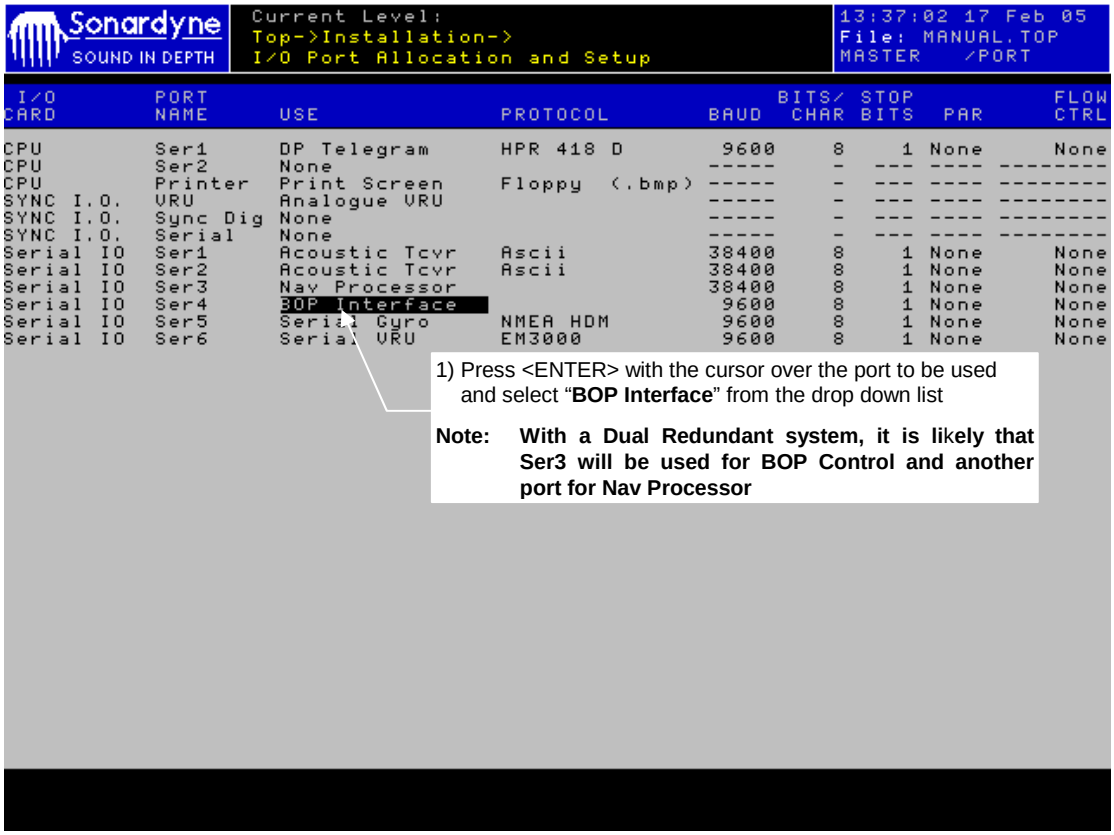
4.13.2 Using a Shared L/USBL Transceiver

This procedure covers the case when a BOP Controller 'shares' a transceiver with the L/USBL system. If the system is a Dual Redundant L/USBL system, one transceiver will be assigned to the BOP Controller and selected under the control of the system.

4.13.2.1 **Set-Up Procedure**

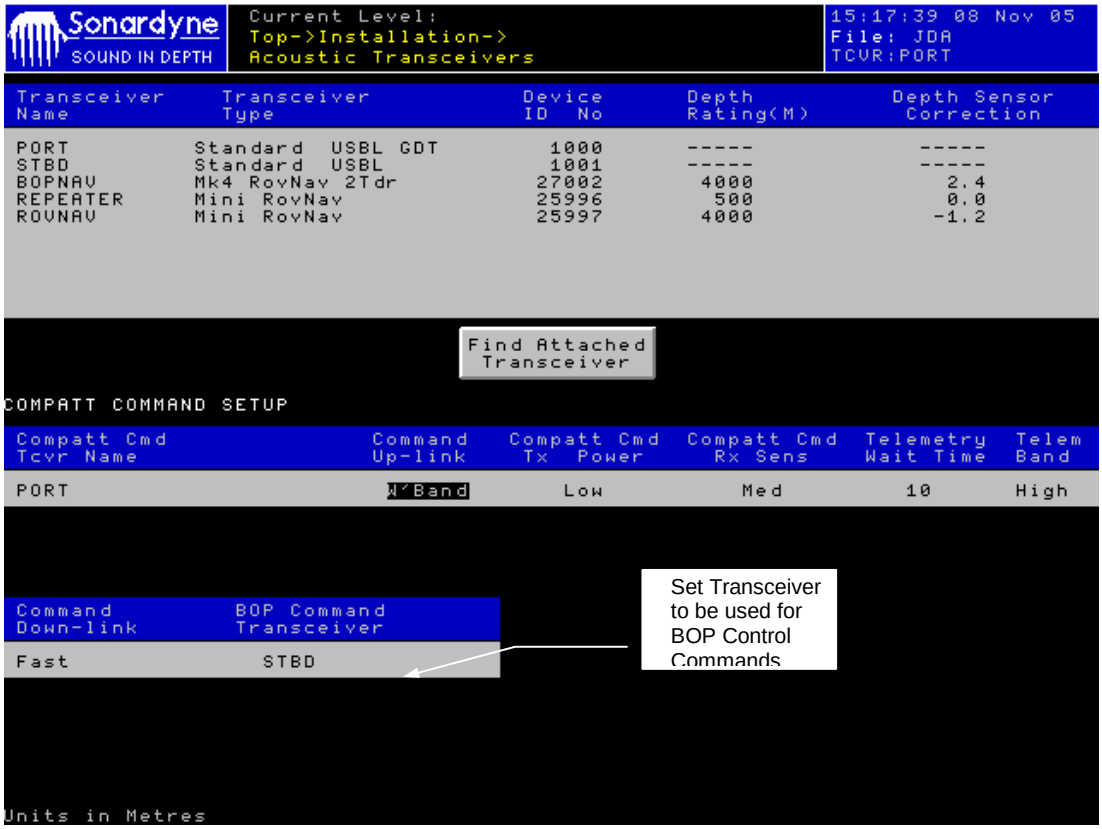
This procedure assumes that a BOP Controller is connected to one of the spare serial ports on the Navigation Processor. If the system is a Dual-Redundant L/USBL system, it is likely that Serial 3 will be used for connection to the BOP Controller on both Navigation Processors, and that the Navigation Processor Link between the dual systems will be moved to a different port because the format is better suited to long cable runs.

All that is necessary then is to assign the spare serial port to BOP Control. From the Installation menu select "**I/O Port Allocation and Setup**":-



- Return to the "**Installation**" menu and select the "**Acoustic Transceivers**" page.

  If not already done, set the Transceiver to be used for BOP Control commands, as shown below:-



Return to the top level menu. The Navigation Processor will pass on all of the commands sent by the external BOP Controller to the Subsea Electronics Module; receiving all of the replies and returning them to the external system. This will be possible both outside Navigation (provided the L/USBL system is powered up) and if the L/USBL system is in Navigation.

4.13.2.2 During Navigation

This procedure assumes that the Reference array has been set up and calibrated as part of the BOP deployment process – using the procedure described in Section 4.5.

Having completed all of the set-up procedures, return to the Top Menu select "**Navigate**". The system will set up the Reference Beacons as previously defined on the Beacon Summary pages ("**Status**" will change automatically to "**Ready**" on the "**NavSetup**" page) and will compute and display the position of the Vessel (and BOP if fitted with a Mobile or Riser Angle Beacon). Commands sent by the external BOP Controller will be passed on by the Navigation Processor to the Subsea Electronics Module, with all of the received telemetered replies being returned to the external system. Navigation will automatically be paused whilst commands are received from the external BOP Controller and sent to the Subsea Electronics Module, with all of the replies being returned to the external system before re-commencing navigation.

See the BOP Controller Manual for details of how it is operated. (Reference: SM-7926-10).

4.13.2.3 **Installation File Archive**

Having finished the installation task, return to the top level Menu and select "**Job File Management**". Select "**Archive Job**" to archive the installation database to a floppy disc.

SECTION 5

5. LUSBL DATA

This section contains information on various prompts and error messages which may be encountered while using an L/USBL system.

5.1 ERROR MESSAGES

5.1.1 Type 1 Messages

Highest Priority messages. The audible alarm is sounded continuously until the error is cleared or the alarm is accepted by pressing the "**ARM"** and "**ALARM"** keys together or <**CTRL**> + <**U**> together.

Comms lost to transceiver <transceiver name>	The 'Master' Navigation Processor has failed to communicate with the named transceiver.
Data Link Failed. Slave Database Misaligned	The data link between 'Master' and 'Slave' Processor in a Dual Redundant System has failed. Therefore the database in the 'Slave' processor will not be kept up to date. The system can still detect activity on the transceiver communications lines and therefore knows that the 'Master' is still active.
Failed COMPATT Command	The system has failed to get an error free reply to a COMPATT command. The operator has to decide whether to Retry, Carry on anyway, or take the Beacon "**Offline"**.
Failed PGT / SSM / WSM Command	The system has failed to get an error free reply to a command sent to a PGT, SSM or WSM beacon. The operator has to decide whether to Retry, Carry on anyway, or take the Beacon "**Offline"**.
No Remote Master. Local system is Master	In a Dual Redundant System, the Navigation Processor has failed to find another Navigation Processor acting as 'Master'. It is therefore automatically taking over as 'Master'.
RAC OUTSIDE ALARM LIMIT 2	The differential tilt angle reported by the Riser Angle Monitoring system is greater than the Major Alarm Trigger Level set.
Ship outside watch circle	The computed position of the vessel is outside the Watch Circle limit set.
NAVGRAPH: Error linking to data modules	The software process NAVGRAPH has failed to connect to some of its data. The system should recover automatically. If the error persists, report it to Sonardyne.
<TaskName> died with exit code <Number> <date&time> Error Shutdown. Press ESC to return to MMI	The named software process has failed. Pressing Escape allows the system to continue operation cleanly. If the problem persists, report it to Sonardyne.

5.1.2 Type 2 Messages

Alarm messages. The audible alarm is sounded in a short burst.

Can't find a receiving transceiver	There are no transceivers set to receive on enabled objects.
Can't find a transmitting transceiver	There are no transceivers set to transmit on enabled objects.
Master/Slave change-over failed	The transfer of 'Master' to this Navigation Processor has failed.
No comms from Master system	The 'Slave' Navigation Processor is not detecting any communications from the 'Master'.
No targets selected	The user has attempted to start Navigation with no active acoustic Beacons.
RAC OUTSIDE ALARM LIMIT 1	The differential tilt angle reported by the Riser Angle Monitoring system is greater than the Minor Alarm Trigger Level set.
Target scheduling paused	The operator has suspended scheduling acoustic cycles.
Cycle aborted due to comms error	There was an error in the transceivers reply so the acoustic cycle was abandoned and a new one was started.
CRC error in tcvr command	The reply from the transceiver is corrupted.
External trigger not detected	The external trigger that starts an acoustic cycle was not received within a reasonable time.
Scheduler paused	The acoustic scheduler is paused. No acoustic ranging will occur whilst in this state.

5.1.3 Type 3 Messages

Information messages. These are transient messages to allow monitoring of the system operation. They require no immediate operator response.

Missed RX command. Cycle lost	The 'Slave' system did not see the RX command that would have been sent by the Master and so the 'Slave' will be unable to process this acoustic cycle.
Missed BR command. Cycle lost	The 'Slave' system did not see the BR command that would have been sent by the Master and so the 'Slave' will be unable to process this acoustic cycle.
The Command Up-link is currently set to Wideband which is not supported by this Compatt. Please change to Slow, Normal or Fast	The system is configured to receive Wideband telemetry from a Mk4 Compatt which this COMPATT type does not support.
Can not use AODC with non GDT hardware	The system is configured to track AODC beacons but is not possible using an Analogue transceiver.
Can not use BPT with non GDT hardware	The system is configured to track BPT beacons but this is not possible using an Analogue transceiver.

Estimating transponder ranges. Please wait	This message is displayed when the system is measuring ranges to the transponders attached to the vehicle. The message goes away once a prediction is made.
Can not use Wideband with pre GDT V8 hardware	The system is configured to track Wideband beacons but this is not possible using an Analogue transceiver.
Can not use HPR400 with non GDT hardware	The system is configured to track HPR400 beacons but this is not possible using an Analogue transceiver.
Waiting for external trigger	This message is displayed when the system is waiting for an external trigger that will start the acoustic cycle.
External sync not detected	The external trigger that starts an acoustic cycle was not received within a reasonable time.
<beacon name> reply detected early (Tat=n,TT=n, <NodeList>)	A reply has been detected from a Beacon at a time shorter than the Turn Around Time. The message shows the Turn Around Time, the Travel Time and the acoustic path in the Node List. Is the value set in the Nav Set-up the same as the Beacon?
<beacon name> reply not detected <NodeList>	The system has failed to detect a reply from the Beacon. Can the Beacon power be increased or the receiver attenuation decreased?
<beacon name> too few good samples (<number > of 8)	The system samples the direction of the Beacon 8 times in each fix. Less than the number set in the Nav Set-up page were of adequate quality. Is there poor signal to noise ratio or reverberation?
Data xchg CRC error (n of m)	An error has been detected while passing data between 'Master' and 'Slave'. It is the nth error in m blocks transmitted since the last re-boot. The system will not have used the bad data it has detected.
DP watch-dog telegram sent	If no valid acoustic data has been available for a watch dog period, the system sends a watchdog telegram to the DP system. The watchdog period can be set in the installation database.
Duplicate DP telegram, index <number>	This message is sent if the system repeats a telegram to maintain update rate to the DP system.
Filling last empty log file	The system keeps a number (default 10) of log files. When all these are full it overwrites the oldest. This message warns that after the current file is full the overwriting will begin. By default this message is not displayed. It can be enabled in the installation database.
Invalid UTC time	The system has not detected the 1 PPS signal.
Missing UTC time string	Though the system is set up for UTC Time of Day input, it has not detected a valid time string for over a second.
Sending COMPATT command (EN,BC,AN etc)	Reporting commands sent to COMPATTs.

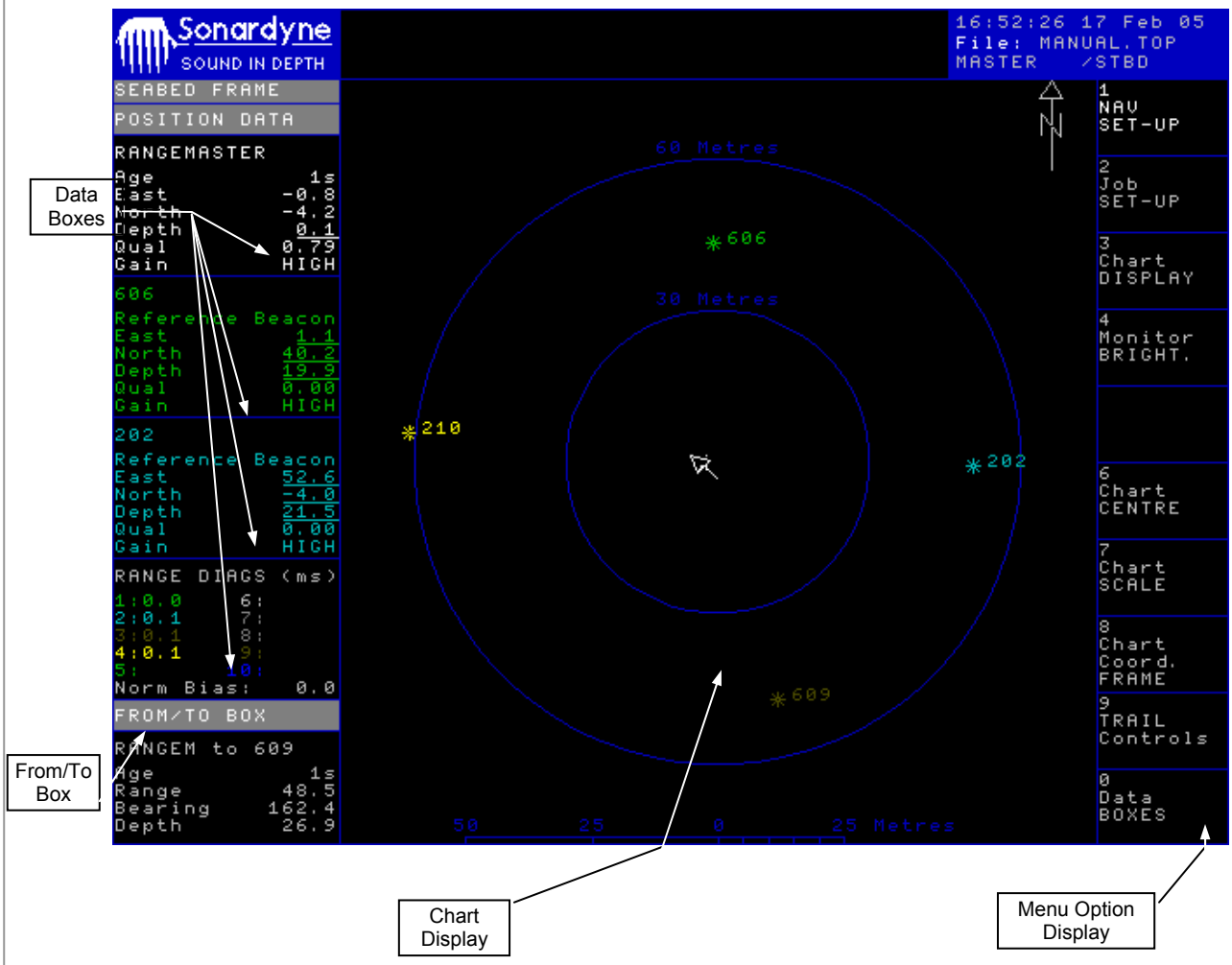
STEER <course> TO CORRECT	The rig should move in the direction indicated to minimise the differential tilt in a Riser Angle Monitoring System.
Waiting for external trigger	The system is waiting to receiver an external trigger to synchronise a responder.
<Taskname> died with exit code <number> <date & time> Error shutdown. Press ESC to return to MMI	The underlying operating system has detected that a task has failed. Record the task name and the number for reporting to Sonardyne. Pressing ESC may recover but it is possible that it will be necessary to create a new job or even reboot the system before the problem can be fully overcome. There are many possible error numbers. 102 indicates a bus trap error.

SECTION 6

6. DISPLAY CONTROL

A range of display controls are available to the operator while in Navigate mode. The main features of the display which are under operator control in this mode are illustrated in Figure 6.1.

FIG 6.1 NAVIGATE MODE DISPLAY



As illustrated in Figure 6.1, the menu options are displayed down the right hand side and six of these may be used to control the appearance of the display. Select any option of interest in the usual way and then select any feature from the sub-options which appear - as follows:-

The "**Chart DISPLAY**" options are summarised in the following:-

- "**Circles & Grid OFF**" - removes circles/grid background
- "**Range CIRCLES only**" - displays circles only in background
- "**GRID only**" - displays grid only in background
- "**Range CIRCLES and GRID**" - displays both circles and grid in background

- "**Chart Outline COLOUR**" - enables outline colours to be selected from menu
- **"Display RISER ANGLES"** - special chart display for MRAMS

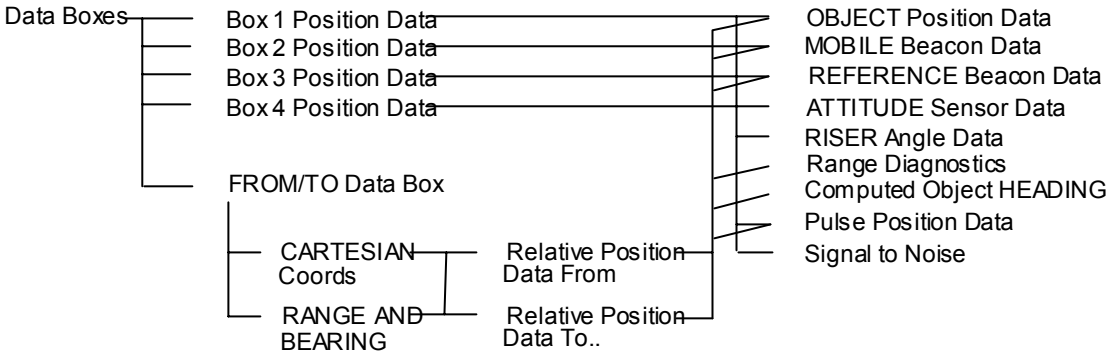
The "**Chart CENTRE**" options are summarised in the following:-

- **"OBJECT Centred Chart Display"** - normally the Vessel - list displayed if more than one (such as a ROV, BOP or Turret Buoy)
- **"MOBILE Beacon Centred Chart Display"** - list displayed if more than one
- **"REFERENCE Beacon Centred Chart Display"** - list displayed if more than one
- **"OBJECT Ref Point Centred Chart Display"** - list displayed if more than one
- **"WAYPOINT Centred Chart Display"** - list displayed if more than one

NOTE: Other Display Controls are available under "**Job SET-UP**" (Sound Velocity, Waypoints, Object Reference Points, etc).

- The **"Chart SCALE**" options are summarised in the following:-
  - "**ZOOM IN**" / "**ZOOM OUT**" and range of fixed scale options available
- The **"Chart Coord FRAME**" option has two sub-options:-
  - "**VESSEL Frame**" - vessel fixed in display with following options:-
    - **"GYRO North Up"**
    - **"Seabed Grid North Up"**
    - **"BOWS Up"**
    - **"STERN Up"**
  - "**SEABED Frame**" - seabed fixed in display with following options:-
    - **"GYRO North Up"**
    - **"Seabed Grid North Up"**
- The **"TRAIL Controls**" options are summarised in the following:-
  - "**Trails Off**" - switches all object trails off
  - "**LINE Trails**" - displays full line trails
  - "**DOT Trails**" - displays dotted line trails
  - "**CLEAR Trail Histories**" - removes all old trails but stays in Trails mode

- The **"Data Boxes**" options are extensive and are summarised in the following menu chart:-



- Position Data Boxes. As illustrated in this menu chart, any of nine types of position data may be selected for insertion in any of the four data boxes. A "**CLEAR BOX**" option is also provided.

- FROM/TO Data Boxes. In this case, a choice of co-ordinate type is offered first. Relative position data between any two of five locations may then be selected. A "**CLEAR BOX**" option is also provided.

SECTION 7

7. SYSTEM CALIBRATION

7.1 DAILY TASKS

7.1.1 Fan Operation

On a daily basis the fan included in the Navigation Processor(s) should be checked for operation. The easiest way to do this is to listen for fan noise.

7.1.2 Sound Velocity

Sound velocity is a very important parameter in the operation of the system. The system estimates range from a knowledge of the elapsed time between transmission of an interrogation and reception of a reply. To convert this time to a range requires an accurate knowledge of sound velocity - a 1% error in velocity translates to a 1% error in range.

The "**Through the Water Column**" value for sound velocity is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction over this depth range.
On a regular basis, sound velocity should be checked and any change in value entered into the system. Sound velocity may be measured using a sound velocity probe or by reading the acoustic range of a beacon directly below the vessel and comparing this with known depth from an accurate depth sensor.

If a current sound velocity profile is available on a floppy disc with the required format (see Section 9.2.3 for format details) it can be input to the system by selecting the "**Press Velocity Profile**" on the "**Sound Velocity**" page and pressing <ENTER>. This information will then be used to automatically compensate for ray refraction between the Transceiver and a USBL target over any depth range.

A simple check of the "**Through the Water Column**" value may be achieved by observing the vessel depth value in the vessel's Data Box on the Chart Display. If this is not zero then it is likely that the 'Through Water' sound velocity value needs adjusting. The value of the vessel's apparent depth, as shown on the display, together with a knowledge of the water depth to the beacon may be used to calculate a new value for sound velocity, as follows:-

$$NSV = OSV \times \left[\frac{(WD + SD)}{WD} \right]$$

where NSV = new value for "**Through the Water Column**" sound velocity

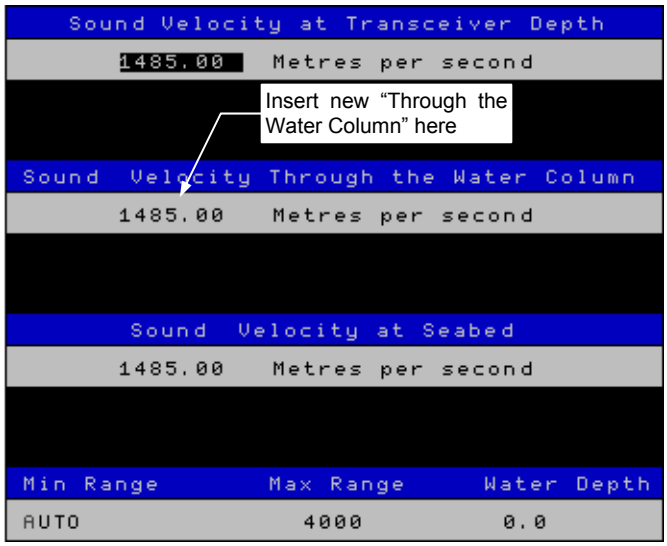
OSV = old sound velocity value

WD = water depth to Beacon

SD = apparent depth for the vessel

The new value may be entered into the system as described in the following paragraph. Having done this, it is important to check that the apparent depth of the vessel is now reading zero.

If the value has changed since the previous day, select "**Sound Velocity**" from the Job Setup menu and enter the new values in the dialogue box which appears - as illustrated below.



Inputting the correct "**Sound Velocity at the Transceiver Depth**" is important when tracking USBL targets at large horizontal offsets, such as a towed geophysical sensor, as it is used to calculate the wavelength of the received signal, which is necessary to estimate the direction of arrival. The sound velocity should be checked on a regular basis and any changes in value entered in the dialogue box on the system. The sound velocity may be measured using a sound velocity probe or computed from the water temperature measured at the depth of the Transceiver.

Correct input of the "**Sound Velocity at Seabed**" is important when making baseline measurements between a seabed COMPATT array during a 'Bottom Up' calibration. The sound velocity may be measured using a sound velocity probe or computed from the water temperature and salinity measured at the array depth using sensors fitted to the COMPATTS.

7.2 ARCHIVING JOBS AND CONFIGURATION

It is good practice to archive the current Job and Installation files (the Installation file holds details of the job configuration) to a floppy disc on a regular basis. This has two advantages. Firstly, a separate library of known working Job and Installation files can be built up - which can be valuable if such files should become corrupted on the hard disc. Secondly, if some problem arises with the current Job file or Installation file, it is a simple matter to restore a recent version of these files from the floppy disc. The four Job File Management menu options involved in this process are:-

- "**Archive Job**". Archives a Job File by copying a file from the hard disc to a floppy disc in a file format of your choice.
- "**Restore Job**". Restores a Job File by copying a file from a floppy disc to the hard disc. This file automatically becomes the current Job file.
- "**Archive Install Files to PC Disc**". Copies an Installation File (includes the configuration details) to a floppy disc - in PC text format.
- "**Restore Install Files from PC Disc**". Restores an Installation File from an external PC format floppy Disc.

As an added precaution, it is good practice to create a back-up copy of Job and Installation files on the hard disc. The "**Copy Job**" facility may be used to this end.

7.3 SIMPLE ARRAY CALIBRATION

7.3.1 'Top Down' Calibration

The USBL capability of an integrated L/USBL acoustic system allows the position of each reference beacon to be determined relative to one another using a 'Top Down' calibration technique, without having to take baseline measurements between them. The system measures the slant range and direction to each beacon from the vessel. Hence, the USBL position of each reference beacon can be determined with respect to the vessel L/USBL position. The accuracy of this calibration is affected by random and systematic errors. These errors include the accuracy of the transceiver measurement, errors in the sound velocity, the accuracy with which the transceiver has been calibrated with respect to the vessel attitude sensors and the accuracy of the vessel attitude sensors themselves. However, the calibrated beacon positions which the 'Top Down' method produces are the best estimate in the presence of these errors. More importantly, it gives the positions of the reference beacons as seen by the USBL transceiver(s). This array calibration method provides the most stable position for DP operations on deepwater drilling vessels because it is only used to maintain the vessel in the position which keeps the acoustic measurements the same.

The 'Top Down' calibration technique is typically completed in under one hour and has the important advantage of providing an uninterrupted supply of acoustic position information to a vessel DP system throughout the calibration. This can be from arrival on station and the deployment of the first beacon, through the array calibration process and during the long term maintenance of the array.

On vessels with multiple transceivers, one transceiver should be configured for L/USBL operation with all others set to LBL mode during both the 'Top Down' calibration process and subsequent tracking, as this provides the best compromised between position update rate and system robustness.

As the integrated system supports operation in a WGS84 earth frame, 'absolute' geodetic co-ordinates for each reference beacon can be determined in WGS84 UTM co-ordinates, should this be required, again without having to measure any seabed baselines. This is a significant advantage when working in areas with rugged bottom topography. However, the accuracy of this calibration is affected by the random and systematic errors listed above. If accurate geodetic co-ordinates are required for the reference beacons they will need to be Boxed in using the CASIUS procedure described in Section 7.4.3.

7.3.2 'Top Up' Calibration

Although the 'Top Down' calibration technique provides a very stable position and high repeatability for deepwater drilling operations, the accuracy when positioning objects close to the seabed using LBL transceivers will be less than that achieved using baseline measurements taken between each array beacon. This is because the 'Top Down' method positions each beacon using the USBL technique where the accuracy is dependant on the calibration of the attitude sensors and the ability to measure beacon directions using USBL. These errors can be minimised using the 'Top Up' calibration technique, without having to take baseline measurements. This uses the additional information available from a BOPNav LBL transceiver deployed on a BOP stack in the centre of the array. The 'Top Up' calibration is completed concurrently with the 'Top Down' calibration typically in under one hour, with the vessel acoustic position information being continuously available to the DP system throughout the calibration.

7.3.3 Baseline or 'Bottom Up' Calibration

An integrated acoustic positioning system can also be used to measure multiple, direct baselines between reference beacons. This is the conventional way of calibrating a LBL array in a local grid using COMPATT 'intelligent' beacons. Provided that the seabed sound velocity has been entered correctly, the 'Baseline' calibration gives the most accurate positioning for survey measurements being made at the seabed. The local grid can then be positioned and oriented in a geodetic frame using simultaneous observations of the vessel position in the geodetic frame from DGPS and the vessel position in the local frame using acoustic observations in a 'Top Down' calibration. Alternatively, the absolute position of one or more beacons can be determined using a CASIUS 'box-in' technique, with the first beacon held "**Fixed"** and the expected position errors entered for the other beacons during all calibrations.

Two different methods are available for making the baseline measurements, 'Array Baseline Measurement' and 'Incremental Baseline Measurement' - both of which are completed outside of Navigation. With each method, the final least squares adjustment uses the initial 'drop positions' and estimated position accuracies of each COMPATT determined from a 'Top Down' calibration or using any other appropriate survey technique, such as CASIUS.

- In the **Array Baseline** method, the system automatically configures selected COMPATTS in turn to the correct mode for baseline measurements*, returning the COMPATT to its original Navigation status after the specified number of baselines have been measured.

  (NOTE: * Mk5 Compatt beacons set up for wideband operation during Navigation will be configured to make all baseline measurements using tone signals).

  The operator is presented with a graphics display which shows the selected COMPATTS, baselines already measured, the current baseline being measured, the actual and predicted values and the number of measurements completed. Multi-path measurements are rejected by a blunder filter based on the expected beacon co-ordinates and an operator selected range window. After all the baselines have been measured, the system carries out an iterative least squares adjustment, rejecting suspect baselines and displaying the results.

- The **Incremental Baseline** method allows the operator to specify Mk4 Compatt beacons between which baselines will be measured and the COMPATTS to be used in the least squares adjustment. This method is used when it is not possible to send commands and receive telemetry from the array COMPATTS from one vessel location.

In situations where arrays are laid in rough terrain, it may not be feasible to measure a full or even a sufficient set of baselines. In this case, the 'Top Down' calibration method will have to be adopted, supplemented as required by baselines which can be measured.

7.4 ATTITUDE SENSOR CALIBRATION

If absolute position accuracy is important (as distinct from good position repeatability), the corrections to be applied to the vessel's Attitude Sensors to calculate the correct the L/USBL directions must be determined.

7.4.1 Transceiver Pitch/Roll Correction

An internal system calibration facility compares the average readings of the vessel 'master' VRU sensors (assumed to define the vessel horizontal reference plane) with the average readings of factory calibrated inclinometers mounted in each transceiver and calculates the corrections to be applied to the VRU readings. Dependant on the VRU, provided the internal calibration is carried out under stable conditions, calibration accuracies within 0.2 degrees are achieved.

7.4.2 Transceiver Alignment Correction

The corrections required to align the transceiver with the vessel gyro can be determined by measuring the direction to a beacon deployed on a known bearing (for example, at the vessel bow).

7.4.3 CASIUS

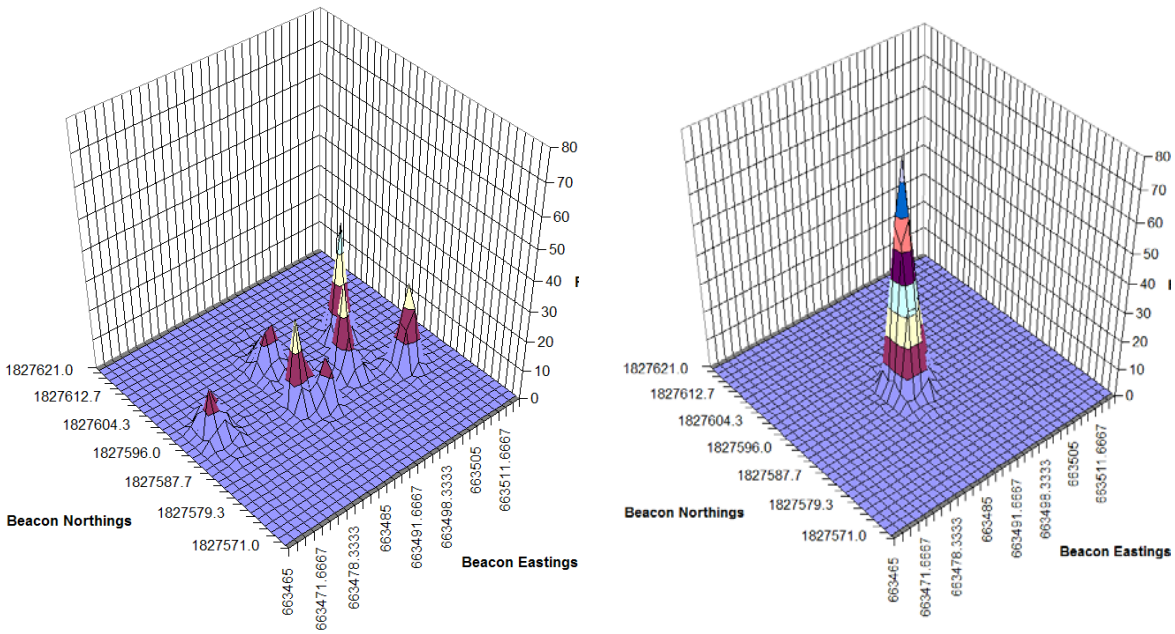
Better calibration accuracy is achieved using a seabed reference beacon operating with the proprietary Sonardyne CASIUS application (**C**alibration of **A**ttitude **S**ensors **i**n **USBL** Systems) running on a separate PC. The vessel is manoeuvred on DGPS to four cardinal points offset at maximum bore-sight angles of 30 degrees from the beacon. At each position, calibration data is logged at each USBL Transceiver with the vessel heading in reciprocal directions.

Additional data is logged with the vessel directly overhead the beacon on two reciprocal headings. Simultaneous DGPS, USBL, VRU and Gyro Compass data is logged by the USBL system at each location. The logged data is either output to the CASIUS application over a serial link or read from a floppy disc, as described in the CASIUS operating manual.

The DGPS and range data is processed off-line to compute an unbiased estimate of the reference beacon position, the through water propagation velocity and the offsets between the DGPS antenna and the transceiver.

The USBL range and direction measurements stabilised by VRU and Gyro measurements are then compared with the correct range and direction calculated from the DGPS position and the previously determined beacon position. From this it is possible to estimate the pitch, roll and heading corrections which have to be applied. The computation process iterates until the results are optimised. The results are presented as graphic plots showing the vessel track, the 'BEFORE' and 'AFTER' beacon position plots and a summary report which lists the correction factors which should be applied. Figure 7.1 illustrates some sample plots produced by CASIUS and Figure 7.2 is an example of a CASIUS Report - taken in 690 metres water.

FIG 7.1 PLOTS OF APPARENT BEACON POSITION BEFORE AND AFTER USING CASIUS



BEFORE **AFTER**

FIG 7.2 USER CALIBRATION REPORT

DISCOVERER 534 **CASIUS calibration report** Casius Version 4.4d Excel 10.0 LUSBL version 6

Comments: DISCOVERER 534 - BAY OF BENGAL - 15/03/03

data file: 03152041- Port.xls Path: D:\Documents and Settings\mrh\My Documents\Clients\TSF\Vessels\Discoverer 534\CASIUS\
report file: Final stb.xlr
log start: 15 Mar 2003 20:41 log end: 16 Mar 2003 00:00 duration: 03:18

INPUTS:	Tp East	Tp North	Tp Depth	Sound vel	Tcvr Stbd Offset	Tcvr Fwd Offset	Pitch Corr	Roll corr	Head corr
Used by USBL	-----	-----	-----	1,499.6	-----	-----	0.00	0.00	0.00
Initial Estimates	663,488.4	1,827,591.3	693.4	1,499.6	10.88	17.40	-----	-----	-----
Estimate accuracy	30.0	30.0	5.0	50.0	1.0	1.0	-----	-----	-----
Distance units are	metres								

Range gate	1.0	angle gate	2.0	% slant range			
Range accy	0.2			Ant Stbd Offset	0.8	Tcvr Index	12
Tcvr Depth Offset	11.16			Ant Fwd Offset	61.1	Beacon Name	506
Tcvr depth	11.16	accuracy	0.5	Ant Height Offset	28.65	Turn Around Time	125 ms
Depth aid angle limit	22.0	depth limit	1.0			DGPS lags USBL by	0 seconds
DGPS protocol	NEMA 0183 GGA						

OUTPUTS:	Tp East	Tp North	Tp Depth	Sound vel	Tcvr Stbd Offset	Tcvr Fwd Offset	Pitch Corr	Roll corr	Head corr
Calculated	663,490.4	1,827,596.4	691.1	1,497.3	11.84	18.15	**0.45**	**0.37**	**2.23**
Calc accuracy	0.06	0.08	0.35	0.46	0.06	0.07	0.01	0.01	0.02

	Before CASIUS	After CASIUS		Box In	Tcvr Attitude
33% Tpdr posns.	8.1	1.7	No. of iterations	2	2
50% Tpdr posns.	12.7	2.3	No. Depth aided		0
68% Tpdr posns.	15.8	3.1	No. of fixes used	618	618
95% Tpdr posns.	19.8	4.9	Average weighted residuals	0.01	0.25

N.B. The Pitch, Roll & Heading corrections are to be entered as the USBL tcvr/ship grid corrections.

An additional advantage of completing a CASIUS calibration(s) at a new location is the determination of the 'absolute' co-ordinates of one or more array beacons. The beacon(s) can then be entered as a Reference(s) in the L/USBL database and with the first beacon held "**Fixed**" and the expected position errors entered for the other beacons during a 'Top Down' array calibration of the remaining beacons.

Full information on the procedure to be used with CASIUS will be found in the CASIUS handbook.

7.4.4 Gyro Correction

Gyro error may be determined using a simple procedure - given that DGPS is available - as follows:-

- With DGPS on, position the vessel immediately above a beacon. Measure the beacon position as a mobile and enter this as a Waypoint.
- Back the vessel away from this position for approximately 570 metres. Using the data in the From/To box, determine the apparent transverse offset to the Waypoint.
- Heading error is this offset divided by 10.

NOTE: If the beacon appears to move to Starboard, the Heading correction should be added as a positive number.

- As a safeguard, return to Navigation and check that the transverse offset is now zero - i.e. the correction has been inserted with the correct polarity.

SECTION 8

8. BASIC FAULT FINDING

8.1 SIMPLE CHECKS

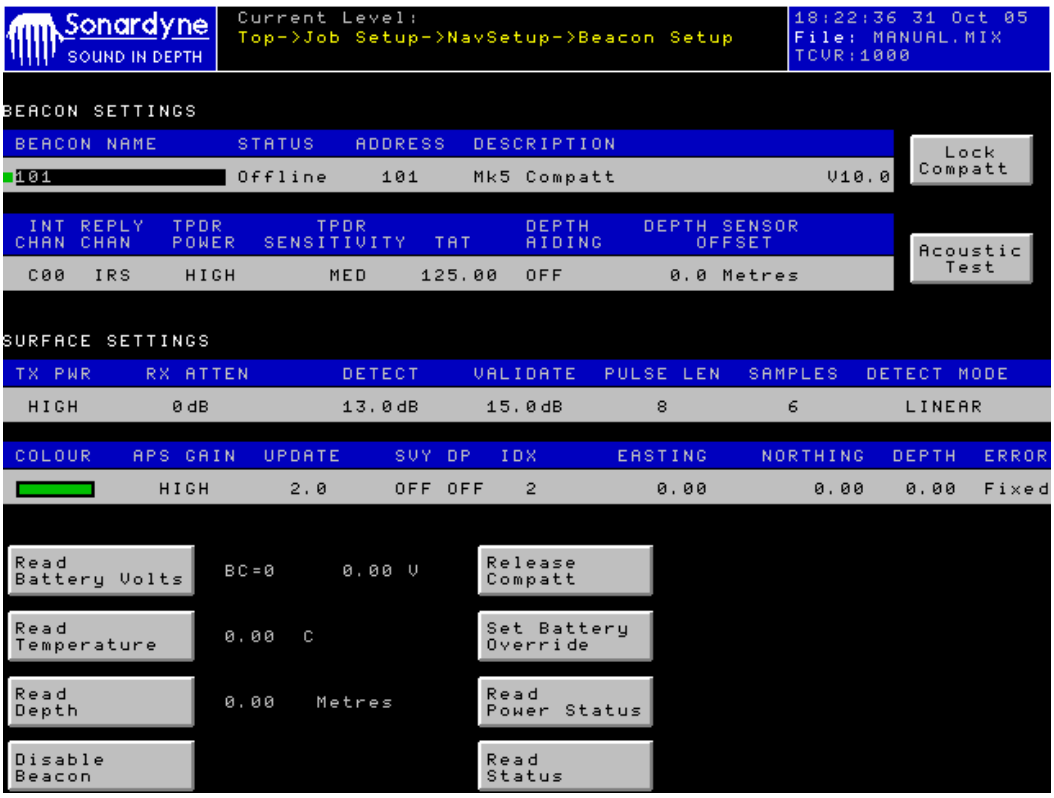
> **NOTE:** As a general rule, it is not advisable to change settings if the system has been working and conditions have not changed.

8.1.1 System Operating but not Giving Good Positions

The course of action depends upon the severity of the problem and whether or not it is possible to leave Navigation. The initial checks assume that the problem is not severe and it is operationally not possible to leave Navigation.

- ❑ Check error messages for errors on Beacons or Transceivers - see Section 5.
- ❑ Set up data boxes to review the age, positions and position quality of Beacons and Objects and the Beacon range diagnostics and confirm sensible values - see Section 9.1.9.
- ❑ Check the depths and positions of Objects and Reference Beacons. These give clues to sound velocity and allied calibration errors.
- ❑ If Beacons are failing to respond:-
  - Go to the "**NAV Setup"** page and review the settings. [If the system has been working and conditions have not changed, it should not be necessary to change the settings].
  - Press <ENTER> when the cursor is over a suspect Beacon name on the "**NAV Setup"** page to enter the "**Beacon Setup"** page. Review the settings.
  - On the "**Beacon Setup"** page for a COMPATT (see Figure 8.1 for a typical "**Beacon Setup**" page for a Mk5 Compatt), collect the "**Battery Voltage"** and Count, "**Status"** and "**Power Status"** from the Beacon by pressing <ENTER> over the appropriate buttons. Check for no errors in the replies and that the settings are as expected. [See Appendix B for descriptions of the COMPATT commands and their telemetry replies]. Note that sending these commands will interrupt the acoustic positioning for a few seconds and may therefore affect a DP output.
  - If a COMPATT beacon is not in the state expected, change the setting in "**NAV Setup"** or, if the displayed settings are correct but the COMPATT status does not match, set the Beacon status to "**Not Set**". The system will automatically send the appropriate commands to the COMPATT.
  - If the system reports errors when sending commands to set up a COMPATT which it has already tried three times, the Operator is asked whether to "**Retry, Continue or Abort**". It is usually worth selecting "**Continue**" because even if the reply is not received correctly, it is likely that, in the quiet of the seabed, the COMPATT has received the command correctly but the Transceiver, in the noisy environment of the vessel, has failed to receive the telemetry reply.

FIG 8.1 BEACON SETUP PAGE



- If a PGT, SSM or WSM beacon is not in the state expected, set the status to "**Not Set**". The system will automatically send the appropriate commands to the Beacon. If the system reports errors when sending commands to set up a Beacon which it has already tried three times, the Operator is asked whether to "**Retry, Continue or Abort**". It is usually worth selecting "**Continue**" because even if the reply is not received correctly, it is likely that, in the quiet of the seabed, the Beacon has received the command correctly but the Transceiver, in the noisy environment of the vessel, has failed to receive the reply.

8.1.2 <u>System not Operating Correctly but Clock Continues</u>

❑ If no Beacons are responding:-

- Leave Navigation. Check communications to the Transceivers and Attitude Sensors on the Top Level menu page. [Select, but do not enter, Navigation using the up/down arrow keys if necessary].

- If communications to Transceivers or Attitude Sensors have been lost, check the settings in the Installation pages. If there are still problems refer to the Installation and Maintenance Manual.

- Re-enter Navigation - it is possible that re-starting Navigation will have resolved the problem.

- Check the Beacon settings as described in paragraph 8.1.1 if it has not been done already.

- ❑ If the Beacons are still not responding:-
  - Archive the current log files and system log file, to floppy disc (see Section 9.3) ready to send to Sonardyne if the fault persists.
- ❑ Use the Transceiver Test programs (see Section 8.2).

8.1.3 The System is not Responding and the Clock has Stopped

- ❑ If possible:-
  - Exit Navigation
  - Archive the current log and system log files to floppy disc (see Section 9.3) ready to send to Sonardyne if the fault persists.
  - If the clock has re-started, re-enter Navigation and check that the system operates correctly.
- ❑ Otherwise:-
  - Reboot the system by pressing the green button (through the hole above the main on/off switch). **Do not turn off/on or reload the software at this stage**.
  - Archive the current log files and system log files to floppy disc (see Section 9.3) ready to send to Sonardyne if the fault persists.
  - Check Installation set-ups. When satisfied, re-check from Section 8.1.1.
  - If the system is running but still not functioning correctly:-
  - Check the lights on the front panel of the Navigation processor.

Include a picture of the lights in any data return to Sonardyne.

  - Use the system test programs described in Section 8.2.
  - If the system is still not functioning correctly:-
  - Contact Sonardyne Customer Support giving as much information as possible regarding the system and the operating conditions at the time (see Section 8.4).
  - It is occasionally possible that re-loading the software will resolve problems.

8.2 NOISE AND RANGE TEST

These are simple tests which are effective checks of a deployed Transceiver. It is necessary that a transponder beacon has been deployed on the seabed in the vicinity of the vessel. Full details of the set-up steps and the procedure for carrying out the tests are given in Appendix A.

8.3 RE-LOADING JOBS, CONFIGURATION AND SOFTWARE

8.3.1 Re-Loading Jobs and Configuration

It is good practice to archive the current Job and Installation files (the Installation file holds details of the job configuration) to a floppy disc on a regular basis. If this is done then, if some problem arises (e.g. file corruption or a hard drive failure), it is a simple matter to restore any lost Job file(s) and Installation details. The two Job File Management menu options involved in this process are:-

- "**Restore Job**". Restores a Job File by copying a file from a floppy disc to the hard disc. This file automatically becomes the current job file.
- "**Restore Install Files from PC Disc**". Restores an Installation File (includes configuration details) from an external PC format floppy Disc.

8.3.2 Re-Loading Software

In the event that the system software has become corrupted or lost for any other reason, the following procedure may be used to restore the system to full operation.

It is assumed that archived Installation (Configuration) files and Job files should be available on floppy discs from previous use of the system. Retrieve these from storage and proceed as follows:-

- Insert Disc 1 from the Installation Set and switch on the unit (or operate the reset button).
- After approximately two minutes, the L/USBL screen will be displayed. Follow on-screen prompts, entering the numbers of all discs when prompted by "**Select Discs to Install**".
- When prompted, eject Disc 1 and insert Disc 2. At the prompt "**Format hard disc**" enter **<1>** (for YES).
- Continue software loading process following on-screen prompts as they occur.
- When the screen prompt "**Installation complete. Re-boot**" appears, eject the current disc in the floppy disc drive and reboot by switching on the unit (or operating the reset button on the Navigation Processor, if already powered up).
- When prompted for a job name, enter an appropriate name. For example, this could be the date and the installer's initials (example format:- 17NOV98.ARN).
- Enter the description of the file, type "**Software Installed**" and press <ENTER>.
- "**Restore**" Installation and Job files from the archive floppies using the appropriate options in the "**Job File Management**" menu - see Section 9.3.

8.4 DATA RETURN TO SONARDYNE

8.4.1 Problem Reporting

- In the event of a recurring problem or being unable to resolve a problem without help, contact Sonardyne Customer Support on:-

  + 44 1252 872288

  or, if a resolution of the problem is urgent, contact the Sonardyne Emergency Help Line on:-

  + 44 1252 877600

  [Sonardyne run a 24-hour emergency help-line, where a call during office hours (08:30 - 17:30 UK time) will be answered directly. Outside office hours, an agency will take your message and alert the appropriate Sonardyne person. The aim is to ensure that emergency requests are dealt with immediately during office hours, and responded to *within 30 minutes* at all other times].

- Supply as much information as possible about the equipment being used and events leading up to the incident. An In-Service Problem reporting form is available in the PCUtils directory of Disk 3 from the system installation set.

- Archive Log files, Job and Installation databases and the System log files. [Note: The Version 6 software automatically puts Job and Installation databases onto the PC floppy with log files].

- Return these to Sonardyne (zipped up) on floppy disk or by e-mail to: USBL.support@sonardyne.co.uk

8.4.2 Additional Information

- Bit Map Files

  Bit Map files from the Noise Test and Range Tests can also be useful clues (see Section 8.2). To create these Bit Map files, set the printer to "**Parallel Printer Screen Dumps and Floppy (.bmp)**" (reboot if the settings have been changed) before going to the test pages. When in the test pages and with a PC-formatted floppy in the drive, press "**Print Screen**" on the keyboard to capture a screen image.

- Console Data

  - Occasionally Sonardyne may request Console Data. The USBL sends a stream of information to the console port of the CPU board. This data may be logged by connecting the RS232 Console output from the back of the CPU Board to a PC comms port using a terminal emulator program. The comms port of the PC should be set to 9600 baud 8N1. The data should be logged using the logging facility of the PC's terminal emulator program.

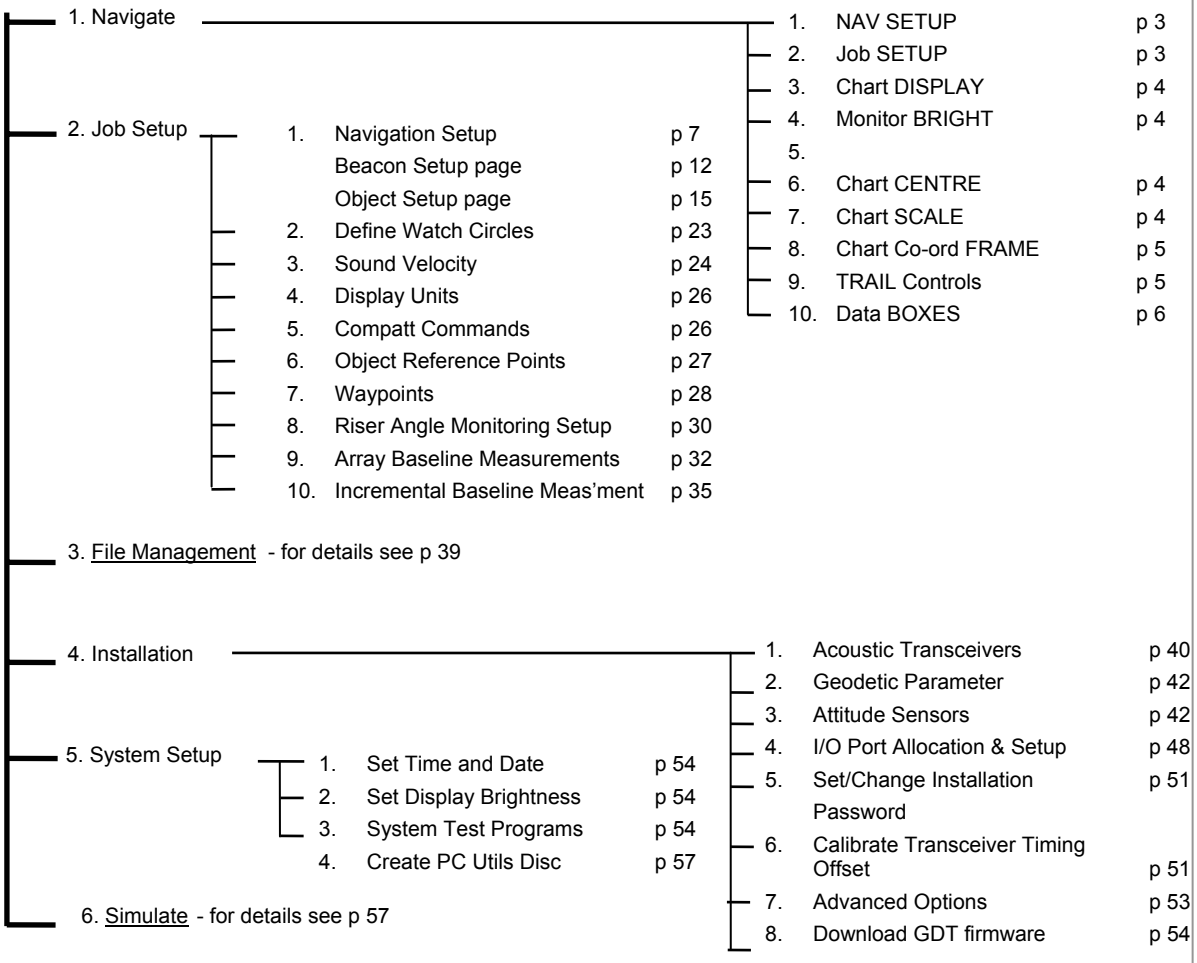
  - It is possible to control the selection of data that is sent to the Console port through the keyboard. Sonardyne may request particular selections. The most common of these is to select Super User mode by typing **$ [shift 4 on the keyboard]** then enter the password "**SUPER**" <ENTER> on the keyboard followed by **<CTRL>B**. This causes the data being sent between the Transceivers and the Navigation Processors to be echoed onto the console. Once the data collection has been completed press **<CTRL>B** again to stop the extra data being transmitted, then type **$** followed by <ENTER> to leave Super User Mode - it will slow the Navigation cycle time down otherwise.

SECTION 9

9. REFERENCE SECTION

This section contains detailed information on the functions available on each of the data pages which can be accessed through the L/USBL menu system. For reference, the top two levels of the menu structure are shown in Figure 9.1. Also shown are the page numbers for each menu option.

FIG 9.1 TOP LEVEL MENU STRUCTURE



- At any level in the menu structure, the currently available menu options are displayed down the right hand side of the main Display Area - see Figure 9.2. Upon powering-up, the system will display the top level menu, with "**Navigate**" highlighted. In this state, the system polls for devices connected to it; such as Transceivers, Attitude Sensors and DGPS, etc. A summary of the system status is then presented in the main Display Area, together with the software and firmware versions installed. Across the top of the display area are three permanent zones:-

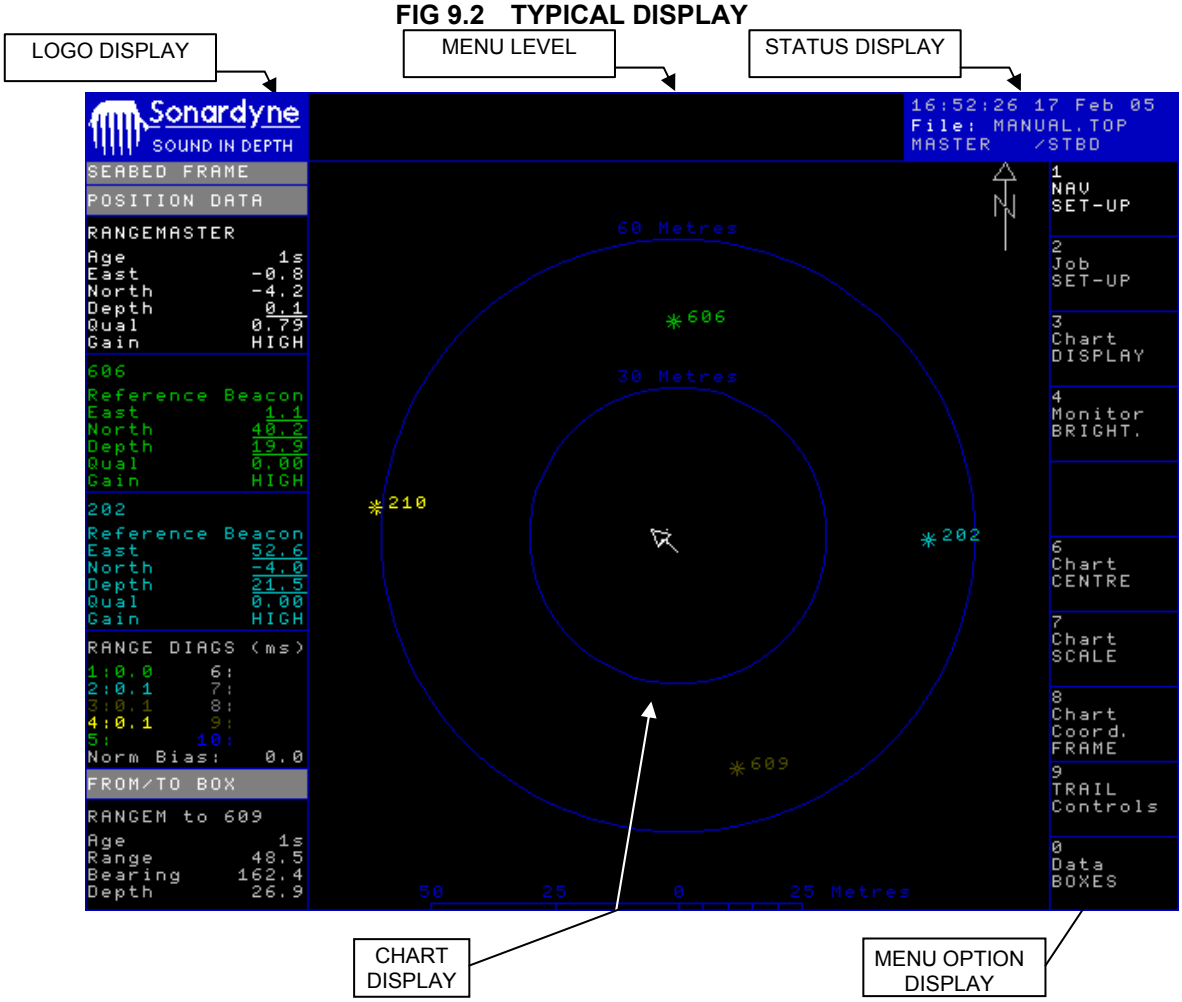
- The left-hand zone contains the Sonardyne logo.

- The centre zone "**MENU LEVEL**" shows the current position in the menu structure (except in Navigate mode where it is used as a message area).

- The right-hand zone (STATUS DISPLAY) contains three rows of text. The top row shows the current system time and date, the second the current "**Job File"** name. The third row shows the Master/Slave status of the local system (always "**MASTER**" for a standard system) plus the name of the Transceiver currently being addressed by the local system.

Below the three top zones is the main Display Area, with the currently available menu options listed to the right. Except when in "**Navigate**" mode, the background colour of the different menu options can be changed to show the selected option using the UP/DOWN cursor keys. [Note that "highlighting" an object on the display in this way causes no other action to be taken by the system].

FIG 9.2 TYPICAL DISPLAY



Pressing the <ENTER> key on the Monitor/Keyboard or on Keyboard unit or the menu key next to any option activates that option and moves the display to the next level down in the menu structure. [Note that "Activating" an object on the display in this way - as opposed to "highlighting" it - does cause the system to take some action].

To read, enter or modify data the operator progresses through the menu structure until the leaf node (or data page) containing the relevant data is reached. Until a data page of the menu structure is reached, menu options continue to appear on the right of the display. Once the data page has been reached, the whole screen, apart from the three zones at the top, is taken up by the data for display, entry or modification.

A number of RULES apply when entering or modifying data on a data page. These are:-

- A record is a complete horizontal line of individual fields.
- The UP/DOWN cursor keys are used to highlight the required record and the LEFT/RIGHT cursor keys to highlight the required data field for entry or change.
- Once a field is highlighted, pressing <ENTER> will cause a dialogue box to appear displaying the legal or safe options for that field. The cursor keys may then used to highlight an option and the choice confirmed by pressing <ENTER>.
- If alpha characters are allowable in a field (e.g. entering a name for a Beacon), the numeric menu keys (on the integrated Monitor/Keyboard) may be used in an alpha mode by first pressing a LEFT, RIGHT or UP cursor key (e.g. for "A" press LEFT cursor key followed by the "1" menu key, for "E" press the UP cursor key followed by the "2" menu key, etc.). Alternatively, of course, if a suitable Keyboard unit is installed, alpha characters may be keyed in more conveniently using the PC-compatible keyboard.
  In many cases where text options are allowable for a field it will be sufficient merely to type the first character of the required options.
- A record may be deleted by pressing DEL, and answering YES to the confirmation question.
- A new record is created by using the DOWN cursor to highlight a line below the lowest current line and pressing <ENTER>.
- The ESC key is used to go back up the menu tree once data entry is complete. To re-enter the top level menu from the Navigate (or Simulate) mode, press the "**ARM**" and "**EXIT NAV**" keys together (or press <**Control C**> on a PC-compatible keyboard).

NOTE: To become familiar with the system the potential operator should create a 'Job' as described in Section 9.3 and then run the system in SIMULATE mode. As far as possible, the system reacts in the same way as in the NAVIGATE mode.

9.1 NAVIGATE OPTIONS

9.1.1 Option 1 -"**NAV SET-UP**"

As in main "**Job Setup**" menu - see Section 9.2.1.

9.1.2 Option 2 -"**Job SET-UP**"

By activating the "**Job SET-UP**" option from within the Navigate mode, the operator may continue to navigate whilst accessing the following range of set-up controls:-

- "**Define WATCH CIRCLES**". As in main **"Job Setup**" menu - see Section 9.2.2.
- "**Sound VELOCITY**". As in main **"Job Setup**" menu - see Section 9.2.3.
- "**Display UNITS**". As in main "**Job Setup**" menu - see Section 9.2.4.
- "**COMPATT Commands**". As in main **"Job Setup**" menu - see Section 9.2.5.
- "**OBJECT Reference Points**". As in main **"Job Setup**" menu - see Section 9.2.6.
- "**WAYPOINTS**". As in main **"Job Setup**" menu - see Section 9.2.7.
- "**Riser Ang Monitoring Setup**". As in main **"Job Setup**" menu - see Section 9.2.8.

- "**Archive LOG FILES to disc**". This option has the same function as "**Archive Logging File to PC disc**" in the "**Job File Management**" menu - see Section 9.3.

- "**ARCHIVE Job File**". This option has the same function as "**Archive Job**" in the "**Job File Management**" menu - see Section 9.3.

9.1.3 Option 3 - "**Chart DISPLAY**"

Under the "**Chart DISPLAY**" option, the operator may choose background features of the chart display:-

- "**Circles & Grid OFF**". Removes range circles and grid lines from chart background.

- "**Range CIRCLES only**". Displays range circles only in chart background.

- "**GRID only**". Displays grid lines only in chart background.

- "**Range CIRCLES & GRID**". Displays both range circles and grid lines in chart background.

- "**Chart Outline COLOUR**". A colour menu is displayed and any of the displayed colours may be chosen to colour the outline objects in the chart display.

- "**Display RISER ANGLES**". Used for displaying Riser Angle, Alarm Limits and Course to Steer. Note that this option is only available if a Marine Riser Angle Monitoring System (MRAMS) has been installed and this option has been enabled by Sonardyne. See Section 4.10 for more information on operating the system in this mode.

9.1.4 Option 4 - "**Monitor Bright**"

This option enables the menu keys to be used to make the display "**DIMMER**" or "**BRIGHTER**".

9.1.5 Option 6 - "**Chart CENTRE**"

Activation of this option enables the chart to be centred on:-

- an **"OBJECT"** Normally the USBL vessel
- a **"MOBILE"** Beacon
- a **"REFERENCE"** Beacon
- an **"OBJECT"** Reference Point
- a **"WAYPOINT"**

NOTE: Activating any of these five options displays a list of items for selection, assuming that more than one item is available for selection. If only one item is available, the selection is activated immediately.

9.1.6 Option 7 - "**Chart SCALE**"

This option enables the operator to zoom in or zoom out or choose the specific scale required. Activate "**ZOOM IN**" or "**ZOOM OUT**" options or the scale required by pressing the appropriate menu key.

9.1.7 Option 8 - "**Chart Co-ord FRAME**"

Activate either the "**VESSEL Frame**" or "**SEABED Frame**" option by pressing the appropriate menu key.

- Under the **"VESSEL Frame**" option, the vessel remains fixed in the centre of the display even if the vessel is moving in the real world. If the vessel is moving, seabed objects would move across the display relative to the stationary vessel. The operator may choose the following orientation options of the chart in vessel terms:-
  - Gyro North pointing upwards on the chart.
  - Seabed Grid North pointing upwards.
  - Vessel Bows pointing upwards.
  - Vessel Stern pointing upwards.
- Under the "**SEABED Frame**" option, seabed objects remain in a fixed position on the display. If the vessel is moving in the real world, it would move across the display relative to the stationary seabed objects. The operator may choose the following orientation options of the chart in seabed terms:-
  - Gyro North pointing upwards on the chart.
  - Seabed Grid North pointing upwards.

Note that the "**SEABED Frame**" option is available only if there is at least one Reference Beacon assigned - or DGPS is enabled. Once activated, the display will remain in "**SEABED Frame**" mode (including on powering up again after powering down) provided one or other of these conditions continues to be met. If neither of these conditions is met the display will automatically revert to "**VESSEL Frame**" mode until such time as one of the conditions is satisfied - at which time the "**SEABED Frame**" mode will resume automatically.

9.1.8 Option 9 - "**TRAIL Controls**"

Under the "**TRAIL Controls**" option, the operator may choose either "**LINE Trails**" or "**DOT Trails**" of object motion. "**LINE Trails**" means that the display shows lines joining the dots representing the fix positions whereas "**DOT trails**" means that there are no such lines. In both cases, the most recent 30 fix positions are displayed on a rolling basis - (NOTE: The 'default' value can be edited on the Installation file using a PC – see Section 9.3). The previous record of trails on the chart may be cleared (activate "**CLEAR Trail Histories**") or the trails mode may be switched off completely (activate "**Trails Off**").

9.1.9 Option 10 - "**Data Boxes**"

9.1.9.1 **Position Data Boxes**

Under this option, the operator may organise the data to be displayed in the data boxes which appear down the left-hand side of the display. For any of the four "**POSITION DATA**" boxes the operator may elect to clear the box ("**CLEAR BOX**" option) or to show any of the following:-

- ❑ OBJECT Position Data
- ❑ MOBILE Beacon Data
- ❑ REFERENCE Beacon Data
- ❑ ATTITUDE Sensor Data
- ❑ RISER Angle Data
- ❑ Range Diags
- ❑ Computed Object HEADING
- ❑ Pulse Position Data
- ❑ Signal to Noise Ratio

NOTE: Only selectable if GYRO available or at least two Reference Beacons assigned.

NOTE: If more than one Beacon or Object is available then a menu of options is presented.

NOTE: Displays magnitude of the difference between measured acoustic travel time and predicted value between each beacon and transceiver. When receiving beacon replies at multiple transceivers, the value is the RMS of the differences.

NOTE: Assigns Position Data Box to display computed Heading provided enough measurements are being taken to enable the system to computer Heading.

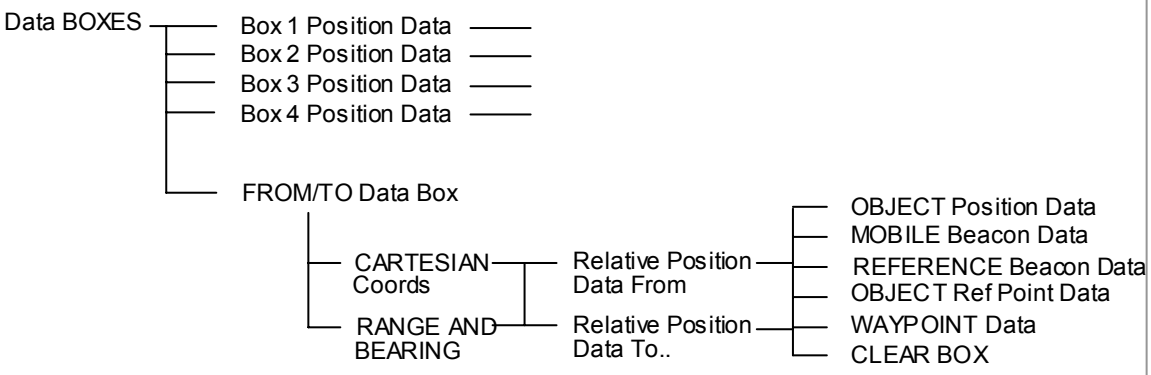
NOTE: Displays data received from generic pulse position beacons, such as salinity in any user defined unit.

NOTE: Displays the Signal to Noise measured at the first operational digital transceiver for each beacon reply.

9.1.9.2 **From/To Data Boxes**

When the operator activates the "**FROM/TO**" Data Box, he is first given a choice of co-ordinate type for defining relative position, then a choice of "**Position Data From**" or "**Position Data To**" before being presented with a list of objects whose relative positions are to be displayed. In many cases, it will only be necessary to change either the "**Position Data From**" setting or the "**Position Data To**" setting. If both have to be changed, set the "**Position Data From**" entry first.

This sequence of menu options is illustrated in the diagram which follows:-



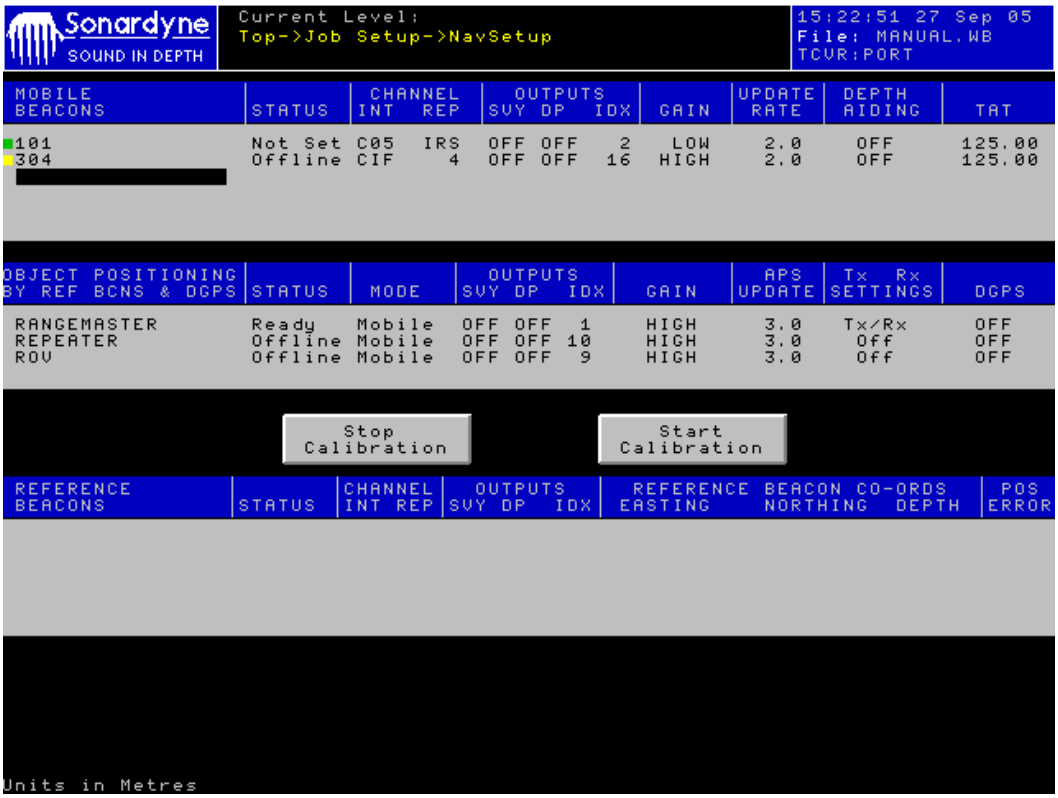
9.2 JOB SETUP OPTIONS

The following options are activated outside of Navigation.

9.2.1 Option 1 - "**Navigation Setup**"

The "**Navigation Setup**" option causes an integrated function page to be displayed, as illustrated in Figure 9.3, which follows:-

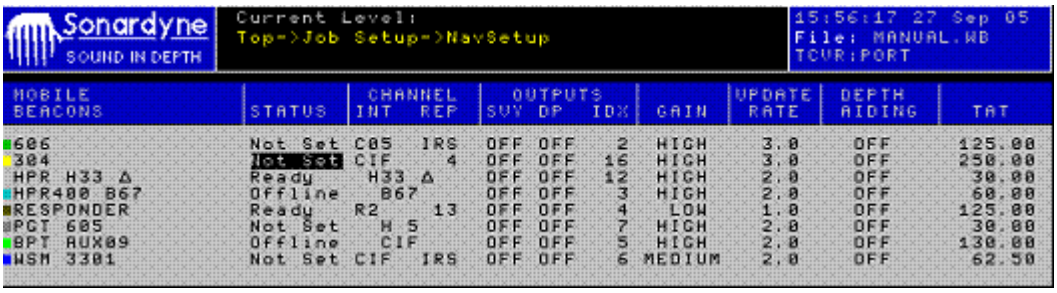
FIG 9.3 NAV SETUP DISPLAY



9.2.1.1 Beacon Navigation Panel

For a new Job File, or if it is required to add new Beacons to an existing Job File, move the cursor to the next blank line in the "**MOBILE BEACONS**" panel, and press <ENTER>. A small window appears - with the heading "**Add Mobile Beacon**". In this window is listed all Beacons known to the System, as illustrated in the "**Select Beacon Type**" panel to the right. Move the cursor to the required beacon and press <ENTER>. Follow the on-screen prompts to enter the data required for each new Beacon. On completion of all data entries, the new 'Mobile' Beacon's data will appear in the list on the "**MOBILE BEACONS**" panel, as illustrated in Figure 9.4, which follows:-

FIG 9.4 MOBILE BEACONS PANEL



The following data should be entered for each Beacon:-

- "**STATUS**". Defines the usability status of a 'Mobile' Beacon. If it is required to change the status of a Beacon, move the cursor to the appropriate row of the "**STATUS**" column and press <ENTER>. A dialogue box will appear offering the following options. Move the cursor to the option required and press <ENTER>.

  - "**Ready**". Meaning that the Beacon is fully active and will respond normally to any interrogation - see "**Not Set**".

  - "**Not Set**". Applies ONLY to COMPATT, SSM, PGT and WSM beacon types, which require set-up commands before they are ready for use. After these commands have been sent, the Beacon status is automatically set to "**Ready**" - see Section 2.3.5.

  - "**Offline**". Meaning the Beacon will not be included in the positioning computation. Note that if the Beacon is in CIF mode (including Alternative-CIF mode) or a CIS mode it will still be interrogated during the Navigation cycle if other beacons are also in CIF/Alternative-CIF mode or Enabled with the same CIS, unless the beacon is Disabled in addition to making it "**Offline**" using the "**Disable/Enable**" button on the Beacon Settings page. (See Appendix H for list of wideband CIS options)

    NOTE: Some COMPATTS are able to respond to other tone signals (nominated to the COMPATT by the system) as though they were 'Alternative' CIF frequencies - enabling operation with multiple vessels / multiple arrays.

  - "**RefBcn**". Meaning that the Beacon is to be changed from 'Mobile' Beacon status to 'Reference' Beacon status. If this option is highlighted and <ENTER> pressed, the Beacon data will disappear from this list and drop down to the "**REFERENCE BEACONS**" panel.

    This would be done if the Beacon's position was known with sufficient accuracy and it was in a position relevant to the ongoing operation. The current co-ordinates for the Beacon become the 'drop' co-ordinates and thus the starting point for a calibration.

  Full details of the set-up for any Beacon may be obtained by positioning the cursor over the Mobile Beacon name in the first column and pressing <ENTER>. A "**BEACON SETTINGS**" page will open - for further information, see paragraph 9.2.1.2.

- "**CHANNEL**" - "**INT**" and "**REP**"

  - "**INT**" [Interrogate]. This column and the "**REP**" column which follows are linked - these two columns define the "**CHANNEL**" Interrogation and Reply signals applicable to this Beacon. If the Beacon is of COMPATT type, the two signals may be chosen independently. If it is not, the Interrogation and Reply signals are either fixed or are pre-settable before the Beacon is deployed (and are therefore fixed once the Beacon is in the water).

    When choosing the Interrogation and Reply signals for a COMPATT using tone signals, choose frequencies which are separated sufficiently to avoid clashing with other Beacons in the vicinity - either associated with the current job or not. The user can either opt to allocate an Individual Interrogation signal to each beacon, which allows the system to control the times of arrival of the reply signals, hence preventing overlapping reply signals, or if the operator can opt to interrogate groups of beacons, such as an array of Reference COMPATTS, using the same interrogation signal (Common Interrogation mode). In this mode signal overlap must be prevented by carefully planning the Turn Around Times (TATs) - see later.
  - When choosing the Interrogation signals for a Mk5 Compatt using wideband signals the much larger number of signals available are sufficient to avoid clashing with other Beacons in the vicinity - either associated with the current job or not (See Appendix H for list of wideband signals). The user can either opt to allocate an Individual Interrogation signal to each beacon, which allows the system to control the times of arrival of the reply signals, hence preventing overlapping reply signals, or if the operator can opt to interrogate a group of beacons, such as an array of Reference Mk5 Compatts, using the same Interrogation signal. In this mode it is advisable to minimise signal overlap by planning the Turn Around Times (TATs), even though the impact of failing to eliminate signal overlap is significantly reduced using wideband signals - see later.

    It is always better to select reply signals with high frequencies, irrespective of whether HPR, Common or Individual Interrogation mode is being used. Whereas the Standard USBL transceiver can operated at all elevation angels from the vertical at any MF frequency, the optimum receive frequency range of the Big Head transceiver to operate at all elevation angles is 19-26kHz. MF frequencies above this can only be used reliably operating within a cone of 52° of the vertical.

    In the non-COMPATT case, the channel entered will appear between the two columns - as illustrated in the H33 and H5 cases in Figure 9.4 - the "H" signifies that the Beacon is using an HPR channel. For PGT and SSM beacons, the channel can be either set through the switches on the bottom end cap, or via the configuration utility supplied with the beacons. To configure the beacon via the serial link, set both switches on the end cap to the '0' position. The Interrogation /Reply frequencies for BPT and AODC beacons are defined by the Beacon 'name' included on the housing.

    WSM beacons have no switches and are only configurable via the PC utility supplied with the beacon. They are interrogated using tone signals and can be configured to reply using either tone or wideband signals. The WSM beacon can be enabled, disabled and released via basic PPM commands. In order to prevent the PPM commands sent to the WSM affecting other beacons, they use high address codes, so that the final PPM signal cannot be validated by any other beacons as the start of a new command. WSM beacons therefore have address in the range 3301-4714. When operating in wideband mode, it is possible to convert between address and the Individual Reply Signal (IRS) by subtracting 3200 from the address. A WSM beacon on address 3402 will therefore reply on IRS 202. If the operator enters an address in the WSM address field the IRS is

automatically updated, and similarly the address will be updated when the IRS is changed. It is important to note, however, that it is only possible to change the address or IRS of the actual WSM beacon via the serial interface. There is no acoustic command to change the IRS of a WSM beacon.

Some Beacons (e.g. Sonardyne Type HPR 300, PGT, SSM and WSM beacons) may be set into a Responder mode in which the interrogation function is executed electronically via an umbilical cable between the vessel and the Beacon. In such a case, the Interrogation Channel is shown as "Rn", where "R" signifies "Responder" and the "n" is the Responder Trigger value (1 to 4), as illustrated in the R2 case in Figure 9.4. Note, however, that if the Transceiver is driven from the CPU Card, options 1 to 4 all use the same output channel.

(See Appendix G for more information on both SONARDYNE and SIMRAD channel frequencies and Appendix H for more information on how to use SONARDYNE wideband beacon signals).

- "**OUTPUTS**" - "**SVY**", "**DP**" and "**IDX**"

  - "**SVY**". Determines whether or not the Beacon is being used to provide a Survey Output from the system. The default setting is "**OFF**". More information on the Survey Output from the system is given in Appendix E.

  - "**DP**". Determines whether or not the Beacon is being used to provide an output to a DP (Dynamic Positioning) system. For HPR 418 Telegrams, a simple ON/OFF facility is provided for this option. If HPR 309 Telegrams are being used, the IDX parameter (see next) must be set. The default setting is "**OFF**". More information on the individual DP telegrams output from the system is given in Appendix F.

    Other options are "**FLW**", "**ON**" and **"FIX"**. The position of any of the "**MOBILE BEACONS**" can be reported to the DP system in 'Ship Frame' rectangular co-ordinates. However, in some DP systems only "**REFERENCE BEACONS**" can be allocated as a DP Reference and it is necessary to set a flag in the DP telegram when it is required to DP on a 'Mobile Beacon'. The beacon may for example be mounted on an ROV - in which case, if option "**FLW**" is selected for the 'Mobile Beacon', the vessel DP system will 'see' it as a fixed 'Reference Beacon' and will, therefore, follow the ROV. This is sometimes referred to as the 'Dog on a Lead' principle. Option "**FIX**" can be selected if the 'Mobile Beacon' is 'static' on the seabed and hence be used as a fixed DP 'Reference Beacon'. Option "**ON**" causes an output to be provided to the DP system, so that the Beacon will appear on the DP screen, but without any follow function.

  - "**IDX**". Is a pseudo Beacon index number used to represent vessel position in some DP telegrams. A value ranging from 1 to 16 may be entered. The DP index should be different from the index of all other Beacons in use in the system.

- "**GAIN**". Defines the level of statistical filtering which will be applied to the Beacon data before use by the system. A "**HIGH"** filter value will cause the system to be more selective about the data it accepts, and will therefore lead to a more accurate result. However, too high a gain value could lead to all data values being rejected and the system, therefore, not working at all. For a 'Mobile Beacon' which may be subject to unpredictable changes in position (such as a ROV), a lower "**MED"** gain value will be necessary. For a diver, the "**LOW**" setting would be necessary.

  The dialogue box which appears in this case offers a range of the three options (**"LOW"**, **"MED"** and **"HIGH"**). Move the cursor to the option required and press <ENTER>.

- "**UPDATE RATE**". Defines at what intervals the Beacon is to be interrogated by the system - in seconds. A range of values from 0.5 to 15 seconds is available. If the update period entered is too short, the system will run as fast as it can but may not comply with the figure specified due to the time taken to receive and decode the Beacon replies. Depending on circumstances, a minimum figure of 0.5 seconds should enable the system to comply. Systems running Version 6.04 and later software operating with digital transceivers running firmware version 6.28 and later support 'Ping Stacking', where interleaved interrogations are used to run the system faster than the water depth would otherwise allow. This feature is particularly useful during tracking operations in deep water. (NOTE: Contact Sonardyne for details how to operate this system feature.)

- "**DEPTH AIDING**". Defines the depth fixing mode in which the Beacon is to operate. If it is required to change Beacon depth status, move the cursor to the appropriate row of the "**DEPTH AIDING**" column and press <ENTER>. A dialogue box will appear, offering the following options. Move the cursor to the option required and press <ENTER>.

  - "**Off**". Means depth aiding is not used for this Beacon.

  - "**Manual**". Means the Beacon depth is to be entered manually. Activating this option will cause a further dialogue box to appear, enabling the depth value (in current Display Units) to be typed in.

  - "**Auto**". If the Beacon is a WSM**,** SSM, PGT, HPR 400, selected BPTs or COMPATT type, activating this option will result in the Beacon being interrogated for its current depth at regular intervals. In the COMPATT case a second dialogue box enables the time (in minutes) between depth interrogations to be entered.

- "**TAT**". Defines the turn-around time applicable to a Beacon. Beacons 'time-out' for a time between detection of the interrogation pulse and transmitting a reply. This may be fixed or, if the Beacon is COMPATT type, may be commanded in increments of 62.5 milliseconds. Even in the case of a fixed-type Beacon, it may be advantageous to enter an exact value if it is known that this particular Beacon is slightly off nominal.

  - SIMRAD 300 series Beacons use 30 milliseconds as a standard.

  - SIMRAD 400 series Beacons use 60 milliseconds as a standard.

  - SONARDYNE HPR 300 (62.5) types use 62.5 milliseconds.

  - SONARDYNE COMPATT types use 125 milliseconds as a standard, but the majority are programmable.

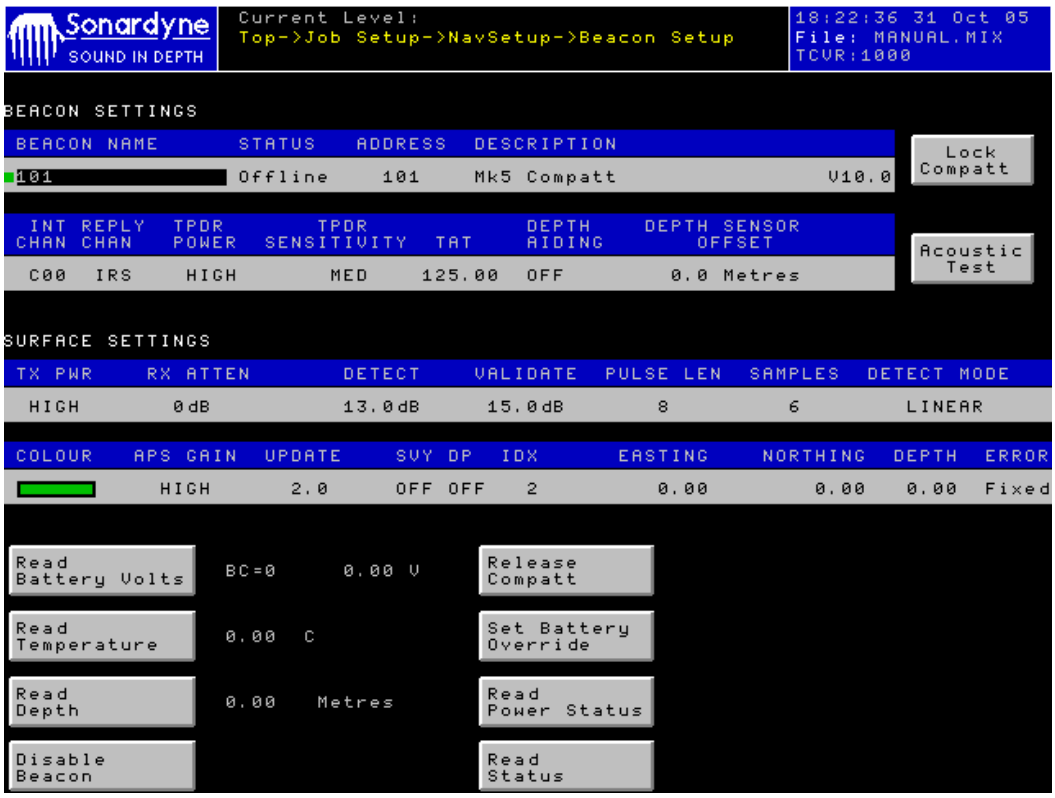
  - SONARDYNE PGT Beacons use 125 milliseconds for Sonardyne channels and 30 milliseconds for HPR 300 channels.

  - SONARDYNE Buoy Positioning Beacons (BPTs) use 400 milliseconds when interrogated on their individual channels and are set to different values by the system when used in a simultaneous mode.

  - SONARDYNE WSM Beacons use 125 milliseconds as a default, but can be configured serially to different values via the PC setup utility that is supplied with the beacons.

9.2.1.2 Beacon Settings Page

FIG 9.5 BEACON SETUP PAGE



A "**BEACON SETTINGS**" page for a particular Beacon may be displayed by pressing <ENTER> when the cursor is over one of the existing Beacon names. This will cause a new page to appear on which are displayed all parameters associated with the Beacon selected, as illustrated in Figure 9.5 for a Mk5 Compatt. This is a very powerful way of setting-up or editing Beacon parameters for a particular Beacon (i.e. this page is the one to use when setting a Beacon up for the first time). However, if it is required to change a particular parameter for several Beacons in the 'Mobile Beacons' list, then it is more efficient to use the "**MOBILE BEACONS**" panel to do so.

Having opened a "**BEACON SETTINGS**" page, all parameters may be changed using the normal editing rules described at the front of this Section. Three of these parameters, "**ADDRESS**", "**TPDR POWER**" and "**TPDR SENSITIVITY**" may only be changed on this summary page for COMPATTS. In order to conserve battery charge and reduce the impact of reverberations, "**TDR POWER**" should be set to "**LOW**" if possible and only increased if communication difficulties with this Transponder become apparent.

If the beacon is a COMPATT, the 'buttons' in the lower half of the page may be used to initiate an acoustic update of any of a range of Beacon parameters - "**Battery Volts**", "**Temperature**" of the sea at Beacon depth, "**Depth**" of the Beacon, Beacon "**Power Status**" and Beacon "**Status**". Note, however, that the reply from the "**Read Power Status**" and "**Read Status**" buttons will only be displayed on the screen if the appropriate "button" is "pressed" and will be displayed using Sonardyne PAN terminology - see Appendix B.

The reply message from the "**Disable Beacon**" button will be either "**Disabled**" or "**Enabled**" depending on the last known status of the Beacon.

The "**Release Compatt**" button may be used to initiate the release of a COMPATT fitted with a Release Mechanism. Three Release commands have to be detected by the COMPATT in sequence, with the system receiving/displaying each reply and counting/displaying the acoustic pings as the release mechanism operates, followed by the final acknowledgement. Prior to sending the Release commands the "**Read Depth**" option should be used to record the current COMPATT depth, which should be repeated following the Release acceptance to confirm the COMPATT is ascending - see Appendix B for more information on this process.

NOTE: If the COMPATT is a "**REFERENCE BEACON**" it should be changed to a "**MOBILE BEACON**" with the "**GAIN"** set to "**MEDIUM"** before releasing.

The reply message from the "**Lock Compatt**" button will either be "**Lock**" or "**Unlock**", depending on the last known status of a COMPATT fitted with the correct firmware - see Appendix B. The "**Lock Compatt**" option prevents the chance of critical navigation parameters, such as a COMPATT reply signal or turn-around delay, being inadvertently changed when operating high reverberant conditions or within acoustic range of other acoustic navigation systems operating in the same frequency band.

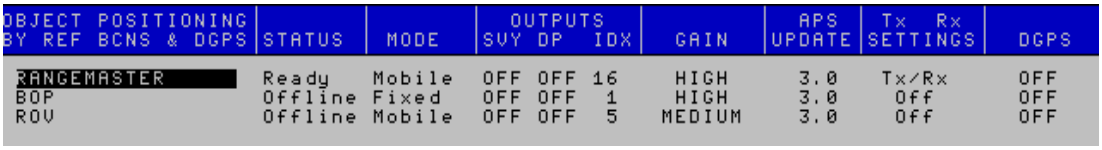
Pressing the "**Acoustic Test**" button will list the available Transceivers that may be used to monitor a Beacon response during a 'Range Test' - see Appendix A.

As an acoustic update proceeds, progress of the transmissions and replies is reported in the third line of the menu level box at the top of the page.

NOTE: If the COMPATT beacon in question is tethered underwater using a release mechanism, the "**Set Battery Override**" button should only be used with great caution. Once set, the normal power drain safeguards built into a COMPATT, which ensure that it will reserve enough battery power to operate the release mechanism, will be overridden. In such cases, this button should only be used where it is known that outstanding work involving the Beacon can be accomplished with only minimal extra battery drain or when COMPATT recovery will be accomplished by some other method, such as recovery by an ROV.

9.2.1.3 Object Positioning by Ref BCNS and DGPS Panel

FIG 9.6 OBJECT POSITIONING BY REF BCNS AND DGPS PANEL



OBJECT POSITIONING BY REF BCNS & DGPS	STATUS	MODE	OUTPUTS SVY	OUTPUTS DP	OUTPUTS IDX	GAIN	APS UPDATE	Tx Rx SETTINGS	DGPS
RANGEMASTER	Ready	Mobile	OFF	OFF	16	HIGH	3.0	Tx/Rx	OFF
BOP	Offline	Fixed	OFF	OFF	1	HIGH	3.0	Off	OFF
ROV	Offline	Mobile	OFF	OFF	5	MEDIUM	3.0	Off	OFF

This panel is located near the centre of the "**NavSetup**" screen and is used to control the Vessel (or any other Object) position calculations, the output of position data to other systems and the input, or not, of DGPS data.

Ten categories of data may be controlled, as follows:-

- **VESSEL OR TRANSCEIVER NAME**. This is entered in the space below the "**OBJECT POSITIONING BY REF BCNS & DGPS**" box (the vessel name 'RANGEMASTER' is entered in the example illustrated in Figure 9.6). If the cursor is positioned over the name of the Vessel/Transceiver on this page and <ENTER> pressed, an Object Setup page opens - see paragraph 9.2.1.4.

- **"STATUS"**. This field refers to the Vessel (or other Object) status as a whole. Options available are "**Offline**" and "**Ready**".

- "**MODE**". Defines the Vessel (or any other Object) motion status. Options available are "**Mobile**" (e.g. a Ship or ROV), "**Static**" (e.g. a BOP fitted with a BOPNav transceiver during a 'Top Up' calibration) and "**Fixed**" (e.g. a calibrated BOPNav transceiver).
- "**OUTPUTS**" - "**SVY**", "**DP**" and "**IDX**"

  - "**SVY**". Determines whether or not the Vessel (on other Object) is being used to provide a Survey Output from the system. The default setting is "**OFF**". More information on the Survey Output from the system is given in Appendix E.

    "**DP**". Determines whether or not the Vessel (or other Object) is being used to provide an output to a DP (Dynamic Positioning) system. For HPR 418 Telegrams, a simple ON/OFF facility is provided for this option. If HPR 309 Telegrams are being used, the IDX parameter (see next) must be set. The default setting is "**OFF**". More information on the individual DP telegrams output from the system is given in Appendix F.

    Other options are "**FLW**", "**ON**" and **"FIX"**. The position of any 'Secondary Object' can be reported relative to the 'Primary Vessel Object' to the DP system in "Ship Frame" rectangular co-ordinates. However, in some DP systems only 'Reference Beacons' can be allocated as a DP Reference and it is necessary to set a flag in the DP telegram when required to DP on a 'Secondary Object' such as an ROV. In which case, if option "**FLW**" is selected for the 'Secondary Object', the vessel DP system will 'see' it as a fixed 'Reference Beacon' and will, therefore, follow the ROV. This is sometimes referred to as the 'Dog on a Lead" principle. Option "**FIX**" can be selected if the 'Secondary Object' is static on the seabed and hence be used as a fixed DP Reference Beacon.

    Option "**ON**" causes an output to be provided to the DP system, so that the Object will appear on the DP screen, but without any follow function.

  - "**IDX**". Is a pseudo Beacon index number used to represent vessel position in some DP telegrams. A value ranging from 1 to 16 may be entered. The DP index should be different from the index of any Beacon in use in the system.

- "**GAIN**". Defines the level of statistical filtering which will be applied to the Vessel position (or any other Object). The Vessel position is computed relative to the Reference Beacons (provided "**DGPS**" is set "**OFF**")**.**

  The dialogue box which appears in this case offers a range of 3 options ("**LOW**", "**MED**" and "**HIGH**"). Move the cursor to the option required and press <ENTER>.

- "**APS UPDATE**". This determines how frequently the 'Reference Beacons' are interrogated and, therefore, how often the Vessel's position (and any other Object) is re-calculated. Three options are presented:-

  - "**Run at Update Rate**". Entering a value of 0 sets the APS Update to "**OFF**" **and** prevents the 'Reference Beacons' from being interrogated. Otherwise a value ranging from 0.5 to 99 seconds may be entered.

If the update period entered is too short, the system will run as fast as it can but may not comply with the figure specified due to the time taken to receive and decode the Beacon replies. Depending on circumstances, a minimum figure of 0.5 seconds should enable the system to comply. Systems running Version 6.04 and later software operating with digital transceivers running version 6.18 and later firmware have the option to support 'Ping Stacking', where interleaved interrogations are used to run the system at update rates faster than the water depth would otherwise allow. This feature is particularly useful during tracking operations in deep water. (NOTE: Contact Sonardyne for details how to operate this system feature.)

- "**Synch to Ext Input**". Entering an offset value ranging between zero and 30 seconds permits the acoustic interrogation of 'Reference' and 'Mobile' beacons' to be synchronised to an external system (such as another acoustic system). All acoustic cycles will then be started at the defined offset following the received trigger*. This facility can be used to limit interference between each system, with the APS UPDATE displaying "**EXT**".

  NOTE: * The trigger port can be set up and edited in the ':External Synch' field on the Installation file using a PC – see Section 9.3

- "**Synch to time of day**". When the system time has been synchronised to a time of day instrument, an "**acoustic window**" can be selected that defines the acoustic update rate. An "**offset**" can then be selected within the acoustic window at which the acoustic cycle will begin. This allows for acoustic cycles to be co-ordinated between separate acoustic systems to minimise acoustic interference, without the need for direct hardware links. In this case the APS UPDATE will display "**TOD**" and sets the overall update rate for **all** References and Mobiles beacons. If the 'time of day' input is lost, the systems will continue to operate using their internal clocks.

❑ "**Tx & Rx SETTINGS**". Four acoustic configurations are possible for each Object in the Version 6 system, as follows:-

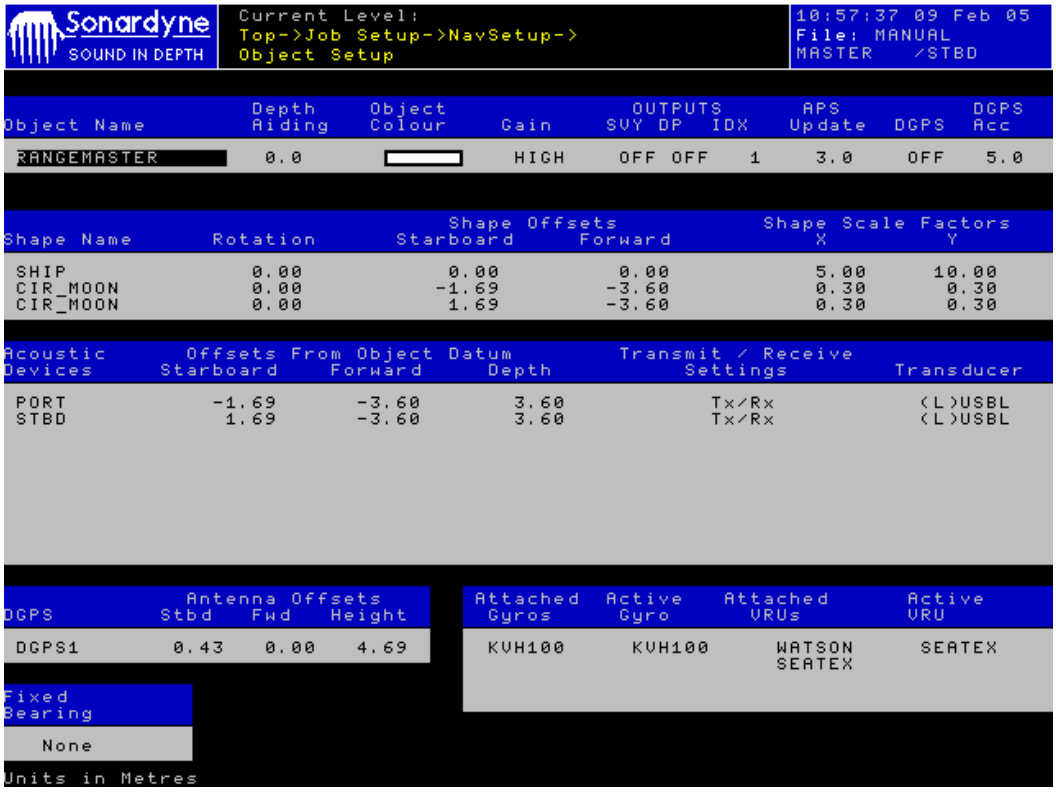
- "**Rx/Tx**". The assigned Transceiver(s) transmits and receives - normal mode
- "**Tx Only**". The assigned Transceiver(s) transmits but does not receive. This mode would be used in BOP or mobile LBL applications
- "**Rx Only**". The assigned Transceiver(s) receives but does not transmit. This mode also would be used in BOP or mobile LBL applications
- "**Off**". The assigned Transceiver(s) neither transmits nor receives, when the Object will not be positioned.

❑ "**DGPS**". This determines whether or not the L/USBL System will accept position reference data from the vessel's DGPS System. Options available are "**OFF**" (default) or **"ON**".

9.2.1.4 Object Setup Page

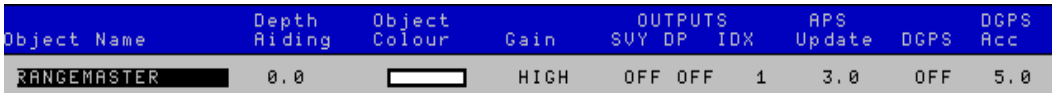
This page is accessed by positioning the cursor over a Vessel/Transceiver name in the "**OBJECTS POSITIONING**" panel on the "**NavSetup**" page and pressing <ENTER>.

FIG 9.7 OBJECT SETUP PAGE



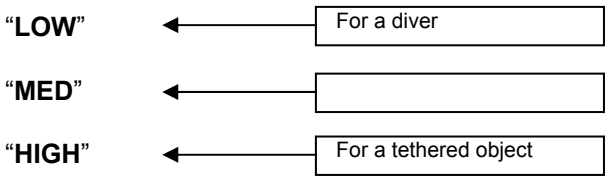
This page summarises all of the parameters relating to the 'Object' (Vessel or Transceiver) selected on the "**NavSetup**" page. Some of these parameters may be set up on the "**NavSetup**" page but, if starting a new job and setting up a first set of parameters for an Object, the task is more easily accomplished here. Main features are:-

- **Object Panel**



  - "**Object Name**". This is a repeat of the name selected on the "**NavSetup**" page.
  - "**Depth Aiding**". Depth of a Transceiver (and hence an Object Datum) can be the most difficult field to determine. Depth Aiding is an option whereby the operator can give the system assistance in its determination. The Options are:-
    - "**Off**". (If no external depth information or depth sensor available). The system will derive the depth from acoustic measurements.
    - "**Manual**". (If actual Object datum depth is known). If this option is selected, a small dialogue box opens so that a Fixed Depth, in current system units, can be typed in; the system will use this depth as an absolute observation.
    - "**Auto**". If depth is to be read from a Transceiver's sensor (such as a Mini ROVNav, Mk4 ROVNav or BOPNav).
  - "**Object Colour**". Object colour on Chart Display may be selected from a list of colours.

- "**Gain**". The gain value is selected from a list depending on its mobility, eg:-



- "**Outputs**" - "**SVY**", "**DP**" and "**IDX**"

  - "**SVY**". Determines whether or not the 'Object' is being used to provide a Survey Output from the system. The default setting is "**OFF**". More information on the Survey output from the system is given in Appendix E.

  - "**DP**". Determines whether or not the Vessel (or other 'Object') is being used to provide an output to a DP (Dynamic Positioning) system. For HPR 418 Telegrams, a simple ON/OFF facility is provided for this option. If HPR 309 Telegrams are being used, the IDX parameter (see next) must be set. The default setting is "**OFF**". More information on the individual DP telegrams output from the system is given in Appendix F.

  - Other options are "**FLW**", "**ON**" and **"FIX"**. The position of any 'Secondary Object' can be reported relative to the 'Primary Vessel Object' to the DP system in 'Ship Frame' rectangular co-ordinates. However, in some DP systems only 'Reference Beacons' can be allocated as a DP Reference and it is necessary to set a flag in the DP telegram when required to DP on a 'Secondary Object' such as an ROV. In which case, if option "**FLW**" is selected for the 'Secondary Object', the vessel DP system will 'see' it as a fixed 'Reference Beacon' and will, therefore, follow the ROV. This is sometimes referred to as the 'dog on a lead' principle. Option "**FIX**" can be selected if the 'Secondary Object' is static on the seabed and hence be used as a fixed DP Reference Beacon.

    Option "**ON**" causes an output to be provided to the DP system, so that the Object will appear on the DP screen, but without any follow function.

  - "**IDX**". Is a pseudo Beacon index number used to represent vessel position in some DP telegrams. A value ranging from 1 to 16 may be entered. The DP index should be different from the index of any Beacons in use in the system.

- "**APS Update**". This determines how frequently the Reference Beacons are interrogated and, therefore, how often the Vessel's position (and/or other Objects) is re-calculated. Three options are presented:-

  - "**Run at Update Rate**". Entering a value of 0 sets the APS Update to "**OFF**" **and** prevents the Reference Beacons from being interrogated. Otherwise a value ranging from 0.5 to 99 seconds may be entered.

    If the update period entered is too short, the system will run as fast as it can but may not comply with the figure specified due to the time taken to receive and decode the Beacon replies. Depending on circumstances, a minimum figure of 0.5 seconds should enable the system to comply. Systems running Version 6.04 and later software operating with digital transceivers running version 6.18 and later firmware support 'Ping Stacking', where interleaved interrogations are used to run the system at update rates faster than the water depth would otherwise allow. This feature is particularly useful during tracking operations in deep water. (NOTE: Contact Sonardyne for details how to operate this system feature.)

- "**Synch to Ext Input**". Entering an offset value ranging between zero and 30 seconds permits the interrogation of 'Reference' and 'Mobile' beacons to be synchronised to an external system (such as another acoustic system). All acoustic cycles will then be started at the defined offset following the received trigger*. This facility can be used to limit interference between each system, with the APS UPDATE displaying "**EXT**".

  NOTE: * The trigger port can be set up and edited in the ':External Synch' field on the Installation file using a PC – see Section 9.3

- "**Synch to time of day**". When the system time has been synchronised to a time of day instrument, an "**acoustic window**" can be selected that defines the acoustic update rate. An "**offset**" can then be selected within the acoustic window at which the acoustic cycle will begin. This allows for acoustic cycles to be co-ordinated between separate acoustic systems to minimise acoustic interference, without the need for direct hardware links. In this case the APS UPDATE will display "**TOD**" and sets the overall update rate for **all** References and Mobiles beacons. If the 'time of day' input is lost, the systems will continue to operate using their internal clocks.

- "**DGPS**". This determines whether or not the L/USBL system will accept position reference data from the vessel's DGPS System. Options available are "**OFF**" (default) or "**ON**".

- "**DGPS Acc**". This determines the weight that the system will give to the DGPS input when computing an Object position. If a large DGPS accuracy value is entered here (say 5 or more), the system assumes that not much weight is to be attached to the DGPS and the system accuracy is therefore to be determined by the acoustic elements. Values, in current system units, between 1 and 99 may be entered.

❑ **Shape Panel**

Shape Name	Rotation	Shape Offsets Starboard	Shape Offsets Forward	Shape Scale Factors X	Shape Scale Factors Y
SHIP	0.00	0.00	0.00	5.00	10.00
CIR_MOON	0.00	-1.69	-3.60	0.30	0.30
CIR_MOON	0.00	1.69	-3.60	0.30	0.30

- "**Shape Name**". A range of standard 'Object' shapes is available from a drop-down list which appears when <ENTER> is pressed while in this field.

- "**Rotation**". Enables the angular orientation of the shape relative to the local, object grid to be varied.

- "**Shape Offsets**". Enables "**Starboard**" and "**Forward**" offsets to be entered to allow for the possibility that the Object datum may not be at the geometric centre of the shape.

- "**Shape Scale Factor**". Allows the aspect ratio of the shape to be varied to suit the current Object by adjusting the "**X**" and "**Y**" scaling.

❑ **Acoustic Devices Panel**

Acoustic Devices	Offsets From Object Datum Starboard	Forward	Depth	Transmit / Receive Settings	Transducer
PORT	-1.69	-3.60	3.60	Tx/Rx	(L)USBL
STBD	1.69	-3.60	3.60	Tx/Rx	(L)USBL

- "**Offsets From Object Datum**" - "**Starboard**", "**Forward**" and "**Depth**". Refers to the offsets of the Acoustic Device (e.g. a Transceiver) from the datum point of whatever Object (Vessel, ROV or BOP etc.) it is mounted on.

- "**Transmit / Receive Settings**". In addition to their normal mode of "Transmitter/Receiver" ("**Tx/Rx**") operation, Transceivers may be set to 'Transmit only' ("**Tx only**") or 'Receive only' ("**Rx only**"). This can have significant noise elimination benefits in certain system configurations when operating in a noisy environment. "When set to "**Off**", the Transceiver neither transmits nor receives.

  "Transducer". When using multiple USBL Transceivers for both array 'Top Down' calibration and during normal operation, the descriptor "**(L)USBL**" is entered in this field for one of the Transceivers and "**LBL**" for the remaining ones.

  In the case of a Mk4 ROVNav or BOPNav Transceiver, which supports operation with two transducers, it is possible to specify here which ("**Tdr1**" or "**Tdr2**") of the two transducers is to be active, or both "**Both**", when it is possible to compute the Object heading). In all other cases, "**Tdr1**" is entered.

❑ **DGPS Panel**

DGPS	Antenna Offsets Stbd	Fwd	Height
DGPS1	0.43	0.00	4.69

- "**Antenna Offsets**" - "**Stbd**", "**Fwd**" and "**Height**". Refers to the offsets of the DGPS antenna from the Vessel's datum.

❑ **Attitude Sensor Panel**

Attached Gyros	Active Gyro	Attached VRUs	Active VRU
KVH100	KVH100	WATSON SEATEX	SEATEX

- "**Attached Gyros**" / "**Attached VRUs**". Enables the name(s) of the Gyros and VRUs available to the system to be entered, or is left blank if there are no such sensors available.

  - Only one Gyro can be interfaced to the L/USBL system at once. However, an external switching device can be used to select which Gyro is interfaced of those available. If more than one Gyro is available it is important to ensure that the correct settings and corrections are applied.

  - Four VRUs are available, all of which can be individually configured and interfaced to the L/USBL system.

- "**Active Gyro**" / "**Active VRU**". Enables the name of the active Gyro/VRU to be entered.

❑ **Gyro Bearing Panel**

Fixed Bearing
56.00

- "**Fixed Bearing**". Offers a range of options to cover the case where there is no Gyro available to the system. Pressing <ENTER> on this field produces a list of options:-

  - "**None**". Where no heading input is to be provided to the system.

  - "**Manual**". Where a fixed heading value is to be used by the system. Selecting this option causes a dialogue box to open enabling a fixed heading value to be entered.

9.2.1.5 Calibration Control Panel

This panel is located near the centre of the screen illustrated in Figure 9.3 and is used to control the starting and stopping times of the 'Bottom-up' calibration process.

FIG 9.8 CALIBRATION CONTROL PANEL

Once more than one Beacon has been 'dropped down' to the "**REFERENCE BEACONS**" panel, the system will automatically start a 'Top Down' calibration process - all other Beacons being calibrated with respect to the first (unless DGPS has been turned "**ON**" when all the Beacons will be allowed to move). This will reduce the position errors of the beacons and consequently of the Object being navigated. In practice, the Easting and Northing co-ordinates of the first Beacon will be fixed and the depth value will be allowed to vary.
The 'Top down' calibration process should be left until the position error of all the 'Reference Beacons' has stabilised at an acceptable value, with very small changes being made to each beacon co-ordinate (approximately one hour). After that time the "**Stop Calibration**" button should be pressed - highlight the button and press <ENTER>. This will cause all the 'Reference Beacons' to become "**Fixed**", with stationary Easting, Northing and Depth co-ordinates and the 'Top Down' calibration to stop. It also has the affect of making any 'Static' Object 'Fixed'.

Pressing the "**Start Calibration**" button will recommence the 'Top Down' calibration, holding the first Reference Beacon to be 'dropped down' "**Fixed**" and setting the position errors of the remaining Reference Beacons to 1 metre / 3.2 feet.

9.2.1.6 Reference Beacons Panel

The "**REFERENCE BEACONS**" panel is located near the bottom of the "**NavSetup**" screen - see Figure 9.9 which follows:-

FIG 9.9 REFERENCE BEACONS PANEL

REFERENCE BEACONS	STATUS	CHANNEL INT	CHANNEL REP	OUTPUTS SVY	OUTPUTS DP	OUTPUTS IDX	REFERENCE BEACON CO-ORDS EASTING	NORTHING	DEPTH	POS ERROR
606	Ready	C05	IRS	OFF	OFF	2	1.11	40.17	19.87	Fixed
202	Ready	CIF	2	OFF	OFF	1	52.58	-3.99	21.52	0.80
609	Ready	CIF	9	OFF	OFF	3	13.92	-50.37	26.96	0.60
210	Ready	C05	IRS	OFF	OFF	4	-59.52	2.54	23.56	1.20

As for the "**MOBILE BEACONS**" navigation panel, 'Reference Beacon' parameters may be changed either by editing entries in this panel or by editing on the "**BEACON SETTINGS**" page (see paragraph 9.2.1.2 and Figure 9.5). In the "**REFERENCE BEACONS**" panel on the "**Navigation Setup"** page, parameters may be set as follows:-

- "**STATUS**". Defines the usability status of a Reference Beacon. If it is required to change the status of a Beacon, move the cursor to the appropriate row of the "**STATUS**" column and press <ENTER>. A dialogue box will appear offering the following options. Move the cursor to the option required and press <ENTER>.

  - "**Ready**". Meaning that the Beacon is fully active and will respond normally to any interrogation - see "**Not Set**".

  - "**Not Set**". Applies ONLY to COMPATT, SSM, PGT and WSM beacon types, which require set-up commands before they are ready for use. After these commands have been sent, the Beacon status is automatically set to "**Ready**" - see Section 2.3.5.

  - "**Offline**". Meaning the Beacon will not be interrogated during the Navigation cycle.
  - "**MobBcn**". Meaning that the Beacon is to be changed from 'Reference' status to 'Mobile Beacon' status. If this option is highlighted (and <ENTER> pressed), the Beacon data will disappear from this list and move back to the "**MOBILE BEACONS**" panel.

  Full details of the set-up for this Beacon (or any other) may be obtained by positioning the cursor over the Beacon name in the first column and pressing <ENTER>. A "**BEACON SETTINGS**" page will open - for further information, see paragraph 9.2.1.2.

- "**CHANNEL**" - "**INT**" and "**REP**"

  - "**INT**" [Interrogate]. This column and the "**REP**" column which follows are linked - these two columns define the "**CHANNEL**" Interrogation and Reply signals applicable to this Beacon. If the Beacon is of COMPATT type, the two signals may be chosen independently. If it is not, the Interrogation and Reply signals are either fixed or are pre-settable before the Beacon is deployed (and are therefore fixed once the Beacon is in the water).

    When choosing the Interrogation and Reply signals for a COMPATT using tone signals, choose frequencies which are separated sufficiently to avoid clashing with other Beacons in the vicinity - either associated with the current job or not. The user can either opt to allocate an Individual Interrogation signal to each beacon, which allows the system to control the times of arrival of the reply signals, hence preventing overlapping reply signals, or if the operator can opt to interrogate a group of beacons, such as an array of Reference COMPATTS, using the same interrogation signal (Common Interrogation mode). In this mode signal overlap must be prevented by carefully planning the Turn Around Times (TATs) - see later.
    When choosing the Interrogation signals for a Mk5 Compatt using wideband signals the much larger number of signals available are sufficient to avoid clashing with other Beacons in the vicinity - either associated with the current job or not. (See Appendix H for available wideband signals). The user can either opt to allocate an Individual Interrogation signal to each beacon, which allows the system to control the times of arrival of the reply signals, hence preventing overlapping reply signals, or if the operator can opt to interrogate a group of beacons, such as an array of Reference Mk5 Compatts, using the same Interrogation signal. In this mode it is advisable to minimise signal overlap by planning the Turn Around Times (TATs), even though the impact of failing to eliminate signal overlap is significantly reduced using wideband signals - see later.

    It is always better to select reply signals with high frequencies, irrespective of whether HPR, Common or Individual Interrogation mode is being used. Whereas the Standard USBL transceiver can operated at all elevation angels from the vertical at any MF frequency, the optimum receive frequency range of the Big

Head transceiver to operate at all elevation angles is 19-26kHz. MF frequencies above this can only be used reliably operating within a cone of 52° of the vertical.

In the non-COMPATT case, the channel entered will appear between the two columns - as illustrated in the H33 and H5 cases in Figure 9.4 - the "H" signifies that the Beacon is using an HPR channel. For PGT and SSM beacons, the channel can be either set through the switches on the bottom end cap, or via the configuration utility supplied with the beacons. To configure the beacon via the serial link, set both switches on the end cap to the '0' position. The Interrogation /Reply frequencies for BPT and AODC beacons are defined by the Beacon 'name' included on the housing.

WSM beacons have no switches and are only configurable via the PC utility supplied with the beacon. They are interrogated using tone signals and can be configured to reply using either tone or wideband signals. The WSM beacon can be enabled, disabled and released via basic PPM commands. In order to prevent the PPM commands sent to the WSM affecting other beacons, they use high address codes, so that the final PPM signal cannot be validated by any other beacons as the start of a new command. WSM beacons therefore have address in the range 3301-4714. When operating in wideband mode, it is possible to convert between address and the Individual Reply Signal (IRS) by subtracting 3200 from the address. A beacon on address 3402 will therefore reply on IRS 202. If the operator enters an address in the WSM address field the IRS is automatically updated, and similarly the address will be updated when the IRS is changed. It is important to note, however, that it is only possible to change the address or IRS of the actual WSM beacon via the serial interface. There is no acoustic command to change the IRS of a WSM beacon.

Some Beacons (e.g. Sonardyne Type HPR 300, PGT, SSM and WSM beacons) may be set into a Responder mode in which the interrogation function is executed electronically via an umbilical cable between the vessel and the Beacon. In such a case, the Interrogation Channel is shown as "Rn", where "R" signifies "Responder" and the "n" is the Responder Trigger value (1 to 4), as illustrated in the R2 case in Figure 9.4. Note, however, that if the Transceiver is driven from the CPU Card, options 1 to 4 all use the same output channel.

(See Appendix G for more information on both SONARDYNE and SIMRAD channel frequencies and Appendix H for more information on how to use SONARDYNE wideband beacon signals).

- "**OUTPUTS**" - "**SVY**", "**DP**" and "**IDX**"

  - "**SVY**". Determines whether or not the Beacon is being used to provide a survey output from the system. The default setting is "**OFF**".

  - "**DP**". Determines whether or not the Beacon is being used to provide an output to a DP (Dynamic Positioning) system. The default setting is "**OFF**". More information on the individual DP telegrams output from the system is given in Appendix F. Other options are "**FLW**", "**ON**" and **"FIX"**. The position of any of the 'Reference Beacons' can be reported to the DP system in 'Ship Frame' rectangular co-ordinates and option "**FIX**" should be selected. Option "**ON**" causes an output to be provided to the DP system, so that the Beacon will appear on the DP screen, but without any follow function.

    "**IDX**". Is a pseudo Beacon index number used to represent vessel position in some DP telegrams. A value ranging from 1 to 16 may be entered. The DP index should be different from the index of all other Beacons in use in the system.

- "**REFERENCE BEACON CO-ORDS**"

  Three data entry options are available under this heading:-

  - "**EASTING**". This is the Easting co-ordinate of a Reference Beacon in either local or global earth reference plane co-ordinates in current System Display Units. A value between 0 and ±10,000,000.0 may be entered.

  - "**NORTHING**". This is the Northing co-ordinate of a Reference Beacon in either local or global earth reference plane co-ordinates in current System Display Units. A value between 0 and ±10,000,000.0 may be entered.

  - "**DEPTH**". The current depth of a Reference Beacon. A value between 0 and 9,999.0 may be entered in the current System Display Units.

    "**REFERENCE BEACONS**" can be 'Dropped Down' from the "**MOBILE BEACONS**" panel, in which case the "**EASTING**", "**NORTHING**" and "**DEPTH**" parameters are those that applied when the Beacon was last interrogated. The system will immediately start to calibrate the Beacon - i.e. updating the Easting, Northing and Depth values. This process will continue until the "**Stop Calibration**" button is pressed.

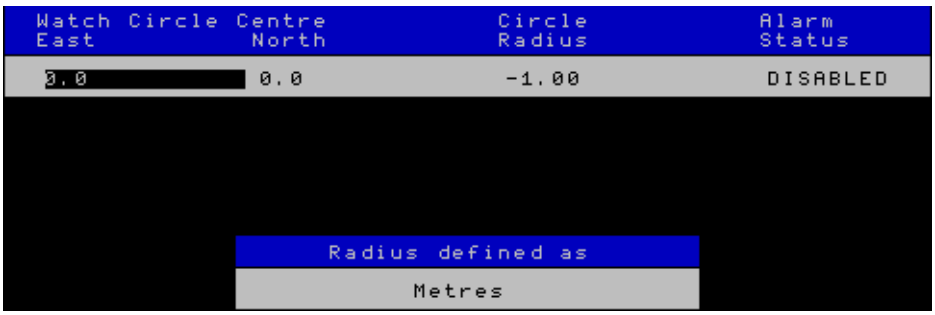
> **NOTE: The co-ordinates and error value for a Beacon cannot be changed manually whilst navigating.**

- "**POS ERROR**". This column displays the calculated value, for each 'Reference Beacon', of the radius of the Beacon's position error circle that is a measure of the repeatability of the observations to that Beacon. This value slowly reduces with each navigation cycle.

9.2.2 Option 2 - "**Define Watch Circles**"

This function will only operate when a Gyro-Compass input is available and the seabed Beacon array is being used as the DP reference. A Watch Circle may be set up around the current vessel position. When the vessel moves outside this circle a level 1 alarm will be generated. The Watch Circles data page is illustrated in Figure 9.10:-

FIG 9.10 WATCH CIRCLES DATA ENTRY



- "**Radius defined as**". Units for the radius of the circle should be defined first - either in Display Units (metres / feet) or in percentage of water depth (in cases where the angle of deviation of the vessel's position from the vertical at the DP reference point is important and has to be controlled). Note, however, that if percentage of water depth is to be set, then water depth must be set on - see "**Sound Velocity Page**" which follows.

- "**Watch Circle Centre**" - "**East**" and "**North**". The centre of the circle needs to be set next. [For example, this could be the position of the seabed object which is to be the centre of the Watch Circle].

- "**Circle Radius**". Enables the radius of the Watch Circle to be set in current System Units.

- "**Alarm Status**". Finally, the watch circle mode should be enabled using the enable/disable facility.

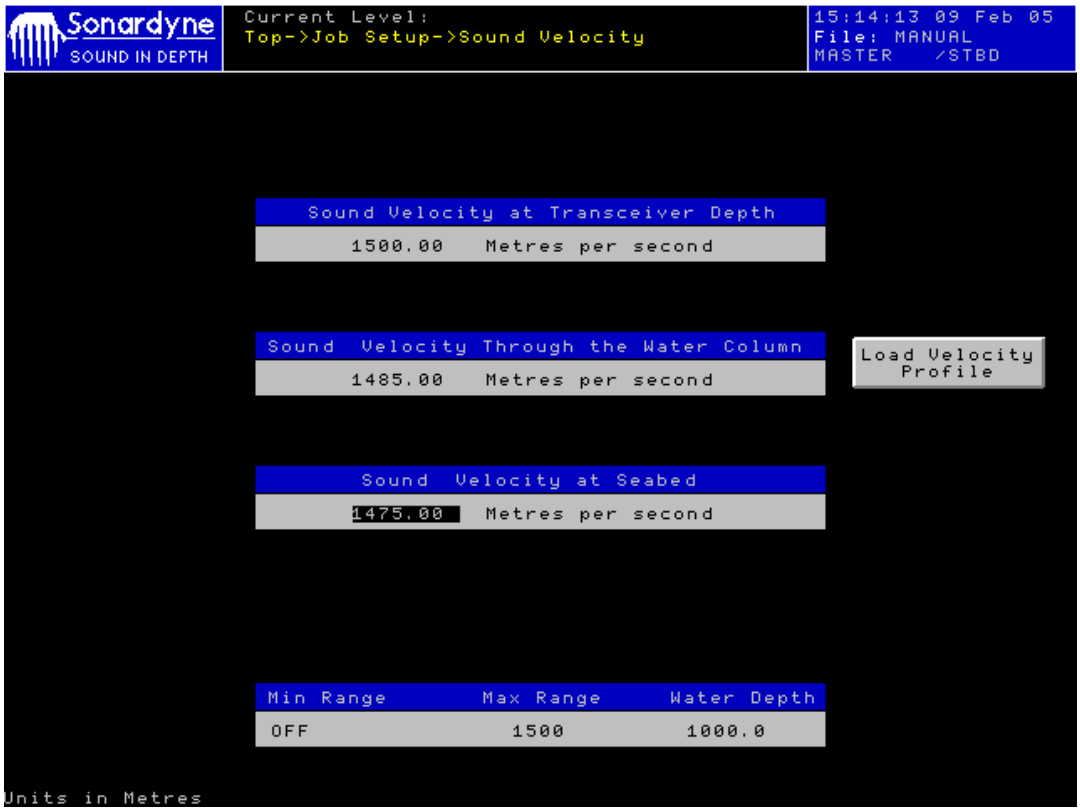
  Once triggered, the alarm will continue unless cancelled by any of the following actions:-

  - The vessel returning within the Watch Circle.
  - The operator pressing the "**ARM**" key and the "**ALARM**" key together - on the Type 7783 Monitor/Keypad - or on the Type 7941 Keyboard unit as appropriate.
  - The operator re-centring the Watch Circle.
  - The operator disabling the Watch Circle facility.

9.2.3 Option 3 - "**Sound Velocity**"

The velocity of sound is necessary to obtain the correct range from the timing measurement and the correct direction or bearing from the 'time-phase' measurements. The data entry panel for this option is illustrated in Figure 9.11, which follows:-

FIG 9.11 SOUND VELOCITY DATA ENTRY



Three velocity parameters are listed. Enter the sound velocity corresponding to the USBL / L/USBL Transceiver depth, the average sound velocity through the water column between the Transceiver and the Beacon array and the sound velocity at the seabed.

- The "**Through the Water Column**" value is the most important. Provided this value is set to the average sound velocity in water between the Transceiver and the working depth, the USBL automatically compensates for ray refraction. There are three ways of determining the "**Through the Water Column**" value:-

  - Load a Sound Velocity Profile by selecting the "**Load Velocity Profile**" and press <ENTER>. The software will automatically compensate for ray refraction between the Transceiver and any Target.

    NOTE: Third party profiles will need to be reduced to a maximum of 50 data sets with the following format:-

    * Five header lines (which will be ignored)

    * Maximum of 50 inputs with the format <Depth, Velocity>

    * Additional fields such as <Salinity, Temperature> will be ignored

  - Use the data recorded using a Sound Velocity Probe to compute the value.

  - Compare COMPATT sensor depth(s) with the acoustic measurement(s) and derive a mean value for the sound velocity that matches the measurements.

- Inputting the correct "**Sound Velocity at the Transceiver Depth**" is important when tracking USBL targets at large horizontal offsets, such as a towed geophysical sensor, as it is used to calculate the wavelength of the received signal, which is necessary to estimate the direction of arrival. The sound velocity should be checked on a regular basis and any changes in value entered in the dialogue box on the system. The sound velocity may be measured using a Sound Velocity Probe or computed from the water temperature measured at the depth of the Transceiver.

- In cases where the "**Sound Velocity at Seabed**" value is required, either input the data recorded with a Sound Velocity Probe or use the COMPATT's environmental sensor data to either measure or calculate the sound velocity. (Formulae for calculating sound velocity from this data are given in Appendix I).

The fields in the bottom row of the "**Sound Velocity**" dialog box may be set as follows:-

❑ "**Min Range"**. This field allows the user to block spurious, short ranges to a beacon during the start up processes of tracking. This field can be set to "**Manual**" or "**Off**".

- "**Manual**". User input minimum expected range in feet/metres.

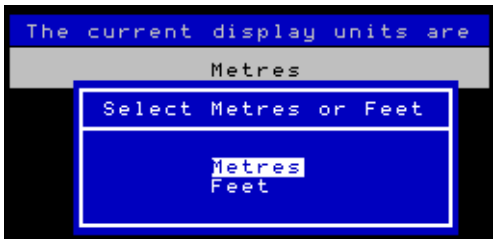
- "**Off**". No minimum range gating will be implemented.

❑ "**Max Range**". This field will limit the time the Transceiver will wait for a reply from a beacon. Set in feet/metres the maximum expected slope distance to the furthest beacon. Any range longer than that set will not be received.

❑ "**Water Depth"**. This field should be set in feet/metres and is used in the automatic setting of blocking periods of array COMPATTs to prevent re-interrogation of the beacons by multipath transmissions.

9.2.4 Option 4 -"**Display Units**"

On entering this menu option, the user presses <ENTER> over the current units and is given a choice between entering and displaying data in metres or feet - the default is metres. [The system, however, will always calculate in metres]. If a change is needed, use the cursor keys to highlight the option required (see illustration to the right) and press <ENTER> to activate it.



In Version 6, the current units are displayed at the bottom of most pages, so that it is only necessary to select this option if it is intended to change units.

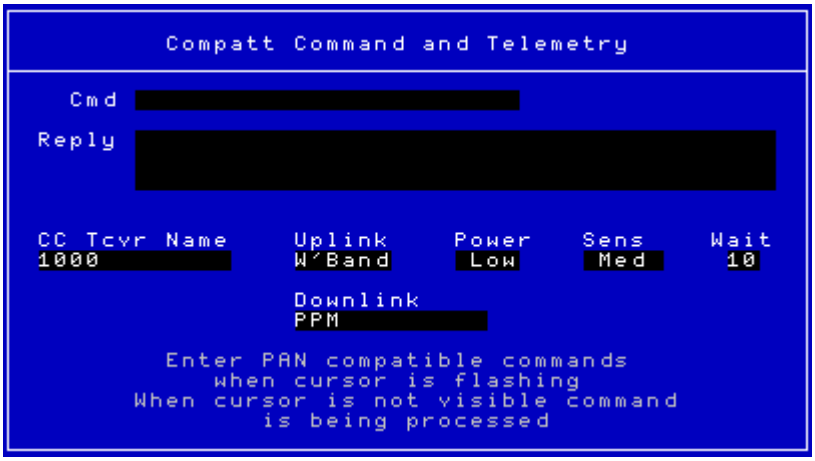
NOTE: If feet are selected, units used are US Survey Feet (3.2808333 feet/m).

9.2.5 Option 5 - "**Compatt Commands**"

This option allows COMPATT commands to be typed in - see Appendix B which lists the COMPATT commands. It is also possible to select the Transceiver used to command and receive the COMPATT telemetry replies, the format and baud rate of the Command "**Downlink**" and Telemetry **"Uplink**" and the Transceiver transmission power level, receive sensitivity and telemetry wait time (see Section 9.4.1).

NOTE: Appropriate Downlink and Uplink settings must be selected

FIG 9.12 COMPATT COMMAND AND TELEMETRY



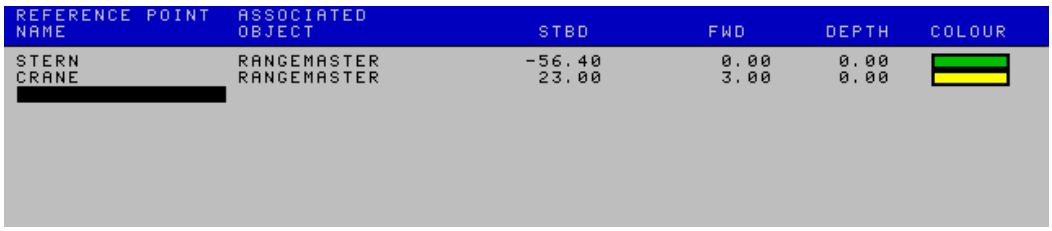
The command is transmitted to the appropriate COMPATT and the telemetered reply decoded and displayed as defined Appendix B**.** Note that, while the system is waiting for a reply to the command, the cursor is not displayed.

This option is useful for checking COMPATT status, battery count, etc, but knowledge of Sonardyne PAN/COMPATT command terminology is necessary, as defined in Appendix B. See also Section 9.2.1.2 and Figure 9.5 which illustrates the "**BEACON SETTING**" page.

9.2.6 Option 6 - "**Object Reference Points**"

Enter the Object "**REFERENCE POINT NAME**" in the highlighted box, as illustrated in Figure 9.13, which follows:-

FIG 9.13 OBJECT REFERENCE DATA ENTRY



Use the right arrow key to move across to the remaining fields, entering the X, Y and Depth co-ordinates of the Object Reference Point (usually the centre of rotation) in the Object local Grid. On entering the colour field, press <ENTER> and a colour menu box appears - choose a display colour and press <ENTER> to confirm.

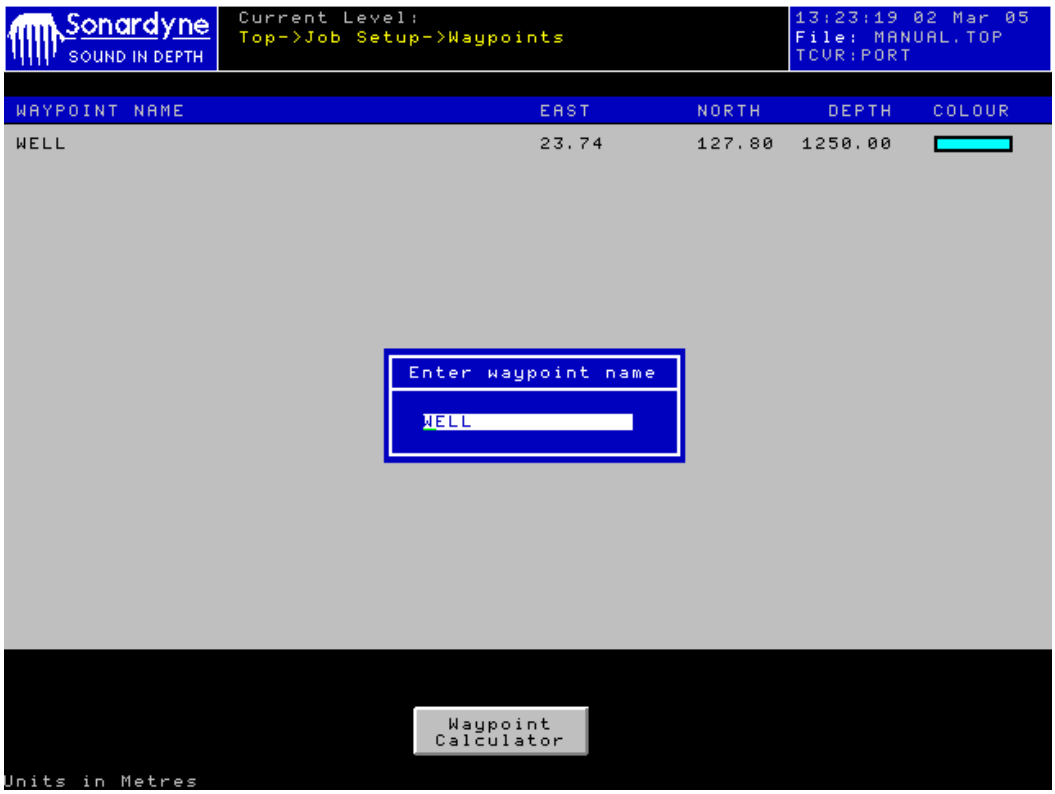
Repeat this procedure for any other Objects (e.g. the Transceiver - or both Transceivers if a Dual-Redundant system). Move the cursor to the blank line below the last "**REFERENCE POINT NAME**" and press <ENTER>. A list of Object names will appear. Select the name to be entered and then complete the data entries for the remaining fields on this line - as described above.

9.2.7 Option 7 -"**Waypoints**"

Activating this option enables a range of Vessel and other reference points to be defined. An integrated function page opens.

This page is illustrated in Figure 9.14:-

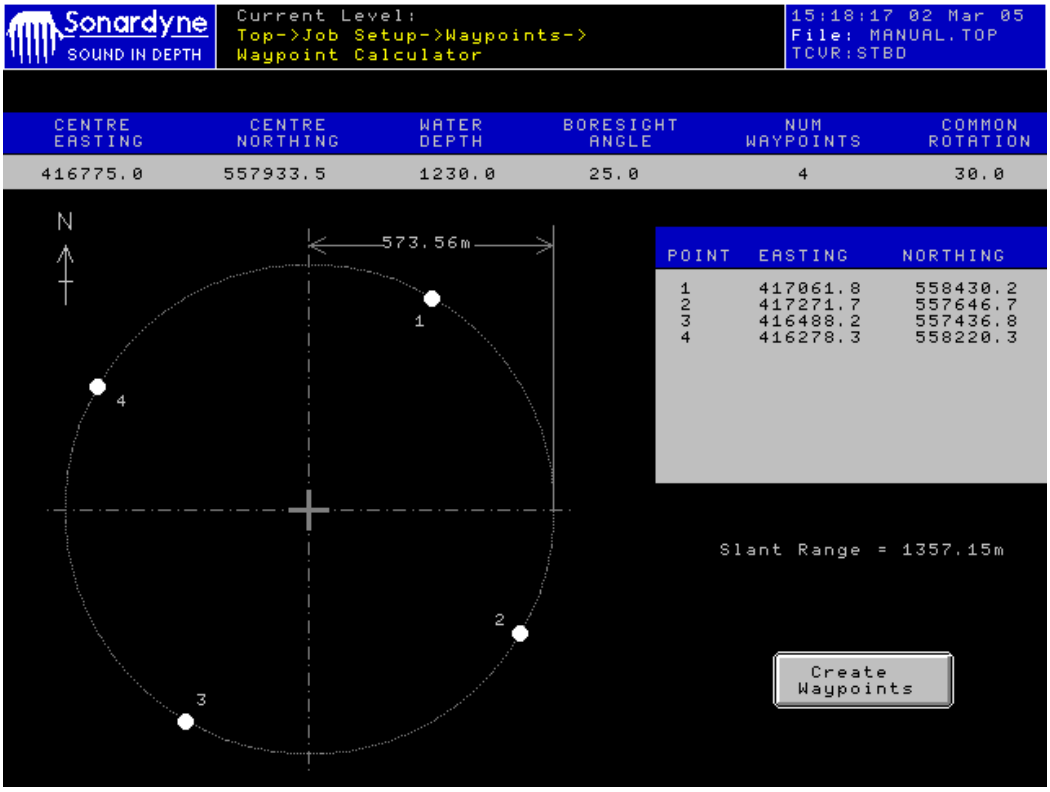
FIG 9.14 WAYPOINTS DATA PAGE



Enter the "**Waypoint Name"** of whichever Mobile Beacon, Reference Beacon or Seabed Waypoint is to be used as a Waypoint in the highlighted box as illustrated in Figure 9.14. Use the right arrow key to move across to the other fields and enter X and Y co-ordinates, Depth and display Colour for the Waypoint. Press <ENTER> on conclusion of all data entry.
Note that the first time DP output is turned on in DP309 format, a Waypoint called "**DP_REF**" is created at the current position of the Vessel. The position reported in DP telegrams thereafter is the position of the Waypoint relative to the Vessel. The colour associated with this Waypoint is black so that it will not appear on the Chart Display. The position of this Waypoint should not be changed. To restart it, delete it - out of Navigation - and allow the system to re-create it at the new position of the Vessel.

- "**Waypoint Calculator**". Pressing the "**Waypoint Calculator**" button displays a page that can be used to determine the relative co-ordinates of Waypoints located at a specified off bore-sight (off axis) angle and orientation from a Vessel mounted USBL Transceiver. This facility is useful for estimating the 'drop positions' of array Beacons to be used for monitoring the position of a DP drilling vessel, or when planning a CASIUS calibration procedure. Six data entry options are available under this heading, as illustrated in Figure 9.15:-

FIG 9.15 WAYPOINT CALCULATOR



- "**CENTRE EASTING**". This is the Easting co-ordinate of the required Vessel position in either local or global earth reference plane co-ordinates in current System Display Units. A value between 0 and ±10,000,000.0 may be entered.

- "**CENTRE NORTHING**". This is the Northing co-ordinate of the required Vessel position in either local or global earth reference plane co-ordinates in current System Display Units. A value between 0 and ±10,000,000.0 may be entered.

- "**WATER DEPTH**". The current depth of Beacon(s) to be deployed on the seabed. A value between 0 and 9,999.0 may be entered in the current System Display Units.

- "**BORESIGHT ANGLE**". This is the required 'off axis' angle in degrees in the vertical plane between the USBL Transceiver and Beacon(s) to be deployed on the seabed.

- "**NUM WAYPOINTS**". This is the number of Waypoints whose co-ordinates will be calculated separated by the appropriate radial angle.

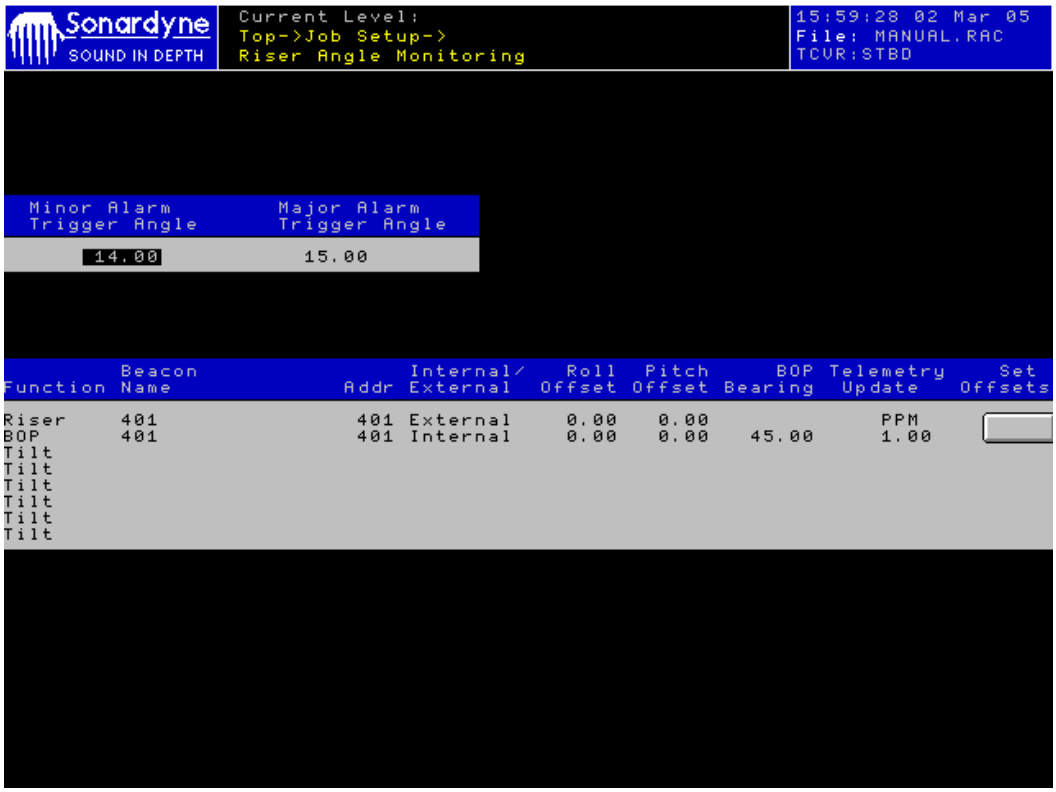
- "**COMMON ROTATION**". This is the orientation in degrees between the Vessel heading and the first Beacon.

Revised co-ordinates for each Waypoint are calculated following each data entry and displayed on the right hand side of a graphical display, together with the radius of the inscribed circle and computed 'Slant Range' to each beacon. Pressing the "**Create Waypoints**" button will cause the computed Waypoint co-ordinates to be entered into the Waypoint database.

9.2.8 Option 8 -"**Riser Angle Monitoring Setup**"

This option applies only to special purpose Riser Angle Compatt (RAC) systems designed to make accurate measurements of the Riser Angle. Alarm limits and a range of RAC parameters may be set. When this option is activated, the screen changes to show an integrated function page, as illustrated in Figure 9.16:-

FIG 9.16 RISER ANGLE MONITORING DATA PAGE



9.2.8.1 **Setting Initial Values**

In the Alarm Limit panel enter the required values for:-

- "**Minor Alarm Trigger Angle**" ('cautionary' limit). The system compares the Riser Angle measured by the Riser Angle Compatt with this limit value and, if exceeded, triggers a Level 2 System Alarm. This Limit Angle should be set initially to 14°. [Once the 'Pitch and Roll Offsets' have been collected - see later -, this angle is set, typically, to 0.5°].

- "**Major Alarm Trigger Angle**" ('failure imminent' limit, triggering a Level 1 System Alarm). Alarm Limit 2 defines the larger of the two Alarm Circles on the display. This Limit Angle should be set initially to 15°. [Once the 'Pitch and Roll Offsets' have been collected - see later -, this angle is set, typically, to 1.0°].

Eight other parameters should be entered in the lower panel, as follows. Go through this procedure twice, firstly for the "**Riser"** and then for the "**BOP**", highlighting each field in turn.

- "**Function**". This refers to the function being performed by the COMPATT concerned. The entries in this column ("**Riser"** or "**BOP**" - Blow Out Protector) are fixed by the system. The six "**Tilt**" entries allow the system to be configured to monitor the tilt of a Riser at up to six points of interest using COMPATTS fitted with inclinometers. (**NOTE:** Care has to be taken in aligning the beacons to the BOP alignment).

- "**Beacon Name**". Move the cursor to the "**Beacon Name**" column on the "**Riser**" row and press <ENTER>. A list of Riser Angle Beacons already defined for positioning via the Nav Setup page will appear. Highlight the Beacon name applicable to this Riser - in some installations, the "Beacon" fitted here will be an external slave Inclinometer Unit connected to the COMPATT being used on the BOP, as illustrated in Figure 9.16.

  - On the **BOP** pass:

    On the second pass through this procedure, enter the Beacon name applicable to the BOP - it may be an external slave Inclinometer Unit in some installations connected to the COMPATT being used on the Riser.

- "**Internal/External**". If the Beacon is a COMPATT, enter "**Internal**". If it is a slave Inclinometer Unit connected to a COMPATT, enter "**External**".

> **NOTE:** The RAC facility computes and displays the differential angle between the Riser and BOP. If a single RAC is mounted on the BOP or Riser with internal and external sensors, the system will request the BOP angle using acoustic telemetry and measure the differential angle by pulse position during each navigation cycle; it then estimates the riser angle. With separate RACs mounted on the BOP and Riser and used in normal RAC mode (interrogated on it's HPR or CIF channel), the system will determine both Riser and BOP angles by pulse position as part of each navigation cycle and deduce the differential angle. However, when a RAC is configured to be interrogated on it's IIF signal channel it does not send the angles by pulse position and has to be configured to collect angles via acoustic telemetry at a specified rate, as would be the case with standard COMPATTS fitted with inclinometer sensors.

- "**Roll Offset**". Enter a Roll offset value of zero at this stage. Correct values will be entered later once offsets have been collected.

- "**Pitch Offset**". Enter a Pitch offset error of zero at this stage.

- "**BOP Bearing**". Leave a blank in the "**Riser"** row. In the "**BOP**" row, enter the bearing (in degrees) of the Beacon inclinometer Roll axis relative to seabed grid North. Thus, if the Roll axis of the Beacon is pointing to starboard of North, enter a number between 0 and 180 degrees, as appropriate, etc.

- "**Telemetry Update**". This is the frequency at which it is required to update the BOP angle - in minutes. In the "**BOP**" row, set this value initially to 1 minute (once offsets have been collected, it is recommended that this value should be increased to at least 60 minutes as a regular check of the BOP attitude).

Having set initial values on this page, press <ESC> twice to return to the top level menu. This will save all settings to the Job File.

9.2.8.2 Measuring Offsets

Offsets are measured by deploying the BOP and Riser at a sufficient depth (say 100 metres / 300 feet) below the Rig where it can be assumed that the system is hanging vertically.

Once this has been done, select "**Navigate**" and return to the "**Riser Angle Monitoring page**", move the cursor to the "**Set Offsets**" button and press <ENTER> and let the system run for five minutes to stabilise.

The system will compute the differential Pitch and Roll angles between the Riser and BOP at the update rate specified for the Riser Angle Beacons on the "**Nav Setup**" page and use telemetry once per minute to collect values for the BOP Pitch and Roll angles. When sufficient measurements have been collected, the average values for these offsets will be calculated and entered automatically on the job database and the updated offset values appear in the "**Roll**" and "**Pitch**" columns on this page.

9.2.8.3 Entering Final Data

Make the following entries on the "**Riser Angle Monitoring**" page:-

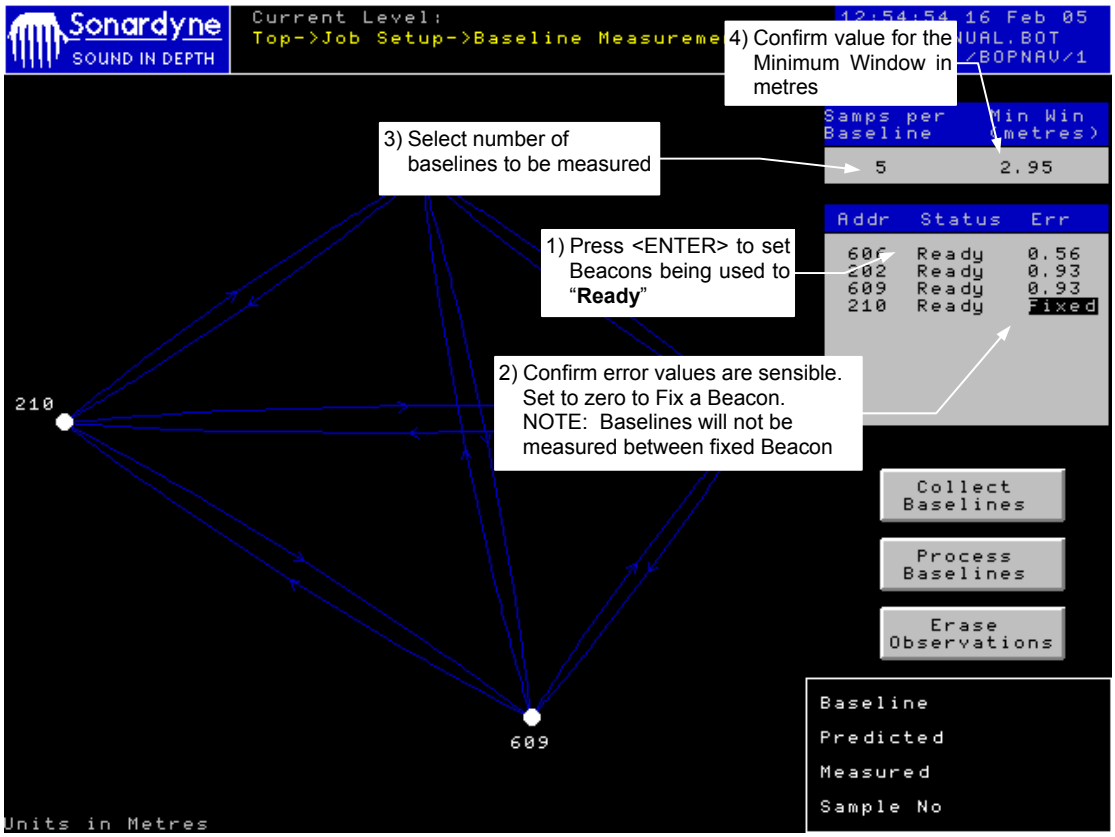
- Change the "**Alarm Trigger Angle**" values to the required angles (typically 0.5° for the "**Minor Alarm**" and 1.0° for the "**Major Alarm**").
- Enter a "**Telemetry Update**" to the required value (typically 60 minutes) as a regular check of the BOP attitude.

The system is now set up ready for use once the BOP and Riser have been fully deployed.

9.2.9 Option 9 - "**Array Baseline Measurements**"

Selecting this option allows an accurate relative array calibration to be completed using the baselines measured between selected COMPATTS. The "**Array Baseline Measurement**" method assumes that reliable COMPATT command reception and telemetry response can be achieved from the vessel to all the COMPATTS being calibrated from a central location within the array. The system will automatically configure each COMPATT in turn to the correct state for taking baseline measurements, re-setting the COMPATTS back to their original Navigation settings. When this option is activated, the screen changes to show an integrated function page, as illustrated in Figure 9.17:-

FIG 9.17 ARRAY BASELINE MEASUREMENT PAGE



9.2.9.1 **Display**

The display shows all the Reference Beacons included in the database in their correct relative positions with those set to "**Ready**" in bold.

9.2.9.2 **Baseline Parameters**

"**Samples per Baseline**". Move the cursor to the "**Samps per Baseline**" window on the baselines parameters box and press <ENTER>. Enter the number of times the baseline measurement is to be repeated (1 to 50).

"**Minimum Window**". Move the cursor to the next field in the baselines parameters box and press <ENTER>. This parameter defines the minimum difference in the selected units between the slant range computed between any two beacons using the initial co-ordinates and the measured baseline. Any values outside this window will be rejected and the baseline measurement repeated. This window is used to reject multipath measurements and is set to a minimum default value of +/- 4 milliseconds (two-way travel time). It gets over-ridden by a window that is set to 2% of the slant range measured from the centre of the baseline between the beacons on the surface, which is added to the 'position error' of the individual beacons. Only if the result of the above falls below the minimum value does that window get applied.

9.2.9.3 **Selected Beacons**

"**Status**". Move the cursor to the "**Status**" column in the Beacon summary box and press <ENTER>. Highlight the required status ("**Ready**" or "**Offline**") to select the Beacons between which it is required to measure baselines.

"**Err**". The error figure refers to the expected accuracy of the initial beacon co-ordinates. The value will normally be the position 'repeatability' determined during a 'Top Down' calibration. If an array calibration is to be carried out using 'Baseline Measurements', the 'Top Down' calibration should have been stopped when the "**POS ERROR**" figures* were just under 1% of the slant range measured from the vessel to the beacons.

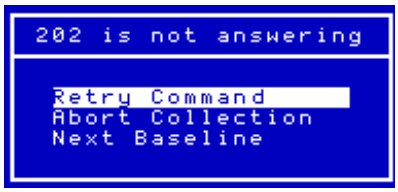
NOTE: * The co-ordinates of any Beacon with the error set to zero will be held Fixed during the calibration adjustment.

9.2.9.4 **Baseline Measurement**

Move the cursor to the "**Collect Baselines**" box and press <ENTER>. The system will set up each selected beacon in turn to the correct state* for taking baseline measurements **to** that beacon. The requisite number of baseline measurements will then be taken **from** each of the other selected COMPATTS in turn **to** that beacon, with each new measurement being indicated by a yellow line drawn between the Beacons.

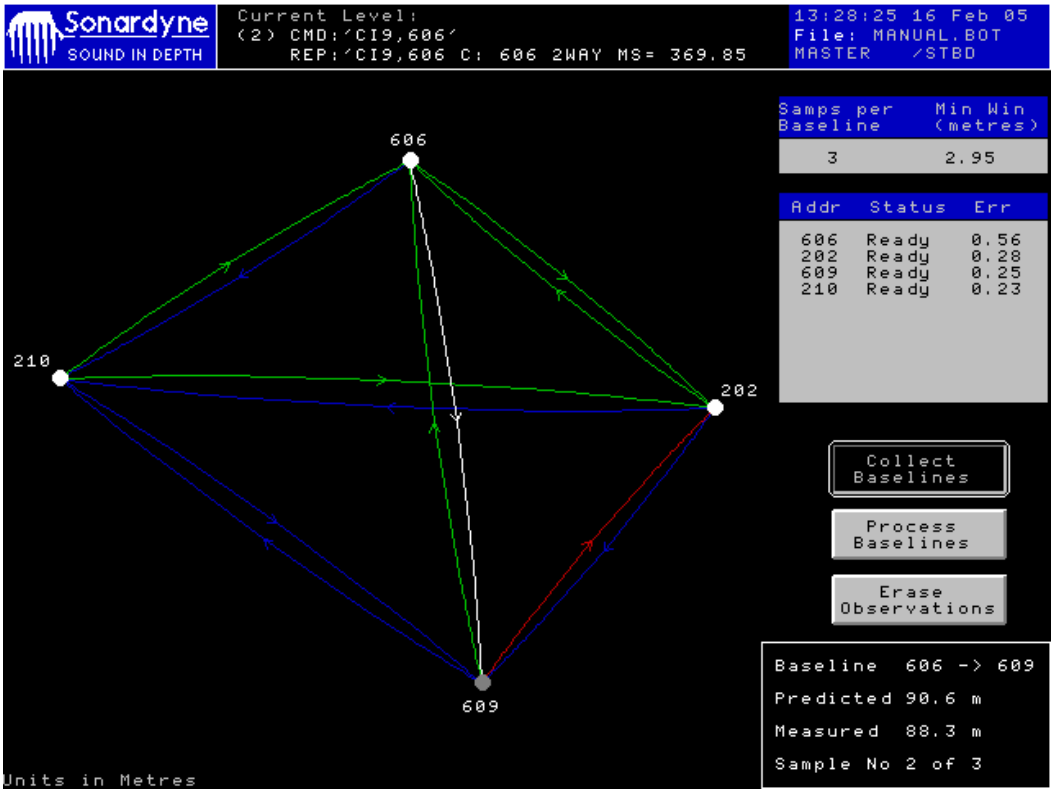
NOTE: *Only Sonardyne digital transceivers and beacons support wideband operation, while analogue transceivers and beacons are still supported in tone mode. All digital beacons will be configured automatically by the system to use tone signals when making baseline measurements, with the beacons being re-set back to their original settings required for Navigation.

The appropriate COMPATT commands and telemetry replies will be displayed in the top menu box. The baseline being measured will be indicated in the baseline summary box on the display together with (a) the "**Predicted**" value calculated from the initial array co-ordinates, (b) the "**Measured**" value and (c) the current "**Sample**" number. Baseline measurements will be repeated if the measured value falls outside the minimum window compared with the predicted value or (a) if Telemetry Errors, (b) a No Reply or (c) a Zero Baseline Measurement is reported. The measurement will be repeated up to three times after which a warning prompt will be displayed, as illustrated in the panel to the right.



The baseline being measured will be displayed in white, failed measurements in Red and baseline measurements completed in both directions between any two selected Beacons indicated by a green colour on the display, as illustrated in Figure 9.18. When the required number of baselines have been measured to a COMPATT, the system will re-set the COMPATT back to its Navigation configuration before moving onto the next Beacon.

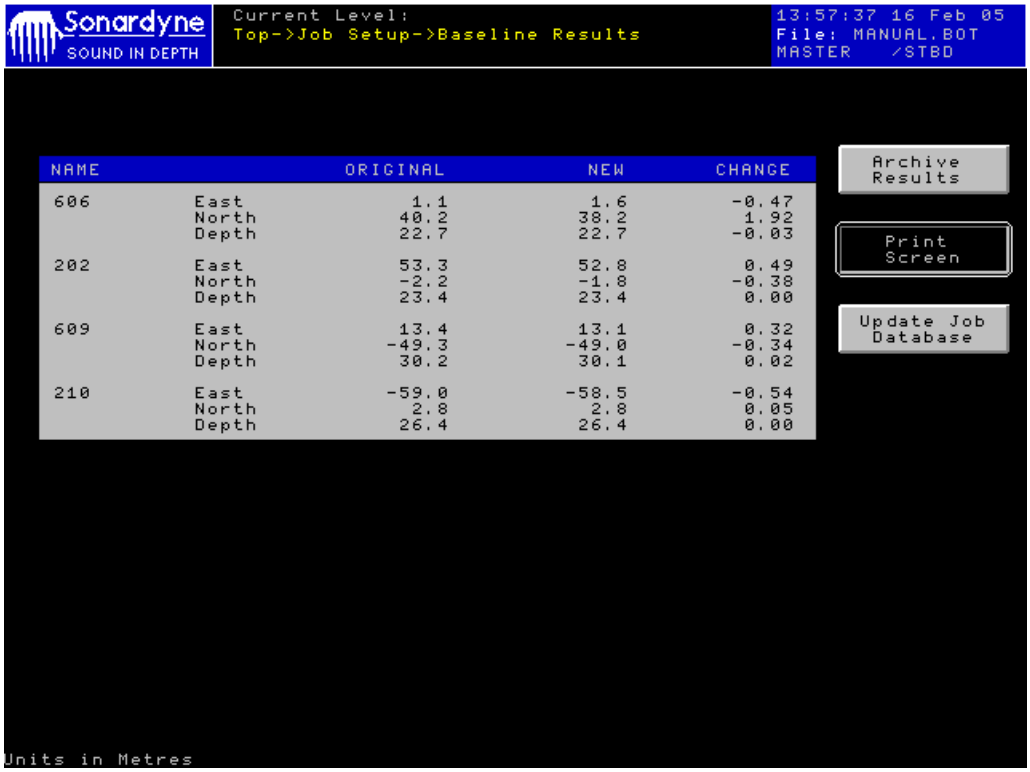
FIG 9.18 BASELINE MEASUREMENT STATUS



9.2.9.5 Calibration Adjustment

Once all the baselines have been measured, (either one-way or two-way) select "**Process Baselines**" and press <ENTER> to process the data. The results of the array adjustment will then be displayed, as illustrated in Figure 9.19, which follows:-

FIG 9.19 CALIBRATION RESULTS PAGE



The system displays the Beacon name, the original co-ordinates and the new co-ordinates using the baseline measurements, together with the amount by which each co-ordinate has changed. The following options are available:-

- "**Archive Results**". Move the cursor to the appropriate window and press <ENTER>. The system will request the operator to insert a disc into the floppy disc drive. A detailed baseline report will be copied to a text file for inspection using a suitable program. This includes the measured baselines and the output from the least squares adjustment showing any baseline measurements which have been rejected. Raw binary data files are also archived to the floppy disc which can be sent to Sonardyne for analysis if required.

- "**Print Screen**". Moving the cursor to the appropriate window and pressing <ENTER> will permit an operator to copy the results of the baseline calibration to a bitmap.

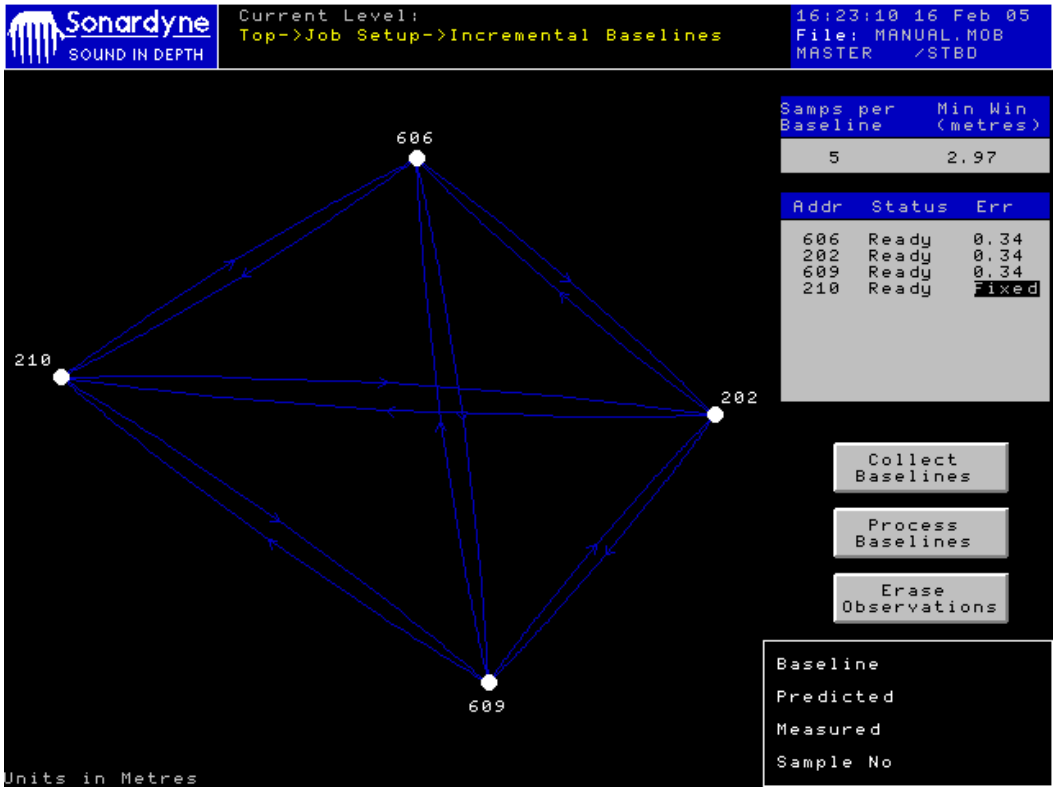
- "**Update Job Database**". Moving the cursor to the appropriate button and pressing <ENTER> will update the current Job database with the results of the baseline calibration.

9.2.10 Option 10 - "**Incremental Baseline Measurement**"

Selecting this option allows an accurate relative array calibration to be completed using the baselines measured between selected Mk4 Compatts configured into an HPR mode. The baselines are collected in an incremental manner. This method allows the operator to specify the Mk4 Compatts between which baselines will be measured and also to specify the Mk4 Compatts to be used in the least squares adjustment. This method is used when it is not possible to send commands and receive telemetry from all the array Mk4 Compatts from one vessel location. The method assumes that each Beacon will be deployed one at time and that their initial drop co-ordinates will be determined in UTM co-ordinates (using the vessel USBL transceiver) before moving onto the next Beacon. Following the deployment of the second and subsequent Beacons, the 'one-way' baselines are measured **from** the Beacon being deployed **to** the previously deployed Beacons.

When this option is activated, the screen changes to show an integrated function page, as illustrated in Figure 9.20:-

FIG 9.20 INCREMENTAL BASELINE MEASUREMENT PAGE



9.2.10.1 **Display**

The display shows all the Reference Beacons included in the database in their correct relative positions with those set to "**Ready**" in bold.

9.2.10.2 **Baseline Parameters**

- "**Samples per Baseline**". Move the cursor to the "**Samps per Baseline**" window on the baselines parameters box and press <ENTER>. Enter the number of times each baseline is to be measured (1 to 50).

"**Minimum Window**". Move the cursor to the next field in the baselines parameters box and press <ENTER>. This parameter defines the minimum difference in the selected units between the slant range computed between any two beacons using the initial co-ordinates and the measured baseline. Any values outside this window will be rejected and the baseline measurement repeated. This window is used to reject multipath measurements and is set to a minimum default value of +/- 4 milliseconds (two-way travel time). It gets over-ridden by a window that is set to 2% of the slant range measured from the centre of the baseline between the beacons on the surface, which is added to the 'position error' of the individual beacons. Only if the result of the above falls below the minimum value does that window get applied.

9.2.10.3 **Selected Beacons**

- **Status**. Move the cursor to the "**Status**" column in the Beacon summary box and press <ENTER>. Highlight the required status ("**Ready**" or "**Offline**") to select the Beacons between which it is required to measure baselines.

- **Err**. The error figure refers to the expected accuracy of the initial beacon co-ordinates. The value will normally be the position repeatability determined during a 'Top Down' calibration If an array calibration is to be carried out using 'Incremental Baseline Measurements', the Top Down calibration should have been stopped when the "**POS ERROR**" figures were just under 1% of the slant range measured from the vessel to each beacon*. It is important to note that baselines will only be measured **to** Beacons which have been set to "**Ready**".

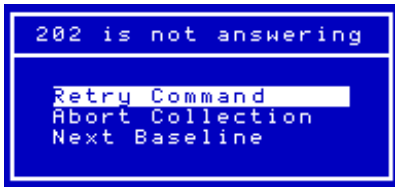
  NOTE: * The co-ordinates of any Beacon with the error set to zero will be held Fixed during the calibration adjustment.

9.2.10.4 Baseline Measurement

Move the cursor to the "**Collect Baselines**" box and press <ENTER>. The system will prompt the operator for the Beacon being used as the "**Interrogator**" - place the cursor on the correct Beacon and press <ENTER>.

The system will then proceed to measure the requisite number of baseline measurements **from** the Interrogator **to** each of the other selected M4 Compatts in turn, with each new measurement being indicated by a yellow line drawn between the Beacons.

The appropriate COMPATT commands and telemetry replies will be displayed in the top menu box. The baseline being measured will be indicated in white on the display and in the baseline summary box on the display together with (a) the **"Predicted**" value calculated from the initial array co-ordinates, (b) the "**Measured**" value and (c) the current "**Sample Number**". Baseline measurements will be repeated if the measured value falls outside the minimum window compared with the predicted value or if (a) Telemetry Errors, (b) a No Reply or (c) a Zero Baseline Measurement is reported. The measurement will be repeated up to three times after which a warning prompt will be displayed, as illustrated in the panel.

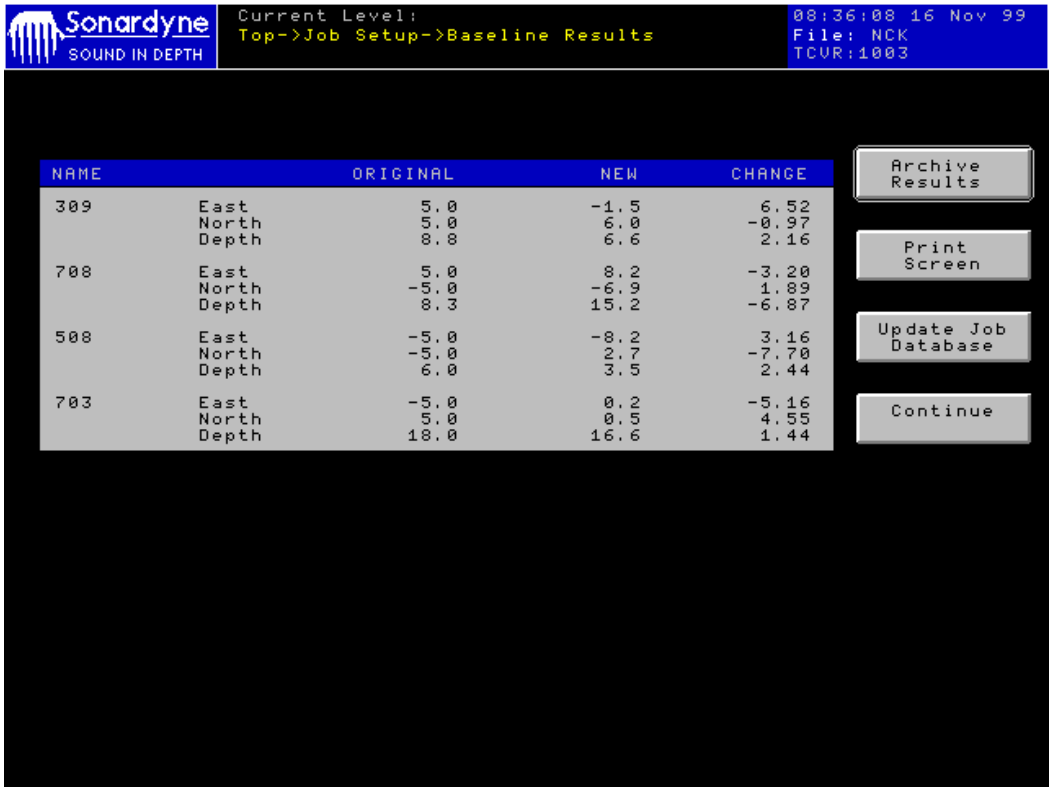


Completed baseline measurements are indicated on the display by a green colour and failed measurements in a red colour. When the required number of baselines has been measured **from** the Interrogating Mk4 Compatt to all the other selected Beacons, the system will return to the "**Incremental Baselines**" page, having stored all the baseline measurements to the current Job File. At this stage the calibration adjustment can be run using the baseline measurements already collected, or the system returned to Navigation ready to deploy the next Mk4 Compatt and the baseline measurement process repeated.

9.2.10.5 Calibration Adjustment

Once all the baselines have been measured, (either one-way or two-way) the data can be processed by placing the cursor over the "**Process Baselines**" button and pressing <ENTER>. The data will be automatically processed and the results of the array adjustment will then be displayed, as illustrated in Figure 9.21, which follows:-

FIG 9.21 CALIBRATION RESULTS PAGE



The system displays the Beacon name, the original co-ordinates and the new co-ordinates using the baseline measurements together with the amount by which each co-ordinate has changed. The following options are available:-

- "**Archive Results**". Move the cursor to the appropriate window and press <ENTER>. The system will request the operator to insert a disc into the floppy disc drive. A detailed baseline report will be copied to a text file for inspection using a suitable program. This includes the measured baselines and the output from the least squares adjustment showing any baseline measurements which have been rejected. Raw binary data files are archived to the floppy disc which can be sent to Sonardyne for analysis if required.

- "**Print Screen**". Moving the cursor to the appropriate window and pressing <ENTER> will permit an operator to copy the results of the baseline calibration to a bitmap.

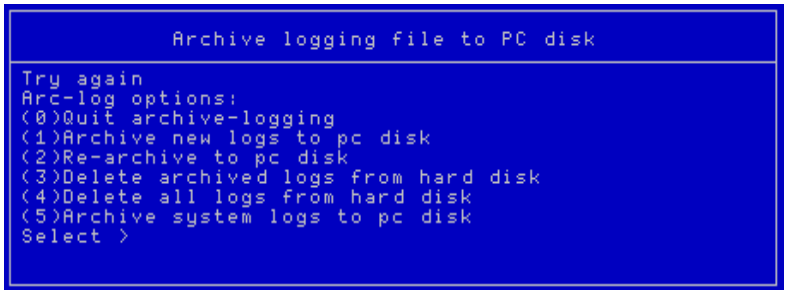
- "**Update Job Database**". Moving the cursor to the appropriate button and pressing <ENTER> will update the current Job database with the results of the baseline calibration.

9.3 JOB FILE MANAGEMENT OPTIONS

The options available under this main menu heading are as follows:-

- "**Select Job**". Choose any stored Job File to be the Current Job File.
- "**Create New Job**". Activate this option if it is required to create a completely new Job File on the hard disc. On activating this option, the user will be prompted for a description. Type in a description and press <ENTER>. Press <ESC> twice to return to the top level menu. The new Job File automatically becomes the current Job File.

  Select "**Job Setup**" followed by "**Navigation Setup**". Enter Beacons as required. For each new Beacon, check the Beacon Setting Page - see Figure 9.5.
- "**Delete Job**". Delete an existing Job File on the hard disc.
- "**Copy Job**". Copy a Job File on the hard disc to another on the hard disc. This allows the operator to save a known working Job before modifying it.
- "**Archive Job**". Archive a Job File by copying a file from the hard disc to a floppy disc in a file format of your choice.
- "**Restore Job**". Restore a Job File by copying a file from a floppy disc to the hard disc. This file automatically becomes the current job file.
- "**Archive Install files to PC disc**". Copy Installation File(s) to a floppy disc (in PC text format) if it is required to edit specific fields.
- "**Restore Install files from disc**". Restore Installation File(s) from an external PC format floppy disc. It is best to carry out a reboot following a 'Restore' of an Installation file.
- "**Archive logging file to PC disc**". The system continuously logs data to the hard disc. On selecting this menu option, the user is presented with different choices to copy the most recent data to a PC-formatted floppy disc in CSV (Comma Separated Variable) format, as illustrated in the following panel.



Data in this format is readily imported into, for example, a spreadsheet such as Sonardyne's V6 analysis facility <PLOT_CSV>, which is available on one of the system Installation Discs.
The final option "**Archive system logs to PC disc**" should be used when reporting technical or operational problems to Sonardyne.

More information on the logging output from the system is given in Appendix E.

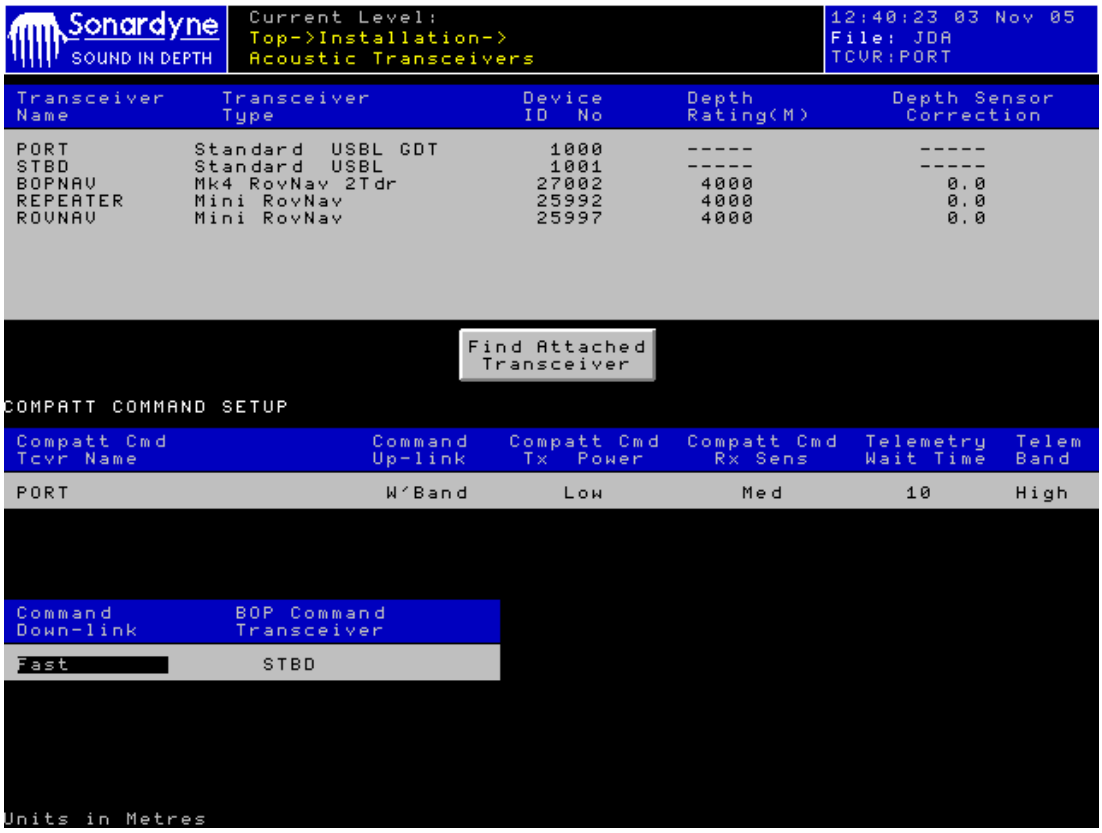
- "**Duplicate Installation Discs**". Creates duplicates of the system Installation Discs so that they can be used as the working copies.

9.4 INSTALLATION OPTIONS

9.4.1 Option 1 – "**Acoustic Transceivers**"

On selecting this option, an integrated function page opens, as illustrated in Figure 9.22 - shown here in BOP Control configuration. Check and/or enter the required Transceiver parameters as described in the following:-

FIG 9.22 ACOUSTIC TRANSCEIVERS DATA PAGE



Enter the following parameters:-

- "**Transceiver Name**". Move the cursor to the next blank row and type in any required name for the Transceiver.

- "**Device ID Number**". Enter the 'Device Number' for the Transceiver - as written on the label on the Transceiver housing. This will then determine the transceiver description displayed in the "**Transceiver Type**" column.

  NOTE: The "**Find Attached Transceiver**" button can be used to find the 'Device Number' for a Transceiver if only one is attached to the system.

- "**Depth Rating (M)**". Enter the depth rating for the Transceiver in metric units. (Relevant to Mini ROVNav, Mk4 ROVNav and BOPNav transceivers only).

- "**Depth Sensor Correction**". Where applicable, enter the depth sensor correction for the Transceiver. (Relevant to Mini ROVNav, ROVNav and BOPNav transceivers only).

On this page also, enter the following parameters:-

- "**Compatt Cmd Tcvr Name**". If more than one Transceiver in use, press <ENTER> and select the one which is to act as the command unit.

- "**Telemetry Receiver**". If more than one Transceiver in use, press <ENTER> and select the one which is to act as the telemetry receiver unit.

- "**Command Up-link**". Three Command up-link baud rates are available for Mk3 and Mk4 Compatts ("**Fast**", "**Normal**" and "**Slow**") - set to "**Normal**" in most circumstances. A much faster baud rate is available for Mk5 Compatts using the "**Wideband**" data link, which should be selected in most circumstances.

  NOTE: The user will be warned by the system to change the Command Up-link from "**Wideband**" when entering a Mk4 Compatt in "**Navigation Setup**".

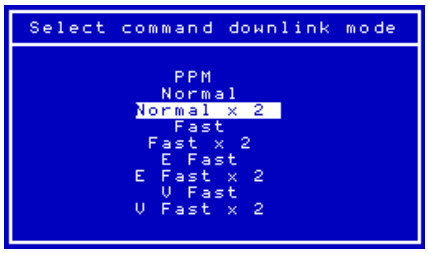
- "**Compatt Cmd Tx Power**". Set to "**High**" unless other acoustic systems are operating in the area and there is a risk of interference. This is the Transceiver transmit power for sending COMPATT commands.

- "**COMPATT Cmd Rx Sensitivity**". Set to High unless operating in a noisy acoustic environment. (This is the Transceiver gain for receiving COMPATT telemetry – four levels available).

- "**Telemetry Wait Time**". This is the time the system will wait for a reply after transmitting a command. The system takes account of Turn-Around-Time and other delays. The entry made here must take account of the slant range of the Transponder furthest away from the Transceivers.

- **"Telem Band**". This is the frequency band that is used for receiving COMPATT telemetry replies and depends on the COMPATT type. The default setting is "**High**", which applies to all COMPATTS, with the exception of Type 7928–02 Switched Beam types used in water depths of 7,000 metres.

- **"Command Down-link**". On selecting this option, the user is presented with the choices illustrated in the following panel when using a GDT Transceiver. The different command modes are arranged in order of speed with the slowest at the top. The fastest option that works reliably should be selected, working up the list as necessary until reliable communications is achieved.



- "**BOP Command Transceiver**". If the system is being used for BOP control, this panel will appear - as illustrated in Figure 9.22. If so, move the cursor down to this panel and press <ENTER>. Select the Transceiver which is to be used as the BOP Command Transceiver from the list which appears.

Deploy each Transceiver into its working position. The position of the Transceiver acoustic transducer(s) (the centre of the transducer face on a L/USBL transceiver) should be measured in the local Object grid and the data entered using this menu option on the "**Object Setup**" page (Section 9.2.1.4). This data will usually be derived from tape measurements and Vessel (or other Objects) drawings, but if possible a rigorous survey should be performed. A CASIUS calibration can be used to confirm any vessel based offsets that maybe in doubt (see Section 7.4).

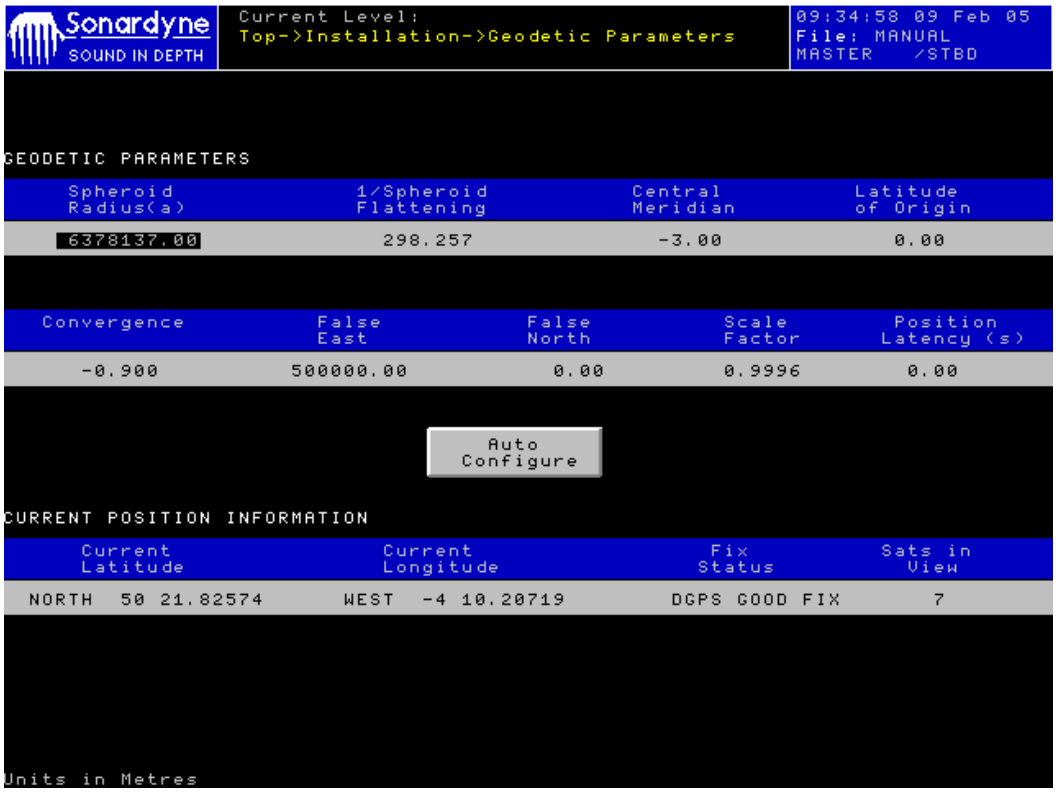
9.4.2 Option 2 – "**Geodetic Parameters**"

Ignore this Section if no DGPS system is fitted.

On selecting the "**Geodetic Parameters**" option, an integrated function page opens, as illustrated in Figure 9.23 - which follows:-

NOTE: This procedure should only be attempted by a fully qualified DGPS operator.

FIG 9.23 GEODETIC PARAMETERS DATA PAGE



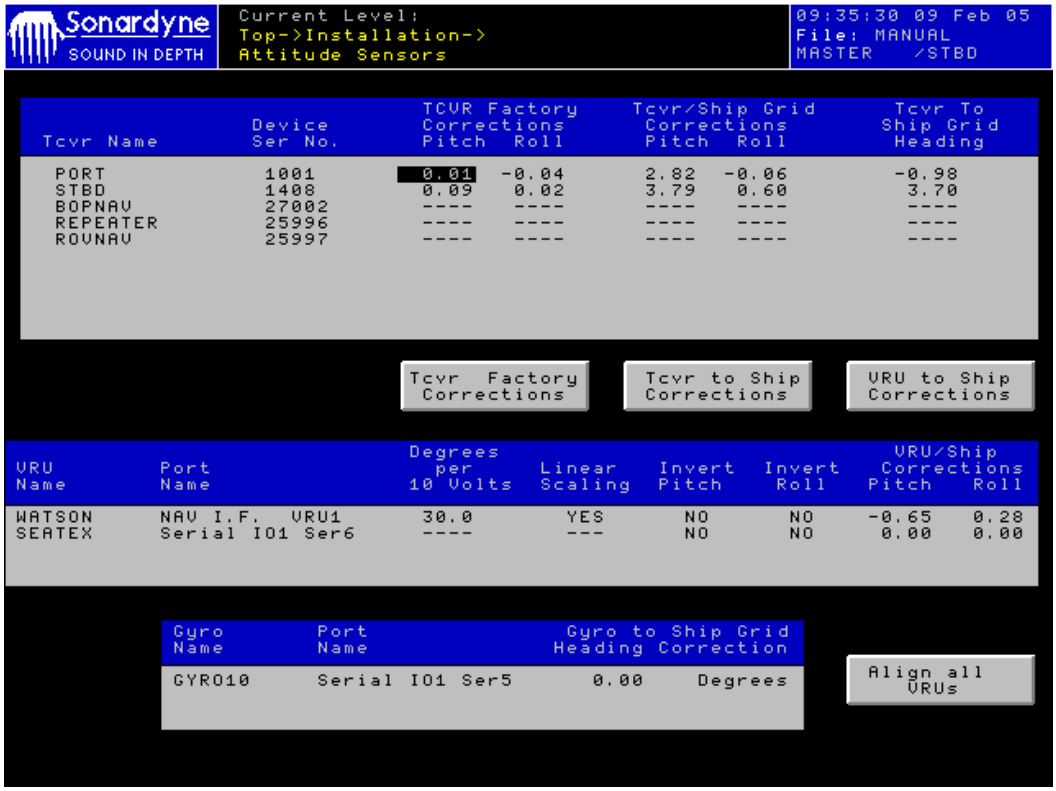
Default settings on this page assume WGS 84 is being used (applies particularly to "**Spheroid Radius**" and "**Spheroid Flattening**"). With the system reading in the "**CURRENT POSITION INFORMATION**" in a WGS 84 format, move the cursor to the "**Auto Configure**" button and press <ENTER>. The system will automatically update the relevant fields with the correct values. If WGS 84 is not being used, the values must be adjusted to suit the co-ordinate system in use.

If other values have to be changed, new data will be provided by the customer. These values, converted if necessary to the current System Display units, should be entered in the appropriate columns of the page.

9.4.3 Option 3 - "**Attitude Sensors**"

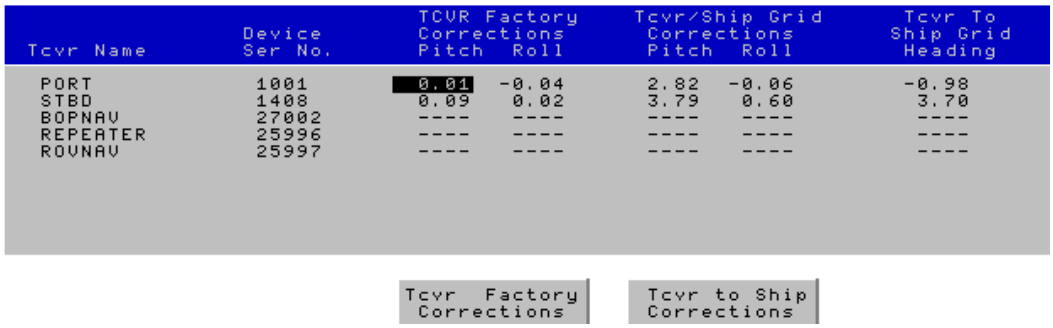
On selecting the "**Attitude Sensors**" option, an integrated function page opens, as illustrated in Figure 9.24 - which follows:-

FIG 9.24 ATTITUDE SENSORS DATA PAGE



9.4.3.1 **Transceiver Corrections Panel**

FIG 9.25 TRANSCEIVER CORRECTIONS PANEL



- "**TCVR Factory Corrections**" - "**Pitch**" and "**Roll**". Before installing the Transceiver on board a vessel, values for the Transceiver's internal Pitch and Roll corrections must be entered. These corrections are used to ensure that the Transceiver's Pitch and Roll outputs are accurate. In many cases, these correction values may be read from the label on the housing.

  If, however, there is any doubt about this, the "**Tcvr Factory Corrections**" test procedure should be run.

  Before running the test, the "**Pitch**" and "**Roll**" corrections should be set to zero on this page.

The Transceiver is then placed on a static (that is not on board a floating vessel), smooth surface and the procedure run by moving the cursor to the "**Tcvr Factory Corrections**" button and pressing <ENTER>.

The Transceiver is turned through 180°, when instructed to do so by the procedure. The test then continues until complete. The correction values calculated by the procedure can be entered automatically in the Pitch and Roll columns.

- "**Tcvr/Ship Grid Corrections**" - "**Pitch**" and "**Roll**". These corrections adjust for the physical mounting angle of the Transceiver relative to the vessel grid, when installed in its working position. (CASIUS, an application available from Sonardyne, is a very effective and more accurate way of determining these corrections - see Section 7.4.3.)

The 'internal' correction procedure is similar in principle to the "**TCVR Factory Corrections**" procedure above. Before running the procedure, the Transceiver has to be installed in its working position with its local North axis aligned with the lubber line of the vessel.

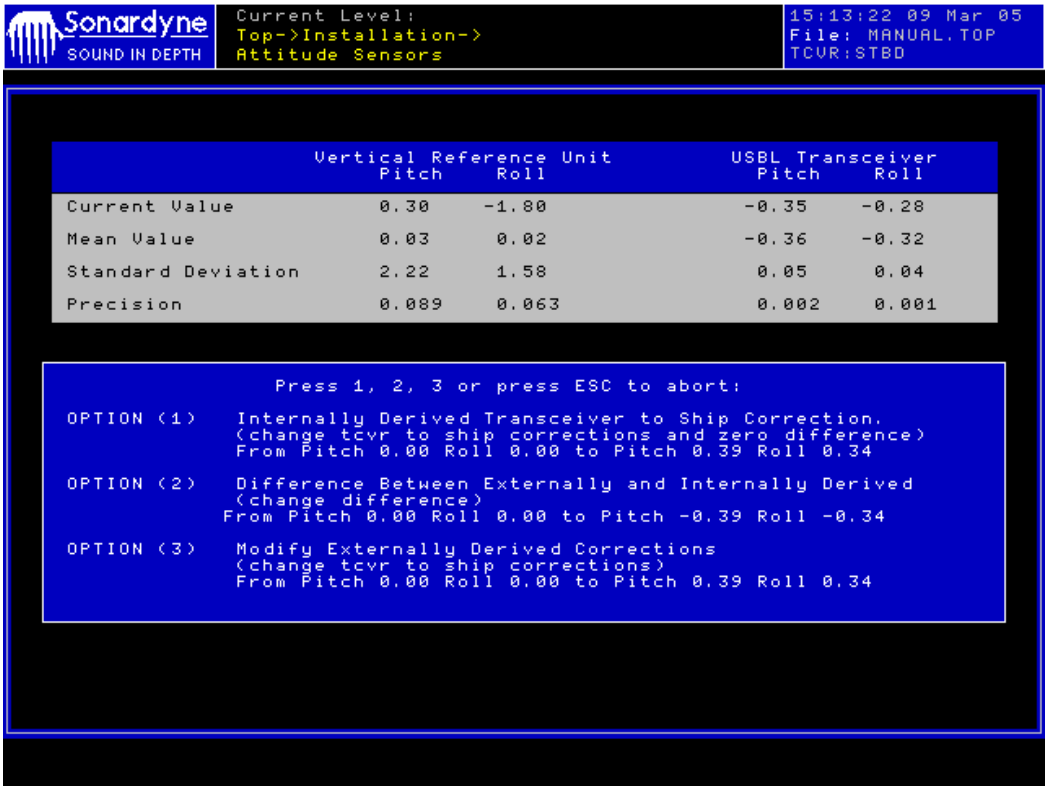
Before starting this procedure, the correct "**Tcvr to Ship Grid Heading**" value has to be entered on this page - see next.

The procedure is run by moving the cursor to the "**Tcvr to Ship Corrections**" button and pressing <ENTER>. If more than one L/USBL Transceiver is installed a highlighted "**Select Transceiver**" box is displayed as illustrated in panel to the right:

Place the cursor on the required Transceiver and press <ENTER>. If more than one VRU is interfaced, the system will then display a highlighted "**Select a VRU**" box - place the cursor on the required VRU and press <ENTER> to run the calibration. The procedure calculates the corrections that should be applied to the VRU data to determine the true Pitch and Roll of the Transceiver frame. Simultaneous measurements are taken from the Pitch and Roll sensors in the Transceiver and from the VRU. Because the Transceiver's Pitch and Roll sensors are subject to acceleration-induced error, a number of measurements are taken, spread over a short period. The "**Current**" and "**Mean**" values for each sensor, together with the "**Standard Deviation**" and "**Precision**" of the measurements and a progress bar displayed. When completed, the correction values calculated by the procedure will be displayed, as illustrated in Figure 9.26.

NOTE: When using a Tilted Transceiver to track USBL targets at large horizontal offsets behind a vessel, such as a towed geophysical sensor, the offset angle has to be allowed for. The offset angle (typically 30 degrees) will be entered under the "**Trcvr/Ship Pitch Correction**" as a positive value if the tilt has achieved by inserting a tilt adaptor between the Transceiver and the deployment pole. In this case the internal tilt sensors are also offset and will measure directly the 'Transceiver to Ship' corrections when compared to the VRU. On the other hand, if the tilt adaptor has been inserted between the USBL transducer array and the transceiver electronics, the tilt sensors will not be tilted. In this case a "**TCVR Factory Pitch Correction"** of +30 degrees needs to be applied to make the tilt sensors measure the correct attitude of the transducer array.

FIG 9.26 ATTITUDE SENSORS CALIBRATION PAGE



The following three calibration options are available:-

- "**OPTION (1)**". Used when no CASIUS derived corrections have been entered in the "**Tcvr/Ship Grid Corrections**" field. It determines any misalignment between the Transceiver and the Ship Grid using the internal attitude sensors.

- "**OPTION (2)**". Used immediately following a CASIUS calibration after the CASIUS derived corrections have been entered in the "**Tcvr/Ship Grid Corrections**" field. It determines the difference between CASIUS corrections and the internal attitude sensors.

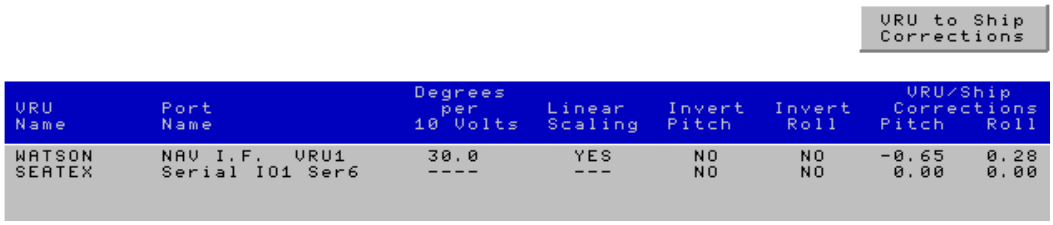
- "**OPTION (3)**". Used after CASIUS derived corrections have been entered in the "**Tcvr/Ship Grid Corrections**" field whenever the transceiver pole has been raised and lowered. The procedure calculates the Transceiver to Ship Grid corrections as in option 1 and then corrects for the difference values derived using option 2.

Any correction values calculated by the procedure will be automatically entered in the "**Tcvr/Ship Grid Corrections Pitch**" and "**Roll**" columns on the "**Attitude Sensors**" page after selecting the required option.

- "**Tcvr to Ship Grid Heading**". This correction is used to eliminate any misalignment in Heading that the Transceiver may have, relative to the vessel grid, when installed in its working position. A simple procedure for deriving this value is included in the USBL Installation and Maintenance Manual. CASIUS, an application available from Sonardyne, is a very effective and accurate way of determining this correction - see Section 7.4.3.

9.4.3.2 VRU Data Panel

FIG 9.27 VRU DATA PANEL



- "**VRU Name**". Move the cursor to the correct row and type in any required VRU name.

- "**Port Name**". Although Figure 9.27 shows the two VRUs using different ports, only one of them is active at any one time. Up to four analogue VRUs can be connected to the system and as many serial VRUs as there are ports available. If port allocation is restricted, it is possible to assign both VRUs to the same port provided a changeover switch is used to switch from one to the other.

- "**Degrees per 10 Volts**". This is the scaling factor for the VRU.

- "**Linear Scaling**". Some VRUs have non-linear scaling - Datawell for example.

- "**Invert Pitch**" and "**Invert Roll**". Set to "**NO**" if the Sonardyne co-ordinate frame convention (see Appendix D) is being used.

- "**VRU/Ship Corrections**" - "**Pitch**" and "**Roll**".

  These corrections are used to eliminate any slight misalignment in Pitch and Roll between different VRUs and an allocated 'master' VRU (when more than one unit is fitted) as well as relative to the vessel grid, when installed in a working position.

  The following procedure may be used to derive the corrections of a single VRU (or 'master' VRU if more than one unit is fitted) relative to the vessel grid and is valid provided the vessel is, on average, stationary during the procedure - that is:-

  - It is tied up alongside a quay and it is not subject to any net linear or rotational acceleration during the period.
  - It is not being re-ballasted during the procedure (changing the average trim or list).
  - The vessel's average heading is not changing during the period.

  It is assumed that a reference surface (horizontal in the vessel grid) is available. The Transceiver should be placed on this surface with its logical north aligned with the lubber line of the vessel (vessel logical north).

  NOTE: If there is any doubt about identifying a horizontal reference surface in the vessel, assume the VRU is correct and omit this VRU/Ship Corrections procedure entirely.

  The procedure runs automatically once the cursor is moved to the "**VRU to Ship Corrections**" button and <ENTER> is pressed. Simultaneous measurements are taken from the Pitch and Roll sensors in the Transceiver and from the VRU. Because the Transceiver's Pitch and Roll sensors are subject to acceleration-induced error multiple measurements are taken, spread over a short period.

The procedure calculates the corrections that should be applied to the VRU measurements to obtain the true attitude (roll and pitch) of the vessel. As the measurements are taken, the expected precision of the correction is displayed.

- "**Align all VRUs**"

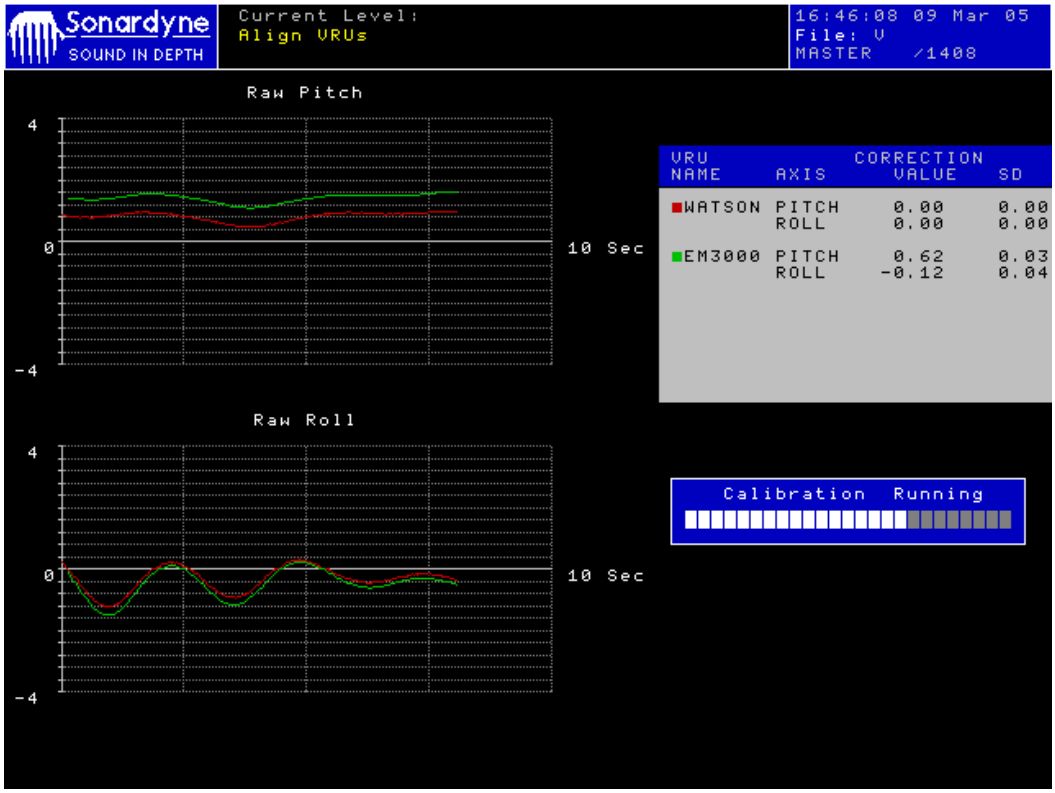
The following procedure is used to derive the Pitch and Roll corrections between different VRUs and a nominated 'master' unit if more than one VRU is fitted and is valid provided the vessel is, on average, stationary during the procedure - that is:-

- It is tied up alongside a quay and it is not subject to any net linear or rotational acceleration during the period.
- It is not being re-ballasted during the procedure (changing the average trim or list).
- The vessel's average heading is not changing during the period.

The procedure runs automatically once the cursor is moved to the "**Align all VRU**" button and <ENTER> is pressed. Multiple measurements are taken from the Pitch and Roll sensors in each VRU spread over a short time period.

The procedure calculates the corrections that should be applied to each VRU measurement to obtain the true attitude (roll and pitch) of the vessel as defined by the 'master' VRU. As the measurements are taken, the results are displayed for each sensor in turn as illustrated in Figure 9.28, together with the current correction values, standard deviations and a progress bar:-

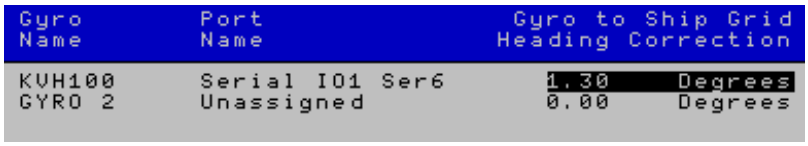
FIG 9.28 ATTITUDE SENSORS CALIBRATION PAGE



The average correction values calculated by the procedure for each VRU are then entered automatically in the VRU/Ship Corrections Pitch and Roll columns.

9.4.3.3 Gyro Heading Correction Panel

FIG 9.29 GYRO CORRECTION PANEL

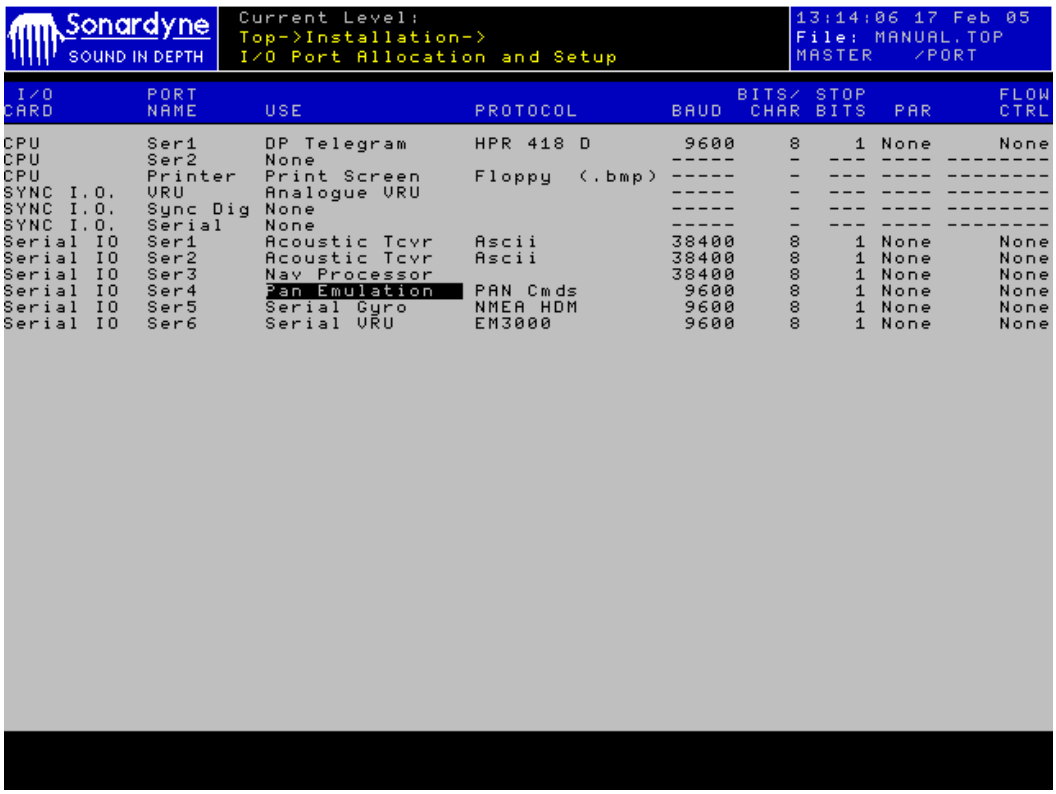


This correction is used to eliminate any slight misalignment in Heading that the Gyro may have, relative to the vessel grid, when installed in its working position. The value should be obtainable from vessel installation data, or may be determined during the installation process. If not, assume that the Gyro is correctly aligned in the vessel grid and enter zero.

9.4.4 Option 4 - "**I/O Port Allocation and Setup**"

On selecting this menu option, a window appears in which are listed all of the existing System I/O ports and the current settings applicable to them - see Figure 9.30:-

FIG 9.30 PORT SETUP PAGE



As details are being entered on this page, it will be found useful if a hard copy log of all entries is kept for future reference. For vessel records, it is valuable to take and print a Bit Map file of the Installation and I/O Port pages.

The following nine data entry options are available under this heading (the first two of which are standard to all systems and may not be edited):-

- "**I/O CARD**". Identifies the circuit board in the Navigation Processor which carries the interface defined on this row. The entries in this column may not be edited.

- "**PORT NAME**". Names the interface on each card. The entries in this column may not be edited.

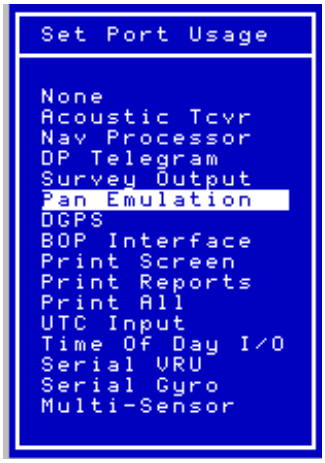
CPU Ser1 is often assigned for DP Telegram use. CPU Ser2 is reserved for Acoustic Transceiver use in a standard system (but not in a Dual-Redundant system).

In a Dual-Redundant system, the Serial I/O ports 1 and 2 should be used for Transceiver communications and the Navigation Processor interlink should be placed on Serial I/O port 3 - as illustrated in Figure 9.30. Figure 9.30 also illustrates typical settings used for the remaining data entry options for the NAV Processor.

- "**Set Port Usage**". Defines how the interface is to be used in the System - i.e. what it is connected to. This entry may be changed by using the arrow keys to move to this location on the screen and pressing <ENTER>. Preferred uses for a Dual-Redundant system with a Serial Card fitted are illustrated in Figure 9.30.

  Depending on which row the cursor is in, a dialogue box will appear, as illustrated here to the right for any Serial port. Select a use as required and press <ENTER>.

  Different dialogue boxes will appear for other rows as appropriate to the function of that row.



  If no Serial Card is fitted, preferred uses are:-

CPU Ser1	DP Telegram
CPU Ser2	Acoustic Transceiver
CPU Printer	Parallel Printer with "Floppy (.bmp)" protocol
SYNC IO VRU	Analogue VRU – if "**None**" is selected, the system will utilise the internal inclinometers in the Transceiver
SYNC IO Sync Dig	Synchro VRU - set to "**None**" if Serial VRU or no VRU used
SYNC IO Serial	Serial Gyro - no other serial use allowed. Set to "**None**" if Synchro Gyro being used

- "**PROTOCOL**". Defines the format of the data which will flow into and out of this port. This entry may be changed by using the arrow keys to move to this location on the screen and pressing <ENTER>. A dialogue box will appear (again specific to the function of the channel in that row). Select a use as required and press <ENTER>. The protocols available for each of the port types is given in the Table which follows:-

PORT USE	PROTOCOLS AVAILABLE
ACOUSTIC TCVR	ASCII
NAV PROCESSOR	Not applicable - internal binary data stream
DP TELEGRAM	HPR 309; HPR 418 D; HPR 418 F; HPR 418 BCD; ATS ASCII; NMEA 0183
SURVEY OUTPUT	HPR 309; HPR 418 D; HPR 418 F; HPR 418 BCD; ATS ASCII; CSV; NMEA 0183
PAN EMULATION	PAN Commands

DGPS	NMEA GGA
BOP INTERFACE	No protocol options
PRINT OPTIONS	ASCII; Epson LQ; Epson FX; HP Thinkjet; HP Laserjet 3; HP Deskjet 320; Floppy (Bit Map)
UTC INPUT	Accepts Trimble time message, or ZDA. PPS source is set through the protocol field
TIME OF DAY	ASCII only - transmits TOD to remote system
SERIAL VRU	TSS; EM 1000; EM 3000; TSM 5265; PRDID; PSATT; PASHR
SERIAL – GYRO	Robertson; NMEA HDT; NMEA HDM; NMEA VHW; NMEA HDG; Sperry LR40/60; SBG Ascii; EM1000; EM3000; TSM5265; PRDID; PSATT; PASHR
ANALOGUE VRU	SETTINGS (electrical interface)
SYNCHRO GYRO	GYRO (electrical interface)
MULTI-SENSOR	Can add up to 4 protocols: EM1000,EM3000,TSM5265,NMEA GGA, NMEA HDT, NMEA HDM, TSS1, PRDID, PASHR, UTC

If no channel is allocated to VRU use, the system will default to using the inclinometers fitted in the Transceiver as a vertical reference.

- "**BAUD**". (⌘) Defines the baud rate at which the interface will operate. This entry may be changed as described above. As before, a dialogue box will appear offering a list of options appropriate to the function.

- "**BITS/CHAR**". (⌘) (⌗) Defines the number of bits comprising each character sent. This entry may be changed as described above. As before, a dialogue box will appear offering a list of options appropriate to the function.

- "**STOP BITS**". (⌘) (⌗) Defines the number of stop bits applicable to this interface. This entry may be changed as described above. As before, a dialogue box will appear offering a list of options appropriate to the function.

- "**PARITY**". (⌘) (⌗) Defines the parity convention to be applied to the interface. This entry may be changed as described above. As before, a dialogue box will appear offering a list of options appropriate to the function.

- "**FLOW CTRL**". (⌘) (⌗) Defines the flow control convention to be applied to the interface. Only XON/XOFF is available at this time. This entry may be changed as described above. As before, a dialogue box will appear offering a list of options appropriate to the function.

  ⌘ If any of HPR 309, HPR 418, ASCII or CSV protocols are selected, default values will be set here - but may be edited, if required.

  ⌗ If "**ACOUSTIC TCVR**" is selected as "**Set Port Usage**", this parameter is auto-set and may not be edited.

9.4.5 Option 5 - "**Set/Change Installation Password**"

Access this option is only necessary during installation to set up the original password or, at some later date, to change the password. If so, select the option and follow the on-screen prompts to effect the change, using the dialogue box illustrated here to the right. Advise all appropriate personnel of the change.

9.4.6 Option 6 - "**Calibrate Transceiver Timing Offset**"

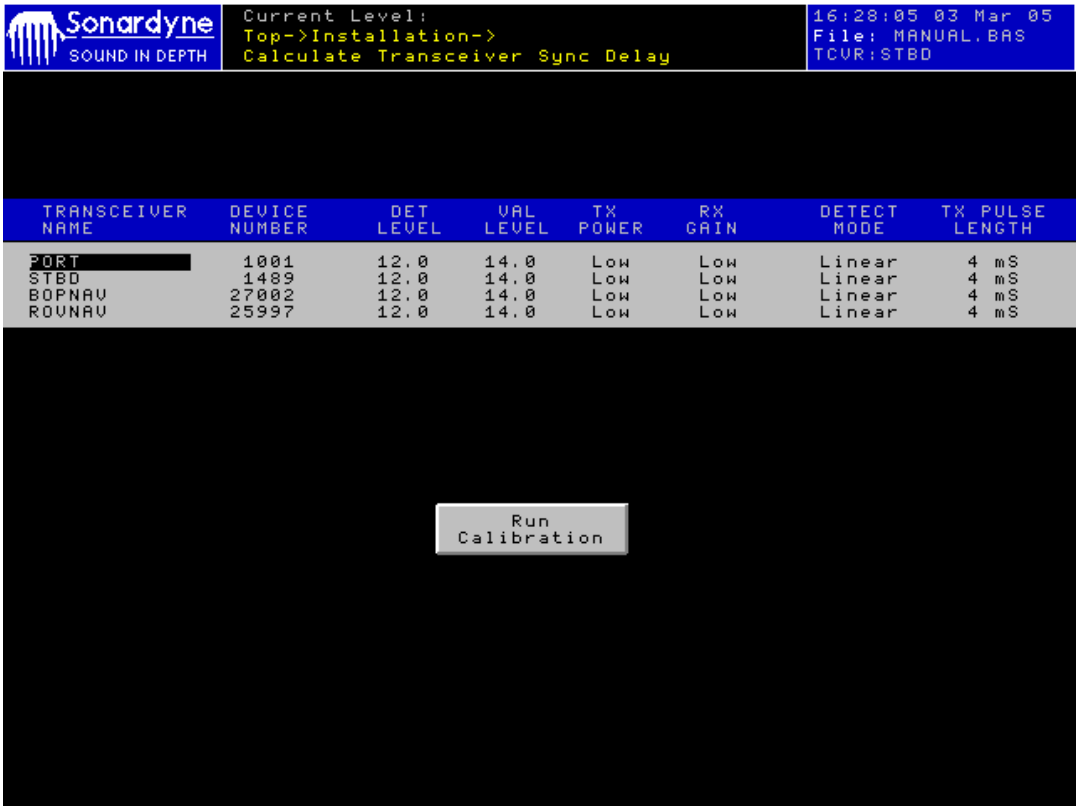
The purpose of the 'Transceiver Timing Calibration' program is to synchronise all the acoustic Transceivers in an L/USBL system. Different types of Transceiver have been observed to have slightly different start times when an acoustic cycle begins. This program will set-up a start delay for each Transceiver so that they all measure accurate range times. The program need only be run once - when the Transceivers are first installed on the vessel.
The program works by sending acoustic pulses between the acoustic Transceivers on different Objects. For example, it would send a pulse from a BOP to the Vessel and then from the Vessel to the BOP. The program then looks at the two range times and, if they aren't the same, it adjusts the Transceivers' timing to make them the same.

The program can only be run on Vessels that have more than one Object. It is not necessary to run the program on a single object installation because the Transceivers on a single object are all of the same type and will all have the same timing offset.

NOTE: It is important that all the Objects involved in the calibration are as stationary as possible. For example, the calibration must not be run whilst the BOP stack is being lowered or whilst an ROV is in motion (if there are Transceivers on these objects).

When Option 6 is selected, the "**Calculate Transceiver Sync Delay**" screen will appear as follows:-

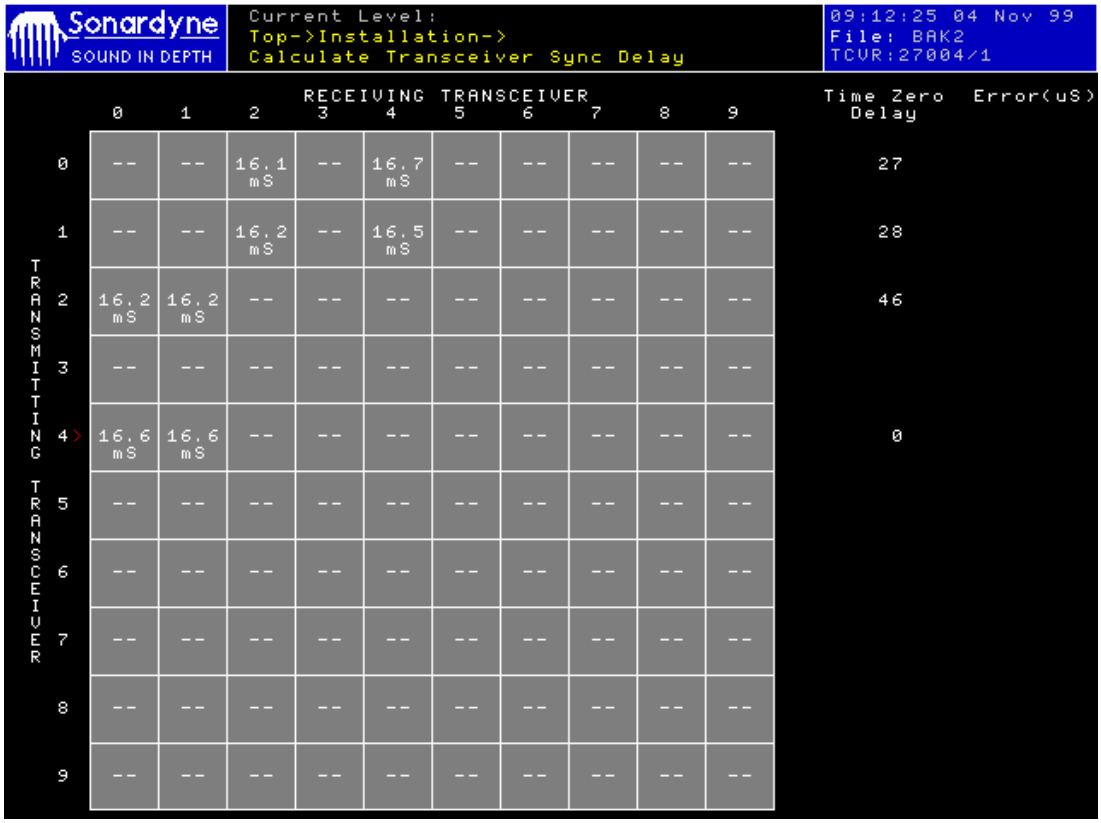
FIG 9.31 TRANSCEIVER SYNC DELAY SETUP PAGE



The screen shows detection and transmission properties that can be configured for each Transceiver. These settings will change depending upon water depth and noise levels. When suitable values have been chosen move the cursor down to the "**Run Calibration**" button and press <ENTER>. From this point the program runs automatically until the user stops it.

The program will check that each of the Transceivers is responding and deselect any that are not. If all the Transceivers on an Object fail to respond, then that Object will be deselected. If there is only one remaining Object, then the test will abort with an error message, otherwise the computational screen will be shown, as illustrated in Figure 9.32:-

FIG 9.32 TRANSCEIVER SYNC DELAY RESULTS PAGE



The grid has Transceiver numbers along each side. Numerical values are shown on the grid at places where a range time between Transceivers will be collected. Initially these will be zero but will change as ranges are collected. The program will collect ranges to and from each Transceiver in the calibration until all the numbers in the grid have been filled in - which will only take a few seconds. At this point, the program will look at the difference between the range times and adjust the Transceivers' timing offsets to correct for any errors.
The process is then repeated with the new timing offsets applied. The ranges are collected again and the timing offsets re-adjusted. The program continues collecting ranges and adjusting the Transceiver timing offsets until the user stops the program by pressing <ESCAPE>. The longer the program runs, the better the calibration becomes - but all Objects must remain as stationary as possible for the duration. A sensible length of time to run the program would be 15 mins.

When <ESC> is pressed, the program will offer the user the following options:-

- Archiving the results to floppy disc
- Saving the calculated timing offsets
- Exit without saving

If the archive option is selected then a Microsoft Excel CSV file is written to the floppy disc. This file contains all the Transceiver timing offsets that were calculated whilst the program was running. Selecting the save option will make the new timing offsets permanent. Exiting without saving will leave the system as it was when the program was started.

9.4.7 Option 7 - "**Advanced Options**"

This option is only available to Sonardyne installation engineers.

9.4.8 Option 8 - "**Download GDT firmware**"

This utility allows a user to upgrade Digital Transceiver firmware from a file received from Sonardyne following the on-screen prompts as they occur. The procedure will take approximately 20 minutes for each Transceiver.

9.5 SYSTEM SETUP OPTIONS

9.5.1 Option 1 - "**Set Time and Date**"

The system has a calendar and a 24 hour clock with a resolution of 1 second. This menu option allows the operator to reset the calendar and the clock. In this way the system may be synchronised to a local time standard within about a second.

The standard rules for data entry apply. Any of the cursor keys may be used to step through the fields, but a consistent routine is to use the RIGHT cursor key to move through each of the time/date fields in turn. [In the case of a 17 inch Monitor installation, the cursor keys will be found on the Type 7941 Keyboard unit.] To modify an entry, move to the appropriate field, press <ENTER> and then use the UP/DOWN cursor keys to change the entry. Press <ENTER> again to confirm the final value.

The best technique is to set all fields so that the displayed time/date is about 30 seconds ahead of local time standard and then press <ENTER> as the local time standard displays the same time.

Alternatively, press <ESC> to do nothing if the time/date settings are correct.

9.5.2 Option 2 - "**Set Display Brightness**"

Use this option only if appropriate. This menu option enables the monitor brightness to be varied to suit the ambient light level. Ten brightness levels are available.

9.5.3 Option 3 - "**System Test Programs**"

For the most part, the System Test Programs available under this option are described in detail in the separate manual covering installation and maintenance procedures for the USBL system. In this section, therefore, only a brief description is given of each utility.

- "**Transceiver Calibration Test**". This utility gives the receivers a functional test to make sure that the calibration values for the transducer elements are unchanged from their factory values. The Transceiver system can inject a test signal into all transducer elements and measure the electrical phase angle in each case with respect to the reference. The last column 'Phase Span' should be less than 10°.

- "**DP Telegram Test**". This utility outputs a DP Telegram, using the parameters set using the I/O Port Setup procedures - see Section 9.4.4. It checks that not only is the hardware of the receiving system receiving and decoding the message correctly, but also the software procedures are interpreting it correctly.

- "**Keypad Test**". This utility tests the function of all keys (and some of the more important key combinations).

- "**Transceiver Test Utilities**". Procedures for using these utilities are given in Appendix A to this manual. There are six utilities available under this option:-

  - Setup Transmit Parameters (only used for tone signals)

  - Setup Receiver Pulse Parameters (only used for tone signals)

- Carry out a Range Test
- Carry out a Noise Test
- Carry out a Backscatter Test (Used by Sonardyne engineers during Installation)
- Transceiver Commands Interface

❑ "**Graphics Display Test**". This utility checks all colours displayed and enables screen aspect ratio and alignment to be adjusted.

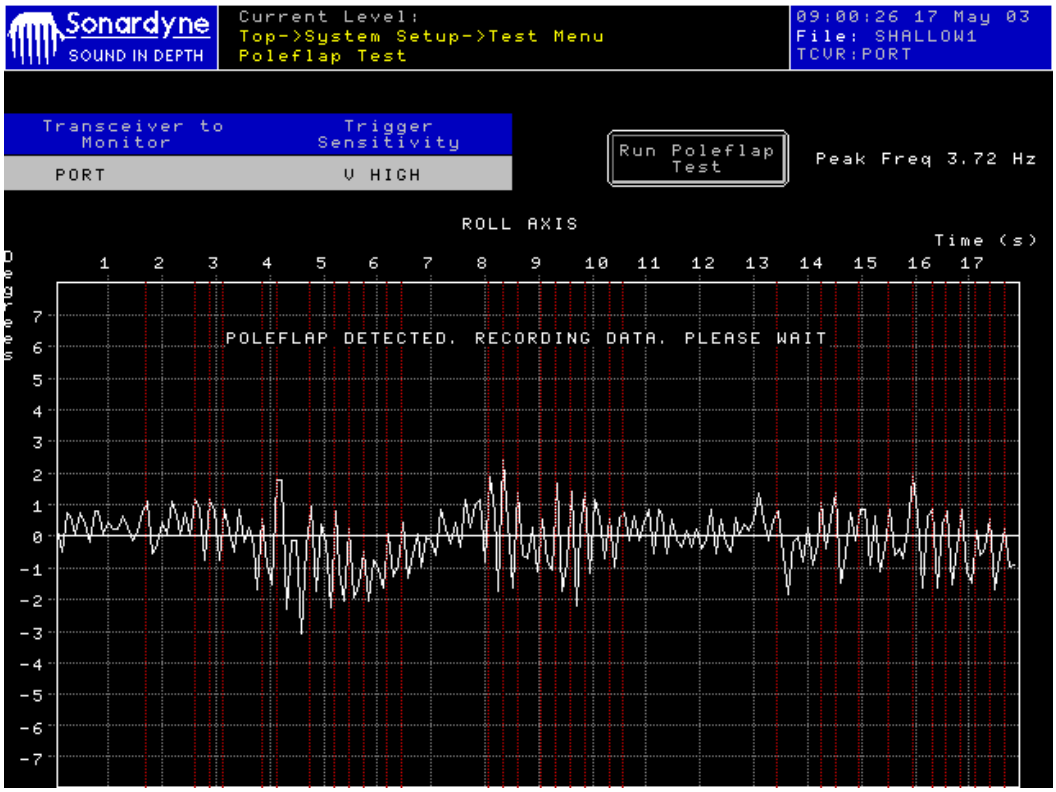
❑ "**Hard Disc Test**". This utility carries out an integrity check of the HD filing system. If this test fails contact Sonardyne for advice.

❑ "**Serial Ports Test Utility**". This test involves using loop-back connectors which can be used on any of the 6 serial ports available on the Serial Card and the two serial ports on the CPU Card. With the connector in place, the test routine checks the serial interface over a range of baud rates (2400, 4800, 9600, 19200 and 38400 baud). However, the set-up for this test requires detailed knowledge of the configuration of the particular system being tested and there is a risk of damage if the correct preparations are not made. Sonardyne should be consulted before attempting this test.

❑ "**Poleflap Test**". This test is used to identify vibration in the transceiver deployment poles. This vibration or flap can have a detrimental effect on the life or performance of the system and should be addressed as potentially serious problem.

Figure 9.33 illustrates the screen which displays the result of carrying out a Poleflap test, which displays an estimated peak frequency vibration of 3.2 Hz.

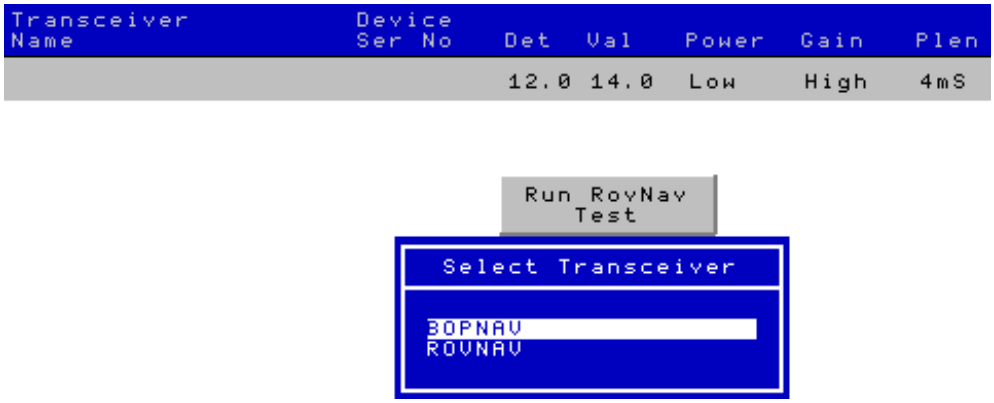
FIG 9.33 POLEFLAP TEST RESULT PAGE



- "**RovNav Range Test**". This test allows the ranging functionality of a Mk4 ROVNav or BOPNav Transceiver to be tested out of the water before a ROV or BOP deployment. This test is described in more detail below:-

  - The program starts automatically when this option is selected from the "**System Test Programs**" list. The operator is presented with a list of all Mk4 ROVNavs or BOPNav Transceivers installed on the system, as illustrated in Figure 9.34:-

FIG 9.34 ROVNAV RANGE TEST SETUP PAGE



The Transceiver to be tested should be selected and <ENTER> pressed to continue.

  - If required, the acoustic "**Power**", "**Gain**" and pulse length "**Plen**" settings that are to be used for the test should be changed. In most cases, these will be left at their default values. When the settings are correct, the cursor should be moved down to the "**Run RovNav Test**" button and <ENTER> pressed.

  - The program will tell the operator to configure an ANT to listen on CIF and respond on channel 0. When the message is accepted, the program will begin transmitting interrogation pulses on each ROVNav/BOPNav acoustic transducer in turn.
  - The operator should now take the ANT to the ROVNav which may be in place on a ROV or a BOPNav Transceiver on a BOP stack. The ANT transducer should be placed adjacent to one of the acoustic transducers and held there until that transducer stops transmitting. This will happen after the Transceiver has received five replies to its interrogations.

  - The operator should then place the ANT transducer adjacent to the other acoustic transducer and again hold it there until that transducer stops transmitting. At this point, the operator should return to the Navigation Processor to observe the results. The system will now be showing the average detection time for each transducer. This number should be very slightly longer than the turn-around time that was entered into the ANT.

  - If the system has not detected enough ranges, then the start button will still be black. Pressing the <ESC> button will stop the test running and cause the program to display any information gathered so far.

9.5.4 Option 4 - "**Create PC Utils Discs**"

This option can be used to copy PC compatible utility files from the V6 system hard disc to a correctly formatted floppy disc for installing on a suitable PC. The utilities include:

- A "**PLOT_CSV"** application that can be used to analyse time stamped data logged with the L/USBL system.
- A "**Sound Speed"** application which computes the sound speed in water from temperature, salinity and depth measurements using different published algorithms.
- A "**PCDP Test"** utility that can be used to generate different DP telegram formats.
- A "**Convergence Calculator"** utility.

9.6 SIMULATE OPTION

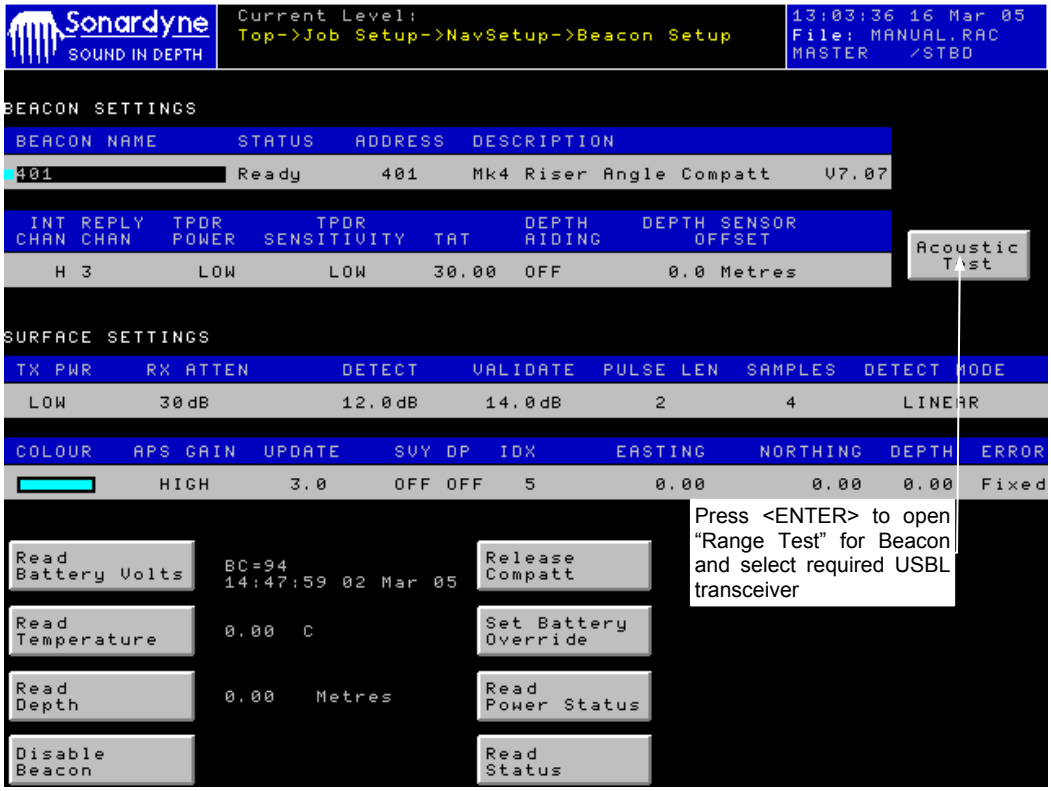
This option allows the operator to run a Job from a simulation. It has the same menu structure as "**Navigate**" and is an excellent way of becoming familiar with the way the system operates.

APPENDIX A

A. NOISE AND RANGE TEST PROCEDURE

NOTE: The 'Noise' and 'Range' tests for tone signals can both be accessed using the "**Transceiver Test Utilities**" menu option, whereas the 'Range Test' for any beacon can be accessed on the "**Beacon Setup**" page using the "**Acoustic Test**" button, as illustrated in Figure A.1:-

FIG A.1 ACOUSTIC TEST – BEACON SETUP PAGE



- Using "**Beacon Setup**" page:

  It is better to access the 'Range Test' through the "**BEACON SETTINGS**" page, as there are an increasing number of Beacon types (such as HPR400, BPT, AODC, WSM and Mk5 Compatt beacons configured for wideband signals) that cannot be set up through the Transmit/Receive test pages. Using the "**Acoustic Test**" option in the "**BEACON SETTINGS**" page, which is only available outside of Navigation, also sets the initial parameters in the 'Range Test' to match those that are set for use in Navigation.

- Using "**Transceiver Test Utilities**":

  Select "**System Setup**" from the top level menu followed by "**System Test Programs**" and then "**Transceiver Test Utilities**". There are six utilities available on this page. Pressing <ESC> terminates any utility.

  The test starts by requesting which Transceiver* is to be used during the test. Respond to the prompt and then proceed through the test procedures in the following order.

NOTE: * Only Sonardyne digital transceivers and beacons support wideband operation, while analogue transceivers and beacons are still supported in tone mode.

A.1 TEST 1 – SETUP TRANSMIT PARAMETERS

This setup routine enables transmit parameters for tone signals to be edited as necessary in preparation for Test No 3. Common settings are:

- "**TX Power**":
  - Use "**Low**" Power for shallow water or in-air testing.
  - "**Low Medium**" Power is not very different in output power from "**Low**" Power and is therefore generally not used.
  - Use "**High Medium**" Power in shallow water if the target is suspected to be deaf or in air.
  - Use "**High**" Power for deep water. NOT FOR USE IN AIR.
- "**TX Pulse Length**":
  - If dealing with COMPATTS using tone signals, set to 4 msec.
  - If dealing with SIMRAD Beacons or SONARDYNE Beacons operating on SIMRAD channels, select 8 msec.
- "**TX Frequency**":
  - For SIMRAD Beacons or SONARDYNE Beacons operating on SIMRAD channels, select the required channel from G21 to G29 (for SIMRAD channels 1 to 9) or G31 to G35 (for the SIMRAD symbol channels).
  - For SONARDYNE MF tone signals, select the desired frequency in the ranges G0 to G14 and G16 (CIF).
  - For SONARDYNE FSK telemetry replies, select the desired frequency in the ranges G18 to G20.

A.2 TEST 2 – SETUP RECEIVE PULSE PARAMETERS

This setup routine enables receive parameters for tone signals to be edited as necessary also in preparation for Test No 3. Common settings are:

Receiver Mode	Normally "**Linear**"
Attenuation	In shallow water, or in a reverberant environment, start at 30 dB attenuation. Otherwise set at 0dB attenuation
Detection Threshold	Start with 12 dB (default setting)
Validation Threshold	Start with 14 dB (default setting)
Sample Rate	Start at 7 kHz but adjust to (say) 6 kHz if the channel to be received is close to a multiple of 7 kHz
Turn Around Time	Use default time
Bandwidth	Start with ± 200 Hz
Multifix Mode	Start with "**Std Ambig/No Auto Tilt**"
Number of Samples	Start with 8
QB Sum Limit	Start with 0.025000 (default setting)

Update Rate	Start with 1 second but increase in deep water
Sound Velocity	Use a sound velocity meter or make an educated guess based on knowledge of the area you are working in
Beacon Type	Select appropriate option
Azimuth	Start with 0 deg
Elevation	Start with 0 deg
RX Frequency	Select required channel. For Sonardyne COMPATTs, the RX frequency name/number is different from the TX frequency name/number – select the required frequency from G0 to G15 (CRF). For SIMRAD and Sonardyne SIMRAD-compatible Transponders and USBL / LUSBL Transponders, the RX frequency name/number matches the TX frequency although different frequencies are used. SIMRAD frequency 4 is not available

A.3 TEST 3 – RANGE TEST

NOTE: The 'Range' test can be accessed either using the "**Acoustic Test**" button on the "**BEACON SETTINGS**" page for each beacon, as illustrated in Figure A.1, or using the "**Transceiver Test Utilities**" menu option. It is better to access the 'Range Test' through the '**BEACON SETTINGS**' page, as there are an increasing number of beacon types (such as HPR400, SSM, PGT BPT, WSM and Mk5 Compatts configured for wideband signals) that cannot be set up through the Transmit/Receive test pages. Using the "**Acoustic Test**" option in the "**BEACON SETTINGS**" page also sets the initial parameters in the 'Range Test' to match those that are set for use in Navigation. The Transmit/Receive pages are provided because they can be useful for looking for tone signals from beacons that are not included the Job database.

The Transceiver Range Test interrogates a Beacon and displays the received pulse graphically. This test uses the transmit and receive parameters set up in options 1 and 2 (or on the "**Beacon** Setup" page) but makes those two pages accessible for editing, if required for tone signals.

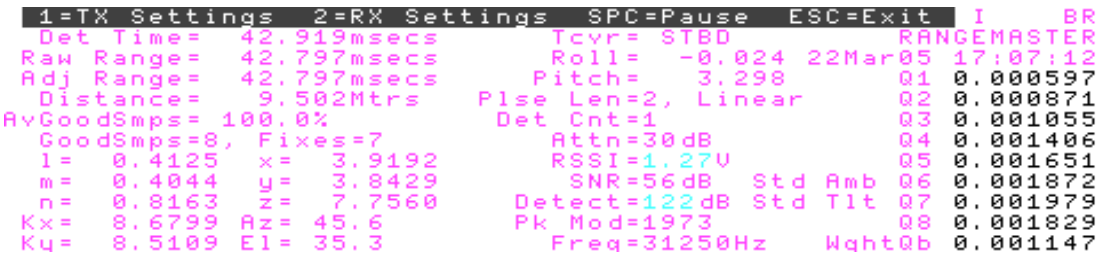
When the "**Acoustic Test**" button on the "**BEACON SETTINGS**" page is selected (or option "**3=Rng Tst**" under the "**Transceiver Test Utilities**"), the system will enter the range test page and the program will start interrogating on the "**INT CHAN**" selected on the "**BEACON SETTINGS**" page (or the frequency selected in the TX setup under "**Transceiver Test Utilities**" for tone signals) and expect to receive on the "**REPLY CHAN**" selected on the "**BEACON SETTINGS**" page (or the frequency selected in the RX setup under "**Transceiver Test Utilities**" for tone signals). If all the parameters are correct and the system and Beacon are in good working order, the system should start ranging to the Beacon. Access to the TX and RX settings is provided at the top of the screen (or by returning the "**BEACON SETTINGS"** page when using the "**Acoustic Test"** facility). The 'Range Test' can be paused and/or resumed by pressing the keyboard space bar "**SPC**".

The 'Range Test' page displays both numeric and graphical information. The numerical data is displayed at the top part of the screen.

A.3.1 Numerical Data

The numerical data, presented in Figure A.2 which follows, gives the results of the direction finding process. This is presented in two ways, l,m,n and x,y,z. The direction cosines l,m,n are multiplied by the total distance to give the three components of distance x,y,z in metres. The distance is calculated from the "**Raw Range**" in milliseconds, adjusted for beacon type offset to give the "**Adj Range**" and converted to a distance using the sound speed through the water column, set to 1485metres per second in this display. The raw and adjusted range reading are the measured time for the beacons reply to reach the system and are displayed in milliseconds, but the "**Distance**" is only accurate if the turnaround time (TAT) is correct.

FIG A.2 RANGE TEST – NUMERICAL DATA



The direction cosines "**l & m"** are determined from the wave vector components "**Kx & Ky"**, when multiplied by the wavelength (which depends on the frequency and sound speed at the Transceiver).

- **Tone Signals:**

  Eight "**Kx, Ky"** pairs are determined along with eight quality factors "**Q1 - Q8"**, for successive intervals within the received pulse. If these factors are small, the "**Kx, Ky"** pairs will be superimposed on top of each other on the "**Kx v Ky"** plot. If the incoming wave contains interference, for example due to a multipath signal, this will be detected and the quality factors will rise (larger residual error sums). If very large (>0.025) there is a high risk of an ambiguity failure and the data is rejected. Nevertheless, the 'Range Test' will still show the "**Kx, Ky"** pair, now probably no longer in the cluster of points formed by the good data.

  The quality factor (Qbsum) readings "**Q1 to Q8"** will be shown white if 'Good' (< 0.025), together with the 'weighted mean value "**WghtQb**" used to calculate the x,y,z distances . a minimum number of six 'Good Samples' need to be white for the mean "**Kx, Ky"** values to be accepted for Navigation. If there is a multipath problem, the later factors (e.g. "**Q6-Q8"**) may be 'Bad' (>0.025) and be shown in red. If multipath interference corrupts the end of the pulse, it is possible to reduce the interval between samples 1 to 8 to only use the beginning of the pulse. This is achieved by reducing the received pulse length. If the "number of good samples" requirement is reduced, it may then be possible to navigate despite multipath interference, provided the early results are good.

- **Wideband Signals:**

  Rather than taking eight measurements through the received signal pulse and reporting how many are 'Good Samples', the wideband signal algorithm attempts to take a single measurement using the 'correlation peak' from each element (see description of envelopes later), from which it extracts both timing and phase information. For compatibility reasons, the success of the algorithm is reported using the number of 'Good Samples' result. As either the Signal to Noise Ratio (SNR) drops or the amount of multipath interference increases, the timing of the peaks may degrade before the phase does. It may still be possible to navigate under high noise conditions by increasing the transceiver "**Detect**" and "**Validate**" levels on the "**Beacon Setup**" page, whereas under high multipath conditions reliable detection may be improved by reducing them.

- Eight 'Good Samples' is used by the wideband signal algorithm to indicate that the timing of the peaks gave a good fit and were successfully used to resolve any phase ambiguities and that the phase of the peaks subsequently gave a good fit, giving an unambiguous USBL position. This results in a single "**Kx/Ky**" & "**Qbsum**" being reported.

- Seven 'Good Samples' is used to indicate that the timing of the peaks gave a good fit but could not be used to resolve ambiguities, but that the phase of the peaks, in conjunction with the standard ambiguity resolver, gives a good USBL position. Again, only a single "**Kx/Ky**" & "**QBsum**" is reported.

- Six 'Good Samples' is used to indicate that the timing of the peaks gave a poor fit, but that the phase of the peaks, in conjunction with the standard ambiguity resolver, was good enough to give an acceptable USBL position. Again, only a single "**Kx/Ky**" & "**QBsum**" is reported.

- Five 'Good Samples' is used by the Wideband Signal algorithm to indicate that the timing of the peaks gave a good fit, but that the phase of the peaks did not. However, by taking eight measurements rather than just the peaks, and in conjunction with the standard ambiguity resolver, at least one sample was good enough to give a USBL fix, although the position may be suspect. In this case, all eight "**Kx/Ky**" & "**QBsums**" are reported with 'Bad' "**QBsums**" (>0.025) being shown in red.

- Four 'Good Samples' is used to indicate that the timing of the peaks gave a poor fit, as did the phase of the peaks. However, by taking eight measurements rather than just the peaks, and in conjunction with the standard ambiguity resolver, at least one sample was good enough to give a USBL fix, although the position will be suspect. Again, all eight "**Kx/Ky**" & "**QBsums**" are reported with 'Bad' "**QBsums**" (>0.025) shown in red.

- Zero 'Good Samples' indicates that no fit could be established.

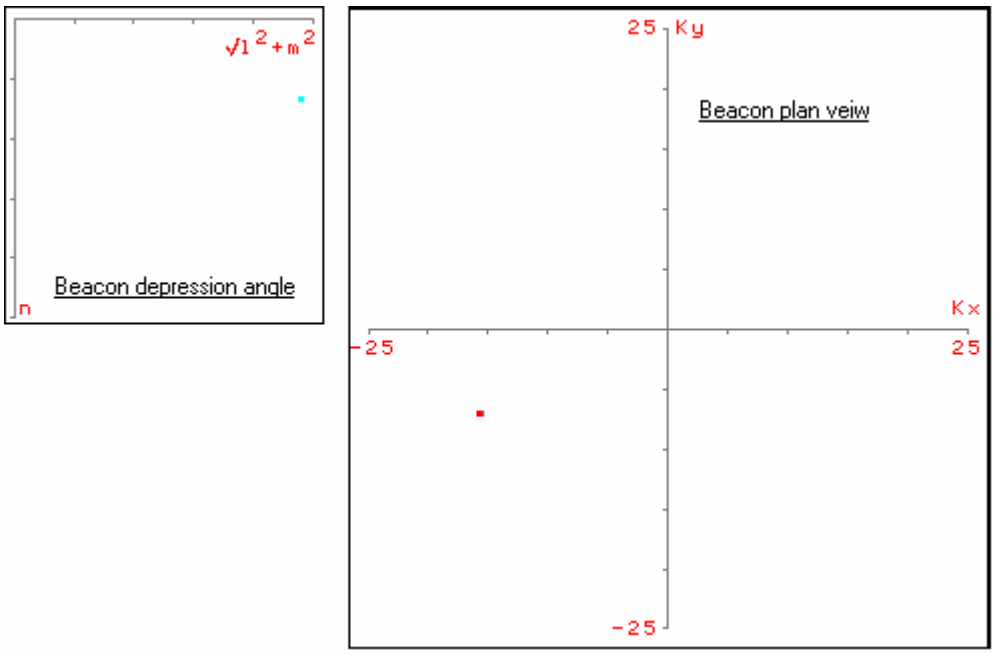
NOTE: The Wideband Signal algorithm never reports three, two or one 'Good Sample(s)'

In the top section of the screen there is also the transceiver being used "**Tcvr=STBD**" in this display, and data regarding the Transceiver "**Roll & Pitch**", the received pulse length in milliseconds "**Plse Len**", the number of 'good' samples, "**GoodSmps**" in each fix and the average number of 'good' samples, "**AvGoodSmps**" over the period for which the test has been running, the attenuation level used, "**Attn**" (and consequent signal strength – "**RSSI"**), the Signal to Noise ratio, "**SNR**" measured at the Transceiver and the detect level, "**Detect**". The Peak Modulus, "**Pk Mod**" is a measure of the "Envelope" of the signal in digital format. The largest possible peak modulus is 2048. The receive frequency finishes the list, "**Freq=31250Hz**" in this display.

A.3.2 Beacon Position Graphs

The Beacon Position Graphs are presented in Figure A.3 which follows. The top left graph displays the elevation angle of the beacon from the vertical. This is calculated from the direction cosines l,m,n displayed nearby. Direction cosines are the beacon positions x,y,z divided by the slant range R. They must therefore all be less than unity, and their squares will always add to up to one ($l^2 + m^2 + n^2 = 1$ or $x^2 + y^2 + z^2 = R^2$).

FIG A.3 RANGE TEST – BEACON POSITION GRAPHS



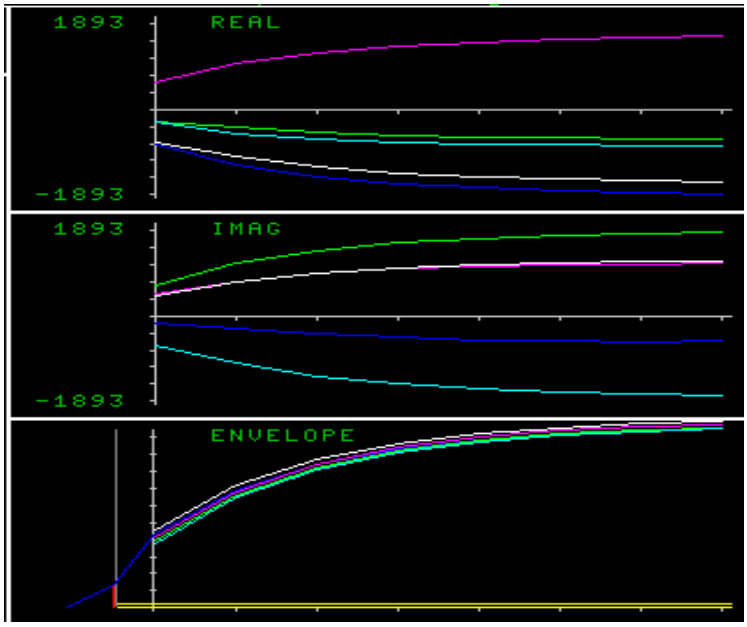
The second larger graph displays a modified plan view, which includes all possible directions. A set of beacons arranged horizontally around the transceiver (z = n = 0) will have direction cosines constrained by $l^2 + m^2 = 1$, and thus lie on a circle in this view. The size of this circle depends on the wavelength (sound speed / frequency). For a typical wavelength of 50mm (1500m/s and 30 kHz), the circle will have a radius of 20 m^{-1}.

Normally the beacon will be nearer to the vertical (n = 1 or R = z). All 8 samples from one "ping" are displayed, and if they all give 'good' data, (quality factors "**Q1 – Q8"** <0.025), all the dots should be superimposed on top of each other at one location, as in this display.

A.3.3 Envelope/Phase Graphs – Tone Signals

The three graphs in the bottom right of the 'Range Test' display (see Figure A.4) are the real, "**REAL**", and imaginary, "**IMAG**", phases of the signals received by the five RX elements, "**ChA – ChE**" and envelope characteristic, "**ENVELOPE**", of the received signals. The envelope graph is a graphical representation of the received signals amplitude and shape in relation to time as detected by the five RX elements. The two yellow lines in the lower part of the graph correspond to the average noise level measured at the Transceiver immediately before the signal arrived and the detect threshold level. A signal whose envelope barely rises above the yellow lines is at the margins of detection. In this situation it would be wise to increase the Beacon source level, or reduce the attenuation in the receive settings page.

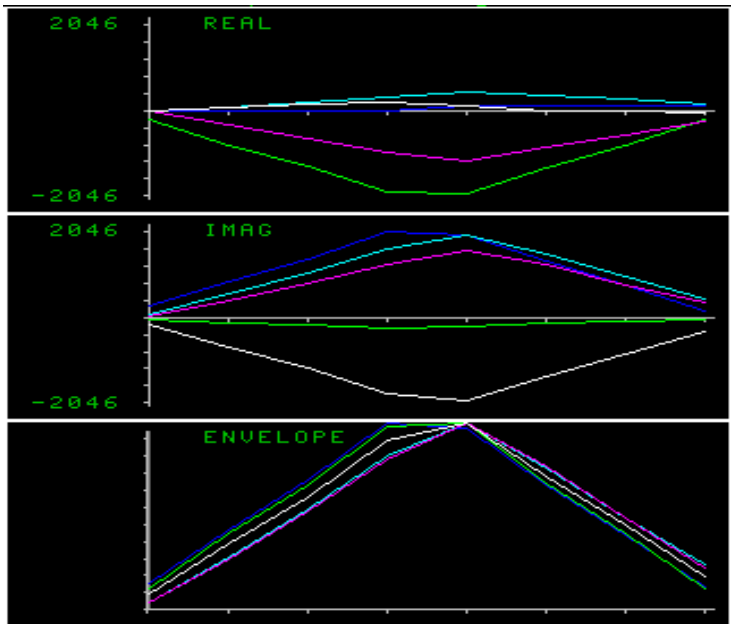
FIG A.4 RANGE TEST – ENVELOPE / PHASE GRAPHS FOR TONE SIGNALS



A.3.4 Envelope/Phase Graphs – Wideband Signals

For Wideband Signals, the Envelope / Phase Graphs show the time response output from the wideband Correlation filter for all five elements. The total time span is just 0.5 milliseconds, and the Envelopes should show a distinct peak for each element, centred around the middle of the graph, as illustrated in Figure A.5 below. For signals arriving off-axis there will be a noticeable difference in the time of the peak from each transducer element.

FIG A.5 RANGE TEST – ENVELOPE / PHASE GRAPHS FOR WIDEBAND SIGNALS



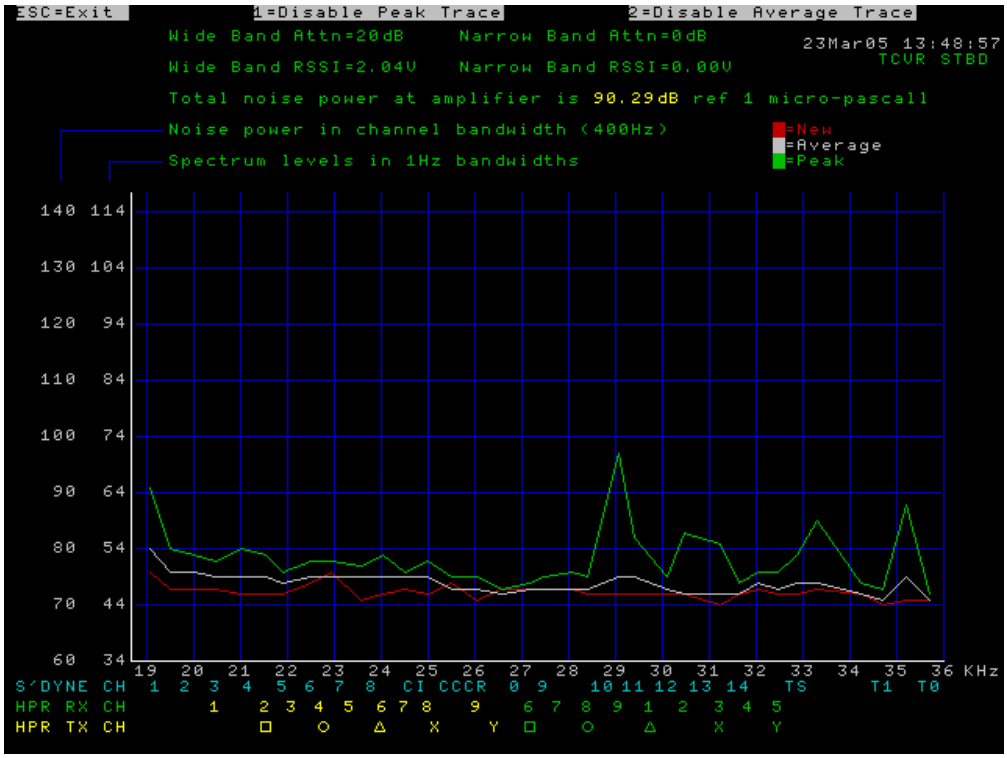
A.4 TEST 4 - NOISE TEST

This routine is essential for trouble-shooting acoustic noise problems at sea and for predicting the maximum range over which the system can be used. It causes the system to go through a receive sequence on each channel and displays the results as in-band noise for each channel using the bandwidth set under Test 2.

When run (select option 4 under the "**Transceiver Test Utilities**"), the program will display a graph with three lines (see Figure A.6). These represent the peak noise level, "**Peak**", average noise level, "**Average**" and the current reading, "**New**". Controls at the top of the screen are used to "**Disable / Enable**" the "**Peak Trace**" and/or the "**Average Trace**". At the bottom of the graph is displayed the frequency scaling and the relative SONARDYNE and SIMRAD HPR tone signal channels, "**CH**". Channels shown in cyan are SONARDYNE tone signals that the L/USBL Transceiver is capable of using. SIMRAD reply signals are green and interrogation signals are yellow. The scaling on the y-axis displays both the 'Spectrum Noise Level' in a 1Hz bandwidth and the 'Noise Power' in the receiver channel bandwidth used to make the measurement set in Test 2.

NOTE: Digital transceivers are treated differently from earlier analogue transceivers with a 12 dB correction being added to the noise measurements, which equates to a 'nominal' transducer Directivity Index. Hence, 12dB should be subtracted from the displayed value when using a digital transceiver to obtain the on-axis noise level as seen by the transceiver.

FIG A.6 NOISE TEST SHOWING TONE SIGNAL REPLIES



In a reasonably quiet environment all the bar lengths will be within a 6 dB spread and will be in the region of 40 dB to 70 dB in a 1 Hz bandwidth. If a particular frequency shows a high level, avoid using tone signal replies on that frequency (as shown at 29 kHz on the display). However, the presence of such interference need not preclude the use of wideband signals on the same carrier.

- **Analogue Transceiver:**

  When setting up an analogue system at a new location or in different conditions, this utility can be used as a guide to setting up the required TX power of the beacon and the relative attenuation that should be applied to the incoming signals from the beacons. The spectrum displayed uses a narrow band filter. The narrow band attenuation, "**Narrow Band Attn**", is set to give a signal strength which lies within the linear range. It is recommended that this value is used where possible in the actual system, except under quiet acoustic conditions when the attenuation should be selected to prevent beacon reply signals clipping, as indicated by a "**+**" sign in the "**Signal to Noise Ratio"** data display box option during tracking. The "**Narrow Band RSSI**" (Receive Signal Strength Indicator) needs to be kept below 0.5 volts for this analysis to be valid. If the maximum attenuation (30 dB) is inadequate to do so, the message "**Overload**" will be displayed and the value will turn red. The narrow band data is then invalid.

  Nevertheless some indication of noise can still be obtained from the "**Wide Band RSSI**". Even when above the linear range (>0.5v), this can be used to calculate the total noise power. The wide band attenuation is thus usually less than the narrow band attenuation, giving a wide band RSSI over 0.5v (unless both are at the minimum 0 dB). The logarithmic response of the system used for this calculation extends up to 2.7 volt DC.

  NOTE: **"Wide Band RSSI"** is a measurement of the noise level over the transducer's full (wide) bandwidth, which should not to be confused in any way with the bandwidth of wideband signals.

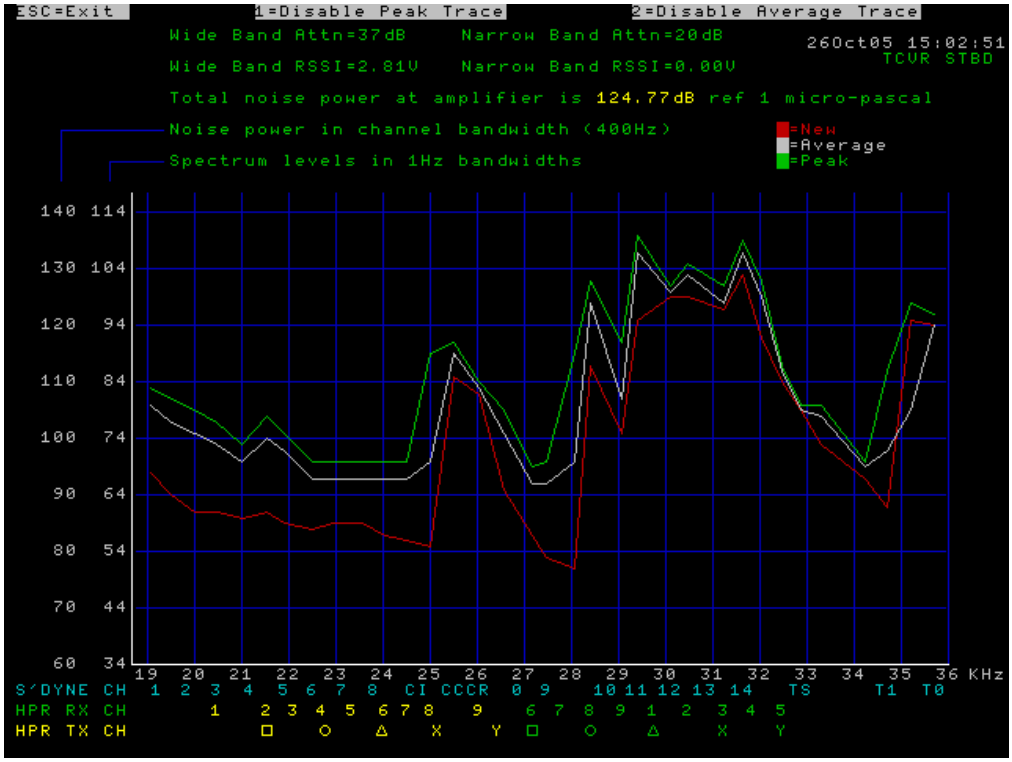
- **Digital Transceiver:**

  The above recommendation **does not** apply to digital transceivers which always report a "**Narrow Band RSSI**" of 0.0V as illustrated in Figure A.6 when only the "**Wide band RSSI**" is applicable. In addition, the "**Wide Band Attn**" reported is different to that reported by analogue transceivers and can be used to give an indication of the validity of the measurement. A digital transceiver reports back (80 dB - actual gain used in the transceiver), and the figure will vary from 20 dB corresponding to the maximum gain (or minimum attenuation), up to 80 dB corresponding to minimum gain (or maximum attenuation). Hence, if the "**Wide Band Attn**" approaches 80 dB, this indicates that the input is being overloaded.

The Noise test is also useful if the system is having difficulty picking up a Beacon / Transponder / COMPATT, or if the system is displaying messages like "**Reply detected early**" which can indicate external interrogation of the Beacons or other transmissions in the water.

Competing tone signals will show peaks which build up over several measurement cycles provided the competing signals are repetitive. Leaving the test running for 5-10 minutes allows the utility to cycle through the frequency band many times reducing the chance of missing an infrequent noise source or transmission and to allow the system to build up a good representation of the noise levels and signals in the water. In contrast, wideband signals will not appear as distinct peaks, but instead as broad 'bumps' spread over an approximate 4 kHz bandwidth, as illustrated in Figure A.7.

FIG A.7 NOISE TEST SHOWING WIDE BAND SIGNAL REPLIES



This utility can also see if a Beacon is being interrogated by an external source, as the reply will be seen indicating that the beacon is replying to the external interrogation. This may be indicated by a peak at the frequency your beacon is replying on when using tone signals, (as shown at 29 kHz on the display in Figure A.6) or as broad 'bumps' over an approximate 4 kHz bandwidth when using wideband signals (as shown on the display in Figure A.7). It is possible to estimate the carrier frequency of a wideband signal from the centre of the 'bump'. However, it is not possible to determine the exact wideband signal, and the presence of such interference should not preclude the use of other wideband signals on the same carrier.
This screen may also be dumped to floppy disc.

NOTES:-

(1) In pre-version 5.10 software, the USBL system uses the same file name for screen dumps and it is necessary to change the file name on a PC to stop earlier dumps being over written - keeping the extension as .bmp.

(2) The background is black and this is not particularly useful for printing. To make use of the screen dump, it is necessary to change the background to white by the use of <Paint> or another program capable of editing Bitmap files. As some of the display is naturally in white it will need to be changed to some other colour before changing the black background to white - or the colour can all be inverted.

(3) Digital transceivers are treated differently from the earlier analogue transceivers with a 12 dB correction being added to all noise measurements, which equates to a transducer Directivity Index, to display a 'nominal' isotropic noise level. Hence, 12dB should be subtracted from the displayed value when using a digital transceiver to obtain the on-axis noise level as seen by the transceiver.

A.5 TEST 5 - TX TEST

This routine can be used to check for the presence of aeration in the top 10 metres of the water column below the Transceiver by looking for signal returns of the second harmonic of a transmitted signal. This process requires specialist knowledge and should not be attempted except with SONARDYNE's help.

A.6 TEST 6 - TRANSCEIVER COMMANDS INTERFACE

This routine enables command mnemonics to be sent manually to the Transceiver. This process requires specialist knowledge and should not be attempted except with SONARDYNE's help.

If testing a dual-redundant version of the L/USBL system, select option 7, "**ESC**", and repeat the whole test sequence for the other Transceiver.

APPENDIX B

B. COMPATT COMMANDS AND REPLIES

B.1 COMMAND/REPLY LIST

COMPATT COMMAND		COMPATT REPLY EXAMPLES
AN5 or AN6	Measure analogue voltage channels 5 and 6 - for additional internal sensors, such as internal inclinometers or a conductivity sensor.	*AN5, 6 = +3.546, -1.928 E : 0* [Channel 5 voltage is +3.546V; Channel 6 voltage is -1.928V]. Voltage resolution 11 bits plus sign.
AN7 or AN8	Measure analogue voltage channels 7 and 8 - for additional external sensors, such as remote inclinometers.	*AN7, 8 = +1.202, -2.744 E : 0* [Channel 7 voltage is +1.202V; Channel 8 voltage is -2.744V]. Voltage resolution 11 bits plus sign.
BC	Battery Check If Battery Check button used in Beacon Summary page, then count and voltage and date / time of measurement are displayed. If L/USBL has detected that 'L2' battery is fitted (from status word "A"), it will also action Receiver battery command when the Battery Check button is used in Beacon Summary page.	*C : 202 BC = 325 V = 27.4 E : 0t* [COMPATT 202, battery count is 325 and battery voltage is 27.4V. No errors]. If COMPATT fitted with 'L2' battery pack, voltage returned is Transmitter battery voltage. If Riser Angle COMPATT, fixed value of 5.0V returned (battery count value still valid).
BX	Battery count and elapsed time reset.	*C : 106 RESET E : 0* [COMPATT 106, battery count and elapsed time have been reset]. Reset command only actionable within 40 seconds of a release being completed. Also, some COMPATT type-dependant prerequisites must be fulfilled before starting release sequence. Mk4 Compatt:- unit must be tilted by more than 45° from vertical and 'J' must be present in status message "A" prior to commencing release sequence. Mk5 Compatt:- this command is not supported. The battery count is stored in the pack, so a fresh pack will set the BC to zero automatically.
CADG:bbbbbb	'Get' the current address of a Mk5 Compatt using the Unit ID (bbbbbb)	*C:aaaa FL:003F E: 0* [COMPATT with Unit ID <bbbbbb> has address <aaaa> with the correct two way wideband receiver fitted]. Only applies to Mk5 Compatts with the down command always sent as a telemetry command.
CADS:bbbbbb,aaaa	'Set' the address (aaaa) of a Mk5 Compatt using the Unit ID (bbbbbb)	*C:aaaa FL:003F E: 0* [COMPATT with Unit ID <bbbbbb> new address is <aaaa> with the correct two way wideband receiver fitted]. Only applies to Mk5 Compatts with the down command always sent as a telemetry command.
CUIDaaa	'Get' the UNIT ID (bbbbbb) of a Mk5 Compatt using the current address (aaaa)	*C:aaaa PENDING ... E: 0 C: aaaa UID:bbbbbb E: 0* [Two part reply (i) COMPATT with address aaaa pending (ii) COMPATT Unit ID is <bbbbbb>]. Only applies to Mk5 Compatts with the down command always sent as a telemetry command.

COMPATT COMMAND		COMPATT REPLY EXAMPLES
CD	Depth Resolution of depth returned is dependent upon max range of depth sensor fitted. Four ranges:- 20bar 0.1m resolution 35bar 0.1m resolution 135bar 0.3m resolution 500bar 1.2m resolution 700bar 0.68m resolution	*C : 203 D = +2563.3 E: 0t* [COMPATT 203, COMPATT depth is 2563.3 metres]. Most COMPATTs operating on 500bar range are only fitted with 250bar sensor, therefore only half of range used. Depth rating of sensor fitted to a particular COMPATT is on bottom end cap label. If Depth check button used in Beacon Summary page, depth displayed here is corrected for COMPATT length and shows depth of acoustic transducer. This is based upon type number of COMPATT entered in job file (since different COMPATT types are of different length between acoustic transducer and depth sensor). If Depth aiding by telemetry selected for a COMPATT, it is this CD command which is actioned at the set interval.
CDTnn	Set Wideband Detection Threshold	*CDT12 C: 101 CDT SET E: 0* [COMPATT 101 Detection Threshold has been set to 12dB It should only be necessary to change the default wideband detection level (15 dB) under severe multipath conditions to achieve reliable detection of the direct path signal (minimum level 10dB) Only applies to Mk5 Compatts with firmware version 1.05 and with a daughter card fitted.
CF 1-14	Change Individual Reply Frequen cy	*C: 108 PENDING ... E: 0 C: 108 RF4/125.0 AEV5.0 E: 0t* [Two part reply (i) COMPATT 108 pending (ii) COMPATT 108 now on Channel 4; TAT at 125ms; status report A and E; version 5.0 COMPATT]. The reply frequency which is changed is dependent upon COMPATT's mode of operation. Compatt in its reset condition or when CIF mode enabled:- CF command changes reply frequency to CIF interrogation as shown in example. If a Compatt is set to Frequency Enable mode, then the IRF reply channel is changed from the default CRF when interrogated on its IIF. Response similar to that shown in the example occurs, but Channel number following RF remains unaltered from that set before CF command sent - because channel for this mode of operation is shown in status message "B" and CF command only returns status message "A". Therefore, to check that CF command has been actioned correctly, a 'TS' command needs to be executed. If a Compatt is set to USBL mode then reply channel changed is the HPR channel. Response similar to that shown in the example occurs but Channel number following the RF remains un-altered from that set before CF command was sent. This occurs for same reason as with Mk 4 Compatt in Frequency Enable mode. The "n" of the 'CFn' command for HPR channels 1 to 9 is replaced by 1 to 9. However, for the old 205 channels - Square (11), Circle (22), Delta (33), X (44), and Y (55) - the "n" is replaced by 10, 11, 12, 13, 14 respectively.

COMPATT COMMAND		COMPATT REPLY EXAMPLES
CG 1-4	COMPATT Gain 4 = Highest Gain 1 = Lowest Gain	*C: 410 PENDING ... E: 0 C: 410 PWR: L2 S2 T1 J2 U2 G1 E: 0* [Two part reply (i) COMPATT 410 pending (ii) COMPATT 410 is set at gain level 1 (G1)] [L,S,T,J and U refer to various reply power levels - see Power Parameters at the end of this section] Mk5 Compatt has all 4 levels of Gain. Mk4 Compatt only has 2, where CG1is low gain, and CG2 is high gain.
CI 1-14	Interrogate another COMPATT on channel n	*C:302 2-WAY MS = 1013.11 E: 0* [COMPATT 302 has a two way ranging time to the COMPATT on channel n of 1013.11 msecs]
CLGnn	Set Wideband Linear Gain Level	*CLG10 C: 101 CLG SET E: 0* [COMPATT 101 Wideband Gain Level has been set to 10dB The default wideband linear gain level (20dB) would only need to be changed to ensure the signal remains linear. Only applies to Mk5 Compatts with firmware version 1.05 and daughter cards fitted.
CLRS	Mk5 Compatt Linear Receiver status	*C:101 CLG20,CDT14.0,ADC-10 E: 0* [Two part reply (i) COMPATT Wideband linear gain level set to 20dB (CLG20), the Wideband detection level set to 14.0dB (CDT14.0) and the received signal level (ADC-10). The linear gain level (default 20dB) should be selected to keep the received signal level between -4 and -10 for optimum performance. When the COMPATT is used in a severe multipath environment it may be necessary to reduce the detection threshold from its default 15dB setting to achieve reliable detection of the direct path signal (minimum level 10dB) Only applies to Mk5 Compatts with firmware version 1.05 and daughter cards fitted.
CPA 1-2	Change Power, All Settings 1 = Low 2 = High	*C: 102 PENDING ... E: 0 C: 102 PWR: L1 S1 T1 J1 U1 G2 E: 0* [Two part reply (i) COMPATT 102 pending (ii) COMPATT 102 has reset power parameters L, S, T, J and U]. From version 7.11, Mk 4 Compatt firmware, a high power double pulse length transmission is available. Standard pulse length is 4ms duration; double is 8ms duration. The setting value for the high power double pulse length is 4. For switched beam COMPATTS Type 7928-02 there are 4 increasing power levels set by CPA1-4, although the top two only affect navigation replies.
CPL 1-2	Change Power - Navigation Replies 1 = Low 2 = High	*Same format reply as CPA but only the L parameter will have changed* For switched beam Compatts, Type 7928-02 there are 4 increasing power levels (CPL1-4)
CPS 1-2	Change Power - Telemetry Start Pulse	*Same format reply as CPA but only the S parameter will have changed*
CPT 1-2	Change Power - Telemetry Data Pulses	*Same format reply as CPA but only the T parameter will have changed*

COMPATT COMMAND		COMPATT REPLY EXAMPLES
CPU 1-2	Change Power - USBL Replies	*Same format reply as CPA but only the U parameter will have changed*
CPJ 7-8	Change Beam Shape	*Same format reply as CPA but only the J parameter will have changed* *CPJ7 forces a switched-beam Compatt to use only the narrow beam transducer for transmissions* *CPJ8 forces a switched-beam Compatt to use only the omni-directional beam transducer for transmissions* An RD command will revert back to normal switched mode of operation
CQ	Digiquartz pressure reading	*C : 407 DQZ CNT = 342000 E: 0* [COMPATT 407 Digiquartz sensor count is 342,000]. Count returned by COMPATT is measured over 9 second period. Thus it is necessary to increase telemetry wait time immediately before using 'CQ' command. This is done by using 'TWn' command and substituting a value of 12 to 15 for 'n'. Once 'CQ' command has been completed then telemetry wait returns to its normal setting of 'TW6'. To obtain pressure value, data sheet supplied with individual COMPATT / COMPATT bottom end-cap will need to be consulted. There are three different forms of data sheet in existence depending upon age and type of COMPATT. Compatts are fitted with Digiquartz sensors that have temperature output, and Digiquartz temperature is readable by use of 'TQ' command. The L/USBL system has no capability of producing pressure or depth from data recovered from a COMPATT equipped with a Digiquartz sensor. This has to be done long hand or on another computer with a program designed for calculating the depth from Digiquartz readings and the value entered into the V6 software manually if Depth aiding is required from Digiquartz COMPATT.
CSL	COMPATT Status Lock	*C: 102 PENDING ... E: 0 C: 102 CRF T2.5/5.5/0.25 EDDL E: 0* [Two part reply (i) COMPATT 102 pending (ii) COMPATT 102 has been locked]. The status of Mk4 Compatts fitted with firmware version **V7.13** and above [with the Multi-User option installed], and all Mk5 Compatts can be 'locked' to prevent critical parameters, such as the IRF and TATs, being inadvertently changed due to command corruption.
CSU	COMPATT Status Unlock	*C: 102 PENDING ... E: 0 C: 102 CRF T2.5/5.5/0.25 EDD E: 0* [Two part reply (i) COMPATT 102 pending (ii) COMPATT 102 has been not been locked]. The status of Mk4 Compatts fitted with firmware version **V7.13** and above [with the Multi-User option installed], and all Mk5 Compatts can be 'locked' to prevent critical parameters, such as the IRF and TATs, being inadvertently changed due to command corruption and has to be un-locked before these parameters can be changed.

COMPATT COMMAND		COMPATT REPLY EXAMPLES
CT	Temperature	*C : 302 TEMP = +15.62 E : 0* [COMPATT 302 temperature sensor reads 15.62°C]. Temperature sensor has lag time of 30 minutes (approx). If Temperature check button is used in Beacon Summary page, water temperature is displayed.
CWC 1-8	COMPATT Wait in Cycle	*C: 305 PENDING ... E: 0 C: 305 CRF T2.5/5.5/1.00 ED E: 0* [Two part reply (i) COMPATT 305 pending (ii) COMPATT 305 replying on CRF, with "Wait in Cycle" time of 1.00 secs. CIF interrogation frequencies are enabled (ED)] This command controls amount of time (in 0.25 second steps) between completion of one command and start of next command in stack within COMPATT when Cycle command is executed. There is a secondary effect for which this command is useful, namely the time between the end of one telemetry block and start of next block for commands that return more than one telemetry reply. When using commands having multiple telemetry replies and first reply decodes correctly without errors but subsequent replies always have errors, using 'CW6' normally solves the problem.
CWR 1-8	COMPATT Wait for Range Time-Out	*C: 305 PENDING ... E: 0 C: 305 CRF T2.5/1.5/0.25 DE E: 0* [Two part reply (i) COMPATT 305 pending (ii) COMPATT 305 replying on CRF, with "Wait for Range Time-Out" time of 1.5 secs. IIF interrogation frequencies are enabled (DE)]. Step size is 1 second with 0.5 second minimum value. Default value is 5.5 seconds.
CWT 1-8	COMPATT Wait before Transmit	*C: 305 PENDING ... E: 0 C: 305 CRF T3.0/2.5/0.25 DE E: 0* [Two part reply (i) COMPATT 305 pending (ii) COMPATT 305 replying on CRF, with "Wait before Transmit" time of 3.0 secs. IIF interrogation frequencies are enabled (DE)]. Step size is 0.5 seconds. Default value is 2.5 seconds - equates to 'CWT5'. This command needs to be treated with great care if values less than default setting are to be used. Increasing value above default is unlikely to cause acoustic problems.
CY CY	Cycle Cycle (cont.)	*C : 102 CYCLE START E: 0* [Initiates start of transmission of a series of parameters stored within the COMPATT (up to 8 maximum)]. Upon completion of cycle, an additional message:- *C : 102 END OF CYCLE E: 0* is returned. NOTE: Not supported by Mk 5 Compatt.
DC	Disable CIF interrogation replies	*C : 312 CRF T2.5/5.5/0.25 DE E:0* [COMPATT 312 now disabled on CIF and enabled on IIF (DE)] For a Mk4 and Mk5 Compatts, only one mode can be enabled at a time so, if 'DC' command is sent to a unit which is currently operating in IIF or USBL mode, the command would be acknowledged but no change of state would occur. If, however, the COMPATT was operating

COMPATT COMMAND		COMPATT REPLY EXAMPLES
		in the CIF mode, it would become fully disabled, just as if a Disable command had been sent.
DI	Disable IIF interrogation replies	*C : 312 CRF T2.5/5.5/0.25 ED E:0* [COMPATT 312 enabled on CIF and now disabled on IIF (ED)]. For Mk 4 Compatts, behaviour is same as with DC command but disables IIF mode.
DS	Disable all interrogation replies	*C : 304 DISABLED E : 0* [COMPATT 304 now disabled]
DU	Disable USBL interrogation replies	*C : 306 CRF T2.5./5.5/0.25 EED E:0* [COMPATT 306 fitted with USBL interrogation channel; enabled on CIF and IIF and now disabled on USBL channel (EED)]. For Mk 4 and Mk5 Compatts, only one mode can be enabled at a time so, if a 'DU' command is sent to a unit which is currently operating in CIF or IIF mode, the command would be acknowledged but no change of state would occur. If, however, the COMPATT was operating in USBL mode it would become fully disabled, just as if a Disable command had been sent.
DW	Disable Wideband interrogations	*C: 104 DISABLED IRS M0104 E: 0* [COMPATT 104 now listens for tone interrogation using previous mode status.] NOTE: Mk 5 Compatt only.
EC	Enable CIF interrogation replies	*C : 320 CRF T2.5/5.5/0.25 ED E:0* [COMPATT 320 now enabled on CIF and disabled on IIF (ED)]. On Mk4 and Mk5 Compatts, this command will turn on CIF mode and turn off IIF mode and USBL mode. NOTE: Mk5 Compatt: If Wideband ranging is enabled (see EW), the status will be WDD.
EF	Enable current interrogation replies and set fast telemetry baud rate	*C : 102 ENABLED E : 0* [COMPATT 102 now enabled at fast telemetry baud rate]. Sets Baud rate of surface controller and COMPATT to 100 Baud. On USBL, default Baud rate is set in installation files. If manual 'EF' command is used, COMPATT is changed to Fast Baud rate until another Baud rate command is sent to it. The USBL system is set to the Fast Baud rate, until another baud-rate-changing command is sent, or data in installation files is changed. If the existing Baud rate in installation data base is simply re-selected, the system treats this as no change and Baud rate would remain at Fast Baud although installation data shows Normal (say). USBL will revert to installation Baud rate if powered down and up again.
EI	Enable IIF interrogation replies	*C : 320 CRF T2.5/5.5/0.25 DE E:0* [COMPATT 320 disabled on CIF and now enabled on IIF (DE)]. On Mk4 and Mk5 Compatts, this command will turn on IIF mode and turn off the CIF and USBL modes. Mk5 Compatt only: If Wideband ranging is enabled (see EW) the status will be DWD.
EL	Elapsed Time	*C : 112 TIME= 1234 E: 0* [COMPATT 112 elapsed time since last reset 1,234 hours].

EP	Enable current interrogation replies, and set Robust wideband telemetry uplink.	*C : 104 ENABLED E : 0* [COMPATT 104 now enabled for Robust wideband telemetry]. The effective baud rate is about 1000 baud. Sets uplink type used by surface controller and COMPATT to Robust. Compatt 5 only.
EN	Enable current interrogation replies, and set normal telemetry baud rate	*C : 104 ENABLED E : 0* [COMPATT 104 now enabled at normal telemetry baud rate]. Sets Baud rate of surface controller and COMPATT to 50 Baud. Otherwise, comments applicable for EF command apply here also except normal baud rate applies instead of fast baud rate. Most USBL systems are set to Normal Baud rate in their installation data base.
ES	Enable current interrogation replies and set slow telemetry baud rate	*C : 105 ENABLED E : 0* [COMPATT 105 now enabled at slow telemetry baud rate]. Sets Baud rate of surface controller and COMPATT to 25 Baud. Otherwise, comments applicable for EF command apply here also except slow baud rate applies instead of fast baud rate.
EU	Enable USBL interrogation replies	*C :106 CRF T2.5/5.5/0.25 DDE E:0* [COMPATT 106 fitted with USBL interrogation channel; disabled on CIF and IIF and now enabled on USBL channel (DDE)]. On Mk4 and Mk5 Compatts, this command will turn on USBL interrogation mode and turn off CIF mode the IIF mode.
EW	Enable Wideband interrogation replies	*C : 104 ENABLED IRS M0101 E:: 0* [COMPATT 104 now enabled to receive Wideband interrogations, and reply with a wideband signal.] NOTE: Mk5 Compatt only.
FE	Enable IIF reply frequency change	*C: 302 PENDING ... E: 0 C: 302 F 2 T2.5/5.5/0.25 EE : 0t* [Two part reply (i) COMPATT 302 pending; no errors (ii) COMPATT 302 replying on Frequency Channel 2 (F 2) - Frequency Channel set by CF command]. If command is actioned when COMPATT has CRF, FSI or RLY showing as reply frequency to Individual interrogation in status word “B”, then IIF mode is enabled (if it was not already enabled) and reply channel is set to Channel 0, indicated by ‘F 0’ in status word “B”. If command is actioned when COMPATT has already previously been set to Frequency Enable mode then IIF mode is enabled (if it was not already enabled) and status word “B” shows current reply channel.
FM	Fast SI Mode	*C: 308 PENDING ... E: 0 C: 308 FSI T2.5/5.5/0.25 EE E: 0* [Two part reply (i) COMPATT 308 pending; no errors (ii) COMPATT 308 now in Simultaneous Interrogation mode fast].
HRP	Heading, Roll and Pitch from Gyro	*C: 104 HRP=356.65,+8.02,-20.41 E: 0* Compatt 104 reads gyro data: Heading 356.65°, Roll +8.02º, Pitch -20.41°. (A Heading values of >360° is an error code.)

NM	Normal Mode	*C: 302 PENDING ... E: 0 C: 302 CRF T2.5/5.5/0.25 EE E: 0t* [Two part reply (i) COMPATT 302 pending; no errors (ii) COMPATT 302 now replying to IIF on CRF].
OV	Low battery override	*C: 607 RF 7/125.0 AOBEV7.8 E: 0* [COMPATT 607 has an alkaline battery(A); the low battery override is in operation(O); the battery count is greater than the alarm level (B); all channels are enabled (E); Firmware version 7.8 is fitted (V 7.8); no errors].
PS	Power Status	C: 305 PWR : Ln Sn Tn Jn Un Gm E: 0 [COMPATT 305 power levels are: (Ln) Long Base Line channels (Sonardyne); (Sn) Telemetry Start pulse; (Tn) Telemetry data pulses; (Jn) Only used in switched beam Compatts – see CPJ commands; (Un) USBL (SIMRAD 309/205) reply channels; (Gm) Gain level] where n is the transmission setting and m is the receiver gain setting of the COMPATT. For Non-Dual Pulse Mk4 Compatts, 'n' may be 1 for low power or 2 for high power and 'm' may be 1, 2, 3, or 4 for gain setting, 1 being lowest and 4 highest. For Dual Pulse Mk4 Compatts, 'n' may be 1 to 8 where 1 to 4 causes pulses of 4ms duration and 5 to 8 causes pulses of 8ms duration (low number end of each range produces the lowest amplitude transmission and high number end of each range produces the highest amplitude transmission). The 'm' may be 1, 2, 3, or 4 for gain setting, 1 being lowest and 4 highest.
RB	RX supply Battery Check	*C: 302 PENDING .. C : 302 BC = 325 V = 27.4 E : 0* [COMPATT 302, battery count is 325 and battery voltage is 27.4V]. On L/USBL if transponder status word "A" has been read and battery type is indicated as 'L2' (i.e. a dual stack battery pack, with 2 separate battery counts), then this command is actioned in addition to the Battery Check command when battery check button is operated in Beacon Summary page.
RD	Reset Default	*C: 810 RF10/125.0 NPEV7.8 E: 0* [COMPATT 810 parameters have been reset to default values: Reply to CIF on channel 10; TAT 125 msecs; Nicad battery fitted (N); low power mode set (P); fully enabled (E); Firmware version 7.8 fitted (V7.8)]. NOTE: A Reset command will return a Mk5 Compatt set to Wideband mode back to Tone mode.
RL	Release	*C : 105 RELEASE No 1 E : 0* [COMPATT 105 acknowledges first of three RL commands]. *C : 105 RELEASE No 2 E : 0* [COMPATT 105 acknowledges second of three RL commands]. *C : 105 RELEASE ACCEPTED E : 0* [COMPATT 105 acknowledges third of three RL commands]. This is followed by 11 to 14 pings on CRF whilst release is actuating and then :-

		C : 105 RELEASE COMPLETE E : 0 The V6 USBL system looks for the first three telemetry replies, counts and displays the CRF pings and looks for the final telemetry reply. If COMPATT has flat battery pack, i.e. 'B' flag is showing in status word "A", then it's response to the first Release command is one CRF ping. Response to the second Release command is two CRF pings. Response to the third Release command is three CRF pings followed by 11 to 14 CRF pings whilst release is actuating and then "Release complete" telemetry. The V6 system is at present unable to show anything other than 'NO REPLY' in this case, but will count and display the release actuating pings. When using L/USBL (or some other controller) to release COMPATT, it is necessary that nothing else is trying to interrogate COMPATT to be released at same time. On L/USBL system that is being used for navigation, select "**Nav Set-up**" and move the cursor to the entry line for the COMPATT to be released and press the <ENTER> key to access the select the "**Beacon Setup**" page. Move the cursor to the "**Read Depth**" field and press <ENTER>, noting down the depth reading. Then move the cursor to the "**Release Compatt**" field and press <ENTER>. The system will ensure the COMPATT is in the correct mode and send the first Release command. **NOTE:-** if the COMPATT is Reference Beacon it should be changed to Mobile beacon with the "**GAIN**" set to "**MED**" before releasing. Wait for a data answer or 'NO REPLY' answer to the first Release command. If answer is data, wait 5 seconds before proceeding, otherwise proceed with second Release command. If answer is data, wait 5 seconds before proceeding otherwise proceed with third Release command. Count the 'pings' reported by the system, waiting for 50 seconds before proceeding irrespective of a 'NO REPLY' or data message being displayed. Send a new "**Read Depth**" command and check that depth is reducing (try at least 3 times). If depth is reducing or telemetry now has persistent errors then COMPATT is on its way up. If, however, depth remains constant, DO NOT send any more Release commands for at least 30 minutes in case COMPATT release mechanism is in open position but hook has not sprung fully open. Return to the Navigation Chart Display so that it may be tracked whilst it is on way to surface. It is useful to set From/To data box to read range and bearing From Vessel to Transponder so that COMPATT position may be monitored to assist recovery. The ranging to a COMPATT which has failed to release should be monitored in case it does become free. However, if it is not free after 30 minutes then repeat release sequence to achieve

		one of two things. Firstly, there is a slight possibility that it will release but secondly, and more likely, is the possibility that release clasp will jam hook shaft and thus prevent it from opening. In this second case, recovery by ROV will be needed.
RM	Relay Mode	*C: 302 PENDING ... E: 0 C: 302 RLY T2.5/5.5/0.25 EE E: 0t* [Two part reply (i) COMPATT 302 pending; no errors (ii) COMPATT 302 now in Relay mode (RLY)].
SI	Simultaneous Interrogation	*SIS;103;+1003.5E 0; 2, 345.12; 4, 234.78; 8, 1014.60i* [COMPATT 103 in SI mode; at depth 1003.51 m; no errors; range on channel 2 is 345.12 msecs; etc.]. NOTE: Mk5 Compatts use six agile receivers to scan around the 12 possible reply channels, to locate valid replies. The first 2-3 interrogation cycles may miss some ranges as a result.
SS	Sound Speed	*C : 102 SS=1485.00 E : 0* For Mk4 and Mk5 Compatts fitted with a sound speed sensor this command returns the sound speed in metres per second as measured at the depth of the sensor. (A reading of 9990 or above indicates an error code.)
TC	Terminate Cycle	*C : 102 TERMINATE CYCLE E : 0* [COMPATT 102 has terminated cycle mode]. TC closes COMPATT command stack and prevents further stackable commands going onto stack. Disabling COMPATT re-enables stack so that it may be re-configured. Stack can hold up to 8 stackable commands and will be the 8 preceding Terminate cycle command. It is possible to stack less than 8 commands by sending a Disable command, then commands to be stacked followed by Terminate cycle command. The stackable commands are:- CI1 - CI14, CD, CT, CQ. NOTE: Not supported by Mk5 Compatts.
TQ	Quartz pressure sensor temperature	*C: 407 PENDING ... E: 0 C : 407 DQZ CNT = 1530000 E: 0* [COMPATT 407 Digiquartz temperature sensor count is 1,530,000]. The L/USBL system has no capability of producing temperature from data recovered from a COMPATT equipped with a Digiquartz sensor. This has to be done long hand or on another computer with a program designed for calculating the temperature from Digiquartz readings and value entered into the V6 software manually if Depth aiding is required from Digiquartz COMPATT.

TS	Transponder Status	*C : 809 RF 0/125.0 ASJPOBDV7.8 E : 0* *C: 809 F7 T2.5/5.5/0.25 DDER E : 0.* Two part reply: Status word "A". COMPATT 809 is on channel 0 indicating that Pulse Position Angle data Telemetry will sent in response to a Common Interrogation; has TAT 125.0 msecs; has alkaline batteries (N); has Simultaneous Receiver fitted (S); the transponder is more than 45° from the vertical (J); is at low power (P); battery alarm override mode is set (O); Battery count exceeds alarm limit (B); the Sonardyne modes are disabled (D); has firmware version 7.8 with no errors. Status word "B". COMPATT 809 will reply to the USBL channel HPR7; has a Wait before Transmit time of 2.5 secs; a Wait for Range Time-Out time of 5.5 secs; a Wait in Cycle time of 0.25 secs; is now enabled on USBL and disabled on CIF and IIF (DDE); Riser Angle Monitoring mode is set to Relative i.e. the difference between BOP and Riser ('R' is used for relative instead of 'D' for differential so as not to be confused with 'D' for Disabled); no errors. Above Transponder status words are for Mk 4 Riser Angle COMPATT (RAC) in reset condition. These words are shown as they show every possible location within TS status words. Status word "A" possibilities:- For COMPATTs other than RACs, RF value in reset condition should match channel number in address. If unit is not reset then any value in range 0-14 is valid. Reset TAT is 125.0 ms. However, it is variable in steps of 62.5ms from 62.5ms to 875.0 ms. TAT field is used to show Sonardyne TAT as USBL TAT is fixed at 30ms. There are four possible battery Types: (A) Alkaline: (N) Ni-Cad: (L) Lithium and (L2) dual voltage Lithium. Letter 'S'; is present if Simultaneous Receiver card is fitted and absent if not fitted. Presence of letter 'J' on a Mk 4 COMPATT indicates that unit is tilted by more than 45° from vertical. Presence of letter 'P' indicates that COMPATT has its Long Base Line channels set to Low power; absence of letter 'P' indicates that Long Base Line channels are set to High power. Presence of letter 'O' indicates that Low Battery alarm has been over-ridden; absence of letter 'O' indicates that Low Battery alarm over-ride is not active. Presence of letter 'B' indicates that Low Battery alarm is set; absence of letter 'B' indicates that Low Battery alarm limit for the battery type fitted has not been reached. Next character is either letter 'D' (to indicate that the Long Base Line interrogation modes are disabled) or letter 'E' (to indicate that a Long Base Line interrogation mode is enabled). Final group of characters before check sum group indicates COMPATT firmware version. NOTE: With Mk5 Compatts if the extra Wideband Rx card is installed, the S flag will not be set.

		Status word “B” possibilities:- First group of characters indicate response of COMPATT to IIF or USBL interrogation. Possibilities are CRF (reset or normal mode condition), RLY (COMPATT replies on CIF and this is used to interrogate any transponders listening on CIF, with replies being received back at Transceiver which sent original IIF), FSI (COMPATT responds on CIF and waits for replies from interrogated transponders and returns depth of COMPATT and ranges to other transponders). If COMPATT is in Frequency Enable mode then ‘Fnn’ is displayed where nn is channel number that COMPATT will reply on in response to IIF interrogation. Similarly, if COMPATT is in the USBL mode, ‘Fnn’ will be displayed, 1 to 9 for HPR 1 to 9, 10 for HPR Square (11), 11 for HPR Circle (22), 12 for HPR Delta (33), 13 for HPR X (44) and 14 for HPR Y (55). Following letter ‘T’ are Wait times displayed in seconds. Default values are 2.5/5.5/.25 for ‘Wait before Transmission’ (Interrogate), ‘Wait while Ranging’, and ‘Wait while Cycle’. Then there is a group of 2 to 4 letters, of which first three show which interrogation modes are Disabled (D) / Enabled (E) and the final letter shows which Riser Angle Mode is enabled if unit is RAC. In MK 4 COMPATTs it is only possible for one mode to be enabled at a time so only valid combinations are :- DDD, EDD, DED and DDE. The RAC unit will return either ‘I’ for Internal sensor only, ‘X’ for external sensors only or ‘R’ for relative (Differential) internal with respect to external sensors. In the V6 system “**Beacon Setup”** page there is a button that actions Transponder Status command. NOTE: MK5 Compatts For CIF and IIF interrogation modes, there is a third option introduced by the wideband functionality. WDD indicates that a wideband interrogation on CIS is enabled. DWD indicates that a wideband interrogation on IIS is enabled
TT 1-14	Turn-around Time	*C: 102 PENDING ... E: 0 C: 102 TA TIME = 312.5 E: 0* [Two part reply (i) COMPATT 102 pending; no errors (ii) COMPATT Turn-around Time now set to 312.5 msecs].

B.2 COMPATT ERROR MESSAGES

All COMPATT replies, when printed, are followed by an error display. If no errors were detected, zero error value (E: 0) will be displayed.

If errors are detected by any of the checks, the error value will be non zero. The error value will be the sum of the values for each error detected as shown in the table below.

Error	Error Value
Error in address acknowledgement	1
Error in command acknowledgement	2
Error in data check bits	10

For example, if all checks fail, "E:13" will be output. If the reply is an acknowledgement word, then only the first two errors may apply - so a failure of both checks would produce “E: 3”.

B.3 POWER PARAMETER CODES

Power Parameter	Description – Power Levels
A	All parameters below
L	LBL interrogations and replies
S	Telemetry - first pulse
T	Telemetry data pulses (after the first)
J	Switched-beam mode
U	USBL interrogation replies

B.4 STATUS CODES

Status Parameter	Description
S	Simultaneous Interrogation set (Mk5 Compatts only: if not set, indicates Wideband Rx card is installed)
J	COMPATT tilted by more than 45 deg.
P	Low power set
O	Battery override set
B	Battery count greater than alarm level
E	Sonardyne Interrogation Mode enabled
D	Unit fully disabled or HPR mode enabled

NOTE: Refer to the PAN Operating Manual, OM-7145 Firmware Version 7 or above, for a full description of all Mk4 Compatt commands in this Appendix and the reply formats.

APPENDIX C

C. GLOSSARY OF TERMS

This appendix contains two glossaries:

- User Operator Terms
- Signal Processing and Communication Terms

C.1 USER OPERATOR TERMS

C.1.1 Acoustic (Beacon)

An instrument that emits acoustic signals. It is used to mark a point on the seabed or is fixed to a Mobile target (qv) so that it can be tracked or positioned within the water column.

The major types of Beacon are described below but some Beacons can be configured as several or any of the types.

- **Acoustic (Transponder) Beacon**

  A particular type of Beacon that emits an acoustic signal when it detects an interrogating acoustic signal.

- **Acoustic (Responder) Beacon**

  A particular type of Beacon that emits an acoustic signal in response to an electrical signal carried to it by cable.

- **Acoustic (Pinger) Beacon**

  A particular type of Beacon that emits signals regularly without an interrogating signal. A SYNCHRONOUS pinger is one that can be synchronised to an external master signal. A PRECISION pinger is one with an accurate internal time standard.

- **Acoustic Transducer**

  A device that converts electrical signals into acoustic signals and vice-versa. A HYDROPHONE is a device used to convert acoustic signals into electrical signals only.

  Note: Often the term is applied to a complete instrument that contains pre-amplifiers, matching networks etc.

- **Acoustic Transceiver**

  An instrument that can generate electrical signals suitable for conversion to acoustic signals by a transducer. It can detect received signals and extract information from them.

  For example some Transceivers can measure the time it takes a signal to travel from a transducer to a Transponder and return. Some can encode and send data in a message and extract digital data from a message (Acoustic Telemetry).

- **Acoustic (Intelligent Transponder Beacon)**

  A particular type of Transponder Beacon that is managed by a micro-controller. It is commonly referred to as a COMPATT (qv). It can decode acoustic telemetered commands from a Transceiver and can send telemetered data to the Transceiver. It can measure the distance between itself and other Transponder Beacons and then telemeter the data to a Transceiver.

  Usually the instrument is capable of measuring its depth and the temperature of the water and may be commanded to telemeter its own internal state back to the surface. It may be used to measure a variety of underwater parameters such as the local sound speed and telemeter these back to the surface. It is used, for example, as an intelligent angle-measuring device in a Riser Angle Monitoring System (qv). Very often is fitted with a release mechanism enabling it to be returned, on command, back to the surface at the end of a mission (or if battery power is low).

  The intelligent Beacon can be developed to the state where it becomes a remotely operated Transceiver.

C.1.2 Acoustic Signal

A message carried by sound pressure waves through the water. In the Sonardyne case, the message has finite length in time.

C.1.3 COMPATT

COMPuting And Telemetry Transponder (see Acoustic Intelligent Transponder Beacon). A range of COMPATTs is available from Sonardyne to perform a variety of tasks.

C.1.4 Co-ordinate Frame

A system that is used to define the position of body in space. The system used is a right-handed Rectangular Cartesian co-ordinate system in three dimensions where the three axes used are orthogonal.

[Sometimes "polar" co-ordinates may be used. The z co-ordinate is the same as above but the position reflected in the x-y plane is expressed as a radius from the z axis and a bearing in degrees measured clockwise from the y axis].

A frame with its z axis vertical and stationary with respect to the seabed is known as a SEABED FRAME or an INERTIAL FRAME. (Normally for convenience the x,y plane where z = 0 is at or just below the lowest point on the seabed in the area. Positions above this plane have a positive z co-ordinate or height. Depth is considered as negative height and is measured from the sea-surface or from a height close to it).

A vessel frame is a frame that is fixed to a vessel.

An RPH (Roll, Pitch and Heading) compensated vessel frame is a frame sharing the same origin as the vessel frame but with the z-axis vertical and the y-axis parallel with a meridian passing through the origin (points true north).

C.1.5 Database

A Database is a body of data stored in a computer memory or on magnetic disc media such as an embedded hard disc or on portable floppy disc.

C.1.6 DP (Dynamic Positioning)

A system that automatically maintains a vessel with a constant heading and in a fixed position in an inertial frame or with respect to a mobile. It avoids the need to anchor a vessel and provides more flexibility in operation.

Normally such a system uses a number of position inputs such as GPS (qv) receivers, taut wire sensors, LBL, SBL or USBL acoustic positioning sensors, wind speed indicators etc. The system controls thrusters on the vessel to maintain position and attitude in yaw.

C.1.7 DP Reference

The acoustic positioning system reports the position of a reference point on the seabed OR a mobile in the vessel's frame OR a stabilised vessel's frame REGARDLESS of what else the system is doing.

This is to maintain compatibility with earlier systems and to provide a standard interface regardless of the type of system used (LBL, SBL, USBL, LSBL, L/USBL etc.) and the manner in which it is being used (e.g. LSBL in SBL or LBL mode).

C.1.8 DP Report

The report an acoustic positioning system sends to a DP system over a serial interface.

C.1.9 Geodetic Co-Ordinates

The earth is modelled by a reference spheroid (of which there is a large selection). The position of any point on or near the earth surface is defined by an angle of latitude and an angle of longitude.

For a point on the spheroid P:-

Latitude is defined as the angle between the normal at P and the plane of the spheroidal equator.

Longitude is defined as the angle between the meridian plane through P and the arbitrarily defined zero meridian plane or the "Greenwich" plane. (See Geodesy, fourth edition, Bomford, Oxford, sections 2.03 and 4.10(d) for more precise definitions.)

NOTE: This co-ordinate system is not the same as the astronomical co-ordinate system.

C.1.10 GPS (Global Positioning System) Attitude Sensor

A system based on the GPS system and a receiver using three or more antennae with known baselines. It is able to compute the instantaneous attitude of a vessel about the roll, pitch and yaw axes.

C.1.11 GPS (Global Positioning System)

A multi-user, 24 hour, worldwide radio navigation system using the NAVSTAR constellation of satellites. GPS receivers are capable of tracking and decoding the data from the satellites and computing the position and velocity of a vehicle in space. The LUSBL system uses the WGS 84 Geodetic Co-ordinate system.

C.1.12 Gyro Compass

A North-seeking Gyroscope uses the properties of a gyroscope when its spin axis is maintained horizontal. The gyroscope senses the spin axis of the earth and will align itself with true north.

C.1.13 Inclinometer

An analogue device, usually fitted into a COMPATT (qv), which measures the angle of the Transponder in which it is mounted with respect to the local vertical.

C.1.14 Mobile

A body that is free to move relative to the seabed through the space between the sea surface and the seabed.

C.1.15 Monitor/Keypad

An instrument that contains a 12 inch colour graphics display monitor and has a keypad in close proximity suitable for operator input to the system.

Note that, in a later version of this unit, incorporating a 17 inch high resolution monitor, the Monitor and Keypad are split into two separate units - Type 7940 Monitor unit and the Type 7941 Keyboard unit. Both are designed for 19 inch rack mounting.

C.1.16 Navigation Processor

An instrument that:-

- Acts as the system controller.
- Accepts operator input from the keypad.
- Generates the display signals for the Monitor.
- Processes the data from the Transceiver into a form suitable for display to the operator and output to a DP system.
- Interfaces to various "attitude" sensors and other navigation systems.

C.1.17 Riser Angle Monitoring System (RAMS) - or Marine Riser Angle Monitoring System (MRAMS)

Used for measuring the differential angle between a BOP (Blow-Out Preventer) on the seabed and the Riser, connecting the BOP to the rig. Comprises a COMPATT type Transponder (qv) which is normally rigidly mounted to the BOP and an external inclinometer unit normally mounted on the Riser and connected by cable to the COMPATT. On command, the system measures the angle of the BOP with respect to the local vertical and reports this back to the surface and can then repeat this process for the Riser using the external inclinometer.

C.1.18 ROV (Remotely Operated Vehicle)

A vehicle controlled and powered over a cable connection so that it can travel in the space between the sea surface and the seabed.

C.1.19 Seabed

The surface of the earth covered by water or sea. The seabed is considered stationary.

C.1.20 Sonardyne Systems

- **LBL (Long-Base-Line) System**

  A system where there are two or more (typically four) Transponders on the seabed. The positions of the Transponders are established by a calibration process in a seabed frame. The distances from a transducer to each Transponder are measured using a Transceiver. The position of the transducer can be computed in the seabed frame.

  It takes its name from the "baselines" joining each Transponder. It is sometimes referred to as a range-range system.

- **SBL (Short-Base-Line) System**

  A system where three or more transducers are fixed to a vessel and connected to a single Transceiver. The position of each transducer is measured and co-ordinated in the vessel frame. By measuring the time of arrival of the signal from a Beacon at each transducer the position of the Beacon in the vessel frame can be computed.

- **LSBL System**

  A hybrid of an LBL and an SBL system.

- **USBL (Ultra-Short-Base-Line) System**

  A system similar in principle to an SBL system except the system uses three or more elements in a single transducer array. The measurements it makes are the differences in "time-phase" of the signals from each element.

  The co-ordinate frame is fixed to the transducer array which must be oriented in the vessel frame to be equivalent to the SBL system.

- **L/USBL System**

  A hybrid of an LBL and a USBL system. It utilises USBL equipment in an LBL configuration.

- **Dual-Redundant L/USBL System**

  Two complete sets of L/USBL equipment working in tandem on a Master/Slave basis. The two sub-systems are cross-linked in such a way that, in the event of a failure of any major element, system operation will continue without the need for operator intervention. From the operator's point of view, operation of the dual-redundant version is essentially identical to that of the standard version.

- **Ping Stacking**

  When acoustic interrogation and reply signals are interleaved in order to improve the position update rate when tracking a vessel or mobile beacon in deep water. (Supported in systems running V6.04 and later software when operating with digital transceivers).

C.1.21 Sound Velocity

For seawater, and for constant temperature, salinity and pressure, the speed at which sound travels in seawater is constant.

C.1.22 Sound Velocity Profile

At different depths the temperature, salinity and pressure vary; therefore the local sound velocity varies.

In practice the depth cannot be measured directly. Therefore pressure measurements are made, and depth computed, using a knowledge of density. Derivation of density requires a knowledge of temperature and salinity. Salinity cannot be measured directly but conductivity can be measured. Therefore a popular method of measuring the sound velocity profile is from a profile of pressure, temperature and conductivity and the use of empirically derived formulae to compute depth and sound velocity.

Sound velocity can be measured directly using a dedicated and calibrated instrument called a sound velocimeter. (One still needs a set of depth measurements).

C.1.23 Submersible

A vehicle that operates below the sea surface carries men in a one atmosphere environment. One man pilots the craft. It carries a supply of air for the men and a supply power for propulsion etc. It is capable of autonomous operation form a vessel for a limited time.

C.1.24 Target

Object to be tracked by acoustic system.

C.1.25 True North

The direction of the shortest line that can be drawn, across the surface of the earth, from the observer and the North Pole. (The North Pole is where the north end of the spin axis of the earth meets the surface.)

C.1.26 UTM (Universal Transverse Mercator)

A Projection system that is used to transform Geodetic co-ordinates into an orthogonal two-dimensional system suitable for representation on a plane such as a chart. Normally the co-ordinates are called easting and northing which are equivalent to x and y respectively.

The UTM system is a worldwide system. Each projection covers 6 degrees of longitude with the central meridian at 3, 9 degrees etc. east of Greenwich and from 84 degrees north to 80 degrees south. The scale factor on a central meridian is 0.9996 (with some exceptions).
The projection is orthomorphic which means that at a point the scale in all directions is the same and there is no LOCAL distortion. However it should be noted that the scale factor changes with distance from the central meridian. For points away from the central meridian grid north and true north diverge. The difference is called the CONVERGENCE which is positive when grid north is east of true north.

Usually, the point where the central meridian meets the spheroid equator is given a false easting of 500,000 m.

Many countries' mapping systems are based on the same system but use a particular reference spheroid, non-standard central meridians, scale factors and different false eastings and northings.

The polar regions are covered by two Zenithal orthomorphic projections.

C.1.27 VRG (Vertical Reference Gyroscope)

A gyroscopically stabilised VRU.

C.1.28 VRU (Vertical Reference Unit)

An instrument that measures the instantaneous roll and pitch of a vessel.

C.1.29 Vessel

A body floating in the sea with at least part of it penetrating the surface. It is free to move and rotate relative to the seabed.

C.2 SIGNAL PROCESSING AND COMMUNICATION TERMS

C.2.1 Bore-sight

The axis about which the transducer maximum power gain is being directed.

C.2.2 Capture Area

The effective aperture size of the array. It is directly related to the array gain.

C.2.3 Carrier to Noise Density

This is the ratio of the signal power(C) to noise power (No) in unit bandwidth (C/No); generally quoted in dBHz.

C.2.4 Directivity Index

This is the ratio of the radiation intensity in the direction of interest compared with an isotropic radiator.

C.2.5 False Alarm

An invalid signal has satisfied all of the detection criteria and the detection process incorrectly declares the presence of a valid signal

C.2.6 False Alarm Probability

The resultant probability of ALL the false alert probabilities.

C.2.7 False Alarm Rate

Predicts the number of false alarms that will occur in a specified time.

C.2.8 False Alarm Number

Predicts the average number of possible decisions between false alarms.

C.2.9 False Alert

An invalid signal has satisfied ONE detection criterion and the detection process incorrectly declares the presence of a valid signal.

C.2.10 False Alert Rate

Predicts the number of false alerts that will occur in a specified time.

C.2.11 Front to Back Ratio for a Transducer

It refers to the ratio of power transmitted in the forward hemisphere of the polar diagram to that transmitted in the reverse hemisphere of the polar diagram.

C.2.12 Kalman Filter

An adaptive filter that provides optimum filtering of a signal that has been subjected to a non-stationary environment (i.e. when the data is significantly changing during the filter convergence time).

C.2.13 Middleton Noise

This noise is impulsive in nature and is described by a Middleton probability density function. There are three classes of noise description - A, B and C:-

- **Class A**

  Typically narrower spectrally than the receiver bandwidth in question and, as such, generates ignorable transients in the receiver's front end (initial linear stages) when source emission terminates.

- **Class B**

  The bandwidth of the incoming noise is larger than that of the receiver's front end stages, so that transient effects both in the build up and decay occur; the latter predominates. To varying degrees, the receiver is "shock excited", particularly for inputs of very short duration; the receiver is said to "ring".

- **Class C**

  The sum of Class A and Class B interference.

C.2.14 Rayleigh Fading Channel

The fading characteristics of the propagating channel are in accordance with a Rayleigh Probability Density function. Such a channel does not support constant signal. The phase of the signal is uniformly distributed between 0 and 2_ radians.

C.2.15 Rayleigh Probability Density Function

A Rayleigh Probability Density function is the instantaneous vectorial addition of two independent zero mean time variant Gaussian processes. The phase of the resultant vector is uniformly distributed between 0 and 2_ radians.

C.2.16 Rician Fading Channel

The fading characteristics of the propagating channel are in accordance with a Rician Probability Density function. Such a channel does support a constant signal level. Associated with this signal is a non-coherent Gaussian signal of lower strength.

C.2.17 Rician Probability Density Function

A Rician Probability Density function is the instantaneous vectorial addition of two independent zero mean time variant Gaussian processes where one of the designated signal vectors is not only consistently larger than the other but remains so during the observation time.

C.2.18 Wideband Telemetry

The wideband telemetry supported by Mk5 Compatts uses wideband signals providing a 1024 baud data rate.

C.2.19 Translinear Mode

The system operates in linear mode for signals within specified dynamic range. Once the input signal level is larger than the upper limit set by the input dynamic range, hard limiting occurs.

C.2.20 Wideband Signals

SONARDYNE have defined a number of wideband carriers on which different codes can be transmitted. The combination of different carriers and codes creates over 420 individual wideband interrogation and reply signals in SONARDYNE wideband systems.

APPENDIX D

D. CO-ORDINATE FRAMES AND SENSE OF OFFSETS AND CORRECTIONS

D.1 CO-ORDINATE FRAME CONVENTIONS

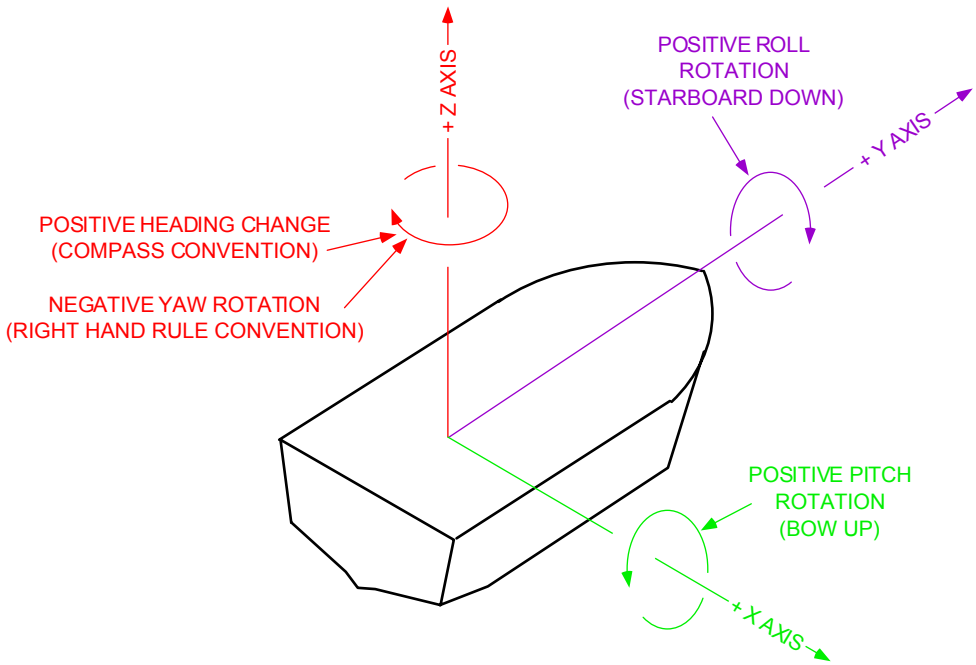
As shown in Fig D.1, the system operates in three dimensions and the co-ordinate frames use three mutually orthogonal "right handed" axes. The axes are labelled x, y, z respectively for easting, northing and depth.

In a right-handed system the following rotations are positive:-

- Positive Yaw rotation - "x" axis rotates towards the current "y" axis direction.
- Positive Pitch rotation - "y" axis rotates towards the current "z" axis direction.
- Positive Roll rotation - "z" axis rotates towards the current "x" axis direction.

  i.e. x ---> y --> z --> x are POSITIVE rotations.

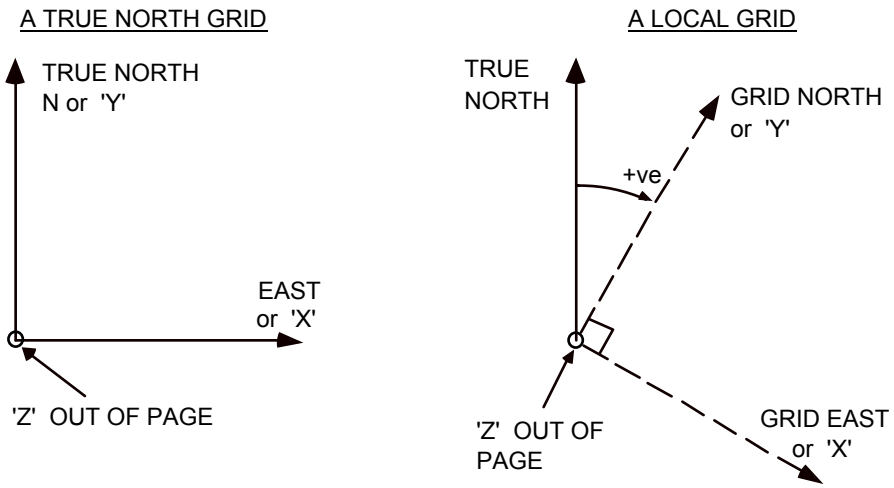
FIG D.1 CO-ORDINATE FRAME CONVENTIONS



In conventional grid situations (see Fig D.2, which follows):-

- The "x" direction is reserved for the "true" east direction, any grid east direction or the "logical" east direction of an object such as the "starboard" direction of a vessel.
- The "y" direction is reserved for the "true" north direction, or any grid north direction or the "logical" north direction of an object based frame, such as the lubber line (fore/aft axis) of a vessel. In the construction industry, the "logical" north is referred to as "plant north".
- The z-axis is reserved for the true vertical direction or, in the case of an object, the "logical" vertical direction. Depth is in the negative direction of the "z" axis.

FIG D.2 CO-ORDINATE GRIDS



D.1.1 Some Exceptions

The convention for the heading of a vessel conflicts with the convention for right-handed systems (which are also used for mathematical trigonometric functions). Vessel heading rotation is in the wrong sense, is 0 to 360 degrees instead of plus and minus 180 degrees and the zero is in the "y" direction instead of the "x" direction. [Everything works mathematically if one forgets the zero direction problem (imagine that the x axis is displaced) and make the heading negative].

D.1.2 Some Examples

Positive Pitch of a vessel is when the bow end of the vessel rises with respect to the aft end.

Positive Roll of a vessel is when the starboard side of the vessel drops with respect to the port side.

Positive displacements and velocities are in the "y" or north direction, "x" or east direction or in the "z" or vertically up direction.

D.1.3 Local Grid

Charts provide a two dimensional representation of the earth's three-dimensional surface. One consequence is that in most places the local representation or local grid does not align perfectly with True North. The angle between these is the local convergence. See UTM in the Glossary, Appendix C.

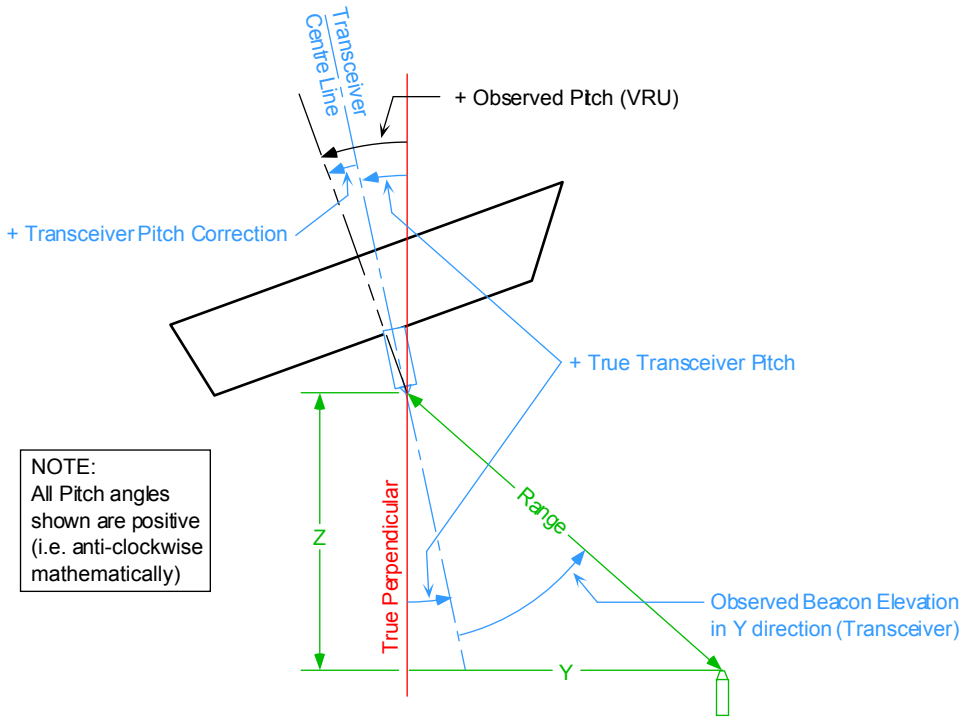
D.2 SIGN CONVENTIONS FOR SONARDYNE CORRECTIONS

In the following, it assumed that alignment errors in the VRU and the Gyro Compass have been corrected by some means external to the Sonardyne system. In other words, if the vessel's Z axis is exactly aligned with the local perpendicular, then the VRU will output 0°,0° and, if the vessel is heading exactly due North, the Compass will output 0°.

The need for corrections within the Sonardyne L/USBL system arises because the Transceiver, as deployed, may not be exactly aligned with the Vessel's grid. These mis-alignments will be measured during the installation phase of a job and corrections applied to all calculations made by the system. Details of these correction calculations are given in the following.

D.2.1 Pitch Axis Corrections

FIG D.3 PITCH AXIS CORRECTIONS



The Transceiver Pitch Correction is used as follows:

True Transceiver Pitch = Observed Pitch - Transceiver Pitch Correction

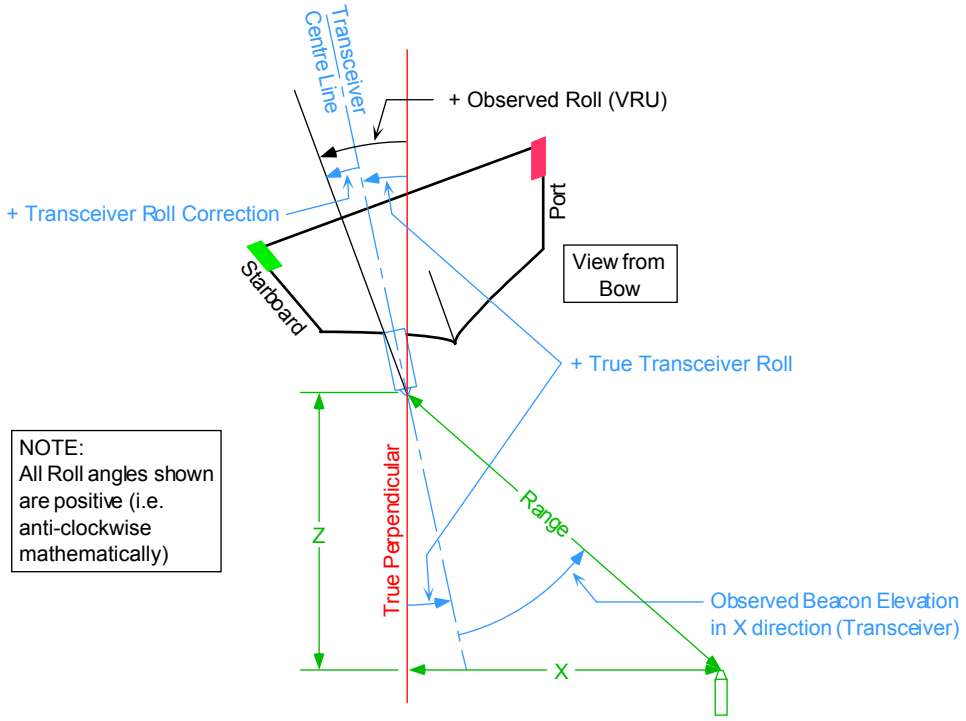
True Beacon Elevation = Observed Beacon Elevation + True Transceiver Pitch

Z = Range x COS (True Beacon Elevation)

Y = Range x SIN (True Beacon Elevation)

D.2.2 Roll Axis Corrections

FIG D.4 ROLL AXIS CORRECTIONS



The Transceiver Roll Correction is used as follows:

True Transceiver Roll = Observed Roll - Transceiver Roll Correction

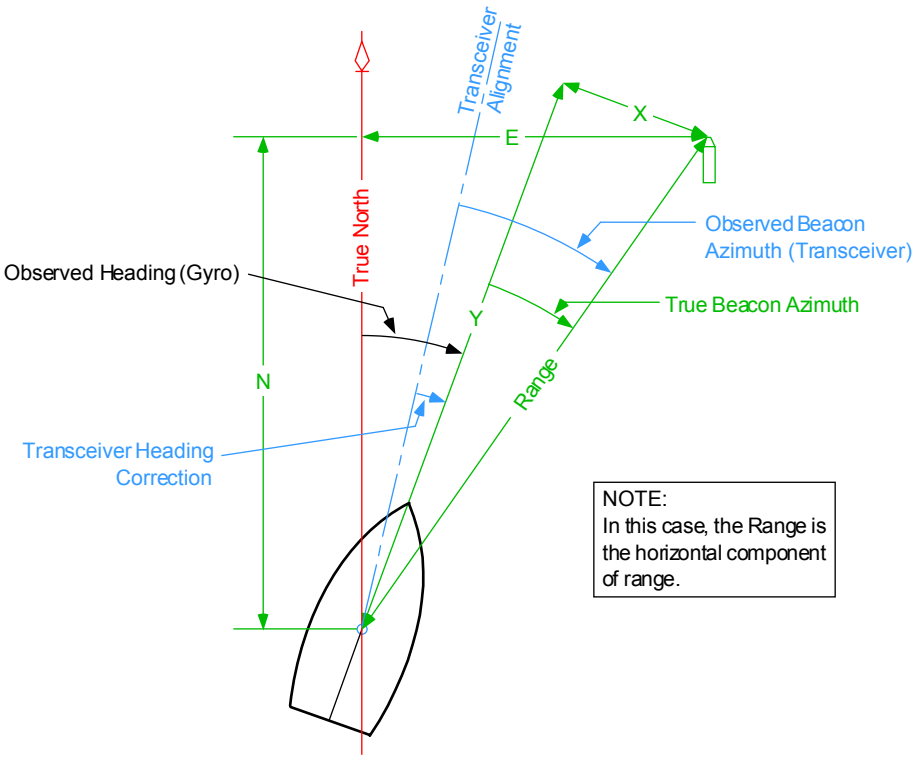
True Beacon Elevation = Observed Beacon Elevation + True Transceiver Roll

Z = Range x COS (True Beacon Elevation)

Y = Range x SIN (True Beacon Elevation)

D.2.3 Azimuth Corrections

FIG D.5 AZIMUTH CORRECTIONS



The Transceiver Heading Correction is used as follows:

True Transceiver Heading	=	Observed Heading - Transceiver Heading Correction
Relative Beacon Azimuth	=	Observed Beacon Azimuth - Transceiver Heading Correction
True Beacon Azimuth	=	Observed Beacon Azimuth + True Transceiver Heading

Y	=	Range x COS (Relative Beacon Azimuth)
X	=	Range x SIN (Relative Beacon Azimuth)
N	=	Range x COS (True Beacon Azimuth)
E	=	Range x SIN (True Beacon Azimuth)

APPENDIX E

E. LOGGING AND SURVEYORS OUTPUTS

This appendix describes the various types of message likely to be encountered in the logging .CSV file and the Surveyor's Output.

The data available in both the logging and Surveyor's Output are generally the same.

The start of each log file has the header record and the field names for all message types.

Specific fields from specific message types can be selected for the Surveyor's Output. The way to do this is described later in this appendix.

The appendix describes the format and content of the messages and gives examples of typical messages. It is organised into five main sub-sections:

- Message Formats
- Selecting Fields for the Surveyor's Output - rules for using the serial port to select fields for output
- Typical Messages - examples of messages sent by Surveyor and replies received
- Use of Terminal Emulator to Extract Survey Output - to view, control and log data
- Logging Data for CASIUS - procedure for using PC Plus to log survey output data for the CASIUS calibration package

The types of message available are:

- Header (Type 0) (Logging output only)
- Transponder (Type 1)
- Ship (Type 2)
- Sensor (Type 3)
- Riser Angle Monitoring (Type 4)
- Analogue Measurement (Type 5)
- Acoustic (Type 6.1)
- DGPS (Type 6.2)
- Depth (6.3)
- Attitude (Type 6.4)

Note that logs may contain additional fields not listed in this Appendix. These are for Sonardyne specialist use and are not relevant to any customer operation.

E.1 HEADER MESSAGES

The header message is created at the top of each log file but is not sent from the surveyor's output port. The following fields are available in the header message:-

Field Name	Meaning	Data Type	Format/ Units/ Range
HEAD	The name of the message type		
Tick_number	The time of the start of the log file	Integer	1/100 second since the last reboot with approximately 71 day roll over
Date/time	The date and time of the start of the log file. This field with the previous one allows translations between tick_number and real time	String	yyyy/mm/dd hh:mm:ss.000
Units	This field specifies the units of length used in the log	String	Either "units: Metres" or "units: Feet"
Scale	The ratio between the selected unit and metres	Float	Ratio
"per metre"	A string to describe the previous field		
Vessel Name	The name of the vessel on which the log was taken	String	

E.2 TRANSPONDER MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
TPDR	The name of the message type.		
tick	The time when the message was sent.	String	Format: hh:mm:ss.000
Name	The name of the transponder or beacon	String	
Index	The Transponder index. There can be a number of Transponders. They are distinguished by the index	Integer	Range: 0-9
fix **See also: Ship message/fix**	The fix number. A number to identify which navigation cycle produced the data. A fix can produce a number of Transponder ranges and hence a number of Transponder messages. The same fix number appears in the ship messages	Integer	0-4294967295
flag	Zero indicates a bad fix, non zero a good fix. See also: Ship message/flag	Integer	

Field Name	Meaning	Data Type	Format/ Units/ Range
Time	The time at which the reply from that transponder was received	String	hh:mm:ss.000
pitch **See also: Ship message/pitch**	The pitch angle of the ship at the time of the fix. Sign convention: Bows up = +ve	Floating Point	Degrees
roll **See also: Ship message/roll**	The roll angle of the ship at the time of the fix. Sign convention: Starboard down = +ve	Floating Point	Degrees
bearing **See also: Ship message/ bearing**	The ship's bearing at the time of the fix	Floating Point	Degrees
Residual	This is field no longer contains the residual information and is reserved for other Sonardyne use		
Quality	The major axis of the horizontal error ellipse for the Transponder	Floating Point	The current LUSBL units. (Metres or feet)
East	The computed easting of the Transponder relative to the ship's datum	Floating Point	The current LUSBL units. (Metres or feet)
North	The computed northing of the Transponder relative to the ship's datum	Floating Point	The current LUSBL units. (Metres or feet)
Depth	The computed depth of the Transponder relative to the ship's datum	Floating Point	The current LUSBL units. (Metres or feet)
Const	The model gain set for the Transponder	Integer	Range 0 - 9
x_angle	The roll angle reported by the transponder if it is a riser angle compatt. If there is a remote sensor with the riser angle compatt, this is likely to be the differential angle. Sign convention: Starboard down = +ve	Floating Point	Degrees
y_angle	The pitch angle reported by the transponder if it is a riser angle compatt. If there is a remote sensor with the riser angle compatt, this is likely to be the differential angle. Sign convention: Bow up = +ve	Floating Point	Degrees
Debug1, 2 and 3	Reserved for use by Sonardyne		

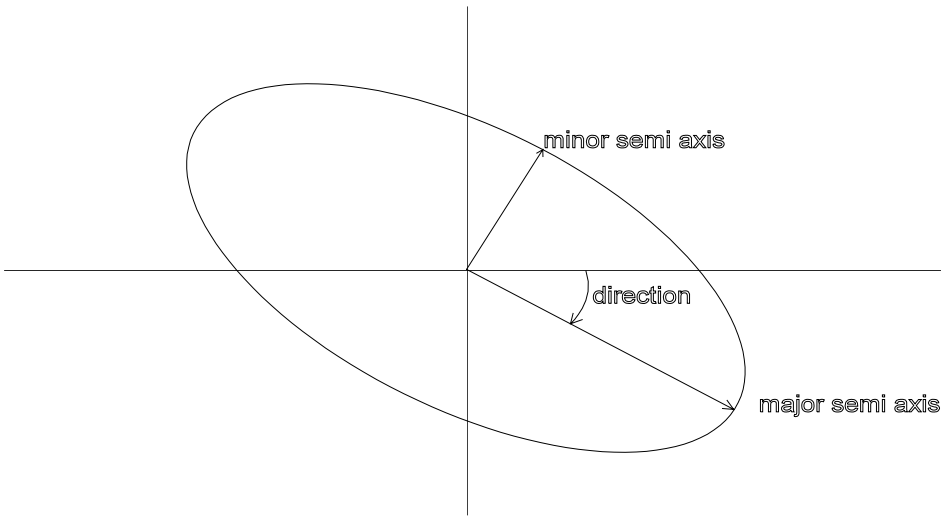
E.3 SHIP MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
SHIP	The name of the message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
Name	The name of the vessel or object	String	
fix **See also: Transponder message/fix**	The fix number. A number to identify which navigation cycle produced the data. A fix can also produce a number of Transponder messages, and Ship messages for other objects positioned in the same navigation cycle	Integer	0-4294967295
flag **See also: Transponder message/flag**	Zero indicates a bad fix, non zero a good fix	Integer	
Time	The time for which the ship position was computed. This is likely to be the time at which the reply from the last transponder was received	String	hh:mm:ss.000
pitch **See also: Transponder message/pitch**	The pitch angle of the ship at the time of the fix. Sign convention: Bows up = +ve	Floating Point	Degrees
roll **Transponder message/roll**	The roll angle of the ship at the time of the fix. Sign convention: Starboard down = +ve	Floating Point	Degrees
bearing **See also: Transponder message/bearing**	The ship's heading at the time of the fix	Floating Point	Degrees
h_ell_drn **See Figure E.1, "Error ellipse"**	Horizontal error ellipse direction. Sign convention: +ve X-axis is 0. +ve is anticlockwise	Floating Point	Degrees
h_ell_maj **See Figure E.1, "Error ellipse"**	Horizontal error ellipse - major radius	Floating Point	The current LUSBL units. (Metres or feet)
h_ell_min **See Figure E.1, "Error ellipse"**	Horizontal error ellipse - minor radius	Floating Point	The current LUSBL units. (Metres or feet)
z_err **See also: Transponder**	The predicted standard deviation of the depth observation. Smaller numbers are better	Positive Floating Point	

Field Name	Meaning	Data Type	Format/ Units/ Range
message/ quality			
Residual	This is field no longer contains the residual information and is reserved for other Sonardyne use		
East	The easting of the ship	Floating Point	Units: The current LUSBL units. (Metres or feet)
North	The northing of the ship	Floating Point	The current LUSBL units. (Metres or feet)
Depth	The depth of the ship	Floating Point	The current LUSBL units. (Metres or feet)
Const	The model gain set for the object	Integer	0 – 9
Debug1, 2, 3, 4 and 5s	Reserved for use by Sonardyne		

FIG E.1 ERROR ELLIPSE



E.4 RISER ANGLE MONITORING MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
RISER	The name of the message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
Index	The Transponder index. There can be a number of Transponders. They are distinguished by the index	Integer	0-9
riser_x **See also: Ship message/pitch**	The pitch angle of the riser either reported from the Riser Angle Transponder or calculated from Differential and BOP pitch. Sign convention: Bows up = +ve	Floating Point	Degrees
riser_y **See also: Ship message/roll**	The roll angle of the riser either reported from the Riser Angle Transponder or calculated from Differential and BOP roll. Sign convention: Starboard down = +ve	Floating Point	Degrees
BOP_x **See also: Ship message/pitch**	The pitch angle of the BOP reported from the Riser Angle Transponder. Sign convention: Bows up = +ve	Floating Point	Degrees
BOP_y **See also: Ship message/roll**	The roll angle of the BOP reported from the Riser Angle Transponder. Sign convention: Starboard down = +ve	Floating Point	Degrees
Differential_x **See also: Ship message/pitch**	The differential pitch angle of the BOP & riser either reported from the Riser Angle Transponder or calculated from Riser and BOP pitch. Sign convention: Bows up = +ve	Floating Point	Degrees
Differential_y **See also: Ship message/roll**	The differential roll angle of the BOP & riser either reported from the Riser Angle Transponder or calculated from Riser and BOP roll. Sign convention: Starboard down = +ve	Floating Point	Degrees
Tilt	The included angle between the axis of the BOP stack and the riser. Sign convention: zero represents Riser in line with BOP axis. All realistic angles will be positive	Floating Point	Degrees
bearing **See also: Ship message/ bearing**	The true bearing of the course to be made good to minimise the tilt angle	Floating Point	Degrees

E.5 ANALOGUE MEASUREMENT MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
ANAL	The name of the message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
Index	The index of the Transponder returning the analogue data. There can be a number of Transponders. They are distinguished by the index	Integer	0-9
Internal	This is a Boolean defining whether data from the internal or external sensor is being reported. Binary Value 0 represents External - 1 represents Internal	Integer	
volts1	A floating point representation of the first analogue voltage measured. With a Riser Angle Transponder this represents Roll at 0.0768 Volts per degree	Floating Point	Units: Volts
volts2	A floating point representation of the second analogue voltage measured. With a Riser Angle Transponder this represents Pitch at 0.0768 Volts per degree	Floating Point	Volts

E.6 ACOUSTIC MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
ACOUSTIC	The name of the DGPS message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
FixNum **See also: Transponder message/fix**	The fix number. A number to identify which navigation cycle produced the data. A fix can also produce a number of Transponder messages, and Ship messages in the same navigation cycle	Integer	0-4294967295
ObsFlag	This field is no longer used, but is reserved for future use		
Nodes	This field defines the nodes associated with the acoustic observation. It is of the form {11,1,12}. The three numbers represent the nodes involved. Transponders (Beacons) have nodes 1 to 10 (index + 1). Transceivers on objects have indices 11 to 20. The above node list indicates that the transponder node 1 (index 0) was interrogated from transceiver index 11 and the reply was received at transceiver index 12.	String	{tt,b,rr}.

Field Name	Meaning	Data Type	Format/ Units/ Range
	The indices of the transceivers are in the order of the transceivers on the Installation/Acoustic Transceivers page. However, LBL transceivers (BOPNav and RovNav) use 2 indices to allow for 2 transducers		
TxTime	The time at which the interrogation was sent to the transponder	String	hh:mm:ss.000
RxTime	The time at which the reply was received from the transponder	String.	hh:mm:ss.000
RxPitch **See also: Transponder message/pitch**	The pitch angle of the ship at the time of the reply from the transponder. Sign convention: Bows up = +ve	Floating Point	Degrees
RxRoll **See also: Transponder message/roll**	The roll angle of the ship at the time of the reply from the transponder. Sign convention: Starboard down = +ve	Floating Point	Degrees
RxHeading **See also: Transponder message/ bearing**	The ship's heading at the time of the reply from the transponder	Floating Point	Degrees
TravelTime	The time between the interrogation and the reply. This time includes any turn around time in the transponder	Floating Point	msec
L	The athwartships direction cosine from the receiving transceiver to the transponder. This direction has been stabilised by VRU to a level reference	Floating Point	unitless ratio
M	The fore/aft direction cosine from the receiving transceiver to the transponder. This direction has been stabilised by VRU to a level reference	Floating Point	unitless ratio
Qbsum	A measure of the quality of the direction data. A larger number is worse. There are 8 samples taken within each acoustic observation. The figure is the mean of the samples with Qbsum better than 0.025	Floating Point	
Mod1 to Mod 8	The magnitude of the received signal for each of the 8 samples	Integer	0 to 2048 - arbitrary units
TTInn	Sonardyne diagnostic information	Floating Point	msec
TTsd	Sonardyne diagnostic information	Floating Point	msec
PredTTsd	Sonardyne diagnostic information	Floating Point	msec

Field Name	Meaning	Data Type	Format/ Units/ Range
llnn	Sonardyne diagnostic information	Floating Point	msec
mlnn	Sonardyne diagnostic information	Floating Point	msec
Predlsd	Sonardyne diagnostic information	Floating Point	msec
Predmsd	Sonardyne diagnostic information	Floating Point	msec
SignalToNoise	The signal to noise ratio for the received signal in dB	Floating Point	dB
DopplerShift	The doppler shift of the received signal in Hertz	Integer	Hertz

E.7 DGPS MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
POSITION	The name of the DGPS message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
FixNum **See also: Transponder message/fix**	The fix number. A number to identify which navigation cycle produced the data. If the DGPS is not enabled, this field will be zero. A fix can also produce a number of Transponder messages, and Ship messages in the same navigation cycle	Integer	0-4294967295
ObsFlag	This field is no longer used, but is reserved for future use		
Node	A node number is given to the source of the position data. There can be a number of sources. They are distinguished by the node number, but the DGPS on the ship usually has node number 21	Integer	21 - 29
RxTime	The time at which the position was valid	String	hh:mm:ss.000
RxPitch **See also: Transponder message/pitch**	The pitch angle of the ship at the time of the position data. Sign convention: Bows up = +ve	Floating Point	Degrees
RxRoll **See also: Transponder message/roll**	The roll angle of the ship at the time of the position data. Sign convention: Starboard down = +ve	Floating Point	Degrees
RxHeading **See also:**	The ship's heading at the time of the position data	Floating Point	Degrees

Field Name	Meaning	Data Type	Format/ Units/ Range
Transponder message/ bearing			
East	The easting of the position (the DGPS antenna)	Floating Point	The current LUSBL units. (Metres or feet)
North	The northing of the position (the DGPS antenna)	Floating Point	The current LUSBL units. (Metres or feet)
PredEast	This field is no longer used and is reserved for use by Sonardyne		
PredNorth	This field is no longer used and is reserved for use by Sonardyne		
Limit	This field is no longer used and is reserved for use by Sonardyne		

E.8 DEPTH MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
DEPTH	The name of the message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
FixNum **See also: Transponder message/fix**	The fix number. A number to identify the navigation cycle to which the data corresponds	Integer	0-4294967295
ObsFlag	This field is no longer used, but is reserved for future use		
Node	This is the node number of the transceiver or transponder to which the depth refers	Integer	1 - 29
RxTime	The time at which the depth was valid	String	hh:mm:ss.000
Depth	The depth of the node	Floating Point	The current LUSBL units. (Metres or feet)
Predict	This field is no longer used and is reserved for use by Sonardyne		
Limit	This field is no longer used and is reserved for use by Sonardyne		

E.9 ATTITUDE MESSAGES

The following fields are available:-

Field Name	Meaning	Data Type	Format/ Units/ Range
ATTITUDE	The name of the message type		
Tick	The time when the message was sent	String	hh:mm:ss.000
FixNum **See also: Transponder message/fix**	The fix number. A number to identify the navigation cycle to which the data corresponds	Integer	0-4294967295
ObsFlag	This field is no longer used, but is reserved for future use		
Obj	This is the number of the object to which the attitude data refers. The objects are numbered as seen on the Nav Setup page starting at 11	Integer	11 - 19
RxTime	The time at which the attitude data was valid	String	hh:mm:ss.000
Pitch **See also: Transponder message/pitch**	The pitch angle of the object at the time of the fix. Sign convention: Bows up = +ve	Floating Point	Degrees
Roll **See also: Transponder message/roll**	The roll angle of the object at the time of the fix. Sign convention: Starboard down = +ve	Floating Point	Degrees
Heading **See also: Transponder message/ bearing**	The object's heading at the time of the fix	Floating Point	Degrees
Predict	This field is no longer used and is reserved for use by Sonardyne		
Limit	This field is no longer used and is reserved for use by Sonardyne		

E.10 SELECTING FIELDS FOR OUTPUT

On start-up, the previous field selections are read from disc, and the field names are sent to the surveyor.

The field selection can be changed by sending commands over the serial port.

- Characters are not echoed.
- The command and field names are case-sensitive.
- The command and field names cannot be abbreviated.

- The maximum length of a command is 250 characters.
- The field names can be in any order, and repeated.
- If no fields are given, there will be no output for that type of message.
- Spaces are allowed before and after commas.
- The backspace character deletes the previous character in a command.
- Control-X deletes all characters in the current command.
- Valid field names for Transponder (type 1) messages:-

  TPDR, tick, name, index, fix, flag, time, pitch, roll, bearing, residual, quality, east, north, depth, const, x_angle, y_angle, debug1, debug2, debug3

- Valid field names for Ship (type 2) messages:-

  SHIP, tick, name, fix, flag, time, pitch, roll, bearing, h_ell_drn, h_ell_maj, h_ell_min, z_err, residual, east, north, depth, const, debug1, debug2, debug3, debug4, debug5

E.11 TYPICAL MESSAGES

Messages of type 1 (Transponder) start with 'TPDR,'

and are followed by the values of the selected fields separated by commas.

Similarly, messages of type 2 (Ship) start with 'SHIP,'

and are followed by the values of the selected fields separated by commas.

Data messages are sent as new data becomes available. For example, the system is started and:-

- The surveyor is sent the currently selected field names

  Surveyor sends: select,1,fix,index,east, north, <cr>

  System sends: * selected,1,fix,index,east,north <cr>

  Surveyor sends: select,2,fix,east,north, <cr>

  System sends: * selected,2,fix,east,north <cr>

- The system does a fix

  System sends: 1,0,2,-99.54,-100.36 <cr>

  System sends: 1,0,3,-100.90,100.80 <cr>

  System sends: 1,0,0,100.13,99.97 <cr>

  System sends: 1,0,1,100.40,-99.74 <cr>

  System sends: 2,1,-0.18,-0.08 <cr>

- The surveyor wants to change the field selection

  Surveyor sends: select,1,index,filt_e,filt_n,filt_d <cr>

  System sends: * selected,1,index,filt_e,filt_n,filt_d <cr>

- The system does a fix

  System sends: 1,2,-99.54,-100.36 <cr>

  System sends: 1,3,-100.90,100.80 <cr>

  System sends: 1,0,100.13,99.97 <cr>

  System sends: 1,1,100.40,-99.74 <cr>

  System sends: 2,2,-0.18,-0.08 <cr>

- The surveyor wants to turn off ship messages

  Surveyor sends: select,2 <cr>

  System sends: * selected,2 <cr>

- The system does a fix

  System sends: 1,2,-99.54,-100.36 <cr>

  System sends: 1,3,-100.90,100.80 <cr>

  System sends: 1,0,100.13,99.97 <cr>

  System sends: 1,1,100.40,-99.74 <cr>

E.12 USE OF TERMINAL EMULATOR TO EXTRACT OUPTUT

E.12.1 Introduction

This section suggests how terminal emulators can be used to view, control and log data. It defines the necessary requirements to be able to do this (see “PRE-REQUISITES” Section - which follows), and how to set two common terminal emulators to control, view and log the data from the Surveyor’s output.

There are several "types" of data that can be sent from the Surveyor’s output. For each type there are several fields. It is possible to control which types of data are output, and also within those types which fields should be present.

The terminal emulator packages will display the data being output on the Surveyor’s output, but also can be used to log the selected data. In addition, it is possible to set up Keys within the terminal emulator package which send commands to control the Surveyor’s output. It is also possible to turn the logging of the data on and off within the terminal emulator package.

This section gives examples for PC Plus and Windows Terminal for setting the Keys and controlling the logging of data from the Surveyor’s output.

In the Section titled “LOGGING DATA FOR CASIUS”, which follows, is an example of how the Surveyor’s output can be used with PC-Plus to log data for the CASIUS calibration software.

E.12.2 Pre-Requisites

- ❑ USBL is configured so that the Surveyor's output is on a serial port that is connected to the PC.
- ❑ The terminal emulator (on the PC) is already configured with the correct serial port, baud rate, etc.
- ❑ One or more Beacons is selected for Surveyor's output in the USBL software.
- ❑ Navigation is running on the Navigation Processor.
- ❑ No fields are already selected for output.

E.12.3 PC-Plus 1.1b

- ❑ Set up the Macro Keys
  - Press *Alt-M* to get the "Keyboard Macros" dialogue box.
  - Press the Down arrow key to select the line that starts with "Alt-1"
  - Press R to change the entry.
  - Delete any existing text using the *delete* key.
  - Type the new text: **select,1,all^m**
  - Press enter.
  - Press the Down arrow key to select the line that starts with "Alt-2" and repeat the process, typing in the text from the table, e.g.

Key	Text to be entered	Effect of key
Alt-0		
Alt-1	**select,1,all^m**	Select all fields of message type 1 (tpdr msg)
Alt-2	**select,1^m**	Turn off all fields of message type 1 (tpdr msg)
Alt-3	**select,2,all^m**	Select all fields of message type 2 (ship msg)
Alt-4	**select,2^m**	Turn off all fields of message type 2 (ship msg)
Alt-5	**select,12,all^m**	Select all fields of message type 12 (range msg)
Alt-6	**select,12^m**	Turn off all fields of message type 12 (range msg)
Alt-7	**select,1,all^m** **select,11,all^m**	Select all fields of message types 1 & 11 (Casius msg)
Alt-8	**select,1^mselect,11^m**	Turn off all fields of message types 1 & 11 (Casius msg)

Note that '**^m**' means type '^' followed by 'm'. Do NOT type Ctrl-M, though subsequent pressing of the Alt n key will cause Ctrl-M to be sent where '**^m**' has been typed during this set-up procedure.

- ❑ Start Logging Data from Surveyor's Output
  - While holding down the *Alt* key, press *F1*.
  - At the prompt: *Enter log filename, or CR for default*, type in a filename for the received data, then press *Enter*. E.g. **c:\usblsurv.txt**.
  - The Words *LOG OPEN* will now appear in the status bar at the foot of the screen.
- ❑ Activate the Data Messages from Surveyor's Output
  - Hold down the *Alt* key and press the appropriate number key (1 3 , 5 or 7 in the examples above). Now release the *Alt* key.
  - **WAIT UNTIL YOU'VE GOT ENOUGH DATA.**
- ❑ Deactivate the Data Messages (optional)

  A field selection remains in effect until a new selection is made. This includes the case where The Navigation Processor is powered down.
  - Hold down the *Alt* key and press the appropriate number key (2, 4, 6 or 8 in the examples above). Now release the *Alt* key.
- ❑ Stop Logging Data from Surveyor's Output
  - While holding down the *Alt* key, press *F1*.
  - The Words *LOG CLOSED* will now appear in the status bar at the foot of the screen.

E.12.4 Windows Terminal 3.n

- ❑ Set up the Macro Keys
  - From the menu bar, select ***Settings***, then ***Function Keys...***
  - This brings up the *Function Keys* dialogue box.
  - Enter the following settings:

Key	Key Name	Text to be entered	Effect of key
F1	tpdr msg ON	**select,1,all^m**	Select all fields of message type 1 (tpdr msg)
F2	tpdr msg OFF	**select,1^m**	Turn off all fields of message type 1 (tpdr msg)
F3	ship msg ON	**select,2,all^m**	Select all fields of message type 2 (ship msg)
F4	ship msg OFF	**select,2^m**	Turn off all fields of message type 2 (ship msg)
F5	range msg ON	**select,12,all^m**	Select all fields of message type 12 (range msg)
F6	range msg OFF	**select,12^m**	Turn off all fields of message type 12 (range msg)
F7	Casius ON	**select,1,all^m select,11,all^m**	Select all fields of message types 1 & 11
F8	Casius OFF	**select,1^mselect,11^m**	Turn off all fields of message types 1 & 11

Note that '**^m**' means type '^' followed by 'm'. Do NOT type Ctrl-M, though subsequent pressing of the Alt n key will cause Ctrl-M to be sent where '**^m**' has been typed during this set-up procedure.

- If ***Keys Visible*** (lower right hand corner of the dialogue box) is not already marked with an X, then click it.
- Click the OK button.

The macro buttons should now be visible at the foot of the Terminal window.

❑ Start Logging Data from Surveyor's Output

- From the menu bar, select ***Transfers***, then ***Receive Text File...***
- Decide on a file name, and type it into the dialogue box.
- Click the OK button.

A status/control bar for the text transfer will appear at the lower edge of the *Terminal* window. The ***Stop*** button will be used later, to stop the ASCII capture.

❑ Activate the Data Messages from Surveyor's Output

- If your mouse is not connected, you can press a macro button by holding down the *ctrl* and *alt* keys while pressing the appropriate function key.
- Click the macro buttons: ***tpdr msg ON***, ***ship msg ON***, and ***range msg ON etc.***.(Without a mouse: *Ctrl-Alt F1 Ctrl-Alt F3* and *Ctrl-Alt F5 etc.*)
- **WAIT UNTIL YOU'VE GOT ENOUGH DATA.**

❑ Deactivate the Data Messages (optional)

- Click the macro buttons: tpdr msg OFF, ship msg OFF, and range msg OFF.
- The data should stop.

❑ Stop Logging Data from Surveyor's Output

- Click the ***Stop*** button mentioned in the section "Start logging data from Surveyor's output".

❑ Other Information

For further information see the chapter about *Terminal* in the *Microsoft Windows User Guide* that comes with Windows 3.n.

E.12.5 Logging Data For CASIUS

To use the Surveyor's output to log data for the CASIUS calibration package, start logging, select only the message types 1 and 11 (Beacon and DGPS). While the manoeuvring is being done, the logging can be left running continuously, but the data stream turned on and off using the macro keys already defined. As an example using PC Plus (see previous sub-section in this Appendix) the following procedure would be adopted.

❑ Enter PC Plus and set up serial port.

❑ Set up the macro keys as defined in PC Plus instructions.

❑ Turn off all data types using macro keys set.

❑ Turn on the logging within PC Plus as described in PC Plus instructions.

- When the ship is in the appropriate place to collect data, turn on data streams for CASIUS using 'Alt 7' check that the data stream is as expected.

- During data collection, turn off and on the data stream using 'Alt 8' and 'Alt 7' as appropriate.

When the manoeuvring is complete, turn off the logging as described in PC Plus instructions.

APPENDIX F

F. DP TELEGRAM FORMATS

This appendix describes the format and contents of HPR 309, HPR 418 (Issue D), HPR 418F (issue F), HPR 418BCD, HPR NMEA and ATS ASCII telegrams sent by the USBL/LUSBL system to the DP system or Survey desk.

F.1 HPR 309 TELEGRAM

F.1.1 Format of HPR 309 Telegram

Field name	Size(bytes)	Byte offset	Default for DP_test
Head	**1**	**0**	**2**
Roll	**2**	**1**	**As required**
Pitch	**2**	**3**	**As required**
Heading	**2**	**5**	**As required**
Transponder index	**1**	**7**	**As required**
X position	**3**	**8**	**As required**
Y position	**3**	**11**	**As required**
Depth	**3**	**14**	**As required**
Position status	**1**	**17**	**0**
Time-out	**1**	**18**	**0**
Transponders in sequence	**3**	**19**	**[automatic]**
Tracking TD angle (Not used)	**2**	**22**	**N/A**
Test (Not used)	**1**	**24**	**N/A**
Transponder type	**1**	**25**	**0**
Transponder specification	**1**	**26**	**0**
Transducers (Not used)	**1**	**27**	**0**
Transducer status (Not used)	**1**	**28**	**0**
Kalman filter window	**1**	**29**	**0**
Checksum	**1**	**30**	**[automatic]**
End of telegram	**1**	**31**	**[automatic]**

Bits 0-5 contain data. Bit 6 is only ever set on the last byte of the telegram.

F.1.2 Definition of Field Names - HPR 309 Telegram

- **Head**

The telegram header - defines the mode of operation.

Bit 0 is set for normal acoustic navigation.

Bit 1 Test mode is set in DP_test mode and Simulate mode.

To set the Head to values other than 2 in DP_test, prior to entering the DP_test screen press the $ key, and enter the password <SUPER> when prompted for an engineers password.

From Version 6.04r2 the Simulate mode can be forced to send telegrams with this bit cleared. Before selecting the Simulate option press the $ key, and enter the password <SUPER> when prompted for an engineers password. On entry to Simulate the system will not flag that it is in test mode.

Bit 2 is not supported by Sonardyne.

Bit 3 is set if the Cartesian Y direction is North. The bit is cleared if the Cartesian Y direction is the vessel forward direction (ship relative co-ordinates).

Bit 4 is set if the data is smoothed by a filter.

Bit 5 is set if the position reference point is the spare reference point.

- **Roll (Inclinometer X angle)**

The roll of the ship.

- Positive direction is port side up.
- Scaled integer, 12bit, 2's complement.
- Resolution = 360.0 / 4096 degrees. (= 0.0878906 degrees)
- Min = 800000h = -2048 -> -180.0 degrees.
- 0 -> 0.0 degrees.
- Max = 7fffffh = 2047 -> (180 - resolution) degrees.

The first byte of this field in the telegram contains the 6 most significant bits, and the next byte contains the 6 least significant bits.

- **Pitch (Inclinometer Y angle)**

  The pitch of the ship.

  - Positive direction is bows up.
  - Scaled integer, 12bit, 2's complement.
  - Resolution = 360.0 / 4096.0 degrees.
  - Min = 800000h = -2048 -> -180.0 degrees.
  - 0 -> 0.0 degrees.
  - Max = 7fffffh = 2047 -> (180 - resolution) degrees.

  The first byte of this field in the telegram contains the 6 most significant bits, and the next byte contains the 6 least significant bits.

- **Heading**

  The heading of the ship.

  - Positive direction is clockwise.
  - Zero is north
  - Scaled integer, 12bit, 2's complement.
  - Resolution = 360.0 / 4096.0 degrees (0.0878906 degrees).
  - Min = 800000h = -2048 -> -180.0 degrees.
  - 0 -> 0.0 degrees.
  - Max = 7fffffh = 4095 -> (360 - resolution) degrees.

  The first byte of this field in the telegram contains the 6 most significant bits, and the next byte contains the 6 least significant bits.

- **Transponder Index**

  Zero means that the position is invalid. Otherwise, this field contains the index of the transponder.

  - 1 to 9 = HPR Channels 1 to 9
  - 10 to 14 = HPR Channels □, O, Δ, X, Y.
  - 15 and 16 are generally used for reporting a vessel LBL solution as a reference beacon message.
  - 17 to 63 = set to 16.

- **X Position**

  The X position of the transponder with respect to the ship's datum in Cartesian co-ordinates.

  - The positive direction is starboard when in Vessel relative mode and East when in North relative mode.
  - Valid when "transponder index" is not zero and when "Status" is not zero.
  - Scaled integer, 16bit (sign-extended to 18 bits), 2's complement.
  - Resolution = 8192.0 / 65536 metres. (= 0.125m)
  - Min = 8000h -> -4096.0 metres.
  - 0 -> 0.0 degrees.
  - Max = 7fffh -> (4096.0 - Resolution) metres.

  The first byte of this field in the telegram contains the 6 most significant bits, the next byte contains bits 6 to 11 and the next byte contains the 6 least significant bits.

- **Y Position**

  The Y position of the transponder with respect to the ship's datum in Cartesian co-ordinate.

  - The positive direction is forwards when in Vessel relative mode and North when in North relative mode.
  - Valid when "transponder index" is not zero and when "Status" is not zero.
  - Scaled integer, 16bit (sign-extended to 18 bits), 2's complement.
  - Resolution = 8192.0 / 65536 metres. (= 0.125m).
  - Min = 8000h -> -4096.0 metres.
  - 0 -> 0.0 degrees.
  - Max = 7fffh -> (4096.0 - Resolution) metres.

  The first byte of this field in the telegram contains the 6 most significant bits, the next byte contains bits 6 to 11 and the next byte contains the 6 least significant bits.

- **Z Position**

  The Z position of the transponder with respect to the ship's datum.

  - The positive direction is down.
  - This is the vertical position of the beacon with respect to the vessel datum. However if the Z datum is on the water line the Z position is also depth.
  - Valid when "transponder index" is not zero and when "Status" is not zero.
  - Scaled integer, 16bit (sign-extended to 18 bits), 2's complement.
  - Resolution = 8192.0 / 65536 metres. (= 0.125m).
  - Min = 8000h -> -4096.0 metres.
  - 0 -> 0.0 degrees.
  - Max = 7fffh -> (4096.0 - Resolution) metres.

  The first byte of this field in the telegram contains the 6 most significant bits, the next byte contains bits 6 to 11 and the next byte contains the 6 least significant bits.

- **Status**

  Flags.

  - Bit 0 is set when the position data is invalid.
  - Bit 1 is set if the data comes from a 'Master' and cleared if the data comes from a 'Slave' in a Dual-Redundant system configuration.
  - Bit 2 is not used and is cleared.
  - Bit 3 is set when the riser angle data is not valid.
  - Bits 4 and 5 are not used and are cleared.

  Watchdog telegrams do not contain valid position data, so bit 0 is set. The roll pitch and heading data is valid in a watchdog telegram.

- **Time-out**

  - Set to Zero for non-inclination transponders.
  - Bit 1 is set if the angle information from an inclinometer or differential inclinometer transponder is incomplete.

- **Transponders in Sequence**

  Flags to indicate which transponders are being used.

  HPR channel:

	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1st byte	**Undefined**	**undefined**	**undefined**	**undefined**	**Y**	**X**
2nd byte	**Δ**	**O**	**□**	**9**	**8**	**7**
3rd byte	**6**	**5**	**4**	**3**	**2**	**1**

  Bits are set for the transponders that are used with all other bits cleared (including those whose meaning is undefined).

- **Tracking TD Angle (Not Used)**

  Set to zero.

- **Test (Not Used)**

  Set to zero.

- **Transponder Type**

  This byte contains a binary number indicating what transponder type the telegram contains data from.

  - Bit 0 is set for a standard transponder/responder.
  - Bits 1 to 4 are not used by Sonardyne, and are set to zero.
  - Bit 5 is set for a Inclinometer Transponder
  - Bit 6 is set for a Differential Inclinometer.

- **Transponder Specification**

  Beacon use indication.

  - Bit 0 is set for a mobile transponder, cleared for a fixed transponder.
  - Bits 1 to 5 are unused and are all cleared.

- **Transducers (Not Used)**

  Not used by Sonardyne and therefore set to zero.

- **Transducer Status (Not Used)**

  Not used by Sonardyne and therefore set to zero.

- **Kalman Filter Window**

  This is the horizontal position quality, rounded to the nearest metre. At one bit per metre, the smaller the value the more stable the measurements.

- **Checksum**

  The result of performing an exclusive-or on all bytes in the telegram up to but not including this byte.

- **End of Telegram**

  This byte marks the end of a telegram.

  It is always 40hex. It is the only byte of the telegram with bit 6 set.

F.2 HPR 418 TELEGRAM (ISSUE D)

There are two HPR 418 messages types supported by Version 6. Message 1 (Section F.2.1) gives information relating to the beacons used in the system. Message 2 (Section F.2.2) gives the LBL position of the Vessel.

REAL format and REAL_64 format as referred to in the 'Message n - Definition of Field Names' below are structured as below:-

REAL = 32 bit floating point data

REAL_64 = 64 bit floating point data

Both of these formats conform to IEEE standard 754. The 32 bit data uses the single precision data format and the 64 bit data uses the double precision format.

F.2.1 HPR 418 (Issue D) Message 1 - Transponder Position Data

F.2.1.1 HPR 418 (Issue D) Message 1 - Format

Field name	Size(bytes)	Byte offset	Default for DP_test
Start Character	**1**	**0**	**55 hex**
Block Length	**2**	**1**	**3A+4*n hex (58+4*n dec)**
Message Type	**1**	**3**	**1**
Destination	**1**	**4**	**30 hex**
Tp_index	**2**	**5**	**1**
Operation_mode	**1**	**7**	**0 (Std Navigation)**
Sync_mode	**1**	**8**	**0 (No sync)**
Tp_type	**1**	**9**	**0 (Std Transponder)**
Tp_operation	**1**	**10**	**0 (Fixed)**
Pos_data_form	**1**	**11**	**0 (Ship head relative)**
Reply_status	**1**	**12**	**0 (OK)**
Filt_x_pos	**4**	**13**	**0.0 (linked to raw)**
Filt_y_pos	**4**	**17**	**0.0 (linked to raw)**
Filt_z_pos	**4**	**21**	**0.0 (linked to raw)**
x_pos	**4**	**25**	**0.0**
y_pos	**4**	**29**	**0.0**
z_pos	**4**	**33**	**0.0**
Slant_range	**4**	**37**	**0.0**

P_course	**4**	**41**	**0.0**
P_roll	**4**	**45**	**0.0**
P_pitch	**4**	**49**	**0.0**
Td_beam	**1**	**53**	**0 (Wide)**
Td_type	**1**	**54**	**0 (Wide Only)**
Td_num	**2**	**55**	**1 (tdcr 1 on tcvr 1)**
Diagnostic	**2**	**57**	**0 (No errors)**
Stand_dev	**4**	**59**	**0**
Instr_data*	**4*n**	**63**	**0.0 (when required)**
Sumcheck	**2**	**63+4*n**	**Automatic**
Stop character	**1**	**65+4*n**	**AA hex**

*Instrument Data is dependent upon the type of transponder and takes n fields. n would be zero for a transponder without instrumentation.

F.2.1.2 HPR 418 (Issue D) Message 1 - Definition of Field Names

- **Start Character**

  This is a single byte start character 55 hex.

- **Block Length**

  A 2 byte block length number from 0 to 65536 defining the number of bytes after Destination field and before Sumcheck. (Message length minus 8). In this case it is set to 3A hex plus the number of bytes of Instrument Data. There will usually be 0 bytes of Instrument Data. The number of Instrument Data bytes is dependent upon the type of transponder.

- **Message Type (**Also see F.2.2.2)

  A single byte defining a number from 0 to 255 which is the type of the message transmitted.

  In this case it is 1.

- **Destination**

  A single byte number from 0 to 255 defining the device to which the message is transmitted.

  This is not used by Sonardyne, but is set to 30 hex.

- **Tp_index**

  Two bytes defining the transponder channel.

  With Sonardyne's L/USBL system it is possible to use a different **Tp_index** number from the acoustic channel in use. This is to cater for COMPATT transponders which would not fit within the Simrad DP index system. This also has the advantage if a DP desk requires 418 telegrams and a Survey Desk requires 309 telegrams, by setting the index to a number between 1 and 16, both systems will work.

  The selection of 9 as the **Tp_index** prior to Version 6.04 L/USBL software causes 009 to be transmitted, which would be displayed as A09 on a DP desk. From Version 6.04 when index 9 is set, 109 is transmitted and the DP desk would display B09.

  The default value for DP_test is 1.

- **Operation_mode**

  A single byte containing the operation mode of the transceiver.

  - 00 = standard navigation mode
  - 01 = simulated position test mode. (Training)
  - 10 = telemetry mode (Not used by Sonardyne)

- **Sync_mode (not used)**

  A single byte containing the synchronisation mode of the transceiver.

  - 0 = no synchronisation
  - 1 = sequence sync. (Not used by Sonardyne)
  - 2 = interrogation sync. (Not used by Sonardyne)

- **Tp_type (Not used by Sonardyne)**

  A single byte defining the transponder type

  - 000 = transponder

- **Tp_operation**

  A single byte defining the operation mode of the transponder:

  - 000 = fixed standard transponder
  - 001 = mobile standard transponder

- **Pos_data_form**

  A single byte defining the position co-ordinate format:

  - Bit 0 = 0 vessel oriented, Cartesian
  - Bit 0 = 1 north oriented, Cartesian

- **Reply_status**

  A single byte defining the transponder reply status:

  - 000 = reply OK
  - 001 = timeout 1 pulse (used as general data rejection status by Sonardyne)

- **Filt_X_pos**

  A value in REAL format.

  The filtered x - position co-ordinates of the transponder. Transponder's horizontal athwart ship distance from reference point in metres.

- **Filt_Y_pos**

  A value in REAL format.

  The filtered y - position co-ordinates of the transponder. Transponder's horizontal fore and aft ship distance from reference point in metres.

- **Filt_Z_pos (Depth)**

  A value in REAL format.

  The filtered z - position co-ordinates of the transponder. Transponder's vertical distance from reference point in metres.

- **X_pos**

  A value in REAL format.

  The raw x - position co-ordinates of the transponder. Transponder's horizontal athwart ship distance from reference point in metres.

- **Y_pos**

  A value in REAL format.

  The raw y - position co-ordinates of the transponder. Transponder's horizontal fore and aft ship distance from reference point in metres.

- **Z_pos (DEPTH)**

  A value in REAL format.

  The raw z - position co-ordinates of the transponder. Transponder's vertical distance from reference point in metres.

- **Slant_range**

  A value in REAL format.

  The direct raw slant range from the vessel's reference point to the transponder in metres.

- **P_course**

  A value in REAL format.

  The vessels course at the time of transponder position measurement; 0 to 360 degrees.

- **P_roll**

  A value in REAL format.

  The vessels roll at the time of transponder position measurement +/-180 degrees.

- **P_pitch**

  A value in REAL format.

  The vessels pitch at the time of transponder position measurement +/-180 degrees.

- **Td_beam**

  A single byte defining the transducer beam.

  - 0 = wide
  - 1 = narrow

  Sonardyne uses value 0 (wide).

- **Td_type**

  Defines the transducer type.

  Sonardyne uses value 0 (wide beam).

- **Td_num**

  A 16 bit word defining the transducer number.

  Sonardyne do not differentiate between transducers and transceivers and always use value 1 (meaning transducer 1 on transceiver 1), as all positions are reported relative to the vessel reference point and the solution may be the result of measurements from more than one transducer.

- **Diagnostic**

  Sonardyne do not use this field and always return 0 (no errors).

- **Stand_dev**

  A value in REAL format.

  This is the horizontal position quality in metres.

- **Instr_data (*)**

  Not currently supported.

- **Sumcheck**

  Sumcheck of the contents of the entire telegram except for the sumcheck itself and the stop character. The sumcheck is a 16 bit integer calculated by normal byte + byte addition.

- **Stop Character**

  This is a single byte stop character AA hex.

F.2.2 HPR 418 (Issue D) Message 2 - LBL Position Data

F.2.2.1 HPR 418 (Issue D) Message 2 - Format

Field name	Size(bytes)	Byte offset	Default for DP_test
Start Character	**1**	**0**	**55 hex**
Block Length	**2**	**1**	**2E hex**
Message Type	**1**	**3**	**1 (change to 2)**
Destination	**1**	**4**	**30 hex**
Tp_array	**1**	**5**	**0**
Td_num	**1**	**6**	**1 (tdcr 1 on tcvr 1)**
Pos_East	**4**	**7**	**0.0**
Pos_North	**4**	**11**	**0.0**
Depth	**4**	**15**	**0.0**
Horr_err_ellipse_direction	**4**	**19**	**0.0**
Horr_err_ellipse_major	**4**	**23**	**0.0**
Horr_err_ellipse_minor	**4**	**27**	**0.0**
Z_Standard_deviation	**4**	**31**	**0.0**
Pos_type	**1**	**35**	**0 (Vessel position)**
Pos_status	**1**	**36**	**0 (OK)**
P_course	**4**	**37**	**0.0**
P_roll	**4**	**41**	**0.0**
P_pitch	**4**	**45**	**0.0**
Diagnostic	**2**	**49**	**0 (No Errors)**
Sumcheck	**2**	**51**	**Automatic**
Stop character	**1**	**53**	**AA hex**

LBL position contains vessel's position relative to the origin at the LBL transponder array. This is the position of the vessel in the LBL array reference frame. The position is transmitted after each position calculation. If the transponder array is north oriented, the co-ordinates are relative true North, else they are relative local north.

F.2.2.2 HPR 418 (Issue D) Message 2 - Definition of Field Names

- **Start Character**

  This is a single byte start character 55 hex.

- **Block Length**

  A 2 byte block length number from 0 to 65536 defining the number of bytes after Destination field and before Sumcheck. (Message length minus 8). In this case it is set to 36 hex.

- **Message Type**

  A single byte number from 0 to 255 defining the type of the message transmitted.

  In this case it is 2.

- **Destination**

  A single byte number from 0 to 255 defining the device to which the message is transmitted.

  This is not used by Sonardyne, but is set to 30 hex.

- **Tp_array**

  A single byte defining the number of the transponder array that is in use, 0,1, 2 and 3. Sonardyne sets this to 0.

- **Td_num**

  A 16 bit word defining the transducer number.

  Sonardyne do not differentiate between transducers and transceivers and always use value 1 (meaning transducer 1 on transceiver 1), as all positions are reported relative to the reference point, and the solution may be the result of measurements from more than one transducer.

- **Pos_east**

  A value in REAL format.

  East co-ordinates in metres. Positive value is East. Negative value is West.

- **Pos_north**

  A value in REAL format.

  East co-ordinates in metres. Positive value is North. Negative value is South.

- **Depth**

  A value in REAL format.

  The depth co-ordinate. Positive value is downwards.

  For the vessel, the depth is the vertical distance from the sea level to the vessel reference point. For ROVs and relay transponders, the depth is the depth below the sea surface of the transducer on the unit.

- **Hor_err_ellipse_direction**

  A value in REAL format.

  Each LBL position measurement has a likelihood ellipse associated with it. It is based on 1 δ in each of the axis. The direction is the angle in degrees between the north axis and the major axis of the ellipse.

- **Horr_err_ellipse_major**

  A value in REAL format.

  The major axis of the likelihood ellipse in metres.

- **Horr_err_ellipse_minor**

  A value in REAL format.

  The minor axis of the likelihood ellipse in metres.

- **Z_standard_deviation**

  A value in REAL format.

  The standard deviation (δ) of the depth in metres.

- **Pos_type**

  A single byte with value:

  - 0 = Position of the vessel
  - 1 = Position of ROV1

    " " "
  - 16 = Position of ROV16
  - 17 = Position of RELAY1
  - 18 = Position of RELAY2
  - 19 = Position of RELAY3
  - 20 = Position of RELAY4

- **Pos_status**

  A single byte with value:

  This variable tells the status of the position calculation.

  - 0 = OK position
  - 1 = Position not OK

- **P_course**

  A value in REAL format.

  An average of the vessels course at the time of transponder position measurement; 0 to 360 degrees.

- **P_roll**

  A value in REAL format.

  An average of the vessels roll at the time of transponder position measurement +/-180 degrees.

- **P_pitch**

  A value in REAL format.

  An average of the vessels pitch at the time of transponder position measurement +/-180 degrees.

- **Diagnostic**

  Sonardyne do not use this field and always return 0 (no errors).

- **Sumcheck**

  Sumcheck of the contents of the entire telegram except for the sumcheck itself and the stop character. The sumcheck is a 16 bit integer calculated by normal byte + byte addition.

- **Stop Character**

  This is a single byte stop character AA hex.

F.3 HPR 418F TELEGRAM (ISSUE F)

F.3.1 HPR 418F Message 1 - Transponder Position Data

As for 418 Issue D Message 1.

F.3.2 HPR 418F Message 2 - LBL Position Data

F.3.2.1 **HPR 418 Message 2 - Format**

Field name	Size(bytes)	Byte offset	Default for DP_test
Start Character	**1**	**0**	**55 hex**
Block Length	**2**	**1**	**2E hex**
Message Type	**1**	**3**	**1 (change to 2)**
Destination	**1**	**4**	**30 hex**
Sequence_number	**2**	**5**	**0**
Time_header (7)	**7**	**7**	**Automatic**
Interrogation_age	**2**	**14**	**Automatic**
Tp_array	**1**	**16**	**0**
Td_num	**1**	**17**	**1 (tdcr 1 on tcvr 1)**
Pos_East	**8**	**18**	**0.0**
Pos_North	**8**	**26**	**0.0**
Depth	**4**	**34**	**0.0**
Horr_err_ellipse_direction	**4**	**38**	**0.0**
Horr_err_ellipse_major	**4**	**42**	**0.0**
Horr_err_ellipse_minor	**4**	**46**	**0.0**
Z_Standard_deviation	**4**	**50**	**0.0**
Pos_type	**1**	**54**	**0 (Vessel position)**
Pos_status	**1**	**55**	**0 (OK)**
P_course	**4**	**56**	**0.0**
P_roll	**4**	**60**	**0.0**
P_pitch	**4**	**64**	**0.0**
Diagnostic	**2**	**68**	**0 (No Errors)**
Sumcheck	**2**	**70**	**Automatic**
Stop character	**1**	**72**	**AA hex**

LBL position contains vessel's position relative to the origin at the LBL transponder array. This is the position of the vessel in the LBL array reference frame. The position is transmitted after each position calculation. If the transponder array is north oriented, the co-ordinates are relative true North, else they are relative local north.

F.3.2.2 HPR 418 Message 2 - Definition of Field Names

- **Start Character**

  This is a single byte start character 55 hex.

- **Block Length**

  A 2 byte block length number from 0 to 65536 defining the number of bytes after Destination field and before Sumcheck. (Message length minus 8). In this case it is set to 36 hex.

- **Message Type**

  A single byte number from 0 to 255 defining the type of the message transmitted.

  In this case it is 2.

- **Destination**

  A single byte number from 0 to 255 defining the device to which the message is transmitted.

  This is not used by Sonardyne, but is set to 30 hex.

- **Sequence_Number**

  This number is set to zero when navigation is commenced and is incremented for each LBL interrogation. The range is from 0 – 65535 and will wrap around to 0 when 65535 is reached.

- **Time_Header (7)**

  The format of the time_header is:

Block Content	Size	Index	Resolution	Range
Day	BYTE	0	1 Day	1 – 31
Month	BYTE	1	1 Month	1 – 12
Year	BYTE	2	1 Year	0 – 99
Hours	BYTE	3	1 Hour	0 – 23
Minutes	BYTE	4	1 Minute	0 – 60
Seconds	BYTE	5	1 Second	0 - 60
1/100th seconds	BYTE	6	1/100th second	0 - 99

  It defines the clock when the position is valid.

- **Interrogation_age**

  Time since last interrogation of array. Resolution 1ms.

- **Tp_array**

  A single byte defining the number of the transponder array that is in use, 0,1, 2 and 3. Sonardyne sets this to 0.

- **Td_num**

  A 16 bit word defining the transducer number.

  Sonardyne do not differentiate between transducers and transceivers and always use value 1 (meaning transducer 1 on transceiver 1), as all positions are reported relative to the reference point, and the solution may be the result from more than one transducer.

- **Pos_east**

  A value in REAL_64 format.

  East co-ordinates in metres. Positive value is East and negative value is West. The co-ordinated are either local co-ordinates or global UTM co-ordinates.

- **Pos_north**

  A value in REAL_64 format.

  East co-ordinates in metres. Positive value is North and negative value is South. The co-ordinated are either local co-ordinates or global UTM co-ordinates.

- **Depth**

  A value in REAL format.

  The depth co-ordinate. Positive value is downwards.

  For the vessel, the depth is the vertical distance from the sea level to the vessel reference point. For ROVs and relay transponders, the depth is the depth below the sea surface of the transducer on the unit.

- **Hor_err_ellipse_direction**

  A value in REAL format.

  Each LBL position measurement has a likelihood ellipse associated with it. It is based on 1 δ in each of the axis. The direction is the angle in degrees between the north axis and the major axis of the ellipse.

- **Horr_err_ellipse_major**

  A value in REAL format.

  The major axis of the likelihood ellipse in metres.

- **Horr_err_ellipse_minor**

  A value in REAL format.

  The minor axis of the likelihood ellipse in metres.

- **Z_standard_deviation**

  A value in REAL format.

  The standard deviation (δ) of the depth in metres.

- **Pos_type**

  A single byte with value:

  - Index number of LBL vehicle

- **Pos_status**

  A single byte with value:

  This variable tells the status of the position calculation.

  - 0 = OK position
  - 1 = Position not OK

- **P_course**

  A value in REAL format.

  An average of the vessels course at the time of transponder position measurement; 0 to 360 degrees.

- **P_roll**

  A value in REAL format.

  An average of the vessels roll at the time of transponder position measurement +/-180 degrees.

- **P_pitch**

  A value in REAL format.

  An average of the vessels pitch at the time of transponder position measurement +/-180 degrees.

- **Diagnostic**

  Sonardyne do not use this field and always return 0 (no errors).

- **Sumcheck**

  Sumcheck of the contents of the entire telegram except for the sumcheck itself and the stop character. The sumcheck is a 16 bit integer calculated by normal byte + byte addition.

- **Stop Character**

  This is a single byte stop character AA hex.

F.4 HPR 418BCD TELEGRAM

This is a condensed 418 telegram to fit within the length of a 309 telegram to overcome hardware buffer size constraints on older DP desks. BCD (Binary Coded Decimal) requires 4 bits (a nibble) to encode a character.

In conventional BDC the values 0 – 9 inclusive are the only valid characters, however some of the bytes in the Simrad specification allow the use of alpha Hexadecimal (hex) characters A – F inclusive. The most common use is D as it is used as a negative indicator in the most significant nibble of a 3 byte field. The Start and end of message fields contain fixed alpha hex values in both nibbles. And the Status bytes which are assembled bit by bit can in some conditions contain alpha hex characters. The check sum byte is also likely to contain hex alpha characters.

F.4.1 HPR 418BCD Message 1 - Transponder Position Data

Field name	Example BCD data	Byte	Default for DP_test
SOT (Start Of Telegram)	**DF**	**1**	**DF**
Head	**01**	**2**	**01**
Status byte 1	**00**	**3**	**00**
Status byte 2	**00**	**4**	**00**
Transponder type	**00**	**5**	**0**
Transponder Index	**01**	**6**	**1**
	33	**7**	
X position raw	**00**	**8**	**As required**
	12	**9**	
	34	**10**	
Y position raw	**D0**	**11**	**As required**
	56	**12**	
	78	**13**	
Z position raw (Depth)	**01**	**14**	**As required**
	34	**15**	
	45	**16**	
Heading	**35**	**17**	**As required**
	99	**18**	
Optional data 1 (Vessel Roll)	**00**	**19**	**As required**
	00	**20**	
	00	**21**	
Optional data 2 (Vessel Pitch)	**00**	**22**	**As required**
	00	**23**	
	00	**24**	
Horizontal error ellipse direction	**00**	**25**	**0**
	00	**26**	

Horizontal error ellipse major	**00** **00**	**27** **28**	**0**
Horizontal error ellipse minor	**00** **00**	**29** **30**	**0**
Checksum	**XX**	**31**	**[automatic]**
EOR (End Of Record)	**FF**	**32**	**[automatic]**

F.4.2 HPR 418BCD Message 1 - Definition of Field Names

- **SOT (Start Of Telegram)**

  This is a single byte start character DF hex.

- **Head**

  This byte indicates the message type and is always 01 hex for a transponder message type 1.

- **Status Byte 1**

  Bit 0 set = position measurement OK.

  Bit 1 set = position is filtered.

  Bit 2 not used by Sonardyne, bit set to 0.

  Bit 3 not used by Sonardyne, bit set to 0.

  Bit 4 not used by Sonardyne, bit set to 0.

  Bit 5 set = data from 'Slave' system, clear = data from 'Master' system.

  Bit 6 set = BCD conversion error.

  Bit 7 not used by Sonardyne, bit set to 0.

- **Status Byte 2**

  Bit 0 – 1 = Transducer number. (not used by Sonardyne, 00=1; 01=2; 10=3; 11=4, bits are set to 01 – Tdr 2).

  Bit 2 – 3 = Transceiver number. (not used by Sonardyne, 00=1; 01=2; 10=3; 11=4, bits are set to 01 – Tcvr 2).

  Bit 4 set = Simulate mode.

  From Version 6.04r2 software the Simulate mode can be forced to send telegrams with this bit cleared. Before selecting the Simulate option press the $ key, and enter the password <SUPER> when prompted for an engineers password. On entry to Simulate the system will not flag that it is in Simulate mode.

Bit 5 set = Mobile transponder.

Bit 6 not used by Sonardyne, bit set to 0.

Bit 7 set = data from Slave system, clear = data from Master system.

- **Transponder Type**

  A single byte defining the transponder type. Sonardyne report all beacons as standard transponders, and so this byte always contains 00.

  - 00 = standard transponder

- **Transponder index**

  Two bytes defining the transponder channel.

  With a Version 6 system it is possible to use a different **Tp_index** number from the acoustic channel in use. This is to cater for COMPATTs which would not fit within the Simrad DP index system. This has the advantage that if a DP desk requires 418BCD telegrams and a Survey Desk requires 309 telegrams, by setting the index to a number between 1 and 16, both systems will work.

  The selection of values less than 256 as the **Tp_index** would be displayed as Axx on some DP desks. Select indices=255+xx and the DP desk displays Bxx..

  The default value for DP_test is index 1.

- **X position raw**

  Three bytes used for the beacon athwart ship position, the MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is $1/10^{th}$ of the unit.

- **Y position raw**

  Three bytes used for the beacon along ship position, the MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is $1/10^{th}$ of the unit.

- **Z position raw**

  Three bytes used for the beacon depth, the MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is $1/10^{th}$ of the unit.

- **Heading**

  Two bytes used for the vessel heading. The LSB is $1/10^{th}$ of a degree.

- **Optional data 1 (Vessel Roll)**

  Three bytes used for the vessel roll or Optional data 1. The MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is $1/10^{th}$ of the unit.

- **Optional data 2 (Vessel Pitch)**

  Three bytes used for the vessel pitch or Optional data 2. The MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is 1/10th of the unit.

- **Horizontal error ellipse direction**

  Each position measurement has a likelihood ellipse associated with it. It is based on 1 δ in each of the axis. Two bytes are used to indicate the direction of the major axis in degrees between the north axis and the major axis of the ellipse. The LSB is 1/10th of the unit.

- **Horizontal error ellipse major**

  Two bytes used to indicate the major axis of the likelihood ellipse in metres.

  The LSB is 1/10th of the unit.

- **Horizontal error ellipse minor**

  Two bytes used to indicate the minor axis of the likelihood ellipse in metres.

  The LSB is 1/10th of the unit.

- **Checksum**

  The result of performing an exclusive-or on all bytes in the telegram up to but not including this byte.

- **EOR (End Of Record)**

  This byte marks the end of a telegram.

  It is always FF hex.

F.4.3 HPR 418BCD Message 2 - Position Telegram LBL

Field name	Example BCD data	Byte	Default for DP_test
SOT (Start Of Telegram)	**DF**	**1**	**DF**
Head	**01**	**2**	**1 (change to 2)**
Status byte 1	**00**	**3**	**00**
Status byte 2	**00**	**4**	**00**
Object type	**00**	**5**	**0**
Transponder Array	**01**	**6**	**0**
X position (raw or estimated)	**00** **00** **12** **34** **56**	**7** **8** **9** **10** **11**	**As required**
Y position (raw or estimated)	**D0** **00** **09** **87** **65**	**12** **13** **14** **15** **16**	**As required**
Z position (raw or estimated)	**12** **23** **45**	**17** **18** **19**	**As required**
Heading	**35** **99**	**20** **21**	**As required**
Not used	**00** **00** **00**	**22** **23** **24**	**[automatic]**
Horizontal error ellipse direction	**00** **00**	**25** **26**	**0**
Horizontal error ellipse major	**00** **00**	**27** **28**	**0**
Horizontal error ellipse minor	**00** **00**	**29** **30**	**0**
Checksum	**XX**	**31**	**[automatic]**
EOR (End Of Record)	**FF**	**32**	**[automatic]**

F.4.4 HPR 418BCD Message 2 - Definition of Field Names

- **SOT (Start Of Telegram)**

  This is a single byte start character DF hex.

- **Head**

  This byte indicates the message type and is always 02 hex for an object message type 2.

- **Status Byte 1**

  Bit 0 set = position measurement OK.

  Bit 1 set = position is filtered.

  Bit 2 not used by Sonardyne, bit set to 0.

  Bit 3 not used by Sonardyne, bit set to 0.

  Bit 4 not used by Sonardyne, bit set to 0.

  Bit 5 set = data from Slave system, clear = data from Master system.

  Bit 6 set = BCD conversion error.

  Bit 7 not used by Sonardyne, bit set to 0.

- **Status Byte 2**

  Bit 0 – 1 = Transducer number. (not used by Sonardyne, bits are set to 01 – tdr 1).

  Bit 2 – 3 = Transceiver number. (not used by Sonardyne, bits are set to 01 – tcvr 1).

  Bit 4 set = Simulate mode.

  From Version 6.04r2 software the Simulate mode can be forced to send telegrams with this bit cleared. Before selecting the Simulate option press the $ key, and enter the password SUPER when prompted for an engineers password. On entry to Simulate the system will not flag that it is in Simulate mode.

  Bit 5 not used by Sonardyne, bit set to 0.

  Bit 6 set = LBL co-ordinates in UTM.

  Bit 7 set = data from Slave system, clear = data from Master system.

- **Object Type**

  A single byte defining the object type has the following possibilities:

  - 00 = Vessel position
  - 01 = ROV 1 position

    " " "
  - 16 = ROV 16 position
  - 17 = Relay 1 position
  - 18 = Relay 2 position
  - 19 = Relay 3 position
  - 20 = Relay 4 position

- **Transponder array**

  Sonardyne fix this byte at 01 hex.

- **X position (raw or estimated)**

  Five bytes used for the object position in Northings, the MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is 1/100th of the unit.

- **Y position (raw or estimated)**

  Five bytes used for the object position in Eastings, the MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is 1/100th of the unit.

- **Z position (raw or estimated)**

  Three bytes used for the object depth, the MSB is used for the sign and therefore the most significant nibble only returns 0 hex for positive or D hex for negative. The LSB is 1/10th of the unit.

- **Not used**

  Three bytes filled with 00 hex.

- **Horizontal error ellipse direction**

  Each position measurement has a likelihood ellipse associated with it. It is based on 1 δ in each of the axis. Two bytes are used to indicate the direction of the major axis in degrees between the north axis and the major axis of the ellipse. The LSB is 1/10th of the unit.

- **Horizontal error ellipse major**

  Two bytes used to indicate the major axis of the likelihood ellipse in metres.

  The LSB is 1/10th of the unit.

- **Horizontal error ellipse minor**

  Two bytes used to indicate the minor axis of the likelihood ellipse in metres.

  The LSB is 1/10th of the unit.

- **Checksum**

  The result of performing an exclusive-or on all bytes in the telegram up to but not including this byte.

- **EOR (End Of Record)**

  This byte marks the end of a telegram.

  It is always FF hex.

F.4.5 HPR 418BCD Message 3 – Transponders in sequence Telegram

Field name	Example BCD data	Byte	Default for DP_test
SOT (Start Of Telegram)	**DF**	**1**	**DF**
Head	**03**	**2**	**1 (change to 3)**
Number of Transponders in use	**05**	**3**	**[automatic]**
Transponder 1	**00** **01**	**4** **5**	**As required**
Transponder 2	**01** **03**	**6** **5**	**As required**
Transponder 3	**02** **07**	**8** **9**	**As required**
Transponder 4	**01** **33**	**10** **11**	**As required**
Transponder 5	**03** **00**	**12** **13**	**As required**
Transponder 6	**00** **00**	**14** **15**	**As required**
Transponder 7	**00** **00**	**16** **17**	**As required**
Transponder 8	**00** **00**	**18** **19**	**As required**
Transponder 9	**00** **00**	**20** **21**	**As required**
Transponder 10	**00** **00**	**22** **23**	**As required**
Transponder 11	**00** **00**	**24** **25**	**As required**
Transponder 12	**00** **00**	**26** **27**	**As required**
Transponder 13	**00** **00**	**28** **29**	**As required**
Not Used	**00**	**30**	**[automatic]**
Checksum	**XX**	**31**	**[automatic]**
EOR (End Of Record)	**FF**	**32**	**[automatic]**

F.4.6 HPR 418BCD Message 3 - Definition of Field Names

- **SOT (Start Of Telegram)**

  This is a single byte start character DF hex.

- **Head**

  This byte indicates the message type and is always 03 hex for a Transponders in sequence message type 2.

- **Number of Transponders in use**

  A single byte indicating the numbers of transponders currently being used to a maximum of 13 transponders.

- **Transponder number 1 to 13**

  A set of two byte fields indicating the index numbers of the transponder in use. The fields are filled in sequential order from 1 to 13. All the fields of greater number than the last field containing an index number are filled with 00 00.

  The range of valid index numbers is 00 01 to 03 00.

  00 01 to 00 99 are interpreted as A01 to A99 plus 01 00 as A100

  01 01 to 01 99 are interpreted as B01 to B99 plus 02 00 as B100

  02 01 to 021 99 are interpreted as C01 to C99 plus 03 00 as C100.

- **Not used**

  One byte filled with 00 hex.

- **Checksum**

  The result of performing an exclusive-or on all bytes in the telegram up to but not including this byte.

- **EOR (End Of Record)**

  This byte marks the end of a telegram.

  It is always FF hex.

F.5 HPR NMEA TELEGRAM

The maximum length of the telegram is 82 characters including the start character <$> and the termination characters <CR> and <LF>. However, the telegram will typically be less than this and will be of variable length, as leading zeros are suppressed.

F.5.1 Format of HPR NMEA USBL Position Telegram

Field name	Data format	Example data	Num characters
Start_character	**$**	**$**	**1**
Address	**PSIMSSB**	**PSIMSSB**	**7**
Time	**,hhmmss.ss**	**,130700.43**	**10**
Tp_code	**,ann**	**,B22**	**4**
Status	**,a**	**,A**	**2**
Error_code	**,aaa**	**,**	**1**
Coordinate_system	**,a**	**,C**	**2**
Orientation	**,a**	**,H**	**2**
SW_filter	**,a**	**,M**	**2**
X_coordinate	**,x.x**	**,-10000.40**	**10**
Y_coordinate	**,x.x**	**,-10000.89**	**10**
Depth	**,x.x**	**,4329.10**	**8**
Expected_accuracy	**,x.x**	**,3.16**	**5**
Additional_info	**,a**	**,I**	**2**
First_add_value	**,x.x**	**,-12.3**	**6**
Second_add_value	**,x.x**	**,-14.0**	**6**
Checksum	***hh**	***hh**	**3**
Termination	**CRLF**	**CRLF**	**2**

F.5.2 HPR NMEA USBL Position Telegram - Definition of Field Names

- **Start_character**

  The single ASCII character <$>.

- **Address**

  The ASCII character string <PSIMSSB> to indicate that the telegram is a Simrad SSBL message.

- **Time**

  The time at which the fix was valid.

  An ASCII character string preceded by a comma, indicating the time in hh (hours) mm (minutes) ss (seconds) . (decimal point) ss (hundredths of seconds)

  <,hhmmss.ss> eg <,035623.19> alternatively the field may be left blank eg <,>.

- **Tp_code**

  The index of the transponder used.

  B01 – B99 = MF channels

  Examples B05, B55, B58

  The format is three ASCII characters preceded by a coma <,ann> eg <,B17>

- **Status**

  A single ASCII character preceded by a coma <,a>

  A = OK, V = not OK eg <,V>

  Note:- when a V is present the Error_code field will contain three ASCII characters otherwise it will be empty.

- **Error_code**

  If the Status field indicates that the data was not OK, this field will contain the string 'Rej' indicating the data has been rejected, otherwise it will be blank.

- **Coordinate_system**

  A single ASCII character preceded by a coma <,a>

  C = Sonardyne always output transponder data in Cartesian co-ordinates with respect to the vessel reference point.

- **Orientation**

  A single ASCII character preceded by a coma <,a>

  H = Vessel Head Up, or N = North up. eg <,H>

- **SW_filter**

  A single ASCII character preceded by a coma <,a>

  F = filtered, or M = measured. e.g. <,F>

- **X_coordinate**

  When no position is calculated the field is empty and only the coma field separator is sent <,>

This field contains the Cartesian X co-ordinate, with the orientation defined by the Orientation field. The options supported by Sonardyne are X = Athwart ship positive to Starboard, and local frame X = positive to the north.

When data is present the field takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Y_coordinate**

  When no position is calculated the field is empty and only the coma field seperator is sent <,>

  This field contains the Cartesian Y co-ordinate, with the orientation defined by the Orientation field. The options supported by Sonardyne are Y = along ship, positive to bow, and local frame Y = positive to the east.

  When data is present the field takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Depth**

  When no position is calculated the field is empty and only the coma field separator is sent <,>

  When data is present its represents depth in metres and takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Expected_accuracy**

  The expected accuracy of the position based on the Major and Minor semi-axes of the error ellipse <,x.x> and is of variable length with leading zeros suppressed.

- **Additional_info**

  A single ASCII character preceded by a coma <,a>

  I = inclinometer and N = none <,N>

- **First_add_value**

  When Additional_info field is N then this field is empty and only the coma field seperator is sent <,>

  When data is present its meaning is controlled by the Additional_info field. The only option supported by Sonardyne is X inclination (roll) with leaning to starboard positive.

  The data field takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Second_add_value**

  When Additional_info field is N then this field is empty and only the coma field seperator is sent <,>

  When data is present its meaning is controlled by the Additional_info field. The only option supported by Sonardyne is Y inclination (pitch) with leaning forward positive.

  The data field takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Checksum**

  The result of performing an exclusive-or on all bytes in the telegram up to but not including this byte in the form<*hh>

- **Termination**

  The ASCII for Carriage Return followed by Line Feed are sent <,CRLF>.

F.5.3 Format of HPR NMEA LBL Position Telegram

Field name	Data format	Example data	Num Char
Start_character	**$**	**$**	**1**
Address	**PSIMLBP**	**PSIMLBP**	**7**
Clock	**,hhmmss.ss**	**,130700.43**	**10**
Tp_array	**,n**	**,1**	**2**
Type	**,aa**	**,Ve**	**3**
Status	**,aaa**	**,A**	**2**
Coordinates	**,a**	**,U**	**2**
X_coordinate	**,x.x**	**,10345678.92**	**12**
Y_coordinate	**,x.x**	**,987654.32**	**10**
Depth	**,x.x**	**,1234.50**	**8**
Major	**,x.x**	**,6.9**	**4**
Minor	**,x.x**	**,3.4**	**4**
Direction	**,x.x**	**,118.6**	**7**
Depth_stdev	**,x.x**	**,3.5**	**4**
Checksum	***hh**	***hh**	**3**
Tremination	**CRLF**	**CRLF**	**2**

F.5.4 HPR NMEA LBL Position Telegram - Definition of Field Names

- **Start_character**

  The single ASCII character <$>.

- **Address**

  The ASCII character string <PSIMLBP> to indicate that the telegram is a Simrad LBL message.

- **Clock**

  The time at which the fix was valid.

  An ASCII character string preceded by a comma, indicating the time in hh (hours) mm (minutes) ss (seconds) . (decimal point) ss (hundredths of seconds)

  The decimal fraction is optional

  <,hhmmss.ss> eg <,035623.19> alternatively the field may be left blank eg <,>.

- **Tp_array**

  The index of the array used.

  The format is a single ASCII numeral preceded by a coma <,n> eg <,1>

  Sonardyne fix the value at 1.

- **Type**

  The index of the object being positioned.

  The valid options being:

  Ve = Vessel

  R1 – R4 = ROV 1 – ROV4

  The format is a single ASCII numeral preceded by a coma <,aa> eg <,R1>

  Sonardyne fix the value at Ve in V5 LUSBL software however V6 LUSBL software allows other values.

- **Status**

  A single ASCII character preceded by a coma <,a> or three ACSII characters preceded by a coma <,aaa>.

  A = OK, ??? = not OK eg <,A>.

- **Coordinates**

  A single ASCII character preceded by a coma <,a>

  C = Cartesian N/E, or U = UTM N/E. eg <,C>.

  Cartesian values are relative to the origin of the array.

- **X_coordinate**

  The X direction data North for Cartesian mode or Northings for UTM mode. The field takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Y_coordinate**

  The Y direction data East for Cartesian mode or Eastings for UTM mode. The field takes the form <,xxx.xx>, and is of variable length with leading zeros suppressed.

- **Depth**

  The depth in metres in the form <,xxx.xx>, of variable length with leading zeros suppressed.

- **Major**

  The major axis of the error ellipse in the form <,x.x> of variable length with leading zeros suppressed.

- **Minor**

  The minor axis of the error ellipse in the form <,x.x> of variable length with leading zeros suppressed.

- **Direction**

  The direction of the major axis of the error ellipse in the form <,x.x> of variable length with leading zeros suppressed.

- **Depth_stdev**

  The depth standard deviation in the form <,x.x> of variable length with leading zeros suppressed.

- **Checksum**

  The result of performing an exclusive-or on all bytes in the telegram up to but not including this byte in the form<*hh>

- **Termination**

  The ASCII for Carriage Return followed by Line Feed are sent <,CRLF>.

F.6 ATS ASCII TELEGRAM

The ATS ASCII telegram is used by Nautronix ATS-S02, ATS-S04 and ATS-S08 systems.

Each line of the data contains position data for one object, is terminated by line feed <LF> and carriage return <CR> characters (ASCII 10 and 13).

The format is:

dd mmm yy hh:mm:ss B:d X:ddd.d Y:ddd.d D:ddd.d P:d.d R:d.d H:ddd.d A:d.d C:d.d E:d<LF><CR>

Where:

- dd mmm yy hh:mm:ss Date and time of receipt of the acoustic reply
- B: Beacon Index 0 = ship, 1-10=beacons 1 to 10
- X: X co-ordinate in metres.
- Y: Y co-ordinate in metres.
- D: Depth in metres.
- P: Ship's pitch in degrees. Positive pitch is Bow up. +/-9.9
- R: Ship's roll in degrees. Positive roll is Port up. +/-9.9
- H: Ship's heading relative to North in degrees. 0-360

- A: Riser angle beacon pitch in degrees (if beacon is RAC)
- C: Riser angle beacon roll in degrees (if beacon is RAC)
- E: Error code (0 – good data, 1 - test mode).

The co-ordinate frame for beacon position data is relative to the ship datum point.

- Positive Y is forward
- Positive X is starboard
- Positive Depth is down

The co-ordinate frame for ship position is the seabed LBL array co-ordinate frame with positive Y North and positive X East. In this case Depth is nominally the position of the ship's datum relative to sea level; however it is highly dependent upon water depth and calibrated beacon depths and is therefore not to be relied upon.

Example telegrams look like:

- 19 Sep 95 11:32:53 B:4 X:-107.3 Y:102.2 D:99.8 P:0.2 R:-0.3 H:25.4 E:0<LF><CR>
- 19 Sep 95 11:32:54 B:0 X:416739.9 Y:5579729.2 D:1.2 P:0.2 R:-0.3 H:25.4 E:0<LF><CR>

APPENDIX G

G. FREQUENCY CHARTS – TONE SIGNALS

Frequency clashes with a USBL or L/USBL system using tone signals can be avoided by prudent choice of interrogate and reply tones for the COMPATTs being interrogated by the system. This is particularly true in the case of an L/USBL system (which tends to utilise more COMPATTs) and where other acoustic systems are in use in the same area of sea.

The general rule is “choose frequencies which are well separated from those being used by other Beacons in the vicinity”. For an L/USBL with (say) four COMPATTs, it is safest to pick four separate Individual Interrogation Frequencies (IIFs) and a different four separate Individual Interrogation Frequencies (IRFs). However, in many cases, it is possible to economise on frequencies and still achieve sufficient discrimination by setting one Common Interrogation Frequency (CIF) and four different IRFs together with four different turn-around times. (Note that, for COMPATTs supplied with appropriate firmware, Alternative-CIF frequencies may be assigned if the basic CIF is already being used nearby on another job).
The diagrams which follow summarise the range of Sonardyne and SIMRAD tone frequencies associated with HPR 309 telegram transmissions (Figure G.1) and HPR 418 telegram transmissions (Figure G.2). Assuming other tone signals being used in the area are known, it is possible, using these diagrams, to select frequencies for the current job which are well separated from each other and all other known frequencies.

The frequency clashes with a USBL or L/USBL system that can arise using tone signals are avoided when using Sonardyne’s wideband signal architecture introduced in 2005 (see Appendix H).

FIG G.1 SONARDYNE AND SIMRAD TONE FREQUENCIES – HPR 309

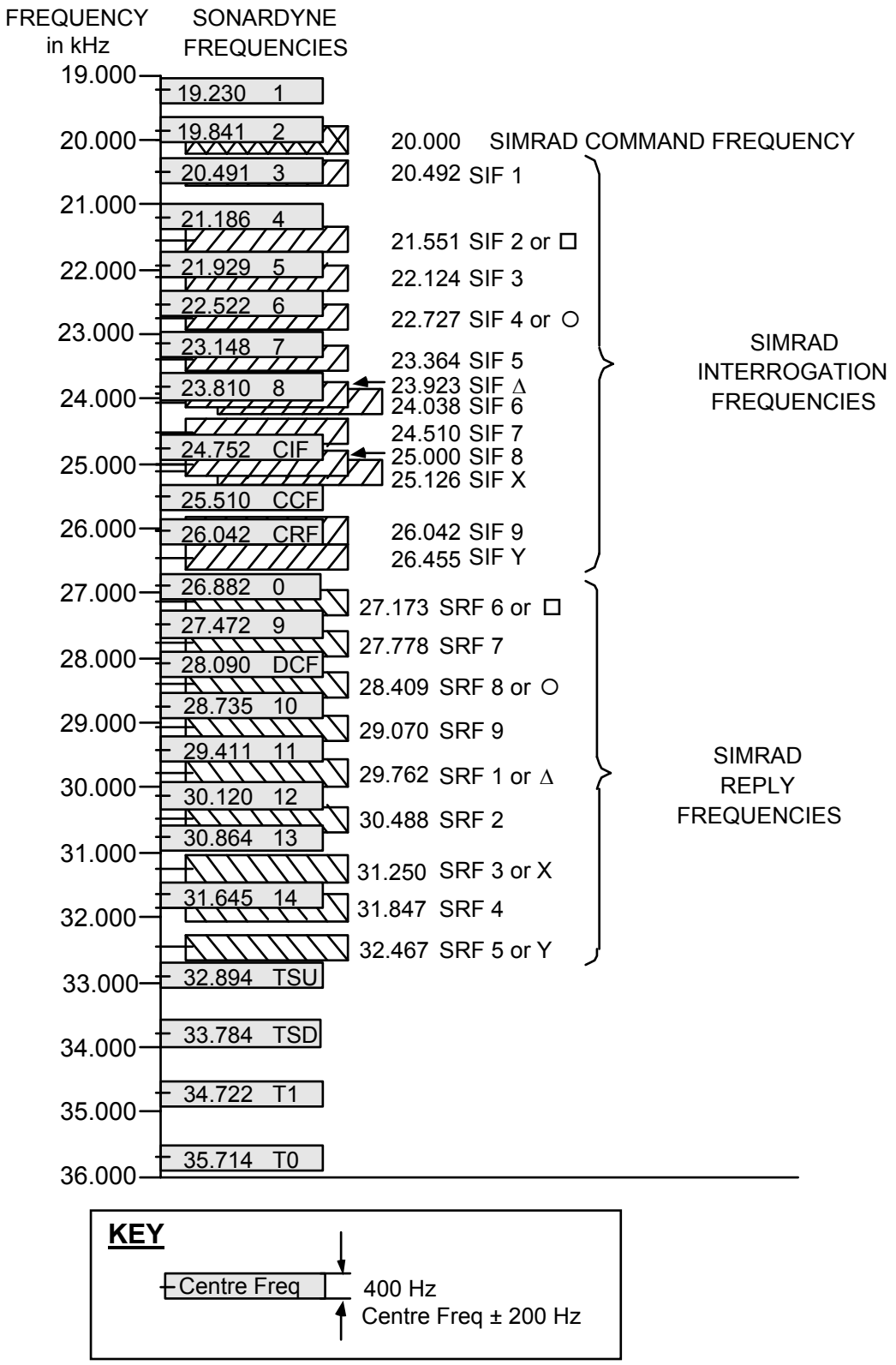
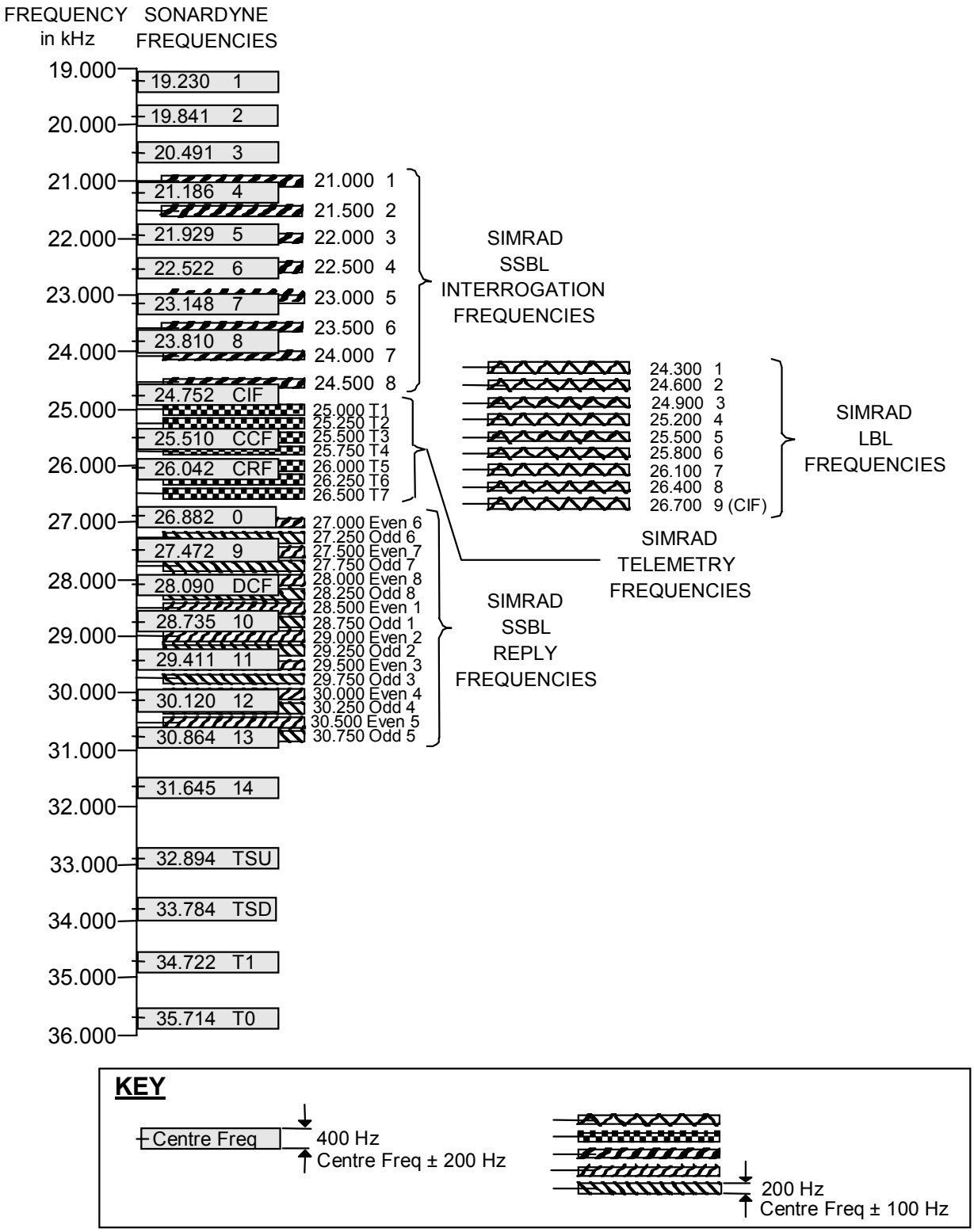


FIG G.2 SONARDYNE AND SIMRAD TONE FREQUENCIES – HPR 418



APPENDIX H

H. OPERATION WITH FUSION COMPATT 5 BEACONS

This Appendix provides a concise overview of the implementation of Wideband mode in Compatt 5 MF transponders.

H.1 INTRODUCTION

Compatt 5 MF transponders, fitted with a Wideband board and loaded with firmware version 1.05 or later, can be used in both conventional Tone mode and SONARDYNE'S new Wideband mode. Figure H.1 shows a Wideband board installed on a Compatt CPU card.

Units which have been fitted with a Wideband board can be identified using the Compatt test software and also by the Fusion label on the Compatt housing, as illustrated in Figure H.2.

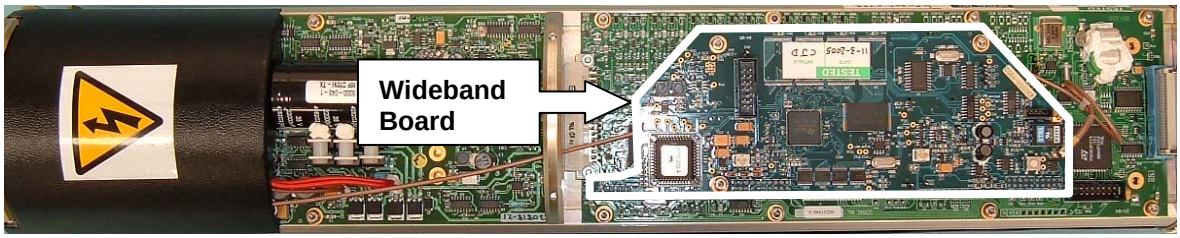


FIG H.1 WIDEBAND BOARD INSTALLATION ON COMPATT 5 CPU CARD

FIG H.2 COMPATT 5 HOUSING LABEL

The major difference between Tone and Wideband ranging modes is that Tone is restricted to a single interrogation channel and 16 reply channels. Sonardyne have defined a number of wideband carriers, on which a number of codes can be transmitted. This gives the user access to more than 400 interrogation and reply signals.

To manage the increase in the number of reply channels, the Wideband signals used by a Compatt 5 are closely linked to the Compatt's Address. In addition, a Compatt 5 Address can be changed via acoustic command as well as by serial link

NOTE: As the address of a Compatt 5 can easily be changed, even following deployment, **it is essential that the Compatt Unit ID number be recorded for each unit as part of the pre-deployment deck check procedures.** The Unit ID is marked on the Compatt housing label, as shown in the example in Figure H.3. It is also reported by the Compatt test software. A Compatt 5 address can be recovered via acoustic command if the unit ID number is known.

FIG H.3 EXAMPLE OF UNIT ID NUMBER LABEL ATTACHED TO COMPATT 5 HOUSING

The Address Code for a Mk4 Compatt and a Compatt 5 in Tone mode is defined by the first two digits of the Compatt Address and the Address Channel defined by the last two digits of the Compatt Address.

In Wideband mode the first two digits define the Compatt Family. In the example shown in Figure H.4, Compatt Address 105 belongs to the Compatt Family that has addresses beginning with 01 (The leading zero in Compatt addresses is commonly suppressed).

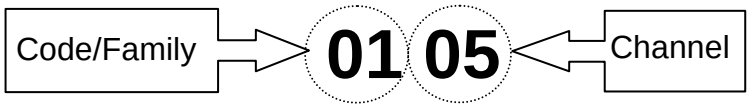


FIG H.4 COMPATT ADDRESS COMPOSITION

H.2 TONE RANGING IN COMPATT 5

When used in Tone mode, MF Compatt 5 units are fully backwards compatible with MF Mk4 Compatts, Dual Band Compatts and all tone-based MF transceivers (PAN, Mini RovNav, Mk4 RovNav, and BOPNav).

Compatt 5 defaults to ranging in Tone mode. In this mode the Address Channel defines the Compatt's Individual Interrogation Frequency (IIF) and default Individual Reply Frequency (IRF).

As the Address Code does not affect ranging channels, arrays can contain Compatts with different Address Codes. However, IRFs can be changed via acoustic command as each array Compatt must transmit a unique reply channel during tracking.

H.3 WIDEBAND RANGING MODE IN COMPATT 5

A suitably configured Compatt 5 can be set to operate in Wideband mode when used as part of a L/USBL system (requires a Digital USBL transceiver loaded with firmware version 8 or later).

Whilst the signal and telemetry schemes supported in Wideband mode differ significantly from Tone the underlying acoustic architecture, in terms of a system of Common and Individual Interrogation and Reply channels, is unchanged.

In Wideband mode, the full Compatt Address defines a Compatt's Individual Interrogation Signal (IIS) and Individual Reply Signal (IRS).

In projects where there is a requirement for simultaneous operation of Wideband systems within acoustic interference range of one another, it is recommended that each user operates using a single Family to simplify signal management.

H.3.1 Wideband Signal Sets

The L/USBL system supports the Primary Compatt 5 signal set which have address codes 01-15. The Common Interrogation Signals use low carrier frequencies, and Individual Reply Signals with high carrier frequencies.

The signal allocation scheme for the Primary Signal Set is as illustrated in Figure H.5 with Common Interrogation Signals in the lower half of the MF band and Individual Reply Signals in the upper half of the band. In addition to a default CIS (CIS 0000) there are 14 alternate CISs to enable the interrogation of multiple arrays using the same Signal Set within interference range of one another.

Carrier Frequency	19.0 to 26.5 (kHz)															27.0 to 33.5 (KHz)													
Navigation Signals	CIS 0001	CIS 0002	CIS 0003	CIS 0004	CIS 0005	CIS 0006	CIS 0007	CIS 0008	CIS 0009	CIS 0010	CIS 0011	CIS 0012	CIS 0013	CIS 0014	CIS 0000	IRS xx14	IRS xx13	IRS xx12	IRS xx11	IRS xx10	IRS xx09	IRS xx08	IRS xx07	IRS xx06	IRS xx05	IRS xx04	IRS xx03	IRS xx02	IRS xx01

FIG H.5 PRIMARY WIDEBAND SIGNAL SET – XX CORRESPONDS TO FAMILY NUMER: 01 – 15

H.3.2 Glossary of Key Terms

Family: A grouping of 14 Compatts each with different signal code and carrier combinations but the same Address Code e.g. 1101, 1102, 1105 etc

Signal Set: A collection of Family codes that are all mutually compatible in that they share a common signal scheme e.g. interrogate low / reply high

IRS Individual Reply Signal

IIS Individual Interrogation Signal

CIS Common Interrogation Signal

CRS Common Reply Signal

H.4 KEY POINTS TO REMEMBER

Wideband ranging mode in Compatt 5 requires that a Wideband board is fitted and the Compatt is loaded with firmware version 1.05 or later

Wideband mode is only supported in Digital USBL transceivers fitted with version 8 firmware or later

The Unit ID number **MUST** always be recorded before deploying a Compatt 5 transponder.

APPENDIX I

I. CALCULATING SOUND VELOCITY

Sound velocity is an extremely important parameter in the operation of an acoustic reference system and accurate results may not be achieved by the system if an inaccurate value for sound velocity is entered in to the system - see Section 9.2.3. The preferred method of determining sound velocity is the use of a sound velocity probe. If a sound velocity probe is not available, then an acceptably accurate value for the sound velocity at the seabed may be calculated by utilising the data provided by a COMPATT's environmental sensors in one of the formulae set out below.

I.1 MEDWIN'S FORMULA

For sea conditions within the following limits:-

Temperature : 0 to 35°C
Depth : 0 to 1000m
Salinity : 0 to 45ppt

use the following formula:-

$$V = 1449.2 + [4.6 \times T] - [5.5 \times 10^{-2} \times T^2] + [2.9 \times 10^{-4} \times T^3] + [1.6 \times 10^{-2} \times D] + [1.33 \times T \times (S - 35)]$$

Where V is the Velocity of sound in water
T is the Temperature in Degrees Celsius
D is the Depth in metres
S is the salinity in parts per thousand

I.2 MACKENZIE'S FORMULA

For sea conditions within the following limits:-

Temperature : -2 to 35°C
Depth : 0 to 8000m
Salinity : 25 to 40ppt

use the following formula:-

$$V = 1448.96 + [4.591 \times T] - [5.304 \times 10^{-2} \times T^2] + [2.374 \times 10^{-4} \times T^3] + [1.34 \times (S - 35)] + [1.63 \times 10^{-2} \times D] + [1.675 \times 10^{-7} \times D^2] - [1.025 \times 10^{-2} \times T \times (S - 35)] - [7.139 \times 10^{-13} \times T \times D^3]$$

Where V is the Velocity of sound in water
T is the Temperature in Degrees Celsius
D is the Depth in metres
S is the salinity in parts per thousand

I.3 UNESCO FORMULA (1983)

In most situations, using one of the above two formulae will suffice. However, for sea temperatures above 35°C, the Unesco formula may be used. Limiting sea conditions are:-

Temperature : 0 to 40°C
Depth : 0 to 1000m
Salinity : 0 to 40ppt

The Unesco formula is:-

$$V = [C_W(t,p)] + [A(t,p) \times S] + [B(t,p) \times S^{3/2}] + [D(t,p) \times S^2]$$

Where:

$$C_w(t,p) = C_{00} + C_{01} \text{ x } T + C_{02} \text{ x } T^2 + C_{03} \text{ x } T^3 + C_{04} \text{ x } T^4 + C_{05} \text{ x } T^5 +$$
$$(C_{10} + C_{11} \text{ x } T + C_{12} \text{ x } T^2 + C_{13} \text{ x } T^3 + C_{14} \text{ x } T^4) \text{ x } P_b +$$
$$(C_{20} + C_{21} \text{ x } T + C_{22} \text{ x } T^2 + C_{23} \text{ x } T^3 + C_{24} \text{ x } T^4) \text{ x } P_b^2 +$$
$$(C_{30} + C_{31} \text{ x } T + C_{32} \text{ x } T^2) \text{ x } P_b^3$$

$$A(t,p) = A_{00} + A_{01} \text{ x } T + A_{02} \text{ x } T^2 + A_{03} \text{ x } T^3 + A_{04} \text{ x } T^4 +$$
$$(A_{10} + A_{11} \text{ x } T + A_{12} \text{ x } T^2 + A_{13} \text{ x } T^3 + A_{14} \text{ x } T^4) \text{ x } P_b +$$
$$(A_{20} + A_{21} \text{ x } T + A_{22} \text{ x } T^2 + A_{23} \text{ x } T^3) \text{ x } P_b^2 +$$
$$(A_{30} + A_{31} \text{ x } T + A_{32} \text{ x } T^2) \text{ x } P_b^3$$

$$B(t,p) = B_{00} + B_{01} \text{ x } T + (B_{10} + B_{11} \text{ x } T) \text{ x } P_b$$

$$D(t,p) = D_{00} + D_{10} \text{ x } P_b$$

C00 = 1402.388;
C01 = 5.03711;
C02 = -5.80852e-2;
C03 = 3.342e-4;
C04 = -1.478e-6;
C05 = 3.1464e-9;
C10 = 0.153563;
C11 = 6.8982e-4;
C12 = -8.1788e-6;
C13 = 1.3621e-7;
C14 = -6.1185e-10;
C20 = 3.126e-5;
C21 = -1.7107e-6;
C22 = 2.5974e-8;
C23 = -2.5335e-10;
C24 = 1.0405e-12;
C30 = -9.7729e-9;
C31 = 3.8504e-10;
C32 = -2.3643e-12;

A00 = 1.389;
A01 = -1.262e-2;
A02 = 7.164e-5;
A03 = 2.006e-6;
A04 = -3.21e-8;
A10 = 9.4742e-5;
A11 = -1.258e-5;
A12 = -6.4885e-8;
A13 = 1.0507e-8;
A14 = -2.0122e-10;
A20 = -3.9064e-7;
A21 = 9.1041e-9;
A22 = -1.6002e-10;
A23 = 7.988e-12;
A30 = 1.1e-10;
A31 = 6.649e-12;
A32 = -3.389e-13;

B00 = -1.922e-2;
B01 = -4.42e-5;
B10 = 7.3637e-5;
B11 = 1.7945e-7;

D00 = 1.727e-3;
D10 = -7.9836e-6;

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