SeaBat 9003

OPERATORS MANUAL

Version 2.2

PART #9003M

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Manual History

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Software History

This manual covers the SeaBat 9003 system up to and including:

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Preface

The SeaBat 9003 Operators Manual is a reference manual that provides information required to install and operate the SeaBat 9003 Multibeam Bathymetry Sonar System.

The installation procedures in this guide are written for personnel who may be novice sonar operators, but are familiar with computer systems, basic electronics and wiring. Procedures are described in a step-by-step sequence. We recommend you proceed from chapter to chapter until your SeaBat installation is completed and basic operation is familiar.

Manual Overview

The organization of this manual is as follows:

Chapter 1, "General Information", provides general component information for the SeaBat 9003.

Chapter 2, "Installation", provides a complete description of the installation procedures and steps to power-up and shutdown the system.

Chapter 3, "System Operation", describes how to operate the SeaBat 9003 system, and also some survey considerations.

Chapter 4, "Options and Upgrades", describes the various options and upgrades available for the SeaBat 9003 system.

Chapter 5, "Maintenance", describes certain routine maintenance procedures and system checks.

Chapter 6, "Trouble Shooting", provides initial checks to determine exact problems.

Chapter 7, "System Interfaces", lists in detail many interfaces available with the SeaBat 9003 system and the configurations possible.

Chapter 8, "Calibration Procedures", provides detailed calibration procedures for operational use on a surface vessel or underwater Remotely Operated Vehicle (ROV).

Chapter 9, "Parts List", provides part numbers and descriptions of all SeaBat 9003 parts and accessories.

Chapter 10, "Related SeaBat Products", provides a list of all SeaBat 9003 related or supporting products.

Manual Revisions

If the information contained in this manual is unclear, please contact your local SeaBat representative for clarification.

RESON strives to maintain up-to-date customer information and may, as necessary, review and revise this manual.

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CHAPTER 1 - GENERAL INFORMATION

1.1 INTRODUCTION

This SeaBat 9000 Series manual covers the SeaBat 9001, 9001S, 9002, 9002S, and 9003 models. It is written for both the first time operator and for the experienced operator who wishes to use a particular section as a reference guide. This manual provides detailed information covering the installation, operation, and maintenance of the system.

What are the models in the 9000 series?

There are five models in the SeaBat 9000 Series. All look very similar; however, their capabilities vary. The models are:

- **9001** - The standard Multibeam Echo Sounder System that is the core unit of all other 9000 models. The 9001 uses 60 individual sonar beams, each measuring 1.5°x1.5°, to create a 90° swath width. All SeaBat 9000 models with the exception of the SeaBat 9003 follow this beam configuration.
- **9001S** - A 9001 which has a switch on the front of the processor to enable the operator to switch from the bathymetric mode to Forward Looking Sonar mode (which emulates the SeaBat Model 6012). See Paragraph 4.9.
- **9002** - Externally, this system looks and operates the same as a 9001; however internally, the sonar head and processor have been modified to allow two (2) SeaBat 9001 systems to work in the same acoustic environment. See Paragraph 4.11.
- **9002S** - The SeaBat 9002S is a SeaBat 9001 that has both the 9001S and 9002 features and capabilities.
- **9003** - Similar to the 9001, but using 40 3°x1.5° beams to create a 120° swath width, rather than the 9001's 60 1.5°x1.5° beams and 90° swath width.

What is a SeaBat 9003?

The SeaBat 9003 is a Multibeam Echo Sounder System which, when located in water, will measure, display, and output data describing the seafloor or any other object located within its field of view.

How does it work?

The can-shaped projector on the top of the sonar head transmits a sound that travels through the water and is reflected by the seafloor, or any object that it "hits". The reflected noise is received through 40 independent transducers located in the curved end of the sonar head where the signal is processed.

The two-way travel time of the transmitted pulse is multiplied by the speed that it travelled (Speed of Sound in Water), to compute the distance of the seafloor from each of the 40 transducers. This computed distance is displayed on the color screen and also output to external devices.

How much seafloor does it profile?

The SeaBat's "field of view" covers an angle of 120° (cross track) by 1.5° (along track). Therefore, when the head is mounted vertically, the profile width is twice the water depth below the sonar head (see Figure 1-1). Although the SeaBat can transmit the signal to a distance of 200 meters (660 ft.), the system was designed to International Hydrographic Organization (IHO) standards to measure the seafloor at a maximum depth of 75 meters.

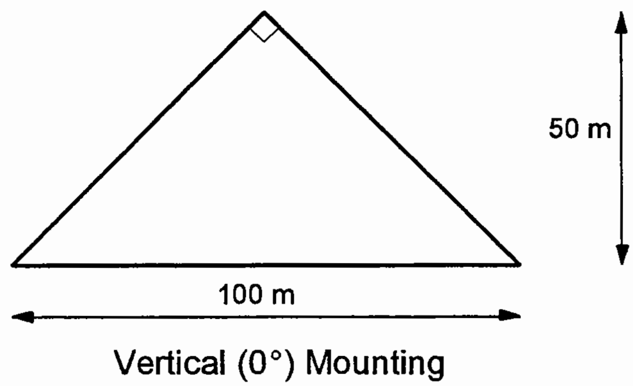


Figure 1-1. SeaBat Mounting Orientation

What is its accuracy?

The SeaBat's transmit frequency is 455 kHz, which equates to a range resolution of 5cm (2"). The accuracy of the system depends on a number of factors, (a) using the correct speed of sound in water, (b) the incident angle at which the signal is reflected from the seafloor, and (c) the distance to the seafloor.

From independent field tests conducted by the National Oceanic and Atmospheric Administration (NOAA), the accuracy of the SeaBat 9000 series was determined, based on the incident angle at which each beam measures the seafloor. The beams reflecting at 120° have an accuracy of 4cm, those at ±45° are 5cm, ±30°are 6cm and at ±15° are <9cm.

The above stated accuracies are those of the SeaBat system. When calculating the true depth, other sensors are required (roll, pitch, heave, tide, velocity, etc.), so the final depth computed depends on the combination of all sensor accuracies. See Chapter 8 - Calibration.

1.2 SAFETY PRECAUTIONS

As with all items of electric/electronic equipment, precautions should be taken to avoid accidents in the work place. Chapter 2 provides detailed procedures for the correct installation of the SeaBat system. Please follow the steps provided for safety and to obtain the best performance from your SeaBat system.

1.3 SYSTEM CONFIGURATION

The SeaBat 9003 Sonar System includes both Dry- and Wet-End Components. Figure 1-2 details the configuration for the Dry-End, while Figure 1-3 depicts the Wet-End Components.

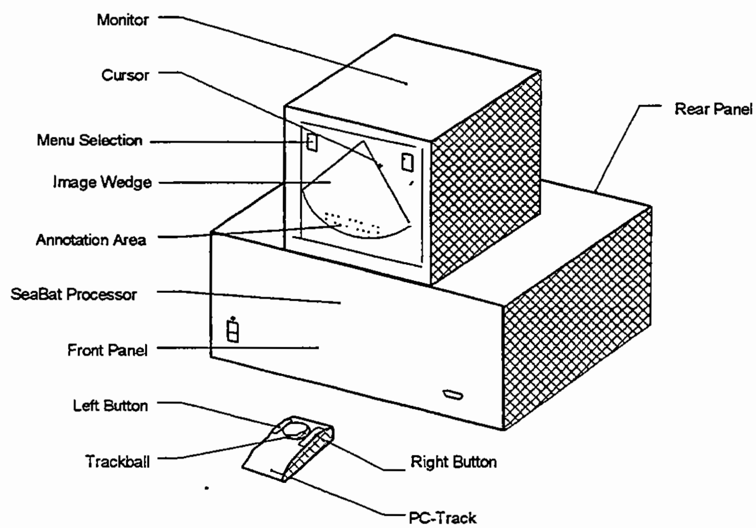


Figure 1-2. SeaBat 9003 Dry-End Configuration

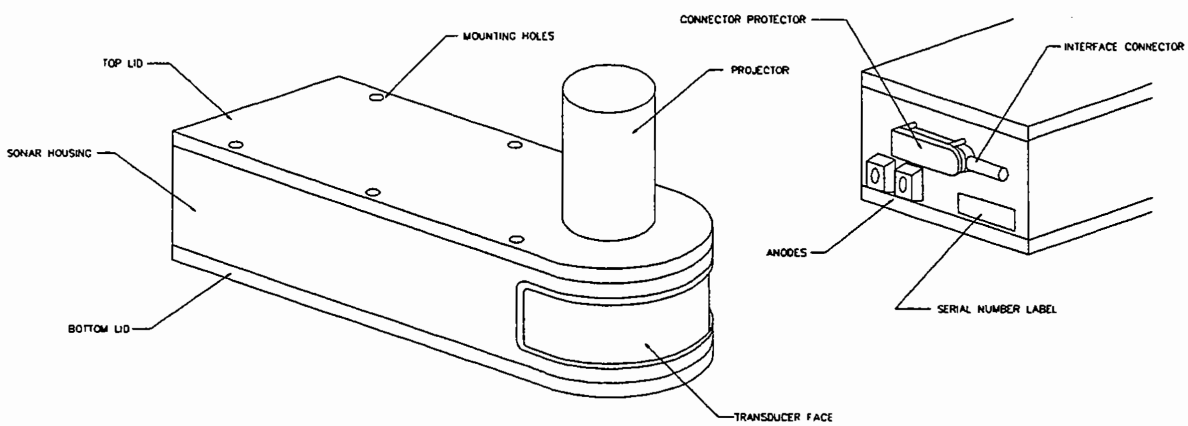


Figure 1-3. SeaBat 9003 Wet-End Configuration

1.4 EQUIPMENT DESCRIPTIONS

A basic SeaBat 9003 system is comprised of four main components and three optional devices. The following provides a brief description of each component, while Figure 1-4 provides a block diagram of the System Layout.

Main Components:

SeaBat Processor . . . Sends controls to the sonar head; receives measured data from the sonar head; controls the processing, display and output of data.

SeaBat Sonar Head . . Pressure-sealed solid state sonar unit that transmits, receives and conducts preliminary processing of sonar data prior to transmitting it to the surface processor via a cable link.

Color Display . . . . Presents the sonar data to the operator and provides menus for the operator to select the mode of operation.

Pointer Device . . . . . . A Trackball, Joystick or Mouse that enables the operator to select modes of operation on the color display.

Data Recording (Optional) Devices:

Video Recorder . . . . . Connects to the SeaBat processor and records the video signal, either in PAL or NTSC format.

External Computer . . . Connects to the SeaBat processor and inputs/outputs data for storage and on line processing.

Chart Recorder/ Processor . . . . . If Option 019 - Side Scan Upgrade is present, then an external recording/display unit is connected to the Chart Recorder outputs on the rear of the SeaBat processor.

The following paragraphs provide technical information on these components to ensure a basic understanding of the SeaBat 9003 system.

Due to the flexibility of the SeaBat system, various configurations can be adapted to meet the requirements of the customer. It is easy to vary the components and interfaces to different equipment: please refer to "Chapter 2 - Installation" and "Chapter 7 - System Interfaces" for a more detailed description of the SeaBat 9003 system and the configurations available. Paragraph 1.6 provides a listing of options, upgrades and accessories available for the SeaBat 9003.

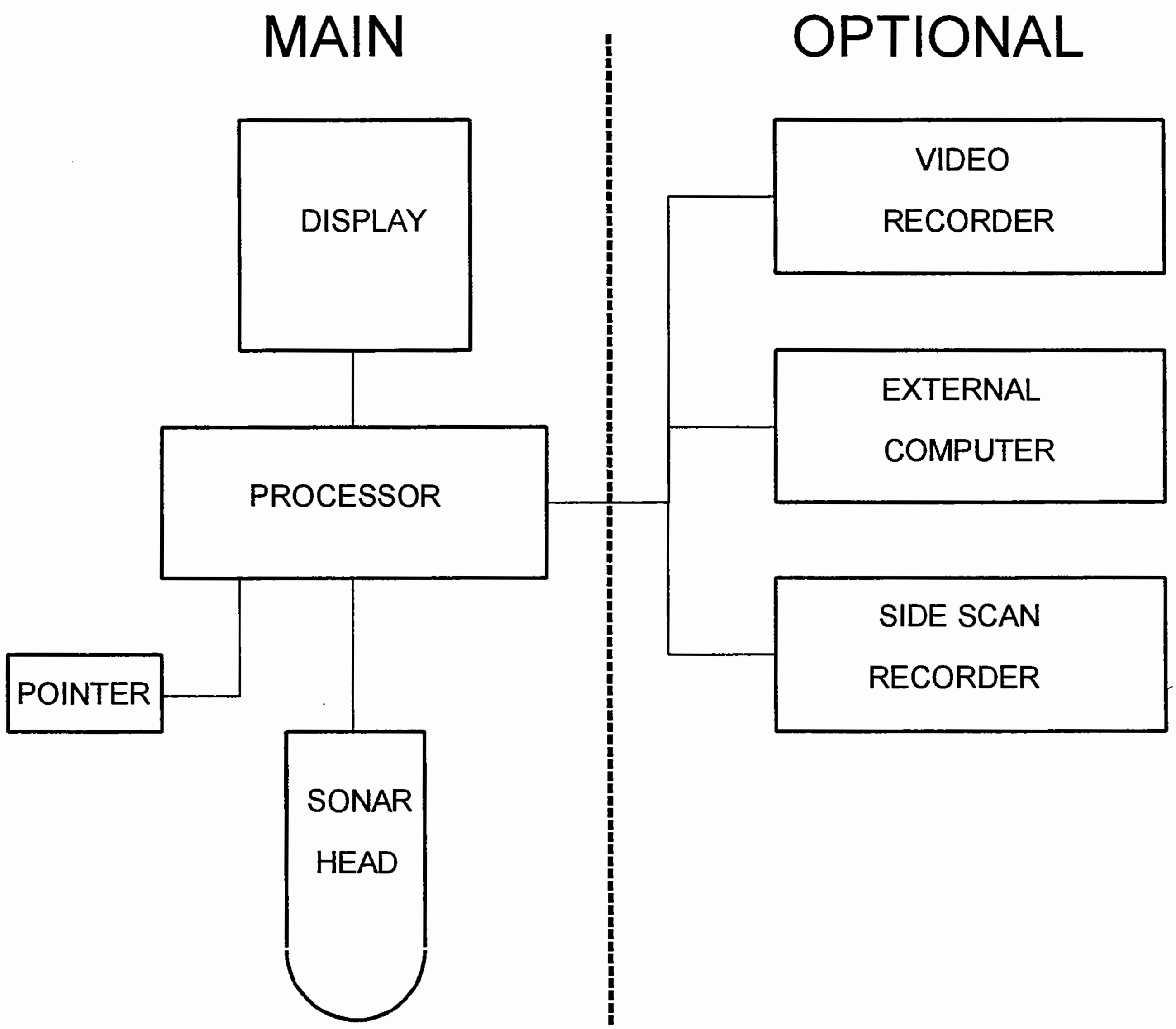


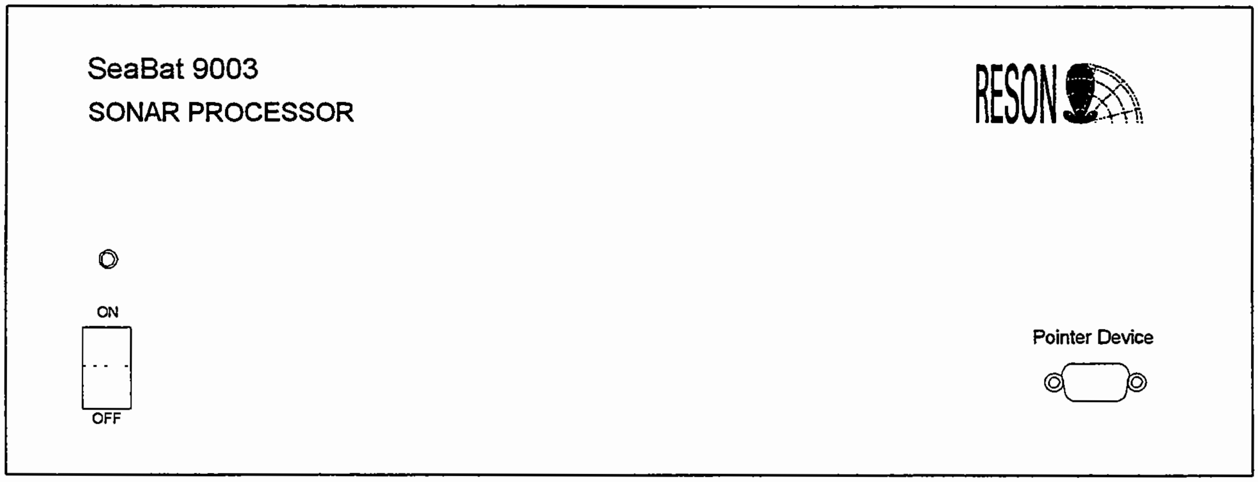
Figure 1-4. Basic SeaBat 9003 System Layout

1.4.1 SeaBat PROCESSOR UNITS

Table 1-1 provides specifications for the SeaBat 9003 processor, while Figure 1-5 depicts the processor's front and back panels.

TABLE 1-1. SeaBat 9003 PROCESSOR - TECHNICAL SPECIFICATIONS

DESCRIPTION	9003
Power Requirements	90/260 VAC, 50/60 Hz, 75-200W max.
Sonar Operating Frequency	455 kHZ
Range Settings	2.5, 5, 10, 25, 50, 100, and 200 meters
Range resolution	5 cm
Display Update rate (Full 120° sector)	2.5, 5, 10 meter range = 15 times/sec. 25 meter range = 13 times/sec. 50 meter range = 7 times/sec. 100 meter range = 3½ times/sec. 200 meter range = 2 times/sec.
Data Input (Uplink)	Pseudo-video, 1.5 MHz black/white video channel
Data Input (Annotation)	RS-232, 1200 baud (Aux #1)
Data Output (Down Link)	RS-232, 300 baud
Data Output (Profile) format	RS-232, 300 to 38,400 baud (Aux #2)
Data Output (Profile) rate	0.21 to 15.15 profiles per second (See Chapter 7.6.2)
Display Video Output	Analog RGB, composite, and S-VHS (S-Video); PAL or NTSC format
Graphics Colors	256 colors (8-bit) [preset ranges]
Display Mode	Sector format (Down)
Display Sector	120°
Input Device	Trackball or Joystick
Dimensions	178x483x406 mm (HWD) [7x19x16 in.]
Weight	11 kgs (24 lbs)
Mounting	19" rack mountable, 5U
Temperature	Operating: 0° to +60°C Storage: -30° to +55°C



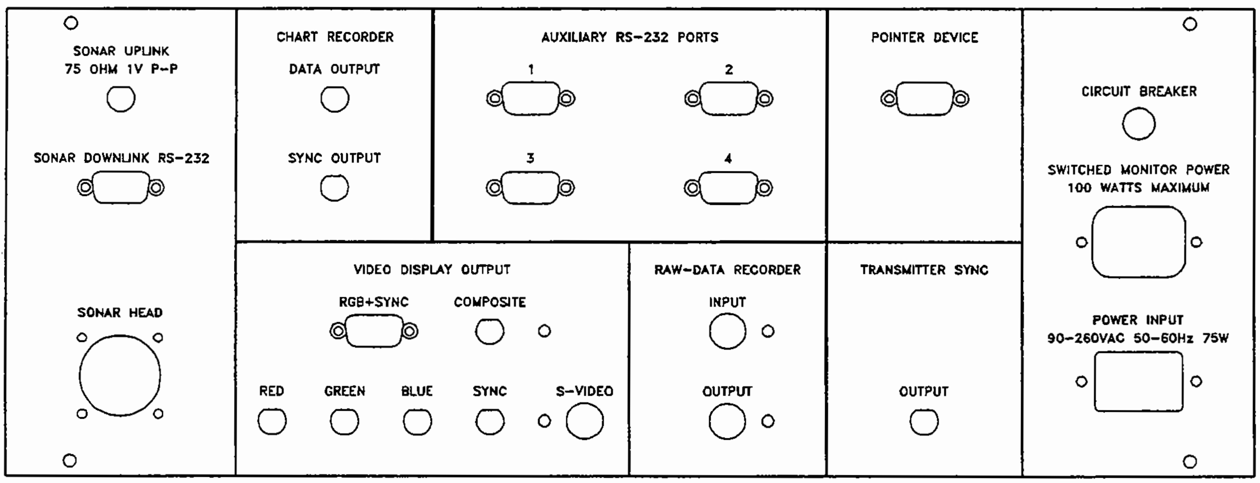


Figure 1-5. SeaBat 9003 Processor - Front/Back Panels

1.4.2 SeaBat SONAR HEAD

The SeaBat sonar head housing is made of hard anodized aluminum and consists of the main body and two lids (top and bottom). In the front section (curved end) the receive array is molded into the main body. Transmission of the sonar pulse is made via the external projector, which is mounted on top of the sonar head.

In order to protect the housing against galvanic corrosion, two sacrificial anodes are mounted on the rear beside the connector, and twelve plastic hole inserts are used to stop metal mounting bolts from coming into contact with the housing. A connector protector housing is provided to reduce the movement of the connector.

Figure 1-6 depicts the can shaped projector unit above the transducer face that transmits the beam, Table 1-2 provides technical specifications for the sonar head, while Figures 1-7 through 1-10 show the transmit and receive beam outputs.

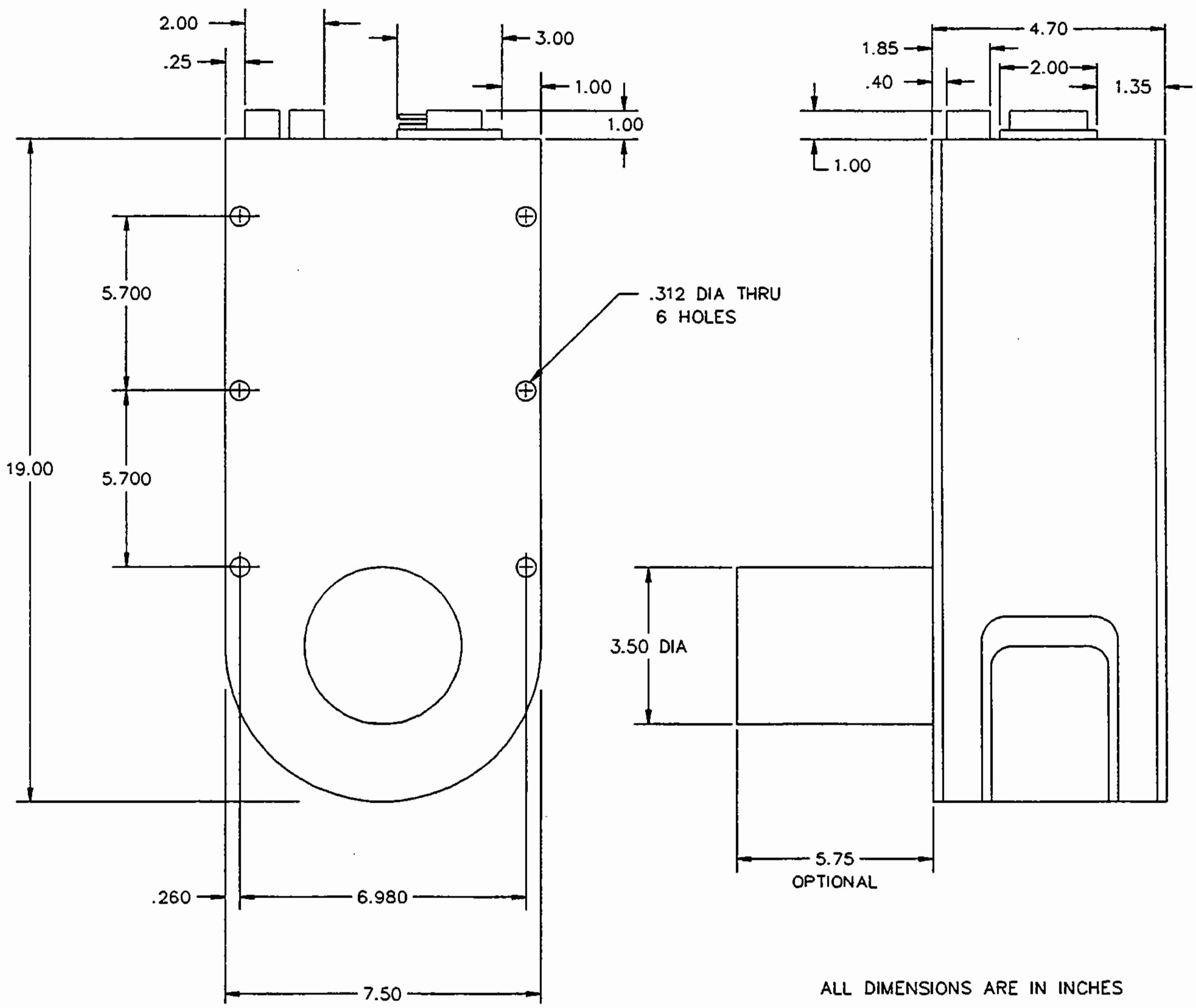


Figure 1-6. SeaBat 9003 Sonar Head

TABLE 1-2. SeaBat 9003 SONAR HEAD - TECHNICAL SPECIFICATIONS

DESCRIPTION	9003
Power Requirements	24 VDC, 2 Amps max. (Power is typically provided from the surface unit via the Standard Processor/Sonar Head cable - See Chapter 7.3.1.)
Sonar Operating Frequency	455 kHz
Range resolution	5 cm
Transmit beamwidth	Horizontal : 130° (external projector) Vertical : 1.5° (external projector)
Receive beamwidth	Horizontal : 3° (-3dB points) each beam Vertical : 15°
Number of beams	40
Update rate (Full 120° sector)	2.5, 5, 10 meter range = 15 times/sec. 25 meter range = 13 times/sec. 50 meter range = 7 times/sec. 100 meter range = 3.5 times/sec. 200 meter range = 2 times/sec.
Uplink Data	Pseudo-video (requires 1.5 MHz black/white video channel)
Downlink Control	RS-232 or RS-422, 300 baud
Operating Depth	Standard 350 and 500 meters.
Dimensions	350m - 265x190x473 mm (HWD), [10.4x7.5x18.6 in.] 500m - 305x190x473 mm (HWD), [12x7.5x18.6 in.]
Temperatures	Operating: -5° to +60°C Storage: -30° to +55°C
Sonar Head Color	350m - Black 500m - Antricite Gray
Weight	350m - Dry: 18 kg (39 lbs) Wet: 5.5 kg (12 lbs) 500m - Dry: 20 kg (44 lbs) Wet: 7 kg (15 lbs)

The SeaBat 9003 sonar head comprises a circular ceramic array. The sonar head transmits one (1) fan shaped beam from the external projector, resulting in a coverage of 130° x 1.5°. The returned signal will be received by the curved array in the front section and then be formed into forty (40) independent beams each having a beam formation of 3° x 15°. Thus, the combined transmit and receive beams yield 40 beams with a 3° x 1.5° rectangular beam pattern (see Figure 1-11, "Mills Cross" Footprint). An example of the transmit and receiving beam patterns are shown in the following figures.

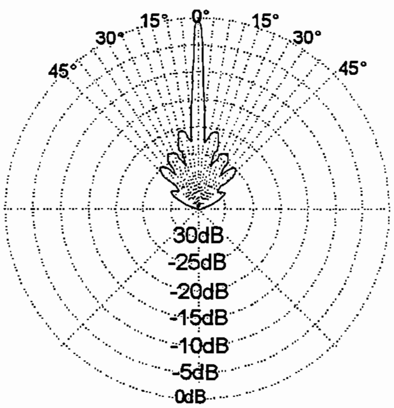


Figure 1-7. 9003 Vertical Transmit Beam

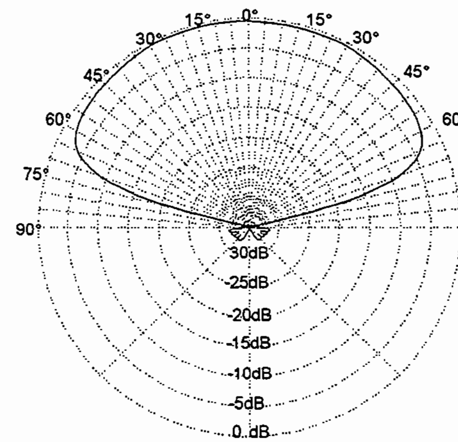


Figure 1-8. 9003 Horizontal Transmit Beam

The operator selections, entered via the pointer device and color display into the topside SeaBat processor, command the sonar head (range [update rate], transmit power, and received gain). The returned signal is initially processed within the sonar head, while further processing is completed within the topside processor prior to its presentation on the operator's color display.

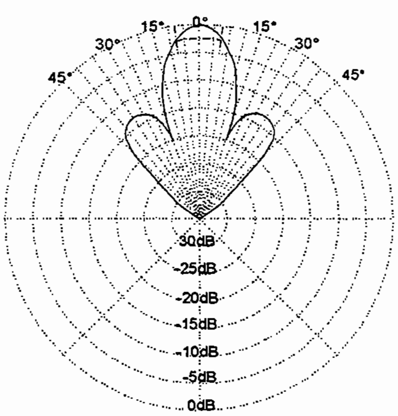


Figure 1-9. 9003 Vertical Receive Beam

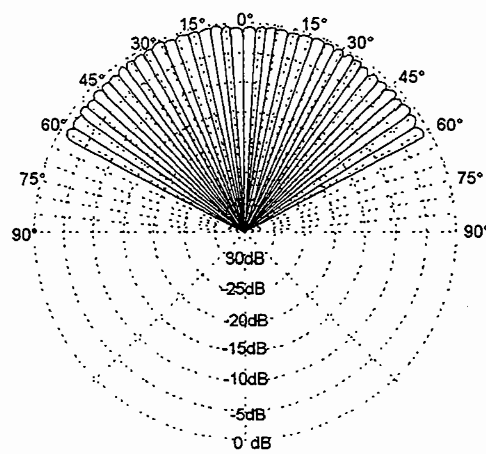


Figure 1-10. 9003 Horizontal Receive Beam

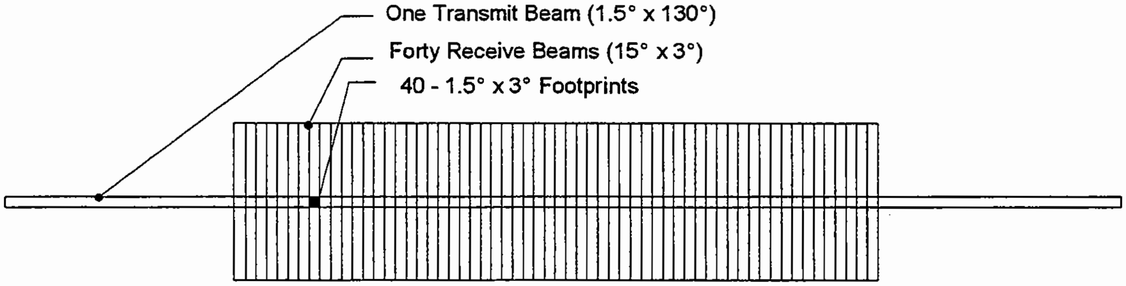


Figure 1-11. "Mills Cross" Footprint

1.4.3 POINTER DEVICES

In order to control the SeaBat, it is necessary to connect a pointer device to the SeaBat processor (front or rear). All operational selections are conducted by the use of a pointer device.

There are two (2) pointer devices recommended by RESON for use with the system, they are:

1. **Standard PC-Trac Trackball**
   This unit is provided standard with each SeaBat system.

2. **SeaBat Joystick Input Control Panel**
   This is an optional component.

The following two sub-sections describe these units. A "mouse" could also be used as a pointer device; however, considering the environmental conditions on a ship, this device may not provide such easy operation.

1.4.3.1 PC-Trac Trackball

The pointer device provided standard with all SeaBat systems is the MicroSpeed PC-Trac Trackball. The trackball provides fingertip operation and greatly enhances cursor control, making precise placement of the cursor fast and easy.

There are three current versions of the PC-Trac Trackball. Table 1-3 provides technical specifications to ensure that if a replacement is required, the correct version is purchased. These units are commonly available from most reputable computer stores.

TABLE 1-3. PC-TRAC TRACKBALL TECHNICAL SPECIFICATIONS	
Dimensions	93.75 x 168.75 x 50 mm (w/l/h) [3.75 x 6.75 x 2 in.]
Weight	0.336 kg [12 oz]
Ball Diameter	56.25 mm [2.25 in.]
Cable - Serial	6-conductor, shielded 6 ft.
Interface - Serial	RS-232C DTE (9-pin female connector)
Power Input - Serial	RS-232C signals RTS, DTR, and TxD RTS, DTR: +6V to +15V @ 2.5mA or -8v to -15V @ 2.5mA TxD: -6V to -15V @ 2.5mA
Cable Conductors	TxD=3, RxD=2, RTS=7, CTS=8, DSR=6, DTR=4, GND=5, Shield=None

CAUTION

The PC-Trac Trackball that the SeaBat utilizes is a **Serial Version.** Two other units that do not work are the Bus- and PS/2 Versions.

The trackball is supplied with a 9-pin RS-232C female connector that attaches to either of the SeaBat processor's "Pointer Device" ports. One port is located on the front panel in the lower-right corner, and a second port is located on the back panel in the upper right area. (Paragraph 2.4.8 provides details for System Installation.)

Using the PC-Trac Trackball is easy. Located around the trackball are three push buttons. To operate the SeaBat, the left and right push buttons are used. Depending on the cursor positioning, each button can be used to switch on a function or to increase/decrease the values within a function. The left button is used to decrease a value and the right button is used to increase the value.

Roll the ball with your fingers. The cursor or pointer on the screen moves in the direction that you roll the ball. To "click," press and release the left or right button.

1.4.3.2 SeaBat Joystick Input Control Panel

Since the SeaBat Joystick Input Control Panel is provided as an option, Paragraph 4.2 is dedicated to detailing this component. The following paragraphs provide basic information regarding the joystick and its operation.

The SeaBat Joystick Input Control Panel enables the operator to change selected displayed settings on the monitor screen, and allows measurements to be taken of objects of interest without moving the cursor. An important feature of the configuration of the Joystick is the placement of the buttons on the panel. Buttons have been arranged to optimize operator performance and allow changes to be made to the display without looking away from the screen. Figure 1-12 provides a diagram of the standard SeaBat Joystick Input Control Panel (P/N TL8039).

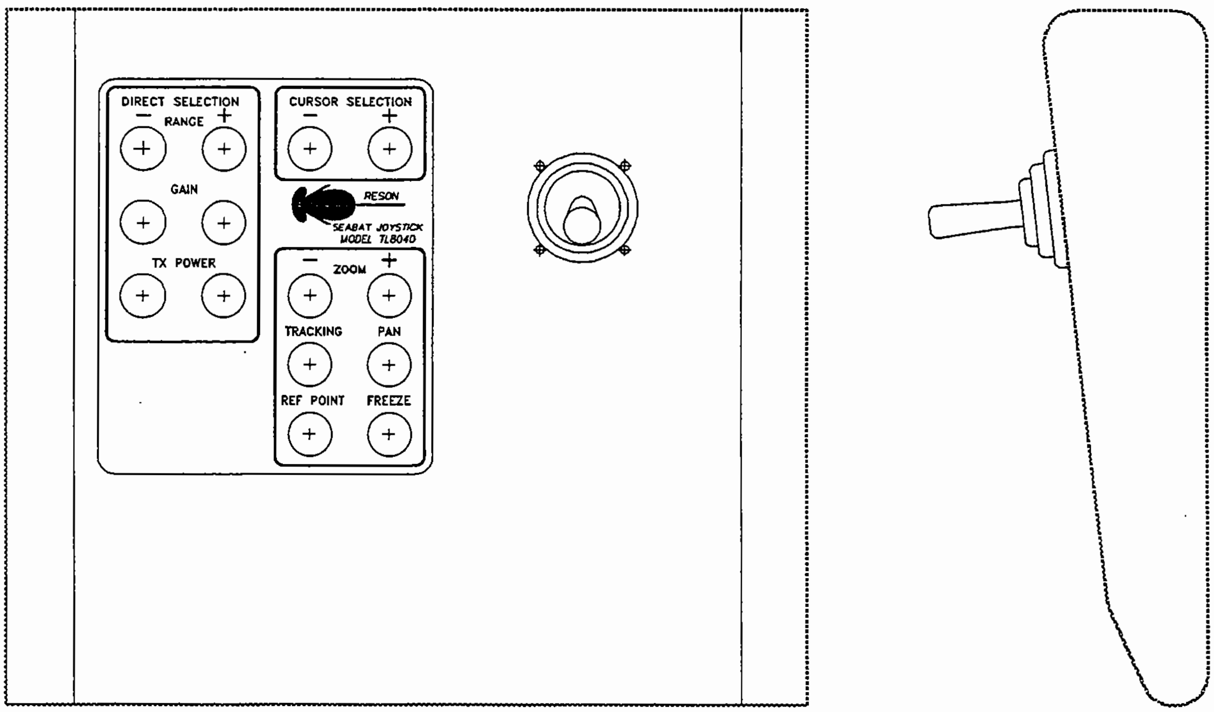


Figure 1-12. Model TL8039 Joystick Control Panel

1.4.4 COLOR DISPLAYS

The use of a display is essential to the operation of any SeaBat system. The SeaBat processor can be interfaced to any number of display units, possibly one that the user may already own.

However, for the majority of deliveries, RESON does provide a color display. The monitor provided and recommended for use with the SeaBat system is either a SONY PVM or Panasonic Color Video Display. Table 1-4 provides technical comparisons between the SONY PVM models and the Panasonic model.

DESCRIPTION	PVM - 13440	PVM - 13420	PVM - 1341	PVM - 1340	PVM - 13540	PVM - 14440M	PVM - 14420M	PVM - 14400M	BT-H1450Y
	SONY								PA
110 VAC Power Supply	✓	✓	✓	✓					
120 VAC Power Supply					✓				
220 VAC Power Supply						✓	✓	✓	✓
Display Formats:									
PAL	✓	✓	✓	✓	✓	✓	✓	✓	✓
SECAM	✓	✓	✓	✓	✓	✓	✓	✓	✓
NTSC 3.58	✓	✓	✓	✓	✓	✓	✓	✓	✓
NTSC 4.43	✓	✓	✓	✓	✓	✓	✓	✓	✓
Input Formats:									
Video In: BNC connector	✓	✓	✓	✓	✓	✓	✓	✓	✓
Audio In: RCA Phono jack	✓	✓	✓	✓	✓	✓	✓	✓	✓
VTR: 8-pin connector	✓	✓	✓	✓		✓	✓	✓	✓
Y/C-Input Video: 4-pin connector	✓	✓	✓	✓	✓	✓	✓	✓	✓
Y/C-Input Audio: phono jack	✓	✓	✓	✓		✓	✓	✓	✓
EXT Sync: BNC connector	✓	✓	✓		✓	✓	✓		✓
Analog RGB/Component:BNC connector	✓	✓			✓	✓			✓
Analog RGB: BNC connector			✓		✓		✓		✓
Analog RGB signal through AV: 0.7 Vp-p ±6 dB, 75 ohms terminated					✓	✓			✓
Digital RGB: 9-pin connector		✓	✓				✓		
RGB Sync Input					✓				✓
CTRL S: Minijack	✓	✓	✓			✓	✓		
Output Formats:									
Video Out: BNC connector	✓	✓	✓	✓	✓	✓	✓	✓	✓
Audio Out: RCA Phono jack	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ext Sync: BNC connector	✓	✓	✓		✓	✓	✓		✓
Y/C-Output Video: 4-pin connector					✓				✓
Analog RGB: BNC connector	✓	✓	✓		✓	✓	✓		
CTRL S: Minijack	✓	✓	✓			✓	✓		

TABLE 1-4. COLOR DISPLAY COMPARISON

1.4.4.1 SONY PVM Color Video Display

The choice of a color display is dependant on the power available at your installation. RESON recommends the PVM-1354Q (120 VAC) or the PVM-1440QM (220-240 VAC).

Table 1-5 provides the general specifications of the SONY PVM display monitor product line. Both the 110v and 220v models have these specifications. Refer to the original SONY Video Display manual delivered with the SeaBat system for a more detailed descriptions of this display unit.

TABLE 1-5. SONY PVM COLOR VIDEO DISPLAY GENERAL SPECIFICATIONS	
Dimensions	346 x 340 x 412 mm (w/h/d) [13.625 x 13.5 x 16.25 in.]
Weight	Approx. 16.5 kg [36 lb 5 oz]
Storage temperature range	-10°C to 60°C [32°F to 104°]
Operating Temperature range	0°C to 35°C (32°F to 95°F)
Humidity	0-90%

1.4.4.2 Panasonic Color Video Display

Some customers have selected the Panasonic BT-H1450Y color video monitor. This video monitor is only suitable for installations that require 220-240 VAC.

Table 1-6 provides the technical specifications for this model. Refer to the original Panasonic BT-H1450Y Video Display manual delivered with the SeaBat system for more detailed descriptions of this display unit.

TABLE 1-6. PANASONIC BT-H1450Y COLOR VIDEO DISPLAY GENERAL SPECIFICATIONS	
Dimensions	356 x 341 x 419 mm (w/h/d) [14 x 13½ x 16½ in.]
Weight	Approx. 14.5 kg [31 lb 14½oz]
Storage temperature range	-10°C to 60°C [32°F to 104°]
Operating Temperature range	0°C to +60°C [32°F to 104°F]
Humidity	20%-80%

1.4.5 VIDEO RECORDER

Any standard VHS or S-VHS video recorder can be utilized to store the real-time SeaBat display image of sonar information. The SeaBat processor's rear panel provides four (4) standard interfaces that all output video data simultaneously and can be utilized to record the image (S-VHS; R, G, B, Sync; RGB+Sync; and Composite).

RESON recommends the use of an S-VHS video recorder (using the S-Video connection). This video format will provide a high-integrity sonar image. Two (2) models that RESON has used extensively are the Mitsubishi HS-U61 and the Mitsubishi HS-U62. Both models are S-VHS compatible.

NOTE

Video images recorded in the S-VHS format **CANNOT** be played back on a standard Video Recorder unless it has S-VHS capability.

1.4.6 EXTERNAL COMPUTER

An external computer or data logger is only required if the sounding data being displayed by the SeaBat is required for either real-time corrections or later processing and presentation. This data is available via the 9-pin RS-232 Aux #2 connection on the rear panel of the SeaBat processor.

RESON has designed and developed the SeaBat 6042 Multibeam Data Acquisition and Presentation System. It can accept data from two SeaBat systems, an external navigation and positioning system, a motion reference unit (MRU) and heading sensor.

The SeaBat 6042 records, adjusts, and displays in real-time all these data for critical real-time decisions while conducting field operations. Contact your nearest RESON representative for information on the SeaBat 6042 Control and Display System Software. See Chapter 10 for a more detailed description of the SeaBat 6042.

1.4.7 CHART RECORDER

A chart recorder is only required if your SeaBat 9003 system has been upgraded with Opt. 019, which enables two side scan beams built into the sonar head to record the seafloor image. The recorder device in this instance should be connected to the two (2) BNC connectors on the rear of the processor (marked "Chart Recorder") to display the output sonar image. See Paragraph 4.19 for a detailed description of this option, the interface requirements, and operation.

1.5 BASIC SeaBat 9003 OPERATION

All SeaBat sonar echo processing takes place within the sonar head. The following provides a basic outline of the system in operation. Please refer to Figure 1-13 for a visual depiction of the process.

1.5.1 TRANSMITTER

The sonar head transmits one (1) fan shaped beam from the external projector. The transmitter provides eight (8) power levels controllable in 3 dB steps. The power level commands are provided by the TLM board via the monitor and dry-end processor. The signal is sent to the seafloor where it is reflected back to the sonar receivers.

1.5.2 RECEIVERS

The receivers contain 29 identical circuit boards. Each board has four (4) identical receiver channels. The outputs of the 114 receiver channels are routed to the beamformers.

1.5.3 BEAMFORMERS

The beamformers consist of ten (10) identical circuit boards. Each board has six (6) identical channels. The function of a beamformer is to form a 3.0° sonar beam with a minimum of sidelobes from the 55 inputs supplied by the receiver channels. The actual beamforming is provided by a delay line which compensates for the curvature of the array. The outputs of the 40 beamformer channels are routed to the detector.

1.5.4 DETECTOR

The detector houses two (2) identical circuit boards. Each board has 20 identical channels. The outputs of the forty (40) detector channels are routed to the multiplexer board.

1.5.5 MULITPLEXER

The multiplexer board formats the 40 channels of sonar data, reference levels, uplink telemetry, and line synchronization into a "pseudo video" signal. The multiplexer receives timing commands from the time and telemetry board. The output of the multiplexer board drives the uplink cable.

1.5.6 TIME AND TELEMETRY

The time and telemetry board (TLM) is controlled by a digital signal processor (DSP) chip that manages all uplink and downlink communications. A non-volatile memory stores the program. The time variable gain (TVG) curves are stored in the memory as well; therefore curve selection is executed by the DSP as the gain setting is changed.

All sonar and analog data is synchronized by internal circuitry, then encoded by the DSP to "pseudo-video" signals that are sent via uplink to the dry-end processor. Once the uplink data is received, custom circuitry inside the controller is required to decode the telemetry.

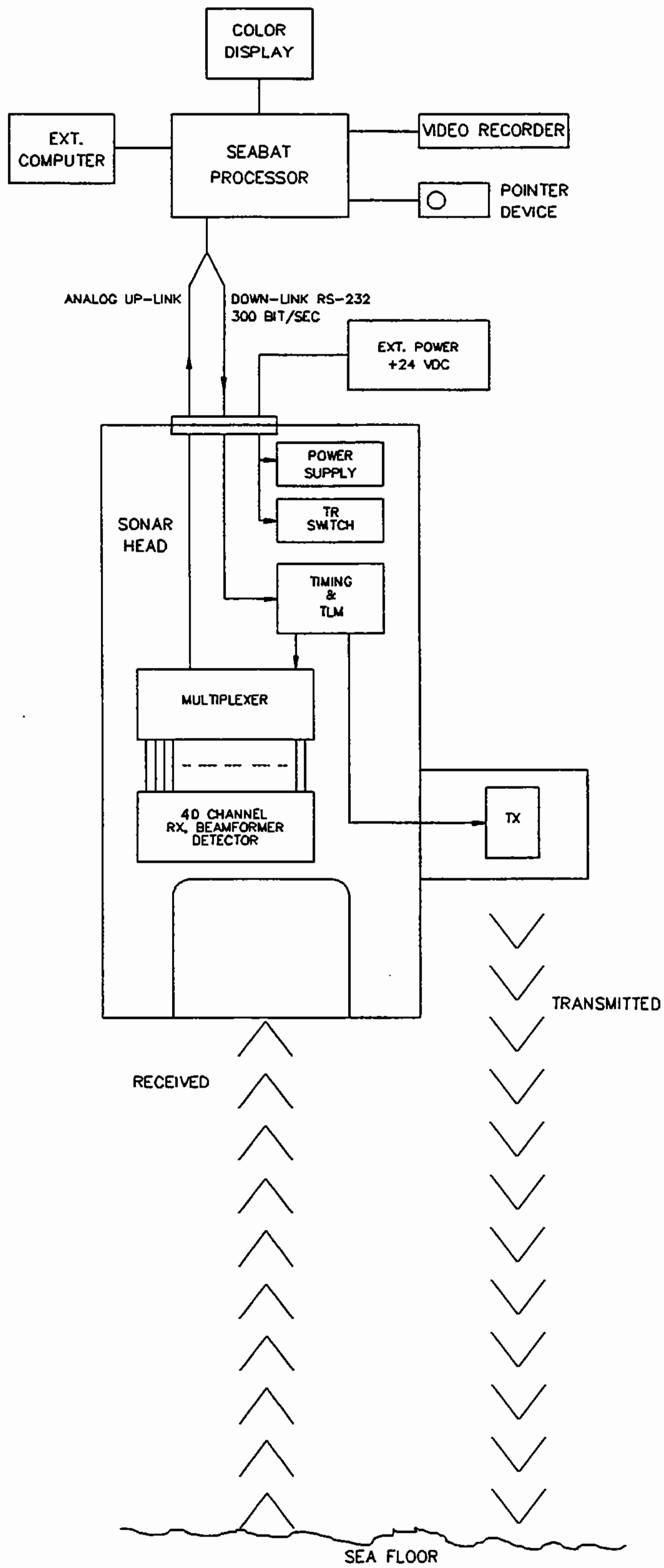


Figure 1-13. SeaBat 9003, System Block Diagram

WARNING
Certain combinations of commands can have disastrous results if used incorrectly. The "^W" and "@" commands should be avoided as they can disrupt sonar and halt operation.

1.5.7 POWER SUPPLY

The power supply board provides +24 VDC, ±12 VDC, ±5.0 VDC, +4.000 VDC and +1.250 VDC to the various circuit boards. A wide range input (18 to 72 volts) DC-DC converter supplies the ±12 volts. The other voltages are generated from the ±12 volt rails using linear regulators. The 24 volts that feed the ±12 volt DC-DC converter and the transmitter is routed through the power supply board where an inline fuse and a 32 volt transient suppressor are located to protect the sonar from power supply voltage transients.

1.5.8 TRANSMIT/RECEIVE (T/R) SWITCH

The T/R switch is located on the receiver mother board and is electronically controlled. The T/R switch is designed so that if the T/R switch pulse from the TLM board fails, the T/R switch will stay in the transmit mode to prevent damage to the transmitter.

1.6 OPTIONS, UPGRADES AND ACCESSORIES

In addition to the basic SeaBat system, there are various options and upgrades available. Chapter 4 provides complete descriptions of these options, while Chapter 10 provides related SeaBat Products available.

The standard options, upgrades and accessories available and applicable to the SeaBat 9003 are:

Opt. 001 - Color Display System (USA - 110V)
Opt. 002 - Joystick Input Control Panel
Opt. 007 - SeaBat Cable Compensation System
Opt. 012 - Combine BNC Sync and Green outputs
Opt. 013 - SeaBat "Class B" Repair Kit
Opt. 019 - Side Scan Sonar Upgrade

1.7 WARRANTY INFORMATION

Your SeaBat warranty gives you specific legal rights. You may also have other rights which vary from country to country.

One-Year Limited Warranty

RESON warrants the SeaBat system against defects in materials and workmanship for a period of one year from the shipment from RESON to the end user. During the warranty period, RESON will, at its option, either repair or replace components which prove to be defective.

The warranty period begins on the date of delivery. Your SeaBat system must be serviced by the RESON office which sold the system (see Chapter 5.6 - Service). The customer shall prepay shipping charges (and shall pay all duty and taxes) for products returned for service. RESON shall pay for the return of the products to the customer, not including duty and taxes.

Exclusions

The warranty on your SeaBat System shall not apply to defects resulting from:

- Improper or inadequate maintenance by customer.
- Unauthorized modification or misuse.
- Opening of the sonar head by anyone other than an authorized RESON representative.
- Operation outside of the environmental specifications for the product.
- Improper site preparation and maintenance.
- Service provided by any but Authorized Service Facilities (see paragraph 5.6).

NOTE

If you are using a mechanical switch box, ensure that it is equipped with a surge protector. Damage to components of the SeaBat system could occur from use of unprotected mechanical switch boxes.

Warranty Limitations

The warranty set forth above is exclusive and no other warranty, whether written or oral, is expressed or implied. RESON specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Servicing During Warranty Period

If your system should fail during the warranty period refer to paragraph 5.6 - Service for the detailed procedures that are required for an authorized repair of your system.

CHAPTER 2 - INSTALLATION

2.1 GENERAL

This chapter describes the SeaBat hardware installation procedures. If you are installing the SeaBat system for the first time, read this chapter in its entirety. Refer to Figure 2-1 for the basic component layout. Sections included in this chapter are:

- Handling Equipment Safely
- Component Checklist
- Installation of the SeaBat

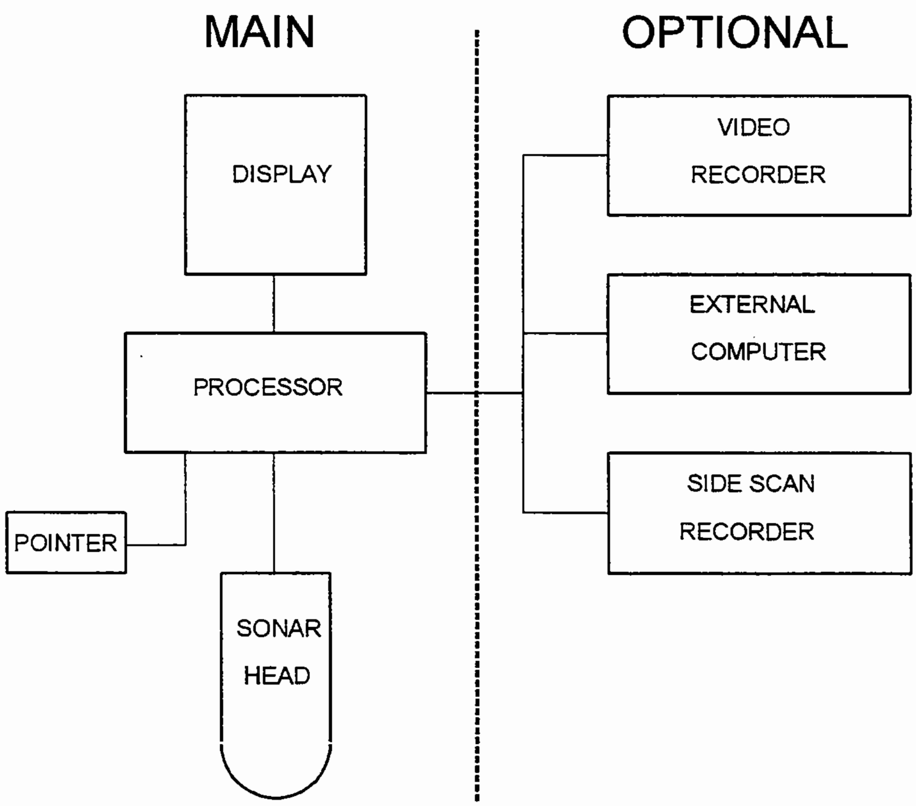


Figure 2-1. Basic SeaBat 9003 System Layout

2.2 HANDLING EQUIPMENT SAFELY

Each SeaBat component, while in its own shipping or flight case (Tables 2-1 and 2-2), is resilient and sturdy enough for shipboard installation and requires only normal care and handling to prevent breakage. Both cases provide:

- Handles which allow two people to carry each piece of equipment easily.
- Tie-down rings for securing the cases directly to fixed stationary objects on your ship, such as decks and counters.

To ensure safe handling of the equipment:

- Inspect each transit case for physical damage prior to opening.
- Inspect each component for physical damage before installation. Check for obvious damage and abuse to the housing, including splits, dents, cracks, broken controls, scratches, lodged foreign objects, damaged interface connectors, excess moisture, and burn marks.
- Use adequate packaging and shock-absorbing materials to ship or store any equipment or accessories that are stored outside of the supplied transit cases.
- Do not drop the equipment.
- Do not place liquids on or near the equipment where the liquid might spill into the pointer device or electronic components.
- Do not smoke or spill ashes on or near the pointer device.
- Ensure that the equipment is properly secured before putting out to sea.

2.3 COMPONENT CHECKLIST

Before you begin the SeaBat installation, perform an inventory check to verify you have all of the required SeaBat components, as referenced with the included packing/shipping list and provided in Table 2-1 or 2-2. The only tool required is a small flat-headed screwdriver to fasten the 9-pin "D" connectors.

The SeaBat system can be shipped in two different types of shipping cases:

- **Shipping Boxes** . . . A set of two large white elephant boxes. Ideal for storage and international shipments.
- **Flight Cases** A set of three transit cases, specially designed for transportation on helicopters and small aircraft.

TABLE 2-1. SHIPPING BOXES

Box No.	Name	Part No.	Contents	Wt/Size (HWD)
1	Sonar Head Case and Cables	TL8035*	1x SeaBat Sonar Head 1x 25 meter Processor unit to sonar head test cable 1x 3 meter Sonar head pigtail cable 1x Pointer device	48 kg (105 lbs) 533 x 787 x 711 mm (21 x 31 x 28 in.)
2	Processor and Monitor	TL8035*	1x SeaBat Processor unit w/power cable 1x Color Display w/power cable [Optional] 1x Processor unit to color display interface cable(s) 1x SeaBat Operators Manual	30 kg (65 lbs) 533 x 787 x 711 mm (21 x 31 x 28 in.)

TABLE 2-2. FLIGHT CASES

Case No.	Name	Part No.	Contents	Wt/Size (HWD)
1	Sonar Head Case	TL8052	1x SeaBat Sonar Head	30 kg (67 lbs) 368 x 318 x 622 mm (14.5 x 12.5 x 24.5 in.)
2	Control Case	TL8053	1x SeaBat Processor unit w/power cable 1x 25 m Processor unit to sonar head test cable 1x Pointer device 1x 3 m Sonar head pigtail cable 1x SeaBat Operators Manual	34 kg (75 lbs) 559 x 750 x 610 mm (22 x 29.5 x 24 in.)
3	Display Case [Optional]	TL8054	1x Color Display w/power cable 1x Processor unit to color display interface cable(s)	30 kg (66 lbs) 496 x 648 x 559 mm (19.5 x 25.5 x 22 in.)

NOTE

There is no standard shipping box or flight case for the optional video recorder or external computer. While the boxes in Table 2-1 have the same part number, the internal partitions are re-configured.

WARNING

Never make assumptions about power on vessels of opportunity. Always check the main voltage with a voltmeter before connecting the equipment. Do not power up the equipment until all interconnections are completed.

2.4 SYSTEM INSTALLATION

This section provides detailed procedures for installing the SeaBat components and device interconnect cables. The SeaBat software is pre-installed in EPROMS housed within both the SeaBat processor and the SeaBat sonar head.

The SeaBat Sonar head housing is made of hard anodized aluminum. This is suitable for normal vessel and ROV installation, but not for long term stationary deployment.

NOTE

The SeaBat Sonar head is currently manufactured to two (2) depth pressure ratings. The 350 meter rated unit has a lid (top and bottom) thickness of 6.5 mm ($^3/_8$"), while the 500 meter rated unit has a lid thickness of 23.7 mm (1").

The following sections describe in detail how to install the SeaBat hardware components.

- Placement of equipment
- Removing transit case covers
- Cable Connections
- Securing Sonar Head to Mounting Plate
- Connecting the Processor to Sonar Head
- Connecting the Processor to Color Display
- Connecting the Processor to Pointer device
- Connecting the Processor to Video Recorder
- Connecting the Processor to external CPU
- Securing the equipment
- Connecting to power
- System check out

2.4.1 PLACEMENT OF EQUIPMENT

The SeaBat System has four (4) main components and three (3) optional recording devices (see paragraphs 1.4.5 and 1.6) that require proper placement:

Main Components:

- SeaBat Processor
- Color Monitor Display
- Pointer device
- SeaBat Sonar Head

Data Recording (Optional) Devices:

- Video recorder
- External Computer/Data Logger
- Side Scan Recorder

The primary considerations for placing the SeaBat components (main and optional) are as follows:

- Place each unit within cable distance of each device. **DO NOT** bend or stretch the connecting cables.

NOTE

To protect the equipment, RESON recommends that it be moved into position before the cases are opened.

- Place the color display on a surface that allows a comfortably seated operator to view the screen at a 10-60° downward angle. Allow adequate air circulation to prevent internal heat build-up. Do not place the display unit on surfaces (rugs, blankets, etc.) or near material (curtains, draperies) that may block the ventilation holes.
- Place the SeaBat processor unit near the color display, either in a 19" rack mount or on the counter top.
- Place the video recorder on a flat, dry surface, ensuring that the entry port for the video cassette is easily accessible and away from dust particles.
- Do not install any component in a location near heat sources such as radiators or air ducts, or in a place subject to direct sunlight, excessive dust, mechanical vibration or shock.
- Do not place videotapes on the top of the display unit. They could be erased by the degaussing coil within the display unit.

Chapter 3, System Operation, provides correct orientation/placement of the Sonar Head for various applications.

2.4.2 REMOVING FLIGHT CASE COVERS

The Color Display Flight Case has a top that lifts off, allowing the display to sit in the box. The bottom of the case can serve as a base for the equipment during operation, or can be removed to accommodate limited space.

The SeaBat processor, once removed from its transit cases, should be securely fastened to a counter top or in a 19" rack mountedrame.

2.4.3 CABLE CONNECTIONS

Lay the cables between the components shown in Figure 2-1. All cables are labeled at each end. The labels indicate where the connection is to be made. Refer to Chapter 7 for a detailed description of the various connection choices and the connectors required. Table 2-3 provides a list of the maximum cable lengths.

CAUTION

Do not bend the cables around tight corners. Do not stretch the cables. Do not use patch cords to extend the cables.

TABLE 2-3. MAXIMUM CABLE LENGTHS

From	To	Cable Type	Length	Radius
Sonar Head	Processor	Standard Cable	200 m	90 mm
		RG-59/U	200 m	50 mm
		RG-108/U		50 mm
		RG-11/U	500 m	90 mm
Processor	Display	4x BNC	5 m	*
		S-Video	2 m	*
Processor	Trackball		2 m	*
Processor	Joystick	6 Conductor w/shield (see Ch. 4 Opt. 002)	5 m	*
Processor	Video Recorder	S-Video	2 m	*
Processor	External Computer (900X Series Aux2)	Standard RS-232 Null Modem Cable	5 m	*
Processor	Mains Power Supply	110V or 220 V	5 m	*

* Radius is normally 24 x diameter of Cable

NOTE

Re-position the components as required if the cables are too short.

2.4.4 SECURING SONAR HEAD TO MOUNTING PLATE

Similar installation concerns arise for each SeaBat sonar head, although the orientation and mounting assemblies may vary.

WARNING

Each sonar head has two sacrificial anodes connected to the rear of the head. These anodes are connected to ensure that the head does not become corroded. To reduce corrosion of these anodes, do not mount the SeaBat sonar head in direct contact with other metals.

- Position the sonar head so that the transducer face (curved end) is clear of any object which may affect the performance.
- The sides of the sonar head are marked with arrows indicating the forward direction.
- Through each side of the sonar head housing are SIX (6) pre-drilled holes, three along each side. These holes are used to secure the sonar head to a customer-supplied, pre-drilled mounting plate that is itself attached firmly to either a mounting pole or assembly system.
- Provided with the SeaBat sonar head are twelve (12) plastic mounting hole insulators. These are placed at either end of each of the six mounting holes to ensure that the inserted bolt does not make contact with the anodized aluminum. The head should not be allowed to contact any metallic surfaces (i.e., vehicle frame and fasteners).
- Ensure that the two sacrificial anodes are in an undamaged condition.
- Ensure that electrical cables are away from the sonar transducer face to avoid noise interference (bright lines and spots) of the system.

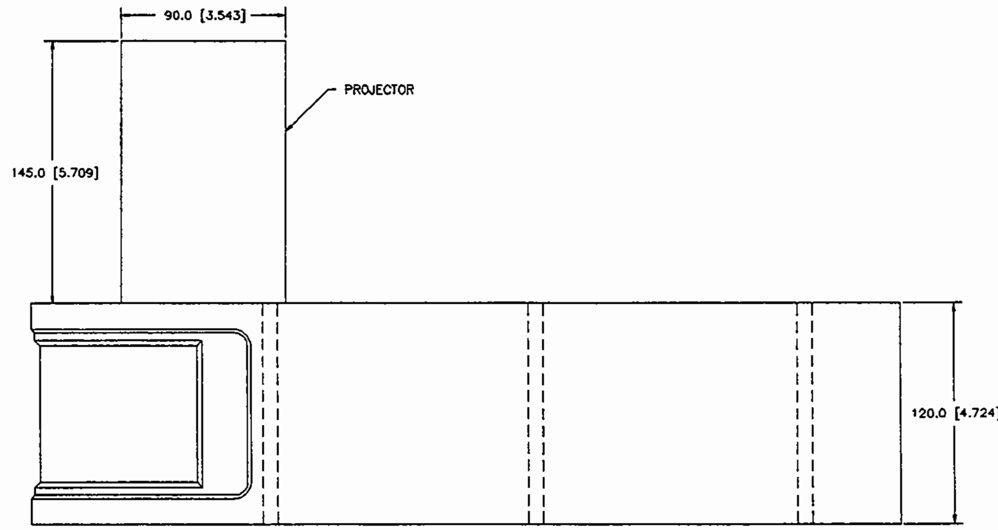
WARNING

The Sonar Head should be protected from excessive falling stones and sand (e.g., rock dumping operations) to protect the anodized finish. Do not block the transducer face with the protection device.

CAUTION

The SeaBat 9003 sonar head has a circular projector attached to the top of the unit that intersects the straight path between the two holes at the front of the head. Allow for this when fabricating a mounting plate that attaches to the top side of the head.

When drilling the holes in the SeaBat mounting plate, refer to Figure 2-2 for the exact position and dimensions of the corresponding holes in the Sonar Head housing.



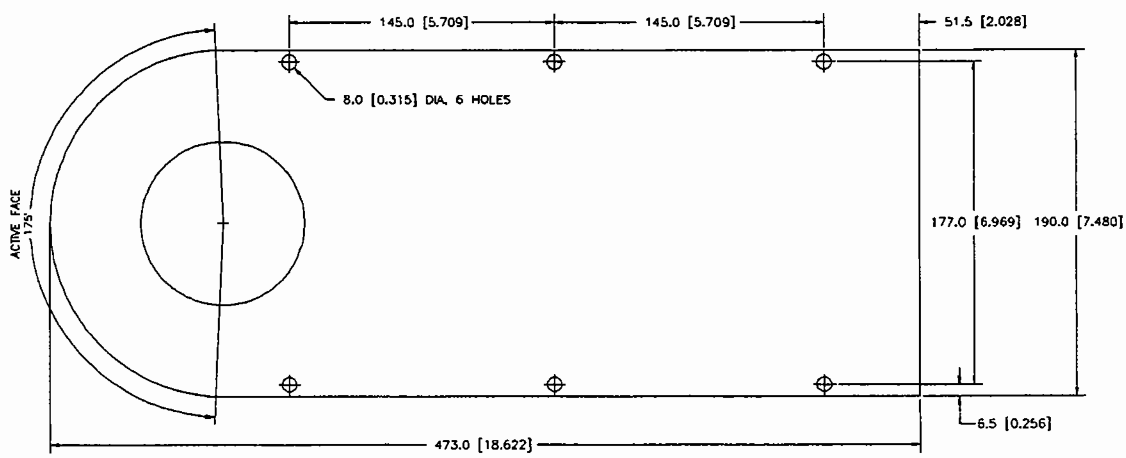


Figure 2-2. SeaBat 9003- Sonar Head Mounting Configuration

2.4.5 MOUNTING DESIGN

Although not supplied as standard equipment, RESON has on numerous occasions provided assistance in the design of mounting assemblies for the SeaBat system. As each vessel is different and mounting requirement differ, it is suggested that RESON be contacted prior to the manufacture of any mount.

2.4.6 CONNECTING SURFACE PROCESSOR TO SONAR HEAD

The 25 meter Processor to Sonar Head Test Cable that is provided with all SeaBat systems serves three purposes:

- Transfers the necessary power from the processor to the sonar head (24 Volts DC, peak current 2 Amps).
- Downlinks the operator commands from the processor to the sonar head.
- Uplinks all the sonar data from the sonar head to the processor.

There are two main methods by which the processor can be connected to the sonar head:

- Directly, by one (1) cable connected from the "Sonar Head" connection on the rear of the processor to the sonar head.
- Custom link, where an existing cable (i.e., ROV umbilical) is used to transmit the Uplink and Downlink commands, while the power is supplied directly from the ROV to the Sonar Head.

Chapter 7 provides detailed specifications of the various cable configurations together with the connectors required and their wiring configurations.

It is necessary, with both connection methods, to ensure that the cable is never pulled, is connected securely to the processor receptacle, is free from any tight corners, and is not exposed to any harsh conditions.

WARNING

Never make assumptions about power on vessels of opportunity. Always check mains voltage with a meter before connecting the equipment. Do not power up equipment until all interconnections are completed.

2.4.7 CONNECTING SURFACE PROCESSOR TO COLOR DISPLAY

There are five (5) methods by which the processor can be connected to an external display, each selected by the type of display utilized and the system configuration. The following are detailed more fully in Chapter 7.

- To provide the best picture quality, use RGB and Sync cables (requires 4x BNC-BNC 75 ohm cables).
- Use the RGB+Sync 9-pin "D" to connect to a multi-sync display that has analog inputs.
- Connect a cable from the "S-Video" connector to a "Y/C-Input" connector on a display monitor. (Note: This connection is usually used to connect the S-VHS video recorder).
- Connect a BNC cable to the "Composite" connector port.
- Connect an AV (EURO-TV) [SCART] connector and an S-Video connector. See chapter 7.4.1 for more information on this connection.

2.4.8 CONNECTING SURFACE UNIT TO POINTER DEVICE

To operate the system, a pointer device must be connected to the SeaBat processor. There are two available connections. Each is a male RS-232 connector labeled "Pointer Device". There is one at the front right of the SeaBat processor and one at the rear. Ensure that only one pointer device is connected at a time.

2.4.9 CONNECTING SURFACE PROCESSOR TO VIDEO RECORDER

A standard video recorder can be used. However, RESON recommends using a video recorder that can record in the S-Video format (an S-VHS VCR), as this will ensure an improved color picture reproduction.

The format of the video output on all connections is either PAL or NTSC. The format currently being utilized is displayed on the screen. Ensure that the output selected matches the requirements of your video recorder. Refer to paragraph 3.4.3b for the procedures to change from the NTSC to PAL format and vice-versa.

For the S-VHS video recorder, connect to the S-Video connector on the rear of the processor.

2.4.10 CONNECTING SURFACE PROCESSOR TO EXTERNAL COMPUTER

Located at the rear of the SeaBat processor are four (4) RS-232, 9-pin "D" connections within an area labelled "Auxiliary RS-232 Ports". The purpose of these four connections are:

Aux #1	Transfer commands into the processor
Aux #2	Transfer profile data out of the processor
Aux #3	Not yet assigned
Aux #4	Not yet assigned

If the input of commands (Aux #1) and/or output is required (Aux #2), then connect the recommended cable to either the Aux Port #1 or Aux port #2 labeled connector on the rear of the SeaBat Processor. Insert the 9-pin RS-232C "D" connector into the required socket. Be sure that the connector is right side up, it only fits one way because of the "D" shape. Once inserted, tighten the two retaining screws using a flat-head screwdriver.

Paragraph 7.6 details the exact protocol and wiring configuration to utilize both the input and output features of the SeaBat processor. Refer to that paragraph to select which feature is required and the recommended method of connection.

WARNING

Never make assumptions about power on vessels of opportunity. Always check mains voltage with a meter before connecting the equipment. Do not power up equipment until all interconnections are completed.

WARNING

Ensure that all equipment power switches are in the OFF position before connecting equipment to the main power supply.

2.4.11 CONNECTING SURFACE PROCESSOR TO SIDE SCAN RECORDER

If your SeaBat System has Option 019 (Side Scan Sonar Upgrade) installed, then the two BNC connectors labelled 'Chart Recorder' on the rear of the SeaBat Processor will be activated. See Paragraph 4-19 for a detailed description of this option.

2.4.12 SECURING THE EQUIPMENT

Ensure that all components of the SeaBat system are securely fastened either in a 19" rack mount or to counter tops prior to the vessel leaving port or commencing operations.

2.4.13 CONNECTING TO POWER

Connect the SeaBat Processor unit and the color display directly to the main power supply. If preferred, the color display can be connected to the rear of the SeaBat processor. The SeaBat processor can operate automatically between 110 VAC, 60 Hz or 240 VAC, 50 Hz.

CAUTION

Unplug each unit from the wall outlet if it is not to be used for several days or more. To disconnect the AC power cord, pull it out by grasping the plug. Never pull the cord itself.

2.4.14 SYSTEM CHECK OUT

Once the SeaBat system has been installed, but prior to its deployment, RESON recommends that an initial check-out of the system's operational features is performed. To complete this, adhere to the following procedures. Should you experience difficulty, and are unable to successfully complete any procedure, then refer to Chapter 6, Troubleshooting.

1. Ensure all cable connections are complete (as a minimum; sonar head to processor, processor to display, trackball to processor, plus power cables).

2. Turn on the power first to the color display and then the SeaBat processor. If other devices are configured, then turn these on.

3. Ensure that the display selections (RGB, S-Video, etc.) reflect the cable connections to the SeaBat processor (on the rear of the display monitor).

4. Within five [5] seconds of power up, the display will show the SeaBat version numbers and dates for a period of five [5] seconds (Figure 2-3). Ensure that this manual covers the processor and sonar head firmware version number displayed.

SEABAT 9003 Processor Firmware Ver. 2.16, 7-FEB-96

Sonar Head Firmware 12-MAY-94

Figure 2-3. SeaBat 9003, Start-up Screen

CAUTION

Upon initial power-up, the screen will display two message lines, the first line shows the Processor Firmware version, and the second line states "Waiting for signal from Sonar Head".
If the head does not respond, then after 5 seconds, the operational screen will be displayed. This sequence indicates the system is not operational as the sonar head did not respond.
For correct operation, the "Waiting for signal from Sonar Head" message should be replaced with the sonar head firmware version date within 5 seconds and prior to the display of the operational screen.

5. The main display will now be presented as a wedged area with the apex at the top of the screen (Figure 2-4).

6. Verify the data and time settings on the display. If they need to be changed, then refer to Chapter 3 (System Operation) for a detailed description.

7. Set the Power value to 8. (To do this, roll the trackball to move the cursor over the menu field named "POWER." Press the right trackball button until the value "8" is displayed.)

8. Listen near the projector for quiet repetitive "clicks". This sound is the sonar head transmitting energy pulses. Depending on the Range Scale value displayed, the "click" could be 4 times to 30 times per second; in any case, the sound should be a rapid clicking noise.

9. Set the receiver Gain value to 10 and the Range value to 100 meters.

10. With the Power still set at "8", briskly rub the transducer face (the rubber, rounded end) with your fingers while looking at the display. You will see the energy generated as your hand moves across the transducer face.

11. Check that the output format (NTSC/PAL) is correct for the display and video output. See paragraph 3.4.3b for a description on how to change the output format.

12. Complete other checks, as necessary, for your operation.

You are ready to deploy the sonar head only when each of the above procedures has been successfully completed.

CAUTION

Unplug each unit from the wall outlet if it is not to be used for several days or more. To disconnect the AC power cord, pull it out by grasping the plug. Never pull the cord itself.

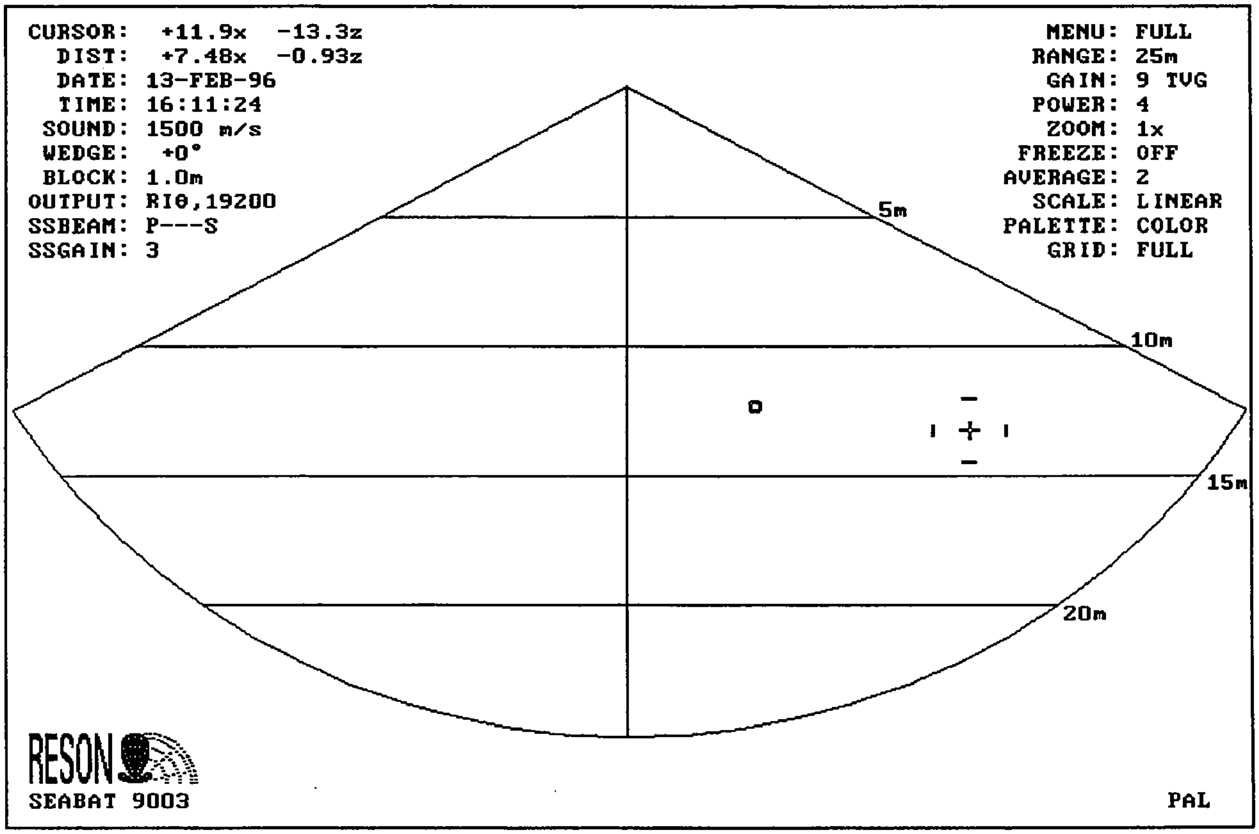


Figure 2-4. SeaBat 9003, Main Display

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CHAPTER 3 - SYSTEM OPERATION

3.1 INTRODUCTION

The SeaBat 9003 system was designed to be easily installed and operated. This we believe, has been accomplished. Prior to describing how to install and operate the system, some information on how the system operates is beneficial.

The SeaBat 9003 is but one of many sensors that operate simultaneously to measure data that are combined to produce a bathymetric map of the seafloor, or otherwise present the results in a useful format. The SeaBat 9003 is the sensor that accurately measures the "relative" profile of the seafloor from a moving platform and is typically called a Multibeam Echo Sounder (MBES). Other sensors that are typically used as the SeaBat's counterparts are:

- *Positioning system*: Used to position the vessel or platform to which the SeaBat is attached.
- *Navigation system*: This is the "heart" of an MBES System that receives all sensor data, time tags and corrects data, and provides navigation control to the vessel.
- *Motion Reference*: *(MRU)*: Measures the motion of the vessel or platform, usually in three (3) axes; Heave, Pitch and Roll. Some new sensors measure a forth axis; Yaw (heading).
- *Velocity Profiler*: Used to measure the speed of sound (SOS) at various depths through the water column.
- *Gyro Compass*: Measures the orientation of the vessel or platform.

To maintain the high accuracy data that is measured by a SeaBat 9003 system that is ultimately used to produce a bathymetric chart of the seafloor, the following data must be known and used to correct each measured profile:

a. The position of the vessel at the exact time of the SeaBat profile.

b. Knowing the vessel heading at the exact time of the profile and the relative offsets between the positioning system and the SeaBat head, the exact position of the SeaBat head is computed.

c. Knowing the Speed of Sound through the water column being measured, each of the forty time-distances (SeaBat head to the seafloor) output from the SeaBat processor are computed.

d. Knowing the motion of the vessel (MRU) at the exact time of the SeaBat profile, the SeaBat head position; each range from the SeaBat head to the seafloor, then the final X,Y,Z location of the seafloor is computed.

The following paragraphs describe these procedures and the basic operation of the SeaBat 9003 System in greater detail to assist you in conducting accurate bathymetric surveys.

3.2 OPERATIONAL CONSIDERATIONS

Prior to start-up of the SeaBat, and especially for first time users of the equipment, attention should be paid to several operational considerations that could affect the productive control of the system; therefore affecting successful results of the operation. Chapter 8 - Calibration provides detailed information on the procedures required to accurately calibrate the MBES system. The following subjects are discussed in some detail in this chapter:

- Sonar Head Positioning
- Orientation of the Sonar Head
  - 9003 on an ROV
  - 9003, pole mounted over the side
- Motion Compensation
- Time Synchronization
- Seafloor Topography
- Survey Line Spacing
- Vessel Speed
- Speed of Sound
- Sonar Path Bending
- Data Storage and Processing

3.2.1 SONAR HEAD POSITIONING

The positioning of the SeaBat sonar head is very important to maintain the high accuracy achieved by the SeaBat 9003. In this paragraph the term "positioning" covers:

- The Real-world positioning of the SeaBat sonar head to some reference datum, and
- The Relative positioning of the SeaBat sonar head on a vessel.

Real-World Positioning:

To know where the SeaBat sonar head is, at each exact moment that a profile is recorded, a positioning and navigation system is required. Several manufacturers offer various positioning and navigation systems. It is not our intent to recommend any particular system over another, but depending on your operational accuracy requirements, consideration should be given to the degree of accuracy that the positioning system measures the vessel position, from which ALL subsequent measurements are based. The accuracy of different positioning systems varies from centimeters to many meters.

To maintain the survey requirements, the position of the vessel, it's orientation (heading) and the X, Y and Z offset distances from the positioning system to the SeaBat sonar head must be accurately known.

The time synchronization between the various sensors is a measurement that many operators overlook. Paragraph 3.2.4 describes this measurement, but it is mentioned here because it is a measurement that affects the positional accuracy of the SeaBat's measured profile.

Utilizing the above information, the real-world position of the SeaBat can be computed. The final accuracy of the Sonar head is directly dependant on the combined accuracies of the equipment utilized. With the position of the SeaBat sonar head known at each moment in time, the relative profile measured can be adjusted for the vessel motion (using an MRU) if required, to compute the Real-World positions of each data point within each profile.

Relative Positioning:

The relative positioning of the sonar head addresses the physical location that is selected to securely mount and orient the head (Chapter 3.2.2). Select a suitable location on the vessel or platform :

- Securely attach the head to the vessel, ensuring a stationary position, even while the vessel is in motion. Any movement of the sonar head will result in errors in the data being measured, affecting the required accuracy.
- Position the sonar head so that the transducer face is clear of any objects. The active angle of the transmitted pulse (from the "can" shaped projector) is 130°. The full 130° is required to properly beamform the end beams.
- Other acoustic devices (i.e., sonar systems, depth sounders, pingers, propeller noise, pump noise, etc.) and electrical cables interfere with optimum SeaBat operation. Mount the SeaBat sonar head away from offending noise sources to reduce the chance of interference and away from electrical cables to avoid interference with the transducer array and subsequent deficiency in system operation.
- Once secured, the head is easily accessible, and if mounted on a vessel can be retracted from the water when travelling at high speeds or entering shallow water areas and docking in port.
- The head can profile the seafloor or intended underwater objects without being blocked by the vessel's hull or other underwater instrumentation.

CAUTION

To reduce corrosion, do not mount the SeaBat in direct contact with other metals. To protect the housing against galvanic corrosion, two sacrificial anodes are mounted beside the connector on the back side of the sonar head, and hole inserts are used to stop the securing bolts from touching the housing.

3.2.2 ORIENTATION OF THE SONAR HEAD

The SeaBat 9003 sonar head can be oriented in any direction, the selected orientation depends upon the user's specific requirements and applications.

The information that you, the user, should take into consideration when mounting the sonar head in a particular orientation is:

a) With the sonar head oriented with the projector facing away from you, the profile displayed will appear, or be oriented, the same as the profile being measured. See Figure 3-1.

b) With the sonar oriented as in a), the beam numbers start on the left with No. 0 and increase to the right to No. 59. Regardless of how the head is oriented, the profile data output via Aux #2 of the processor, is ALWAYS in the sequence from beam No. 0 to No. 39.

c) Whatever the orientation mounting angles are of the sonar head (along the pitch, roll, and yaw axis [see Chapter 3.2.3]), they should be used to externally correct each measured profile.

To assist the operator in correlating the actual profile to the displayed profile, the SeaBat 9003 sonar head is typically mounted where the projector points parallel to the vessel heading in the direction of travel. This equates to the Port side of the vessel on the left of the screen and the Starboard on the right.

The following paragraphs provide examples of some typical mounting configurations that RESON has experienced.

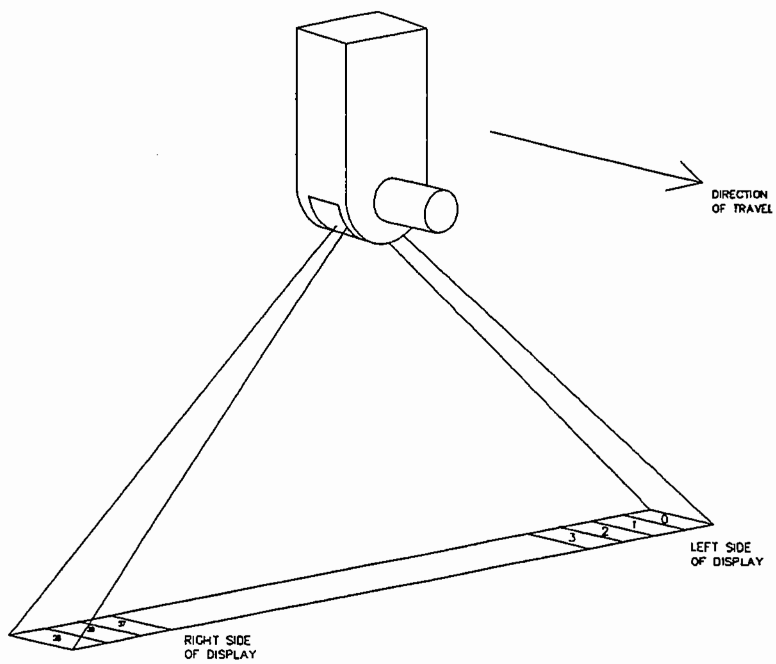

Figure 3-1. Numbering of SeaBat 9003 Beams.

3.2.2.1 SeaBat 9003, ROV Mounted

Figure 3-2 represents a typical mounting arrangement of a SeaBat 9003 on an underwater Remotely Operated Vehicle (ROV). When this unit is mounted vertically, it provides a view of the seafloor within its 120° sector that measures a profile across the seafloor that is a width equal to 3.5 times the distance of the sonar head from the seafloor.

The depth at which the SeaBat can operate is governed by which SeaBat 9003 is utilized and the depth rating of your selected ROV. There are two (2) depth rated SeaBat's, one to 350 meters [1,150 ft] and one to 500 meters [1,650 ft].

For any ROV installation, the custom cable configuration between the sonar head and topside processor is utilized. See Paragraph 7.3.2 for a detailed description of the many possible cable configurations. The reason for the custom cabling is that:

- The surface processor can only power the sonar head over a standard test cable to a maximum of 150 meters.
- The operating vessel utilizes an umbilical to send commands down to the ROV and receive data back. This cable can also carry the SeaBat's uplink and downlink commands.
- An ROV usually has sufficient voltage (24v) to power the SeaBat sonar head directly.

NOTE

Because power to the SeaBat is supplied, in this case, by the ROV, the operator must set the SeaBat transmit power value to "OFF" before turning the processor off to ensure that the SeaBat is actually no longer transmitting.

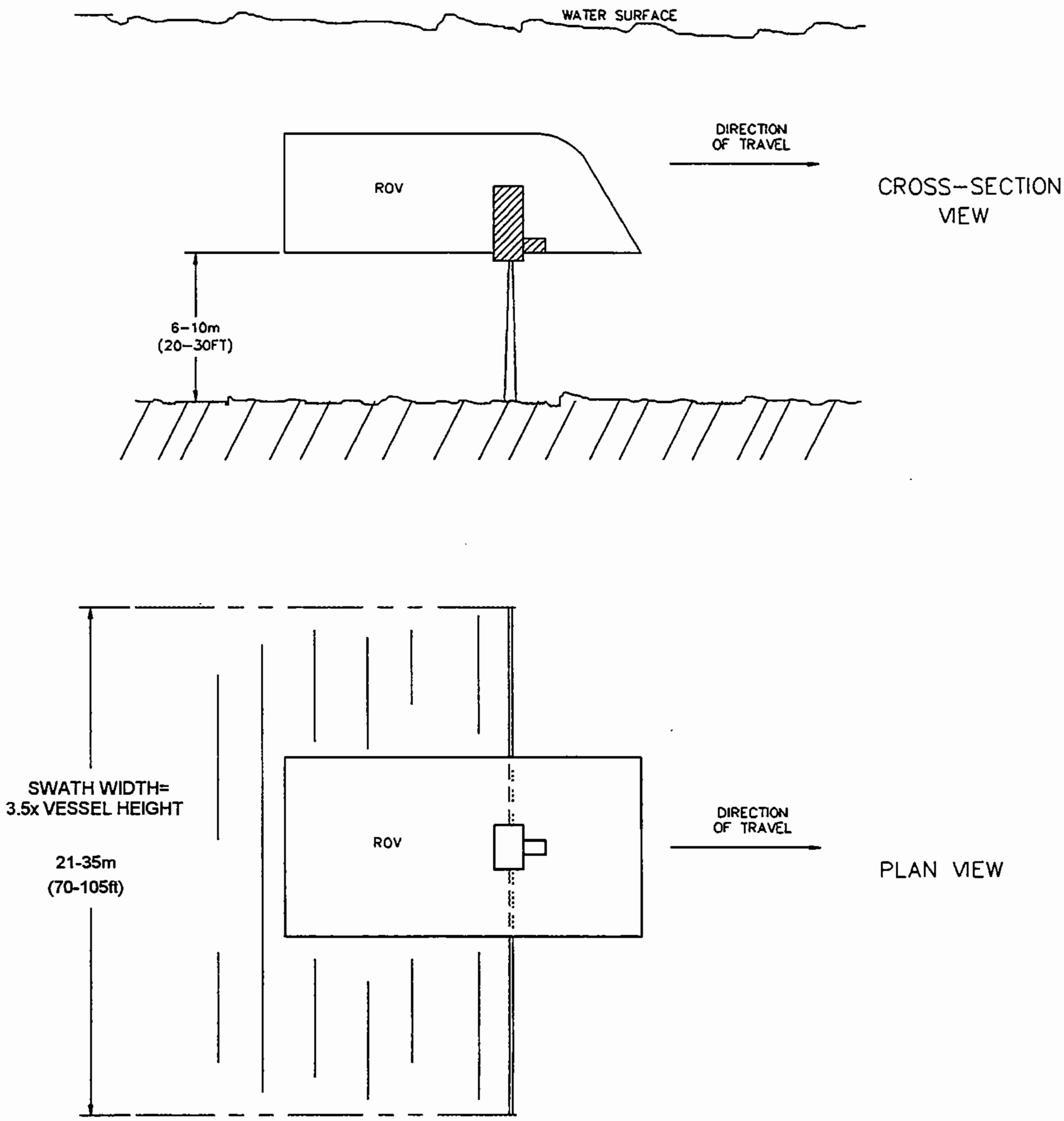

Figure 3-2. SeaBat 9003, Orientation on an ROV

3.2.2.2 SeaBat 9003, Vessel Mounted

As the SeaBat 9003 Multibeam Echo Sounder sonar head is so portable and easy to install, it is typically mounted on an over-the-side mount. It can be housed through the vessel's hull, but prior to any design of such a housing, RESON should be contacted to ensure that the performance of the system is not degraded by an unacceptable design.

The mounting angle is typically vertical, as depicted in Figure 3-3. With this configuration, the system provides a swath width equal to 3.5 times the measured water depth. This swath encompasses forty (40) seafloor data points that are measured to compute the seafloor profile. This information is displayed on the color screen and also exported via Aux #2 to an external computer for data storage and processing (see Chapter 3.2.10).

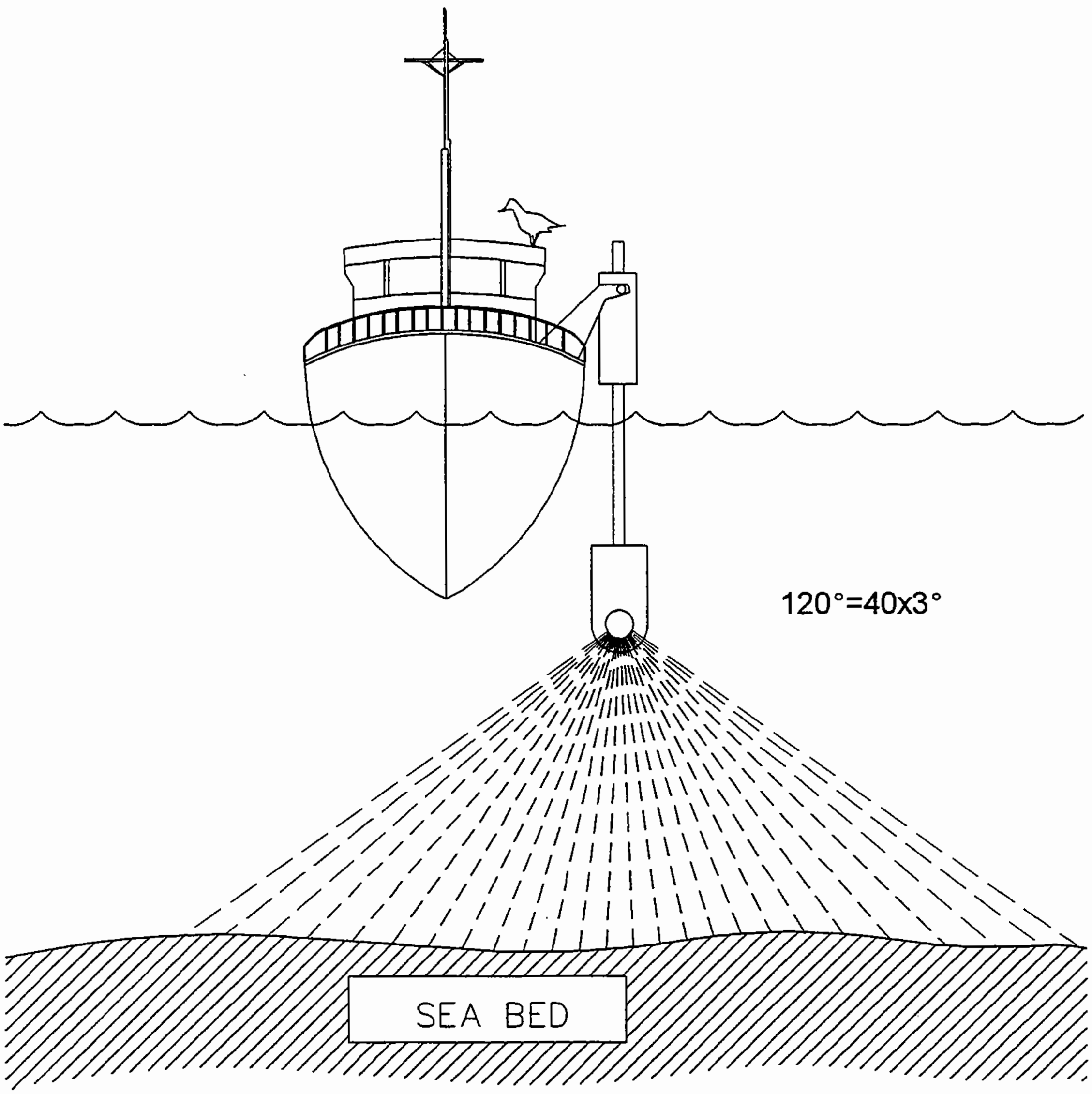

Figure 3-3. SeaBat 9003, Mounted Over the Side - Vertically

3.2.3 MOTION REFERENCE UNIT (MRU)

Movement of the SeaBat does not influence the accuracy or provide any distortion within a single profile, because the SeaBat 9003 system transmits one pulse and measures the reflected signal simultaneously through the forty receivers. However, any movement of the SeaBat between successive profiles could produce errors if the relative changes in orientation are not known or used for correction. Not all projects require the measurement of these movements, the decision to use an MRU depends on the project requirements, the amount of motion, and the location of the SeaBat.

A typical MRU measures the motion of the platform in 3-axes; Roll, Pitch, and Heave. The "Roll" value is the movement in the "X" axis [cross-track], which typically produces the largest correction values. The Pitch value is the movement in the "Y" axis [along track] and the "Heave" value is the movement in the "Z" axis [vertical]. Some new MRU systems now have a 4th axis that is "Yaw" which is a heading correction. See Figure 3-5 for a graphical view of these axes.

All MRU correction values are measured and used to correct the "relative" profile once it has been transmitted from the SeaBat system. As the MRU corrections are but one of a number of corrections that need to be made to the recorded profile (SeaBat Position, Heading, Time Synchronization, etc.) an external computer is recommended to manage these correction functions.

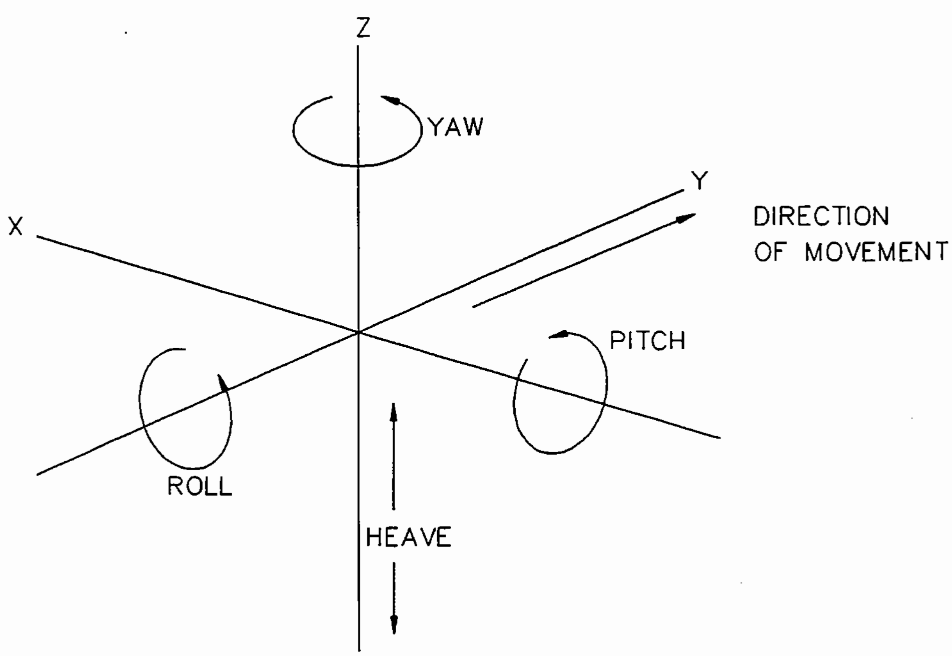

Figure 3-4. Orientation Rotations

3.2.4 TIME SYNCHRONIZATION

The synchronization, based on time, of the recorded data is necessary to produce maps or reports that require the merging of successive SeaBat profiles. As a minimum, the exact location of the SeaBat sonar head at the time that a profile was recorded is required to provide any correlation.

When recording these two sensors (SeaBat profile and Position location), the exact time that each value was recorded is essential, because the SeaBat profile (or any other sensor) is not recorded at the "exact time" that the Position is. There must be a position recorded just before and immediately following the SeaBat profile recording. In this way the first Position recorded and the second Position recorded will be interpolated to produce the x, y position for the time that the SeaBat Profile was measured (see example below).

If the following was recorded,

Time	Event
09:22:10.00	Position: X=20; Y=40 recorded
09:22:15.00	SeaBat Profile recorded
09:22:20.00	Position: X=60; Y=60 recorded

then the X,Y position for the SeaBat profile would be computed to equal; X=40, Y=50.

This procedure would also be completed for the MRU values, the heading values, depth values, etc. As can be seen, the accurate time synchronization of this data is essential to maintain the high accuracy obtained by using the SeaBat 9003 system.

3.2.5 VESSEL SPEED

This chapter addresses the maximum speed that a vessel (or platform) can travel through the water while maintaining operability. The calculation of vessel speed in reference to the computation of bottom coverage is provided in Chapter 3.2.6.2 - Survey Speed.

There are two factors when calculating the maximum vessel speed achievable:

- Mount Design
- SeaBat Transmit/Receive Beam Geometry.

3.2.5.1 Mount Design

Typically the survey vessel will travel at maximum speeds when traversing to/from the work area. At these times the SeaBat is retrieved from the water to reduce drag on the mount assembly and also to stop any possibility of damaging the head from any flotsam in the water.

Attention should be made to the design of the mount to ensure that, not only will it withstand fast survey speeds, but also that it does not vibrate and cause errors in depth movement.

Surveys have been conducted using a SeaBat at a vessel speed in excess of 12 knots.

3.2.5.2 SeaBat Beam Geometry

The SeaBat system's beam geometry was designed such that there should not be a limitation to the speed of the survey vessel. The maximum speed calculation is based on the along-track beam transmit angle (1.5°) and the along-track beam receive angle (15°/2), and not allowing the vessel to go so fast that it is ahead of the beam opening angle to receive the signal.

In 25 meters of water, using a speed sound of 1480 m.p.s., the vessel would have to be travelling at over 200 knots (106 m.p.s.) before the SeaBat would miss the reflected bottom return.

3.2.6 COVERAGE

Coverage is the percentage of the seafloor that the Multibeam Echo Sounder (MBES) has illuminated to compute depths, and is computed in both the cross-track and along-track directions.

3.2.6.1 Cross-Track Coverage

Cross-Track coverage addresses the area that a single update illuminates the seafloor in the port/starboard orientation and the overlap of illumination between parallel survey lines.

Single Update

The SeaBat system illuminates the seafloor based on the 40 beams, supporting a cross-track illumination subtended by 120° (40x3°). The cross-track will be 3.5x measured water depth.

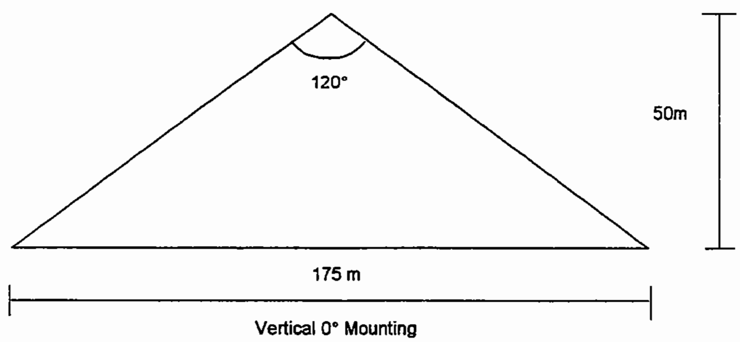

Figure 3-5. SeaBat Mounting Orientation

Survey Line Overlap

To maintain a minimum of 100% coverage, attention should be paid to the spacing between survey lines. The calculation of line spacing is dependent on the width of a single update, changes in bottom topography, and tolerances for vessel line keeping.

Considerations should include, but not be limited to:

- Changes in bottom topography
- Line keeping
- Surveying from shallow/deep water areas
- SeaBat head rotation
- Roll magnitude

CAUTION

When surveying a generally flat seafloor with a single head rotated, then the survey line direction should be the same on adjacent lines.

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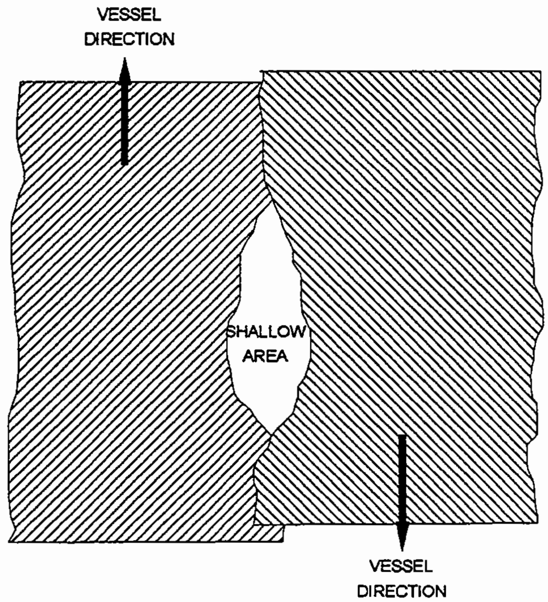
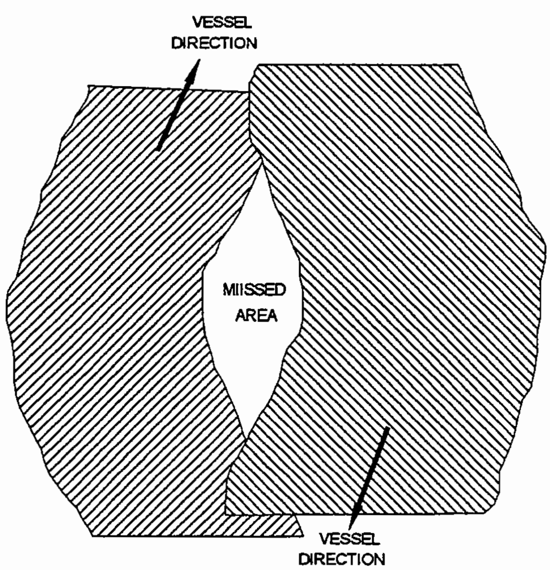
a. Changes in Bottom Topography:

A shallower area will result in surveying a narrower swath, should the survey line spacing not account for the narrower swath then a gap in coverage can result.



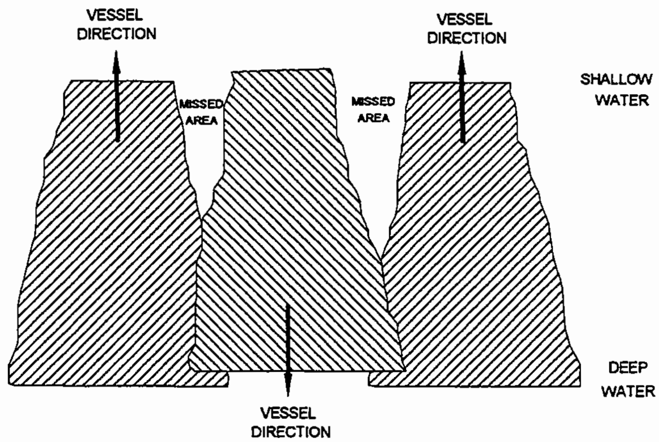
b. Line Keeping:

Allowances for the vessel to stray from the intended survey line should be made, to ensure that gaps in coverage do not result.



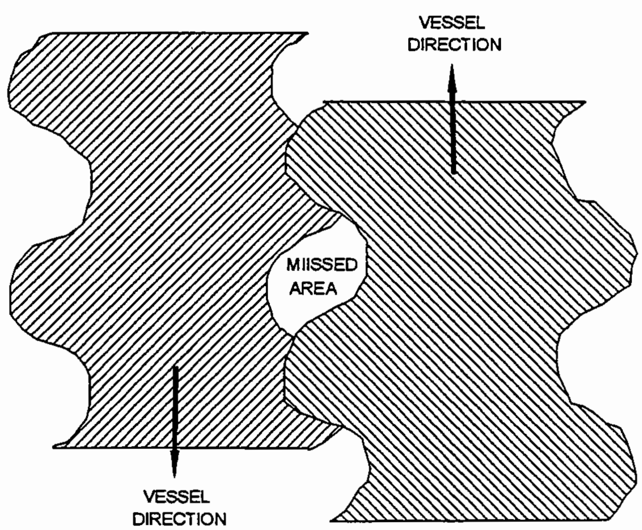
c. **Surveying Between Deep/Shallow Areas:**

As a shallower area will result in a narrower swath, allowances should be made in the survey line spacing and/or orientation.



d. **Roll Magnitude:**

Allowances for the expected roll values should be made to ensure that areas are not missed when the roll of the vessel is in opposite directions on two adjacent survey lines.



The size of the beam pattern projected onto the seafloor is also of consideration. As each of the forty beams is 3°, the size of the footprint for each beam is dependent on the distance of the seafloor from the sonar head (slant range) and the angle (incident angle) at which the beam intersects the seafloor. Figure 3-6 provides a diagram of the incident angle.

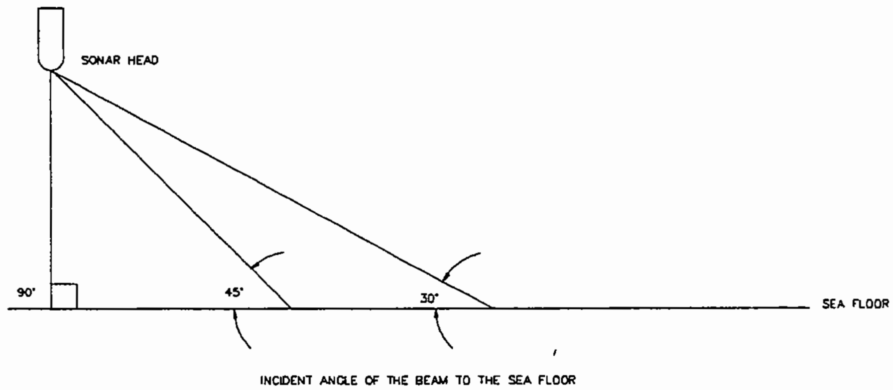


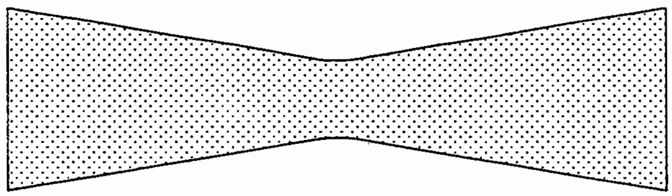
Figure 3-6. Incident Angle of the Beam to the Seafloor

3.2.6.2 Along-Track Coverage

Along-Track coverage addresses the area that a single update illuminates the seafloor in the bow/stern orientation and the overlap of illumination between successive SeaBat updates, which is based upon the vessel survey speed over the bottom and the update rate of the SeaBat.

Single Update

The SeaBat system illuminates the seafloor with a single transmit pulse that is 1.5° along-track. Depending on the distance of the seafloor from the sonar head, the area subtended by this 1.5° will vary in size. The illumination of seafloor from one single update is typically a 'bowtie' shape, where the narrow point is below the head (shortest distance assuming a flat seafloor).



Survey Speed

To maintain 100% coverage along-track, the vessel must not travel a distance in one second that is longer than the number of SeaBat profile outputs in a second multiplied by the shortest along track illumination distance.

Table 3-1 provides the number of R-Theta profiles that the SeaBat outputs in one second based on your interface baud rate and the range that the SeaBat is operating at.

TABLE 3-1. R-THETA OUTPUT DATA RATES

Output Baud Rate	Profiles Per Second				
	SEABAT 9003				
	Range ≤10m	Range 25m	Range 50m	Range 100m	Range 200m
300	0.21	0.21	0.21	0.21	0.21
600	0.43	0.43	0.43	0.43	0.43
1200	0.86	0.86	0.86	0.86	0.86
2400	1.71	1.71	1.71	1.71	1.71
4800	3.43	3.43	3.43	3.43	1.73
9600	6.86	6.86	6.85	3.45	1.73
19200	13.71	13.51	6.85	3.45	1.73
38400	15.15	13.51	6.85	3.45	1.73

For example: If,

SeaBat Range = 25M
Baud Rate = 9600

then, the number of profiles per second = 6.86 (Table 3-2)

If the water depth below the head = 15M
then the footprint size = 0.39 x 0.39M (Table 3-1, 90° inclination angle)

Therefore, the max. distance in one second:
= 6.86 x 0.39
= 2.6754 meters per second
= 5.3 knots (≈.5 mps = 1 knot)
(speed over ground)

Note that this speed calculated is speed over the ground. If you need to travel faster and still maintain 100% coverage, then the only variable that can be changed is the number of outputs per second from the SeaBat, which is controlled by changing the baud rate.

If you increase the baud rate from 9,600 (6.86) to 19,200 (13.51), then the maximum speed is 10.5 knots (5.27 m.p.s.).

Figure 3-7 provides a quick reference to the maximum speed (19,200 baud setting) that can be used when surveying in varying water depths with the different SeaBat range scales. Also note that the 100% coverage factor is based on the beam's footprint size below the sonar head, and that the coverage percentage will increase (possibly as much as 500%) for the outer beams, depending on the seafloor topography and line spacing.

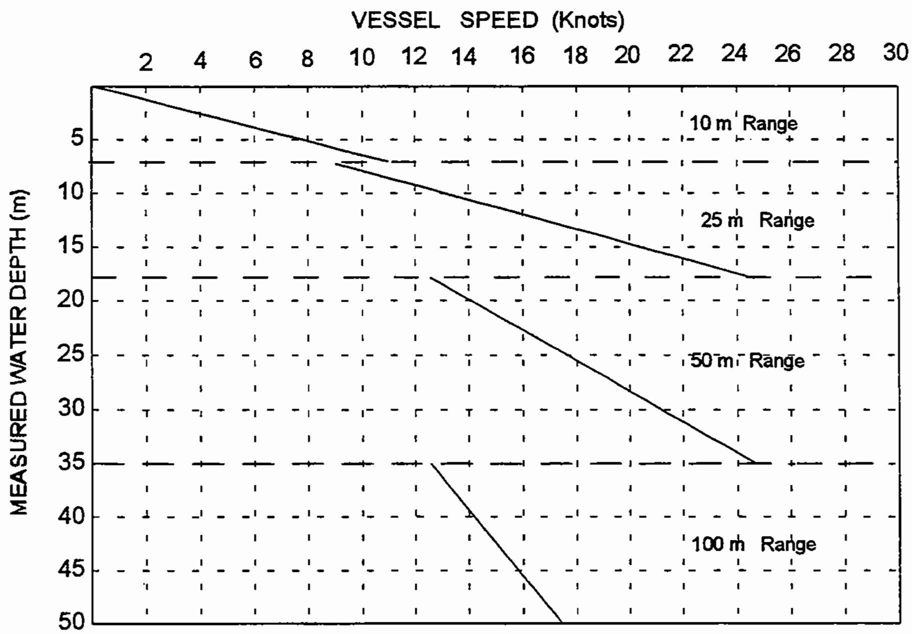


Figure 3-7. Max. Vessel Speed v. 100% Coverage @ 19,200 baud

To use Figure 3-7, if we assume the seafloor to be flat, with a water depth of 30 meters, we would need the SeaBat range setting to be 50 meters to ensure that the complete profile is within the SeaBat wedged area. Therefore:

1. Follow the Measured Water Depth of the table (left side) to the 30 meter line, at that point you are within the 50m Range band, thereby confirming the SeaBat range setting required.
2. Follow the 30 meter line until it intersects with the solid diagonal line.
3. At this location move vertically up, to read the maximum vessel speed.
4. For this example it is 21 Knots.

3.2.6.3 Density of Soundings

Density of data points and coverage are two different things. Maintaining 100% coverage alone may not result in an area being adequately surveyed, as a wide transmit beam will illuminate a large area, however only one depth will be derived, that may not be representative of the seafloor terrain. See Figure 3-8.

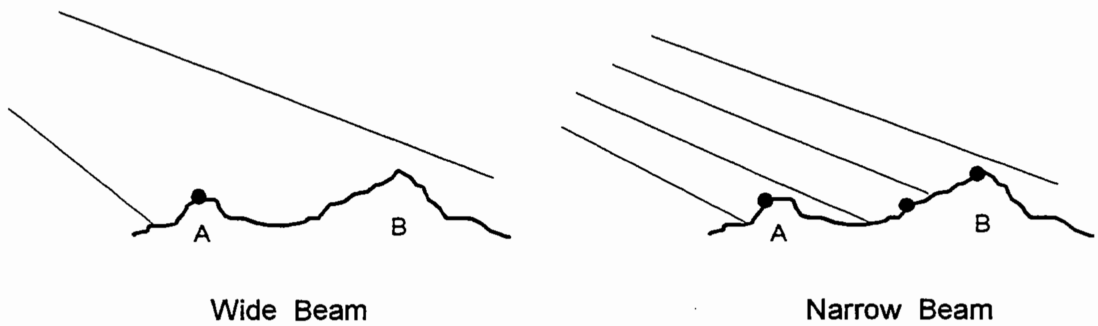


Figure 3-8. Wide Beam vs. Narrow Beam Coverage

Depending on the incident angle of the beam and its beam angle, with a wide beam the shallower area 'B' may be missed by having a better reflection and shorter distance to area 'A'. Using a narrower beam angle, more depths are determined that will improve the measurement of the seafloor profile. The SeaBat 9003 series transmit beam (cross-track) is 3°.

Some customers state that a 100% coverage is required, and as previously discussed this is only the illumination of the seafloor, and could be represented by one sounding every 10 square meters. If the requirement was 100% coverage to locate any rocks larger than .5 meter, then a minimum of one sounding every .5 meter would be required.

To determine the sounding density, both the cross-track and along-track distances are used to compute the density area.

Cross-Track: The beam cross-track footprint size is used (as one sounding is equal to one beam footprint), which is controlled by the water depth (beam slant range) and incident angle that the beam intersects the seafloor.

Along-Track: The distance travelled between successive SeaBat updates provides the amount of soundings recorded along the line. This is controlled by the vessel survey speed and the SeaBat output rate.

NOTE

The density will decrease from the area directly below the sonar head toward the outer beams, as the beam cross-track footprint distance increases.

3.2.7 SPEED OF SOUND

The SeaBat 9003, as with any other echo sounder system, uses the speed of sound (velocity) that the acoustic pulse travels through the water to compute the depths across the swath.

With a single beam echosounder, one vertical depth is typically measured and the velocity value measured throughout that depth is used to compute the actual depth.

With a multibeam echosounder, only a few beams travel vertically, the majority travel at an angle from the transducer head to/from the seafloor. Therefore, for accurate depth measurement, a velocity profile is required to correct for the varying speeds and bending of the beams. The correction is conducted outside the SeaBat MBES, as only one constant velocity is entered by the operator into the display menu and used for real-time correct and display of profile data. The output format (See Paragraph 7.6) includes the velocity used by the operator in real-time and provides the two-way travel time for each sounding, so that a receiving computer (SeaBat 6042, Hypack, etc.) has to recompute the depths using velocity calculations to correct for curvature, if required. See Chapter 3.2.8 - Path of Sound.

3.2.7.1 Speed of Sound Measurement

Prior to any survey being conducted, plus at any time during the survey, a velocity check is conducted to measure the actual speed of sound through the water column being measured. The typical calibration is a "Bar Check", where a metal "bar" is lowered below the transducer to a known distance. Measurements are taken and the speed of sound (Figure 3-9) is adjusted until the system measures the correct distance. Other calibration techniques exist and can be found in any reputable hydrographic manual.

CAUTION

The depth displayed on the SeaBat screen DOES NOT include the Transducer Draft, so ensure that when calibrating the SeaBat using a Bar Check this distance is accounted for.

The following table provides potential errors (in meters) that will be experienced in the measured range when an incorrect speed of sound is used. The table is based on a datum speed of sound of 1480 meters per second (mps) with the "X" Axis in increments of ±10 mps, and the "Y" Axis are ranges from 5 to 75 meters.

The SeaBat 9003 multibeam system measures the slant range; therefore any velocity errors will result in an error in all three axes (X,Y, and Z).

TABLE 3-2. ERRORS DUE TO INCORRECT SPEED OF SOUND

RANGE	ERROR IN SPEED OF SOUND (Meters Per Second) - ≈ 1480 mps									
	±10	±20	±30	±40	±50	±60	±70	±80	±90	±100
5	0.03	0.07	0.10	0.14	0.17	0.20	0.24	0.27	0.30	0.34
10	0.07	0.14	0.20	0.27	0.34	0.41	0.47	0.54	0.61	0.68
15	0.10	0.20	0.30	0.41	0.51	0.61	0.71	0.81	0.91	1.01
20	0.14	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	1.35
25	0.17	0.34	0.51	0.68	0.84	1.01	1.18	1.35	1.52	1.69
30	0.20	0.41	0.61	0.81	1.01	1.22	1.42	1.62	1.82	2.03
35	0.24	0.47	0.71	0.95	1.18	1.42	1.66	1.89	2.13	2.36
40	0.27	0.54	0.81	1.08	1.35	1.62	1.89	2.16	2.43	2.70
45	0.30	0.61	0.91	1.22	1.52	1.82	2.13	2.43	2.74	3.04
50	0.34	0.68	1.01	1.35	1.69	2.03	2.36	2.70	3.04	3.38
55	0.37	0.74	1.11	1.49	1.86	2.23	2.60	2.97	3.34	3.72
60	0.41	0.81	1.22	1.62	2.03	2.43	2.84	3.24	3.65	4.05
65	0.44	0.88	1.32	1.76	2.20	2.64	3.07	3.51	3.95	4.39
70	0.47	0.95	1.42	1.89	2.36	2.84	3.31	3.78	4.26	4.73
75	0.51	1.01	1.52	2.03	2.53	3.04	3.55	4.05	4.56	5.07

3.2.8 THE PATH OF SOUND

Sound waves typically travel in direct paths over the limited distances measured by the SeaBat sonar head, and work on the concept called "line-of-sight". This means that the acoustic underwater signal will be reflected by objects within its "line-of-sight". Objects hidden behind large natural or man-made objects will not be seen.

When a sound wave or SeaBat signal is being transmitted near a large object, a "zone of silence" or "shadow zone" is formed on the backside of such an object and the reception of the signal is blocked or greatly diminished. Shadow zones may be eliminated by moving away from such objects until a clear line-of-sight is established.

Sound waves in water will be reflected or refracted (bent) by thermoclines. A thermocline is the boundary between layers of water with different densities. The density of water changes mainly by the variations in it's temperature and salinity. A typical rule is that water becomes denser as it becomes deeper, however as with all rules, they are not exact. So a speed of sound check should be conducted within the water column that is to be measured. The sun increases the temperature of the top layer of the water, while the rain run-off from the land decreases the salinity content.

A typical velocity profile is shown in Figure 3-9. Since the SeaBat Sonar System measures the time travelled for both vertical and slant sound paths, then post processing, utilizing the time output from the SeaBat and the correct speed of sound for that ray path, may be necessary for some high precision projects.

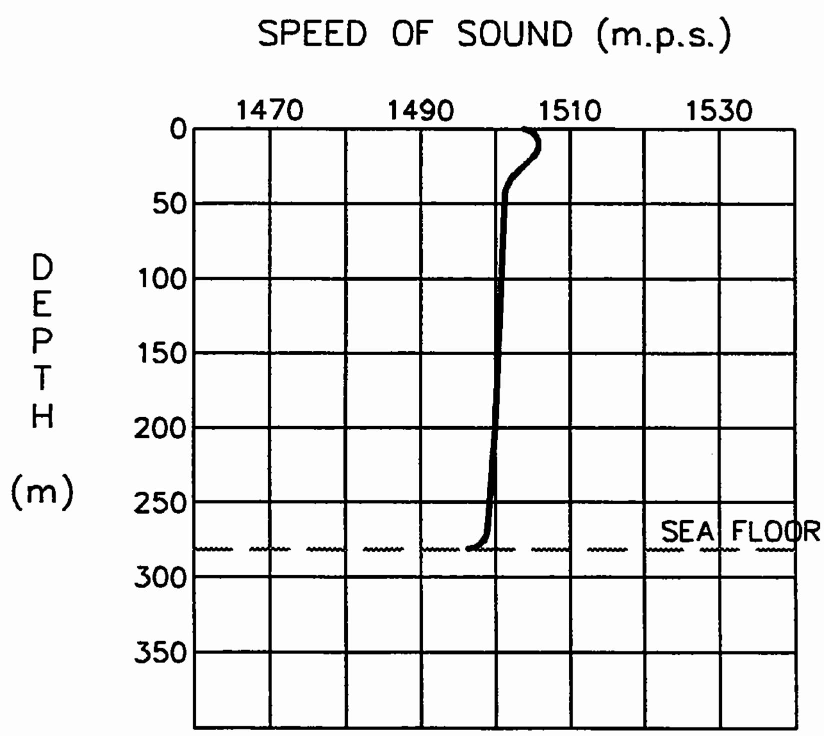
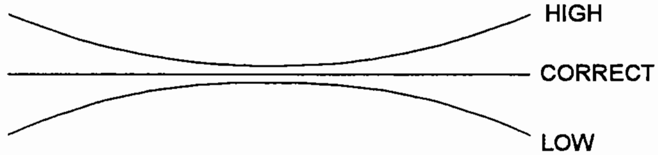


Figure 3-9. Typical Velocity Profile

When measuring a flat seafloor and using the correct speed of sound, then the result will be a flat seafloor. However if an incorrect speed of sound is used then the profile measured will be either a 'bowl' or 'mound' effect.



The vertical depth error will vary depending on the error in the speed of sound, the water depth, and the angle from the sonar head to the seafloor. At an angle of ±45° for every 10 metres of water depth and ±10 metres per second in velocity error the vertical depth error between the center and outer beams will be 4.6 cm.

3.2.9 REAL-TIME DATA STORAGE

A standard SeaBat 9003 system allows for the storage of two types of data in two formats:

1. The SeaBat's Color Display can be recorded to a VHS format video recorder in either PAL or NTSC format.

2. Aux #2 Port of the SeaBat processor outputs the computed profile that is displayed on the SeaBat color screen. These data are formatted in the RS-232 format and can be stored on an external computer system.

RESON has also developed a software package, the SeaBat 6042, that was designed to receive in real-time: two SeaBat profiles, each SeaBat's position, the platform's heading, and the heave, pitch and roll movements from an MRU. These data are then displayed and stored in real-time in plan, profile and 3D formats (see Paragraph 10.3). For more information regarding this product, please contact your nearest RESON representative.

3.3 APPLICATION NOTES

The SeaBat was developed initially for applications requiring an ROV; however this sonar system functions equally well when mounted to a surface vessel.

3.3.1 HYDROGRAPHIC SURVEYING - VESSEL MOUNTED

The SeaBat system provides a method to precisely map the seafloor terrain while cruising over it at high speeds. Utilizing a multibeam system provides the user with the ability to map 100% of the seafloor, thereby not missing any isolated rocks or obstructions.

The SeaBat system was utilized in locating and mapping the rock obstructions that were hit by the Queen Elizabeth II when it ran aground off the coast of Martha's Vineyard, Massachusetts, USA on August 7, 1992. The system revealed a rocky area with random pinnacles in less than 35 feet of water, while previous charts indicated a depth of 39 feet at the site.

Outdated surveying techniques using a single beam echo sounder could not discern obstructions located between the survey lines. Apparently, during the previous survey in 1939, no survey line was run that took the vessel directly over the pinnacles, and as such they were never located until the Q.E.II luxury liner "found" them.

The SeaBat was installed on the NOAA vessel "Rude" and departed the dock in less than 2 hours from the arrival of the system. The sonar head was mounted vertically at a depth of 13 feet (ft) below the water line on the end of a pole secured to the starboard side of the vessel. The SeaBat was oriented and secured to profile parallel to the vessel track.

Using NOAA's existing survey procedures (based on a single beam echo sounder), survey lines were conducted in a grid fashion with a line spacing of 10 ft in both directions. With an average water depth of 40 ft, the SeaBat profiled the seafloor with a swath width of 54 ft (twice the measured distance of 27 ft (40 ft water depth minus 13 ft draft). With the swath width of 54 ft and a line spacing of approximately 10 ft, the SeaBat 9001 system recorded the survey seafloor with a coverage of over 600%. With this volume of data and the varying vessel headings, it was possible to model the seafloor terrain and back compute to find that the vessel had a 2° list to port.

3.3.2 HYDROGRAPHIC SURVEYING - ROV MOUNTED

A SeaBat system, depth rated to 600 meters, was installed on an ROV and navigated over an area at a depth of 530 meters below the North Sea. Positioned by a Sonardyne long baseline (LBL) acoustic positioning system and corrected for motion by a Seatex MRU-5 sensor, the ROV "floated" at a height of approximately 20 meters above the seafloor.

Eiva A/S of Denmark provided the "NAVIBAT" real-time navigation system that correlated all the on-board sensors and provided real-time navigation, data collection and presentation of the data. Final charts and maps were produced utilizing the Eiva "NAVILINE" data processing system, the results of which can be seen in Figures 3-10 and 3-11.

The computed depth of the terrain surveyed with the SeaBat 9001 produced accuracies better than 10cm, and final charts were produced at both a 1:500 scale and 1:200 scale. The later having a plotted contour interval of 20cm.

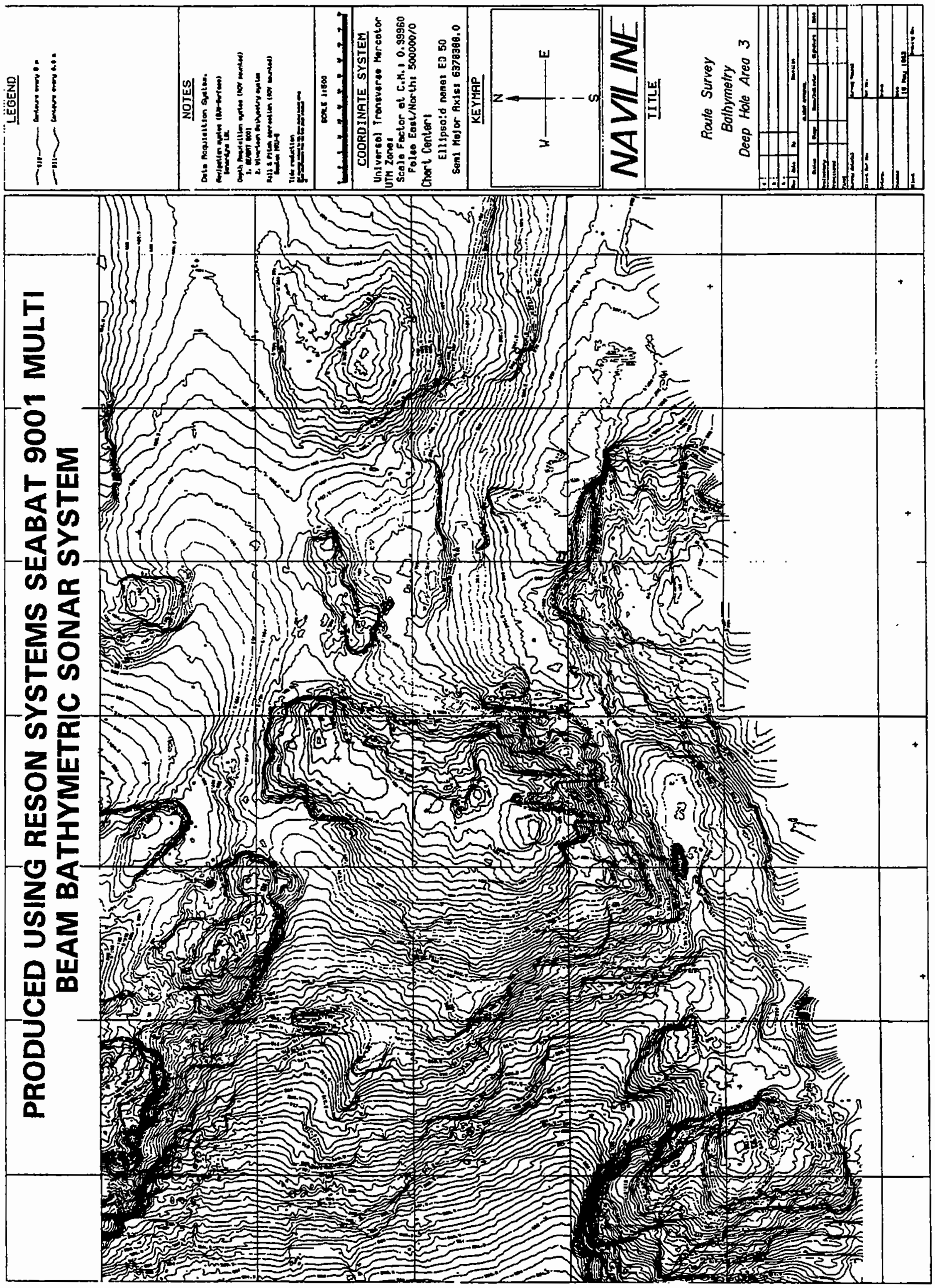


Figure 3-10. Naviline Contour Map

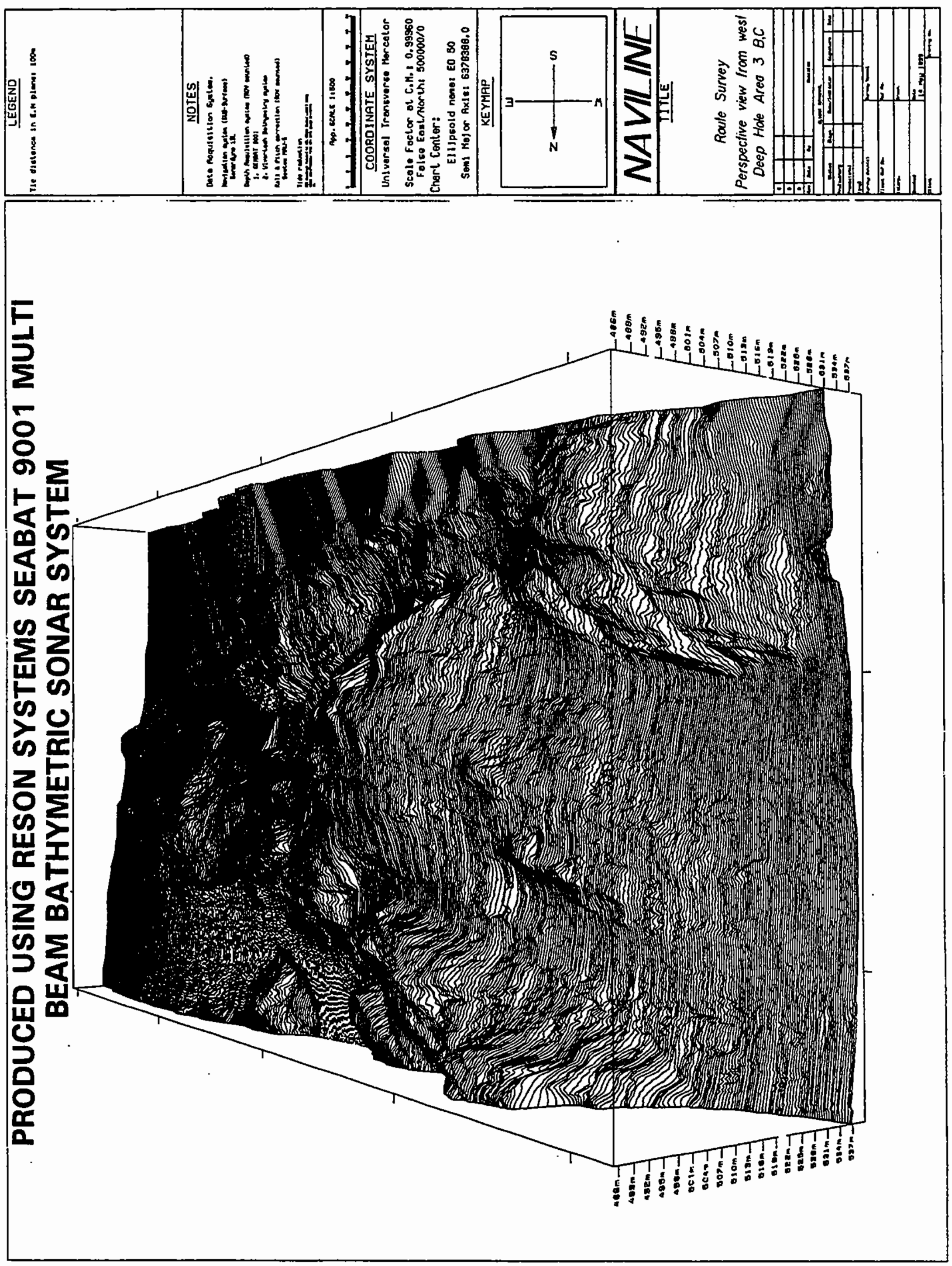


Figure 3-11. Naviline 3D Map

3.3.3 PIPELINE TRENCHING AND BURIAL

The SeaBat enables pipeline trenching and pipeline burial profiling to be accomplished without the aid of divers.

Placing the SeaBat in a position in front of and/or behind an underwater trenching plough or rock dumping ROV to generate a cross profile of the trench, or to view the covered pipe and verify depth of covering, accurate measurements are obtained and indicate whether the forward speed of the plough or ROV is too fast, or too slow. In the case of pipeline trenching operations vehicle speed determines whether a trench is too shallow (ROV is too fast) or whether the trench is too deep (ROV too slow).

Figure 3-12 depicts a Pipeline Burial Operation using two SeaBats; one positioned in front of the ROV to follow the pipeline and one positioned in the rear to determine depth of rock "dumped" to bury the pipe.

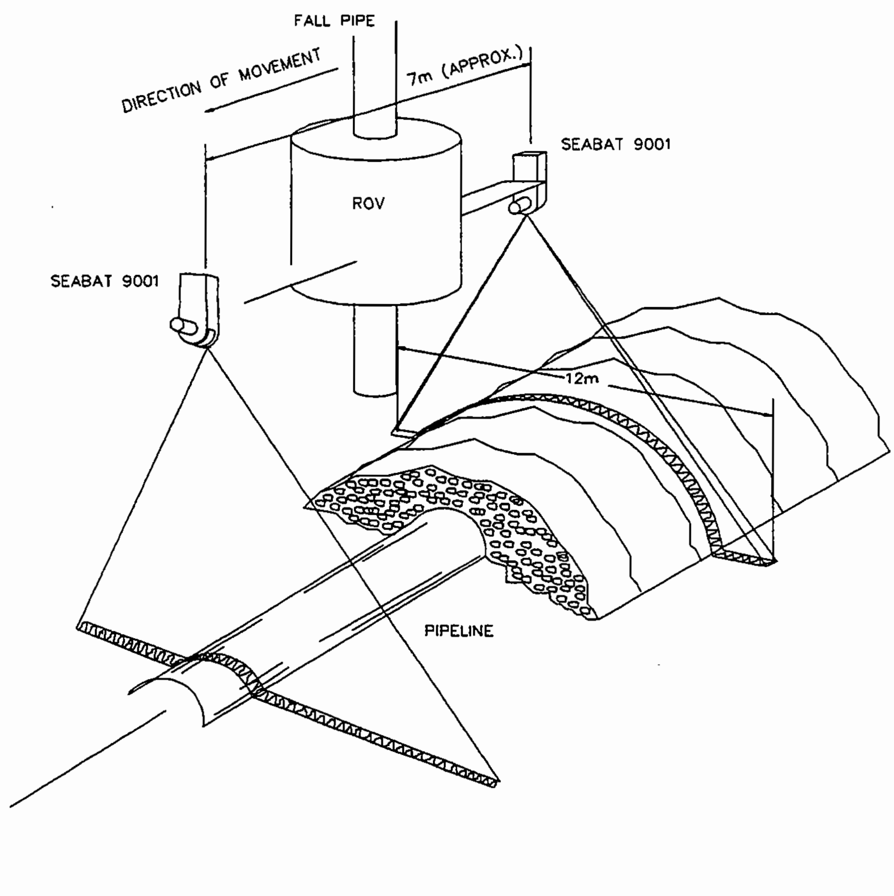


Figure 3-12. Pipeline Burial Operation Using two SeaBats

3.4 BASIC OPERATIONAL STEPS

Step-by-step procedures for operation will be approached in this general overview. Since the operator has the option of using either a Trackball- or Joystick-type pointer, instructions will be provided in a basic manner for moving the cursor and making the various menu selections. Refer to the pointer device operators manual for specific instructions on the operation of these components.

3.4.1 COMPONENT CONNECTION CHECKOUT

Proper connection of all components should be verified prior to start-up.

CAUTION

Equipment should be located away from heat sources, such as radiators or air ducts, and should not be subjected to direct sunlight, excessive dust, mechanical vibration or shock.

Main Components

- **SeaBat Processor.** Check the SeaBat processor to be sure that it is connected to the Sonar Head by one of two methods: (1) directly, by a single cable connected from the Sonar Head connection on the rear of the Processor to the Sonar Head or (2) custom linked, where an existing cable (i.e., ROV umbilical) is used to transmit the Uplink and Downlink commands (Paragraph 2.4.5 - Installation 'Connecting Surface Processor to Sonar Head' and Paragraph 7.3 - 'Sonar Head to Processor').

CAUTION

Ensure that the cable is never pulled, is connected securely to the processor receptacle, is free from any tight corners and is not exposed to any harsh conditions.

- **Color Monitor Display.** The RESON recommended connection, to provide the best picture quality, is the use of RGB and Sync cables (4x BNC-BNC 75 ohm cables). Connect the monitor at the rear processor panel. Refer to Paragraph 2.4.7 - Installation 'Connecting Surface Processor to Color Display', for four other connection methods.
- **Pointer Device.** The pointer device is connected at one of two places; either at the front or at the rear processor panel (Paragraph 2.4.8 - Installation 'Connecting Surface Processor to Pointer Device').

Data Recording (Optional) Devices

- **Video Recorder.** This component is connected to the S-Video connector on the rear panel of the sonar processor (Paragraph 2.4.9 - Installation 'Connecting Surface Processor to Video Recorder').
- **External Computer.** The external computer is connected to the rear panel of the sonar processor at Aux #1 or #2 port (Paragraph 2.4.10 - Installation 'Connecting Surface Processor to External Computer').

3.4.2 NORMAL START-UP PROCEDURE

After completing component checkout and ensuring that all equipment is properly connected to it's power source, you are ready to perform system start-up.

First switch on the Display Monitor, allowing sufficient time for it to 'warm-up' and then switch on the SeaBat processor. The system is now operational.

Within five [5] seconds of power up, the display will show the SeaBat version number and date for a period of five [5] seconds (Figure 3-13). Ensure that this manual covers the processor firmware version number displayed (see Software History, page iii).

SeaBat 9003 Sonar Processor Firmware Ver. 2.16, 7-FEB-96

Sonar Head Firmware 12-MAY-94

Figure 3-13. SeaBat 9003, Start-up Screen

CAUTION

Upon initial power-up, the screen will display two message lines, the first line shows the Processor Firmware version, and the second line states "Waiting for signal from Sonar Head".
If the head does not respond, then after 5 seconds, the operational screen will be displayed.
This sequence indicates the system is not operational as the sonar head did not respond.
For correct operation, the "Waiting for signal from Sonar Head" message should be replaced with the sonar head firmware version date within 5 seconds and prior to the display of the operational screen.

The main display will now be presented as a wedged area with the apex at the top of the screen (Figure 3-14).

NOTE
Upgrades between Ver 2.10 and Ver 2.13 Processor Firmware incorporated changes to the display menus, so depending on the version you have these menus may vary. See Paragraph 3.4.4.

3.4.3 MENU DISPLAY VALUE SELECTIONS

All SeaBat systems utilize the color monitor as the method by which the operator can see the sonar data collected and, by moving the pointer device, make real-time changes to the way the system operates and displays the information.

The majority of the screen is occupied by a wedge-shaped image that, within its borders, displays the sonar data collected by the SeaBat system. The SeaBat 9003 has the apex of the wedge at the top center of the screen (see Figure 3-14).

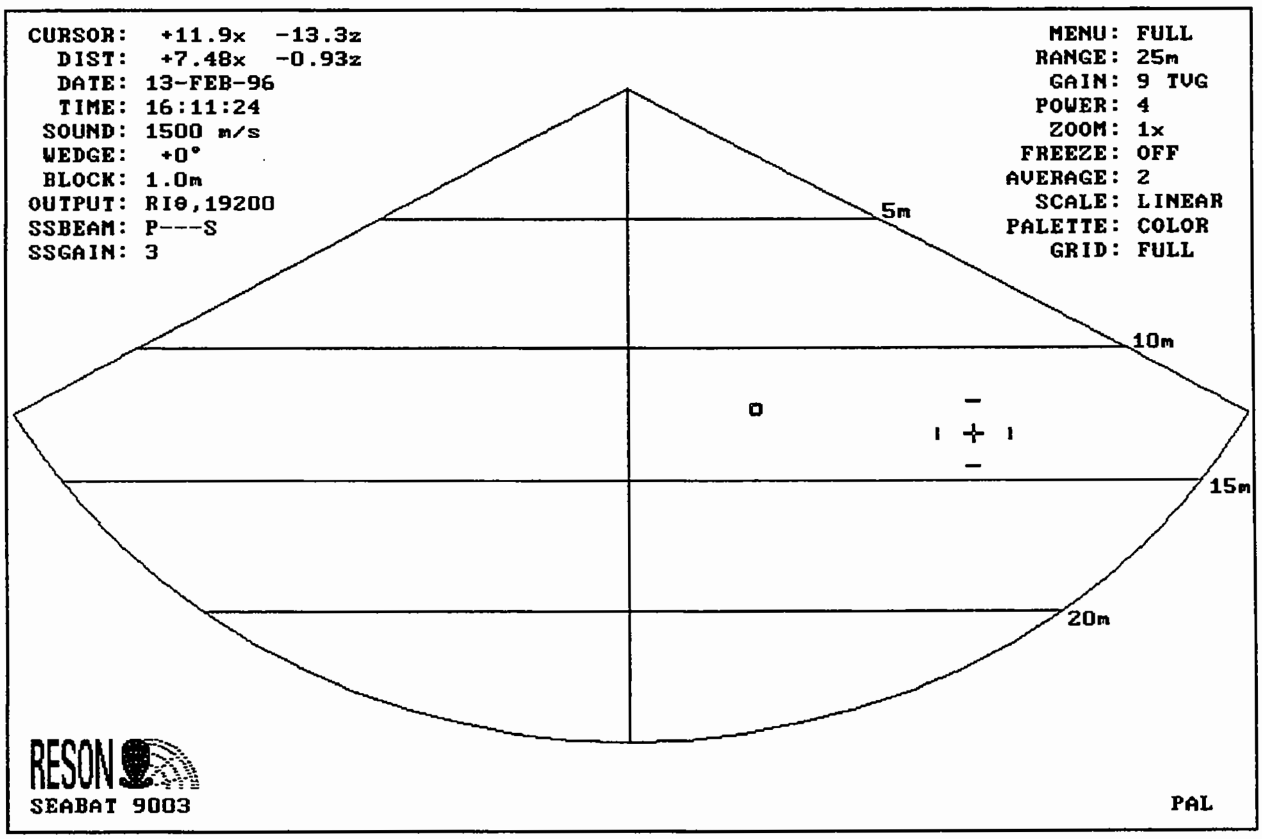


Figure 3-14. SeaBat 9003, Main Display

Located outside the wedge area, in the four corners are:

a. RESON Logo and SeaBat model in use (bottom left).
Ensure that the SeaBat you are using is the correct model for the operation you wish to perform.

b. The display format (NTSC or PAL) (bottom right).
The SONY PVM range of color monitors can operate in either the NTSC or PAL video format. Ensure that if a video recorder is connected, the required format is displayed on the front of the SeaBat screen. To change from PAL to NTSC or vice-versa, hold down both pointer/cursor buttons and move the trackball (or joystick) for approximately 10 seconds. This will command the SeaBat processor to change the video output format.

c. A System Menu Block (Cursor, Dist, Date, Time, Sound, etc.) (top left)

d. An Operation Menu Block (Menu, Range, Gain, Power, etc.) (top right)

As described in c and d above, displayed on all SeaBat Systems are two (2) blocks of menu features. These blocks are located in the upper left- and upper right-hand corners. Refer to Figure 3-14.

The two menu blocks contain various menu selections and each are activated differently:

Right - Operation Menu

This block contains the variables most commonly changed, and are accessible using the following procedure:

a. Move a cursor over the menu item selected to be changed, a box will be displayed around the menu title and value.
b. Press either the left or right pointer/cursor button. The left will decrease the value, while the right will increase the value. The SeaBat system perceives the alteration to the values and automatically corrects itself to reflect the changes to the menu item value.
c. When the required menu item value is displayed, then move the cursor away from the menu item, the box will disappear and the selected value will remain and be effective until it is next changed.

Left - System Menu

This block contains the variables less commonly altered, and are accessible using the following procedure:

a. Move the cursor over the menu item selected to be changed and press the left pointer/cursor button. A box will then appear around the menu title and the word **"SET"** will replace the menu title.
b. While keeping the cursor within the box, press either the left or right pointer/cursor button. The left will decrease the value, while the right will increase the value. Both the Date and Time selections have 3 values displayed in their boxes (DD-MMM-YY and HH-MM-SS), the cursor must be placed over the respective values for them to be changed.
c. When the required menu item value is displayed, then move the cursor over the **SET** title, ensuring that the cursor stays within the box.
d. Press the left pointer/cursor button. The word **SET** will be replaced by the selection's correct title and the values entered will be changed. It is only at this point that the entered value(s) become effective.

Paragraph 3.4.4, On Screen Commands, describes each menu function in detail.

3.4.4 ON-SCREEN COMMANDS

The following paragraphs describe in detail a combination of the menu selections and displayed values that are available on the SeaBat 9003 System.

3.4.4.1 Menu

This menu item is only available in Ver. X.YY and later firmware versions. It provides the operator the ability to reduce the number of menu items available. There are three selections: FULL, MINI, and OFF.

FULL:

CURSOR:	RANGE:
DIST:	GAIN:
DATE:	POWER:
TIME:	ZOOM:
SOUND:	FREEZE:
WEDGE:	AVERAGE:
BLOCK:	SCALE:
OUTPUT:	PALETTE:
SSBEAM:	GRID:
SSGAIN:	

MINI:

CURSOR:	MENU: MINI
DIST:	RANGE:
DATE:	GAIN:
TIME:	POWER:

OFF:

CURSOR:	MENU: OFF
DIST:	

3.4.4.2 Range

This menu item allows the operator to select seven (7) pre-determined range settings (2.5, 5, 10, 25, 50, 100, and 200 meters). Although the SeaBat 9003 system emits sufficient power to transmit to the maximum distance, this system is designed to track the seafloor at a maximum depth of 75 meters.

3.4.4.3 Gain

The gain menu item allows the operator to select the amount of receiver gain applied to the returned sonar signal. All SeaBat systems display a value that is from 0-15 (16 settings) and changes the receiver gain by 3.5 dB per setting.

There are two types of gain corrections, Time Variable Gain (TVG) and Fixed Gain (FIX). After manually selecting through the 0-15 TVG values, the 0-15 FIX selections are presented.

In Version 2.11 and later firmware versions, the SeaBat has been upgraded with Automatic Gain Settings. Automatic TVG is prefixed AT, while Automatic Fixed Gain is prefixed AF. Each Automatic Gain selection provides 5 threshold levels to select from - 1 to 5.

The threshold level selected determines how many pixels displayed will be in clipping, i.e. saturated. The lower the threshold number the dimmer the display.

Threshold Level	No. Pixels in Clipping
1	1-30
2	20-50
3	40-70
4	60-90
5	80-110

> For example:
> If the value AF2 is selected, then the system will automatically adjust the received signal using a Fixed Gain and maintaining 20-50 pixels in clipping.

CAUTION

Auto Gain and Auto Power should never be selected simultaneously.

A general rule in selecting an Automatic Gain Setting is that the allowable number of pixels in a clipping will change the display in relationship to the range selected as the number of pixels displayed will vary.

3.4.4.4 Power

The selection of this menu item allows the operator to increase or decrease the amount of power that the SeaBat sonar head transmits. The selections are from OFF to power settings 1 to 8, and then AUTO. The maximum power setting of 8 outputs ≈ 0.8 kW.

When using Auto Power setting, labelled "AUTO", the following steps should be followed:

- Prior to setting the Power to AUTO, go over the general area while maintaining the power level in approximately the center of its range (3-5) and adjusting the gain value until the profile displayed is correct.
- Once this is achieved, then set the Power to AUTO.
- This will ensure that when operating with the same conditions the seafloor will be tracked while also allowing the maximum Auto Power range adjustment in either direction.

If AUTO power is selected, then the system will adjust the power level to maintain the profile. During Auto Power, if you were to manually adjust the gain, then the power setting would change, or if the bottom changed then the power level would automatically change. When Power is in Auto, the label "AUTO" is displayed followed by the Power Value that the system is using.

In firmware Version 2.11 and later, five additional Automatic Power settings were added: A1 to A5. The addition of the number 1 to 5 enables the SeaBat to maintain a power value that results in a certain number of displayed pixels being clipped, i.e. saturated. The lower the threshold level, the dimmer the display.

Threshold Level	No. Pixels in Clipping
1	1-30
2	20-50
3	40-70
4	60-90
5	80-110

CAUTION

Auto Gain and Auto Power should never be selected simultaneously.

A general rule in selecting an Automatic Power Setting is that the allowable number of pixels in a clipping will change the display in relationship to the range selected as the number of pixels displayed will vary.

3.4.4.5 Zoom

The zoom feature allows the sonar image to be displayed on a larger scale. The zoom settings available are x2, x4, x8, and x16 or until the data resolution equals the vertical screen resolution.

First, place the cursor over the area you wish to zoom in on. When this function is selected, the screen enlarges the "zoomed area" and displays the outline of the area within the 120° wedge outline at the top of the display.

To move the "zoomed area", either move the cursor within the wedged outline, or move the cursor within the sonar image display, and press the right control button. In either case the "zoomed area" will be re-centered on the selected point.

When the zoom function is activated, it does not affect the update rate or quantity of data being processed. It only controls the portion of the sonar image being displayed.

3.4.4.6 Freeze

When this feature is selected the sonar image that is currently being displayed is frozen, thereby allowing the measurement and review of data presented. This option toggles (by selection) between Freeze ON and Freeze OFF.

CAUTION

When Freeze is ON, a test profile is output on Aux #2.

3.4.4.7 Average

This feature allows the operator to select the number of update images to average and display. The selections available are OFF, 2, 4, 8, and 16. The use of this feature is not recommended if the RS-232 profile output is utilized as the profile output will be an average profile and can result in errors in producing accurate maps.

3.4.4.8 Scale

The scale menu selection allows the operator to select the echo intensity color mapping function. Using the palette selected (see Paragraph 3.4.4.9), the color range is divided into 256 colors that represent the strength of the signal by either a Linear Scale (Figure 3-15), a Logarithmic (Log) 20dB Scale (Figure.3-16) or a Logarithmic 30dB Scale (Figure 3-17). The Clipping value is the point where the signal is nearly saturated. The Log 20 and Log 30 scales increase weak signals.

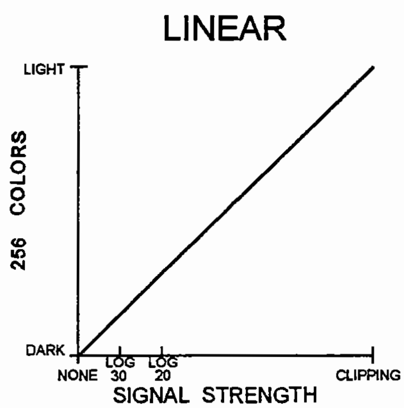


Figure 3-15. Linear Scale

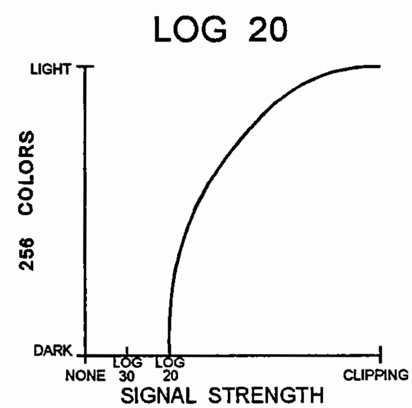


Figure 3-16. Logarithmic 20 dB Scale.

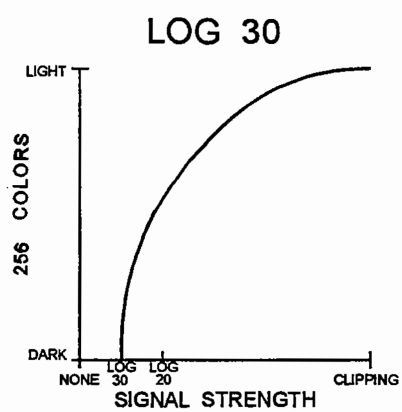
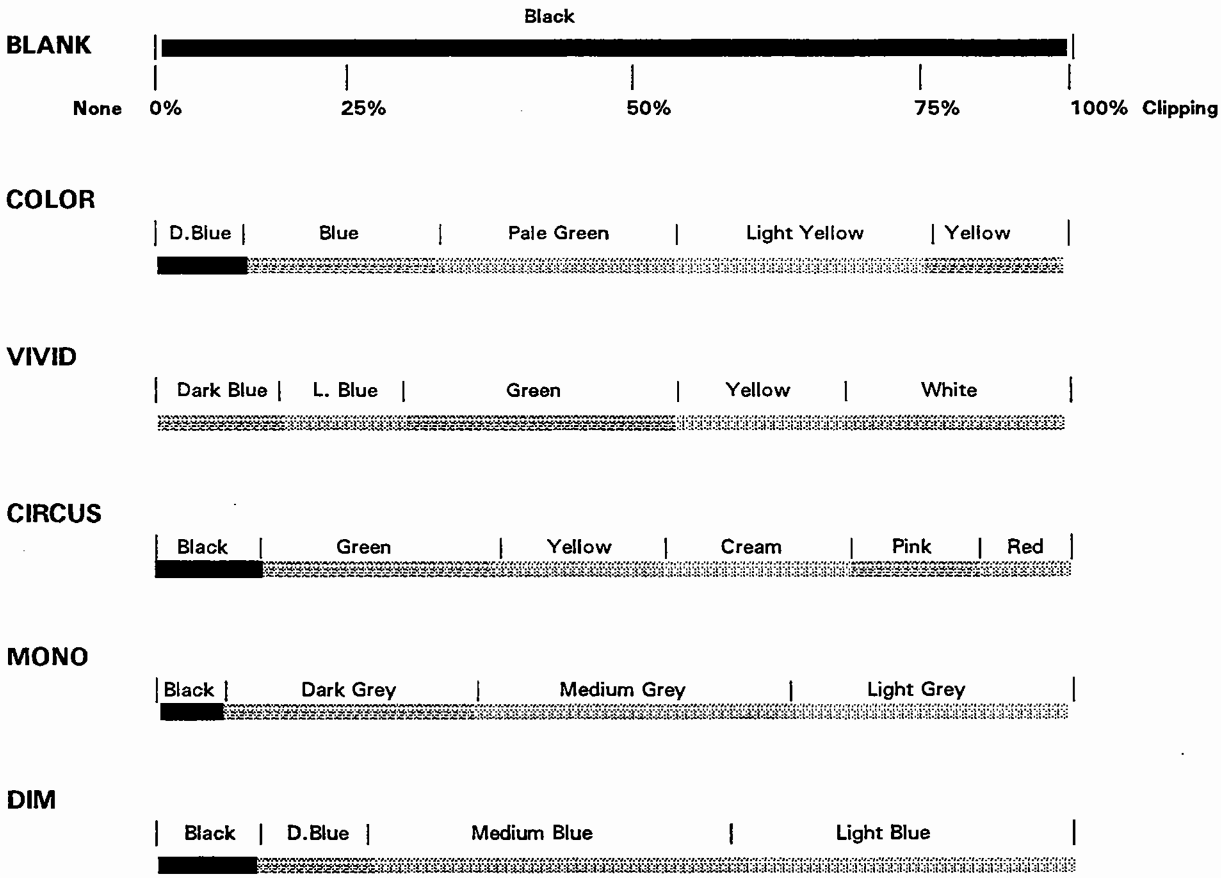


Figure 3-17. Logarithmic 30 dB Scale.

3.4.4.9 Palette

This feature allows the operator to display the sonar image in various colors, based on the signal strength. The scale selected (Linear, Log 20, or Log 30) determines the signal strength range, and is represented by 256 colors that are within each palette.

The palettes currently available, and their respective color ranges are:



3.4.4.10 Grid

This menu selection allows the operator to control the display of the border and scale lines around the sonar image wedge. The menu selections are:

FULL	:	Displays the border around the Sonar wedge area and the measurement scale lines.
BORDER	:	Displays only the border around the Sonar wedge area and no measurement scale lines.
DOTCHK	:	Usually only detected bottom points with a quality value of 3 are displayed.
OFF	:	Displays no border around the Sonar wedge area and no measurement scale lines.

3.4.4.11 Cursor

When the cursor is within the sonar wedge area, then the information displayed by the Menu selection labelled CURSOR, is the cursor position in reference to the sonar head (e.g., -4.85x -12.1z (distance in meters along the X and Z axis)).

If a Joystick is utilized (Opt. 002), then the button labeled "Ref Point", when depressed, will output the cursor position via Aux #1 port on the rear of the processor. See Paragraphs 4.2 and 7.6 for detailed descriptions of this feature and communication protocol.

3.4.4.12 Distance

When the cursor is within the sonar wedge area and the left pointer cursor button is pressed (or Ref Point button on the Joystick Control panel), a small square is displayed and anchored at the current cursor position. Now when the cursor is moved, the square stays stationary and the distance value displays the relative offsets between the square location and the current cursor position (e.g., -9.24 x 8.21z [distance in meters along the X and Z axis]).

To remove the anchored block from the screen, either move the cursor outside the wedge area and press the left button or press the left cursor button twice or, in the case of Joystick control, press Ref Point twice.

3.4.4.13 Date

Displays the computer date, or the Julian day number entered via Aux Port #3 (see Chapter 7.6.3). The format displayed is DD-MMM-YY, where DD is the day of the month, MMM is the month, and YY is the year. The date can be changed by following the procedures described in Chapter 3.4.3.

The date value is part of the profile data output from the Aux Port #2.

3.4.4.14 Time

Displays the computer time, or the time entered via Aux Port #3 (see Paragraph 7.6.3.). The format displayed is HH-MM-SS, where HH represents the hours within a 24 hour clock, MM is the minutes, and SS is the seconds. The time can be changed by following the procedures described in Paragraph 3.4.3.

The time value is part of the profile data output from the Aux Port #2.

3.4.4.15 Sound

This displayed value is the speed of sound through the water (in meters per second) that the SeaBat is utilizing to compute the measured distances and produce the sonar image. Additionally, the SeaBat 9003 uses this data to compute the seafloor profile.

As the SeaBat measures the time taken for the transmitted sound to return to the receiver it is important to enter the correct speed at which that sound travels through the body of water.

The SOUND menu item allows the externally measured speed of sound through the water to be entered into the SeaBat for its use. The range allowed is from 1400 to 1650 meters per second. If the sound velocity is not known, then a value from 1480 to 1500 is typical for open seawater areas.

The speed of sound through the water is determined by the temperature, conductivity and salinity of the water that the pulse travels through. To change this value, refer to the procedures described in Paragraphs 3.2.7 and 3.4.3.

The sound value is also part of the profile data output from the Aux Port #2.

3.4.4.16 Wedge

This feature allows the operator to rotate the display of the sonar image wedge to the same angle at which the Sonar Head is mounted. The allowable range if from -25° to +25°, and is entered in 1° increments. To change this value, refer to the procedures described in Chapter 3.4.3.

When this value is changed, the screen freezes for approximately ten (10) seconds while the system computes the orientation values, before resuming operation. The changing of the Wedge value does not affect the output of profile data from a SeaBat 9003. The output values are still based on a mounting angle of zero degrees (0°).

3.4.4.17 Block

This feature allows the operator to select a "minimum distance", in meters, from the SeaBat sonar head that will not be investigated to detect the seafloor. A value of one (1) meter is typical. To change this value, refer to the procedures described in paragraph 3.4.3.

CAUTION

When selecting a Block distance in an area near a shoal or a jetty/harbor wall, the SeaBat will be unable to detect objects and output their values if they are closer than the block distance entered.

3.4.4.18 Output

Data output is provided at a rate of 0.21 up to 15.15 profiles per second (see Paragraph 7.6.2.2). There are three output formats available (X,Z format, R-Theta, and RI-Theta), each are described in detail in Paragraph 7.6.2).

This menu selected allows the operator to select which format to output and also the speed that the data is transferred (Baud Rate). The selections available are:

X Z: 9600 baud
Rθ: 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 baud.
RIθ: 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 baud.

3.4.4.19 Side Scan Beam

This is described in Paragraph 4.19.

3.4.4.20 Side Scan Gain

This is described in Paragraph 4.19.

3.4.5 NORMAL SHUT-DOWN PROCEDURE

When operation is complete, simply flip the toggle switch on the front of the SeaBat processor to the OFF position, and then switch off the display monitor.

RESON strongly recommends that the daily maintenance procedures, outlined in Chapter 5 of this manual, be performed immediately after shut-down. It is especially important to care for the wet-end equipment as soon as possible.

CAUTION

Unplug each unit from the wall outlet if it is not to be used for several days or more. To disconnect the AC power cord, pull it out by grasping the plug. Never pull the cord itself.

NOTE

If the SeaBat Sonar Head is powered by an external power source, then ensure that the Power value displayed on the SeaBat screen is set to zero (0) prior to switching off the processor, as the external power source will still power the Sonar Head, and the Head continues to transmit using the settings previously selected.

CHAPTER 4 - OPTIONS AND UPGRADES

This chapter provides independent descriptions of the various options and upgrades that are available for the SeaBat 9003 Sonar Systems.

Information regarding the following equipment is contained in this chapter:

Opt. 001 - Color Display System (USA - 110V)
Opt. 002 - Joystick Input Control Panel
Opt. 004 - SeaBat Mounting Plate and Poles
Opt. 007 - SeaBat Cable Compensation System
Opt. 012 - Combine BNC Sync and Green Outputs
Opt. 013 - SeaBat "Class B" Repair Kit
Opt. 019 - Side Scan Sonar Upgrade

NOTE

Each option/upgrade description utilizes a page numbering system independent of that system contained in this manual.

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OPTION 001
COLOR DISPLAY SYSTEM (USA - 110V)

4.1 INTRODUCTION

A color display is integral to the operation of any SeaBat system, in that it displays the sonar data and provides control menus to the operator. The SeaBat processor's display outputs can be interfaced to many display units; however, RESON recommends the use of the SONY PVM 1344Q for use where 110V is available.

TABLE 4.1-1. SONY PVM 1344Q FEATURES

DESCRIPTION	SONY PVM 1344Q
110 VAC Power Supply	✓
Display Formats:	
PAL	✓
SECAM	✓
NTSC 3.58	✓
NTSC 4.43	✓
Input Formats:	
Video In: BNC connector	✓
Audio In: RCA Phono jack	✓
VTR: 8-pin connector	✓
Y/C-Input Video: 4-pin connector	✓
Y/C-Input Audio: phono jack	✓
EXT Sync: BNC connector	✓
Output Formats:	
Video Out: BNC connector	✓
Audio Out: RCA Phono jack	✓
Ext Sync: BNC connector	✓
Analog RGB: BNC connector	✓
CTRL S: Minijack	✓

4.1.1 SONY PVM 1344Q SPECIFICATIONS

Table 4.1-2 provides the general specifications of the SONY PVM 1344Q model. Refer to the original SONY Video Display manual delivered with the SeaBat system for more detailed descriptions of this display unit.

TABLE 4.1-2. SONY PVM COLOR VIDEO DISPLAY GENERAL SPECIFICATIONS

Dimensions	346 x 340 x 412 mm (w/h/d) 13 5/8 x 13½ x 16¼ inches
Weight	Approx. 16.5 kg (36 lb 5 oz)
Storage temperature range	-10°C to 60°C (32°F to 104°)
Operating Temperature range	0°C to 35°C (32°F to 95°F)
Humidity	0-90%
Power Requirements	110 VAC

4.1.2 CONNECTING THE COLOR DISPLAY SYSTEM

There are two methods by which the SeaBat processor can be interfaced with the Sony PVM 1344Q Color Display. Located on the rear of the SeaBat processor unit is an area labeled "Video Display Output" that provides four possible output formats. Figure 4.1-1 shows the two that can be used.

1. Four (4) BNC - R,G,B, and Sync.
2. One (1) Y/C - S-Video

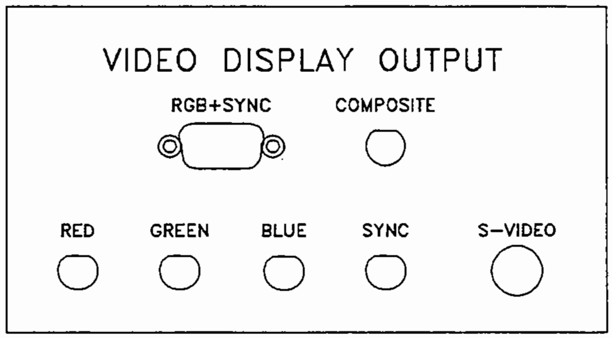

Figure 4.1-1. SeaBat Video Outputs

NOTE

The format of the video signal transmitted from the SeaBat processor is either PAL or NTSC, depending on the output format selected by the operator. To change the video output format from/to PAL/NTSC, hold down both trackball buttons or Joystick "Cursor Select" buttons and roll the trackball or joystick for approximately ten (10) seconds.

4.1.3 FOUR (4) BNC - R,G,B, AND SYNC

Connect the four (4) BNC connector cables to the 4x BNC outputs on the rear of the Sony display that are labeled "IN" under the IN and OUT groups labeled R/R-Y, G/Y, B/B-Y, and Ext. Sync. Connect the other end of each cable to the respective connection on the rear of the SeaBat processor. The horizontal and vertical synchronizing rates equal those of the NTSC and PAL video formats.

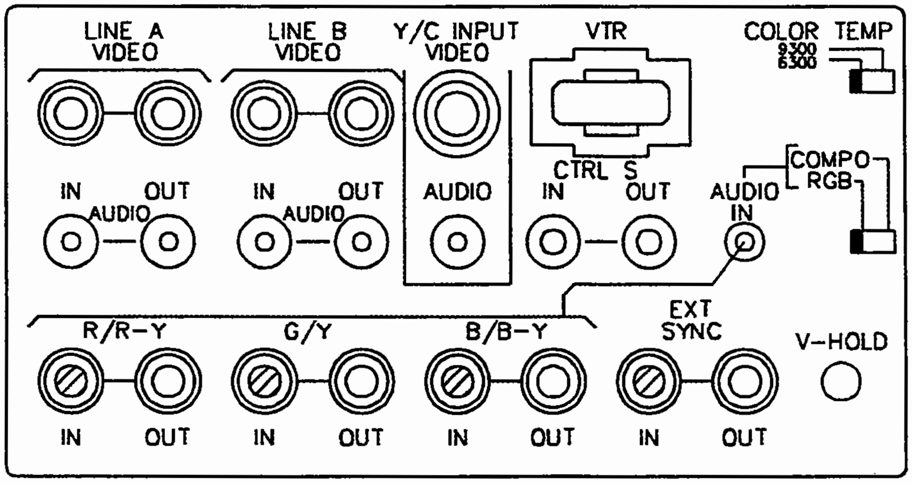

Figure 4.1-2. Sony Display Connection Plate

The Red, Green, and Blue outputs drive 0.75 volt peak-to-peak signals into 75 ohm terminated loads. The three (3) color outputs do not contain sync pulses. The Sync output drives a 4 volt peak-to-peak signal into an unterminated load.

Do not attempt to drive two (2) displays by using the four (4) BNC connectors and the 9-pin RGB connector simultaneously, the signal will be degraded.

4.1.4 S-VIDEO

This connection is primarily used for recording the display on a VHS video recorder, as the BNC connection provides a better image. To use this connection, an S-Video cable, (also known as Super Video, Y/C, or luminance/chrominance signals) is connected between the 'S-Video' connection on the rear of the SeaBat Processor (see Figure 4.1-1) and the 'Y/C Input Video' connection on the rear of the Sony display (Figure 4.1-2).

Luminance, synchronization, and blanking information are all combined into this one signal but the chrominance information is supplied on a second signal. These two outputs each drive a 75 ohm terminated load.

Table 4.1-3 provides a description of the Y/C (S-Video) connection, while Figure 4.1-3 shows the connector.

TABLE 4.1-3. Y/C (S-VIDEO) FEMALE OUTPUT CONNECTOR

PIN No.	SIGNAL	DESCRIPTION
1	Y-output	1 Vp-p, sync negative into 75 ohms
2	CHROMA sub-carrier-output	300 mVp-p into 75 ohms
3	GND for Y-output	GND
4	GND for CHROMA-output	GND

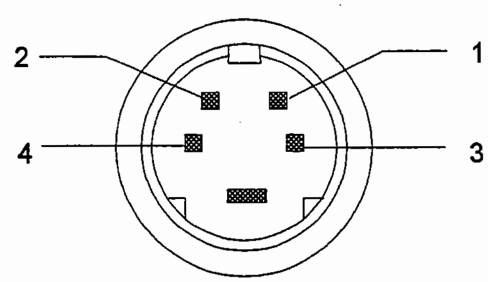

Figure 4.1-3. Y/C (S-Video) Connector.

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OPTION 002
JOYSTICK INPUT CONTROL PANEL

4.2 INTRODUCTION

There are two (2) Joystick Input Control Panels, Model TL8039 and Model TL8040. The only difference between the two models is that the TL8040 has additional buttons to externally control the tilt of the SeaBat (when the head is mounted on a tilt mechanism). Both models are available as a standard option to RESON SeaBat systems.

The Joystick Input Control Panel enables the operator to change selected displayed settings on the monitor screen and also allows measurements to be taken of objects of interest without moving the cursor. An important feature of the configuration of the Joystick is the placement of the buttons on the panel. Button arrangement has been accomplished to optimize operator performance and to allow changes to be made to the display without looking away from the screen. Reference Figures 4.2-1 and 4.2-2 for the schematic of both Joystick Input Control Panels.

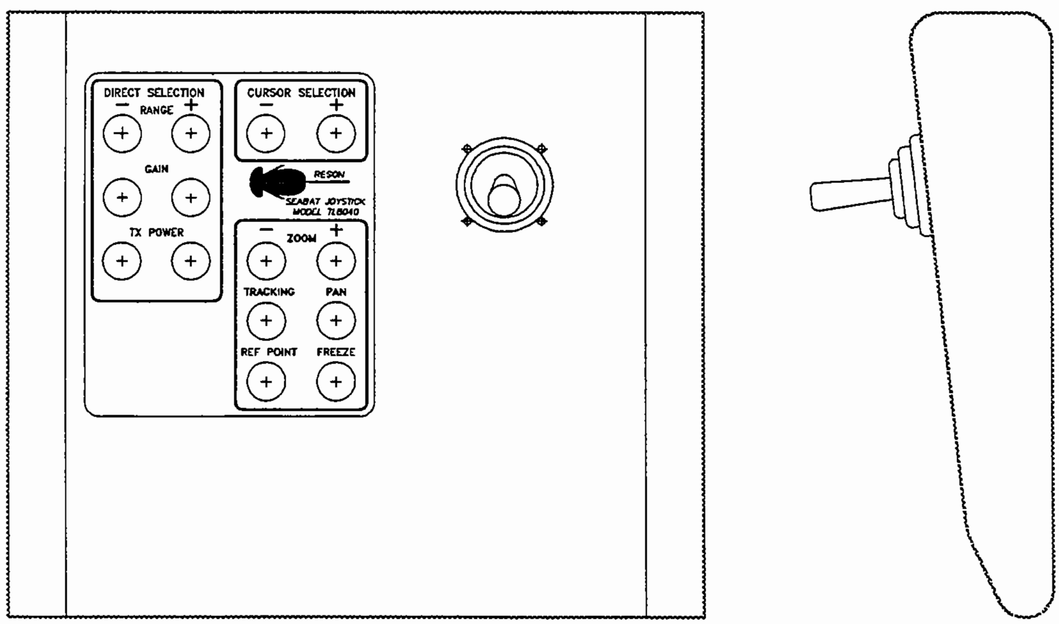


Figure 4.2-1. Model TL8039 Joystick Control Panel

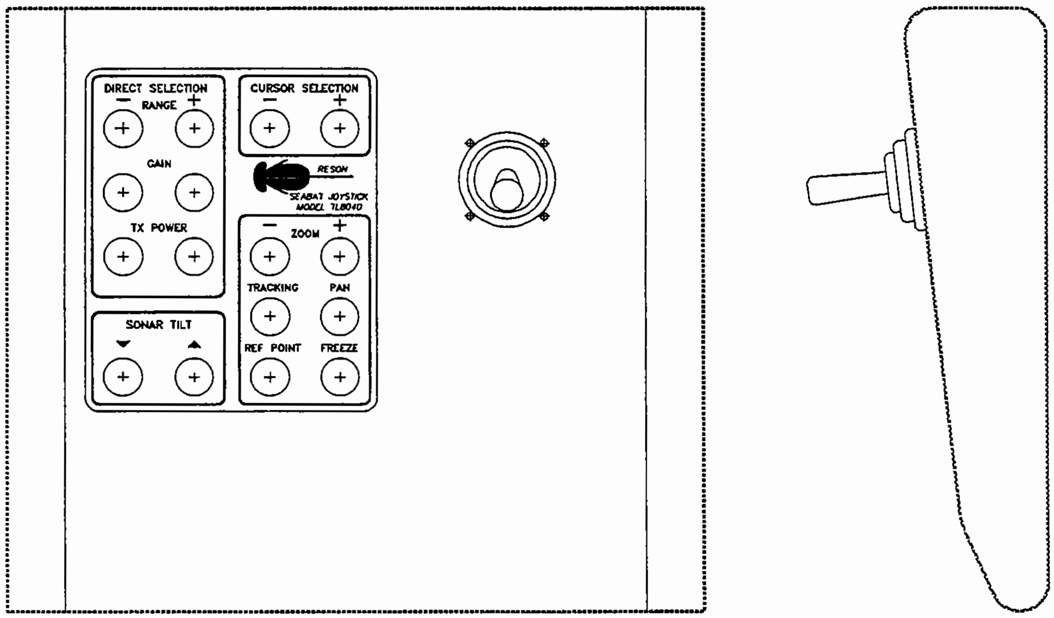


Figure 4.2-2. Model TL8040 Joystick Control Panel

4.2.1 CONNECTING THE JOYSTICK

Table 4.2-1 provides connector assignments for Joystick Input Control Panels (models TL8039 and TL8040). The Joystick can be connected to the pointing device plug on the front or the rear of the processor controller (see Figure 4.2-3). The power requirements for the Joystick are the ±12V provided by the SeaBat Processor unit. Reference Figures 4.2-4, 4.2-5 and 4.2-6 for the pin configurations of both models of Joystick Input Control Panels.

TABLE 4.2-1. PAN/TILT CONNECTOR ASSIGNMENTS		
Button	Pin No.	Contact
Tilt▲	1,2	OC, max xx V, yy A
Tilt▼	3,4	OC, max xx V, yy A
Note: Mating connector: Amphenol ###		

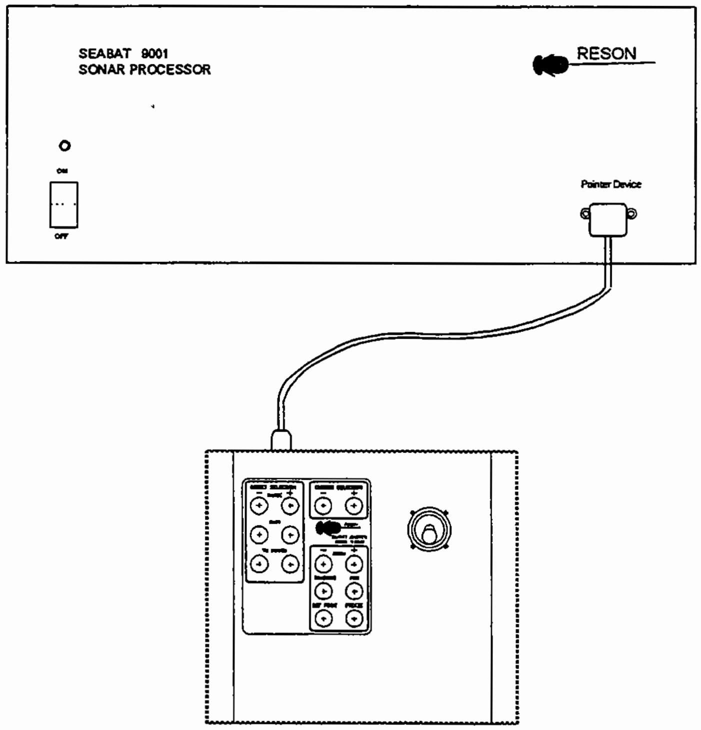


Figure 4.2-3. Connecting Joystick to Processor

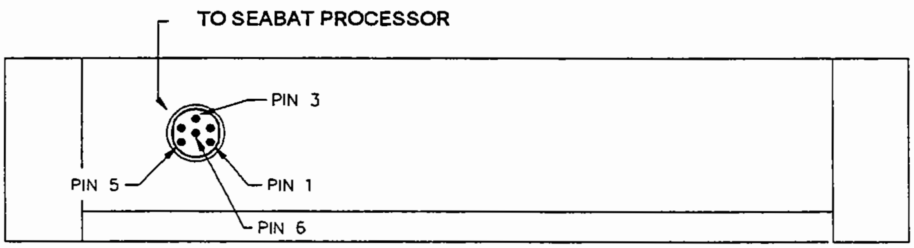


Figure 4.2-4. TL8039 Connections

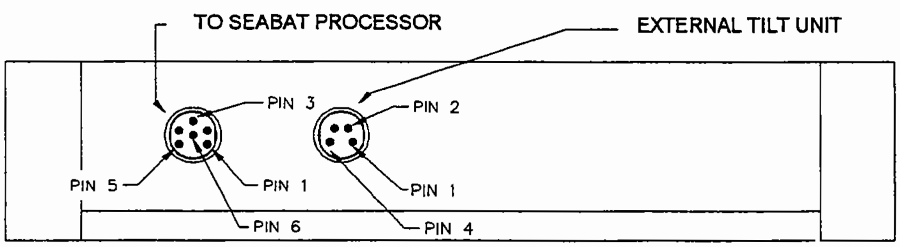
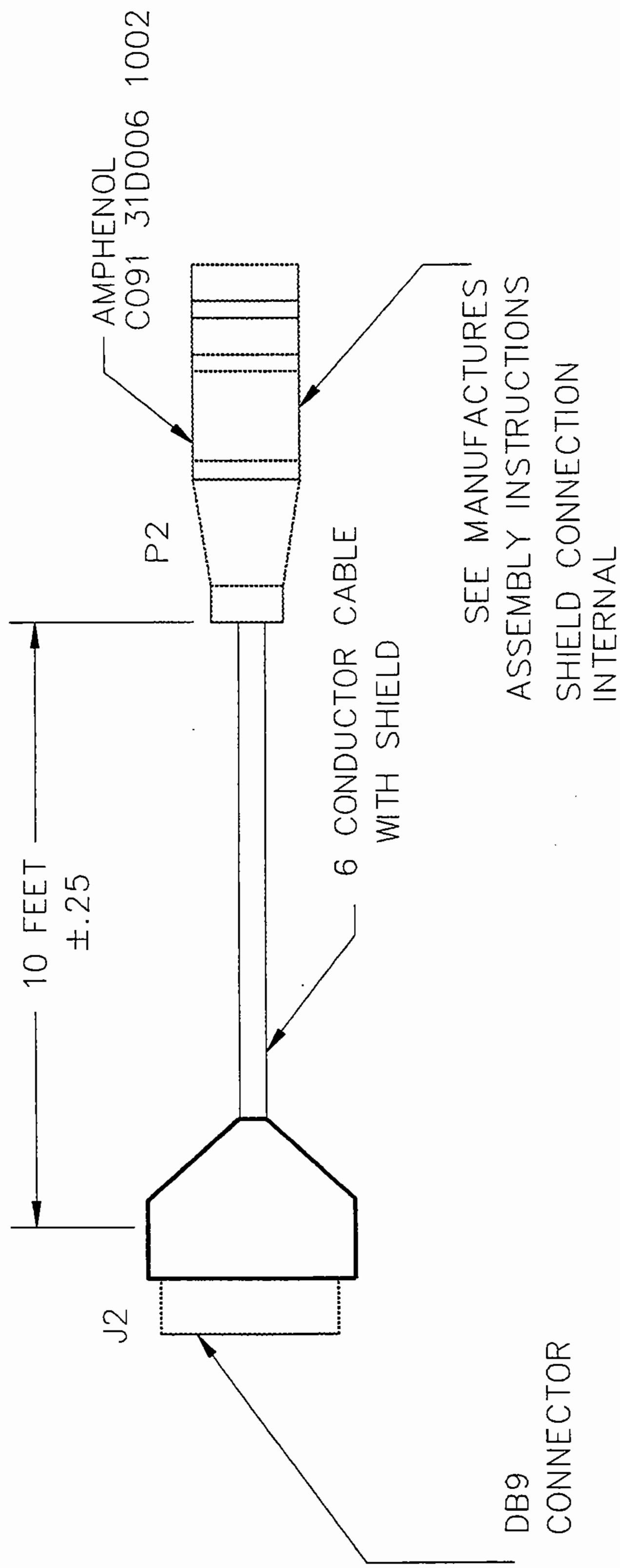


Figure 4.2-5. TL8040 Connections



FROM	TO	WIRE COLOR	MNEM
J2-2	P2-1	GRN	TXD-
J2-3	P2-2	BLU	RXD-
J2-HOUSING	P2-HOUSING	SHIELD	SHIELD
J2-9	P2-4	RED	+12V
J2-1	P2-5	BRN	-12V
J2-5	P2-3	BLK	GND

Figure 4.2-6. Joystick to SeaBat Cable Connections

4.2.2 JOYSTICK OPERATION

The Joystick can be utilized to move the cursor over the whole monitor area in order to select command functions or perform target tracking/measurements. The target position/distance measurements will be indicated digitally on the screen. The menus on the display screen can be accessed by selecting one of the buttons on the Joystick or by placing the cursor on the menu position and changing the settings by using the buttons. Refer to Figure 4.2-1 for Model TL8039 Control Button Configuration and Figure 4.2-2 for Model TL8040 Control Button Configuration. The following functions can be performed by selecting the appropriate control button:

RANGE

This menu item allows the operator to select seven (7) pre-determined range settings (2.5, 5, 10, 25, 50, 100, and 200 meters). Although the SeaBat 9003 system emits sufficient power to transmit to the maximum distance, this unit is designed to track the seafloor to a maximum depth of 75 meters.

GAIN

The gain option allows the operator to manually select the amount of Gain applied to the returned sonar signal. The range available is from 0 to 15, in 1 step increments. Each value increases the Gain by approximately 3.5 dB (the range, therefore, is from 3.5 to 56 dB).

TX POWER

The TX Power function controls the power emitted from the sonar head. This function is utilized to increase and decrease the Sonar Head Projector power. The effects of this increase or decrease will be seen on the screen. This menu allows the operator to select OFF and power levels 1 through 8 (8 = .5kW electrical).

SONAR TILT

The two (2) sonar tilt buttons are only available on the TL8040 Model, and are not connected to the SeaBat System. These buttons are designed to control the pan and tilt functions of an external unit (see Figure 4.2-5).

CURSOR SELECTION

Positioning the cursor on any menu item allows the operator to increase or decrease the value for that particular selection.

ZOOM

The zoom feature allows the sonar image to be displayed on a larger scale. The zoom settings available are OFF, x2, x4, x8, and x16 <u>or</u> until the data resolution equals the vertical screen resolution.

When this function is selected, the screen enlarges the "zoomed area" and displays the outline of the area with the 120° wedge outline at the apex of the sonar display.

To move the "zoomed area", move either the cursor within the wedged outline, or the cursor within the sonar image display, and press the right control button. In either case the "zoomed area" will be re-centered on the selected point.

When the zoom function is activated, it does not affect the update rate or quantity of data being processed. It only controls the portion of the sonar image being presented.

TRACKING

When the cursor is located within the sonar wedge area and the tracking button is depressed, the cursor coordinates that appear on the screen will be transmitted through the Auxiliary Serial Port #1 located on the rear of the Sonar Processor unit. Each time data is transmitted, the cursor briefly rotates to an "X".

PAN

This function only operates when you are at a certain level of ZOOM. If the operator sees a point of interest he can put the cursor on it and hit Pan and the object of interest will be centered on the sonar screen. The small wedge can be utilized also, by clicking the cursor onto the area of interest. The same area on the big wedge will be shown. This is especially useful if the item of interest is located at one of the far edges of the image.

REF POINT

When the REF Point button is utilized it will place a small white box on the screen. You can utilize this function to measure distances between two points (by clicking on to both ends of an image). The measurement reading can be seen on the Distance menu. To remove the ref point, press the Ref Point button twice.

FREEZE

When this feature is selected, the sonar image currently displayed is frozen, thereby allowing time for measurements and the review of data presented. This option is selected by toggling between Freeze ON and Freeze OFF. When Freeze ON is activated, the sonar transmit and data processing is still conducted, only the updating of the display of data is stopped.

CAUTION

When Freeze is ON, a test profile is output.

OPTION 004
SeaBat MOUNTING PLATE AND POLES

4.4 INTRODUCTION

Paragraph 2.4.5 provides a basic introduction to this Option. Typically, the mount design will vary from one installation to another, and the exact design of the mount will change.

To support demonstrations and acceptance testing on the SeaBat system, RESON has designed a versatile mount that, although is not perfectly suited to every vessel installation, is adaptable and meets the needs of mounting the SeaBat on a vessel of opportunity. If selected, RESON can assist in the manufacture and installation of your mount.

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OPTION 007
SeaBat CABLE COMPENSATION SYSTEM

4.7 INTRODUCTION

Because SeaBat users may require cable lengths of greater than the 25 meter cable supplied with the system for their various applications, and because signals will be lost or become weak if longer cables are used, RESON offers Option 007, the SeaBat Cable Compensation System. This system provides the method in which the processor is able to receive strong, uninterrupted signals from the sonar head even when cables of up to 5000 meters long are used.

This system is comprised of a Signal Generator, which provides a known signal that can be used to calibrate various cable lengths, and the Cable Compensation Box, which is the actual piece of equipment into which adjustments are made and calibration is performed.

4.7.1 SETUP PROCEDURE

Though the actual calibration and adjustment process may take only fifteen (15) to thirty (30) minutes to accomplish, additional time for setup will be required. Calibration and adjustment should be performed by qualified technicians. Figure 4.7-1 depicts the cable components.

- Disconnect the dry end of the Sonar Head cable from the Sonar Processor.
- Plug the dry end of the cable into the Cable Compensation System. Plug the Cable Compensator box (using its attached 2-meter cable) into the Sonar Processor.
- Disconnect the wet-end of the Sonar Head cable from the Sonar Head.
- Plug the wet-end of the cable into the Signal Generator and set it to 75-Ohm (standard for the SeaBat Sonar Head).
- Turn on all the power. Green lights should be displayed on the Cable Compensation System and Signal Generator boxes. If no lights appear, then the box is not receiving the specified 24 volts.
- Connect a 20 MHz or better oscilloscope to the "Sonar Uplink" BNC connector on the back of the Sonar Processor. Use a one or two meter long BNC-to-BNC patch cable. Set the scope to 0.2 volt/div and 20 uS/div. Use delayed-sweep or some other scope feature to allow the clear sighting of the entire rising edge. Use high-frequency reject trigger, because the Sonar Processor adds large asynchronous 100nS pulses and 14.2 kHz noise onto the square-wave. Do not be concerned with this noise as adjustments are made to the Cable Compensation System (the noise does not occur when a normal sonar signal is applied).

  The 5 kHz square-wave should appear at over 0.5 volt peak-to-peak with flat tops and bottoms (the leading edges may be rounded). If a sharp kink appears at the top and bottom of the wave a few microseconds after the rise and fall, inspect the cable for an impedance change (sometimes caused by cable damage or by mixing 50-ohm and 75-ohm pieces of cable).

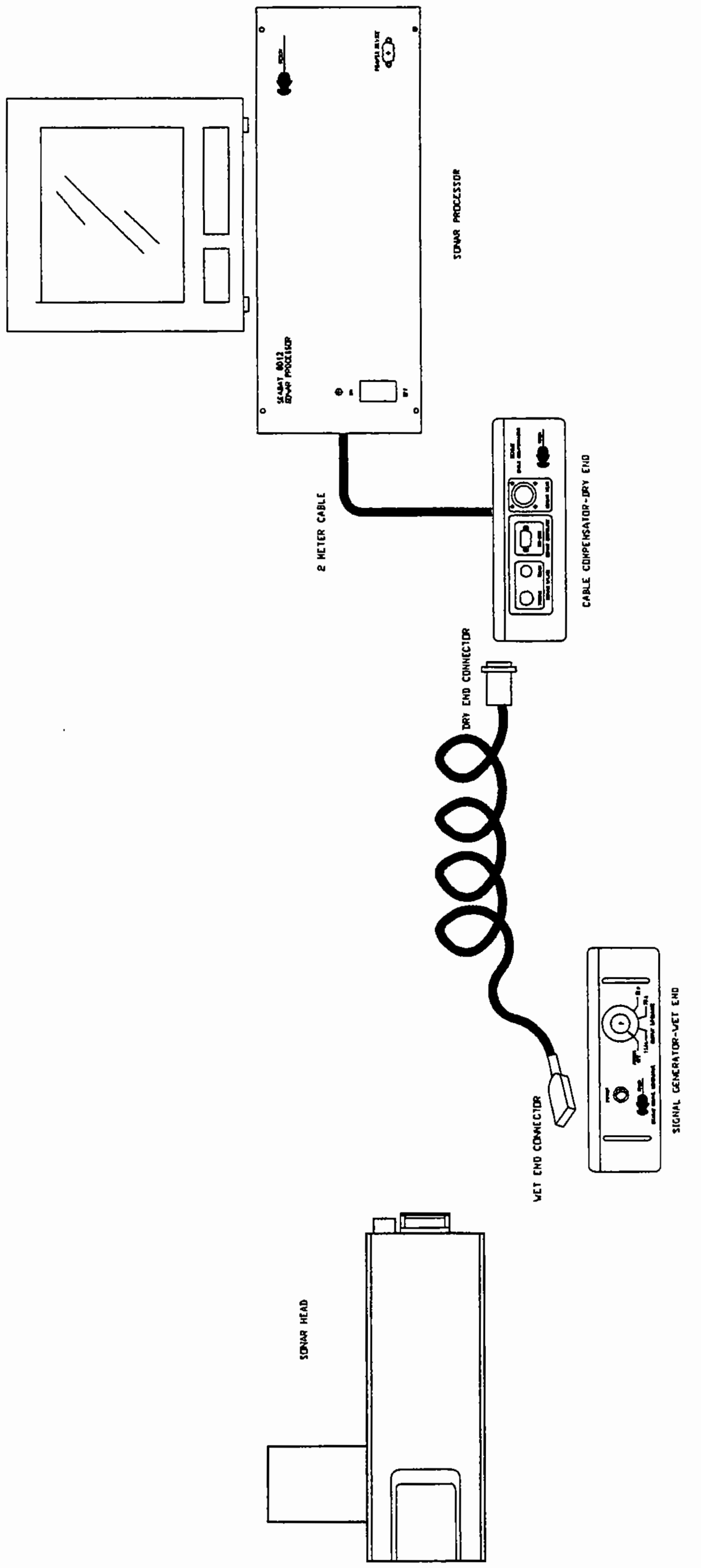

Figure 4.7-1. SeaBat Cable Compensation System Components

- Shut-Down power to the system. Remove the lid from the Cable Compensation System box. Inside are small rotary switches that adjust the amount of signal boost over several frequency bands. The rotary switches are turned while monitoring the square-wave on the oscilloscope. The goal is to achieve 1.0 volt peak-to-peak, a 0.5 microsecond or better risetime from 4% to 96% (not from 10% to 90%), and a flat top with less than 4% overshoot and ring.

  NOTE: 4% is one 2-millimeter sub-division on a 5-centimeter oscilloscope waveform.

- Refer to SeaBat Cable Compensation System Users Manual for detailed calibration and adjustment techniques.

Proper adjustment/calibration results in very good compensation (Figure 4.7-2), while improper adjustment/calibration results in marginal compensation (Figure 4.7-3).

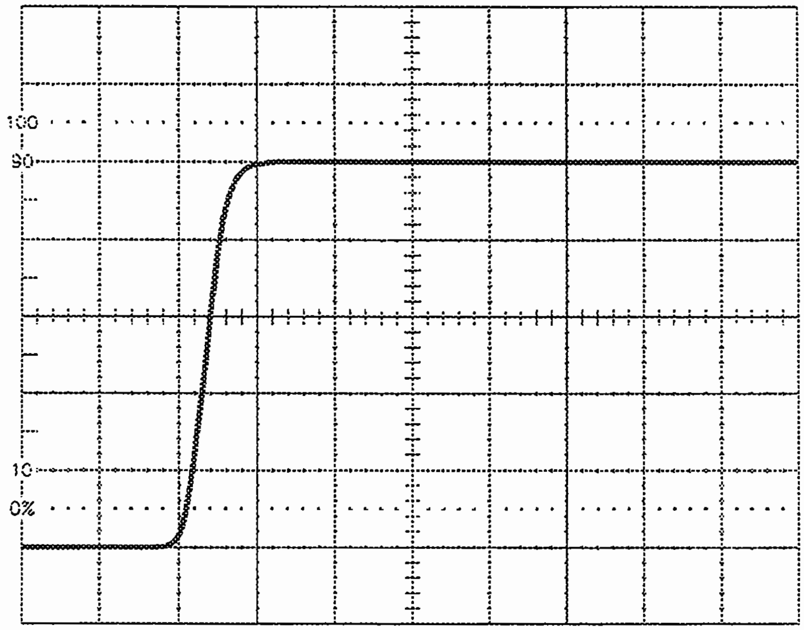

Figure 4.7-2. 0.5us/div, 0.2V/div, Very Good Compensation

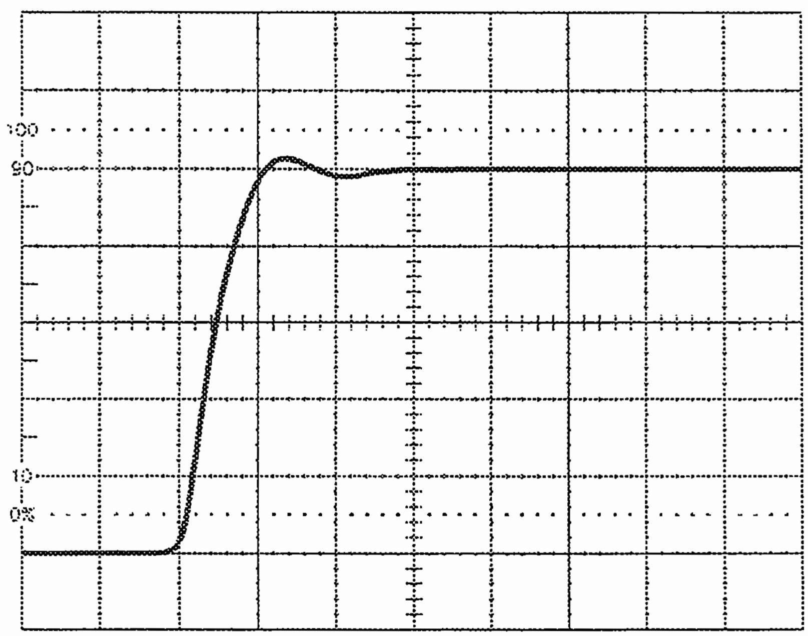

Figure 4.7-3. 0.5us/div, 0.2V/div, Marginal Compensation

OPTION 012
COMBINE BNC SYNC AND GREEN OUTPUTS

4.12 INTRODUCTION

There are four (4) different combinations of interfaces to a color display that are available on the SEABAT processor back panel; they are:

- Four (4) BNC - R, G, B, and Sync.
- 9-pin female - R, G, B and Sync.
- One (1) BNC - Composite.
- One (1) Y/C - S-Video.

Some RGB monitors; however, use only three (3) inputs (Red, Green + Sync, and Blue), rather than the typical 4-wire input configurations shown above (Red, Green, Blue, and Sync). For these units, RESON offers a Sync-On-Green Adapter. This adapter uses resistors to combine the green and sync signals.

4.12.1 INSTALLING THE ADAPTER

Figure 4.12-1 depicts the adapter connection at the rear of the processor. The six-pin male side of the adapter is attached at the RGB + Sync position and the other end is connected at the Sync output. This then provides the 3-wire configuration.

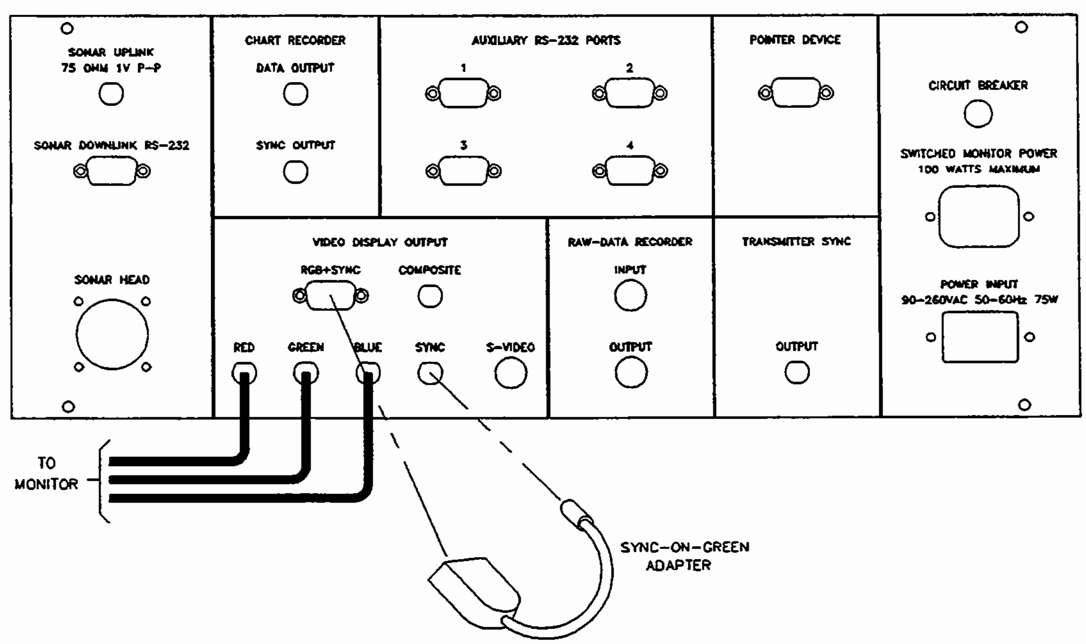

Figure 4.12-1. Sync-On-Green Adapter

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OPTION 013
CLASS B REPAIR KIT

4.13 INTRODUCTION

As mentioned and discussed in Chapter 5 - Maintenance, the SeaBat system requires minimum maintenance and any repairs that require the opening of the SeaBat sonar head are to be completed by a RESON trained technician.

This Option is therefore only of use to SeaBat customers who wish to maintain a basic level of spares for their RESON 'trained' technician to utilize for field repairs.

4.13.1 COMPONENT LIST

Part Number	Description
87000009	Class B Repair Kit, comprising:
75000040	Beamformer PCB - 6012/9001 Sonar Head, 1 ea.
75000060	Detector PCB - 6012/9001 Sonar Head, 1 ea.
75000070	Multiplexer PCB - 6012/9001 Sonar Head, 1 ea
75000080	Timing & Telemetry PCB - 6012/9001 Sonar Head, 1 ea.
75000190	Power Supply for Sonar head, 1 ea.
85000021	3 Meter SeaBat Cable pigtail, 1 ea.
81336146	Screws for removing Lid, 10 ea.
81134741	Screw for fastening SeaBat Lid, 50 ea.
83002279	O-Ring for SeaBat Lid (inner ring - lid), 2 ea.
83002280	O-Ring for SeaBat Lid (outer ring - housing), 2 ea.
85000022	Plastic Protective Fitting, 12 ea.
85000023	Zinc Block -Sacrificial Anode, 2 ea.
62000004	20-TAP, 2.0 usec delay line (for any of the 6 channels of the beamformer PCB), 4 ea.
82000005	Spring ground clips, 10 ea.
64500006	SeaBat Sonar Head Female Dummy Plug Protector - LPDC9F, 1 ea.
64500007	SeaBat Sonar Head Cable Male Dummy Plug Protector LPDC9M, 1 ea.
64500001	SeaBat Sonar Head Bulkhead Connector, 1 ea.
84000013	#902 "McKay" Zinc/Teflon Anti-Sieze, 1 can
80000003	Torque Wrench, 30"-140" lbs., Ratchet, 1 ea.
80000002	M3 Hex Key, for screw removal, 3 ea.
80000006	Center Punch, To aid in screw removal if needed, 1 ea.
84000003	Aqua Lube, O-ring grease, 6 oz.
84000012	#242 "LOCTITE" Threadlocker, 1 ea. 10 ml bottle

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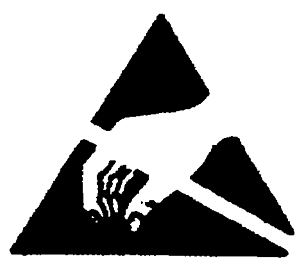
OPTION 014
EPROM UPGRADE

4.14 INTRODUCTION

The SeaBat 9003 Processor contains two sets of Erasable Programmable Read Only Memories (EPROMs). These semi-conductor memories contain the SeaBat Firmware software of the basic systems, as well as any options ordered by the customer (see Chapter 4) and are pre-installed within both the SeaBat Processor and the SeaBat Sonar Head. The EPROMs are erasable only via electronic pulses and are rated as Class 3 Sensitive.

WARNING

Class 3 EPROMs are susceptible to damage
from ESD voltages greater than 4,000 - 15,999 volts.



CAUTION

Contains parts and assemblies
susceptible to damage by
electrostatic discharge (ESD)

One set of EPROMS, type 27C010, is housed within the Sonar Processor and is replaceable in the field as upgrade (Option 014), please see paragraph 1.6 of this manual. The other set, type 27C64, is housed within the Sonar Head and is replaceable only at a RESON facility or by an Authorized RESON Service Technician. EPROMS are available to upgrade SeaBat Systems from their current Firmware Software Version to the most up-to-date and to provide options; such as, side-scan, switchability and configurations for dual-head upgrades. The latest version available (as of 1 February 1996) is Firmware Software Version X.YY, dated DY MON YR. Please refer to paragraph 4.14.2 for instructions on how to determine what version you are currently using and to Appendix C for a description of the changes made to each version.

For the purposes of this manual, additional information on the type 27C64 EPROMS will not be included, since they are not replaceable in the field. For comparative purposes; however, their specifications are provided in TABLE 4.14.1 at the end of this chapter.

NOTE

Refer to paragraph 1.7 for important information on Warranty Exclusions and Limitations and to paragraph 5.6 for service information.

WARNING

Do not expose EPROMS to UV light as this will cause erasure of the software data stored within

4.14.1 UPGRADE CHECKOUT

Upon receipt of Upgrade 014 (EPROMS U49 and U50), perform the following checks to insure that equipment was not damaged during shipping and that the EPROMS you ordered contain the software upgrades and/or options required:

- Check the labels on the EPROMS. One is marked U49 and the other is U50. The version number will also be noted.
- Count the pins, there should be 36 for each EPROM.
- Check that the pins are: equally aligned, are not bent, flattened or in any way damaged at their contact points and are secured to the base of the EPROM.
- Notice that one side of the base of the EPROM has a notch or indentation. This will be helpful later during installation.

After completing component checkout and ensuring that the EPROMS are not damaged, you are ready to perform system start-up to verify the software version number currently on your system (refer to paragraph 3.4 for start-up procedures).

Switch on the Display Monitor, allowing sufficient time for it to 'warm-up' and then switch on the SeaBat processor.

Within five [5] seconds of power up, the display will show the SeaBat version number and date for a period of five [5] seconds (Figure 4.14-1). Ensure that the EPROMS you received reflect a higher version number on their label (unless they are replacement EPROMS) than the version shown on the screen.

SeaBat 9003 Sonar Processor Firmware Ver. 2.16 7-FEB-96 Sonar Head Firmware 12-MAY-94

Figure 4.14-1. SeaBat 9003, Start-up Screen

CAUTION

Upon initial power-up, the screen will display two message lines, the first line shows the Processor Firmware version, and the second line states "Waiting for signal from Sonar Head". If the head does not respond, then after 5 seconds the operational screen will be displayed. This sequence indicated the system is not operational as the sonar head did not respond. For correct operation, the "Waiting for signal from Sonar Head" message should be replaced with the sonar head Firmware version number and date within 5 seconds and prior to the display of the operational screen.

The main display will now be presented; the SeaBat 9000 series will be a wedged area with the apex at the top of the screen.

4.14.2 EPROM INSTALLATION

The installation of the Upgrade EPROMs (type 27C010) can be accomplished in the field by anyone competent with a screwdriver and an IC Extraction Tool (EPROM Plucker).

WARNING

Ensure that the processor power switches are in the closed (OFF) position before performing EPROM isntallation.

---

1. Using a cross-hatched phillips screwdriver, remove the four screws from the processor lid. Set the screws aside in a safe place for later reinstallation. Notice the circuit breaker protection tab on the underside of the lid. Note the location for proper reinstallation of the lid later.

2. Locate EPROMS U49 and U50 in the Processor Controller Board. The board is etched to indicate where the EPROM indentation (notch) should be seated. The EPROM number is also provided.

3. Remove the new EPROMs from their packaging and set aside for installation. Set the package aside to receive the old EPROMs.

4. Using the IC Extraction Tool, gently rock the EPROM from left to right while pulling straight up from the 36 pin sockets. Be sure not to exert pressure in any one direction during extraction, since this can bend the pins. Remove both EPROMS and place in the packaging from the new EPROMS.

5. No tools are required to seat the new EPROMS. Assure that you have aligned the indented (notched) end of the EPROM with the indentation etched on the Controller Board. Placing the EPROM marked U49 at the Controller Board designation for that number, align the 36 pins of the EPROM with the 36 sockets of the Controller Board. Providing gentle and even pressure, insert the pins in the sockets.

   Assure that you have aligned the indented (notched) end of the EPROM with the indentation etched on the Controller Board. Placing the EPROM marked U50 at the Controller Board designation for that number, align the 36 pins of the EPROM with the 36 sockets of the Controller Board. Providing gentle and even pressure, insert the pins in the sockets.

6. Visually recheck that the indentations on the EPROM and the indentation etched in the Controller Board are aligned.

7. Visually check that the numbers on the EPROMs (U49 and U50) correspond to the numbers etched on the Controller Board.

WARNING

Be sure that the EPROMS are in their proper positions as indicated on the Controller Board. Improper placement can cause serious damage to the EPROMs and possibly blow the board.

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8. Secure the old EPROMs in the packaging from the new EPROMs and tape to the inside of the Processor lid. This ensures that there is always a backup immediately available should something happen to the EPROMS installed in the Processor Controller Board.

9. Pick up the processor lid and visually realign the circuit breaker protection tab over the circuit breaker (rear left of the processor). Place lid securely on the Processor, ensuring that the box taped inside the lid is not touching or obstructing anything on the Controller Board. Reinstall the four screws removed previously.

You have completed EPROM installation and are ready to verify the software. Repeat the procedures outlined in paragraph 4.14.1 and paragraph 3.4 for system start up. Perform System Check Out (paragraph 2.4.12) to verify system functionality.

4.14.3 SPECIFICATIONS

TYPE	CAPACITY	SPEED-ACCESS (ns)	SPEED-WRITE (ns)	CURRENT DRAIN-ACTIVE (mA)	CURRENT DRAIN-STANDBY (mA)	VOLTAGE (read/write)	# PINS
27C010	1 Mbits	150, 200, 250	2.5	30	0.1	5 V/12.75 V	32
27C64	64 kbits	200, 250, 350	5	30	0.140	5 V/12.75 V	28

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CHAPTER 5 - MAINTENANCE

5.1 INTRODUCTION

The SeaBat Series of Sonar Systems require minimum routine operator maintenance. However, as with all electronic equipment that is installed in a hostile environment, daily inspection and periodic maintenance ensures that when the system is required for a critical project, it performs to the high standards expected.

The following paragraphs provide step-by-step maintenance instructions (for those components that can be serviced by the operator in the field) to ensure the SeaBat system performs successfully.

WARNING

Exclusions to the warranty provided with the SeaBat apply under the following conditions:

- Improper site preparation and maintenance.
- Improper or inadequate maintenance by customer.
- Unauthorized modification of system.
- Opening of the Sonar Head by anyone other than an a RESON trained technician.
- Service provided by any but RESON Authorized Service Facility/representative.

Please review paragraph 1.7 of this manual (Warranty Information) for complete list of exclusions.

CAUTION

Prior to general or corrective maintenance of any component, disconnect the component from the power source.

5.2 INSPECTION

A basic inspection of the SeaBat system should occur at the beginning of each operational day. Perform the following:

1. Check the outside of the SeaBat processor for signs of damage or spillage of liquids.
2. Check the outside of the SeaBat sonar head for any signs of damage or corrosion.
3. Ensure that the two anodes are secure at the rear of the unit and that they are no less than half their original size of 24 x 31.25 x 13mm (.096 x .125 x .52in.). Please see paragraph 5.5.2 if replacement of the anodes is necessary.
4. Check the outside of the color display monitor for signs of damage or spillage of liquids.
5. Check all the interface cabling. Look for signs of damage; cuts, abrasions, exposed wires. Check that the connectors are securely fastened. Do not allow objects to rest on cabling.
6. Power-up the SeaBat to ensure that it is operating correctly.

Should your inspection raise any concerns, or a need for further investigation, then refer to the following maintenance sections or Chapter 6, Troubleshooting, for detailed procedures to follow.

5.3 DAILY MAINTENANCE

The following sections provide the recommended maintenance to be completed on a daily basis. Adhering to these tasks will ensure that the SeaBat system operates reliably.

NOTE

Keeping an Operator Maintenance Log is recommended to allow for scheduled maintenance and to track all procedures performed on the SeaBat throughout the year.

CAUTION

The processor surface unit should be turned off before connecting or removing the underwater cable.

CAUTION

Do not expose Dry-end surface equipment to saltwater.

5.3.1 SeaBat PROCESSOR

The only daily maintenance required for this unit is to ensure that it is kept clean by periodically wiping with a damp cloth. Disconnect the unit from it's power source when not in use.

5.3.2 SeaBat SONAR HEAD

The following maintenance tasks for the SeaBat sonar head should be completed:

- when the sonar head is removed from the water,
- prior to packing of the sonar head,
- after initial unpacking of the system,

1. Unplug the cable from the sonar head.
2. Rinse with fresh water and wipe off excess water and grease.
3. Place silicone grease (Dow Corning DC4 or equivalent) on the male connector attached to the sonar head.
4. If the sonar head is to be demobilized and/or packed away, then place the mating female dummy plug on the connector. Otherwise reattach the sonar cable to the sonar head.
5. Keep marine growth off the transducer face. This can be removed with a Scotch-Brite pad and water.
6. Keep grease, oil, and solvents off the transducer face.
7. Inspect the sacrificial anodes, and replace if necessary (see paragraphs 5.2 and 5.5.2 for further information).
8. Inspect the sonar housing carefully for corrosion, especially in areas where the anodized coating has been damaged.

CAUTION

To avoid salt damage/corrosion, be sure to rinse the wet-end unit with fresh water after each use.

5.3.3 POINTER DEVICE - PC-TRAC TRACKBALL

The PC-Trac does not require much maintenance; however, it should be dusted occasionally with a dry cloth. Use rubbing alcohol or commercial typewriter cleaner to wipe off fingerprints and smudges (avoid ammonia- or petroleum-based household cleaners). Just dip a cotton swab in the cleaner, rub the dirty area, and then wipe it off with a clean cloth.

5.3.4 SONY PVM COLOR DISPLAY

To maintain the as-new condition of the unit, periodically clean it with a soft cloth. Stubborn stains may be removed with a cloth lightly dampened with a mild detergent solution. Never use strong solvents such as thinner or benzine, or abrasive cleansers since these will damage the cabinet.

5.4 ONE (1) YEAR SCHEDULED MAINTENANCE

It is recommended that the complete SeaBat system is returned to a RESON facility for a system check-out, cleaning, and re-calibration check of the sonar head. Prior to shipping the system to RESON, refer to Paragraph 5.6, Service, for merchandise return instructions.

5.5 CORRECTIVE MAINTENANCE

The SeaBat Processor allows for no corrective maintenance to be performed in the field by other than RESON trained service technicians. The Sonar Head allows for very minimal corrective field maintenance. The following paragraphs do outline; however, procedures for components that can be maintained in the field, and while they are minimal, they are nonetheless very important.

5.5.1 SeaBat PROCESSOR

There is no corrective maintenance required for the SeaBat processor.

WARNING

Servicing of the SeaBat processor should be performed by authorized RESON service facilities/representatives only.

5.5.2 SeaBat SONAR HEAD

The only corrective maintenance procedure required for the SeaBat sonar head is the replacement of spent or damaged anodes. Anodes must be replaced if they have degraded to less than half their original size (please see paragraph 5.2 for measurements) or if they have been damaged or cracked.

Items required to replace the anodes are:

- New anodes, hex nuts and washers
- Hex-key
- Dow grease

These parts can either be purchased separately from RESON or can be purchased as On Board Spare Kit 2 (contact your nearest RESON representative for further information).

Using the hex-key, extract the hex nut from the Sonar Head housing and through the anode. A washer is in-place behind the anode. Remove it.

Thread the hex nut through the anode, the washer and hand-tighten to the Sonar Head housing. Be sure the washer is in place behind the anode and in front of the sonar head housing. This washer ensures circulation of water between the two pieces of equipment.

WARNING

Servicing of the SeaBat sonar head should be performed by authorized RESON service facilities/representatives only.

5.5.3 POINTER DEVICE - PC-TRAC TRACKBALL

If the PC-Trac trackball is dirty, or if something should spill on it, then follow these steps for cleaning the inside:

a. Turn off the SeaBat Processor.

b. Turn the PC-Trac trackball upside down. Holding the unit together firmly, remove the three screws in the bottom of the case.

c. While continuing to hold the top and bottom halves of the case together, turn the PC-Trac right side up. Remove the cover.

d. Lift the ball out. Clean the ball and the parts of the three roller surfaces (Figure 5-1) that come in contact with the ball (do not remove needed oils on the shaft). Use a good detergent cleaner on the ball and rubbing alcohol or typewriter cleaner, on a cotton swab or clean cloth, to clean the hubs.

e. When all parts are clean and dry, replace the ball, the cover, and the screws.

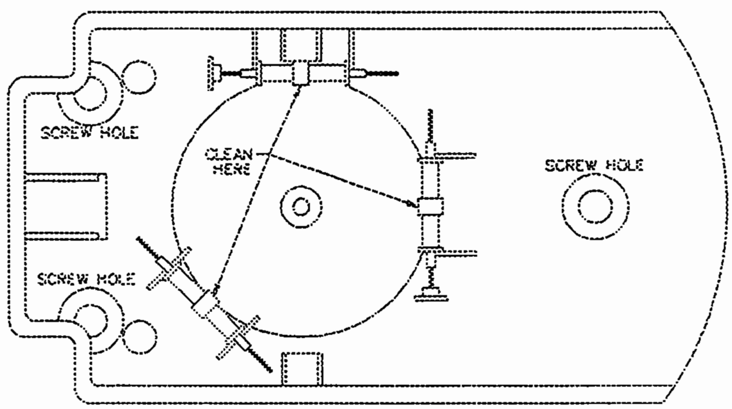

Figure 5-1. "PC-Trac Trackball"

5.5.4 SONY PVM COLOR DISPLAY

Corrective maintenance of the Sony PVM color display is warranted if:

- the power cord or plug is damaged or frayed,
- liquid has been spilled into the set,
- the set has been exposed to rain or water,
- the set has been dropped or the cabinet is damaged,
- the set exhibits a distinct change in performance, or
- the set does not operate normally when following the operating instructions.

Please refer to the original manufacturer's operation manual supplied with the display unit.

WARNING

To reduce the risk of electrical shock, do not remove cover (or back) of unit. Refer servicing to qualified personnel.

WARNING

Adjust only those controls that are specified in the operating instructions. Improper adjustment of other controls may result in damage requiring extensive work by a qualified technician to restore the set to normal operation.

WARNING

Do not attempt to service the unit, since opening the cabinet may expose you to dangerous voltage or other hazards. Refer all servicing to qualified personnel.

5.6 SERVICE

If you are experiencing difficulty with your SeaBat system and have tried all of the trouble shooting procedures (Chapter 6), then contact the **SeaBat Service Department** at the following addresses for further instructions:

RESON, Inc.	RESON SYSTEM A/S	RESON SYSTEM UK
300 Lopez Road	Fabriksvangen 13	Methlick
Goleta, CA 93117	3550 Slangerup	Aberdeenshire, AB41-0EL
U.S.A.	Denmark	United Kingdom
Tel#: 1-805-964-6260	Tel#: 45-47-38-0022	Tel#: 44-651-806-888
Fax#: 1-805-964-7537	Fax#: 45-47-38-0066	Fax#: 44-651-806-889

Before returning any equipment for service, you will need to follow the standard RESON return procedure:

1. Contact a RESON office to obtain an approved RMA (Returned Merchandize Number) number.
2. Complete the Failure Analysis Report Form (Appendix B).
3. Pack the equipment in the original shipping containers, enclosing a copy of the Damage Report.
4. Ship the equipment to your RESON representative at the applicable address to the attention of: SeaBat Service Department. Also state on the shipping label the RMA Number.

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CHAPTER 6 - TROUBLESHOOTING

6.1 INTRODUCTION

This chapter addresses the steps that the field operator can take to determine the cause of any problem that may occur with the SeaBat 9003 system. Should a problem occur within the SeaBat Sonar head or Processor, then as a minimum, a RESON trained technician with a Field Spares Kit should be commissioned to complete the field repairs.

It is expected that the typical SeaBat operator will use this guide to locate the problem, and should it be outside of the SeaBat units, then correct the problem, otherwise reference the problems on the enclosed 'Failure Analysis Report Form' (Appendix B) and return the damaged unit to a RESON facility for repairs.

6.2 TROUBLESHOOTING GUIDE

Table 6-1 provides troubleshooting procedures for problems that could occur while operating the SeaBat system. To use this troubleshooting guide, simply read through the problem column until you reach the one you are experiencing. Should you not locate a reference to your problem, please refer to Chapter 5.6 - Service to obtain phone numbers for the nearest RESON office, where technicians will be able to answer your questions.

TABLE 6-1. TROUBLESHOOTING PROCEDURES

<table>
<tr><th colspan="2">PROBLEM</th><th>CAUSE</th><th>REMEDY</th></tr>
<tr>
<td>1</td>
<td>One or more dark spokes in sonar data area.</td>
<td>This is typically caused by either a bad beamformer or detector channel(s). Could also be a bad MUX channel, however, this is very unlikely.</td>
<td>
This requires the replacement of the defective board in the Sonar head. This is only accomplished by a RESON trained technician.

To assist the determination of which board is defective, follow these steps:

1. Use the following formula to determine the beam number (e.g. 0-39):

$$B = INTEGER\left(\frac{\alpha + 60.5}{3.0}\right)$$
where α = angle of the dark spoke in degrees.

α may be found by the following:

α = - arctan(x / z), where x and z are the cursor position readout.

2. Using the computed 'α' value, determine which beamformer or detector board/channel is causing the problem.

<table>
<tr><th>Beam # (B)</th><th>Beamformer Board/Chan</th><th>Detector Board/Chan</th></tr>
<tr><td>0</td><td>1/1</td><td>2/1</td></tr>
<tr><td>1</td><td>1/2</td><td>2/2</td></tr>
<tr><td>2</td><td>1/3</td><td>2/3</td></tr>
<tr><td>3</td><td>1/4</td><td>2/4</td></tr>
<tr><td>4</td><td>1/5</td><td>2/5</td></tr>
<tr><td>5</td><td>2/1</td><td>2/6</td></tr>
<tr><td>6</td><td>2/2</td><td>2/7</td></tr>
<tr><td>7</td><td>2/3</td><td>2/8</td></tr>
<tr><td>8</td><td>2/4</td><td>2/9</td></tr>
<tr><td>9</td><td>2/5</td><td>2/10</td></tr>
<tr><td>10</td><td>3/1</td><td>1/1</td></tr>
<tr><td>11</td><td>3/2</td><td>1/2</td></tr>
<tr><td>12</td><td>3/3</td><td>1/3</td></tr>
<tr><td>13</td><td>3/4</td><td>1/4</td></tr>
<tr><td>14</td><td>3/5</td><td>1/5</td></tr>
<tr><td>15</td><td>4/1</td><td>1/6</td></tr>
<tr><td>16</td><td>4/2</td><td>1/7</td></tr>
<tr><td>17</td><td>4/3</td><td>1/8</td></tr>
<tr><td>18</td><td>4/4</td><td>1/9</td></tr>
<tr><td>19</td><td>4/5</td><td>1/10</td></tr>
<tr><td>20</td><td>5/1</td><td>2/11</td></tr>
<tr><td>21</td><td>5/2</td><td>2/12</td></tr>
<tr><td>22</td><td>5/3</td><td>2/13</td></tr>
<tr><td>23</td><td>5/4</td><td>2/14</td></tr>
<tr><td>24</td><td>5/5</td><td>2/15</td></tr>
<tr><td>25</td><td>6/1</td><td>2/16</td></tr>
<tr><td>26</td><td>6/2</td><td>2/17</td></tr>
<tr><td>27</td><td>6/3</td><td>2/18</td></tr>
</table>
</td>
</tr>
</table>

PROBLEM		CAUSE	REMEDY
			28 6/4 2/19 29 6/5 2/20 30 7/1 1/11 31 7/2 1/12 32 7/3 1/13 33 7/4 1/14 34 7/5 1/15 35 8/1 1/16 36 8/2 1/17 37 8/3 1/18 38 8/4 1/19 39 8/5 1/20
2	No uplink signal. Using an oscilloscope, you see no sync pulse on the uplink signal.	If you are sure that there is no uplink signal coming from the sonar head, the problem is most likely the MUX board in the Sonar head.	Before calling a RESON technician, be sure that the uplink cable is not connected to some sort of power source such as 24 volts or the vehicle lights. Normally, uplink driver death is caused by applying some sort of power to the uplink output pins.
3	No sonar data or noise looks constant over whole range. Otherwise, system appears to work normally.	Normally a case of damaged receivers in the Sonar head. This is usually caused by a bad power supply board or a bad TLM board. Power supply problems are usually caused by the loss of the +1.250 volt supply (LOBIAS) or the +4.000 volt supply (HIBIAS). A bad TLM board will show up as a loss of TVG ramp (best viewed in the 100 meter range at a gain setting of 9).	The Sonar head requires replacement of the defective board(s) by a RESON trained technician.
4	Receiver noise does not look normal - either looks too quiet or extremely noisy. Best observed on the 100 meter range at a receiver gain of 9.	Receivers are picking up excess noise or are oscillating causing the receivers to saturate. Excess noise pickup is normally due to the transducer array being too close to wires carrying noisy signals like motor power or AC power.	The remedy is to move the head away from the wires or move the wires away from the head. Most of the time, just immersing the head in water will solve the problem.
		Problem can also be caused by a damaged T/R switch in the Sonar head.	The Sonar head requires replacement of the defective T/R switch by a RESON trained technician.
		Problem could also be caused by poor grounding via the grounding spring clips mounted internally between the Sonar housing and it's lids.	The Sonar head requires opening by a RESON trained technician and the replacement of the defective grounding clip(s).
5	Transmit power is low especially at the lower ranges.	If the transmit power appears to be normal at longer ranges but reduced at the shorter ranges, then the problem is most likely due to the transmitter capacitor bank charging circuit in the Sonar head.	The Sonar head requires replacement of the defective components by a RESON trained technician.
		Other problems that can cause these symptoms are a bad pass transistor or bad power control circuitry on the transmit board, both are located in the Sonar head.	The Sonar head requires replacement of the defective components by a RESON trained technician.
6	Transmit power is low or non existent.	The suspect components are the TLM board (unlikely), bad transmitter board, bad output transformer, or capacitor bank charging circuit, transmitter wire from the main mother board to the receiver mother board, or the switching transistors on the receiver mother board. All these components are located in the Sonar head.	The Sonar head requires replacement of the defective components by a RESON trained technician.
7	Sonar head appears completely dead.	Blown 4 amp fuse in the Sonar head, check that power supplied to the head is a maximum of 2 amps prior to replacing the unit.	The Sonar head requires replacement of the blown fuse by a RESON trained technician.

PROBLEM		CAUSE	REMEDY
8	Image on the display screen shows yellow (palette = color mode) chunks.	The sonar uplink is possibly bad. This could be caused by uplink not connected properly (see the installation section) or by having a length of uplink cable that is the wrong impedance.	Check the cable and replace where necessary.
9	Image on the display screen looks normal at first, but odd lights appear on the display.	This indicates that damage to the Sonar processor has occurred.	The Sonar Processor requires replacement or repair by a RESON trained technician.
		It is remotely possible that the 2x EPROM's on the Processor mother board (U49 & U50) have become unseated.	Open the Processor cover, locate EPROMS U49 & U50 and ensure that they are seated correctly.
10	Any problems that appear to be a sonar processor problem.	Besides checking for the obvious such as broken wires, any problem with this unit requires the servicing by a trained RESON technician.	The Sonar Processor requires replacement or repair by a RESON trained technician.
11	Displayed image and/or text is hard to read.	A slight rainbow effect is normal, though should not be excessive. Try another type monitor.	Replace the monitor with another one.
		Hard to read text could be the result of the monitor not working well with interlaced video. The dots on the diagonal edges of the grid should be evenly spaced.	Replace the monitor with another one.
12	Processor and display monitor won't power-up.	The defective unit is unplugged or the wrong power line voltage has been applied.	Check that the AC power cord is not unplugged and/or power switches are in the OFF position. Check the line voltage for proper power (Processors requirements are 110 to 240 VAC, 50-6- Hz).
13	Nothing is displayed on the monitor screen.	Incorrect wiring versus selections between the Sonar Processor and Color Display.	Ensure that the display monitor is connected to the SeaBat processor and that the correct interface selection is made on the display monitor control panel, to reflect the cable connections.
		Brightness and/or Contrast settings are incorrectly set.	Check that the contrast and brightness controls are properly set.
14	"Awaiting Sonar Uplink" message is displayed, but no message saying sonar head is responding.	The Sonar head is not connected to the Processor.	Check the connection from processor to sonar head. It is either disconnected or defective. The sonar head is not receiving at least 20 VDC.
		The processor is receiving a poor quality uplink signal.	Attach the 25 meter test cable directly from the processor to the sonar head to test the system.
15	Sonar image displayed within the wedge area does not appear to be accurate.	The Power value is incorrectly set.	Increase the Power and Gain Values, or use the AUTO Power setting..
		The Range selected is too short to reach the seafloor.	Decrease or Increase the Range value until the range displayed covers the seafloor area.
		The left most beam is too dim, accompanied by a periodic brightness of the entire 120° image.	The uplink cable signal is distorted. Check the impedance.
16	The cursor on the screen does not respond to the pointer device.	The pointer device is not connected to the Processor.	Check that pointer device is connected to the processor. Connect another pointer device if required.
		Two Pointer devices are connected to the Processor (one at the front, and one at the rear).	Disconnect one of the Pointer devices.

	PROBLEM	CAUSE	REMEDY
17	The changes made by the Operator to the menu values are not reflected in the sonar image.	This indicates downlink problems.	Check that the wiring feeding the downlink input for proper polarity signal (RS-422 vs RS-232); baud rate, data structure and connectors. Attach the 25 meter test cable directly from the processor to the sonar head to test the system.
18	Playback of the recorded video does not reflect the real-time image. The image is distorted, appears to be folded or rolls vertically.	Incorrect selection of the Video output format (PAL or NTSC).	Check that the VCR recorder is recording in the same (NTSC vs PAL) format as the processor/display.
End:			

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CHAPTER 7 - SYSTEM INTERFACES

7.1 INTRODUCTION

All SeaBat systems are equipped to interface with various external components. Some of these components are necessary to properly operate the system, while others are optional. All interface connections are managed by the SeaBat processor, with the majority made at the rear of the nineteen inch (19") rack mountable unit. See Figure 7-1 for the back panel layout.

This chapter provides both the basic descriptions of each interface, plus technical information as to the exact wiring and protocol required for successful operation. The eight (8) groups of interfaces available are:

1. Power Connection
2. Sonar Head to Processor
3. Video Display Output
4. Chart recorder
5. Auxiliary RS-232 ports
6. Raw-Data Recorder
7. Pointer Device
8. Transmitter Sync

The following paragraphs provide the various methods for proper interfacing of external components.

WARNING

Do not vary the interfacing procedures outlined in this chapter. Severe damage can be caused to the sonar equipment if the external components are improperly connected.

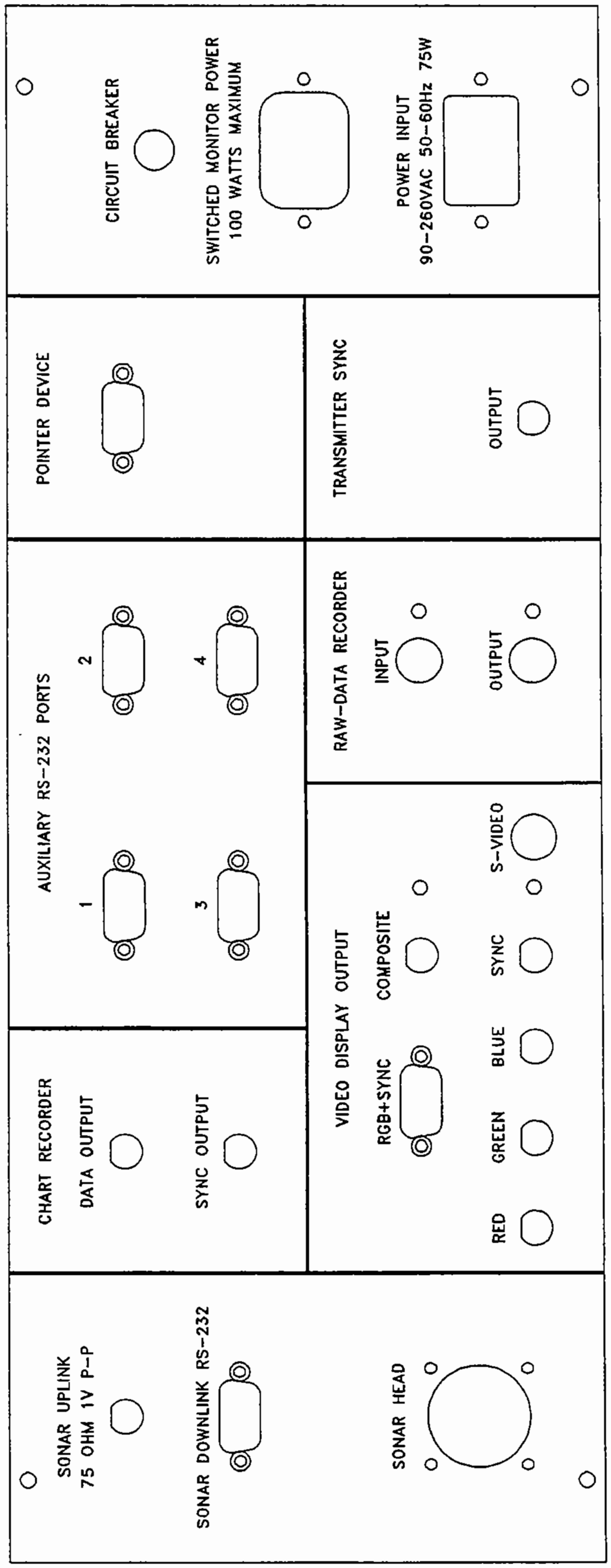


Figure 7-1. SeaBat 9003 Processor Interface - Back Panel

7.2 POWER CONNECTION

The first and most important connection is the power supply. The power connection and required voltage varies for each component. Chapter 1, General Information, provides both technical and general information regarding the external components recommended by RESON. Operation and power requirements (obtained in user manual supplied with the external components) should be adhered to for correct interface.

SeaBat Processor

The main power supply connection is located at the right rear of each SeaBat processor. The processor has an switching power supply that allows the system to operate from 90 to 260 VAC and between 47 and 440 Hertz. Ensure that all system connections are secure prior to connecting the processor to the main power supply and switching on the system.

SeaBat Sonar Head

The standard 25 meter Processor unit to Sonar Head test cable enables the processor to provide the necessary power to the sonar head. If a custom wiring configuration is utilized, then ensure that the power received at the sonar head is 24 VDC (range 22 to 28). The maximum current consumption is 2 amps.

7.3 SONAR HEAD TO PROCESSOR

The sonar head is connected to the processor to achieve the three following objectives:

1. To provide power to the sonar head. The requirement at the head is 24 volts DC with a peak current of 2 amps.
2. Transmit all the operator commands from the processor to the sonar head (Downlink).
3. Transmit all the sonar data from the sonar head to the processor (Uplink).

There are two (2) main methods by which the processor can be connected to the sonar head:

1. Utilizing one (1) standard cable, connected from the "Sonar Head" connection on the rear of the processor to the sonar head.
2. Using a custom connection, where an existing cable (i.e., ROV umbilical) is used between the "Sonar Uplink" and "Sonar Downlink" connectors on the rear of the processor and sonar head.

The following sections provide descriptions on these methods and the various cable configurations possible, while Figures 7-2 and 7-3 provide diagrams showing the interface requirements at the processor and sonar head, and Figure 7-4 shows the uplink data format. Refer to Chapter 9 - Parts List.

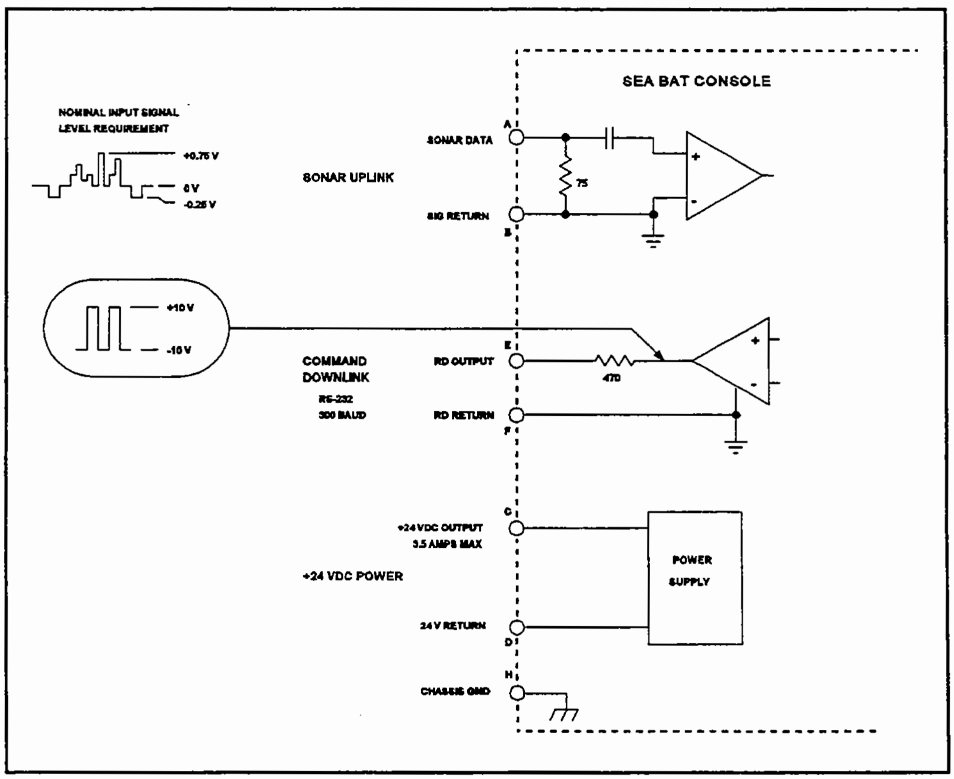


Figure 7-2. SeaBat 9003 Processor Interface

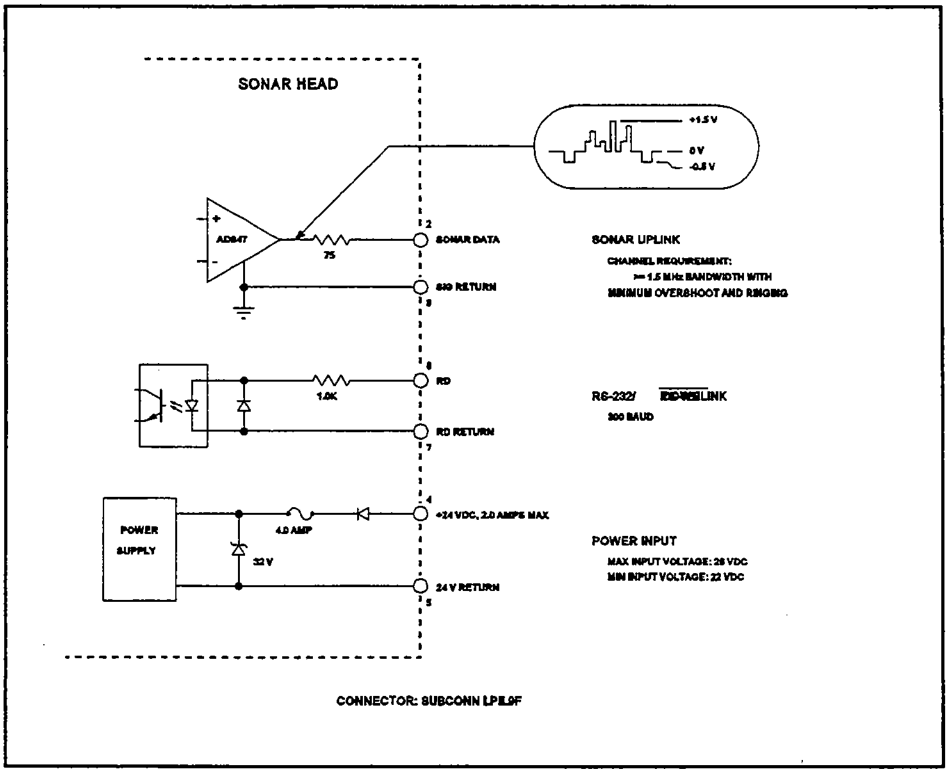
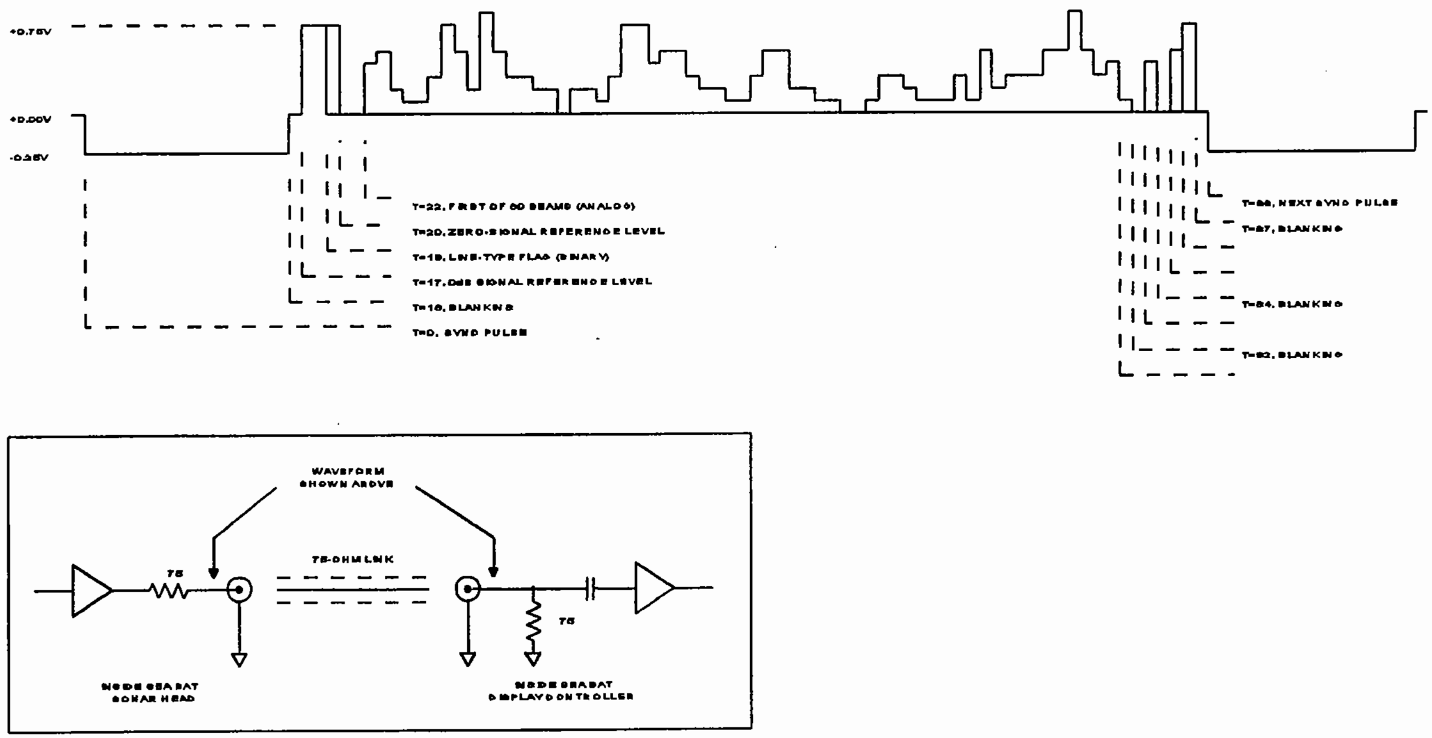


Figure 7-3. SeaBat 9003 Sonar Head Interface



COMMENTS

1. EACH LINE OF PSEUDO VIDEO IS DIVIDED INTO 88 TIME INTERVALS OF 800.0nS. THERE ARE NO "VERTICAL" SYNC PULSES.
2. THE VOLTAGES OF THE 60 BEAMS AND THE TWO RESERVED SIGNALS MAY SLIGHTLY EXCEED THE 0dB REFERENCE LEVEL.
3. THE SIGNAL LINK BANDWIDTH SHOULD BE AT LEAST 1.8MHz, GAIN ACCURACY 1dB. MINIMIZE RING AND OVERSHOOT.
4. THE DISPLAY CONTROLLER REFERENCES THE POSITION OF ALL INFORMATION TO THE LEADING EDGE OF THE SYNC PULSE (T=0). STABILITY OF PULSE POSITION AND WIDTH IS CRITICAL. IF THE COMMUNICATION LINK IS DIGITAL, IT MUST BE PROPERLY ANTI-ALIASED (OR SYNCHRONIZED) TO PREVENT PULSE EDGE JITTER.
5. THE SEABAT PSEUDO VIDEO WAVEFORM IS INTENDED TO BE COMPATIBLE WITH PURELY ANALOG VIDEO LINKS. RESON RESERVES THE RIGHT TO ALTER THE DETAILS OF THIS WAVEFORM IN THE FUTURE.

Figure 7-4. SeaBat 9003 Pseudo Video Uplink Data Format

7.3.1 SeaBat STANDARD CABLE

The twenty-five meter (25m) cable provided by RESON with the SeaBat system can be utilized either as an operational cable or as a test cable. If a longer cable is required, then it is recommended that RESON is informed so that the correct length and wiring configuration can be provided. The standard cable connects to the receptacle labeled "Sonar Head" on the rear of the SeaBat processor and directly to the male connector on the rear of the SeaBat Sonar head. This cable, provided with each SeaBat system, has the following specifications:

- 1 twisted-shielded-pair (TSP), #22 AWG conductors, foil shield with #22 drain wire, 100 volt rating, 4 - #16 AWG conductors.
- Filler and water blocked for crush and moisture resistance
- Maximum cable diameter of 0.50 inches.
- 0.045 Black polyurethane jacket, 0.44lb/meter.

NOTE

The power output from the SeaBat processor can only operate the Sonar head through a maximum standard cable length of 150 meters. Utilizing longer cables requires an external power source to the sonar head.

There are currently two (2) standard cable configurations, one cable has molded connectors on both ends (Figure 7-5), while the other cable has the Sonar Subcon connector (or pigtail) spliced onto the SeaBat cable approximately eighteen inches (18") from the sonar end (Figure 7-6).

Figures 7-5, 7-6 and 7-7 show the cable connections, wiring colors, and the connectors at either end.

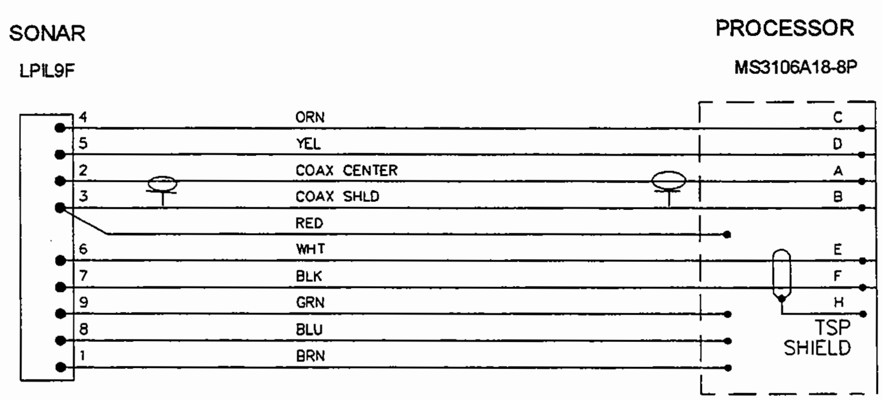


Figure 7-5. SeaBat Standard 25m Cable - Complete

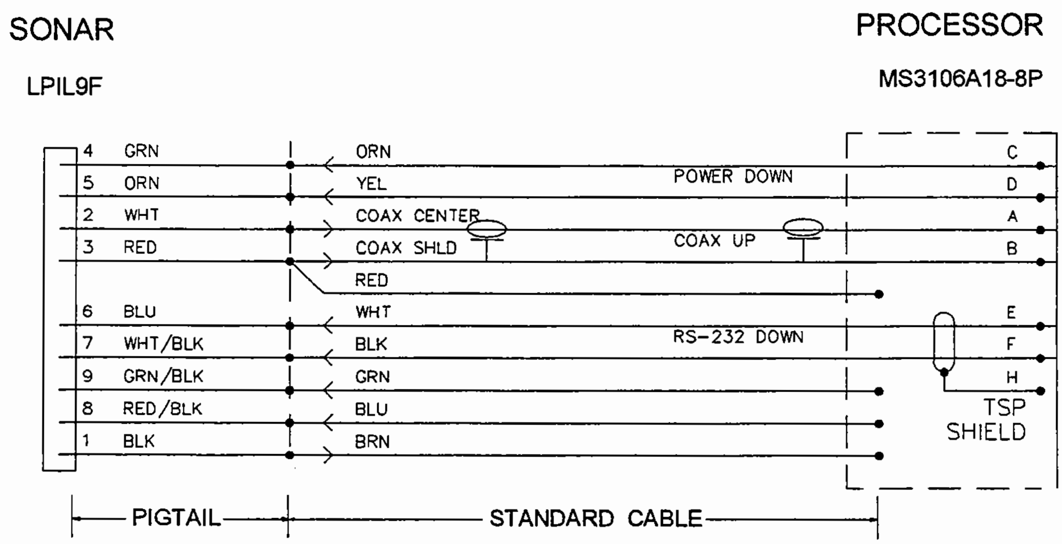


Figure 7-6. SeaBat Standard 25m Cable - with Pigtail

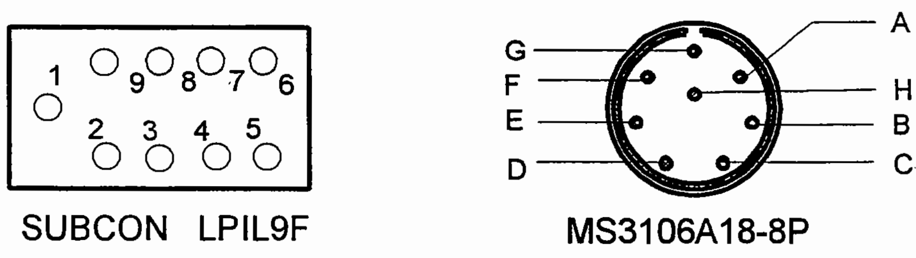


Figure 7-7. Standard Connector Pin Assignments

7.3.2 SeaBat CUSTOM CABLES

The custom communication cable between the SeaBat processor and Sonar Head is utilized when the distance between the two units is greater than 150 meters, or when a client's existing cable is utilized (i.e., ROV umbilical).

There are three control functions to consider:

Power:
- The power is provided from an external source into the sonar head connector.
- The sonar head requires 24 volts DC with a peak current of 2 amps.
- Cable resistance is to be a maximum of 5 Ohms for both cable conductors.

Downlink:
- This can either be a dedicated cable or can be multiplexed on an existing data channel line.
- The downlink data cannot be combined on the same line as the uplink data.
- The downlink cable is connected to the SeaBat processor's 9-pin RS-232 output (labeled "Sonar Downlink 9-pin RS-232") connector on the rear of the processor.

Uplink:
- This can either be a dedicated line or can be multiplexed on a Video Mux channel line.
- The video channel uplink must be, at a minimum, able to support a black and white picture with no ghosting and with a good resolution.
- The uplink data cannot be combined on the same line as the downlink data.
- The uplink cable is connected to the SeaBat processor's BNC output (labeled "Sonar Uplink 75 Ohm 1V P-P") connector on the rear of the processor.
- Use standard video fibre optic link.

Figures 7-8, 7-9, and 7-10 provide three (3) possible custom wiring configurations.

Cabling Considerations:

- To avoid ground loops, the ground signals for the RS-232 (downlink) , the 24 VDC power and the pseudo-video (uplink) should not be connected to each other.
- The 24 VDC is nominal. The voltage to the sonar head should be in the range ***22 V to 28 V including any cable losses***. Add umbilical losses if necessary.
- The Pseudo-Video Uplink gives a video output of 1 Vpp into its proper termination of 75 ohms. At the surface it should yield about the same value ±1dB. It is assumed to be transmitted with no loss. The uplink should have a 3dB bandwidth of a least 1.5 MHz and a signal to noise ratio (dynamic range) of 50dB or better, including radiation into the coax cable. The uplink can be on a fibre optic link, a short coax, or a buffered coax system or a combined link.
- The RS-232 down link can be transmitted on a twisted pair with less than 250 nF capacitance and less than 100 ohm resistance per wire.
- If an external power supply is required, then preferably it should be a linear one. If it is a switching type, then it should have a fixed, high switching frequency above 1 MHz or if below 455 kHz, then not a sub-multiple of 455 kHz. (The worst frequency is ≈ 150 kHz [455/3]). The external power supply must not interfere with the 455 kHz sonar.

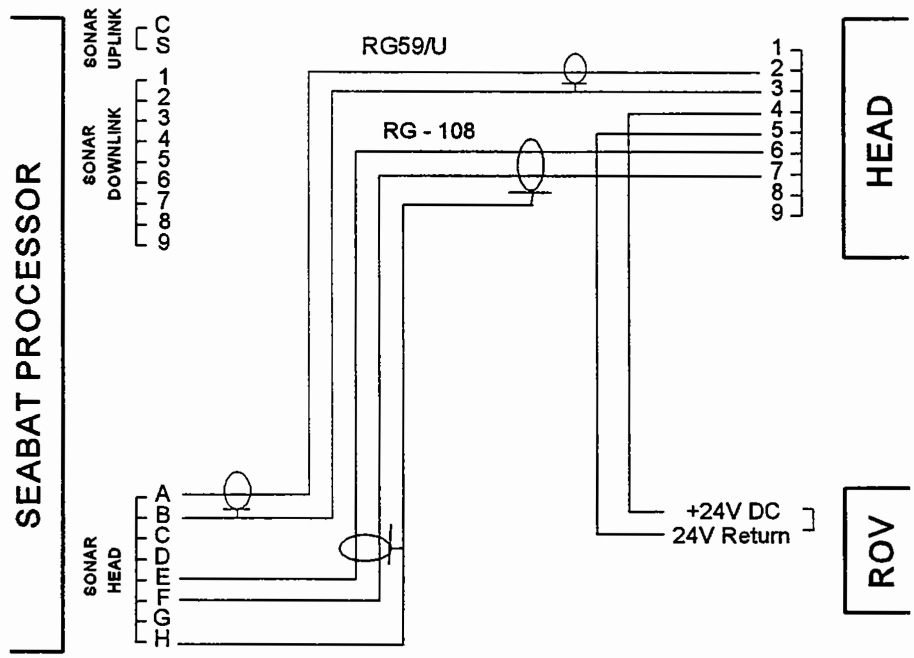


Figure 7-8. Custom Wiring Diagram #1

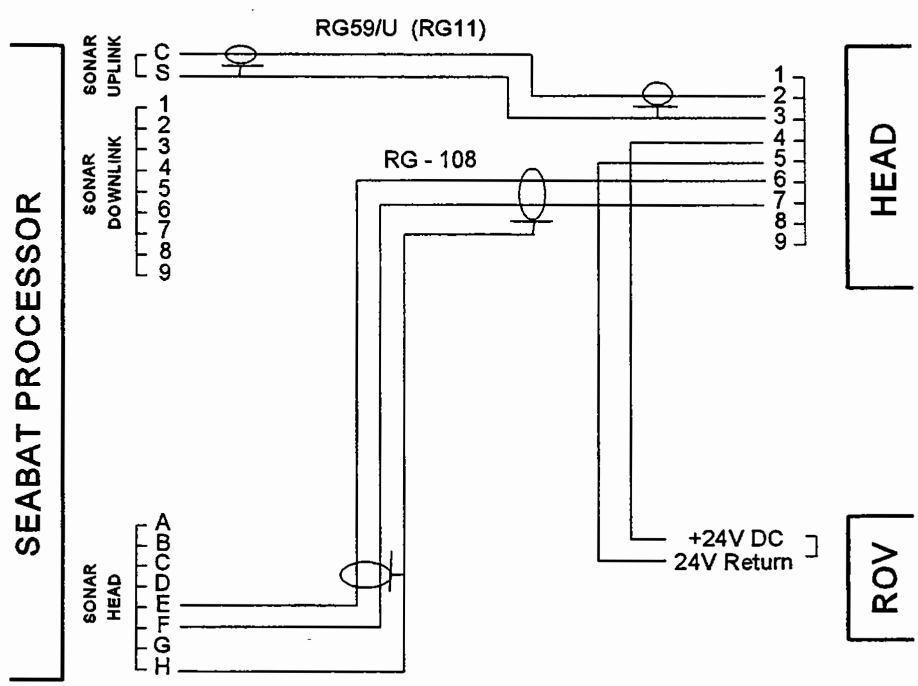


Figure 7-9. Custom Wiring Diagram #2

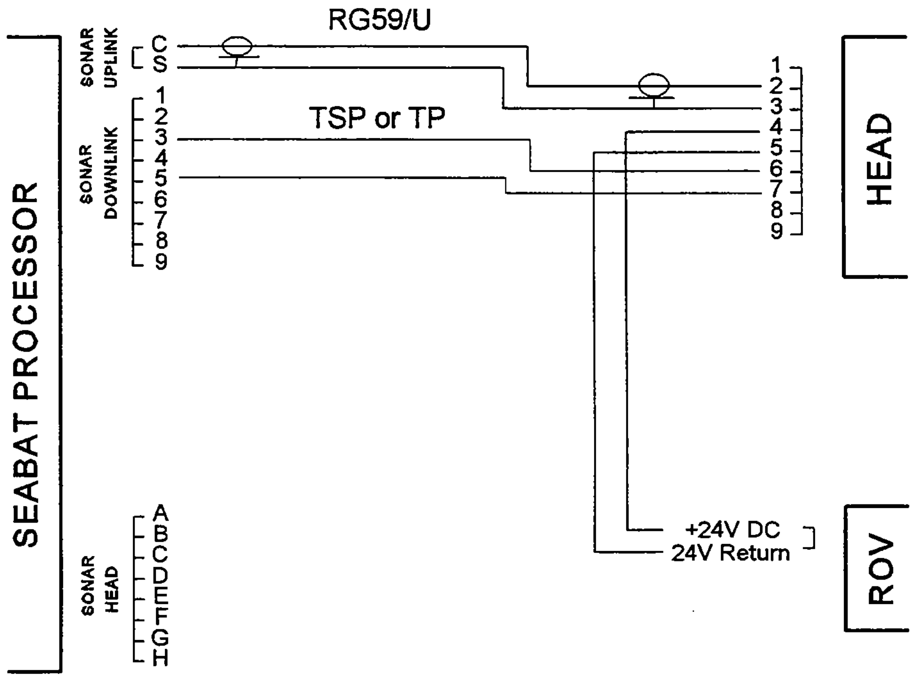


Figure 7-10. Custom Wiring Diagram #3

7.4 VIDEO DISPLAY OUTPUT

The SeaBat processor provides four (4) different combinations of interfaces to a color display monitor and VHS or S-VHS Video Recorder. Located on the rear of the SeaBat processor unit is an area labeled "Video Display Output" that provides the four possible video output formats (Figure 7-11). The following paragraphs provide descriptions of each SeaBat Video format available:

1. Four (4) BNC - R,G,B, and Sync.
2. 9-pin female - RGB and Sync.
3. One (1) BNC - Composite.
4. One (1) Y/C - S-Video.

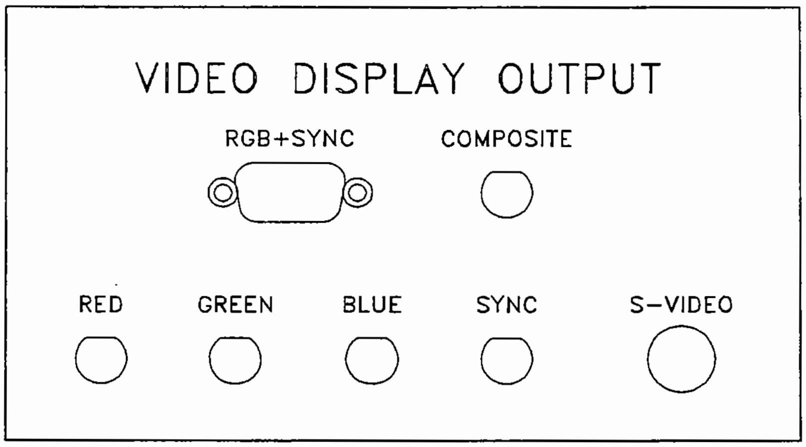


Figure 7-11. SeaBat Video Outputs

NOTE

The format of the video signal transmitted from the SeaBat processor is either PAL or NTSC, depending on the output format selected by the operator. To change the video output format from/to NTSC/PAL; Hold down both trackball buttons or Joystick "Cursor Select" buttons and roll the trackball or joystick for approximately five (5) seconds.

7.4.1 FOUR (4) BNC - R,G,B AND SYNC

Connect the four (4) BNC connector cables to the 4x BNC outputs on the rear of the SeaBat processor that are labeled Red, Green, Blue, and Sync. Connect the other end of the cables to an NTSC or PAL color monitor or recorder that accepts the RGB Sync interlaced video signals. The horizontal and vertical synchronizing rates equal those of the NTSC and PAL video formats, depending on which mode is selected.

The Red, Green, and Blue outputs drive 0.75 volt peak-to-peak signals into 75 ohm terminated loads. The three (3) color outputs do not contain sync pulses. The Sync output drives a 4 volt peak-to-peak signal into an unterminated load.

The display processor video mode (NTSC or PAL) must be selected to match the scan rate of the monitor or recorder used, unless it has automatic switching. The SONY PVM 1342Q and 1440QM color monitors have automatic mode switching.

Do not attempt to drive two (2) monitors by using the four (4) BNC connectors and the 9-pin RGB connector simultaneously, the signal will be degraded.

Some European SONY PVM color display monitors provide an AV (EURO-TV) 21-pin connector. To use it, fabricate an interface cable that connects to the SeaBat's 4x BNC outputs. Figure 7-12 provides the wiring connections for this configuration.

The synchronization is provided separately by using an S-Video cable, to ensure that this interface configuration works, the two following functions must be completed:

- Connect the AV (EURO-TV) [SCART] connector and S-Video connector simultaneously.
- Simultaneously push in, and keep depressed the "AV" and "Y/C" buttons on the front of the display monitor.

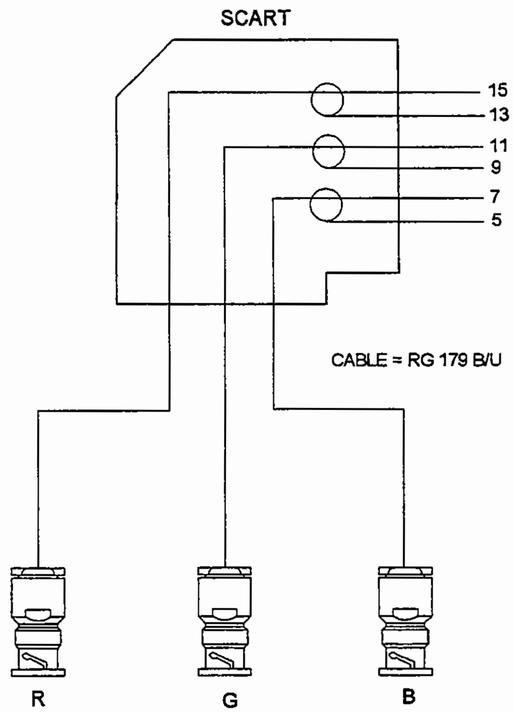


Figure 7-12. AV (EURO-TV) [SCART] - RGB Cable Connections

RESON provides an adapter for monitors that require 3-wire inputs (Red, Green + Sync and Blue). For further assistance, contact your RESON representative for information on Green-on-Sync Adapter (Option 012).

7.4.2 9 PIN - R,G,B AND SYNC

Connect the 9-pin "D" connector output to an NTSC or PAL color monitor or recorder that accepts RGB Sync interlaced video signals. The horizontal and vertical synchronizing rates equal those of the NTSC and PAL video formats, depending on which mode is selected.

The display processor video mode (NTSC or PAL) must be selected to match the scan rate of the monitor or recorder used, unless it has automatic switching.

NOTE

Although the SONY PVM model 1342Q and 1442QM have a 9-pin RGB connector, it is a digital connector and **CANNOT** display the SeaBat output.

Do not attempt to drive two (2) monitors by using the four (4) BNC connectors and the 9-pin RGB connector simultaneously, the signal will be degraded.

Table 7-1 shows the wiring configuration for the 9-pin connection. Notice that the horizontal and vertical synchronization signals are separate. RESON utilizes an NEC Multisync monitor; however it does not display the interlaced signal adequately, so there are no recommended color displays that utilize this output format.

TABLE 7-1. RGB 9-PIN OUTPUT CONNECTOR

Pin No.	Signal	Description
1	Red Output	0.75 Vp-p into 75 ohms
2	Green Output	0.75 Vp-p into 75 ohms
3	Blue Output	0.75 Vp-p into 75 ohms
4	Horizontal Sync Output	5 Vp-p into unterminated load
5	Vertical Sync Output	5 Vp-p into unterminated load
6	Ground	
7	Ground	
8	Ground	
9	Ground	

7.4.3 BNC - COMPOSITE

Connect this output to an NTSC or PAL color monitor or recorder that accepts a composite video signal. If the display device also accepts S-Video or RGB signals, you should use those connections instead, as they provide a superior image quality.

Luminance, chrominance, synchronization, and blanking information are all combined into this one signal. The output drives a one (1) volt peak-to-peak signal into a 75 ohm terminated load.

The display processor video mode (NTSC or PAL) must be selected to match the type of monitor or recorder used, unless it has automatic switching. The SONY PVM 1342Q and 1440QM color monitors have automatic mode switching.

Avoid using simple "T" adapters to connect two or more 75 ohm devices, as the signal will be degraded.

7.4.4 S-VIDEO

Connect this output to an NTSC or PAL color monitor or recorder that accepts S-Video signals (also known as Super Video, Y/C, or luminance/chrominance signals). If the display device also accepts RGB signals, you should use those connections instead, as they provide a better image quality.

Luminance, synchronization, and blanking information are all combined into this one signal but the chrominance information is supplied on a second signal. These two outputs each drive a 75 ohm terminated load.

The display processor video mode (NTSC or PAL) must be selected to match the type of monitor or recorder used, unless it has automatic switching. The SONY PVM 1342Q and 1440QM color monitors have automatic mode switching. Table 7-2 provides the wiring configuration for the Y/C Female Output Connector.

Avoid using simple "T" adapters to connect two or more 75 ohm devices, as the signal will be degraded.

TABLE 7-2. Y/C (S-VIDEO) FEMALE OUTPUT CONNECTOR

PIN No.	SIGNAL	DESCRIPTION
1	Y-output	1 Vp-p, sync negative into 75 ohms
2	CHROMA sub-carrier-output	300 mVp-p into 75 ohms
3	GND for Y-output	GND
4	GND for CHROMA-output	GND

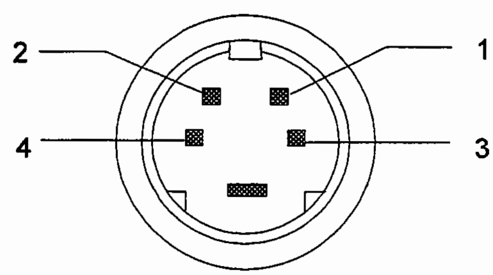


Figure 7-13. Y/C (S-Video) Connector.

7.4.5 VIDEO RECORDER INTERFACE

As described in the previous four sections, the output format from all Video Display Output connections on the rear of the SeaBat processor are in either an NTSC or PAL video format. Therefore any one of them can be used, and the choice is based upon the interface connections available on the Video Recorder to be used.

7.4.5.1 S-VHS Format

Highly recommended is the use of an S-VHS recorder, this not only provides a superior video copy but also is the easiest for interface cabling. To utilize the S-VHS (S-Video) format make the cable connections as shown in Figure 7-14.

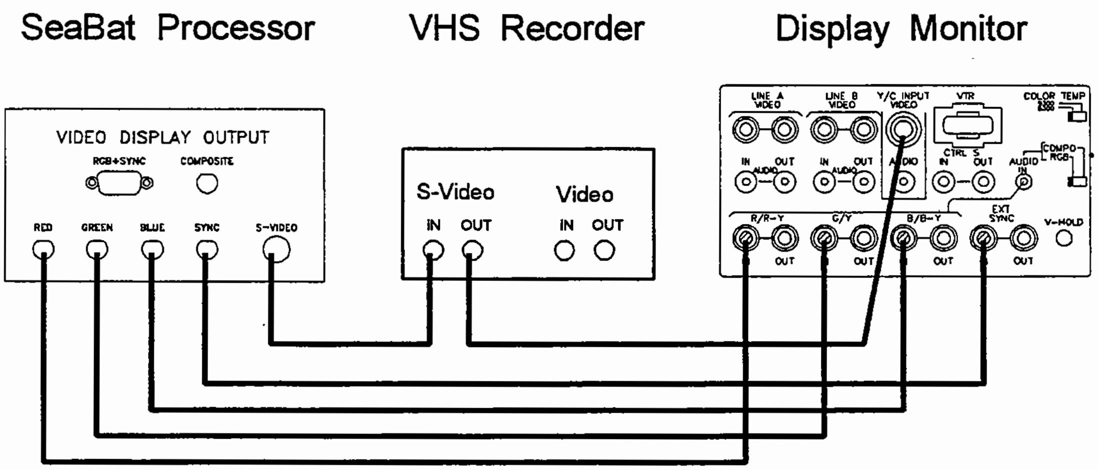


Figure 7-14. S-VHS Cable Connections

With this cabling configuration the operator can change the displayed picture on the SeaBat screen from RGB/S to S-Video and either view the direct data, or the one being recorded on video tape.

7.4.5.2 VHS Format

If an S-VHS Video Recorder is not available then a standard VHS recorder is required. To utilize this type of model make the cable connections as shown in Figure 7-15.

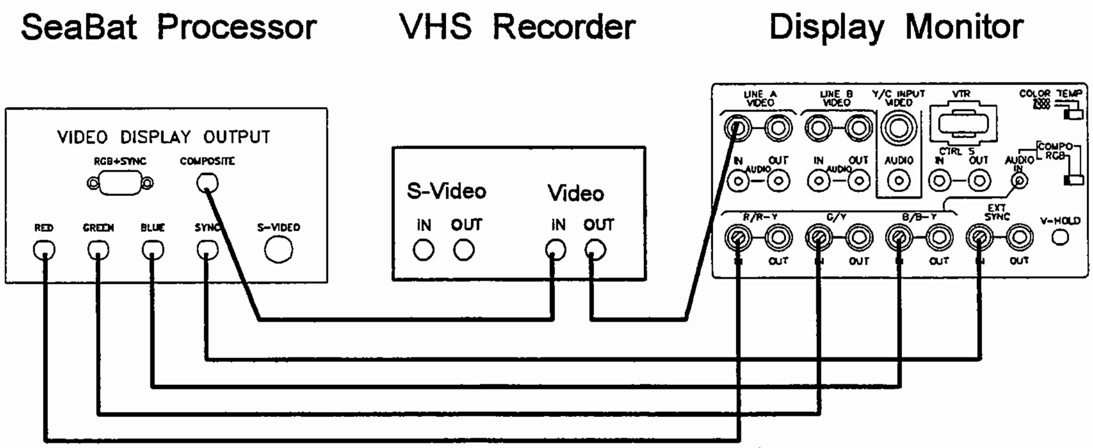


Figure 7-15. VHS Cable Connections

With this configuration the operator has to select between RGB or Line A to display either the real time data or that being recorded, respectively.

7.5 CHART RECORDER

This output is reserved for future use. Do not connect anything to it.

7.6 AUXILIARY RS-232C PORTS

There are four (4) auxiliary RS-232C communication ports on the rear of each SeaBat processor unit. Table 7-3 provides the communications available on the SeaBat 9003 and the following paragraphs describe in detail the protocol and message formats. The protocol field consists of data transfer values required. For example 1200,N,8,1 equates to:

1200 . . . baud rate of the data transfer (bits per second)
N . . . . . . No parity
8 . . . . . . Eight Data Bits
1 . . . . . . One Stop Bit

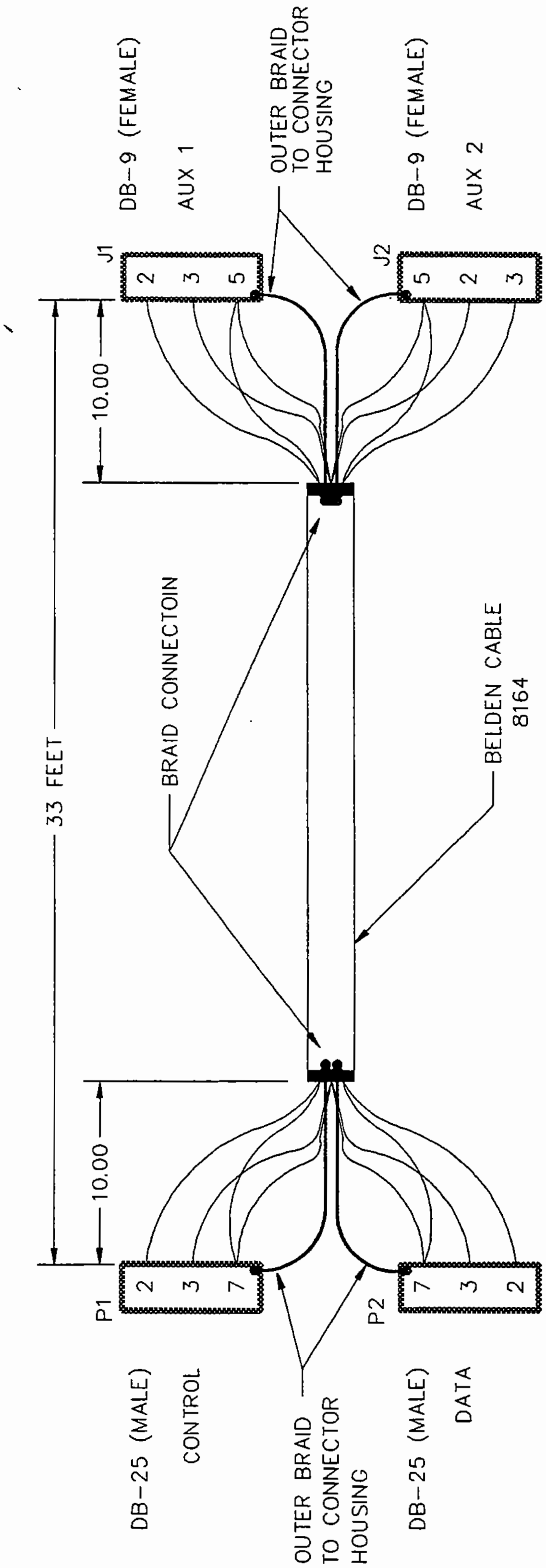
TABLE 7-3. AUXILIARY PORT ASSIGNMENTS			
Feature	**AUX No.**	**Protocol**	**Systems**
Input - Display Text	1	1200,N,8,1	All SeaBat's
Input - Control Commands	1	1200,N,8,1	All SeaBat's (v.2.8 +)
Output - Relative Cursor Position	1	1200,N,8,1	All SeaBat's - Only available with Joystick option
Output - Bathymetry profile data.	2	9600,N,8,1 300-34800 baud	SeaBat 900X series SeaBat 900X v.2.7+
Input - External Clock/Calendar	3	600,E,7,1	All SeaBat's

Figure 7-16 provides the wiring configuration for a optional RESON supplied AUX 1 and AUX 2 RS-232 Interface cable.

7.6.1 AUX PORT #1

The AUX Port #1 allows both the input and output of information to the SeaBat processor. The interface cable that is attached to Aux Port #1 has a 9-pin RS-232C female connector and is wired as shown in Table 7-4.

TABLE 7-4. AUX #1 AND AUX #2 PIN CONNECTIONS	
Pin No.	**Assignment**
2	Receive Data (into processor)
3	Transmit Data (out of processor)
5	Ground



PAIR	TWISTED PAIR COLOR	FROM	TO
PAIR #1	WHT	P1-2	J1-2
	BLK	P1-7	J1-5
PAIR #2	GRN	P1-3	J1-3
	BLK	P1-7	J1-5
	BRAID	P1-HOUSING	J1-HOUSING
PAIR #3	RED	P2-2	J2-2
	BLK	P2-7	J2-5
PAIR #4	BLU	P2-3	J2-3
	BLK	P2-7	J2-5
	BRAID	P2-HOUSING	J2-HOUSING

Figure 7-16. SeaBat Aux #1 and Aux #2 Interface Cable

7.6.1.1 Input - Display Text

This port allows an external device to transmit ASCII text to the SeaBat for annotation on the SeaBat color display. A rectangular window that is two (2) lines high and 24 characters in length is located near the apex of the sonar image wedge. This window will display the ASCII characters received via Aux Port #1.

Uppercase and lowercase ASCII characters are displayed with the usual end of line wrapping and scrolling action. Using simple control codes, the invisible cursor can be repositioned for type over affects. In addition to the standard ASCII character set, there are 31 greek and math symbols available. Table 7-5 provides a listing of the control characters available.

TABLE 7-5. AUX #1 CONTROL COMMANDS

Command	Feature
Control A	Cursor Left
Control B	Cursor Right
Control C	Cursor Down
Control D	Cursor Up
Control E	Clear to End of Line
Control Fx	Display one of 31 greek/math symbols (x is A through ' ')
Control H	Destructive Backspaces
Control I	Non-destructive Tab (tab-stop at every eight (8) column)
Control J	Line Feed
Control K	Cursor Home (upper left corner)
Control L	Clear Window (also homes cursor)
Control M	Carriage Return (without linefeed)
End:	

7.6.1.2 Input - Control Command

You also have the ability to externally control the Range, Gain, Power, and Averaging settings of the SeaBat system. Table 7-6 provides the ASCII control characters that are transmitted by an external device and received via Aux Port #1 of the SeaBat processor.

TABLE 7-6. ASCII CONTROL CHARACTERS.

GAIN	
Ctrl.Y K	0
Ctrl.Y L	1
Ctrl.Y M	2
Ctrl.Y N	3
Ctrl.Y O	4
Ctrl.Y P	5
Ctrl.Y Q	6
Ctrl.Y R	7
Ctrl.Y S	8
Ctrl.Y T	9
Ctrl.Y U	10
Ctrl.Y V	11
Ctrl.Y W	12
Ctrl.Y X	13
Ctrl.Y Y	14
Ctrl.Y Z	15

AVERAGING	
Ctrl.Y a	Off
Ctrl.Y b	2
Ctrl.Y c	4
Ctrl.Y d	8

POWER	
Ctrl.Y 0	OFF
Ctrl.Y 1	1
Ctrl.Y 2	2
Ctrl.Y 3	3
Ctrl.Y 4	4
Ctrl.Y 5	5
Ctrl.Y 6	6
Ctrl.Y 7	7
Ctrl.Y 8	8

RANGE (M)	
Ctrl.Y A	2.5
Ctrl.Y B	5
Ctrl.Y C	10
Ctrl.Y D	25
Ctrl.Y E	50
Ctrl.Y F	100
Ctrl.Y G	200

7.6.1.3 Output - Relative Cursor Position

This feature is only available when a Joystick Option 002 is utilized with the SeaBat system. Located on the control panel of the joystick is a button labeled "Tracking". When pressed, the white cursor on the screen rotates and its position is output from the SeaBat processor via Aux Port #1 using the following ASCII format:

CP####.#m↕↕↕↕.↕dCRLF

where:

CP	String Header - "Cursor Position"
####.#	Signed distance in meters (floating).
m	Descriptor - meters.
↕↕↕↕.↕	Signed bearing in degrees (floating).
d	Descriptor - degrees.
CR	Carriage Return
LF	Line Feed

7.6.2 AUX PORT #2

The high speed data output provides a header and the forty (40) sets of bathymetry data computed by the SeaBat 9003. The output is provided using a protocol of 9600,N,8,1 via a serial DB9-pin RS-232 connector, with the signals on pins 2 and 3 and ground on pin 5. Table 7-7 provides pin assignment connections.

TABLE 7-7. AUX #1 AND AUX #2 PIN CONNECTIONS

Pin No.	Assignment
2	Receive Data (into processor)
3	Transmit Data (out of processor)
5	Ground

There are two data output formats:

1. Range values.
2. Range/Intensity Values

The following paragraphs provide descriptions of these two data output formats.

7.6.2.1 Range values (R-Theta)

This format provides the 40 data range values from the sonar head to each detected seafloor point in each beam. Table 7-8 shows the "R-Theta" format, while Figure 7-17 provides an example of the SeaBat 9003 "R-Theta" data. Where applicable the most significant byte is transmitted first.

TABLE 7-8. SeaBat 9003 - "R-THETA" FORMAT BATHYMETRY DATA PACKET

Descriptor	Description
Packet Sync Header	Four 8-bit bytes (0xFF, 0xFF, 0x00, 0x00), This sequence never occurs anywhere else in the packet.
Packet Type and Subtype	Two 8-bit bytes (0x01, 0x01)
Year (0..99), Month (1..12), Day (1..31), Hour (0..23, Minute (0..59), Second (0..59)	Six 8-bit bytes. This is the clock inside the sonar processor. During external clock input, the year, month, and day values are forced to 99
Sound Velocity (meters/sec)	One 16-bit word, most significant byte first. This equals the value set on the sonar processor screen.
Latency (milliseconds)	One 16-bit word, most significant byte first. This is the time between the sonar ping, and the time of transmission of the fourth byte of this packet's sync header. If averaging is enabled, it's the time from the first ping.
Sample Rate (hertz)	One 16-bit word, most significant byte first. This is the SeaBat's digitizing frequency for each sonar beam.
Beam Range and Quality Values	Sixty 16-bit words, most significant byte first, only the first 40 are valid. Ignore the last 20. Upper 14 bits is the range (round-trip travel time, in samples). To compute the range in meters, multiply by sound velocity, divide by sample rate, and divide by 2. Lower two bits is data quality (0 is bad, 3 is good).
Checksum	One 16-bit word. Unsigned sum of all the preceding 8-bit bytes, but not including the packet sync header.

With this data packet format there is also the operator selected option for the baud rate that is output from the SeaBat system. The baud rate selected determines the number of data packets per second that are transmitted. Table 7-9 provides the baud rate versus output rate per range selected.

```
00000000: FF FF 00 00 01 01 60 02  0F 0F 09 02 05 DC 00 B0
00000010: 37 7D 0B E5 0D FD 0E 6D  0C B1 0C C5 0E 14 0F 76
00000020: 0E F2 0B 08 0E D7 0E C7  0E 4B 0B 71 0E 4A 0E F8
00000030: 09 F0 0F B1 0A 12 0B 3A  0D 9C 0D 46 0E 12 0C 48
00000040: 0A 98 0B 8C 0E CC 0C 6C  0F 00 0B B9 0D 6D 0C 3C
00000050: 0D 5C 0E A8 0B A8 0B 04  0E 8D 0D 70 0C 9C 0A FC
00000060: 0E E1 00 04 00 04 00 04  00 04 00 04 00 04 00 04
00000070: 00 04 00 04 00 04 00 04  00 04 00 04 00 04 00 04
00000080: 00 04 00 04 00 04 00 04  00 04 1A 0C
```

A sample set of R-Theta Data is provided above. Each set begins with the characters FF FF 00 00 (underlined), the remaining 136 bytes are the data as described in the previous table.

As an example, if we take the packet shown, it converts to:

1996, FEB, 15	(Year, Month, Day)
15 09 02	(Hour, Minute, Seconds)
1500 m/s	(Speed of Sound)
176 mS	(Latency)
14205 hertz	(Sample Rate)

The first data point (Beam #1) is 02F9h which means:

Time = 02F9Ch = 761 samples
Quality = 01h = Poor Co-Linearity
1 = Good Brightness

The range = (761 * 1/14205 * 1500) / 2 = 40.18 meters

Figure 7-17. SeaBat 9003 "R-Theta" Data

The full R-Theta packet contains a total of 140 bytes/characters and at an output rate of 19,200 baud, has a transmit time of 0.073 seconds (10*140/19200).

The forty theta values in the R-Theta output format are computed as follows: The first beam is at bearing -58.5°, the second is at -55.5°, the third is at -52.5°, each beam following at 3° gradations up to the last beam at bearing +58.5°. On the monitor, the first beam (-58.5°) appears at the left of the screen, the last beam (+58.5°) appears at the right.

Each sounding has a quality value assigned. A quality of 3 means good co-linearity, good brightness, and frequent occurence. Quality 2 = good co-linearity, poor brightness and occurs sometimes. Quality 1 = poor co-linearity, good brightness and occurs occasionally. Quality 0 = poor co-linearity, poor brightness and occurence is occasional. If the quality value is 0 and the range = 1, then this is definitely a bad point; this rarely occurs.

TABLE 7-9. R-THETA OUTPUT DATA RATES					
Output Baud Rate	Profiles Per Second				
	SeaBat 9003				
	Range ≤10m	Range 25m	Range 50m	Range 100m	Range 200m
300	0.21	0.21	0.21	0.21	0.21
600	0.43	0.43	0.43	0.43	0.43
1200	0.86	0.86	0.86	0.86	0.86
2400	1.71	1.71	1.71	1.71	1.71
4800	3.43	3.43	3.43	3.43	1.73
9600	6.86	6.86	6.85	3.45	1.73
19200	13.71	13.51	6.85	3.45	1.73
38400	15.15	13.51	6.85	3.45	1.73

7.6.2.2 Range values (RI-Theta)

This format is identical to the R-Theta Format (Paragraph 7.6.2.2.) with the addition of the intensity values for each beam and setup parameters for the SeaBat.

Table 7-10 shows the "RI-Theta" Format, while Figure 7-18 provides an example of the SeaBat 9003 "RI-Theta" data. Where applicable the most significant byte is transmitted first.

TABLE 7-10. SeaBat 9003 - "RI-THETA" FORMAT BATHYMETRY DATA PACKET

Descriptor	Description
Packet Sync Header	Four 8-bit bytes (0xFF, 0xFF, 0x00, 0x00), This sequence never occurs anywhere else in the packet.
Packet Type and Subtype	Two 8-bit bytes (0x02, 0x01)
Year (0..99), Month (1..12), Day (1..31), Hour (0..23, Minute (0..59), Second (0..59)	Six 8-bit bytes. This is the clock inside the sonar processor. During external clock input, the year, month, and day values are forced to 99
Sound Velocity (meters/sec)	One 16-bit word, most significant byte first. This equals the value set on the sonar processor screen.
Latency (milliseconds)	One 16-bit word, most significant byte first. This is the time between the sonar ping, and the time of transmission of the fourth byte of this packet's sync header. If averaging is enabled, it's the time from the first ping.
Sample Rate (hertz)	One 16-bit word, most significant byte first. This is the SeaBat's digitizing frequency for each sonar beam.
Beam Range and Quality Values	Sixty 16-bit words, most significant byte first, only first 40 are valid. Ignore last 20. Upper 14 bits is the range (round-trip travel time, in samples). To compute the range in meters, multiply by sound velocity, divide by sample rate, and divide by 2. Lower two bits is data quality (0 is bad, 3 is good, 1 and 2 are not presently used).
Intensity values for all 60 beams	60 bytes in length, only first 40 are valid. Ignore last 20. Each byte represents the intensity of each beam. The value is 0-254 and is relative to the current power and gain values.
Current range setting	One 8-bit character. Ignore the zero. Values 'A' through 'G' indicate range 2.5, 5, 10, 25, 50, 100, 200 meters.
Current power setting	One 8-bit character. Ignore the zero. Values '0' through '8' indicate power Off, 1, 2, 3, 4, 5, 6, 7, 8.
Current gain setting	One 8-bit character. Ignore the zero. Values 'K' through 'Z' indicate TVG 0 through 15. Values 'k' through 'z' indiacte FIX 0 through 15.
Current averaging setting	One 8-bit byte. Values 0 through 4 indicate averaging 1,2,4,8,16.
Current sidescan beam setting	One 8-bit character. Ignore the zero. Value 4 is port-starboard, 5 is port-center, 6 is center-starboard, 7 is sidescan beams disabled.
Current sidescan gain setting	One 8-bit character. Ignore the zero. Values '[' through 'h' indicate sidescan gain 1 through 14.
Current projector	One 8- bit byte. Ignore the zero. Value 1 indicates face array projextor, 2 indicates cylinder projector.
Unused spare bytes	Three unused zero bytes.
Checksum	One 16-bit word. Unsigned sum of all the preceding 8-bit bytes, but not including the packet sync header.

With this data packet format there is also the operator selected option for the baud rate that is output from the SeaBat system. The baud rate selected determines the number of data packets per second that are transmitted. Table 7-11 provides the baud rate versus output rate per range selected.

```
00000000: FF FF 00 00 04 01 60 02  08 0E 35 0B 05 DC 04 98
00000010: 37 7D 25 0F 22 3F 1F F7  1E 03 1C 17 1B 2B 19 9B
00000020: 18 8B 17 AF 16 E7 16 2B  15 A7 15 13 14 B7 14 53
00000030: 14 0B 13 D7 13 AF 13 93  13 83 13 87 13 9F 13 BB
00000040: 13 DF 14 17 14 77 14 D3  15 3F 15 B7 16 47 16 F3
00000050: 35 81 18 A7 19 EF 1A C7  1C 7B 1D F3 3B C1 3B A9
00000060: 25 11 00 04 00 04 00 04  00 04 00 04 00 04 00 04
00000070: 00 04 00 04 00 04 00 04  00 04 00 04 00 04 00 04
00000080: 00 04 00 04 00 04 00 04  00 04 B3 9A A4 88 86 77
00000090: 93 68 9B A2 84 99 AD C6  CE FA F7 DA EA FA FA FA
000000A0: FA F6 FA B9 BD AA A4 88  8A B6 A8 81 7E 7F 75 D1
000000B0: DD 9B 01 01 01 01 01 01  01 01 01 01 01 01 01 01
000000C0: 01 01 01 01 01 01 47 37  4B 00 07 67 02 00 00 00
000000D0: 39 9B
```

A sample set of RI-Theta data is provided above. Each set begins with the characters FF FF 00 00 (underlined), the remaining 206 bytes are the data as described in the previous table.

As an example, if we take the packet shown , it converts to:

1996, FEB, 8	(Year, Month, Day)
14 35 11	(Hour, Minute, Seconds)
1500 m/s	(Speed of Sound)
1176 mS	(Latency)
14205 hertz	(Sample Rate)

The first data point (Beam #1) is 250F which means:

Time = 943h = 2371 samples
Quality = 11h = Good Co-Linearity
3 = Good Brightness

The range = (2371 * 1/14205 * 1500)/2 = 125.18 meters

The full RI-Theta packet contains a total of 210 bytes/characters and at an output rate of 19,200 baud, has a transmit time of 0.109 seconds (10*210/19200).

The forty theta values in the RI-Theta output format are computed as follows: The first beam is at bearing -58.5°, the second is at -55.5° the third is at -52.5°, each beam following at 3.0° gradations up to the last beam at bearing +58.5°. On the monitor, the first beam (-58.5°) appears at the left of the screen, the last beam (+58.5°) appears at the right.

Each sounding has a quality value assigned. A quality of 3 means good co-linearity, good brightness and it's occurence is frequent. Quality 2 = good co-linearity, poor brightness and occurs sometimes. Quality 1 = poor co-linearity, good brightness and occurs occasionally. Quality 0 = poor co-linearity, poor brightness and occurence is occasional. If the quality value is 0 and the range = 1, then this is definitely a bad point, this rarely occurs.

TABLE 7-11. RI-THETA OUTPUT DATA RATES					
Output Baud Rate	Profiles Per Second				
	SeaBat 9003				
	Range ≤10m	Range 25m	Range 50m	Range 100m	Range 200m
300	0.14	0.14	0.14	0.14	0.14
600	0.29	0.29	0.29	0.29	0.29
1200	0.57	0.57	0.57	0.57	0.57
2400	1.14	1.14	1.14	1.14	1.14
4800	2.29	2.29	2.29	2.29	1.73
9600	4.57	4.57	4.57	3.45	1.73
19200	9.14	9.14	6.85	3.45	1.73
38400	15.15	13.51	6.85	3.45	1.73

7.6.3 AUX PORT #3

On all SeaBat processors, the Aux Port #3 currently allows a NAVIT SDC-4 external clock (or external computer configured with a "Navitronics SDC-4" data format) to enter the current day and time into the SeaBat display controller.

The SDC-4 clock outputs every second with an eleven (11) character data string.

Where:

DDD	-	Julian Day (000 to 365)
HH	-	Hours (00 to 23)
MM	-	Minutes (00 to 59)
SS	-	Seconds (00 to 59)
CR	-	Carriage Return
LF	-	Line Feed

The output is provided using a protocol of 600,E,7,1 via a serial DB9-pin RS-232 connector, with the signals on pins 2 and 3 and ground on pin 5.

NOTE

The Day and Time values received by the SeaBat are only used for display and bathymetry output, they **ARE NOT** used to change the SeaBat processor's clock.

When the external clock interface is utilized, then the data entered will be displayed on the SeaBat screen for five (5) seconds or until the next data packet is received. The Julian day is displayed in the Date field and the Time is displayed in the Time field. Note that if a data packet is not received by the SeaBat processor within 5 seconds of the previous one, then the processor's clock will take over and display its values in the same fields. The entered Day and Time values also are included in the profile data that is output via Aux Port#2 for all SeaBat 9003 Systems.

7.6.4 AUX PORT #4

This port is reserved for future use. Do not connect anything to it.

7.7 RAW-DATA RECORDER

This output is reserved for future use. Do not connect anything to it.

7.8 POINTER DEVICE

This feature allows a Trackball or Joystick (Opt.002) to be connected to either the back or the front of the SeaBat processor unit. A pointer device is an essential component of any SeaBat System. To connect either device, plug the 9-pin connector into the receptacle and secure by tightening the two screws attached to the connector mount.

Do not connect two pointer devices to the processor simultaneously. RS-232 signals, in addition to DC power, pass through this connector. Refer to Paragraph 1.4.3.1 for technical information on the pointer provided with the SeaBat system.

7.9 TRANSMITTER SYNC

The transmitter sync output is an option that provides the means to synchronize external devices with the SeaBat transmitter ping.

This output is a 0V to 5V rectangular pulse whose rising edge is coincident with the sonar head transmitter ping. This output has an internal 1k ohm current limiting resistor.

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CHAPTER 8 - CALIBRATION

8.1 INTRODUCTION

This Chapter describes in detail the calibration procedures that should be adhered to when utilizing the SeaBat 9000 Series Multibeam Echo Sounder System to collect high resolution, high accuracy topographical data for seabed mapping or other subsea survey purposes.

Using the SeaBat and adhering to the calibration procedures described herein, final X,Y,Z results have proven depth accuracies to be within the International Hydrographic Organization (IHO) recommended standards for inshore hydrographic surveys.

If the SeaBat 9003 is utilized for mapping or surveys with less rigorous accuracy requirements, it may not be necessary to follow these procedures. It is however good survey practice to conduct the following calibrations regardless of the specific requirements.

The calibrations included herein do not relate directly to, or influence, the resolution and the relative measurement accuracy of the unprocessed SeaBat data as such. However, when utilizing the SeaBat system for seabed mapping, the SeaBat will be an integral part of a complete survey spread comprising a number of other survey systems and sensors. The absolute accuracy of the end result, for example a topographical chart or seabed profiles etc., will depend on determining the magnitude of a number of systematic errors prior to commencement of the field work, such that these errors can subsequently be corrected for during the logging and/or post-processing of the SeaBat data. These calibration procedures are intended to outline how the presence and magnitude of certain of these errors can be established and thus corrected for.

8.1.1 USING THE SeaBat 9003 MULTIBEAM BATHYMETRY SONAR SYSTEM

For every update the SeaBat 9003 Multibeam Bathymetry Sonar System measures 40 slant ranges from the head to the seabed across a 120° swath, i.e. a swath width of 3.5 times the water depth below the vertically mounted sonar head.

To produce, for instance, a topographical seabed chart from SeaBat data, the relative range measurements from each beam of the SeaBat 9003 must be converted to depths and the center positions of the insonified areas on the seabed must be determined, or in other words the relative SeaBat data must be converted to absolute X, Y, Z data that can be utilized for plotting.

To achieve this the following data must be known:

- The horizontal position of the SeaBat head relative to a predetermined reference system.
- The depth of the SeaBat head relative to a predetermined vertical datum.
- The orientation of the SeaBat head, i.e. the heading of the SeaBat head relative to a predetermined reference system and the pitch and roll of the head, relative to the vertical.
- The up and down motion of the SeaBat head i.e. the heave during measurement.

Ideally all the above data should be determined instantaneously and simultaneously with each SeaBat update, however, this is near impossible.

In order to establish the position, depth, orientation and motion of the SeaBat head, the following additional survey sensors/systems are required:

- A surface positioning system and a subsea positioning system, if the SeaBat is mounted on an ROV.
- A bathymetric depth or pressure sensor, if the SeaBat is mounted on an ROV.
- A Motion Reference Unit (MRU) or a heave compensator and a pitch and roll sensor.
- A north seeking gyro compass.

During the survey work a computerized navigation and logging system should be utilized to record all the data from both the SeaBat system and all the above additional survey sensors/systems. This data is then processed to convert the relative slant range measurements of the SeaBat system to X, Y and Z co-ordinates in a geodetic reference system, thus enabling the plotting of a topographical chart of the seabed.

The absolute accuracy of a topographical survey utilizing the SeaBat system will naturally depend on the resolution and the accuracy of the SeaBat itself. However, the necessity of utilizing the above survey systems and sensors introduces a number of both random and systematic errors that does not necessarily affect the accuracy of collected SeaBat data directly, but will affect the overall accuracy of the processed result.

Due to the characteristics and the magnitude of the above errors, the accuracy of the overall result of a bathymetric survey will mostly be affected by the inherent accuracy of each of the above survey sensors and the way these sensors are individually calibrated and operated. Comparatively, the inherent accuracy of the actual SeaBat system will only influence the overall accuracy slightly due to the high resolution and accuracy of the system.

8.1.2 RANDOM ERRORS

The random errors that affect the above survey sensors are directly related to the inherent accuracy of the respective sensors, and as such, the effect of these errors on the results cannot be avoided. In order to constrain the magnitude of these errors, it is imperative that the various sensors are well maintained and operated according to manufacturers specifications and in accordance with good survey practice. Furthermore, since the magnitude of these errors are essentially dependant on the technical specifications of the equipment, the choice of the above survey sensors should be carefully considered when planning the work.

8.1.3 SYSTEMATIC ERRORS

Each of the above survey sensors/systems will be affected by individual systematic errors that are functions of the system design and operation. These systematic errors must be corrected for in order to ensure the best possible quality of the final result. In order to accomplish this, the magnitude of the systematic errors must be determined by means of specific equipment calibrations. The procedures herein do not comprise these specific equipment calibrations.

Apart from the above equipment specific systematic errors, the accuracy of the results, when utilizing the SeaBat System, will also be affected by a number of factors caused by environmental elements that can have a detrimental effect on the accuracy of the actual SeaBat data if they are not corrected for.

Furthermore, in order to utilize the data from the above survey sensors, the exact physical relation and/or alignment between the SeaBat sonar head and each of the above survey sensors/systems must be accurately known. The accuracy of the results will consequently also depend on how accurate this relationship can be determined. Any errors in the description of the relation/alignment will not affect the SeaBat data, as such, but will still have an adverse affect on the overall accuracy of the survey results.

Finally, as it is necessary to record data from a number of independent survey sensors/systems simultaneously, and since these systems often cycle at different frequencies, the data from each individual survey sensor system must be synchronized in order to utilize the data for further processing.

8.1.4 POSITIONING THE SeaBat

The surface positioning system, or if the SeaBat head is ROV mounted; the combination of the surface and subsea positioning system, is utilized to determine the absolute horizontal position of the SeaBat sonar head relative to a predetermined geodetic reference system. For inshore work the reference system will typically be the local national reference system, for offshore work it is typically the global UTM system.

The choice of positioning system(s) for the survey work is important in the respect that the inherent equipment accuracy will directly influence the accuracy of the final result.

There will generally be a physical separation between the SeaBat head and the antenna for the positioning system or, if the SeaBat is ROV mounted, between the head and the responder transponder for the subsea positioning system. In order to back-calculate the position of the SeaBat head from the known position of the antenna or the responder, the offset between the SeaBat sonar head and the antenna/responder must be known.

The offset is typically determined by tape measurement relative to a local reference system on the vessel or the ROV. This local system will be defined with one axis coinciding with the centerline of the vessel or ROV and with the origin coinciding with the vessel center of gravity (CoG) or on the ROV, the SeaBat head.

In order to apply the offset, the heading from the SeaBat head to the antenna or responder must be known, relative to the above geodetic reference system. The heading is usually measured by means of a gyro compass that will determine the heading of the vessel or the ROV relative to True North.

To use the data from the gyro compass the alignment between the zero index line of the gyro and the centerline of the vessel or the ROV must be known. This is established by aligning or calibrating the gyro compass against a known baseline while it is installed on the vessel or mounted on the ROV (Ref. Chapter 8.3.2).

Errors in establishing the offset between the SeaBat head and the antenna/responder or an error in the alignment of the gyro will affect the accuracy of the positioning of the SeaBat sonar head. Hence, the accuracy of the positions of the depths determined from the slant range measurements will be affected. An offset error will cause a translation error in these positions of similar magnitude. A gyro alignment error will especially affect the determined positions of the outer beams.

8.1.5 SeaBat DEPTH MEASUREMENT

In order to use the SeaBat data as echo soundings or depth measurements, the distance from the SeaBat head to the vertical datum must be known. This is achieved by establishing the distance from the SeaBat head to the local sea level either by measuring the draft of the head, if ship borne, or by utilizing a bathymetric pressure sensor when the head is ROV mounted. The vertical datum for seabed surveys are typically MSL, LAT, or MLLW.

The measurement of the depth of the seabed is consequently composed of the distance from the head to the seabed, as measured by the SeaBat, and the known depth of the head relative to local sea level.

The local sea level is affected by a number of environmental elements, the most significant are waves and tide. In order to correlate the depth measurements to the vertical datum, the magnitude of these elements must be established and subsequently corrected for. Other oceanographic and environmental elements that affect the local sea level may also be determined and corrected for. In case a bathymetric pressure sensor is utilized to determine the depth of the SeaBat, the air pressure and the water density must also be known.

The SeaBat 9003 system does not measure depths, as such, but for each update the system measures 40 slant ranges from the sonar head to the seabed across a 120° swath. The slant range from the SeaBat head to the seabed is determined by measuring the two-way travel time of an acoustic signal from the sonar head to the seabed. Knowing the velocity of sound in the water column, the measured signal travel time can be converted to slant range. To ensure the integrity and high accuracy of the actual SeaBat, data it is imperative that the velocity of sound though the water column is accurately established.

To further convert the slant ranges to depths, the angle of each beam must also be known relative to vertical. This is described in more detail in Chapter 8.1.6 'Orientation of the SeaBat Head.'

8.1.5.1 Heave

The variations of the local sea level due to waves are only significant when utilizing a ship-borne SeaBat system. Waves will cause the vessel to heave, the influence of this heaving motion on the SeaBat data should be compensated for by means of a heave compensator.

When utilizing the SeaBat 9003, the heave is typically determined and compensated for by means of a Motion Reference Unit (MRU). The MRU uses three linear accelerometers, aligned along each of the three axes of the sensor, to determine any up and down motion of the sensor relative to a state of equilibrium.

The effect of the heave, if uncompensated, on the depth measurements will be directly proportional to the magnitude of the heave, which again will be a function of vessel size and wave height and wave period, but could easily amount to several meters.

It should be noted that the heave sensor will have a maximum range and a maximum rate of change that will limit the operational conditions within which it will work accurately. During marginal weather conditions it is imperative to assess the quality of the heave compensation to ensure that the SeaBat data is not being adversely affected by excess heave.

On a vessel, the SeaBat data is compensated for heave in real-time in the computerized data logging system after the measured slant ranges have been converted to depths.

For an ROV mounted SeaBat, the up and down motion of the ROV will in principle affect the SeaBat data in a similar fashion as the heave will affect data from a vessel mounted SeaBat. The MRU on a ROV will not be able to give sensible heave data as there is no state of equilibrium, but as the depth sensor typically cycles with the same or even higher frequency than the SeaBat, the depth of the SeaBat head can be accurately determined for each SeaBat cycle through accurate time tagging of the data, and heave compensation, as such, is therefore not necessary.

8.1.5.2 Tide

For inshore work the variations in local sea level due to tide is typically measured by means of a tide gauge. The same method can be applied offshore but when working far from shore the tidal variations are usually established by means of co-tidal charts where the known tidal variation in a reference port is extrapolated to the survey area by means of predetermined co-tidal factors. The local tidal variations in sea level vary a great deal from being negligible to amounting to several meters.

Tidal variation is usually compensated for during the post-processing of the SeaBat data, but it is possible to apply corrections in real-time using either predicted tide correction or from a radio telemetred tide guage.

8.1.5.3 Sound Velocity

To convert the measured signal travel time to slant range, the velocity of sound in the water column must be known. In order to accurately establish this sound velocity, a CTD or TS probe is utilized to measure temperature and conductivity or salinity against depth. These data are then used to calculate the velocity of sound in the water through the water column, typically at 5-10 meter depth intervals.

The applicable mean velocity can then be determined for the appropriate part of the water column that the SeaBat will be measuring through, and entered into the SeaBat system.

For inshore shallow water work the sound velocity can, if necessary, be established by a "Bar Check". In this case, a pole or bar is suspended a known distance beneath the SeaBat sonar head. The sound velocity entered into the SeaBat system can then be adjusted until the correct distance measurement is achieved between the transducer and the bar.

It should be noted that the sound velocity in sea water can change substantially with both location and time, and it is therefore important that such variations are established prior to commencement of the calibrations and the survey work. Using the wrong velocity of sound will affect the SeaBat data and cause a scaling of the determined slant ranges and hence the depths, and will therefore also affect the positions of the determined depths.

As the velocity of sound in sea water is typically around 1500 m/s, an error of 10 m/s in this velocity will cause an error in a 50 m slant range of 0.3 m.

8.1.5.4 Water Density and Air Pressure

When the SeaBat sonar head is ROV mounted, the depth relative to local sea level is determined by means of a bathymetric pressure or depth sensor. In order to accurately utilize this sensor to determine the depth, the average density of the water column must be known, and also the local air pressure.

Similarly to the sound velocity, the water density can be computed from CTD data. Usually the density is computed simultaneously with the sound velocity for the same 5-10 meter depth interval. The applicable mean density can then be determined and entered into the bathymetric system.

The variations in local air pressure is established by means of a barograph. The air pressure can be read directly at any time and entered into the bathymetric system. Variation in sea level caused by change in air pressure is usually assumed to be directly proportional to the air pressure, such that an increase in air pressure by 1 MBar will result in a subsequent decrease in water level of 1 cm and vice versa.

8.1.6 ORIENTATION OF THE SeaBat HEAD

The orientation of the SeaBat head must be known in order to convert the measured slant ranges to depths and to determine the position of each of the determined depths.

The orientation around the three axes is determined by measuring the pitch and roll of the SeaBat head relative to vertical, and by measuring the heading of the sonar head relative to a pre-defined reference system. (See Figure 8-1 SeaBat Axis System)

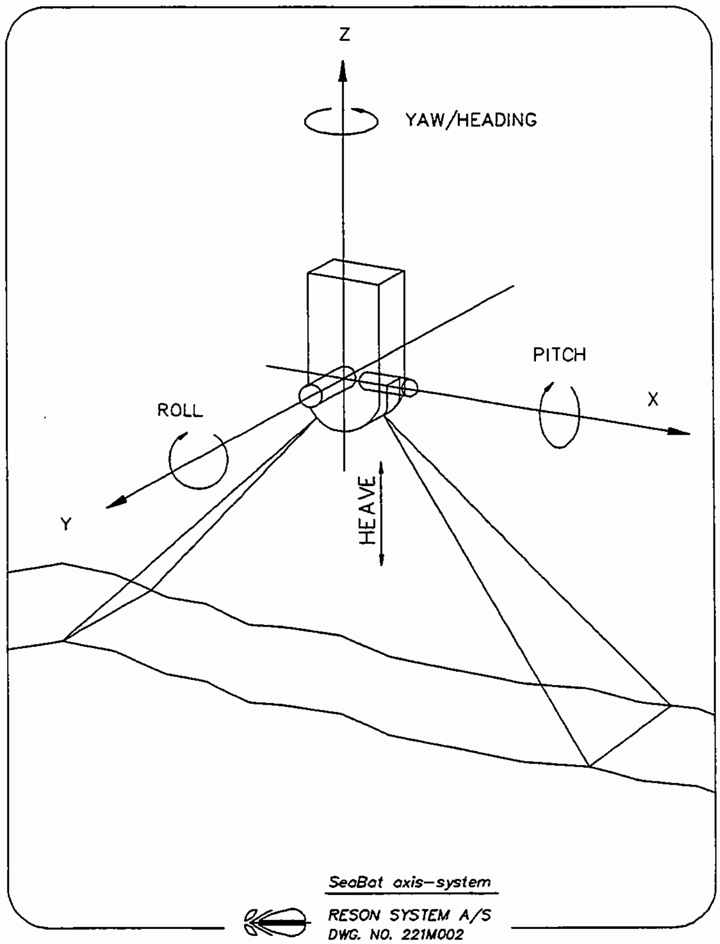

Figure 8-1.SeaBat Axis System

8.1.6.1 Pitch and Roll

The orientation of the SeaBat head relative to vertical is measured by means of pitch and roll sensors. These sensors are typically an integral part of the MRU. (See Figure 8-2, Pitch and Roll Alignment.)

In order to use the data from the pitch and roll sensors, the alignment between the axes of the MRU and the SeaBat head must be known. This is usually achieved by ensuring that the housing of the MRU and the housing of the SeaBat head are aligned when the equipment is installed on the vessel or the ROV. Any misalignment will obviously cause the measured pitch and roll of the SeaBat head to be in error.

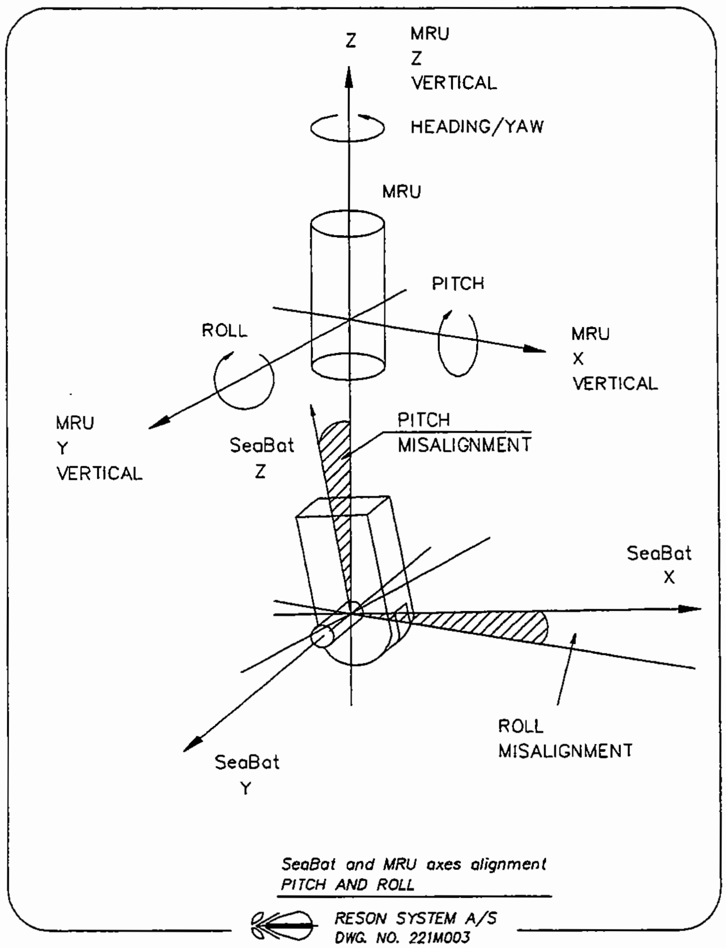

Figure 8-2. Pitch and Roll Alignment

Any error in the measured roll of the SeaBat head can cause substantial errors in the conversion from slant range to depth. A roll error of 1° on a 50 m slant range will cause a 0.6 m error in the resulting depth.

Any error in the measured pitch of the SeaBat head will primarily have a detrimental effect on the accuracy of the positions that are determined for each slant range/depth. The pitch error will have to be substantial before it has a recognizable affect on the determined depths. A pitch error of 1° will cause an along-track error in the position of 0.4 meter when the SeaBat head is 25 meters above the seabed.

8.1.6.2 Heading

The heading of the SeaBat head is usually determined relative to the geodetic reference system by means of a north seeking gyro compass. In order to use the data from the gyro compass, the alignment between the Y-axis or Roll-axis of the SeaBat head and the zero index line of the gyro must be known (See Figure 8-3, Gyro Axis).

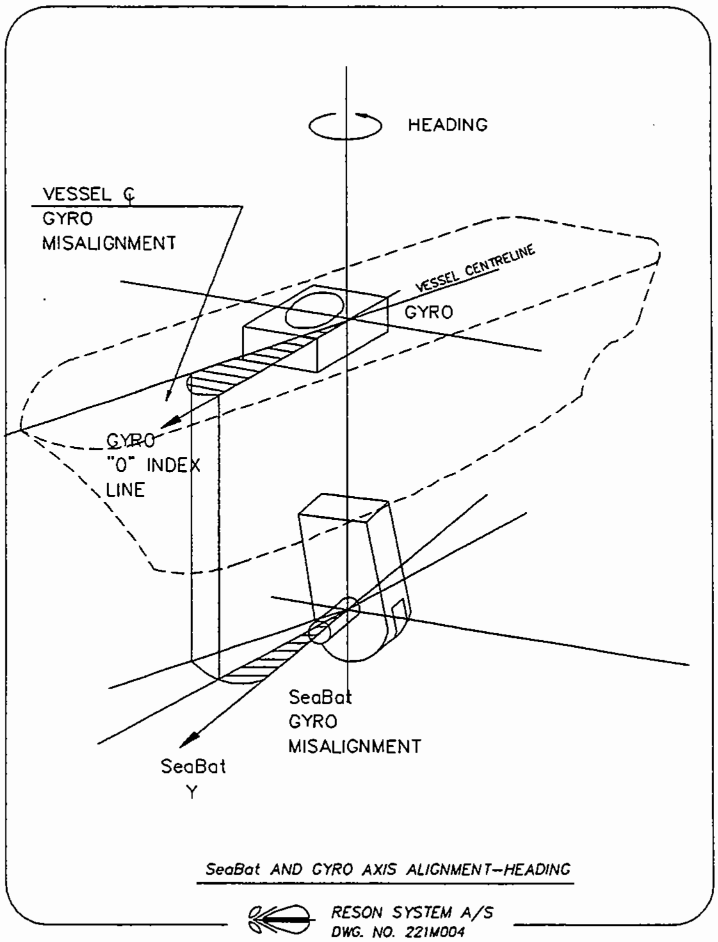

Figure 8-3. Gyro Axis

The alignment between the zero index line of the gyro and the centerline of the vessel or ROV must be also be known. Having established the latter alignment, the alignment between the gyro and the SeaBat head is usually achieved by ensuring the housing of the SeaBat head is parallel to the centerline of the vessel or ROV. Any misalignment will obviously cause the measured heading of the SeaBat head to be in error.

Any error in the measured heading of the SeaBat head will have a detrimental effect on the accuracy of the positions of the determined depths. For the center beams below the sonar head, this effect will be negligible, but will increase toward the outer beams. A heading error of 1° will cause an along-track error in the position of 0.4 meter on the outer beams when the SeaBat head is vertically mounted and is 25 meters above the seabed.

8.1.7 DATA TIMING SYNCHRONIZATION

Ideally, all the above attitude data should be determined instantaneously and simultaneously with each SeaBat update. This is however not always possible.

The update rate of the SeaBat system is faster than some of the other required survey sensor systems and most of the sensors cycle at different frequencies. As a result, the computerized on-line data logging system will handle data from a number of survey sensor systems that operate with different data output rates. Data from the positioning system will for instance require real-time processing in order to navigate the vessel or ROV along the survey lines and to simultaneously compute positions of the SeaBat head. Position data is therefore not available at a faster rate than the cycle time of the navigation program.

In order to utilize the SeaBat data, the position, depth and orientation of the SeaBat head must be known for each scan. However, since the SeaBat will update much faster than some of this data can be computed and/or logged, some of the data, for instance the positions of the SeaBat head, may have to be interpolated for a considerable number of SeaBat scans.

In order to enable accurate interpolation of slower cycling data and to enable further processing of the SeaBat data, it is imperative that the data from the miscellaneous survey sensor systems be accurately synchronized with the collected SeaBat data.

Any lack of synchronization between the computed positions and the SeaBat data will result in along track errors in the positions of the determined depths. Lack of synchronization between the depth, pitch, roll and heading data and the SeaBat data will result in errors both in the determined depths and also in the computed positions of these depths. The magnitude of these errors will obviously depend on the magnitude of the synchronization error and the amount of movement that the vessel or ROV is experiencing.

8.1.8 PURPOSE OF CALIBRATION PROCEDURES

The calibration procedures herein describe how the physical relation/alignment between the SeaBat head and the other survey sensor systems can accurately be established.

The calibration procedures include a description of the methodical approach by which the presence and/or magnitude of any residual errors can be detected. These errors result from inaccuracies in establishing the above relationship and also errors caused by lack of synchronization between the SeaBat data and the data from the various survey sensor systems.

The calibration procedures concern the following residual errors that, if not corrected for, can otherwise adversely affect the survey results:

- Synchronization errors between position, depth, pitch and roll data and the SeaBat data.
- Error in the pitch of the SeaBat head as determined by the pitch sensor (MRU).
- Error in the roll of the SeaBat head as determined by the roll sensor (MRU).
- Error in the heading of the SeaBat as determined by the north seeking gyro compass.

These calibration procedures only concern the errors that relate to the determination of the position, orientation and motion of the SeaBat head, and not the to required equipment specific calibrations of all of the above survey sensor systems.

The basic principles of the procedures for calibration of the SeaBat system are the same whether the SeaBat sonar head is mounted on a vessel or on a ROV, and although there are subtle differences the procedures are to a large extent identical. For reference, the following calibration procedures are specific to each of the two mounting options.

8.2 CALIBRATION CONDITIONS

The procedures herein are based on the assumption that a number of conditions are fulfilled prior to commencement of the SeaBat calibrations. These are especially conditions with respect to choice and calibration of other survey equipment, that are presumed to be managed by the survey contractors themselves, according to their own calibration and survey procedures.

Furthermore there are some conditions, with respect to environmental and other data, that are a prerequisite to the execution of the calibrations. The actual choice of calibration area is also included.

8.2.1 SURFACE AND SUBSEA POSITIONING SYSTEMS

The inherent accuracy of the surface and subsea positioning systems is typically the single most important factor for the overall accuracy of the final result. To a large extent the choice of surface and subsea positioning system will, therefore, be the most significant contributor to the achievable accuracy.

The following calibration procedures are intended to detect potentially very small errors. The SeaBat data must be processed to contour charts, cross profiles and longitudinal profiles to enable interpretation of the calibration results. To achieve a useful result of the calibrations, the choice of surface and subsea positioning system is also of the utmost importance.

In order to achieve useful calibration results, the surface positioning system should ideally be able to operate with a relative accuracy at sub meter level. It should be noted that it is the relative rather than the absolute accuracy that is of importance for the calibration results.

For shallow water inshore work where the SeaBat head will typically be fitted on a vessel. The choice of surface positioning system will rarely be a problem. In these areas the surface positioning systems will typically be a differential GPS satellite based system or a high frequency range/range system like "Microfix" or a laser range/bearing system like "Polarfix", i.e. systems capable of relative accuracy at decimeter level.

For offshore work the choice of a surface positioning system is typically governed more by the availability of systems in the survey area than by specific requirements. The available systems for offshore use will rarely be capable of operating with a relative accuracy better than 2-3 meters. It is therefore recommended that the SeaBat calibrations are always conducted in near-shore areas where high accuracy surface positioning systems can be utilized.

When utilizing an ROV mounted SeaBat head the subsea positioning system will typically be either a vessel mounted Ultra Short Base Line acoustic system (USBL) or a seabed deployed Long Base Line acoustic system (LBL). Since the LBL systems operate independent of the surface positioning system and since the system is capable of operating with a relative accuracy at decimeter level this is potentially an ideal system for calibration purposes. However, it should be noted that due to the relatively slow measurement rate of the system, especially for dynamic use, this emphasizes the requirement for correct synchronization between the SeaBat data and the positioning data.

The typical accuracy of a vessel mounted USBL system is 1% of the slant range between transducer and the transponder/responder. Providing that the USBL system works within specifications, it is therefore recommended that the use of USBL systems for calibration purposes should be limited to water depths less than 75-100 meters. It should be noted though, that the performance of some USBL systems, under certain circumstances, can degrade significantly in shallow water.

By a recently developed method, the horizontal ROV motion can also be determined by "dead reckoning". The heading data is utilized together with speed data, determined by means of a Doppler Log mounted on the ROV to accurately determine the ROV motion over a short period of time. This data can then be utilized to enhance the quality of the USBL data during the filtering/smoothing of the ROV position data. It should be noted that the quality of the USBL position data can be substantially improved by the use of a Doppler log.

The accuracy requirements to the surface and subsea positioning systems from a calibration point will, to some extent, depend on the certainty and accuracy with which the physical relation/alignment between the SeaBat sonar head and the other survey sensors can be determined onshore and with the vessel alongside.

Both surface and subsea positioning systems should be calibrated in compliance with manufacturers specifications and according to good survey practice prior to commencement of the sea-born part of the SeaBat calibrations. These necessary calibrations are not part of SeaBat Calibration procedures.

8.2.2 OTHER EQUIPMENT CALIBRATIONS

The bathymetric pressure sensor, the MRU and also the TS or CTD probe should be subject to a full bench or factory calibration, at regular intervals, in order to ensure that the equipment is working within specifications. The bench calibration basically comprises comparison of the output data against a known standard, for instance by comparing the reading from the pressure sensor against a known established pressure, or by comparing the pitch and roll data from the MRU against known established orientations. These bench calibration procedures are not part of the SeaBat Calibration procedures.

It is recommended that the above equipment has been subject to such a bench calibration within six (6) months prior to the work.

Usually the vessel and ROV gyro compasses are calibrated after installation on the vessel and ROV (ref. Chapter 8.3.3 and 8.4.3). It is however recommended that the survey gyro compass for both vessel and ROV be subject to a bench calibration immediately prior to the actual installation of the gyro. This bench calibration should comprise comparison between the gyro reading and a known heading on each of the four cardinal points for a period of 4-6 hours on each heading, not only to establish the index error of the gyro but also to ensure that the gyro is not subject to excessive drift.

8.2.3 ENVIRONMENTAL AND OTHER DATA

It is a prerequisite that the velocity of sound in the water column be established for the calibration area immediately prior to the sea born part of the SeaBat calibration. It is recommended that the sound velocity is determined for every 2.5-5 meter water depth for that part of the water column through which the SeaBat will be measuring. The data should be analyzed to ensure that the latter part of the water column is reasonably homogeneous with no distinct changes of sound velocity due to thermoclines or other factors.

In order to minimize the effect of tide on the calibration results, even if corrected for, it is recommended that the sea born part of the SeaBat calibration be carried out at slack water, and that the data for each calibration line be collected within as short a time span as possible.

If the calibration is conducted inshore, but for offshore work, accurate tidal data may not be readily available, and there may be other reasons why these variations cannot be accurately established. Providing the above recommendation is complied with, and providing that the tidal range is not excessive, it may be possible to avoid correcting the SeaBat data for tide without adversely affecting the calibration results.

If the SeaBat is ROV mounted, the mean density of the water column must also be determined in the calibration area immediately prior to calibration. The variation in air pressure should also be accurately established during calibration. Both density and air pressure should be entered into the bathymetric system, the air pressure should be updated every 3-6 hours, such that any influence on the results can be avoided.

8.2.4 CHOICE OF CALIBRATION AREA

The sea born part of the SeaBat calibration can be carried out on various types of seabed, as there is a certain flexibility in the procedures; such that by slight alterations to the procedures various types of seabed can be accommodated.

The ideal calibration area should comprise:

- An area of even seabed 500 to 1000 meters long and 50 to 100 meters wide
- A slope of sufficient gradient to enable accurate processing of the SeaBat data to present the data as contours with 0.5 meter interval
- An area of flat even seabed of similar size and including a seabed feature that can be distinguished easily on both a contour chart and on cross profiles and longitudinal profiles of the seabed.

8.3 CALIBRATION OF VESSEL MOUNTED SeaBat

The calibration of the vessel mounted SeaBat basically comprise two separate operations. First, the physical relation/alignment between the SeaBat sonar head and the other survey sensors on the vessel must be established as accurately as possible in a controlled environment. This will typically take place during mobilization while the vessel is tied up at the dock. The second part comprise sea born calibration where actual SeaBat data is collected and subsequently processed and analyzed to detect any time synchronization errors or residual alignment errors.

8.3.1 SeaBat MOUNTING ON VESSEL

In order to minimize the influence of alignment errors that, despite the following calibration may be undetected, it is important that the SeaBat sonar head is mounted with the axes as closely aligned to the axes of the MRU as possible. On a vessel, the SeaBat sonar head and the MRU will usually be separated, with the MRU placed above the water. A physical alignment of the housing of the units may not be possible unless the vessel can be trailored. The SeaBat sonar head and the MRU must therefore be aligned with the axes as close to the vertical and horizontal planes and the centerline of the vessel as possible.

To a large extent, accurate alignment of the vessel mounted SeaBat sonar head can be achieved by accurate design and manufacturing of the mounting assembly.

NOTE

For Mounting Instructions please refer to Paragraph 4.4 - Option 004.

When using the SeaBat on small survey launches and dingies, the MRU and SeaBat sonar head can be mounted on the same assembly, similar to an ROV mounted SeaBat. If this assembly is designed and engineered such that the SeaBat head and the MRU are rigidly fixed together, then any misalignment between the axes of the SeaBat head and the MRU can be determined through a bench calibration. The assembly must be placed in a jig where the actual pitch and roll of the SeaBat head can be determined with an accuracy that is significantly better than the accuracy of the MRU, e.g., by means of ordinary land survey methods. By comparing the actual pitch and roll data with the measured data from the MRU, any offsets or misalignments can be determined. To confirm the consistency, this should be done for a series of pitch and roll values between ±20° in steps of 5°.

8.3.2 VESSEL OFFSETS

After mounting the SeaBat sonar head, the offset between the head and the antenna(s) for the positioning system(s) must be determined accurately. The offsets of sensors mounted on the survey vessel are referenced to a vessel reference point (VRP), usually the center of gravity (CoG). Offsets are measured along-ships and athwart ships relative to the centerline of the vessel and the perpendicular line that intersect the centerline through the VRP. Vertical offsets are usually referenced to the waterline of the vessel.

Depending on the size/shape of the vessel, its survey speed, and the water depth, each vessel will experience varying squat distances. This vertical movement of the vessel must be determined and accounted for when computing the trial depth. The squat calibration tests are not part of these procedures.

Offsets should be tape measured. When establishing the vertical offsets, the most important parameter is the draft of the SeaBat sonar head. An error in the applied draft value will directly affect the measured depths.

8.3.3 VESSEL GYRO

The calibration of the vessel gyro is usually the responsibility of the survey contractor, but due to the importance of this calibration the following recommended gyro calibration procedure is included for reference.

Prior to the mobilization of the survey vessel, a baseline with known azimuth should be established parallel to a quay side where the vessel is berthed. It is recommended that the azimuth of this baseline be determined with an accuracy that is better than half the resolution of the gyro compass. This can easily be achieved by ordinary land survey methods.

During installation of the gyro compass on the vessel, the gyro compass should be aligned parallel to the centerline of the vessel and secured tightly. The centerline of the vessel should be established by tape measurements and confirmed by means of the general arrangement drawings. Two points should be marked on both sides of the vessel, fore and aft, and separated as far as possible. The distance from these points to the centerline of the vessel should be known. It is important that the marking of the centerline and the latter points is permanent so that results can be compared if the procedure must be repeated.

Prior to calibration the gyro compass should go through the warm up and settlement period recommended by the manufacturer, and be set with the correct latitude and speed.

With the vessel tied up tightly against the quay side, the gyro reading should be recorded while simultaneously establishing the true heading of the centerline of the vessel by measuring the distances from the points on the side of the vessel to the baseline on the quay side. At least three sets of simultaneous observations should be carried out, each comprising 20-30 data sets recorded over a time span of 10-15 minutes. This procedure should then be repeated on the reciprocal heading. The gyro should be allowed sufficient time to settle after turning the vessel, and the results from the reciprocal headings should agree within the accuracy of the gyro.

CAUTION
If a Magnetic Compass is being utilized, then caution should be taken in applying the corrections for magnetic variation and True Grid North in comparison with the surveyed baseline.

By comparing the observed gyro readings and the calculated vessel centerline headings, any misalignment between the zero index line of the gyro and the centerline of the vessel can be established and consequently corrected for in the on-line navigation system.

8.3.4 VESSEL MOTION SENSOR

Due to long term drift in the accelerometers, the measurement accuracy of an MRU will slowly degrade with time. It is therefore recommended that the MRU be subject to a full bench calibration on a regular basis. The bench calibration requires complete motion and vibration free conditions. Such conditions are seldom achievable in the field.

Some MRU's allow a field calibration check of the status of accelerometers. Here the MRU data is logged internally in the system, while the sensor is moved through a series of pre-defined orientations. The data collected for each of these orientations is then analyzed internally to check the calibration status of the sensor.

In order to accurately align the heave, pitch and roll axes of the MRU and the SeaBat sonar head, the two units should be located near each other with the yaw or "Z" axes aligned. The ideal solution is to have the two units mounted in the same assembly, so the housing of the units can be physically aligned. However, the MRU will usually be placed above the water and the unit must be aligned relative to the vertical, horizontal planes and the centerline of the vessel.

Due to the different ways in which alignment errors affect the SeaBat data, the pitch alignment error is the most difficult to detect. When mounting the SeaBat head and the MRU it is important to align the roll axes of the units as close to horizontal as possible, thus ensuring that both units are as close to vertical as possible around the pitch axis (See Figure 8-1. SeaBat Axis System).

After the MRU is installed and secured, any misalignment or offsets in pitch and roll should be established by logging the average roll and pitch angles over a sufficient time span to establish accurate pitch and roll offsets. Some MRU's have a built-in function that will determine the offsets or "mount angles". This procedure should be carried out while the vessel is tied up loosely, with the vessel ballasted (as for working conditions), with all work onboard halted, and with the vessel evenly balanced and without list. The time span over which the average roll and pitch values should be established depends on the size of the vessel and the weather conditions. It is recommended to record data for 10-15 minutes for a vessel in the water and 3-5 minutes for a trailered vessel.

The established pitch and roll offsets should then be corrected for either in the MRU control and display unit (CDU) itself or in the data logging system.

8.3.5 COLLECTING CALIBRATION DATA

The sea borne part of the SeaBat calibrations should, as a minimum, comprise one survey line across an area of even seabed with a slope of sufficient gradient to enable accurate processing of the SeaBat data to present the data as contours with 0.5 meter interval. The survey line should be perpendicular to the gradient of the slope, and of sufficient length to collect data along 500-1000 meters, depending on vessel speed. The location of the calibration area and the survey line should enable a run-in of sufficient length to enable the vessel to establish a constant speed prior to commencement of the logging of data.

During collection of calibration data this survey line should be run once on reciprocal headings. During these two transits of the line, the speed of the vessel should remain constant, and equal to the anticipated survey speed, and the same speed should be maintained in both directions. The line should then be run once more in one direction only with a constant speed of twice the survey speed. The choice of the initial vessel speed during data collection is not significant, as such. The important point is that the speed should remain constant and equivalent on opposite headings, and that there is a significant difference between the vessel speed for the two transits of the line on the same heading.

Ideally two more survey lines should also be run across an area of flat, even seabed with a seabed feature that can be distinguished easily on both a contour chart and on cross profiles and longitudinal profiles of the seabed. The two lines should be parallel and equidistant from the seabed feature by such a distance that the feature will be crossed by the outer beams of the SeaBat. The distance between the survey lines and the seabed feature should be at least 25-30 meters. These two lines should be run on reciprocal headings and with constant and equivalent vessel speed as above. One of the two lines should then be run again on the same heading as for the first transit with constant but significantly higher vessel speed than during the first transit.

The data logging during calibration should include all updates of all survey sensors as well as the SeaBat, as per normal survey procedure.

Usually, any data time synchronization errors will cause permanent distortion of the collected SeaBat data. The disclosure of timing errors will therefore generally result in one or more of the above lines having to be re-run after elimination of the errors, in order to ensure that such errors no longer exist.

8.3.6 CALIBRATION DATA PROCESSING

The analysis of the calibration data comprise a comparison of corresponding data from the various transits of the survey lines.

For each transit of the above survey lines all the collected calibration data should be processed to produce a Digital Terrain Model (DTM). During processing, the data should be corrected for tide and other factors.

From the DTM the following should be derived:

- A contour chart with 0.5 m contour interval.
- A longitudinal profile of the seabed along each survey line and for each transit.
- Cross profiles of the seabed perpendicular to the survey line. For each line and transit, several profiles should be plotted such that they coincide.
- A longitudinal profile through the seabed feature for each of the transits of the survey lines on either side of the feature.

If DTM processing is not available, the above profiles can be determined directly from the SeaBat data. The longitudinal profiles will then have to be drawn from single beam data, and the cross profiles from single swath data. Under such circumstances particular attention must be given to the line-keeping and roll motion of the survey vessel during the calibrations, otherwise it could prove very difficult to select corresponding data from the different line transits for comparison. It should also be noted that the data analysis will be inherently less accurate than if using a DTM.

The horizontal and vertical scales for the contour charts and the longitudinal and cross profiles must be chosen such that detailed analysis of the data is possible, for instance scales of 1:500 and 1:50 respectively. The charts and profiles for each of the above areas should either be plotted so that the data from each transit of the lines can be compared (either by plotting on a transparent media such that charts can be overlaid) or plotted on the same chart but with different line types so that data from each transit can be distinguished.

8.3.7 CALIBRATION DATA ANALYSIS

If the SeaBat data is not affected by any of the following systematic errors, the data from each transit of each of the above survey lines should match within the horizontal and vertical accuracy of the processed data. By presenting the collected calibration data as contour charts, longitudinal profiles and cross profiles, corresponding contours and profiles can be compared for the different transits of the same line. Any discrepancies or differences between the compared data will most likely be the result of systematic errors that have not been corrected for.

When analyzing the calibration data, the inherent absolute accuracy of the data should be taken into consideration. Differences in the processed results, from data collected over the same area of seabed and for each of the transits of the line, can obviously show a certain amount of dissimilarities caused by the inherent accuracy of the data. The resulting effect on the SeaBat data, of any systematic errors, therefore have to be of a magnitude significantly larger than the inherent accuracy of the data in order to determine the character and the magnitude of such errors.

8.3.8 TIMING OF SeaBat AND SURVEY SENSOR DATA

Lack of time synchronization between the SeaBat data and the data from the heave, pitch, roll, pressure and heading sensors and also positioning data will, to some extent, affect the SeaBat data differently, it is therefore possible to detect the presence of the specific timing errors through careful analysis of collected data.

As a result of the collected data being recorded in a dynamic situation, the effect of timing errors on the SeaBat data can be variable, even if the timing error is constant, whereas the misalignment errors will affect the collected SeaBat data in an unchanging manner. The inner and outer beams will often be affected to a varying degree. Variable effects of that kind obviously make it difficult to quantify the magnitude of any such errors, and consequently it is often an iterative process to correct for, or eliminate, timing errors. It is, however, also the varying characteristic of the effect of timing errors that enable the detection of such errors.

The effect on the SeaBat data of any alignment errors will be identical for any transit of a line that is traversed on the same heading. By utilizing data from the transits of the survey lines that are run on the same heading but with different speed it is possible to analyze the data with respect to timing errors irrespective of the presence of any alignment errors that may also affect the data.

The occurrence of timing errors should be prevented initially through the design of the on-line navigation and data logging system. Timing errors can usually be avoided through precise time tagging of data which will enable accurate interpolation of any data from the survey sensors that may not be measured at exactly the same time as the respective SeaBat scans.

Due to the complexity of the way timing errors affect the SeaBat data it will, in some cases, only be possible to detect timing errors in a general sense without being able to identify the specific cause. Both because the affect of some timing errors will be similar and also because the affect often will be of a magnitude that impedes detection.

Even though heave, pitch and roll data is usually determined by one sensor (the MRU) any time synchronization error between SeaBat data and MRU data will affect the SeaBat data differently for the three separate elements. Heave, pitch and roll data is therefore described individually in the following paragraphs.

8.3.8.1 Heave Data Timing

Time synchronization errors between the SeaBat data and the heave data will cause the SeaBat data to be erroneously heave corrected and thus cause variable errors in the determined depths. Such errors will be apparent on a longitudinal profile plotted from the SeaBat data as an undulating tendency of the seabed profile, with short wavelength and often with steep exaggerated troughs and peaks.

If the seabed over which the calibration data was collected is reasonably even, such undulation will be immediately apparent from the longitudinal seabed profiles from any of the survey lines.

8.3.8.2 Bathymetric Pressure Sensor Data Timing

Time synchronization errors between the SeaBat data and the data from the bathymetric pressure sensor will cause variable errors in the absolute depths determined from the combination of SeaBat and pressure sensor data.

The longitudinal profiles from the transits of any line run on the same heading but with different speed, should coincide within the absolute accuracy of the depth measurement. By comparing the corresponding longitudinal profiles from these transits, such an error will be apparent as a variable difference between the profiles that significantly exceed the tolerance of the determined depths.

8.3.8.3 Pitch Data Timing

Time synchronization error between the SeaBat data and the pitch data will primarily cause variable along track errors in the positions of the determined depths. To a lesser extent, it will also cause variable errors in the actual depths. The latter depth errors will most often be relatively small compared to the absolute accuracy and be virtually impossible to detect.

The depth contours from the two transits of the line run across the slope on the same heading, with different vessel speed, should coincide within the accuracy of the positioning of the SeaBat head. By comparing the corresponding contours from these transits, variable positioning errors will be apparent as a variable difference between the horizontal position of corresponding contours that significantly exceed the tolerance of the computed positions of the SeaBat head.

Variable depth errors will be apparent as variable differences between corresponding cross profiles from these transits that significantly exceed the tolerance of the measured depths.

8.3.8.4 Roll Data Timing

Time synchronization error between the SeaBat data and the roll data will cause variable errors in the determined depths and will also, to lesser extent, cause variable cross-track errors in the positions of these depths. The outer beams will be affected the most. The latter position errors will be virtually impossible to detect.

By comparing corresponding cross profiles, from the respective transits of the line run across the slope on the same heading, with a different vessel speed, variable depth errors will be apparent as variable differences between corresponding cross profiles.

8.3.8.5 Heading Data Timing

A time synchronization error between the SeaBat data and the heading data will cause variable along-track errors in the positions of the determined depths. The outer beams will be affected the most.

By comparing corresponding contours, from the transits of the line run across the slope on the same heading, with a different vessel speed, such an error will be apparent as a variable horizontal difference between the position of the contours that becomes more prominent towards the outer beams.

8.3.8.6 Positioning Data Timing

A time synchronization error between the SeaBat data and the computed positions will cause along-track errors in the positions of the determined depths. Providing that the timing error is constant, the affect on the positions will also be constant, but the effect will increase in magnitude with increased vessel speed.

By comparing the contours, from the respective transits of the line run on the same heading but with a different vessel speed in the sloping area, such an error will appear as a parallel displacement of corresponding contours that significantly exceed the tolerance of the computed positions of the SeaBat sonar head. If the timing error is variable, the differences between corresponding contours will likewise be variable.

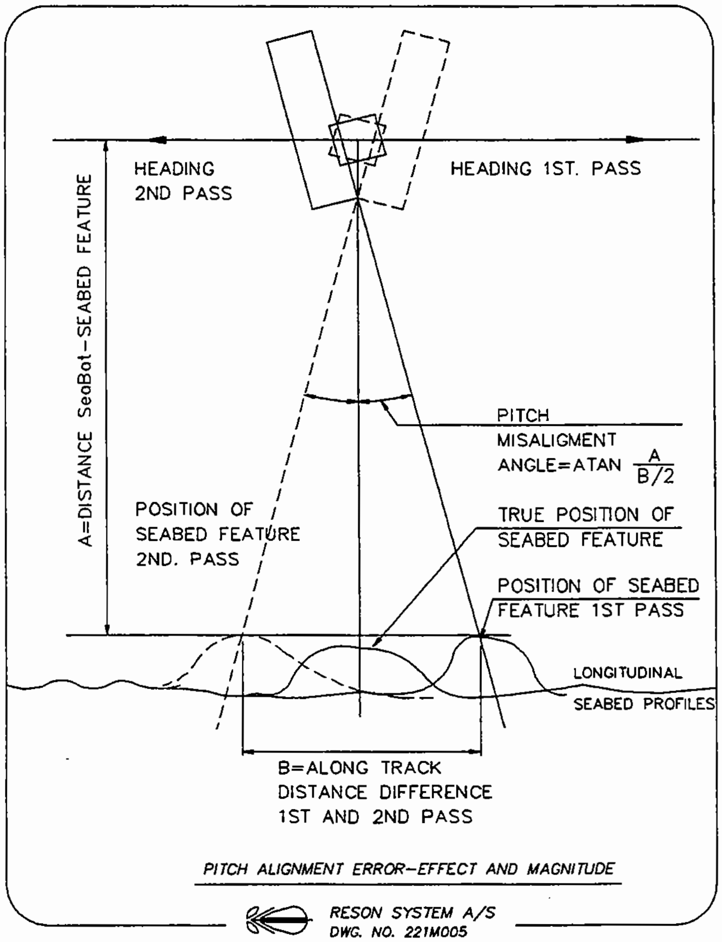

Figure 8-4. Pitch Alignment Error-Effect and Magnitude

By comparing the contours from the respective transits of the line run on the same heading, but with different vessel speed in the flat area, such an error will appear as a horizontal along-track difference in the position of the seabed feature, as indicated by the contours or by the longitudinal profiles through the seabed feature.

A constant position data timing error will have an identical effect on the processed results as the pitch alignment error described below. The effect of a pitch alignment error on the results will; however, be constant with constant depth and will be independent of vessel speed. The affect on the results from line transits with the same heading will be identical. It is therefore possible to identify a position timing error irrespective of the presence of a pitch alignment error. Any position data timing error should; however, be identified and corrected for prior to collecting and/or analyzing the data for the following pitch alignment error.

8.3.8.7 Timing vs. Alignment Errors

Since pitch, roll and heave correction is usually conducted on-line while logging the data, and since the effect of timing errors is variable, the above timing errors may affect the collected calibration data permanently. It may not be possible to recover the data by re-processing even after having identified any timing errors

Provided that the data from the above survey lines is found to be unaffected by any timing errors, the same data can be utilized for analysis for the following alignment errors. If the presence of any timing errors are detected in the first batch of calibration data, the above lines must be re-run in order to collect one more series of calibration data, once the timing errors are eliminated.

8.3.9 PITCH ALIGNMENT ERROR

Any vertical misalignment between the roll axes of the SeaBat sonar head and the MRU will cause the measured pitch of the head to be in error. Such an alignment error will be constant.

A pitch alignment error will cause along track errors in the positions of the determined depths. As the error is constant, the affect on the positions will also be constant with constant distance from the SeaBat sonar head to the seabed. The effect on the data will; however, increase with an increase of this distance. The effect on the data will be similar for all beams across the swath.

By comparing the contours, from the respective transits of the line run on reciprocal headings, but with equivalent vessel speed in the sloping area, such an error will appear as a parallel displacement of corresponding contours, that increase with depth, and that significantly exceed the tolerance of the computed positions of the SeaBat head.

By comparing the contours, from the respective transits of the line run on reciprocal headings but with equivalent vessel speed in the flat area, such an error will be apparent as a horizontal along-track difference in the position of the seabed feature, as indicated by the contours or by the longitudinal profiles through the seabed feature.

Depending on the consistency of the data, the pitch alignment error (or offset) can be determined by converting from rectangular to polar co-ordinates half the distance separating the corresponding contours and/or half the along-track difference in the seabed feature position over the depth of the feature below the SeaBat head.

8.3.10 ROLL ALIGNMENT ERROR

Any vertical misalignment between the pitch axes of the SeaBat head and the MRU will cause the measured roll of the head to be in error. Such an alignment error will be constant.

A roll alignment error will cause errors in the determined depths. As the error is constant, the affect on the depths will also be constant with constant slant range. The effect on the data will however be negligible on the vertical beams and increase in magnitude towards the outer beams.

By comparing the corresponding cross profiles of the seabed, from the respective transits of any the above lines run on reciprocal headings, such an error will be apparent as an angular misalignment between these profiles. Depending on the consistency of the data, the roll alignment error (or offset) can be determined as half the angle between the profiles.

8.3.11 GYRO ALIGNMENT ERROR

Any horizontal misalignment between the roll axis of the SeaBat sonar head and the zero index line of the gyro compass will cause the measured heading of the head to be in error. Such an alignment error will be constant.

A gyro misalignment will cause errors in the positions of the determined depths. The effect will be negligible for the center beams and will increase in magnitude towards the outer beams.

By comparing the contour charts from the line run on reciprocal headings either side of the seabed feature, such an error will be apparent as a difference in the horizontal position of the feature as indicated by the contours.

By comparing corresponding contours from the line run on reciprocal headings across the slope, such an error will be apparent as an angular misalignment between these contours.

Depending on the consistency of the data, the gyro alignment error or offset can either be determined by converting from rectangular to polar co-ordinates half the along track distance separation in the seabed feature position over the horizontal distance from SeaBat head to the feature, or as half the angular misalignment between corresponding contours.

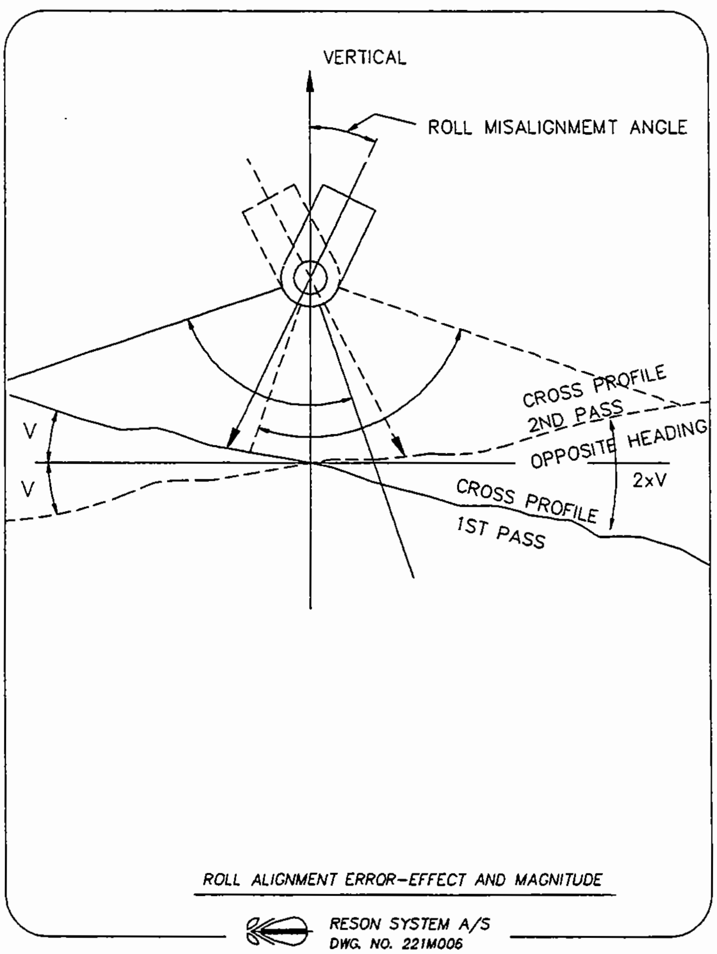

Figure 8-5. Roll Alignment Error-Effect and Magnitude

8.3.12 ALIGNMENT CORRECTION

The above alignment errors should be corrected for either in the on-line logging system, or during the post-processing of the data.

Since the effect of these errors does not permanently degrade the collected data, the correction values can be determined through trial and re-processing. Different correction values can be tried and the data subsequently re-processed to determine the best possible agreement between corresponding contours, seabed profiles or seabed feature positions.

8.3.13 RECOMMENDATIONS

As it is evident from the description of the data analysis above, it is not strictly necessary to run all of the above survey lines. Due to the complexity of the way the timing errors affect the SeaBat data, and due to the general difficulties in detecting such errors, it is however recommended to include all the lines during the collection of calibration data.

It is also evident that it could be difficult both to detect and quantify data timing errors if the presence of such errors are suspected after the calibration data is analyzed, but without certainty of specific type of error, it is recommended that the above calibration data collection is repeated for further analysis.

Should analysis of the calibration data reveal presence of timing errors, it is imperative that the cause of the errors be established so that it can be eliminated. Only when the data show no, or constant, remaining systematic differences between corresponding profiles and contours, should the calibration/analysis proceed.

8.4 CALIBRATION OF ROV MOUNTED SeaBat

The calibration of the ROV mounted SeaBat basically comprises two separate operations. First the physical relation/alignment between the SeaBat head and the other survey sensors on the ROV must be established as accurately as possible in a controlled environment. This part will typically take place during mobilization while the survey vessel is alongside and the ROV can be placed on the quay side. The second part comprises sea-borne calibrations where actual SeaBat data is collected and subsequently processed and analyzed to detect any time synchronization errors or residual alignment errors.

8.4.1 SeaBat MOUNTING

In order to minimize the influence of alignment errors that, despite the following calibrations may be undetected, it is important that the SeaBat head is mounted with the axes as closely aligned with the axes of the MRU as possible. On an ROV, the SeaBat head and the MRU will usually be mounted adjacent to each other and it will be possible to ensure that housing of the units are aligned. To a large extent accurate alignment between the axes of the SeaBat head and the MRU can be achieved by accurate design and fabrication of the mounting assembly. If this assembly is designed and engineered such that the SeaBat head and the MRU are rigidly fixed together, then any misalignment between the axes of the SeaBat head and the MRU can be determined through a bench calibration. The assembly must be placed in a jig where the actual pitch and roll of the SeaBat head can be determined with an accuracy that is significantly better than the accuracy of the MRU, for instance by means of ordinary land survey methods. By comparing the actual pitch and roll data with the measured data from the MRU any offsets or misalignments can be determined. To confirm the consistency, this should be done for a series of pitch and roll values between $\pm 20°$ in steps of $5°$.

NOTE

For mounting Instructions please refer to Paragraph 4.4 - Option 004.

8.4.2 ROV OFFSETS

After mounting the SeaBat sonar head, the offset between the head and the responder/transponder for the subsea positioning system must be determined. The offsets of sensors mounted on the ROV are referenced to a vessel reference point (VRP), usually the acoustic center of the SeaBat sonar head. Horizontal offsets are then measured relative to the axis system centered in the VRP and with the axes parallel to the axes of the ROV. Vertical offsets are usually also referenced to the VRP.

The ROV offsets should be established by tape measure.

8.4.3 ROV GYRO

The calibration of the ROV gyro is usually the responsibility of the survey contractor, but due to the importance of this calibration the following recommended gyro calibration procedure is included for reference.

The same baseline, with known azimuth, that is established for the vessel gyro calibration should be used for the calibration of the ROV gyro. It is recommended that the azimuth of this baseline is determined with an accuracy that is better than half the resolution of the gyro compass.

During installation of the gyro compass on the ROV, the gyro compass should be aligned parallel to the centerline of the ROV and secured. For easy reference, and in order to ensure repeatability, it is best to use one of the edges of the frame or skids to represent the longitudinal axis of the ROV. Two points should be marked on the frame or skid of the ROV fore and aft and as greatly separated as possible. It is important that the marking of these points be permanent so that results can be compared if the procedure must be repeated.

Prior to calibration, the gyro compass should go through the warm up and settlement period recommended by the manufacturer, and be set with the correct latitude and speed.

With the ROV placed adjacent to, and approximately parallel with the baseline, the gyro reading should then be logged and the true heading of the longitudinal axis of the ROV established by measuring the distances from the two points on the side of the ROV to the baseline. Gyro data should be recorded for at least 30-45 minutes. This procedure should then be repeated on the reciprocal heading. The gyro should be allowed sufficient time to settle after turning the ROV, and the results from the reciprocal headings should agree within the accuracy of the gyro.

By comparison between the observed gyro readings and calculated ROV headings, any misalignment between the zero index line of the gyro and the longitudinal axis of the ROV can be established and consequently corrected for in the on-line navigation system.

8.4.4 ROV MOTION SENSOR

Due to long term drift in the accelerometers the measurement accuracy of an MRU will slowly degrade with time. It is therefore recommended that the MRU be subjected to a full bench calibration on a regular basis. The bench calibration requires complete motion and vibration free conditions, such conditions are seldom achievable in the field.

Some MRU's allow a field calibration check of the status of accelerometers, whereby the MRU data is logged internally in the system while the sensor is moved through a series of pre-defined orientations. The data collected for each of these orientations is then analyzed internally to check the calibration status of the sensor.

In order to accurately align the pitch and roll axes of the MRU and the SeaBat head, the two units should be located as closely as possible. Preferably the two units should be mounted in the same assembly so that the housing of the units can be physically aligned, and such that any misalignment between the axes of the unit can be determined by measurement.

After the SeaBat sonar head and the MRU are installed and aligned, the alignment between the axes of the MRU/SeaBat and the axes of the ROV should be established. With the ROV placed on the quay side the roll and pitch angles, as measured by the MRU, should be logged over 5-10 minutes, and at the same time the actual attitude of the ROV should be established by means of conventional land survey methods or by means of a level of sufficient accuracy.

The alignment between MRU/SeaBat axes and the axes of the ROV is not critical since the SeaBat data is pitch and roll corrected, but these corrections should be kept to a minimum by ensuring the MRU/SeaBat are aligned with the ROV axes within a few degrees.

8.4.5 COLLECTING CALIBRATION DATA

The sea-borne part of the SeaBat calibrations should, as a minimum, comprise one survey line across an area of even seabed with a slope of sufficient gradient to enable accurate processing of the SeaBat data to present the data as contours with 0.5 meter interval. The survey line should be perpendicular to the gradient of the slope, and of sufficient length to collect data along 500-750 meters, depending on ROV speed. The location of the calibration area and the survey line should enable a run-in of sufficient length to enable the ROV to establish a constant speed prior to commencement of the logging of data.

During collection of calibration data, this survey line should be run once on reciprocal headings. During these two transits of the line, the speed of the ROV should remain constant, and the same speed should be maintained in both directions. The line should then be run once more in one direction only with a constant speed of twice the speed during the first transit. The choice of the initial ROV speed during data collection is not significant as such. The important point is that the speed should remain constant and equivalent on opposite headings, and that there is a significant difference between the ROV speed for the two transits of the line on the same heading.

It is not critical whether the line across the slope is run with constant depth or constant altitude, the important issue is to keep the ROV speed constant and the attitude stable during the transits of the line. The height of the ROV above the seabed should be such that the swath width is at least 40-50 meters, in order to ensure a good coverage of the cross profiles.

Ideally, two more survey lines should also be run across an area of flat, even seabed with a seabed feature that can be distinguished easily on both a contour chart and on cross profiles and longitudinal profiles of the seabed. The two lines should be parallel and equidistant from the seabed feature by such a distance that the feature will be crossed by the outer beams of the SeaBat. The distance between the survey lines and the seabed feature should be at least 25-30 meters. The two lines should be run on reciprocal headings and with constant and equivalent ROV speed. One of the two lines should then be run again on the same heading, as for the first transit, with constant, but significantly higher ROV speed than during the first transit.

The data logging during calibration should include all updates of all survey sensors as well as the SeaBat, as per normal survey procedure.

Usually any data time synchronization error will cause a permanent distortion of the collected SeaBat data. The disclosure of timing errors will therefore generally result in one or more of the above lines having to re-run after elimination of the errors in order to ensure that they no longer exist.

8.4.6 CALIBRATION DATA PROCESSING

The analysis of the calibration data comprises a comparison of corresponding data from different transits of above survey lines.

For each transit of the above survey lines all the collected calibration data should be processed to produce a Digital Terrain Model (DTM). During processing, the data should be corrected for tide and other known environmental elements.

From the DTM the following should be derived:

- A contour chart with 0.5 m contour interval.
- A longitudinal profile of the seabed along each survey line and for each transit.
- Cross profiles of the seabed perpendicular to the survey line. For each line and transit several profiles should be plotted such that they coincide.
- A longitudinal profile through the seabed feature for each of the transits of the survey lines on either side of the feature.

If DTM processing is not available, the above profiles can be determined directly from the SeaBat data. The longitudinal profiles will then have to be drawn from single beam data, and the cross profiles from single swath data. Under such circumstances particular attention must be given to the line-keeping and roll motion of the ROV during the calibrations, otherwise it could prove very difficult to select corresponding data from the different line transits for comparison. It should also be noted that the data analysis will be inherently less accurate than if using a DTM.

The horizontal and vertical scales for the contour charts and the longitudinal and cross profiles must be chosen such that detailed analysis of the data is possible, for instance scales of 1:500 and 1:50 respectively. The charts and profiles for each of the above areas should either be plotted so that the data from each transit of the lines can be compared (either by plotting on a transparent media such that charts can be overlaid) or plotted on the same chart, but with different line types such that data from each transit can be distinguished.

8.4.7 CALIBRATION DATA ANALYSIS

If the SeaBat data is not affected by any of the following systematic errors, the data from each transit of each of the above survey lines should match within the horizontal and vertical accuracy of the processed data. By presenting the collected calibration data as contour charts; longitudinal profiles and cross profiles, corresponding contours and profiles can be compared for the different transits of the same line. Any discrepancies or differences between the compared data will most likely be the result of systematic errors that have not been corrected for.

When analyzing the calibration data, the inherent absolute accuracy of the data should be taken into consideration. Differences in the processed results, from data collected over the same area of seabed and for each of the transits of the line, can obviously show a certain amount of dissimilarities caused by the inherent accuracy of the data. The resulting effect on the SeaBat data, of any systematic errors, therefore have to be of a magnitude significantly larger than the inherent accuracy of the data in order to determine the character and the magnitude of such errors.

8.4.7.1 Timing of SeaBat and Survey Sensor Data

Lack of time synchronization between the SeaBat data and the data from the heave, pitch, roll, pressure and heading sensors and also positioning data will, to some extent, affect the SeaBat data differently. It is therefore, possible to detect the presence of the specific timing errors through careful analysis of collected data.

As a result of the collected data being recorded in a dynamic situation, the effect of timing errors on the SeaBat data can be variable, even if the timing error is constant, whereas the misalignment errors will affect the collected SeaBat data in an unchanging manner. The inner and outer beams will often be affected to a varying degree. Variable effects of this kind obviously makes it difficult to quantify the magnitude of any such errors. Consequently it is often an iterative process to correct for, or eliminate, timing errors. It is; however, also the varying characteristic of the effect of timing errors that enable the detection of such errors.

The effect on the SeaBat data of any alignment errors will be identical for any transit of a line that is traversed on the same heading. By utilizing data from the transits of the survey lines that are run on the same heading, but with different speed, it is therefore possible to analyze the data with respect to timing errors irrespective of the presence of any alignment errors that may also affect the data.

The occurrence of timing errors should be prevented initially through the design of the on-line navigation and data logging system. Timing errors can usually be avoided through precise time tagging of data, which will enable accurate interpolation of any data from the survey sensors that may not be measured at exactly the same time as the respective SeaBat scans.

Due to the complexity of the way timing errors affect the SeaBat data, it will in some cases only be possible to detect timing errors in a general sense without being able to identify the specific cause. This is true because the affect of some timing errors will be similar and also because the affect often will be of a magnitude that impedes detection.

Even though pitch and roll data is usually determined by one sensor (the MRU) any time synchronization error between SeaBat data and MRU data will affect the SeaBat data differently for the separate elements. Pitch and roll data is; therefore, described individually in the following paragraphs.

8.4.7.2 Bathymetric Pressure Sensor Data Timing

For the ROV mounted SeaBat, the data are not heave compensated as such. Instead the depth of the SeaBat sonar head must be determined for each scan. As a result it is imperative that the SeaBat data and the pressure sensor data is time synchronized.

Time synchronization errors between the SeaBat data and the data from the bathymetric pressure sensor will cause variable errors in the absolute depths determined from the combination of SeaBat and pressure sensor data.

The longitudinal profiles from the transits of any line run on the same heading but with different speed should coincide within the absolute accuracy of the depth measurement. By comparing the corresponding longitudinal profiles from these transits, such an error will be apparent as a variable difference between the profiles that significantly exceeds the tolerance of the determined depths.

8.4.7.3 Pitch Data Timing

A time synchronization error between the SeaBat data and the pitch data will primarily cause variable along-track errors in the positions of the determined depths. To lesser extent, it will also cause variable errors in the actual depths. The latter depth errors will most often be relatively small compared to the absolute accuracy and be virtually impossible to detect.

The depth contours from the two transits of the line run across the slope on the same heading, with different vessel speed, should coincide within the accuracy of the positioning of the SeaBat sonar head. By comparing the corresponding contours from these transits, variable positioning errors will be apparent as a variable difference between the horizontal position of corresponding contours that significantly exceed the tolerance of the computed positions of the SeaBat sonar head.

Variable depth errors will be apparent as variable differences between corresponding cross profiles from these transits that significantly exceed the tolerance of the measured depths.

8.4.7.4 Roll Data Timing

A time synchronization error between the SeaBat data and the roll data will cause variable errors in the determined depths and will also, to lesser extent, cause variable cross-track errors in the positions of these depths. The outer beams will be affected the most. The resulting position errors will be virtually impossible to detect.

By comparing corresponding cross profiles, from the respective transits of the line run across the slope on the same heading, with different vessel speed , variable depth errors will be apparent as variable differences between corresponding cross profiles.

8.4.7.5 Heading Data Timing

A time synchronization error between the SeaBat data and the heading data will cause variable along-track errors in the positions of the determined depths. The outer beams will be affected the most.

By comparing corresponding contours, from the transits of the line run across the slope on the same heading, with different vessel speed, such an error will be apparent as a variable horizontal difference between the position of the contours that becomes more prominent towards the outer beams.

8.4.7.6 Positioning Data Timing

A time synchronization error between the SeaBat data and the computed positions will cause along-track errors in the positions of the determined depths. Providing that the timing error is constant the affect on the positions will also be constant, but the effect will increase in magnitude with increased ROV speed.

By comparing the contours, from the respective transits of the line run on the same heading but with different ROV speed in the sloping area, such an error will appear as a parallel displacement of corresponding contours, that significantly exceeds the tolerance of the computed positions of the SeaBat sonar head. If the timing error is variable, the differences between corresponding contours will likewise be variable.

By comparing the contours, from the respective transits of the line run on the same heading but with different vessel speed in the flat area, such an error will appear as a horizontal along-track difference in the position of the seabed feature. This will be indicated by the contours or by the longitudinal profiles through the seabed feature.

A constant position data timing error will have an identical effect on the processed results as the pitch alignment error described below. The effect of a pitch alignment error on the processed results will; however, be constant with constant depth and will be independent of ROV speed. The effect on the results from the line transits with the same heading will be identical. It is therefore possible to identify a position timing error irrespective of the presence of a pitch alignment error. Any position data timing error should; however, be identified and corrected for prior to collecting and/or analyzing the data for the following pitch alignment error.

8.4.7.7 Timing vs. Alignment Errors

Since pitch and roll correction is usually conducted on-line while logging the data, and since the effect of timing errors is variable, the above timing errors may affect the collected calibration data permanently. Even after having identified any timing errors it may not be possible to recover the data by re-processing.

Provided that the data from the above survey lines is found to be unaffected by any timing errors, the same data can be utilized for analysis for the following alignment errors. If the presence of any timing errors are detected in the first batch of calibration data, the above lines must be re-run in order to collect one more series of calibration data, once the timing errors are eliminated.

8.4.8 PITCH ALIGNMENT ERROR

Any vertical misalignment between the roll axes of the SeaBat sonar head and the MRU will cause the measured pitch of the head to be in error. Such an alignment error will be constant.

A pitch alignment error will cause along track errors in the positions of the determined depths. As the error is constant, the affect on the positions will also be constant with constant distance from SeaBat head to seabed. The effect on the data will; however, increase with an increase of this distance. The effect on the data will be similar for all beams across the swath.

By comparing the contours, from the respective transits of the line run on reciprocal headings, but with equivalent ROV speed in the sloping area, such an error will appear as a parallel displacement of corresponding contours, that increase with depth, and that significantly exceed the tolerance of the computed positions of the SeaBat head.

By comparing the contours, from the respective transits of the line run on reciprocal headings, but with equivalent ROV speed in the flat area, such an error will be apparent as a horizontal along-track difference in the position of the seabed feature. This will be indicated by the contours or by the longitudinal profiles through the seabed feature.

Depending on the consistency of the data, the pitch alignment error (or offset) can be determined by converting from rectangular to polar co-ordinates half the distance separating the corresponding contours and/or half the along track difference in the seabed feature position over the depth of the feature below the SeaBat head (Figure 8-4).

8.4.9 ROLL ALIGNMENT ERROR

Any vertical misalignment between the pitch axes of the SeaBat sonar head and the MRU will cause the measured roll of the head to be in error. Such an alignment error will be constant.

A roll alignment error will cause errors in the determined depths. As the error is constant, the affect on the depths will also be constant with constant slant range. The effect on the data will however be negligible on the vertical beams and increase in magnitude towards the outer beams.

By comparing the corresponding cross profiles of the seabed, from the respective transits of any the above lines run on reciprocal headings, such an error will be apparent as an angular misalignment between these profiles. Depending on the consistency of the data, the roll alignment error (or offset) can be determined as half the angle between the profiles (Figure 8-5).

8.4.10 GYRO ALIGNMENT ERROR

Any horizontal misalignment between the roll axis of the SeaBat sonar head and the zero index line of the gyro compass will cause the measured heading of the sonar head to be in error. Such an alignment error will be constant.

A gyro misalignment will cause errors in the positions of the determined depths. The effect will be negligible for the center beams and will increase in magnitude towards the outer beams.

By comparing the contour charts from the line run on reciprocal headings either side of the seabed feature, such an error will be apparent as a difference in the horizontal position of the feature as indicated by the contours.

By comparing corresponding contours from the line run on reciprocal headings across the slope, such an error will be apparent as an angular misalignment between these contours.

Depending on the consistency of the data, the gyro alignment error (or offset) can either be determined by converting from rectangular to polar co-ordinates half the along-track distance separation in the seabed feature position over the horizontal distance from SeaBat head to the feature, or as half the angular misalignment between corresponding contours.

8.4.11 ALIGNMENT CORRECTIONS

The above alignment errors should be corrected for either in the on-line logging system or during the post-processing of the data.

Since the effect of these errors does not permanently degrade the collected data, the correction values can be determined through trial and re-processing. Different correction values can be tried and the data subsequently re-processed to determine the best possible agreement between corresponding contours, seabed profiles or seabed feature positions.

8.4.12 RECOMMENDATIONS

As is evident from the description of the data analysis above, it is not strictly necessary to run all of the above survey lines. Due to the complexity of the way the timing errors affect the SeaBat data, and due to the general difficulties in detecting such errors, it is however recommended to include all the lines during the collection of calibration data.

It is also evident that it could be difficult both to detect and quantify data timing errors, if the presence of such errors are suspected after the calibration data is analyzed, but without certainty of a specific type of error, it is recommended that the above calibration data collection is repeated for further analysis.

Should analysis of the calibration data reveal presence of timing errors, it is imperative that the cause of the errors is established so that they can be eliminated. Only when the data show no, or constant, remaining systematic differences between corresponding profiles and contours, should the calibration/analysis proceed.

CHAPTER 9 - PARTS LIST

9.1 PROCESSOR SURFACE UNIT

TABLE 9-1. SeaBat 9003 - PROCESSOR PARTS				
No.	Part No.	Qty	Description	Notes
1	85103002	1	SeaBat 9003 Processor Surface Unit - Complete	
2	85000006	1	SeaBat Processor Power Cable	
End				

9.2 SONAR HEAD

TABLE 9-2. SeaBat 9003 SERIES - SONAR HEAD PARTS				
No.	Part No.	Qty	Description	Notes
1	85103001	1	SeaBat 9003 Sonar Head, depth rated to 350 meters.	
2	85103006	1	SeaBat 9003 Sonar Head, depth rated to 500 meters.	
3	64500006	1	SeaBat Sonar Head Female Dummy Plug Connector	
4	85000022	12	SeaBat Sonar Head Plastic Mounting Hole Inserts	
End				

9.3 SeaBat CABLES

TABLE 9-3. SeaBat 9003 SERIES - CABLES AND CONNECTORS				
No.	Part No.	Qty	Description	Notes
1	85000020	1	25 meter processor to sonar head cable	
2	85000021	1	3 meter sonar head pigtail cable	
3	6700001-xx	1	SeaBat cable in xx meters in addition to 85000020	
4	64001005	4	2 meter BNC to BNC cable (processor to display)	
5	64500007	1	SeaBat sonar head cable male dummy plug connector	
End				

9.4 SeaBat ACCESSORIES

TABLE 9-4. SeaBat 9003 SERIES - ACCESSORIES				
No.	Part No.	Qty	Description	Notes
1	85000008	1	SONY PVM 1342Q color display monitor (110v)	
2	EC6023	1	Rack Mount Assembly for EC6039	
3	60000003	1	PC-TRAC Trackball Input Device	
4	85100003	1	SeaBat Joystick Control Panel - Basic	
5	85100004	1	SeaBat Joystick Control Panel - with Pan & Tilt control	
6	9003M	1	SeaBat 9003 Operators Manual	
7	TL8034	1	SeaBat Maintenance Manual	
8	89100002	1	Flight Case - Sonar Head	
9	89100003	1	Flight Case - Processor and cable	
10	89100004	1	Flight Case - SONY PVM Color Display	
11	89100002	1	Shipping Case - Sonar Head	
12	89100003	1	Shipping Case - Surface Processor, Cables	
13	89100004	1	Shipping Case - Color display	
End				

9.5 PURCHASING INFORMATION

To receive the latest SeaBat parts list or to place an order:

1. Contact the Sales Department in your nearest RESON office.
2. Request a quotation for the parts required.
3. Submit a confirming purchase order, itemizing each part by its part number, quantity required and the quoted price. Include the delivery location and method of shipment.
4. The parts will be delivered within the quoted time period.

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CHAPTER 10 - RELATED SeaBat PRODUCTS

10.1 SeaMux

10.2 Power Protection Unit (PPU)

10.3 SeaBat 6042

10.4 SeaBat 6012

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APPENDIX A - GLOSSARY OF TERMS

Bathymetry	The measurement or mapping of the seafloor topography using water depths.
Baud	Unit of speed for the transfer of data. The speed in baud is the number of discrete conditions or events per second.
Beamformer	A delay line that compensates for the curvature of the array.
BIT	(BInary digiT). The smallest unit of information in a binary system: a 1 or 0 condition.
Correction Values	Measurements used to correct the "relative" profile once it has been transmitted from the SeaBat system.
Custom Link	An existing cable (i.e., ROV umbilical) which is used to transmit Uplink and Downlink commands.
Data Bits	The number of bits in each 'packet' of data being transferred from the SeaBat processor.
Data Recorder	Video Recorder or External Computer.
Downlink	Provides operator commands from the processor to the sonar head.
EEPROM	Electrically Erasable Programmable Read Only Memory. Semi-conductor memory that is erasable via electronic pulses.
EPROM	Erasable Programmable Read Only Memory. Semi-conductor memory that is erasable via ultra-violet light and re-programmable.
Firmware	The SeaBat's software program stored permanently in the EPROM. There are two firmware locations, each having their own version number. (1) Processor and (2) Sonar Head.
Gyro Compass	Measures the orientation of the vessel or platform.
Line-of-site	The area in which acoustic underwater signals are reflected by objects (typically, sound waves travel in direct paths).
Motion Reference Unit (MRU)	Measures the motion of the vessel or platform, usually in three (3) axes; Heave, Pitch and Roll. Yaw, a fourth axis, is also measured by some newer model sensors.
Navigation System	Computes the offset position of the SeaBat from the positioning system and provides navigation control to the vessel.
NTSC	Format of the video signal transmitted from the SeaBat (operator selected). This format is used throughout the United States.
Packet	A group of data bits transmitted as a whole.

PAL	Format of the video signal transmitted from the SeaBat (operator selected). This format is used throughout Europe and other countries, excluding the United States.
Parity BIT	A data bit, set at "0" or "1", is a character advising you that the total number of bits in the data field is even or odd.
Positioning System	Positions the vessel or platform to which the SeaBat is attached.
Protocol	A formal set of conventions governing the formatting and timing of message exchange between the SeaBat processor and an external device. Protocol consists of: baud rate, parity, data bits and stop bits.
Real-World Positioning	The exact position of the SeaBat sonar head at the exact moment that a profile is recorded. With the position of the SeaBat sonar head known at each moment in time, the relative profile measured can be adjusted for the vessel motion if required, to compute the Real-World positions of each data point within each profile.
Relative Positioning	The physical location that is selected to securely mount and orientate the head.
(ROV)	Remotely Operated Vehicle (submersible).
RS-232	The interface between the SeaBat processor and external devices employing serial binary data interchange.
Shadow Zone	Formed on the backside of an object because the reception of the signal is blocked or greatly diminished.
Software	A computer program and instructions.
Speed-of-Sound (SOS)	The speed at which acoustic pulse travels through water.
Speed-of-Sound, Datum	1480 meters per second (mps).
Speed-of-Sound Value	Computation of travel time for each beam from the sonar head to the reflected seafloor and back again.
Stop Bit	In asynchronous transmission, the last bit, used to indicate the end of a character which serves to return the data line to its original state.
Survey Line Spacing	The distance between parallel survey lines that are traversed to build a grid to cover an intended survey area.
Swath	Encompasses forty (40) seafloor data points that are measured to compute the seafloor profile.
Thermocline	The boundary between layers of water with different densities.
Time Synchronization	The synchronization, based on time, of the recorded data to produce maps or reports that require the merger of successive SeaBat profiles.
Transducer Face	The rounded rubber end of the sonar head.

Transmitter Sync	An option that provides the means to synchronize external devices with the SeaBat transmitter ping.
Uplink	Provides all the sonar data from the sonar head to the processor.
Velocity Profiler	Used to measure the speed-of-sound (SOS) as it travels through the water column.
Zone of Silence	Please refer to shadow zone.

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APPENDIX B - FAILURE ANALYSIS REPORT FORM

Included as Appendix B is a blank Failure Analysis Report Form. To expedite the servicing process, the shaded areas of the following table must be completed and returned to RESON with any equipment for servicing.

RESON	SeaBat FAILURE ANALYSIS REPORT (FAR)		FAR NO.
Customer:	MODEL:		SN:
WARRANTY REPAIR YES NO		REPAIR COST $ (TO CUSTOMER)	
FAILURE REPORT		PREPARED BY:	
DESCRIPTION OF FAILURE/CONDITION: SYMPTOMS:			
ANALYSIS C.A. RECOMMENDATION		PREPARED BY:	
INVESTIGATION METHODS/FINDINGS: DETERMINED CAUSE OF FAILURE:			
CORRECTIVE ACTION: EFFECTIVITY:			
CLOSURE		PREPARED BY:	
ITEM DISPOSITION: CORRECTIVE ACTION:			

APPENDIX C:
SeaBat 9003 REVISION HISTORY

VERSION	6012	9001	9003	CHANGES
v1.0 08-Aug-88	•			First official SONARFLEX firmware release. (This is ancient history.)
v2.1 08-Aug-91	•	•		First official SeaBat firmware release.
v2.2 27-Feb-92	•	•		Add read-wait-state to DSP 2-port RAM to satisfy new 2101 timing data.
	•	•		Add DSP_STOP process to overcome occasional won't-boot problem.
v2.3 27-Mar-92	•	•		FIFO now sucked dry, not reset. U13 now disables READ during FIFO reset.
v2.4 07-Apr-92		•		Fix bug in BathySin/BathyCos which misplaced beams 0-29 in output data.
v2.4.A1 17-Nov-92	•	N/A		Move second annotation line to top-right of screen. Add ^N cursor control.
	•	N/A		Change external clock input format to YYMMDDHHMMSS, 1200 baud.
v2.4.A2 09-Mar-93	•	N/A		Change annotation into four fields of 14 characters at bottom of screen.
	•	N/A		Add support for joystick power up/down buttons.
	•	N/A		Remove the slash from the ASCII "zero" character.
				Borland C: Use Thomas Designs' SVGA 800x600 BGI driver.
				Borland C: Use COM1 mouse input by disabling IRQ4.
v2.5 28-Jan-93		•		Add BLANK palette option.
	•	•		Add downlink byte for sonar head projector selection.
	•	•		Add support for joystick power up/down buttons.
	•	•		Locate non-volatile RAM settings at unmoving address. (Generally useless.)
	•	•		Remove the slash from the ASCII "zero" character.
		•		Disable FREEZE command, because it rudely freezes the output data.
	•			Distance display angle now -180..+180, not 0..360.
		•		Cursor and distance display now X-Z, not range-bearing.
	•	•		Add wedge-tilt menu item and geometry mods. Table calc takes 10 seconds.
	•	•		Fixed (almost certainly) the stray-line-from-left-edge bug.
				Borland C: Use Thomas Designs' SVGA 800x600 BGI driver.
				Borland C: Use COM1 mouse input by disabling IRQ4.

VERSION	6012	9001	9003	CHANGES
v2.6 18-Feb-93		•		Experimental version of R-theta data format, with baud rates 300..19200.
		•		Fix accidental clearing of UART_ACR, which messed up baud selector.
	•	•		Two independent sets of non-volatile RAM settings (for EPROM switching).
	•	•		Easy-compile flags: BottomDetect, BeerCan, Flip, FlatGrid, SecondEprom.
		•		DSP outputs bathy data at start of next frame, for more accurate latency.
v2.7 16-Mar-93		•		Latency now adjusts for single/dual head mode, and uses millisecond clock.
		•		Add 38400 baud R-theta output choice.
	•	•		Can use annotation port to change head's "single/dual" EEPROM bit.
	•	•		New power-up version message with three-second viewing time.
	•	•		Change "TILT" message to "WEDGE".
v2.8 27-Apr-93	•	•		Annotation port: Control range, gain, power, average using Ctrl-Y codes.
	•	•		Tracking cursor output: Angle always ±45° regardless of wedge tilt.
v2.8.A1 27-Apr-93	•	N/A		Enable BottomDetect mode.
v2.9 20-Jul-93	•	•		Add fixed-gain settings "0 FIX" through "15 FIX". Remote 'k' through 'z'.
		•		Bottom detect: Sidelobe-subtract, Brightest-group-of-5, Middle-of-target.
		•		Bottom detect: Reduce size and improve uniformity of 60 dancing dots.
		•		Auto-power mode: Maintains 0<clipped<30, rate=0.6Hz. Remote '9'.
	•	•		Track/Freeze outputs raw image, SCR sync port, 115.2k baud, CMOS level.
		•		Eliminate DepthAdjust (-5cm), discard first sonar line (another -5cm).
	•	•		Move image ½ bin closer, centering each data bin on the correct range.
v2.10 05-Aug-93		•		Set brightness quality (bit 0) if target exceeds background brightness.
		•		Set co-linearity quality (bit 1) if several targets lie nearly in a row.
		•		Display dancing dots only if both quality bits are good.
		•		Fix v2.9 averaging-mode bug: Dots no longer get stuck at max range.

VERSION	6012	9001	9003	CHANGES
v2.10.A1 17-Apr-94	• • • •	N/A N/A N/A N/A		Add support for joystick tilt buttons. Sends tilt commands to wet end. Display tilt angle. (Tilt and pan A/D values are spliced into uplink packet.) Include tilt angle in cursor output packet. New Reson Logo.
v2.11β 21-Jun-94	 • •	• • • • • • • • • • •		Detect single/dual head mode and display 9003 or 9002 in logo. Add DOTCHK grid mode which displays bathy dots of all qualities. Activate FREEZE feature (gone since v2.5). Output data still freezes rudely. Add MENU menu item. Selects partial or full menu display. New Reson Logo. Optional 120° and 20-beam versions. Minor grid mods. Always 60 outputs. Sidescan output to chart recorder. New SSGAIN 1..14 menu item. Additional auto-power settings A1..A5 (clipping thresholds). Add tvg&fixed auto-gain settings A1T..A5T, A1F..A5F (clipping thresholds). Add RI-THETA packet format which include 8-bit intensity value. Add remote-control selections for auto power and gain.
v2.11β.A1 31-Aug-94	•	N/A		Enable BottomDetect mode.
v2.12 8-Sep-94		• •		Add sidescan beam selector menu item and downlink. (No remote control.) Modify RI-THETA packet to include range, gain, power, and other status.
v.2.13 2-Nov-94		 •		Internal: For non-standard projector mode, display Bv=???° message. Modify RI-THETA packet to include projector mode plus 3 spare bytes.
v.2.13.A1 2-Nov-94		•		Use face projector, display Bv=15° message.
v.2.13.B1 11-Jan-95	•	•		Add 15 & 20m ranges. H,I remote codes. Head & DSP run at 25m. Known latency bug.
v.2.13.B2 10-Apr-95	•	•		Compiler v.8.3.1. Fix latency bug in v.2.13.B1
v.2.14 28-Jun-95		• •		Intensity values now represent true amplitude peaks. Clipped 1..250. New SSBEAM=OFF disables sidescan output.
v.2.15 08-Jan-96		•		Fix sidescan beam-select bug in v.2.14.

VERSION	6012	9001	9003	CHANGES
v.2.15.A1 19-Jan-96		•		Select alternate projector, Display $\beta v = 2{,}5°$ message.
v.2.16 12-Feb-96			•	Add support for 120° head. DSP accepts number-of-beams value.
	•	•	•	Raw-image-dump no longer accidentally toggles freeze.
end:				