SONIC 2024/2022

BROADBAND MULTIBEAM ECHOSOUNDERS

Operation Manual V3.0

Part No. 96000001

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Authorship

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1 INTRODUCTION

1.1 Outline of Equipment

The R2Sonic Sonic 2024 and Sonic 2022 Multibeam Echosounder (MBES) is based on fifth generation Sonar Architecture that networks all of the modules and embeds the processor and controller in the sonar head's Receive Module to make for a very simple installation. The Sonic Control Graphical User Interface (GUI) is a simple program that can be installed on any Windows based computer and allows the surveyor to control the operating parameters of the Sonic 2024/2022. Sonic Control communicates with the Sonar Interface Module (SIM) via Ethernet. The SIM supplies power to the sonar head, synchronises multiple heads, time tags sensor data, relays commands to the sonar head, and routes the raw multibeam data to the customer's Data Collection Computer (DCC).

The Sonic 2024 and Sonic 2022 work on a user selectable frequency range of 200 kHz to 400 kHz so it is adaptable to a wide range of survey depths and conditions. The user can adjust the operating frequency, via the Sonic Control GUI, *on the fly,* without having to shut down the sonar system or change hardware or halt recording data. The Sonic 2024/2022 has a user selectable opening angle, from 10° to 160°, using all 256 beams; the desired opening angle can be selected on *the fly* without a halt to data recording. The selected swath angle can also be rotated port or starboard, whilst recording, to direct the highly concentrated beams towards the desired target. Both the opening angle and swath rotation can be controlled via the mouse cursor.

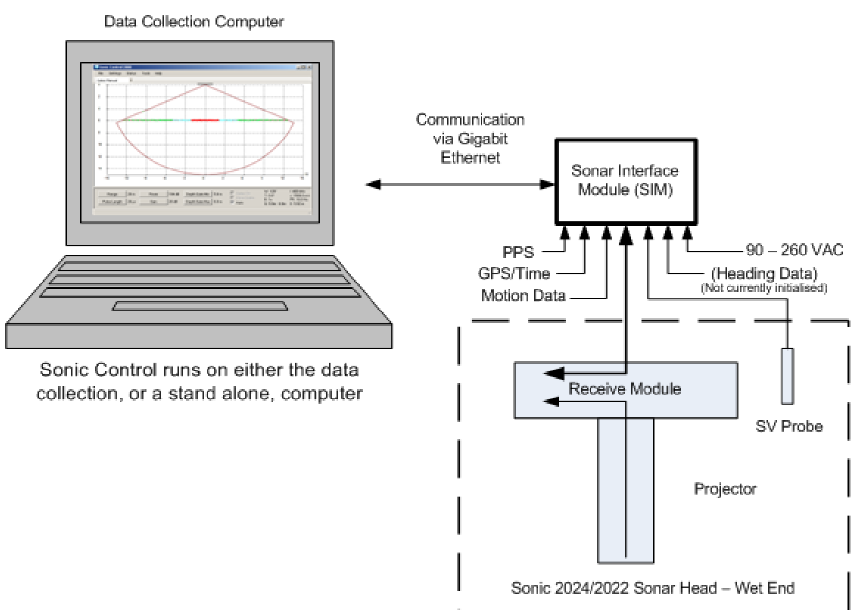

Figure 1: Sonic 2024/2022 Block Diagram

1.2 How to use this Manual

This manual is designed to cover all aspects of the installation and operation of the Sonic 2024 and Sonic 2022. It is, therefore, recommended that the user read through the entire Operation Manual before commencing the installation or use of the equipment.

1.2.1 Standard of Measurement

The Metric system of measurement is utilised throughout this manual; this includes temperature in degrees Celsius.

METRIC	IMPERIAL
10mm (0.010m)	0.39 inches
100mm (0.100m)	3.9 inches
1000mm (1.0 metre)	39.4 inches
100 grams (0.100kg)	3.5 oz
1000 grams (1.0 kilogram)	2.2 pounds
10° C	50°F

Table 1: Metric to Imperial conversion table

2 SONIC SPECIFICATIONS

2.1 Sonic 2024 System Specification

System Feature	Specification
Frequency	400kHz / 200kHz
Beamwidth – Across Track	0.5°@ 400kHz / 1.0° @ 200kHz
Beamwidth – Along Track	1.0° @ 400kHz / 2.0° @ 200kHz
Number of Beams	256
Swath Sector	10° to 160° (user selectable)
Maximum Slant Range	500 metres
Pulse Length	15µSec – 500µSec
Pulse Type	Shaped Continuous Wave (CW)
Depth Rating	100 metres (3000 metres optional)
Operating Temperature	0° C to 40° C
Storage Temperature	0° C to 55° C

Table 2: System Specification

2.2 Sonic 2022 System Specification

System Feature	Specification
Frequency	400kHz / 200kHz
Beamwidth – Across Track	1.0°@ 400kHz / 2.0° @ 200kHz
Beamwidth – Along Track	1.0° @ 400kHz / 2.0° @ 200kHz
Number of Beams	256
Swath Sector	10° to 160° (user selectable)
Maximum Slant Range	500 metres
Pulse Length	15µSec – 500µSec
Pulse Type	Shaped Continuous Wave (CW)
Depth Rating	100 metres (3000 metres optional)
Operating Temperature	0° C to 40° C
Storage Temperature	0° C to 55° C

2.3 Sonic 2024 Dimensions and Weights

Component	Dimensions (L x W x D) / Dry Weight
Receiver Module	480mm x 109mm x 190mm / 12.9kg
Projector	273mm x 108mm x 86mm / 3.3kg
Sonar Interface Module (SIM)	280mm x 170mm x 60mm / 2.4kg
Receive module and Projector mass in water	**5.9kg (Fresh)**

Table 3: Component Dimensions and Mass

2.4 Sonic 2022 Dimensions and Weights

Component	Dimensions (L x W x D) / Dry Weight
Receiver Module	276mm x 109mm x 190mm / 7.7kg
Projector	273mm x 108mm x 86mm / 3.3kg
Sonar Interface Module (SIM)	280mm x 170mm x 60mm / 2.4kg
Receive module and Projector mass in water	**4.0kg (Fresh)**

2.5 Sonic 2024/Sonic 2022 Electrical Interface

Item	Specification
Mains Power	90 – 260 VAC; 45 – 65 Hz
Power Consumption (SIM and Sonar Head)	75 Watt (Sonic 2022: 54 Watt)
Power Consumption (Sonar Head Only)	50W avg.; 90W Peak (Sonic 2022: 35W avg.; 70W Peak)
Uplink/Downlink	10/100/1000Base-T Ethernet
Data Interface	10/100/1000Base-T Ethernet
Sync IN/OUT	TTL
GPS Timing	1PPS; RS232 NMEA
Auxiliary Sensors	RS232
Deck Cable Length	15 metre (optional to 50 metres)

Table 4: Electrical Interface

2.6 Sonic 2024/2022 Ping Rates

RANGE	PING RATE
2 - 7	60.0
10	48.4
15	34.3
20	26.6
25	21.7
30	18.3
35	15.9
40	14.0
50	11.3
70	8.2
100	5.8
150	3.9
200	2.9
250	2.3
300	1.9
400	1.7
450	1.3
500	1.2

Table 5: Ping Rate table

WARNING

THE RECEIVE MODULE IS FILLED WITH OIL THAT WILL FREEZE TO A SOLID AT -10°C. DO NOT STORE OR USE THE SYSTEM BELOW 0°C.

2.7 Acoustic Centre

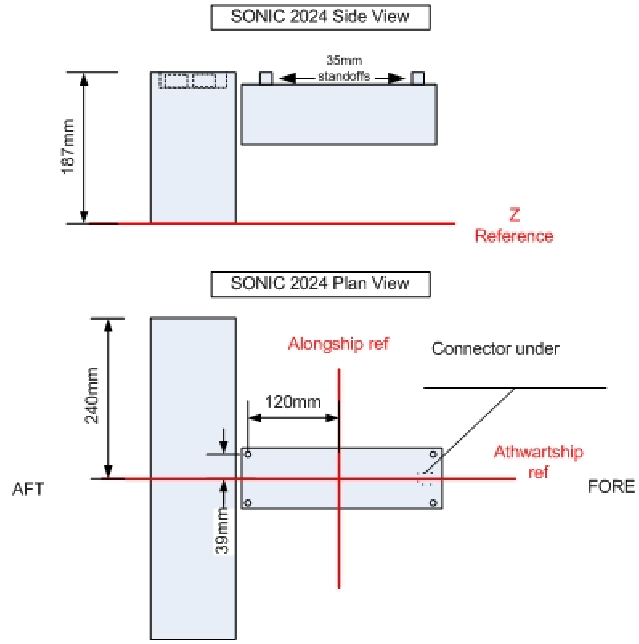

Figure 2: Sonic 2024 Acoustic Centre

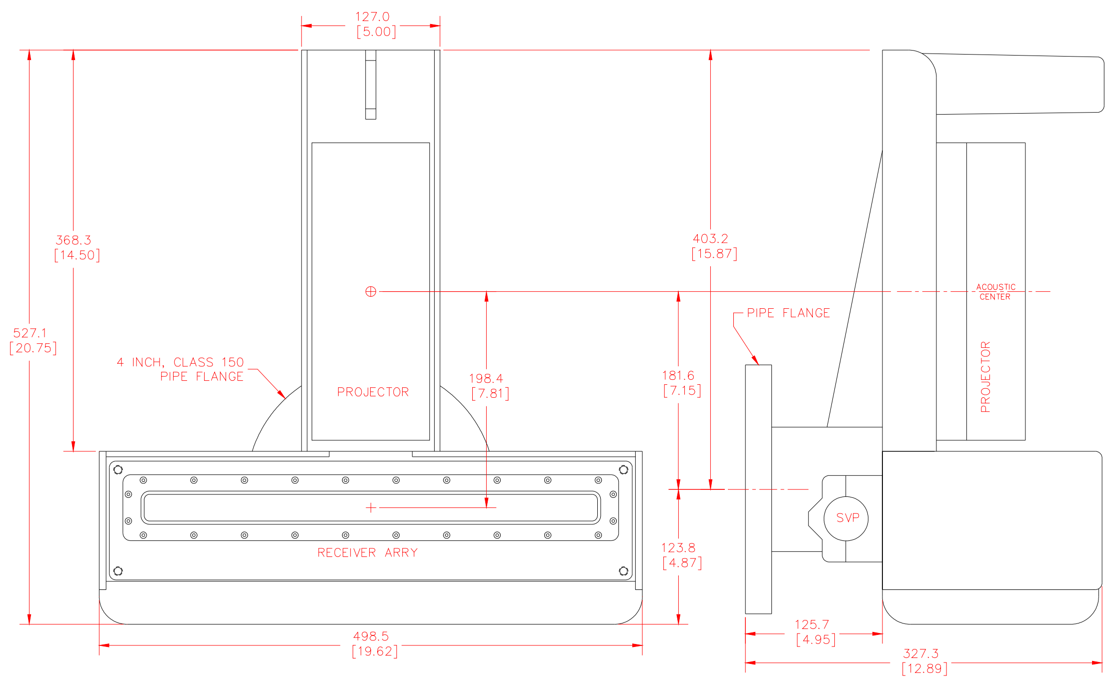

Figure 3: Sonic 2024 Acoustic Centre as Mounted

Centre of Flange to Alongship offset = 181.6mm

Top of Flange to Z reference = 327.3mm

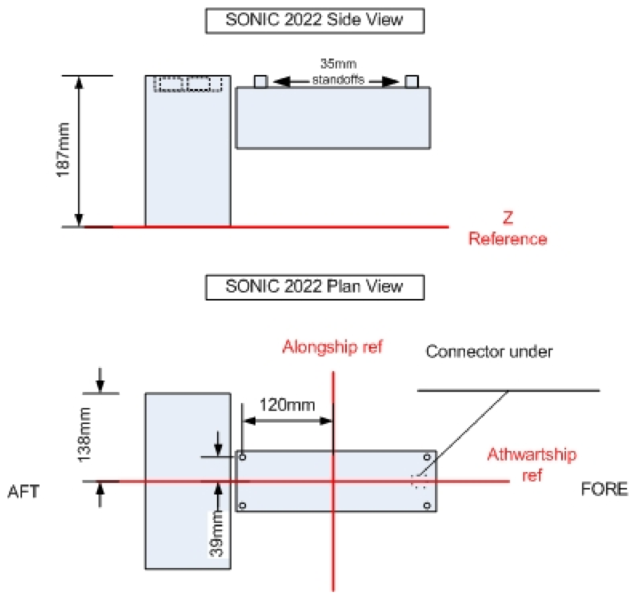

Figure 4: Sonic 2022 Acoustic Centre

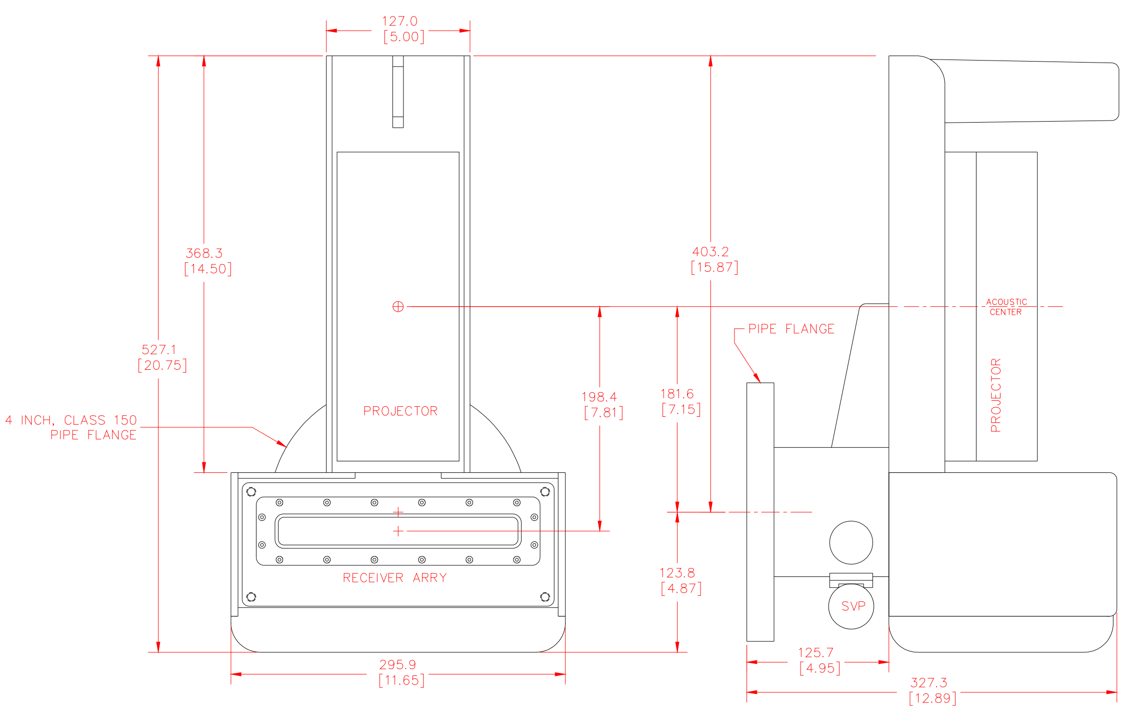

Figure 5: Sonic 2022 Acoustic Centre as Mounted

Centre of Flange to Alongship offset = 181.6mm

Top of Flange to Z reference = 327.3mm

3 SONIC 2024/2022 SONAR HEAD INSTALLATION – Surface Vessel

The Sonic 2024/2022 can be installed on an over-the-side pole, through a moon pool, or as a permanent hull mount. The light weight, small size, and low power consumption makes the Sonic 2024/2022 ideal for underwater vehicle (ROV and AUV) installations.

WARNING
DECK LEAD MINIMUM BEND RADIUS = 150MM

3.1 Sonic 2024/2022 Receive Module Installation

The Sonic 2024/2022 sonar head is mounted on the standard R2Sonic mounting frame as shown below.

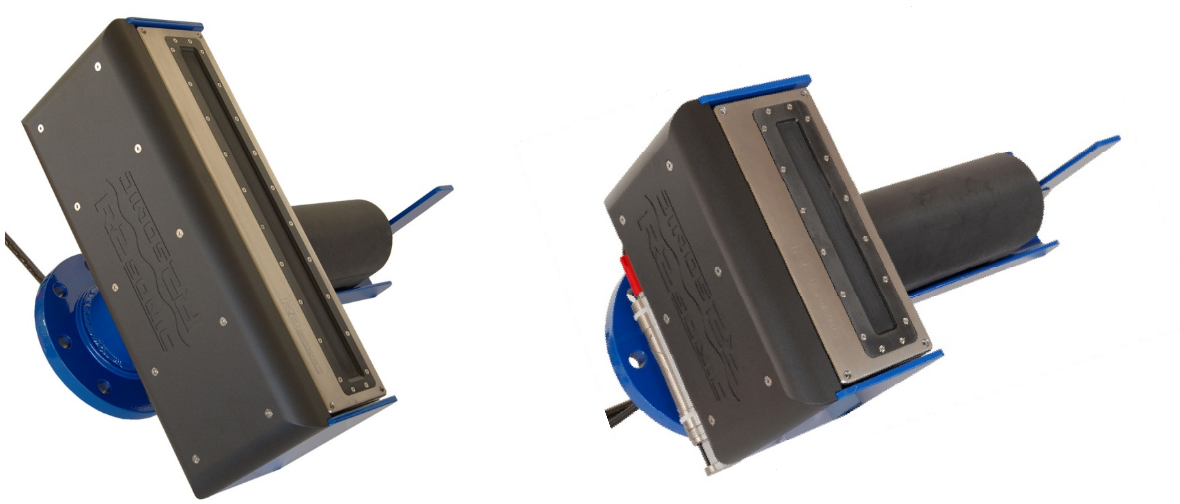

Figure 6: Sonic 2024 and Sonic 2022 on the mounting frame

If the Sonic 2024/2022 sonar head is not pre-mounted, the following guidelines must be followed for proper operation of the system.

- The Receive Module is orientated with the narrow part of the face towards the projector (see above).
- The projector is orientated with the connector towards the end with the protective fin.
- The Projector must be mounted with the correct 35mm standoffs in place.

3.1.1 Mounting the Sonic 2024/2022 Receive Module

Sonic 2024

Sonic 2022

Figure 7: Top side of Receive Module

Sonic 2024

Sonic 2022

Figure 8: Receive Module Face

The Receive Module is held to the mounting frame by 4 pass-through bolts, which are threaded on both ends. The end with the shorter thread is inserted in the pass-through and secured through the face of the receiver; the other end is inserted into the mounting bracket and secured. To prevent galling, two layers of Teflon™ thread seal tape shall be applied to the bolt's threads.

Figure 9: Receive Module securing bolt

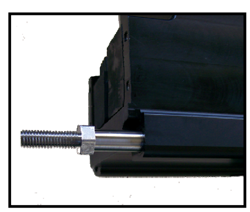

Figure 10: Insert short threaded side of bolt in pass-through and tighten to receiver face

3.1.2 Receive Module

The Receive Module has two connectors; the female connector is for the Projector cable, the male connector is for the deck lead that goes to the SIM. There is a securing 'ear' on top of the Receive Module to secure the cables with a cable tie or other similar securing methods. Seat the 0.439m projector cable first. A light spray of silicon lube (3M Silicon Lubricant, **3M ID:** 62-4678-4930-3) will aid in seating the connectors. The deck lead passes through the hydrophone pole and then through the flange opening. Seat the deck lead after seating the projector cable. ENSURE that all connections are tight with no visible gaps.

Figure 11: Seated connectors (Sonic 2024 on left and Sonic 2022 on right)

Sonic 2024

Sonic 2022

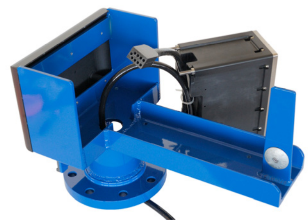

Figure 12: Receive Module with cables connected

Next, mount the Receive Module in the mounting frame. This can be most easily done by putting the receive module face on a piece of cardboard or other material and then lowing the mounting frame down with the threaded bolts passing through the mounting frame. The securing bolts, after passing through the frame, should be wrapped with 2 wraps of Teflon™ tape.

Figure 13: Position the insulating bushing, then wrap threads with Teflon tape, then secure with flat washer, locking washer and then nut.

3.1.3 Mounting the Projector

The projector is secured to the frame with two, 35mm stand offs. The stand-offs allow room for the Projector to Receive Module cable to be run. A 6mm drive hex screw secures the projector through the stand-off. **The Projector's connector faces towards the protection fin**. Connect the 0.439m interconnect cable's female end to the Projector's male bulk head connector. When the connectors are mated, there should be no visible gap between them. A very light spray of silicon lubricant will aid seating the connector.

Figure 15: Projector Stand-off

Figure 14: Sonic 2024 Projector

Sonic 2024

Sonic 2022

Figure 16: Mounting the projector

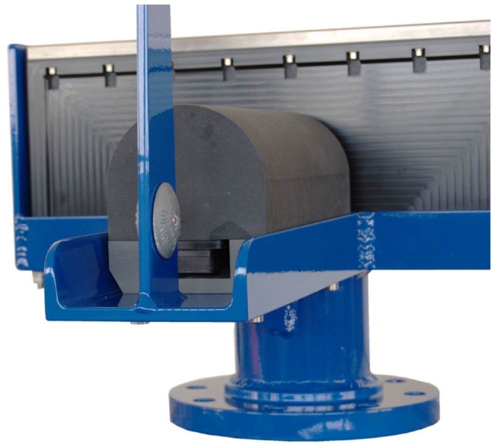

Figure 17: View of the mounted Projector; NB. Connector is facing protective fin

3.1.4 Correct Orientation of the Sonic 2024 and Sonic 2022

The Sonic 2024/2022 is designed to be installed with the projector facing forward, or towards the bow. However, if the installation requires the projector to face aft, in Sonic Control, the user can select the orientation to projector aft and this will re-orientate the data output to reflect the projector orientation.

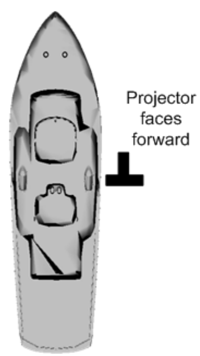

Figure 18: Correct Orientation of the Sonic 2024 and the Sonic 2022

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3.2 Sonar Head Installation Guidelines

3.2.1 Introduction

The proper installation of the Sonic 2024/2022 sonar head is critical to the quality of data that will be realised from the system. No matter the type of installation (hull mount, moon pool, or over-the-side pole), the head must be in an area of laminar flow over the array. Any vibration or movement of the sonar head, independent of vessel motion, will result in reduced swath coverage and noise in the data. To this end, the head must be installed on as sturdy a mounting arrangement as possible; fore and aft guys are NOT recommended as a means to obtain this stability.

The initial investigation of where to mount the sonar head should take into account any engines, pumps, or other mechanical equipment that may not be operating at the time, but may be a cause of vibration or noise when operating under normal survey conditions.

The structural stability of any decks, bulkheads, or superstructure, which will be employed when mounting the sonar head, must be taken into account and strengthened if necessary.

3.2.2 Over-the-Side mount

The over-the-side mount is normally employed for shallow water survey vessels and/or temporary survey requirements. The over-the-side mount consists of a frame structure that is attached to the vessel's hull or superstructure. A pole will be attached to the frame, normally through the use of swivel flanges, flanges, or other means by which the head can be swung up when not in use and deployed when needed. A similar mounting arrangement is the bow – mount, which is specialised form of an over-the-side mount.

In order to ensure stability of the pole, it should have a securing arrangement as close to the water line as possible. As stated above, the use of fore or aft guy wires is strongly discouraged.

When the pole is in the 'up' position it should be secured so that there is no or little movement that would be a strain on the flanges or mount. The head should be washed with fresh water as soon as possible and inspected for any damage or marine growth. If the head is to remain in the 'up' position; a covering should be put over the head that will protect it from the sun.

Figure 19: Typical over-the-side mount

3.2.3 Moon Pool Mount

Deploying the sonar head through a moon pool is usually a more stable mounting arrangement than an over-the-side pole. A moon pool is an area, within a vessel, that is open to the water. The sonar head is normally mounted in such a way that it can be deployed and recovered through the moon pool. The pole or structure that the sonar head is mounted on is normally shorter and sturdier than an over-the-side mount; this can allow for higher survey speeds.

3.2.4 Hull Mount

The hull mount is the sturdiest of all possible ways to mount a sonar head. With a hull mount, the sonar head is physically attached to the vessel's hull. With this way of securing the sonar head, there is no possibility of movement, outside that of the movement of the vessel.

There are disadvantages to the hull mount: the head cannot be inspected easily for marine growth or damage; the vessel may be restricted in the depth of waters that can be surveyed, due to the head being permanently attached to the hull.

A normal hull mount will also involve the fabrication of a fairing, on the hull, to ensure correct flow patterns over the sonar head.

3.2.5 ROV Mounting

The Sonic 2024/2022 is ideal for undersea operations due to its compact size and low power consumption. With all processing being done in the Receive Module, all that is required is to provide Ethernet over single mode fibre optic communication, between the SIM and the Receive Module. The 48VDC is supplied via the ROV's own power distribution.

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4 Sonic 2024/2022 Mounting: Sub-Surface (ROV/AUV)

4.1 Installation Considerations

- A 1000BASE-T link (best time sync accuracy) is preferred; however, with bathymetry only information, 100BASE-T will work. 10BASE-T will also work, but is not recommended. Bathy data requires 2 Mb/s data rate at a maximum ping rate of 60 pings/s. For future compatibility, please use 100BASE-T at minimum, snippets will not work with 10BASE-T; however, snippets will work over a 100BASE link.
- Average power, for a Sonic 2024 is 50W (1A), peak is 100W (2A); for a Sonic 2022 it is 35W (0.73A), peak is 75W (1.5A). The peak power of 100W (75W) occurs just after transmit and typically lasts for a few ms (depends on transmitter power setting). If you use a separate power supply for the sonar, we recommend using a 120 to 150W power source to supply the head, but less if installing a Sonic 2022.
- The sonar up/down link is all done through the Ethernet channel. Thus, no other hardware is required except for the Ethernet media converters (copper to fibre, fibre to copper). As a precaution, placing additional filtering on the output of the 48V supply to the sonar head is a good idea to prevent vehicle electronic noise from getting into the sonar head. A common mode choke, on the 48V line, is recommended. The Bourns (JW Miller) PM3700-50-RC common mode choke works well (surface mount part). A Bourns 8102-RC choke, which is easier to install (non-surface mount) can also be used.
- The supplied deck cable is a special cable with Ethernet pairs which are rated to 3000 meters water depth. **Do not substitute this cable, as the Ethernet data pairs need to meet certain important specifications**. When terminating the Ethernet connections to your own connector, **the Ethernet twisted pairs need to terminate right at the connector pins**, maintaining the twist on the wires as close to the connector pins as possible. On the bulkhead connector, **use CAT5, or better** Ethernet cable, from the connector, to the Ethernet media converter. Use adjacent pins for each wire pair. If 100BASE (or 10BASE) Ethernet is used, only the green and orange pairs are required. All four pairs, including blue and brown, are only required when using gigabit Ethernet.
- **Using a connector with a pigtail spliced on to the deck leads' Ethernet pairs has a low probability of working**. If the deck lead must be terminated to a pigtail, the pigtail length must be as short as possible, probably no more than 7-8cm. There are no special considerations for the power conductors other than the connector being able to handle 48VDC and 2 amperes. The drain (shield) wire does not need to be terminated.

4.1.1 Ethernet wiring considerations

The sonar head and SIM use gigabit Ethernet ports. There are rules, regarding number of pairs of wire to use, between different Ethernet ports, those rules are:

- **Gigabit to Gigabit**

  Need all four pairs. If only two pairs used, in an attempt to force the ports to 100BASE-T, the ports will not negotiate and the result will be no connection. Sometimes it's not obvious if a port is Gigabit enabled; try connecting unknown ports to a gigabit Ethernet switch and see what speed it connects at via the status lights on the switch.

- **Gigabit to 100BASE-**T

  Two pairs (green and orange on TIA/EIA-568-B wiring) can be used. Be sure to test this with a modified patch cable (cut the brown and blue pairs) before committing to the chosen Ethernet equipment as there may be surprises hidden in the equipment.

- **100BASE-T to 100BASE-T:**
  You can use two pairs.

When connecting to the SIM, use either of the AUX Ethernet ports for the sonar head Ethernet connection.

4.2 ROV Installation Examples

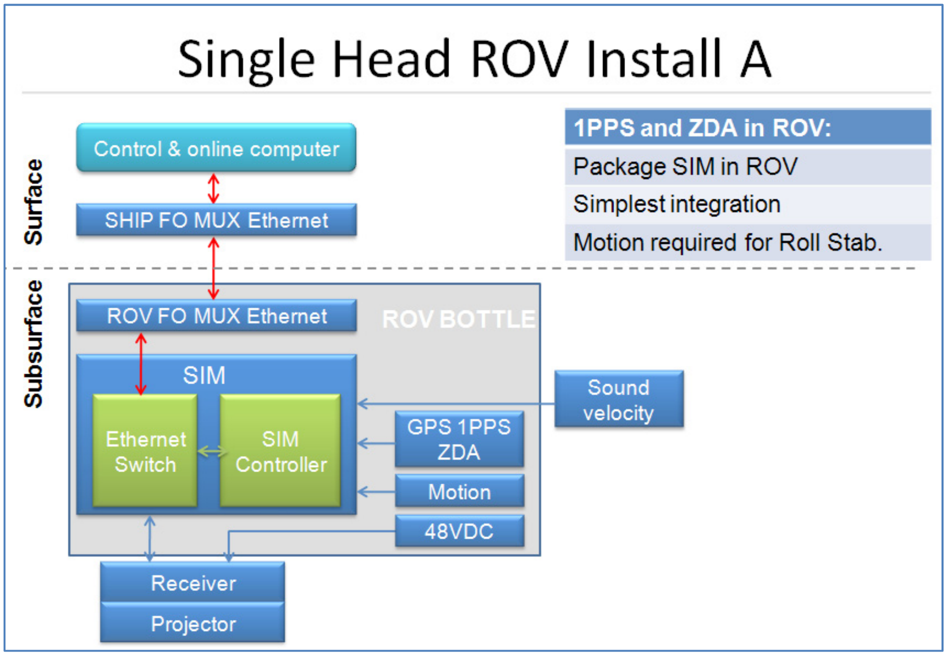

Figure 20: Single Head ROV Installation scheme A

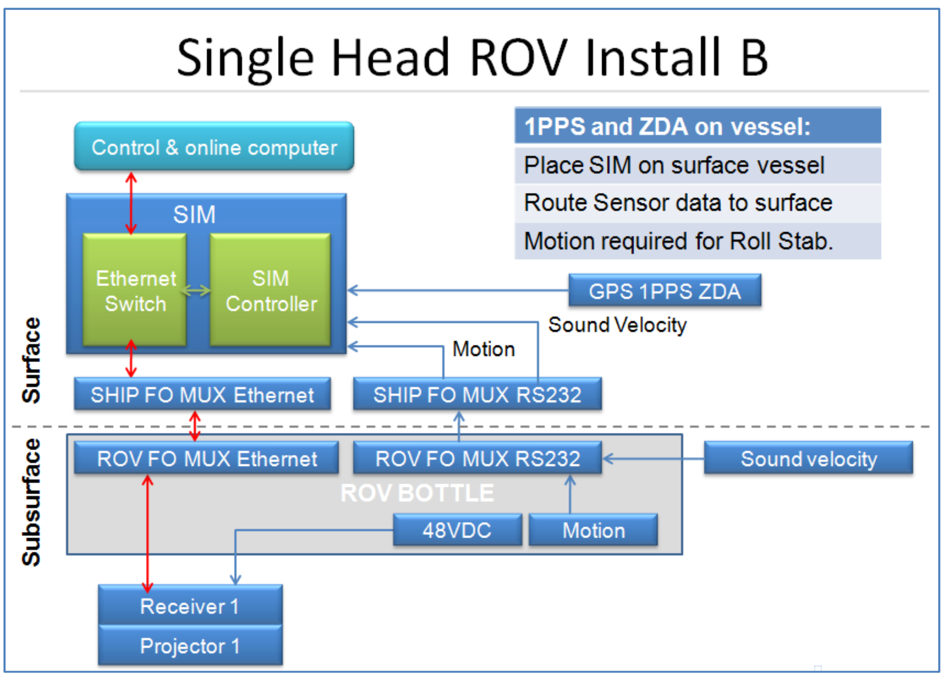

Figure 21: Single Head ROV Installation scheme B (Preferred)

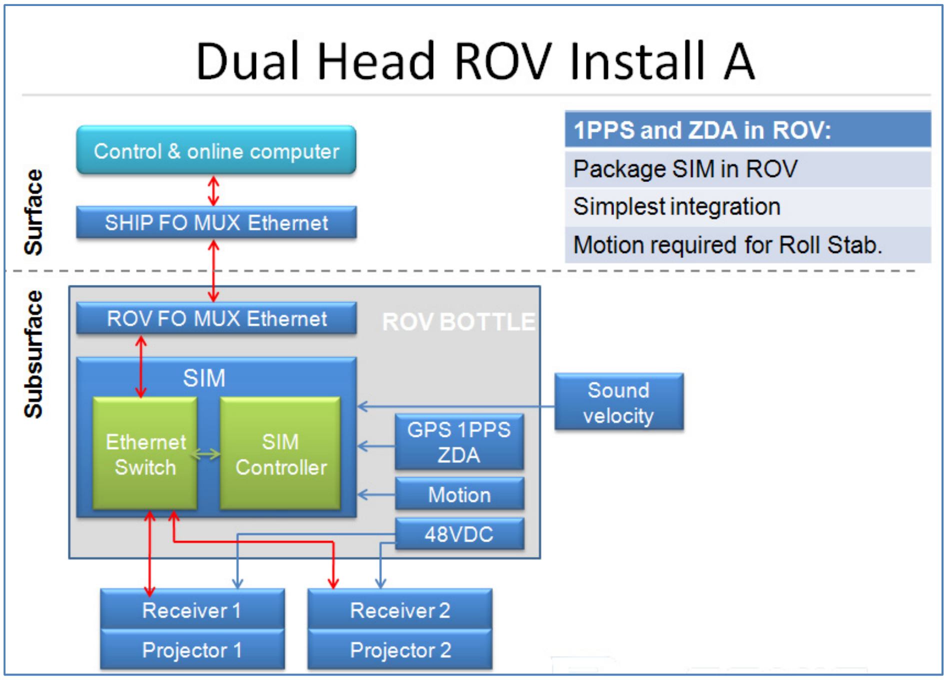

Figure 22: Dual Head ROV Installation scheme A

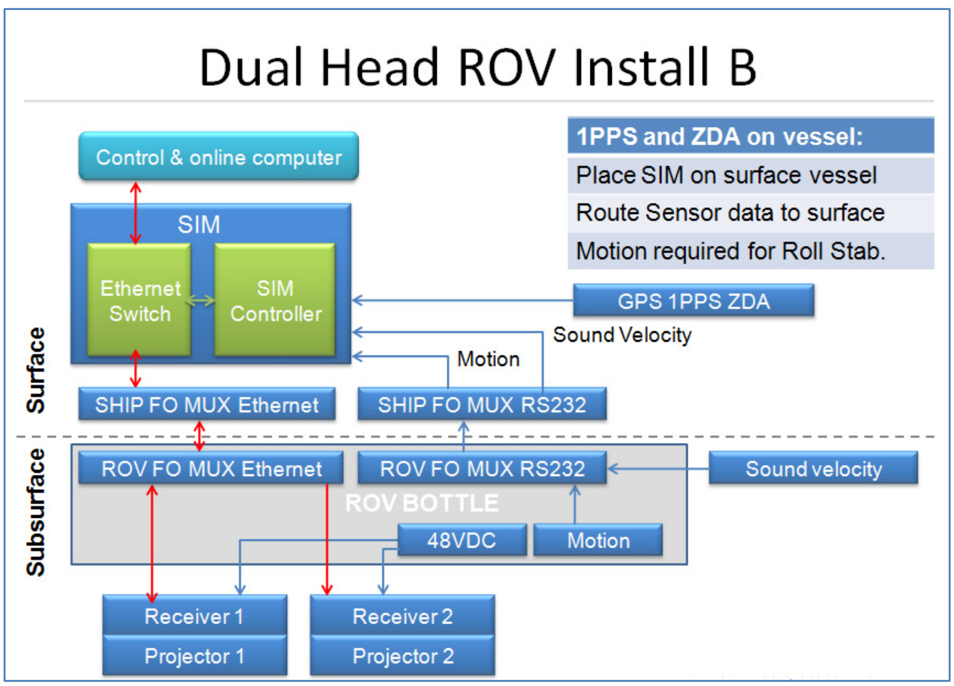

Figure 23: Dual Head ROV Installation scheme B (Preferred)

5 SONIC 2024/2022 SONAR INTERFACE MODULE (SIM) INSTALLATION and INTERFACING

5.1 Sonar Interface Module (SIM)

Figure 24: Sonar Interface Module (SIM)

The Sonar Interface Module is the communication centre for the Sonic 2024/2022 multibeam system. The SIM receives commands from Sonic Control 2000 and passes the commands to the sonar head. The SIM also receives the PPS and timing information, which is transferred to the sonar head to accurately time stamp all bathymetry data in the sonar head. The data, from the sonar head, passes through the SIM's Gigabit switch and onto the data collection computer. Sound velocity, from the probe located near the sonar head, and motion data are also interfaced to the SIM to be passed onto the sonar head.

5.1.1 Physical installation

The 15 metre cable, from the Sonic 2024/2022 Receive Module, connects directly to the SIM via an Amphenol ™ style connector. Therefore, the SIM must be located within 15 metres of the sonar head (a 50 metre cable is an option). The SIM is not water or splash proof, so it must be installed in a dry, temperature- controlled environment.

The SIM is small and light enough so as to be unobtrusive, but care needs to be taken that it is secured in such a manner so that it will not fall or move whilst the vessel is at sea. The SIM can be secured to a surface (horizontal or vertical) through the pass-through holes that are under the corner trim pieces. The holes accept: #8-32 pan head, M4 pan head or M5 socket head cap screws. The trim piece can be removed by hand to expose the securing holes.

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Figure 25: Removal of trim to expose securing holes

5.1.2 Electrical and Interfacing

The SIM has four DB-9 male connectors on the front. The label, on the top, clearly shows all connections. Beginning on the left front, the connections are: GPS, Motion, Heading, and Sound Velocity. At present time the GPS time message (for timing), sound velocity, and motion (for roll stabilisation) inputs are enabled. Next to each DB-9 are two vertical LEDs; the top LED responds to the input data: Green – receiving data that is being decoded; Red – no connection; Orange – receiving data that cannot be decoded (wrong baud rate or format setting in the Sonic Control Sensor Settings menu).

On the second row up are three BNC connections as well as three Ethernet connections. The BNC, which is above the GPS DB-9, receives the one Pulse Per Second (PPS) from the GPS receiver. The PPS, along with the GPS time information on the DB-9, is used to time stamp and synchronise all data.

The two BNC connections, to the right of the Ethernet connectors, are used to receive and send synchronisation triggers to and from other systems.

Mains voltage (90 – 260VAC) is input via the IEC connector. Above the connector is a rocker switch which turns on the system.

The SIM outputs the bathymetry data via the Ethernet on the Ethernet connection marked DATA (as marked on the label on top of the SIM). The other Ethernet connections are for future use.

Figure 26: SIM Interfacing Physical Connections

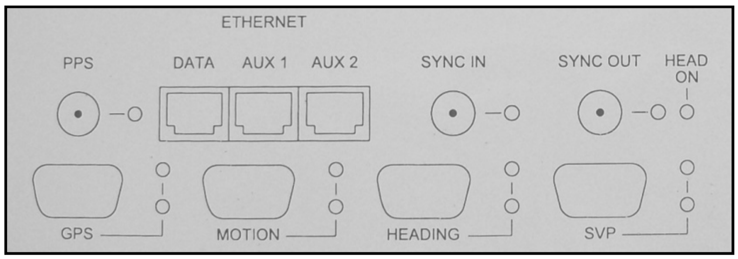

Figure 27: SIM Interfacing Guide (from label on top of the SIM)

NB. Again, at the present time, the SIM only takes in the PPS, NMEA Time message, sound velocity and motion data and not heading information.

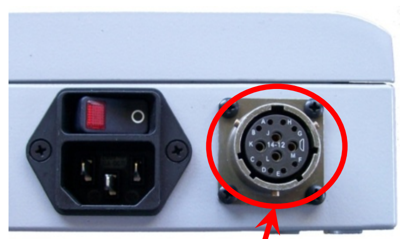

Figure 28: SIM IEC mains connection and deck lead Amphenol connector

Figure 29: Impulse connector

Function	Impulse Pin Number	Amphenol MS Pin Number	R2Sonic 10013A Wire Colour
Data 1+	4	A	Blue
Data 1-	5	B	Blue/White
Data 2+	7	C	Green
Data 2-	8	D	Green/White
Data 3+	11	E	Brown
Data 3-	12	F	Brown/White
Data 4+	9	G	Orange
Data 4-	10	H	Orange/White
Data Shield	6	n/c	Drain Wire
Power +	1	J,M	Red, Yellow (#18AWG)
Power Return	2	K,L	Black, Blue (#18 AWG)

Table 6: Deck Lead Pin Assignment (Gigabit Ethernet and Power)

5.1.3 Serial Communication

All serial interfacing is standard RS-232 protocol.

Pin	Data
2	Receive
3	Transmit
5	Ground

Table 7: DB-9M RS-232 Standard Protocol

Pin	Data	Function
1	*Receive2*	*Secondary Serial Port*
2	**Receive**	**Primary Serial Input**
3	**Transmit**	**Primary Serial Output**
4	+12VDC	+12VDC Power
5	**Ground**	**Data and Power Common**
6	N/C	Not Connected
7	+12VDC	+12VDC Power
8	N/C	Not Connected
9	*Transmit2*	*Secondary Serial Output*

Table 8: SIM DB-9M Serial pin assignment

5.1.4 Time and PPS input

5.1.4.1 Connecting PPS and Time to the SIM

In order to provide the most accurate multibeam data possible, the Sonic 2024/2022 takes in the GPS Pulse Per Second (PPS) and NMEA ZDA time message or an ASCII UTC message, which is associated with the pulse, to accurately time stamp the Sonic 2024/2022 data. The data collection software will take in the same PPS and time message to synchronise the computer clock and the auxiliary sensor data.

The PPS is normally a TTL (transistor – transistor logic) pulse. The pulse is transmitted to the SIM and the data collection computer via a coaxial cable (such as RG-58); the cable is terminated with BNC connectors so that it is easy to use a 'T' adaptor to parallel the PPS to different locations. Connect one end of the coaxial cable to the GPS receiver's PPS output (via a 'T' adaptor, if required) and the other end to the SIM BNC labelled PPS. When a pulse is received, the light next to the BNC connector will blink at 1 Hz.

The standard time message is a NMEA sentence identified as $GPZDA. The time message must go to both the SIM and the data collection computer, so the message must be either split or output on two different RS-232 ports on the GPS receiver.

5.1.4.2 Trimble UTC: UTC yy.mm.dd hh:mm:ss ab<CR><LF>"

Trimble GPS receivers provide the PPS time synchronisation message with an ASCII UTC string and not the ZDA string. When interfacing a Trimble GPS, use the UTC message and not the ZDA for timing information. If both the ZDA and UTC are input, the UTC will take priority; the SIM will automatically ignore ZDA while receiving UTC. The UTC status code ('ab') is ignored.

Setting up the time synchronisation is done through the Sonic Control software detailed in Chapter 6.

In that each of the SIM serial ports provides 12VDC on selected pins, it is not recommended to use a fully wired serial interface cable as this may cause some GPS receivers to stop sending data. Use a cable with only pins 2, 3 and 5 wired, if possible.

5.1.5 Motion Input

The roll component, of the motion data, is used for roll stabilisation. Currently, the only acceptable format is the standard TSS1 data string. It is recommended to set the motion sensor to output the highest baud rate and highest update rate possible, preferably 100 Hz or higher.

Connect the motion data to the DB-9 labelled Motion, on the SIM. Setting up the serial port parameters is done through Sonic Control, which is covered in Chapter 6.

5.1.6 SVP input

5.1.6.1 Connecting the sound velocity probe

The sound velocity probe is used to provide the sound velocity at the sonar head, which is used for the receive beam steering. It is not used for refraction correction; that must be accomplished in the data collection software employing a full water depth sound velocity cast.

5.1.6.2 Valeport miniSVS

The miniSVS comes with a 15 metre cable. The cable carries both the DC power (8 – 29V DC) to the probe and the data from the probe to the SIM. The miniSVS is set for a baud rate of 9600 and will start outputting sound velocity (Format: <sp> xxxx.xxx m/sec) as soon as power is applied. The miniSVS cable is terminated with a female DB-9 RS-232 connector; this is attached to the male DB-9 RS-232 connector, on the SIM, marked SVP. The probe is powered through the SIM's serial port 12VDC supply.

Setting up the SVP input is done through the Sonic Control software detailed in Chapter 6.

6 OPERATION OF THE SONIC 2024/2022 VIA SONIC CONTROL

The Sonic 2024/2022 multibeam echosounders are controlled by the Sonic Control software. The Sonic Control GUI does not require a dedicated computer and is usually installed on the user's data collection computer.

6.1 Installing Sonic Control Graphical User Interface

Sonic Control is supplied on a CD or as an attached file. There is no installation program, merely decompress the program to a folder in a root directory of the computer. Send the R2Sonic.exe to the desktop, as short cut,

Figure 30: Sonic Control Icon on desktop

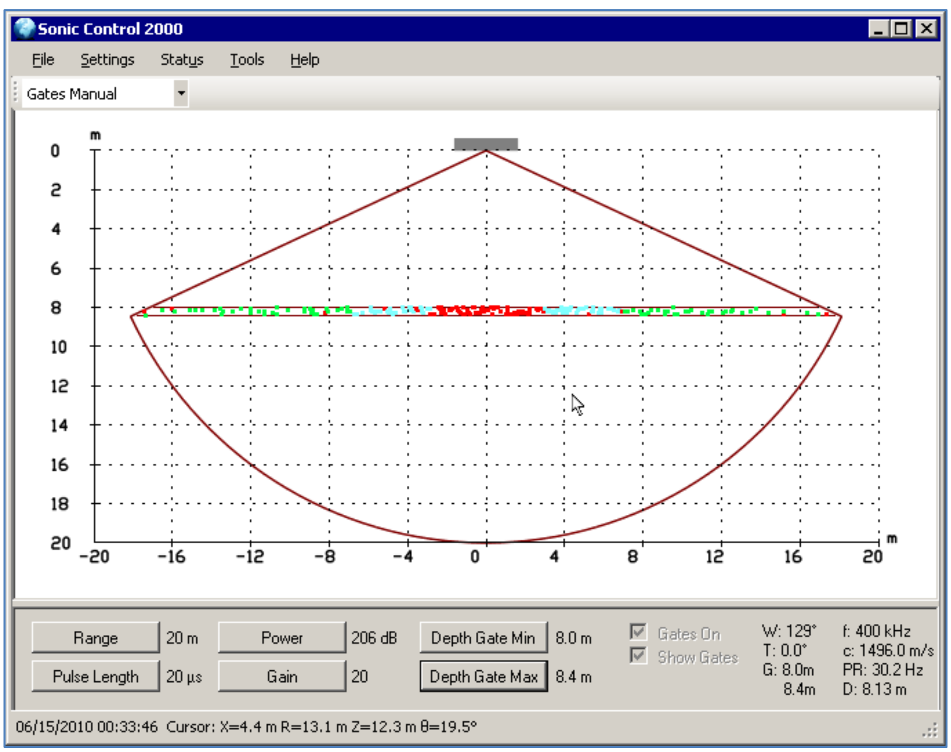

Figure 31: Sonic Control 2000

6.2 Network Setup

All communication, between the Sonic 2024/2022 and the SIM and data collection computer is via Ethernet. The first step in setting up the sonar system is to establish the correct Ethernet parameters, which include the IP (Internet Protocol), Subnet Mask and UDP (User Datagram Protocol)base port under Settings | Network settings.

6.2.1 Initial Computer setup for Communication

Prior to starting Sonic Control 2000 for the first time, the computer's network parameters must be set correctly to establish the first communication.

Open the computer's network connections. Identify the NIC (Network Interface Card) that is being used for the Sonic system and select Properties (usually by using the right mouse button context menu, highlight the Internet Protocol (TCP/IP) and select properties. Select '**Use the following IP address'** and enter:

IP address: 10.0.1.102

Subnet mask: 255.0.0.0

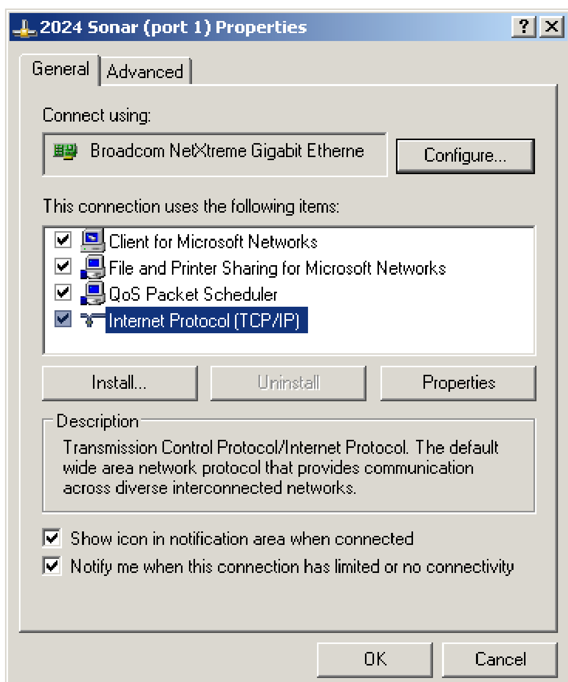

Figure 32: Windows XP Internet Properties

Select Internet Protocol and then select Properties to enter the correct IP and Subnet mask.

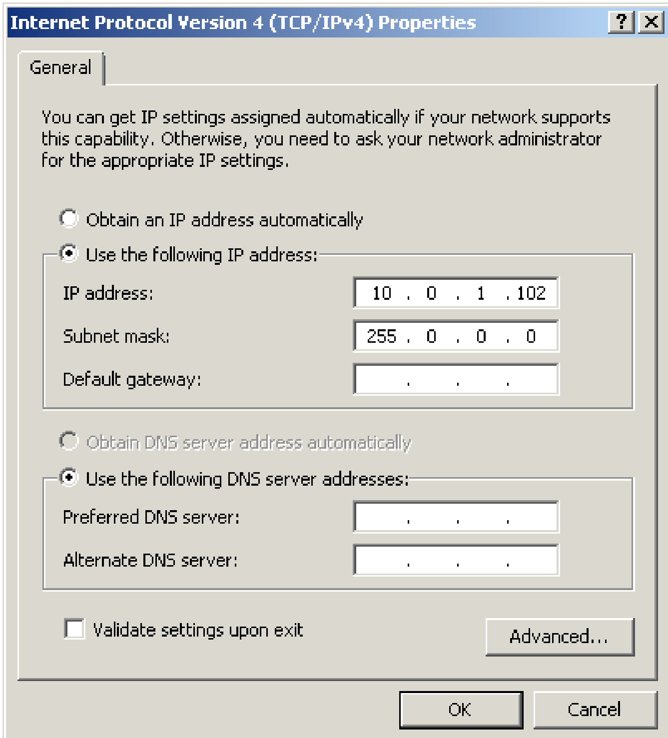

Figure 33: IP and Subnet mask setup

It is very important that the exact settings, as shown in Figure 33, are entered. This will allow initial communications to be established with the Sonic system; once communication is established, the IP address can be user configured.

WARNING

ALL COMPUTER FIREWALLS MUST BE DISABLED TO INSURE COMMUNICATION.

6.2.2 Discover Function

The sonar head and the SIM have initial IP and UDP ports to establish communication (see below). **Communication will not be established until the serial number of sonar head and the SIM are entered in the settings for Sonar 1**, in the Sonic Control 2000 Network settings.

Use the Discover function to request the serial number information from all attached R2Sonic equipment. The Discover function will automatically transfer the serial numbers to the correct field.

6.2.2.1 Default Network Configuration

Head IP:	10.0.0.86	BasePort: 65500
SIM:	10.0.0.99	BasePort: 65500
GUI:	10.0.1.102	BasePort: 65500
Bathy:	10.0.1.102	BasePort: 4000
Snippets:	10.0.1.102	BasePort: 4000

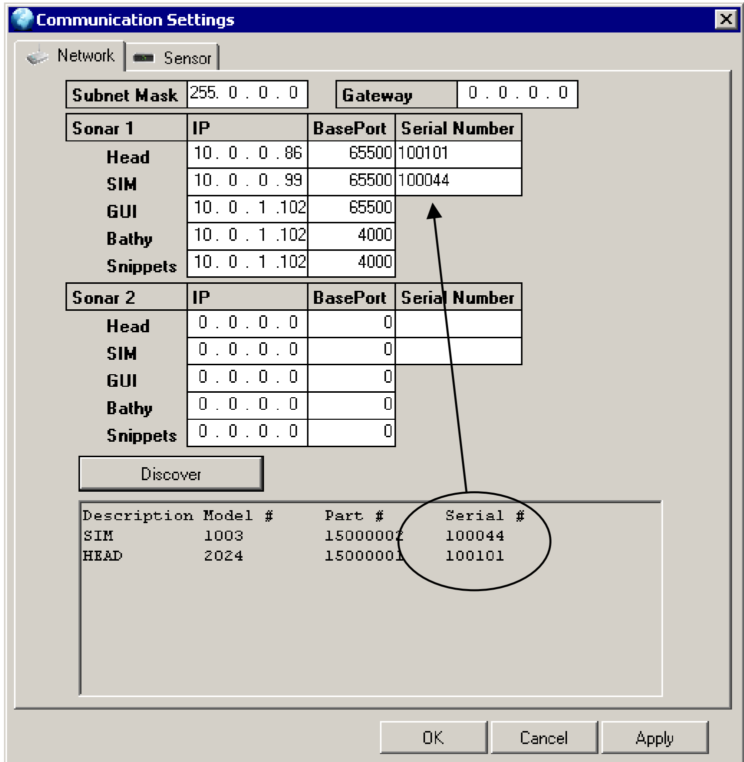

Figure 34: Sonic Control Network setup

Until the correct serial numbers are entered, there will be no communication. Once the correct serial numbers are entered, click **Apply** and dots will be visible in the wedge display signifying communication is established. Using Discover will guarantee that the serial numbers will be entered correctly and verify Ethernet communication between devices.

6.2.3 Configuring Network Communication

- The network settings allow freedom in selecting IP numbers for various pieces of equipment.
- The most important settings to get right are the Subnet Mask (upper left corner of the Network settings dialog) and the GUI IP number. If these numbers are wrong, the Sonic Control program will not be able to configure the sonar head and SIM. The GUI IP number and subnet mask, entered in the Network Settings dialog, is the IP address and subnet mask assigned to the computer that is running the Sonic Control program.
- To verify computer network setup run **ipconfig/all** from the command line or command prompt.

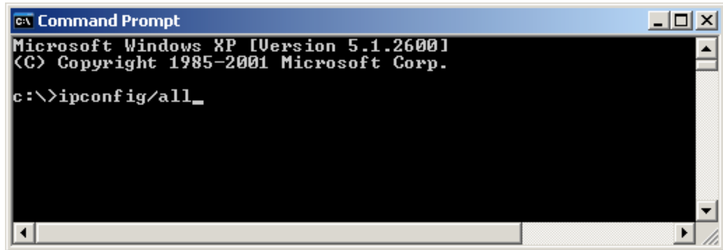

Figure 35: Command prompt-ipconfig/all

- The Sonic Control program is required to send networking configuration to the sonar head and SIM whenever the sonar head and/or SIM are powered up.
- If the GUI IP number and subnet mask are set correctly, the Discover button will list the R2Sonic devices attached to the network. If the GUI IP number and/or subnet mask is set wrong, Discover will not work and the sonar head and SIM will not configure.
- Settings for Sonar 1:

  Head IP: Any unique IP number within the network subnet.
  Head BasePort: Any number between 49152 and 65535. Preferred is: 65500.
  SIM IP: Any unique IP number within the network subnet.
  SIM BasePort: Any number between 49152 and 65535. Preferred is: 65500.
  GUI IP: Same IP number of the computer running the Sonic Control software.
  GUI BasePort: Any number between 49152 and 65535. Preferred is: 65500.
  Bathy IP: IP number of the computer running bathymetry data collection software.
  Bathy BasePort: Base port number that the bathymetry data collection software requires.
  Snippets IP: IP number of the computer running snippets data collection software.
  Snippets BasePort: Base port number for Snippets, Snippets will be output on a port, which is the base port plus 6. With a base port of 4000, Snippets will be on port 4006.

- Settings for Sonar 2:
  All entries must be zero. Serial numbers are left blank.
- Once networking is set up, Sonic Control will automatically connect upon power up; there is no need to go back into the Network Settings

6.3 Sensor Setup (Serial Interfacing)

The Sonar system receives various data on the SIM serial ports as noted in Section 5. Select **Settings | Sensor** setting to setup the serial communications parameters.

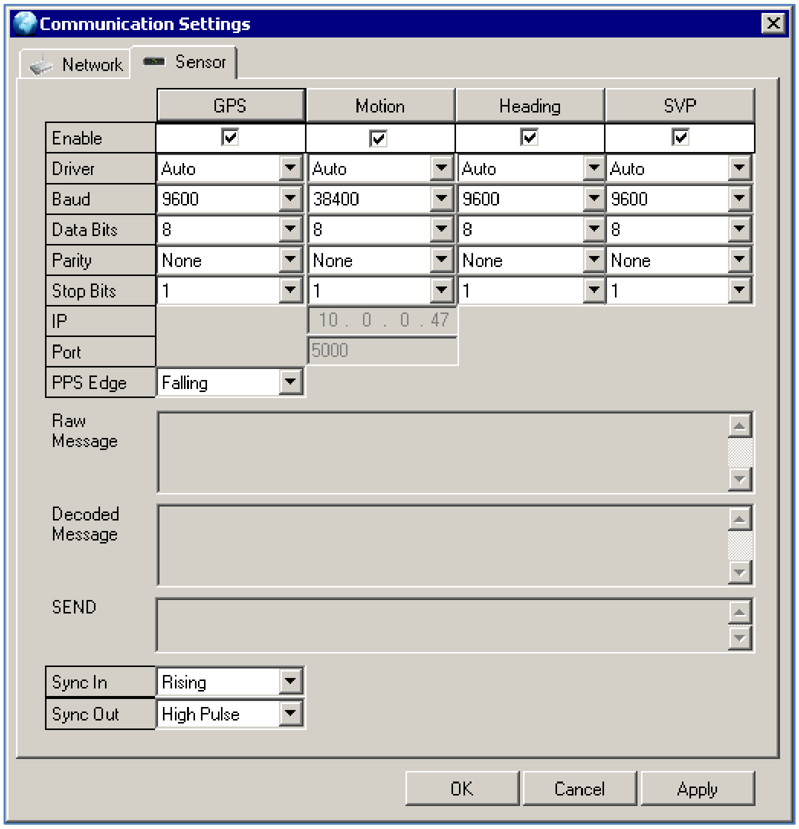

Figure 36: Sensor communication settings

6.3.1 GPS

The GPS input is for the ZDA time message ($GPZDA) or Trimble UTC message, other NMEA messages may be in the same string; it is not necessary to isolate the ZDA or UTC. In the GPS receiver's operation manual, there will be an entry that will detail which edge of the PPS pulse is used for synchronisation; this will be either synch on rising edge, or synch on falling edge. Selecting the correct polarity is vital for correct timing.

The firmware supports the ZDA integer part (HHMMSS) and accepts PPS pulses if they pass a basic stability test: the last two pulses must be within 200ppm. If the PPS is unstable or absent, the SIM's internal clock free-runs with a high degree of accuracy.

The decoded time, from the bathymetry packet, is visible in the main display on the lower left along with the cursor position information. If the displayed time is 01/01/1970 it indicates that timing is not set up correctly.

6.3.2 Motion

Currently, the motion data is used for roll stabilisation and must be in the TSS1 Format. The motion data should be at the highest possible baud rate, with the motion sensor configured for the highest output possible; at a minimum 100Hz update.

6.3.3 Heading

Not currently enabled.

6.3.4 SVP

This is used to set the communication for the sound velocity probe mounted on the sonar head.

6.3.5 Message displays

Not currently enabled

6.3.6 Synch In / Synch out

Used to receive or send synchronisation TTL pulses. This is under development.

6.4 Sonar Settings

The Sonic 2024/2022 has many features that provide the user with the versatility to tailor the system to any survey project; these features can be controlled either through the Operation Settings or with the mouse cursor.

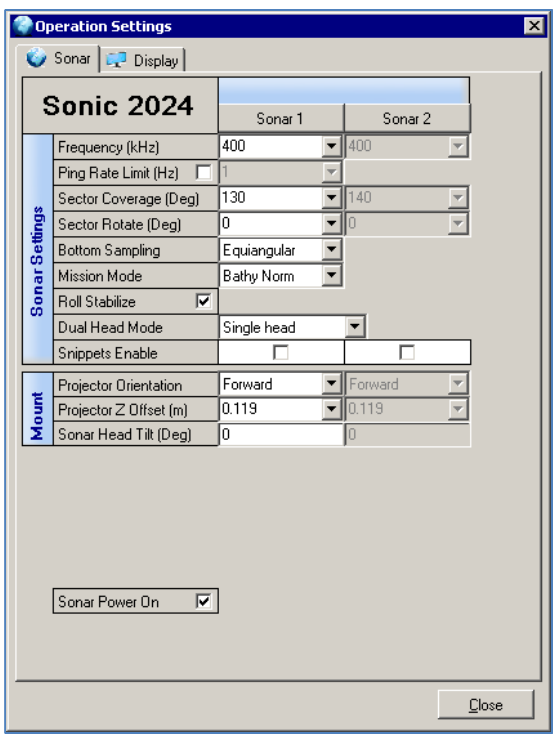

Figure 37: Sonar Operation Settings window

6.4.1 Frequency

The Sonic 2024/2022 operates on a user selectable frequency, from 200 kHz to 400 kHz, in 10 kHz steps. The operating frequency can be changed on the fly; there is no need to stop recording data, go offline, or load any firmware. The operating frequency is selected via the drop down menu next to Frequency (kHz).

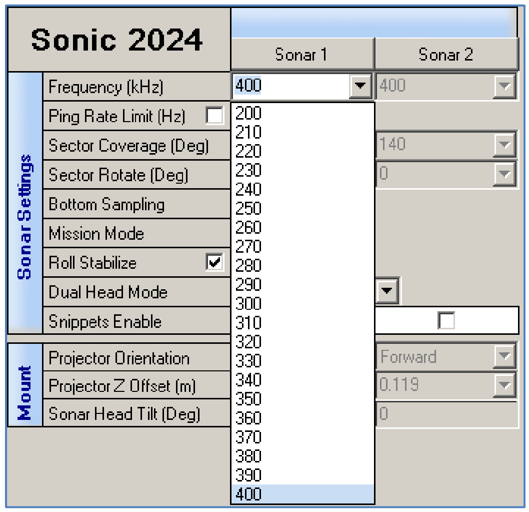

Figure 38: Operating Frequency Selection

6.4.2 Ping Rate Limit

The Sonic 2024/2022 can transmit at a rate up to 60 Hz (60 pings per second), this is called the Ping Rate. At times, it may be desirable to reduce the ping rate to reduce the collection software file size or for other reasons. Highlight the box next to Ping Rate Limit and the ping rate limit drop down box will be activated; select a predefined ping rate or enter a manual rate.

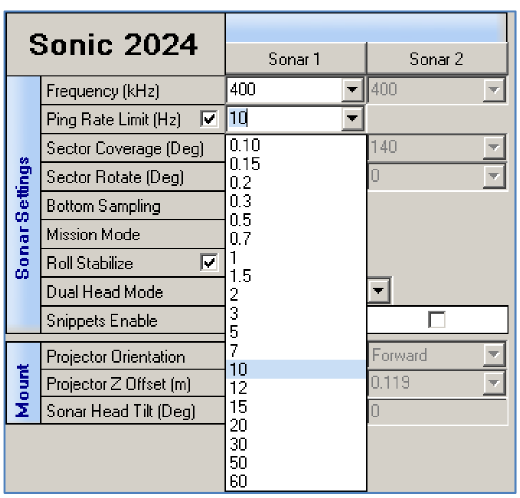

Figure 39: Ping Rate Limit

6.4.3 Sector Coverage

The Sonic 2024/2022 allows the user to select the swath sector from 10° to 160°. All 256 beams are used, no matter what the selected sector coverage that is chosen. The smaller the sector, the higher the sounding density is within that sector. Changing the Sector Coverage can be done on the fly, with no need to stop recording data or to go offline.

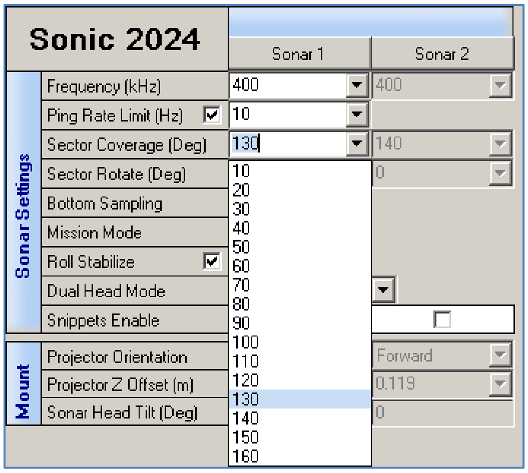

Figure 40: Sector Coverage

The Sector Coverage can also be controlled via the mouse cursor, inside the wedge display.

Position the cursor on either of the straight sides of the wedge; the cursor will change to a double arrow and the sector can be reduced or increased. When using the cursor to change the sector coverage, the change only takes place when the mouse button is released.

The sector angle will be numerically visible in the lower left hand corner of the wedge display while the mouse button is depressed.

6.4.4 Sector Rotate

The Sonic 2024/2022 has the capability to direct the selected sector to either port or starboard, allowing the user to map vertical features, or areas of interest, with a high concentration of soundings resulting from the compressed sector.

First, change the sector coverage to the desired opening angle; this will concentrate the 256 beams within the sector.

Second, rotate the swath towards the feature to be mapped with high definition. This is done on the fly, with no need to stop data recording or to go off line.

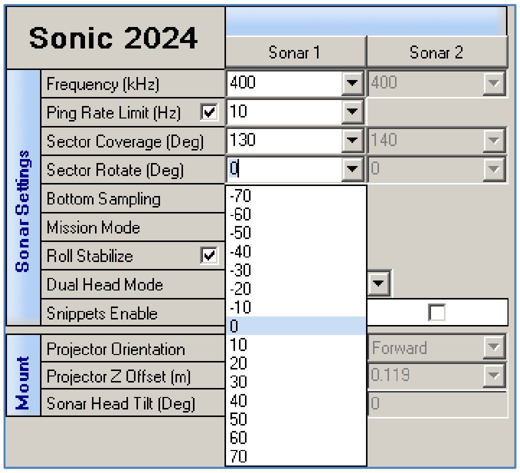

Figure 41: Sector Rotate

The sector can also be rotated using the mouse cursor, in the wedge display. Position the cursor on the curved bottom of the wedge; the cursor will change to a horizontal double arrow, the wedge can now be rotated to port or starboard. The angle of rotation is numerically visible in the lower left hand corner of the wedge display during rotation. A clockwise rotation is positive, an anti-clockwise rotation is negative.

The change only takes place when the mouse button is released.

6.4.5 Bottom Sampling

There are two options: Equiangular or Equidistant. In equidistant mode, all beams are equally distributed, within the sector. There are limits to what the equidistant can do, based on opening angle and bottom topography; it is best on flat sea floor and with an opening angle (Sector Coverage) equal to, or less than, 130°.

6.4.6 Mission Mode

The versatility, built into the Sonic 2024/2022, is further enhanced with the ability to adapt the system to the nature of the survey task: normal survey or surveying a vertical feature. There are two Mission Modes:

- **Bathy Norm**: Normal bathymetry survey
- **Bathy VFeature**: With the ability to map vertical surfaces, without physically rotating the sonar head, this Mission Mode provides improved detection methods tailored to mapping vertical features. This specialised mode greatly reduces the corner 'ringing' seen in older technology systems.

The Mission Mode can be changed on the fly, with no need to stop recording data.

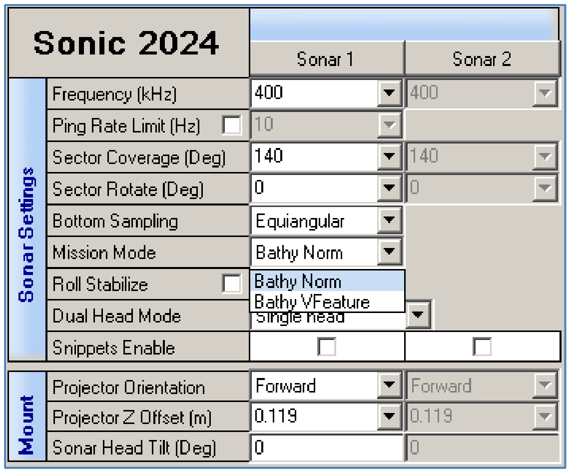

Figure 42: Mission Mode

6.4.7 Roll Stabilize

When a motion sensor is interfaced to the SIM, the data can be stabilised for roll motion of the vessel. With the advanced roll stabilisation, in the Sonic 2024/2022, there is no need to stop recording or go off line to change between roll stabilised and non-stabilised mode, nor is there a need to go into the data collection software and identify the data as roll stabilised. The R2Sonic roll stabilisation has been developed based on recommend methods from various data collection software companies.

Roll stabilisation only works within the 160° maximum sector, any swath rotation or large sector size (opening angle) that attempts to go beyond the 160° limit will cause the system to stop roll stabilisation.

As stated in the SIM interfacing, it is recommended that the TSS1 data be at the highest update rate possible.

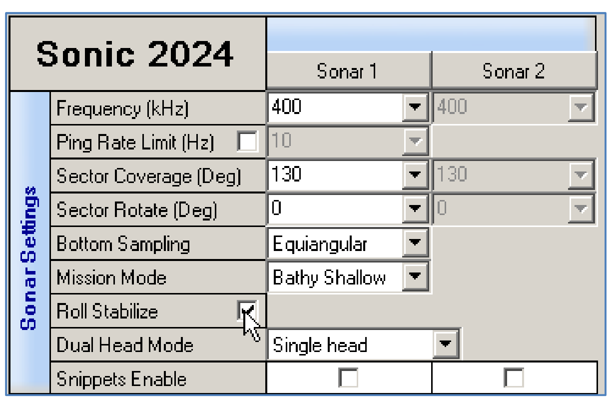

Figure 43: Roll Stabilize

6.4.8 Dual Head Mode

The selections are: Single Head, Simultaneous Ping or Alternating Ping. When the dual head mode is selected, a second wedge display will be available in Sonic Control 2000.

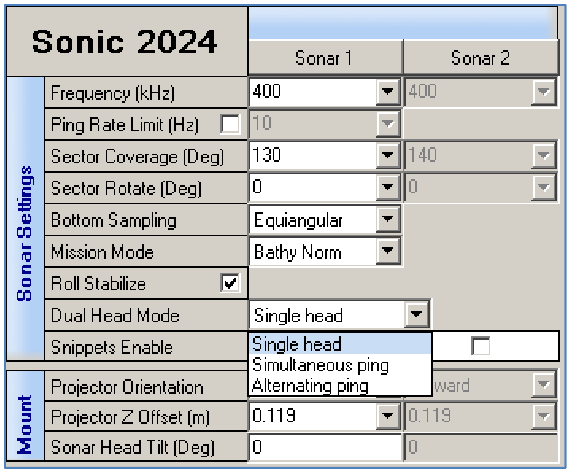

Figure 44: Dual Head Mode

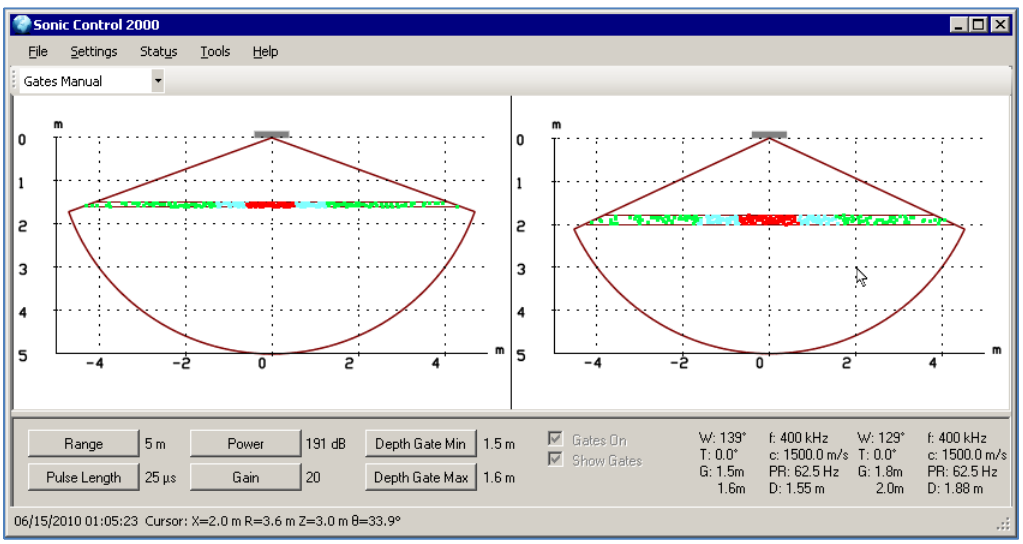

Figure 45: Dual Head Mode active

In dual head mode, certain controls: Range, Power, Pulse Length, and Gain set both sonar heads.

NB. For a dual head system, the Discover function will only list the systems. Discover does not auto-fill the serial numbers for a dual head system. Correct serial numbers must be entered by hand for both systems.

6.4.8.1 Dual Head default settings

To make it easier to set up the system for dual head operation, there is a specific settings file that can be loaded that will set all of the defaults for a dual head configuration. Under the File menu selection, select Load Settings.

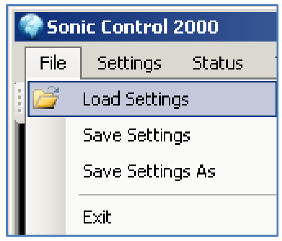

Figure 46: Load Settings menu selection

The available settings files will be shown. There are two Factory Default initialisation files; one for single head, the other for dual head.

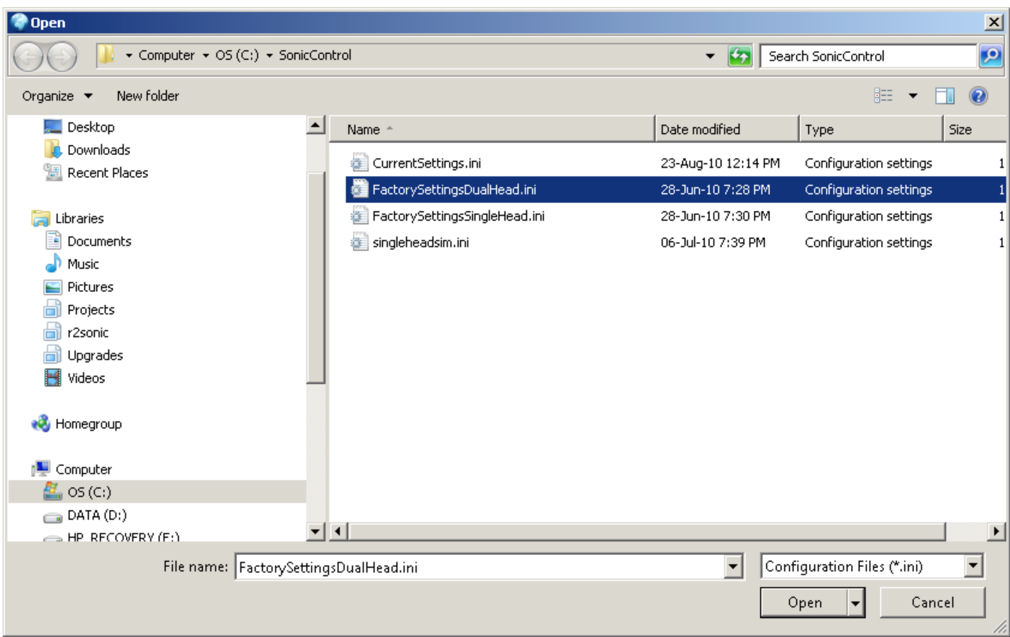

Figure 47: Selecting Factory default settings file for dual head operation

When the file is loaded, Sonic Control will be configured for dual head mode, this includes the default network settings.

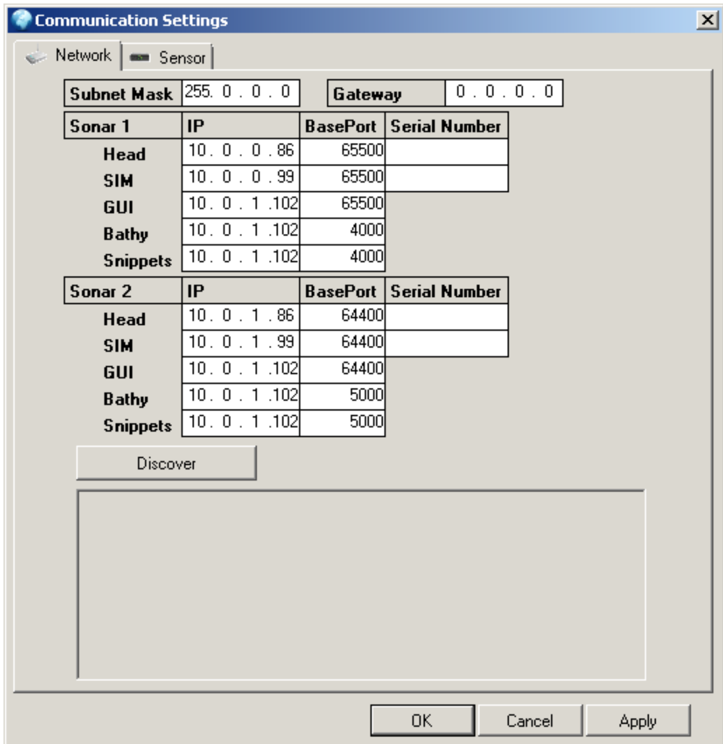

Figure 48: Default dual head network settings

6.4.9 Snippets Enable

If the Snippet option is installed in the Sonic 2024/2022, the Snippets can be turned on and off by ticking the box next to Snippets Enable.

6.4.10 Mount

6.4.10.1 Projector Orientation

The preferred orientation is with the projector facing forward. This configuration has been tested at speeds up to 12 knots, with excellent results (hull and moon pool mounting). However, if installation requires the projector to face aft, this setting is used to renumber the beams to reflect the aft orientation

6.4.10.2 Projector Z Offset (m)

Using the standard R2Sonic mounting frame, the projector is mounted at a precise distance, relative to the receive array, with a Z offset of 0.119m: the default. If the projector is not mounted in the same vertical relationship to the receive array, an offset can be entered here to compensate for that vertical offset.

The default Z offset value is 0.119m; this is the physical distance between the receive array ceramic face and the centre point of the projector array, as used with the standard R2Sonic mounting frame (with 35mm projector standoffs). **Do not change** this value unless the projector is mounted with a different vertical offset, relative to the receive array. Please contact R2Sonic for further guidance on mounting the projector with a different vertical offset.

6.4.10.3 Head Tilt

If the sonar head is physically tilted to port or starboard, the tilt angle is entered here to rotate the wedge and depth gates.

6.5 Ocean Setting

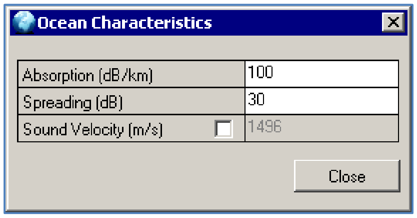

Figure 49: Ocean Characteristics

Ocean Characteristics include Absorption and Spreading loss, which are the main components of the Time Variable Gain (TVG) computation, and Sound Velocity (for receive beam steering).

6.5.1 Absorption: 0 – 120dB/km

Absorption is influenced primarily by frequency and the chemical compounds of boric acid $B(OH)_3$ and magnesium sulphate $MgSO_4$.

It is highly recommended that the local absorption value be entered. If this is not known, a good on-line source is: http://resource.npl.co.uk/acoustics/techguides/seaabsorption/[1]

Appendix V provides a table of absorption values based on operating frequency.

6.5.2 Spreading Loss: 0 – 60 dB

Spreading loss is the loss of intensity of a sound wave, due to dispersion of the wave front. It is a geometrical phenomenon and is independent of frequency. The sound wave propagates in a spherical manner, the area of the wave front increases as the square of the distance from the source. Therefore, the sound intensity decreases with the square of the distance from the projector. Spreading loss is not dependent on frequency.

Spreading loss is not a setting that normally needs to be changed except when surveying in deeper depths. As spreading loss is not dependent on frequency, the setting is unaffected by a change in operating frequency. A general default value of 20 – 30 is normally sufficient for most survey conditions.

For more detailed information on absorption and spreading loss, please refer to Appendix V Basic Acoustic Theory.

[1] Linked with the kind permission of the National Physical Laboratory; Teddington, United Kingdom TW11 0LW; NPL reserves the right to amend, edit or remove the linked web page at any time .

6.5.3 Time Variable Gain

Absorption and spreading loss are the main components of the Time Variable Gain (TVG) computation.

TVG Equation

$$TVG = 2*R*a/1000 + Sp*\log(R) + G$$

α = Absorption Loss db/km
R = Range in metres
Sp = Spreading loss coefficient
G = Gain from Sonar Control setting

TVG is employed in underwater acoustics to compensate for the nature of the reflected acoustic energy. When an acoustic pulse is transmitted in a wide pattern, the first returns will generally be from the nadir region and very strong. As the receive window time lengthens, the weaker returns are received. Using a fixed gain would apply either too much gain for the early returns or insufficient gain for the later returns. The solution is to use TVG. The function of TVG is to increase gain continuously throughout the receive cycle. Therefore, smaller gain corresponds with the first returns (normally the strongest) and higher gain corresponds to the later returns (normally the weakest). This function is represented in, what is called, the TVG curve.

6.5.3.1 TVG Curve

The TVG curve can be either shallow or steep depending mostly on the Absorption value to define the shape of the curve. The Spreading Loss will determine the amplitude of the gain.

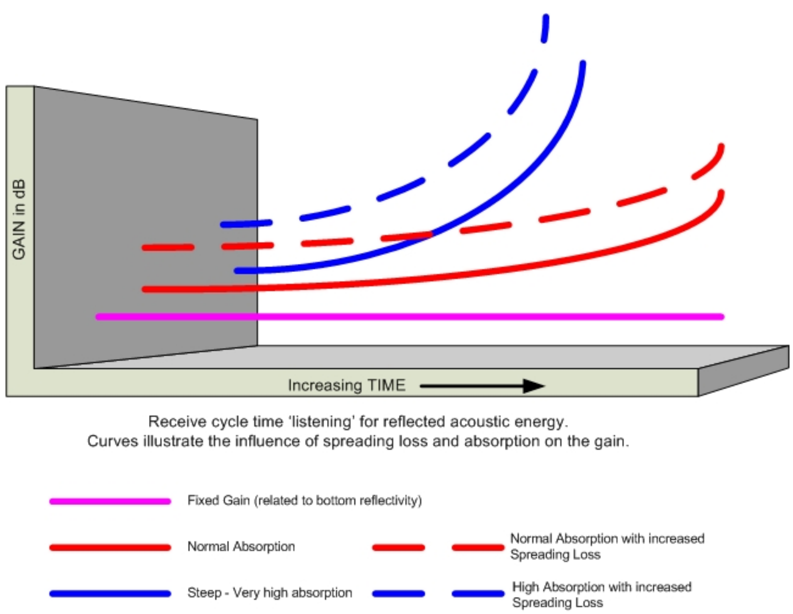

Figure 50: TVG Curve Concept

6.5.3.2 Sound Velocity

The speed of sound, at the receiver's face, is required to do the receive beam steering, which is required for all flat array sonars. The angular acoustic wave front strikes each receive element, but at a different time and phase depending on the angle of the return. By introducing a variable delay to each receive element's information, the phases can be aligned and the beam can be 'steered' in the direction of the return. In order to accurately apply the correct delay, three factors have to be known or measured: The physical distance between each receive element is known, the time of reception at each receive element is measured, the speed of sound at the receiver face must be known or measured (for this reason there is a sound velocity probe attached to the mounting frame).

The beam steering can be accomplished, without a sound velocity probe, by entering in the correct sound velocity for the area around the sonar head. To manually enter a sound velocity, check the box for 'Use Custom velocity' and enter a velocity.

WARNING

The wrong sound velocity, at the sonar head, will cause erroneous data. There are currently no known post processing tools to correct for this.

If the sound velocity is wrong, the beam steering will be in error. If the sound velocity is greater than what it really is at the face of the receiver, the ranges will be shorter and thus the bottom will curve up or 'smile'. If the sound velocity is less than what it really is at the face of the receiver, the ranges will be longer and the bottom will curve down or 'frown'. This error can be confused with a refraction error caused by the wrong water column sound velocity profile. The refraction error can be corrected by entering the correct water column sound velocity profile, however; erroneous beam steering cannot be corrected as it is part of the beam data.

Therefore, for accurate beam steering to take place, an accurate sound velocity must be provided to the Sonic 2024/2022.

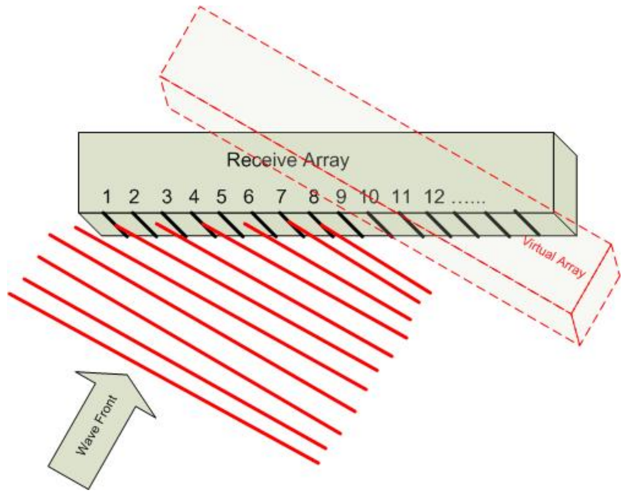

Figure 51: The angular acoustic wave front will strike each receive element at a different time

As the wave progresses across the face, each receive element will see the wave at a slightly different time and thus a slightly different phase. The formed beam is steered in the direction of the acoustic wave by selectively adding delay to each receive element's data until the data is coherent and in phase. In Figure 46, receive element 1 would have the most delay applied, whereas receive element 8 would have no delay; thus a 'virtual array' will be formed.

6.6 Tools | Firmware Upgrade

When R2Sonic issues a firmware upgrade, it will be made available to the customer, allowing the customer to upgrade their system by themselves. There are two firmware upgrades possible: SIM upgrade and/or sonar head upgrade. The upgrade file will be designated either Simb$ (SIM) or Head$ (sonar head); the extension will be *.bin.

Place the upgrade file in a directory on the computer hard drive. Go to Tools | Firmware Upgrade; use the browse button to search for the correct upgrade file to down load to either the SIM or the sonar head.

Figure 52: Select Tools; Firmware Upgrade

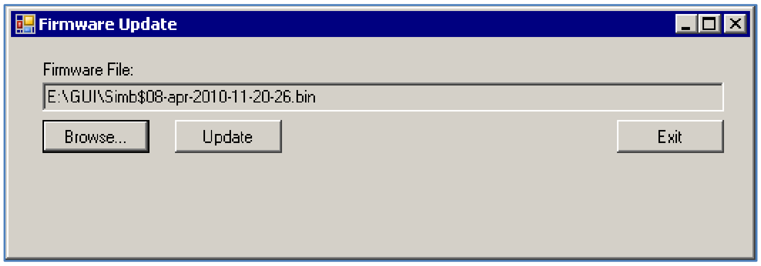

Figure 53: Select correct upgrade .bin file

Once the Update button is clicked on, a batch file will automatically run and download the .bin to the appropriate place.

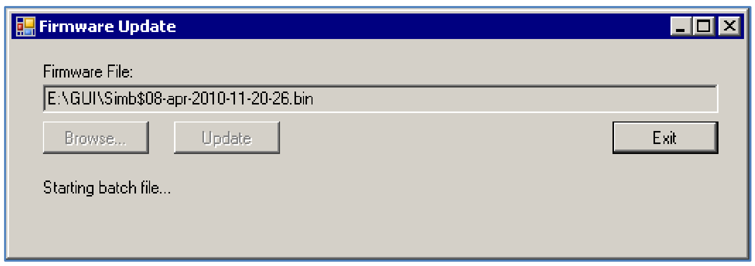

Figure 54: A batch file will automatically load the upgrade file

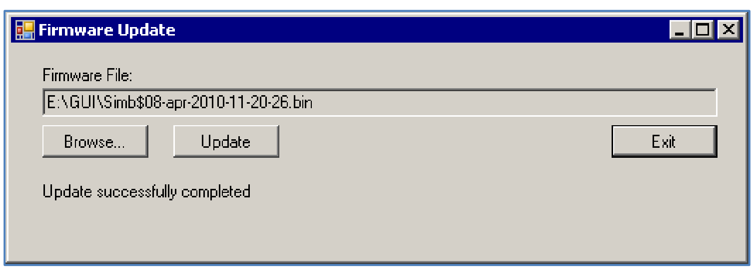

Figure 55: Message displayed when the upgrade process is complete

There are two cases where the upgrade process may fail; one is if the wrong type of file is selected, the other is if there is no communication with the part of the sonar that is to be upgraded. Each instance will provide an error message.

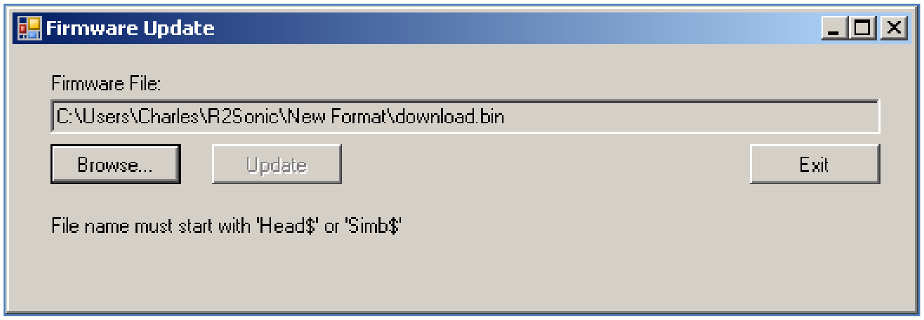

Figure 56: Error if wrong file chosen for upgrade

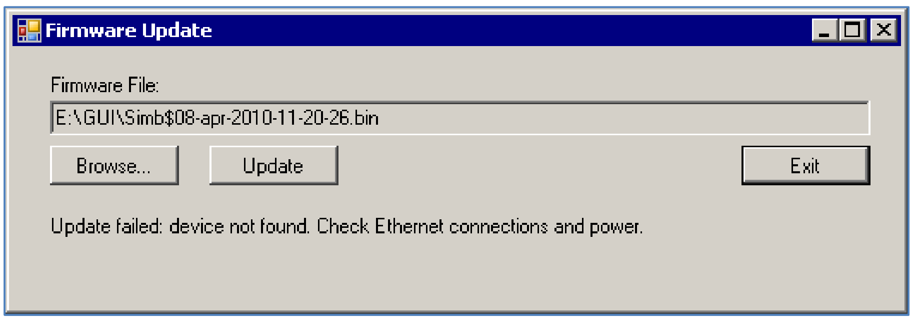

Figure 57: Error if component cannot be found

6.7 Display settings

The user can customise the colour scheme of Sonic Control's main window.

Dot Colors provides a means to view instantaneous information by colouring the bottom detections dots for the detection algorithm being employed when Magnitude is selected.

Selecting Intensity provides a grey scale representation of the return data's acoustic strength. This Dot Color mode can be very helpful in balancing the power, gain and pulse length for optimal operation of the system. The Brightness (dB) sets a base reference for the depiction of the acoustic return strength.

Under Draggable Sector Outline, the user can enable or disable the feature to use the mouse cursor to change opening angle and swath rotation.

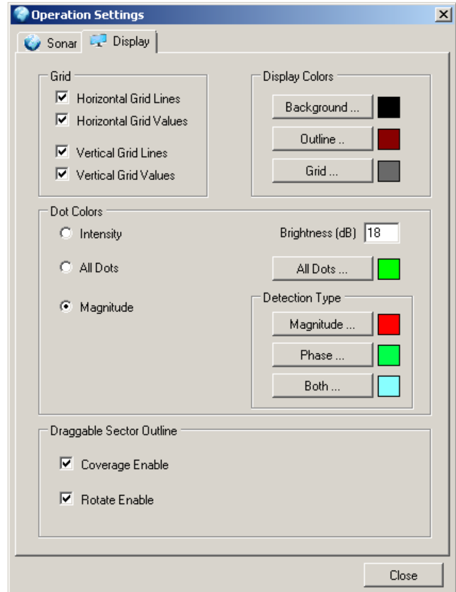

Figure 58: Display Settings

6.8 Main Operation Parameters

The main operating parameters of the Sonic 2024/2022 are controlled by the buttons in the lower portion of the window.

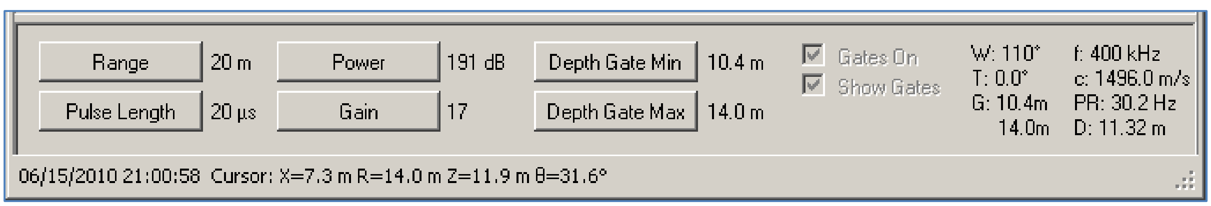

Figure 59: Operating parameter buttons

To change a value, position the mouse cursor on the button then use the left mouse button to decrease the value and the right mouse button to increase the value.

The right hand side of the panel provides system information:

- W: Wedge sector (opening angle)
- T: Sector Tilt angle
- G: Minimum and maximum depth gate settings
- f: Operating frequency
- c: Sound velocity at the sonar head
- PR: Ping rate
- D: Nadir depth

The lower left area displays the time, which is decoded from the bathymetry packet and the current cursor position, relative to the sonar head. The angular information is represented by theta Θ.

6.8.1 Range: 0 – 500 metres

The Range setting sets the maximum ***slant range*** of the Sonic 2024/2022. The maximum slant range determines how fast the Sonic 2024/2022 can transmit; this is the Ping Rate. What the range setting is doing is telling the Sonic 2024/2022 the length of time that the receivers should be 'listening' for the reflected acoustic energy. If the Range setting is too short, some of the returning energy will be received during the subsequent receive period, i.e. out of synch, and will be seen as noise.

It is easy for the operator to maintain the correct Range setting by noting the bottom detection dots relationship to the straight legs of the wedge display.

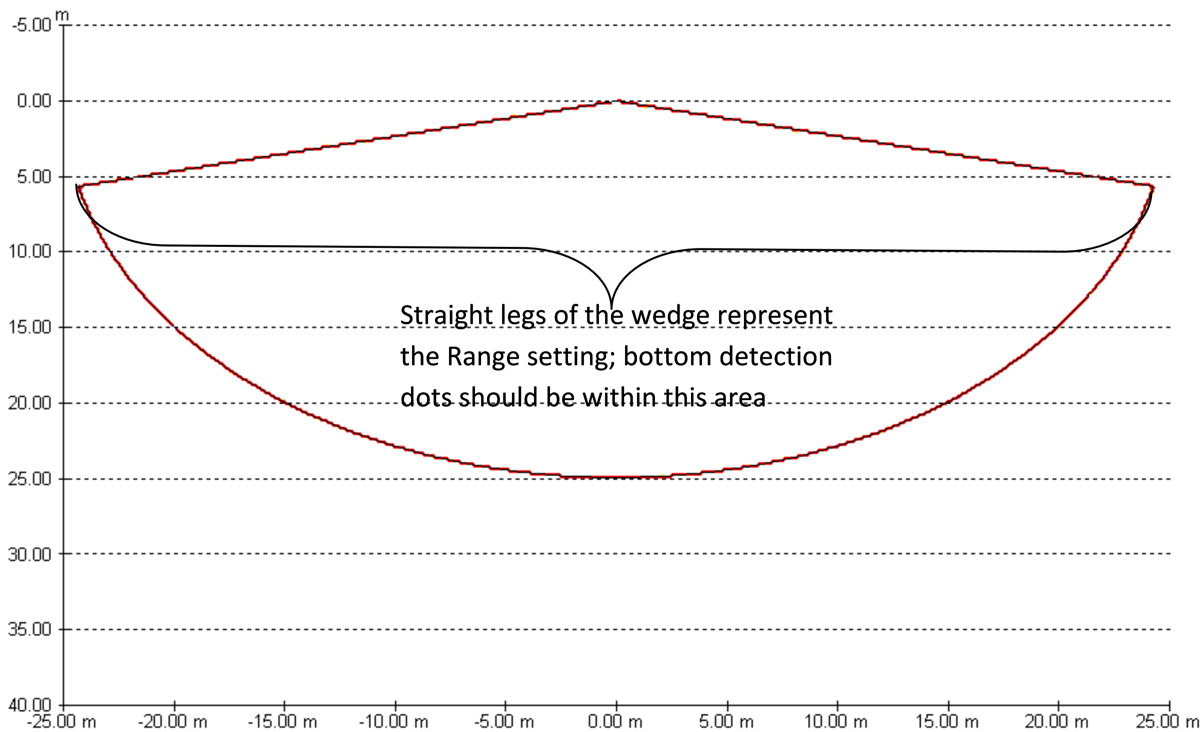

Figure 60: Range setting represented in the wedge display

6.8.2 Power: 0 – 221 dB

The Power setting sets the source level of the transmit pulse; this is represented in Figure 60, below. The Sonic 2024/2022 should be operated with sufficient power to enable good acoustic returns from the sea floor. The value will change based on water depth, bottom composition, and operating frequency. In general, higher power is better for getting decent bottom returns rather than using receiver gain to obtain the returns. If the Power setting is too low, more receiver gain will need to be used to capture the bottom returns; this can mean more extraneous noise will also be received. The increase in noise will require more processing time; it is better to slightly increase the Power to increase the strength of the bottom returns and, thus, allow for a lower receiver gain setting. If too much power is used, the receivers can be over-driven (saturated); this will result in noisy data and/or erroneous nadir depth readings. A good balance of source level (Power) and receiver gain is the desired end.

6.8.3 Pulse Length: 15µsec – 500µsec

Pulse length determines the transmit pulse duration time. The Sonic 2024 pulse length range is from 15µsec to 500µsec. The pulse length does not affect the pulse amplitude, which is determined by the Power setting. The general guide line is to maintain as short a pulse length as possible to optimise the resolution, but not so short as to weaken the transmit pulse. Generally, as the water gets deeper the pulse length will have to be increased to get more 'total' power in the water. The default pulse length will depend on the chosen operating frequency.

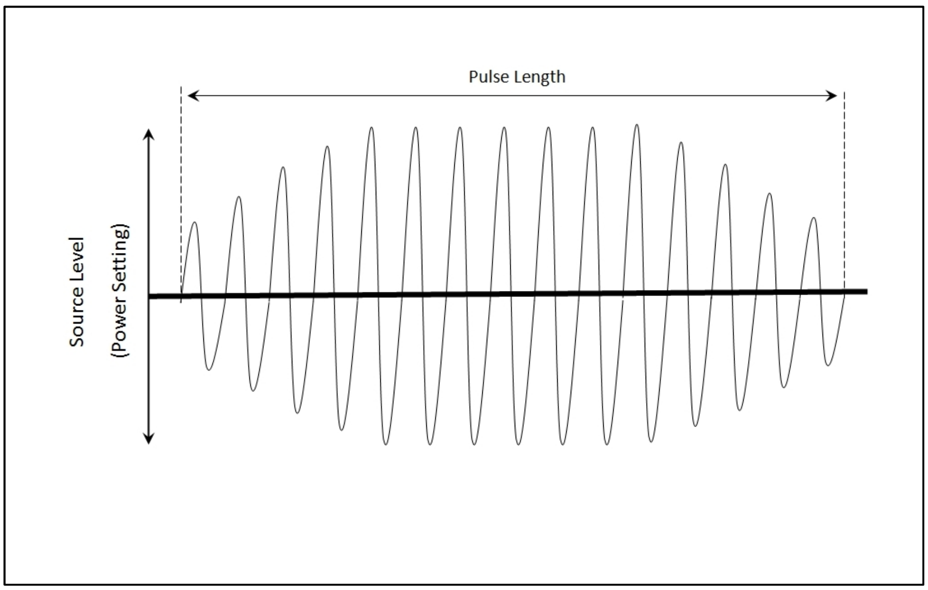

Figure 61: Transmit Pulse

6.8.4 Gain: 1 – 45

Receiver gain is in 2 dB steps from 1 to 45. This adjusts the gain of the sonar head receivers.

6.8.5 Depth Gates

The depth gate allows the user to eliminate noise or other acoustic interference by the limits set in the Minimum and Maximum Depth.

Depth Gates are turned on or off via the drop down selection in the upper left hand portion of the Sonic Control window.

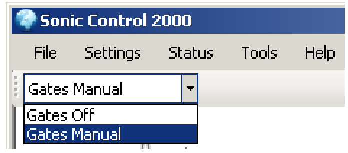

Figure 62: Depth Gates on and off control

The depth gates can also be changed using the mouse in the wedge display. Click and drag on either depth gate; the cursor will change to a double arrow, drag the gate to the new depth and release the mouse button. The depth gate position is visible in the lower left hand section of the display. When the mouse button is released the gate will be updated in the Operation Parameters area.

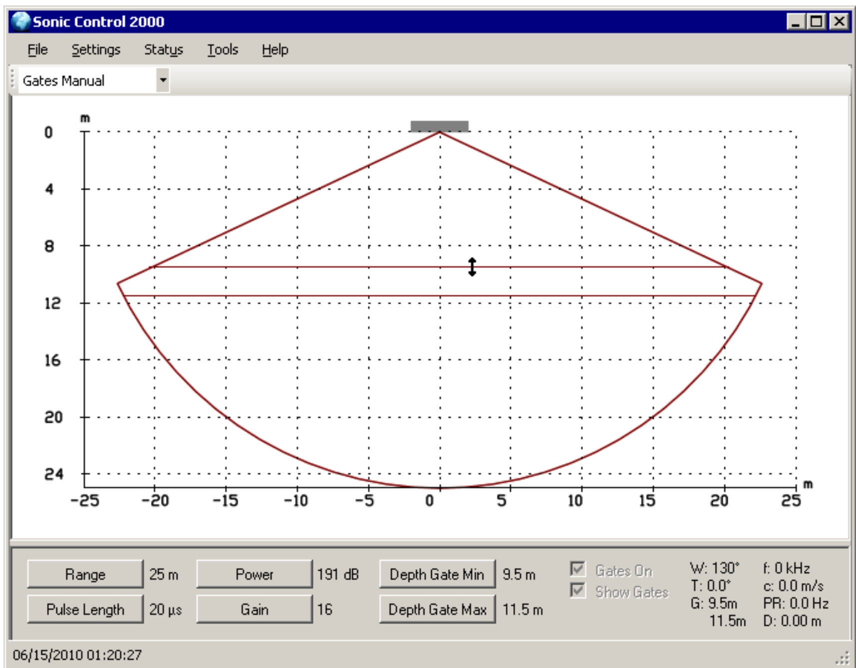

Figure 63: Dragging depth gates to new location

If the minimum or maximum depth gate eliminates good data, the data are lost as it will not be included in the Sonic 2024/2022 output. In the data collection software there will also be a form of depth gates. If the data are eliminated there, it is more than likely that the data is flagged and not really deleted, so it can be recovered.

The main reason to use the Sonic 2024/2022 depth gates is to eliminate interference of the bottom detection process. Depending on bottom composition, multiple returns can occur. There will be a secondary and possibly a tertiary return that arises from the initial bottom returns being reflected by the water surface and then back up again to the receiver. These second and third returns can be strong enough to influence the bottom detection process. Using the Sonic 2024/2022 depth gate will enable the Sonic 2024/2022 to search only a small area of the entire beam for a bottom detection, therefore, only the area around where the energy from the actual bottom returns are will be searched to derive a bottom detection. Although the user enters a depth for the gate setting, to the Sonic 2024/2022 this is a time to start searching and a time to stop searching.

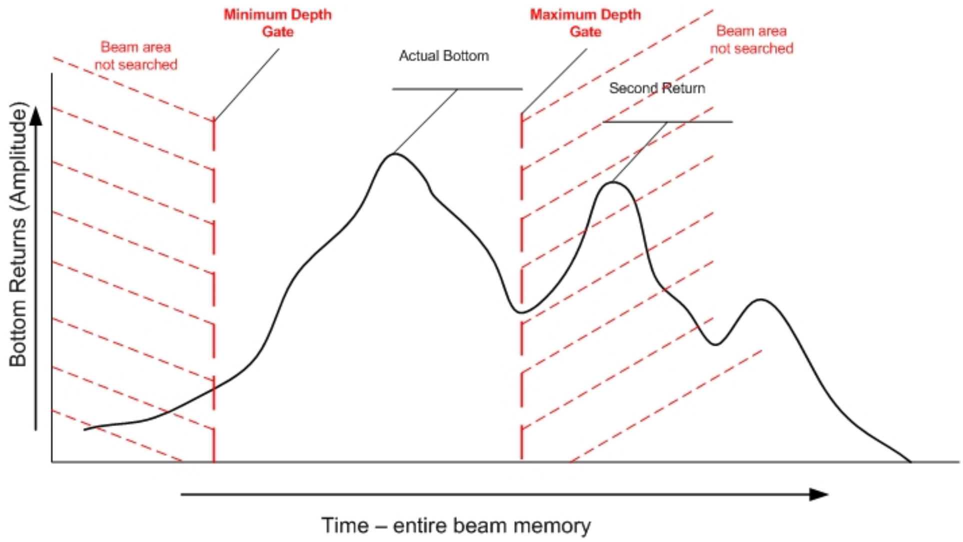

Figure 64: Graphical representation of depth gate

The above representation illustrates how the depth gate narrows down the bottom detection search area (in time) to only the area where the true bottom is expected. If the Maximum Depth gate was not in this location, the second return could be strong enough so as to influence the bottom detection process.

Again, it must be borne in mind that if the depth gate is set such that true bottom detections are 'gated out'; those data are lost entirely and cannot be recovered.

6.9 Save Settings

When Sonic Control is launched, it will always load the default settings configuration file located in the Sonic Control installation directory (CurrentSettings.ini). The default configuration file will save any local configuration changes during operation of the system.

When a user defined configuration is saved, like dualhead.ini, Sonic Control will still use the default configuration file to store local changes while operating the sonar. This is equivalent to copying the default configuration file to a configuration file with another name.

When a user defined configuration is loaded, Sonic Control will use the default configuration file to store local changes while operating the sonar. This is equivalent to copying the loaded configuration file to the default configuration file.

6.10 Operating Sonic Control on a second computer

There may be circumstances where it is preferred to run Sonic Control on a different computer than the computer where the data collection software is running. With the IP Discover firmware, the user can change IP addresses as well as UDP ports. By doing Discover (in Settings | Network Settings), the system looks for all attached R2Sonic equipment, which will be indentified by model and serial number. Once the serial number is discovered, it is used to assign an IP and UDP port to the sonar head and the SIM, after this is done, the IP and UDP ports can be changed.

6.10.1 Two computer setup

1) Set the data collection computer's networking to IP address 10.0.1.102 as usual
2) Setup Sonic Control, on the data collection computer, as normal: do Discover and apply the settings to establish communication with the system
3) Set the second computer's networking to IP address 10.0.1.105 (using this as an example)
4) Load Sonic Control on the second computer, but do not connect the second computer to the SIM until directed to below
5) Open Sonic Control on the second computer
6) Go to Settings | Network settings and change only the GUI IP address to 10.0.1.105 (see illustration below)
7) Connect a LAN cable from the second computer to one of the free RJ45 ports on the SIM (there will now be 2 Ethernet cables connected to the SIM)
8) On the data collection computer's Sonic Control, go to Settings | Network Settings and change only the GUI IP to the IP of the second computer: 10.0.1.105 (see illustration below)
9) Do not change any other IP or Port, only the IP for the GUI is to be changed
10) Select Apply: the GUI, on the data collection computer, will no longer update nor will it be able to control the multibeam
11) On the second computer, open Sonic Control
12) Under Network settings, use Discover to obtain the serial numbers of the SIM and sonar head and Apply; this computer now controls the Sonic system.
13) This example used IP address 10.0.1.105, but any IP can be entered as long as it adheres to the restrictions set by the subnet mask

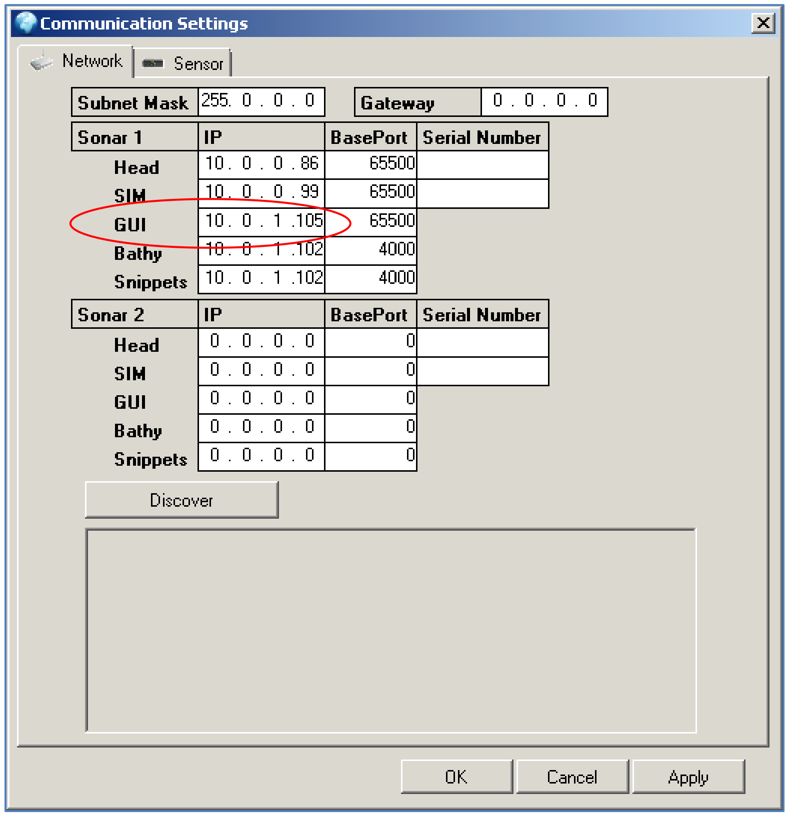

Figure 65: Change in GUI IP

6.10.2 Changing back to one computer

1) Open Sonic Control on the data collection computer.
2) Change the GUI address to 10.0.1.102
3) On the second computer, change the GUI IP address back to 10.0.1.102 and Apply.
4) Sonic Control, on the data collection computer now controls the system.

Disconnect the second computer's Ethernet cable from the SIM.

7 SONIC 2024/2022 THEORY OF OPERATION

The Sonic 2024/2022 transmits a shaped continuous wave pulse at the user- selected frequency. The transmit pulse is narrow in the along-track direction, but very wide in the across-track direction. The reflected acoustic energy is received via the Sonic 2024/2022 receivers; within the Receive Module the beams are formed and the bottom detection process takes place. The resultant bottom detections (range and bearing) are then sent via Ethernet, through the deck lead, to the SIM. The SIM then sends the data out to the Sonic Control software and the data collection software.

7.1 Sonic 2024/2022 Sonar Head Block Diagram

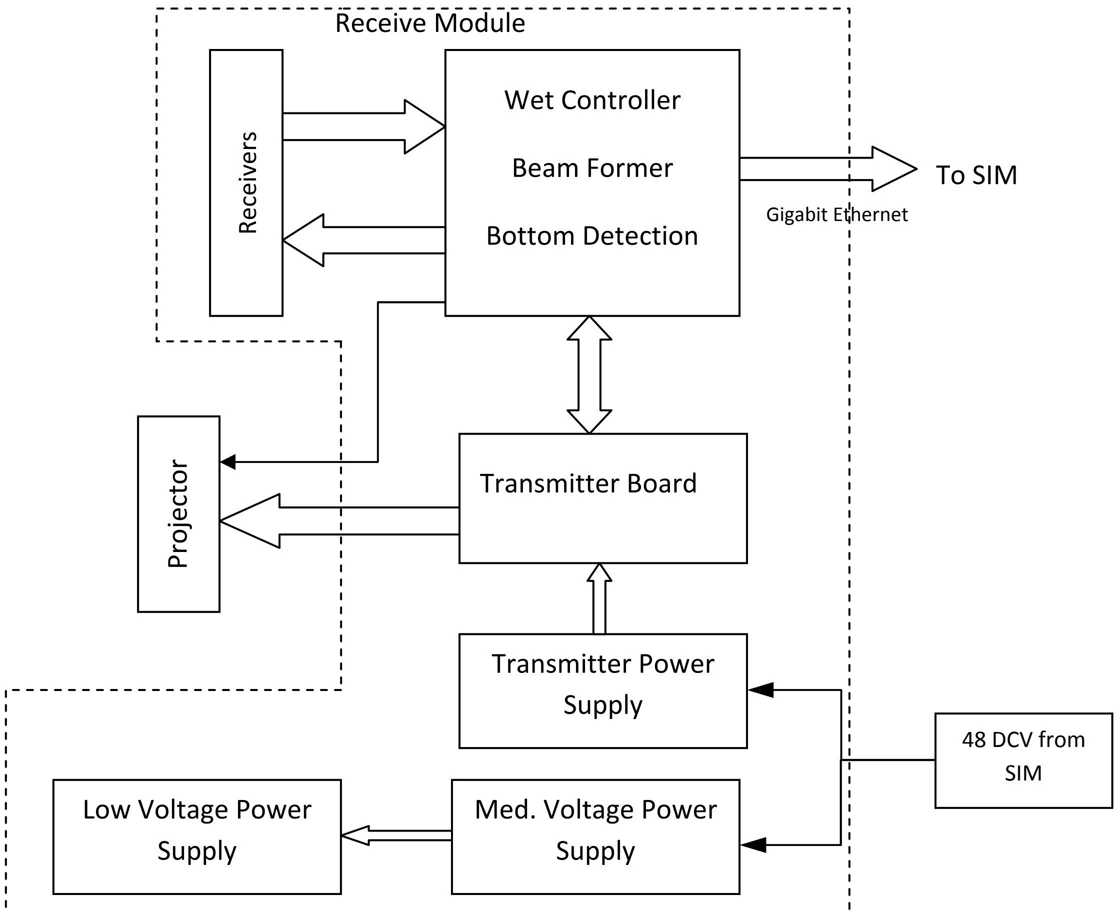

Figure 66: SONIC 2024 Sonar Head Block Diagram

7.2 Sonic 2024/2022 Transmit (Normal Operation Mode)

The projector is comprised of a precisely arranged set of composite ceramics. The projector, itself, can transmit over a wide frequency range, which makes it unique amongst multibeam echosounders. A pulse, at the chosen operating frequency, excites the ceramics which converts the electrical energy to acoustic energy. The pulse originates from the Wet Controller board in the Receive Module, which is then passed onto the Transmitters and out to the Projector. The amplitude of the pulse is set by the transmit Power setting in Sonic Control 2000; the Pulse Length setting in Sonic Control 2000 determines how long the pulse excites the ceramics.

The projector's transmit pattern ensonifies the seafloor in a very wide across-track, but narrow along-track pattern as the vessel moves along the survey line. The across-track angle is 160°; the along-track angle depends on frequency. The 400 kHz along-track pattern is 1°. The along-track lengthens out to 2° at 200 kHz. This is the Normal Operating Mode and not extended Vertical Mapping Mode.

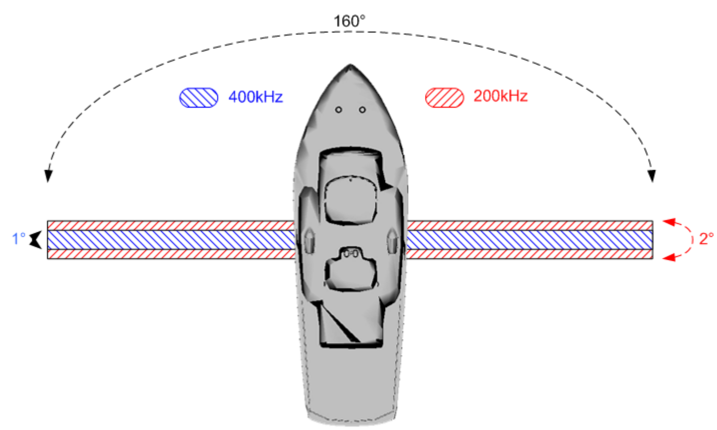

Figure 67: Transmit pattern

Depending on the water conditions, sea floor composition and other factors, a portion of the acoustic energy that strikes the seafloor will be reflected back towards the surface. The return acoustic energy will strike the Sonic 2024/2022 receiver's ceramics.

7.3 Sonic 2024/2022 Receive (Normal Operation Mode)

The Projector is comprised of composite ceramics that convert electrical energy to acoustic energy. The composite ceramics, in the Receive Module, convert the reflected acoustic energy back to electrical energy. The small electrical voltage, generated by the ceramics, is amplified and then passed onto the receivers. The output of the receivers goes directly to the Wet Controller board in the Receive Module.

In general, the receive pattern is 130° (normal bathymetry survey) in the across-track. The along-track pattern depends on the frequency; from 23° at 400 kHz to 40° at 200 kHz.

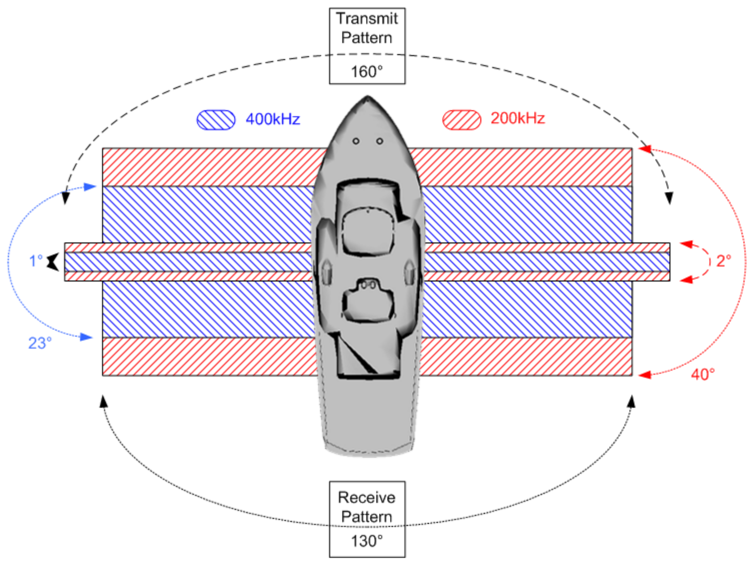

Figure 68: Receive pattern with Transmit pattern

The Wet Controller board contains the FPGA that performs the beam forming and bottom detection operation; time tags the data; and formats the sonar data for output back up to the SIM. The bathymetry data is output as a Range and Bearing (from the sonar head's acoustic centre) for each beam. Other outputs include: side scan, beamformed imagery, and snippets.

The output of the Wet Controller board is sent through the deck lead, to the SIM's Gigabit switch and onto the data collection computer though one of the SIM's external RJ45 connections.

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7.4 Sonic 2024/2022 Sonar Interface Module (SIM) Block Diagram

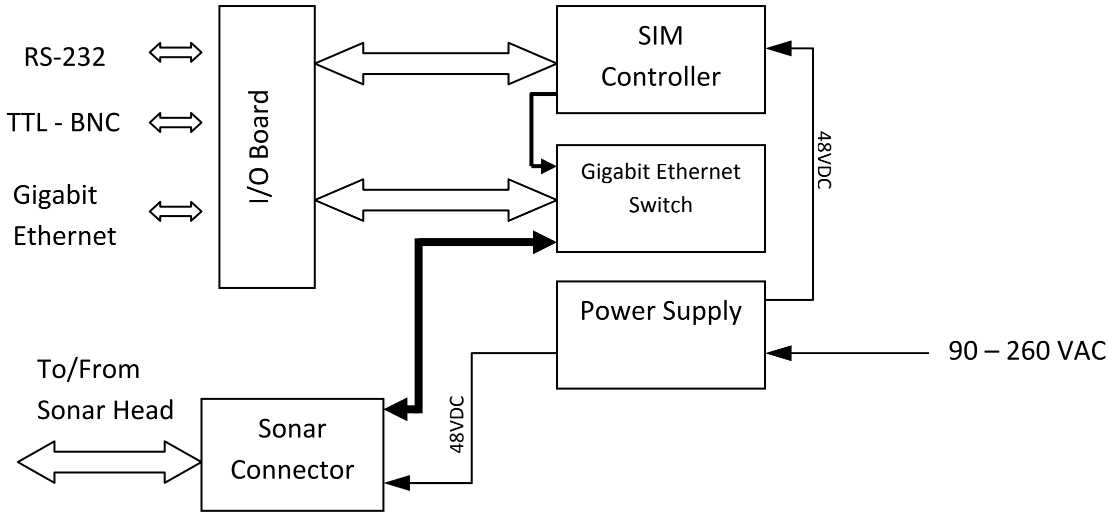

Figure 69: Sonar Interface Module Block Diagram

7.4.1 Sonar Interface Module (SIM) Block Diagram

7.4.1.1 SIM Power Requirement

The SIM operates within a voltage range of 90 to 260 VAC. The mains voltage is converted in the various DC voltages required for the operation of the Sonic 2024/2022. Primarily, 48 VDC is sent to the Receive Module to power the sonar head.

7.4.1.2 SIM Controller

The SIM Controller card primarily does time stamping of sensor data and deals with RS-23 and BNC data.

7.4.1.3 SIM – Sonic Control 2000 interfacing

Sonic Control 2000 communicates with the SIM over the Gigabit Ethernet DATA RJ-45. Commands, from Sonic Control 2000 are transmitted to the SIM and then to the Sonic 2024/2022. The Sonic 2024/2022 data passes through SIM to the data collection software.

7.4.1.4 SIM – RS-232 Interfacing

The SIM receives the GPS PPS and time message (NMEA ZDA), the sound velocity from the probe near the sonar head and the motion sensor data (for the depth gates). These data are routed through the SIM Controller to the Ethernet switch for transmission to the sonar head.

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APPENDIX I: Multibeam Survey Suite Components

8 Auxiliary Sensors and Components

A multibeam survey system is comprised of more components than just the Sonic 2024/2022 Multibeam Echosounder. These components are the auxiliary sensors, which are required to provide the necessary information for a multibeam survey. This does not mean that these sensors are a minor part of the survey system; each auxiliary sensor is required for any multibeam survey operation. The required sensor data:

- Position: Differential Global Positioning System Receiver
- Heading: Gyrocompass
- Attitude: Motion Sensor
- Refraction correction: Sound Velocity Probe

Each of the individual sensors requires their own setup and operation procedures. The details, discussed here, concerning the installation and calibration of the auxiliary sensors, is supplemental to any and all manufacturer's documentation.

8.1 Differential Global Positioning System

The Global Positioning System (GPS) is well known to all surveyors. There was a period of time when the GPS position was intentionally made less accurate; this was Selective Availability (SA). When SA was enacted, the GPS position became too inaccurate for survey use. It was during this period that the concept of differential corrections was established. Differential corrections were derived from users monitoring the GPS position at a known survey point and computing the corrections required to adjust the various pseudo ranges to make the GPS position agree with the known survey position. If a vessel was operating within the local area and observing the same satellite constellation, the derived pseudo range corrections could be applied on board to make for a more accurate and consistent position. The corrections are normally transmitted over a radio link and applied within the GPS receiver.

8.1.1 Installation

The first and foremost consideration when installing the DGPS system is the location of the respective antennae. Both the GPS antenna and the differential antenna (if they are two separate antennae) need to be mounted on the vessel in such a way so as to have a totally unobstructed view of the sky.

When installing the GPS antenna, the surveyor should be aware of the position of the stacks and masts; in particular are davits or cranes that may be currently in a stored position, but will be in use during survey operations. If mounting the antenna on a vessel that has helicopter landing facilities, coordinate the placement of the antenna with the personnel in charge of helicopter operations.

When the location for the antennae has been determined the next step is determining how the coaxial cable, connecting the antenna and the receiver, is to be run. The cables should be run in such a manner so as to be protected from possible damage. Cables should not be run through hatches or windows, if it can be avoided; if such runs are necessary, then a block or other such obstruction should be placed so that the hatch or window will not close on the cable. If the cables are to be suspended between two points, a rope or other line should be strung to carry the weight of the cables. Cables should never be kinked; all cables have a minimum bending radius, if it is known adhere to it, if it is not known, use common sense. Do not run cables in a manner that they will become safety hazards on the vessel, causing personnel to trip or be caught on them. Avoid running cables along voltage carrying lines.

It is important to mark the cables at both ends to denote what they are and to where they go.

The connection to the antenna may be required to be completely water proofed (depending on the manufacturer's recommendations) using electrical tape, with a secondary covering of self-amalgamated tape. Ensure that there are no air gaps in the tape; they will become a channel for water. If a cable is to be run upwards from the antenna, form a drip loop by leaving slack in the cable that will hang below the antenna connector. This will allow any water that flows down the cable to collect and drip from the slack loop instead of running into the connector.

The cables, connectors and antennae should be inspected regularly for signs of damage, corrosion or abuse. Any abrasions on the cable should be securely taped; if possible, a waterproof coating should also be applied.

8.1.2 GPS Calibration

Prior to commencing survey operations, the accuracy of the Differential GPS position and transformation to local datum should be determined. There are two main methods to determine the accuracy of the DGPS position and data transformation. For both methods, a local land survey benchmark is required.

8.1.2.1 Position Accuracy Determination Method 1

The GPS antenna is physically placed over the survey benchmark. The surveyor will ensure that the antenna has a clear view. This is particularly important if the benchmark being used is in a dock area. The surveyor will also ensure that, if a separate antenna is used to receive differential corrections, that it is not blocked.

The GPS position data should be logged, in the data collection software, for not less than 15 minutes. The collected data can then be averaged, standard deviations determined, and compared to the published position of the survey benchmark.

The two main causes of error, in this area, are:

- Wrong geodetic transformations being applied to the WGS-84 position derived from GPS.
- Erroneous coordinates for the Differential reference station.

8.1.2.2 Position Accuracy Determination Method 2

This method is most easily accomplished during the gyrocompass calibration. The antenna remains mounted on the vessel. The surveyor will set up on the known survey benchmarks; using standard land survey techniques, the exact absolute position of the antenna can be determined. During the period that the surveyor is 'shooting in' the GPS antenna, the GPS position will be logged on board, the averaging and statistical analysis will be as above.

The surveyor will need to take numerous shots to also obtain an average, due to the possible movement of the vessel while alongside.

8.2 Gyrocompass

Utmost care is required for the installation of the gyrocompass. The gyrocompass is a sensor that cannot be situated randomly. The purpose of the gyrocompass is to measure the vessel's heading. In order to do this, the gyrocompass should be placed on the centre line running from the bow stem to the midpoint of the stern. If it is not possible to place the gyrocompass on the centreline of the vessel, it can be mounted on a parallel to the centre line.

All survey grade gyrocompasses will be plainly marked for alignment on the centre line. This marking may be an etched line fore and aft on the mounting plate, or possibly metal pins on the front and the back of the housing that point down. If no marking exists, then measuring the fore and aft faces and finding the centre may be sufficient.

No matter how well the gyrocompass is placed, there exists a possible error between the true vessel's heading and the gyrocompass derived heading. Any new installation of a gyrocompass should include a gyrocompass calibration. There are various methods to perform a gyrocompass calibration; the best method employed will be determined by the location of the vessel, the time allotted for the calibration and the resources at hand.

8.2.1 Gyrocompass Calibration Methods

After the installation of gyrocompass (henceforth termed gyro) on a vessel, that gyro should be calibrated to ensure that the heading it determines is the true heading of the vessel.

If the error is large, the gyro can be physically rotated to align itself with the true vessel heading. Small errors can be corrected, either by internal adjustment to the gyro, or in the software that receives the gyro reading.

8.2.1.1 Standard Land Survey Technique

One of the most accurate methods to determine the gyro error involves the use of standard recognised land survey techniques. The time and equipment involved requires that a substantial period be allotted for such a calibration.

- If possible, the vessel will be berthed alongside a quay or dock that has a survey benchmark located in close proximity.
- If a survey benchmark is not located close to the berth, then the surveyor will have to run a transit from the nearest, suitable, local survey bench mark to establish a point on the quay that has a well defined position. From this point another point should be established along the quay to form a baseline.
- When the vessel comes alongside, all lines should be made as taut as possible. The gyro should be allowed 2 hours to settle down after the vessel has come alongside.
- The stern of the vessel should be measured, with a metal tape, to determine the centre point of the stern. A survey reflector will be placed at this position. Another survey reflector will be placed exactly at the bow. It will be verified that the reflectors are accurately placed on the centre line of the vessel by either measurements or survey techniques.
- The surveyor will set up on one benchmark; a round of readings will be taken from the benchmark to the fore and aft reflectors. Simultaneous to this, the survey personnel will record the gyro heading as it is read by the survey computer. Any variation between the digital output and the physical gyro reading should be remedied prior to the commencement of readings. It is recommended that the personnel on the vessel and the surveyors on the quay be in constant communication to assist in coordinating the measurements.
- One round of readings will be considered to be not less than 30 sets, a set being one reading each from the bow and stern reflectors.
- Upon completion of the round from benchmark one, the surveyor will move to benchmark two and repeat the process.
- Upon the completion of all rounds, from the two benchmarks, the vessel will turn about. With the vessel, now heading on the reciprocal heading, the gyro will be allowed at least 1 hour to settle down.
- When the gyro has been given sufficient time to settle down, a further series of range and bearing measurements will be made in exactly the same manner as before.

When all readings are completed, the surveyor will calculate the azimuth between the two survey reflectors for each set of readings. The azimuth readings will be compared with the headings taken on board the vessel from the gyro itself. If there has been little or no movement of the vessel, an average can be taken of the azimuths and for the gyro readings and compared. By calculating the standard deviation of the readings, the surveyor can determine the degree of movement during the recording process. If the deviation is greater than the stated accuracy of the gyro, the comparison readings should be based on simultaneous time.

If physical adjustments are required, they should be made and the calibration process repeated. If the adjustment is determined to be minor and can be accounted for in the survey software, the correction value should be entered and then verified using the calibration process. This check of the calibration value can be an abbreviated version of the calibration process detailed above.

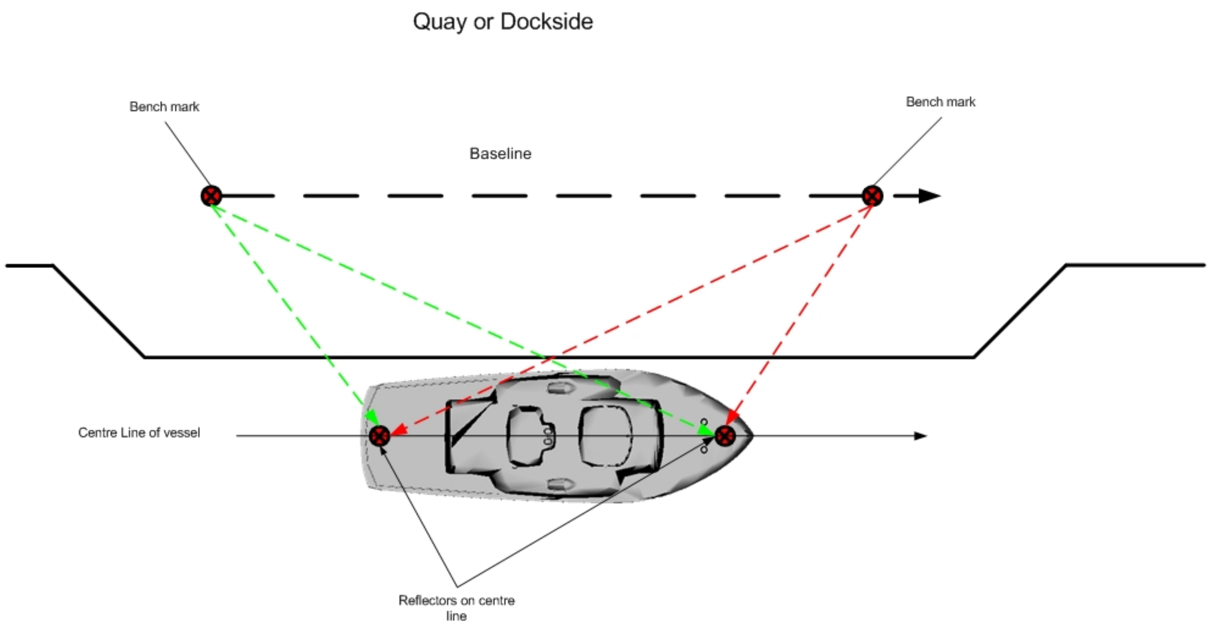

Figure 70: Gyrocompass Calibration method 1

- Quayside Benchmarks have known geodetic positions.
- Measure Range and Bearing to reflectors on vessel centre line.
- Using Range and Bearing to reflectors, determine geodetic position for reflectors.
- Calculate bearing from stern reflector to bow reflector will give the true heading of the vessel.
- True heading of vessel is then compared to gyrocompass reading taken at the same time as the Range and Bearing measurements.
- Benchmarks do not have to be on the quay, but should be in a position to give accurate Range and Bearing to the reflectors.

8.2.1.2 Tape and Offset Method of Gyro Calibration

This method relies on measuring the offset distance from a baseline on the quay, with a known azimuth, to a baseline that is established on the vessel. There are greater areas for error when using this method, particularly in establishing a baseline with known azimuth.

A baseline is established on the quay as close as possible to the vessel's side. It is very important that the azimuth of this baseline be as accurately determined as possible. The baseline should be of a length that will exceed the baseline that is established on the vessel.

A baseline is established on the vessel that is parallel to the centre line of the vessel. It should not be assumed that the side of the vessel is parallel to the centre line. This baseline should be on the deck that faces the dock. The baseline on the vessel should be as long as possible, the longer the better.

With the vessel secured alongside the quay, the vessel baseline will be compared to the quayside baseline. Two points will be established on the quayside baseline that corresponds exactly to the fore and aft positions on the vessel baseline. That is: the points that are established on the quayside baseline should be normal to the points on the vessel baseline.

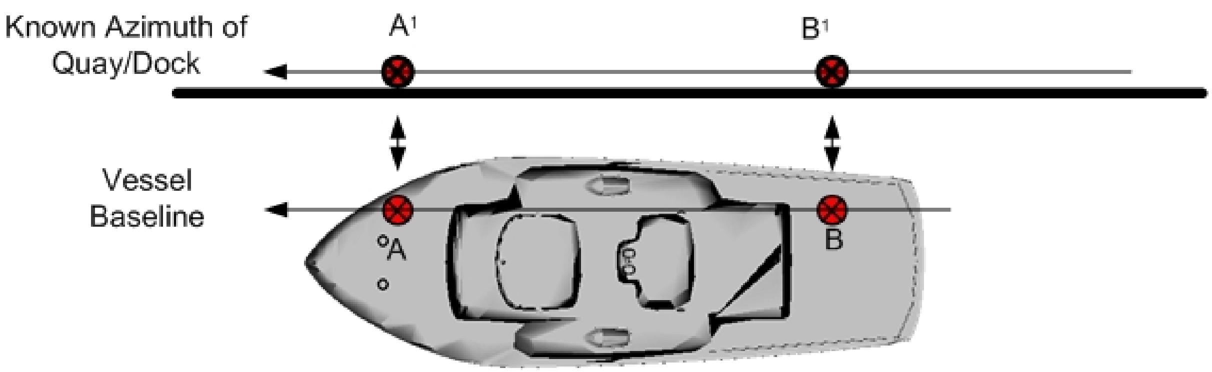

Figure 71: Gyro Calibration Method 2

The example, below, will illustrate the math involved.

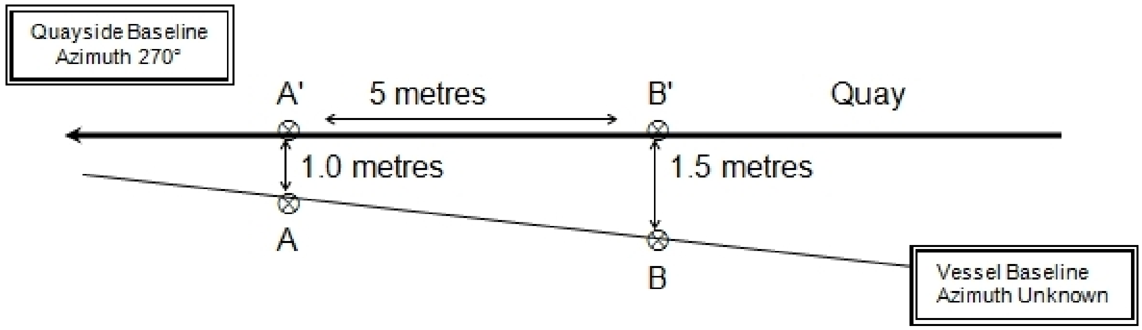

Figure 72: Gyro Calibration Method 2 example

A to A'	1.0 metres	**B to B'**	1.5 metres
Side a	5.0 metres	**Side b**	1.5 – 1.0 = **0.5 metres**
Angle b'	Arctan 0.5/5.0 = 5.7°		
Ship Azimuth = 270° + 5.7° = **275.7°**			

Table 9: Gyro Calibration Method 2 computation

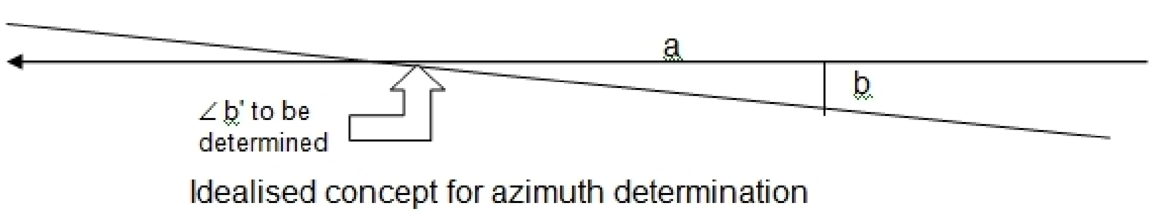

Figure 73: Idealised concept of Gyro Calibration Method 2

In this example, the vessel heading for this set of readings is 275.7°; this would be compared to the gyro reading recorded at the same time the offsets were measured.

In the above example, if the bow was further out from the quay than the stern, the angle b' would be subtracted from the azimuth of the quay, i.e. 270° - 5.7° = 264.3°.

8.3 The Motion Sensor

The motion sensor is used to determine the attitude of the vessel in terms of pitch, roll and heave. Pitch is the movement of the bow going up and down. Roll is the movement of the port and starboard side going up and down. Heave is the vessel going up and down.

The sonar head is physically attached to the vessel; as the vessel moves, so does the sonar head. The motion sensor reports the movements of the vessel to the data collection software; the data collection software, using the offsets to the motion sensor and to the sonar head, computes the movement at the sonar head to correct the multibeam data for pitch, roll and heave.

One important aspect of the motion sensor is the sign convention used by the motion sensor as compared to the sign convention used in the collecting software. The surveyor must be aware of the convention that is used and what adjustments are necessary, if any, to ensure that the convention is consistent with the data collection computer.

There exist two major areas of thought as to where the motion sensor should be situated. One group believes that the motion sensor should go as close to the multibeam as possible, even if the multibeam is mounted on an over-the-side pole. The second group believes the motion sensor should be placed as close to the centre of rotation for the vessel as possible.

Placing the motion sensor on the hydrophone pole would seem to solve for all movement of the pole itself, but in fact the motion sensor, mounted in this fashion, can provide false attitude measurements. This is particularly true when there is significant roll; the motion sensor on the pole can interpret a portion of this roll as heave, which is not true. By placing the motion sensor as close to the centre of rotation (also called the centre of gravity) as possible, only the real heave of the vessel will be measured. All software will solve for the motion of the sonar head, based on the offsets that have been entered into the setup files for the vessel configuration; this is called a lever arm adjustment. The other consideration is that the motion data is usually applied to the GPS antenna. The GPS antenna is usually mounted high on the vessel, so any pitch or roll will induce a large amount of movement in the GPS antenna thus providing a false position due to the antenna movement. If the motion sensor is mounted on the hydrophone pole, it is reporting an exaggerated motion because it is far from the centre of motion of the vessel; this exaggerated motion then would be applied to the GPS antenna position and the vessel position computation would be in error.

The other consideration is that the alignment of the motion sensor must be on or parallel to the centre line of the vessel; it is essential to prevent 'bleed-over' of pitch and roll. If the motion sensor is not aligned with the centre line, when the vessel rolls some of the roll will be seen as pitch as the motion sensor's accelerometers and gyros are not aligned with the axes of the vessel it is mounted on. It is more difficult to obtain this precise alignment if the motion sensor is placed on the pole.

Mount the motion sensor as close to the centre of rotation (or centre of gravity as possible) and perfectly aligned to the centre line of the vessel.

The motion sensor should be mounted on as level a platform as possible. After mounting the motion sensor, the actual 'mounting angles' should be measured. Some motion sensors contain internal programs that can measure the mounting angles. Some data collection software packages also include the capability to measure mounting angles. The mounting angles are the measured degrees of the actual physical mounting of the motion sensor. This is to compensate for sloping or warped decks. Many decks have some slope to them and this should be accounted for to ensure that the pitch and roll values that the motion sensor derives is for vessel movement and not for its physical mounting on the deck. The mounting angles should be measured prior to any multibeam calibration and not changed after the calibration.

Prior to measuring the mounting angles, the vessel should be put in good trim by the engineer. On a small vessel it is important that the angles be measured without undue influence from people standing around. A false measurement can be induced by two people sitting on the gunwale having a conversation while the measuring process is being completed. It is usually a good idea to have all personnel leave a small vessel during the measuring process.

If the motion sensor mounting angles have been entered in the motion sensor or the data collection software, they can only be changed prior to the multibeam calibration (patch test); they are not to be changed after the patch test.

It is important to keep the motion sensor in mind when surveying. A motion sensor takes time to 'settle down' after a turn or a speed change and most of the settling down will depend on the heave bandwidth that is entered into the motion sensor. Some motion sensors can take in position, speed and heading data to assist them in the settling process. Depending on the degree of the turn or the amount of the speed change a practical period of 2 minutes should be allowed for the motion sensor to settle. It is prudent to plan the survey to allow for a long enough 'run in' to the start of data collection to allow the motion sensor time to settle and the heave normalise. If this is not done, many times motion artefacts or erroneous depths will be seen at the beginning of line and the processed data will not be correct.

Monitor the motion sensor (all data collection software provides a time series window to monitor individual data) to ensure that it is operating properly.

8.4 Sound Velocity Probes

There are two basic types of sound velocity probes. One type measures the parameters of sound velocity in water; those being **C**onductivity (Salinity), **T**emperature, and **D**epth (Pressure), these are normally referred to as CTD probes. The other type of probe contains a small transducer and has a reflecting plate, at a known distance from the transducer that reflects the sound, the time is measured for this transmission and the sound velocity determined by that measurement; these are called Time of Flight probes. There is third type, known as the Expendable Bathythermograph (**XBT**) which is launched and as it passes through the water column sends back temperature readings (through two very thin wires); it is not recovered, it is expendable.

The CTD and Time of Flight probes store the data internally. The data is downloaded to a computer after the probe is recovered.

8.4.1 CTD Probes

The CTD probe type of sound velocity probe has instruments to measure the conductivity of the water, water temperature, and a pressure sensor to measure depth. The CTD probe is a good choice if any of this information is also required; to obtain a velocity a formula must be used.

There are various formulae available that are based on the parameters that are recorded by the CTD. The UNESCO algorithm is considered a universal standard and was put forth by C-T. Chen and F.J. Millero in 1977. The Chen-Millero (and Li) equation is complex as is Del Grosso’s (1974) and have been termed Refined. Simple formula, such as Mackenzie’s (1981), also yields good results.

When using a CTD, it is very important that the probe be allowed to sit, fully submerged, in the water for a few minutes prior to deploying it; this is to allow the probe to reach equilibrium with the water temperature It is also important that the tube, through which the water flows pass the sensors, is checked for obstructions or marine growth.

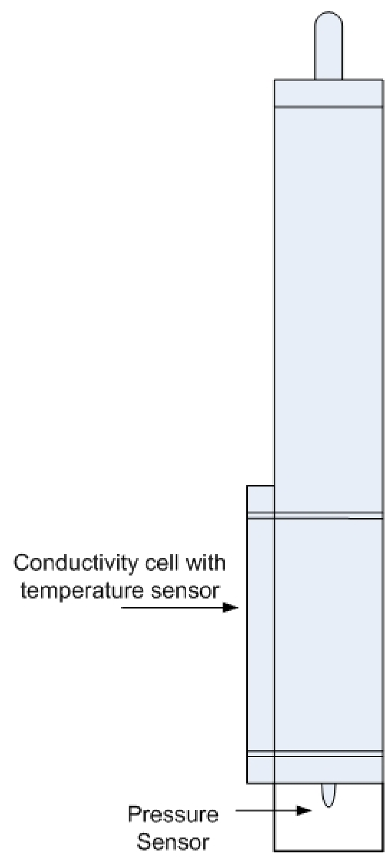

Figure 74: CTD Probe

8.4.2 Time of Flight Probe

The Time of Flight probe incorporates a transducer that transmits an acoustic pulse that reflects back from a plate that it is at a very precise distance from the transducer. The two-way travel time is measured, divided by 2, and the sound velocity determined. The Time of Flight probe is usually considered more accurate for multibeam survey work.

The sound velocity probe that is mounted close to the Sonic 2024/2022 sonar head is a time of flight probe.

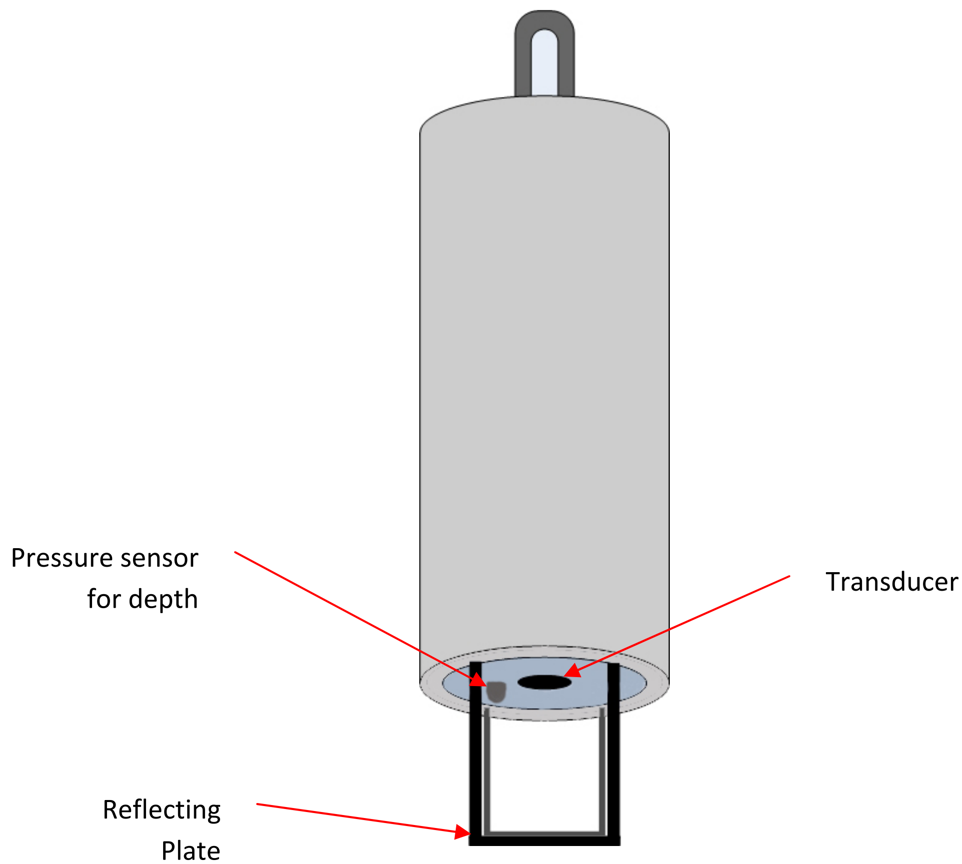

Figure 75: Time of Flight SV probe

8.4.3 XBT Probes

The XBT is a probe which free falls through the water column at a more or less constant speed (the probe is designed to fall at a known rate so that the depth can be inferred) and measures the temperature as it passes through the water column. Inside the probe is the thermograph, which is attached to a spool of very fine wire. Two very small wires transmit the temperature data from the probe back to a computer. The XBT is not recovered. XBT probes can be launched whilst underway and are used extensively by Navy and Defence forces for rapid determination of the sound velocity without stopping the vessel.

8.5 The sound velocity cast

There are no set rules for when to take a measurement of the water column sound velocity. Common sense is a good guideline. The conditions, detailed below, have a major influence as to when to take a sound velocity cast.

8.5.1 Time of Day

Throughout the day the upper level sound velocity characteristic will change mainly due to solar heating or cooling due to cloud cover or precipitation. Another main element of the time of day changes is tides.

When working in tidally influenced areas, the sound velocity can change drastically due to a salt wedge that moves in and out with the tide. The surveyor must be aware of the relationship of the time of the tide to the salt wedge.

8.5.2 Fresh water influx

Any river, stream or runoff will drastically change the sound velocity through the introduction of freshwater and also through a temperature difference.

8.5.3 Water Depth

The sound velocity cast should always be made in the deepest part of the survey area. The sound velocity profile cannot be extrapolated to deeper depths as there are too many possible variables.

8.5.4 Distance

If the survey area is large, then it is quite possible that there will be differences across the range of the survey area even in open water.

8.5.5 Deploying and recovering the Sound Velocity Probe

The guide lines for deploying and recovering the sound velocity probe are based on common sense, but are sometimes ignored during the actual operation. The guidelines, below, are for a hand cast in shallow water. The softline, used for the cast, should be marked to provide an indication of the amount of line out.

8.5.5.1 Shallow water sound velocity cast / deployment by hand

1. Plan where the cast is to be made.
    a. In a small area, deploy in the deepest part of the survey area.
    b. Always do a cast prior to starting the survey.
2. Liaise with the captain or office of the watch with the plan position and time of deployment and time required for the cast.
3. Prepare the probe for casting (some probes may need to be programmed prior to each launch).
4. Secure the probe to the downline with a bowline knot or shackle.

5. **Secure the bitter end of the downline to the vessel.**
6. Request permission, from the bridge or helm, to deploy and await their OK to launch.
    a. Bridge or helm to ensure that the vessel is out of traffic.
    b. Bridge or helm to assess wind and sea conditions and advise as to which side of vessel the deployment should be made.
7. Put the probe in the water until it is totally covered and let it remain there for a period of time to acclimate to the sea temperature. This is very important with a CTD type of probe, but of less concern for a time-of-flight probe.
8. Verify the water depth.
9. Lower the probe at a constant rate; only the downcast should be used.
10. Try not to allow the probe to touch the bottom.
11. Recover the probe rapidly.
12. As soon as the probe is on deck, notify the bridge or helm that they are free to manoeuvre, but remain in the area.
13. Rinse the probe with fresh water and dry thoroughly.
14. Download the cast and verify that it looks good.
15. Load the cast into the data collection software.

8.5.5.2 Deep Water Cast / Deployment by mechanical means

A cast in deeper water requires more preparation and planning. A deep water cast can be considered to be any cast that is deployed via an ‘A’ Frame, winch, or other mechanical means. Even a shallow water cast can fall under this definition when mechanical means are used.

One of the main concerns, in a deep water cast, is that the probe will not go straight down due to the current flow or vessel drift due to wind and/or currents. This being the case, weights must be used to ensure the cable (and probe) go as straight down as possible.

Unless the sound velocity probe is designed to have additional weight attached to it, no weights should be attached to the sound velocity probe. The weights, which enable deployment as straight as possible, are attached to the end of the cable. The probe should be attached to the cable approximately 3 – 5 metres above the weights; if the weights hit the bottom this should provide enough scope for the probe to land clear of the weights.

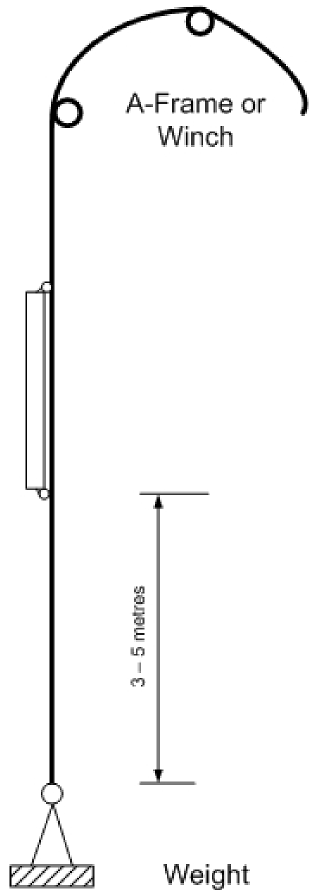

Figure 76: Deploying a sound velocity probe via a winch or A - Frame

The other major consideration when deploying a probe in deeper water, is that the vessel must be stationary longer and will drift. If there is a large variation in depths, the depth when the probe went in, may not be the same depth when the probe reaches the bottom. It is essential that enough cable be deployed to ensure a full profile to the sea floor.

APPENDIX II: Multibeam Surveying

9 Introduction

Multibeam surveying affords the surveyor with many advantages, but it also requires more thought behind the survey itself.

9.1 Survey Design

Multibeam surveying survey planning is very different than single beam survey planning. The main considerations are line spacing and line direction. In single beam surveying, lines are normally spaced based on the scale of the desired chart. The line direction is normally at the discretion of the surveyor. In multibeam surveying, the surveyor has to plan the survey carefully, with thought to overlap between adjacent lines and the direction that those lines are run.

9.1.1 Line Spacing

The entire concept of multibeam surveying is based on the swath coverage that defines the multibeam system. The survey lines should be designed so that there is 100% overlap in coverage between adjacent lines. As swath width is a function of water depth, it follows that the spacing between lines may not be constant. Looking at a chart of the survey area, the surveyor should be able to determine the swath width that will be obtained and can design the line spacing accordingly.

A large overlap in swath coverage is required due to various factors. One prime factor is roll. As the vessel rolls the swath coverage will vary in relation to this roll. If the vessel rolls to port (port-side down), the swath coverage on the port side will be lessened, whereas the swath coverage on the starboard side will increase. If there is not sufficient overlap in swath coverage there could be gaps in coverage, between adjacent lines, due to the roll.

If the helmsman has problems keeping the vessel on the designated line, this could case gaps if the vessel goes off line to opposite directions on adjacent lines.

Unexpected shallows will reduce the swath coverage. If the lines are designed with very little overlap, a shallow area on the lines will see reduced swath coverage and the possibility of gaps between the lines.

9.1.2 Line Direction

In single beam surveying, the usual practice is to survey normal to the contours. The concept is to cut the contours at 90° to obtain the best definition of the slope. Multibeam survey is exactly opposite of this; in multibeam survey the lines are planned to survey parallel to the contours. Multibeam surveying can be likened to side scan surveying; the best definition is obtained when the slope is within the port or starboard swath coverage. There will be poor definition of the slope covered by the nadir beams, as they act similar to a single beam echosounder.

In setting up the survey lines, if the lines were to run up and down slope, the spacing would have to vary between the start and the end of the lines, as the swath coverage would vary due to the change in water depth. The lines would not be parallel. By surveying along the contours, the depths will remain more or less constant so that the spacing does not have to change from beginning to end. However, the spacing between adjoining lines may vary due to increased or decreased depth.

9.1.3 Line Run-in

As was previously noted, it is good survey practice to allow the motion sensor and gyro time to settle after making a turn. With this in mind, the surveyor should set up the survey lines so that an adequate lead in, before the start of data recording, is allowed.

Extra lead in time allows the helmsman the opportunity to get on to the line and make any adjustments that are necessary to counteract wind or current conditions. It is much better for the vessel to be a little off of the planned survey line, but heading in a straight direction, rather than 'fish-tailing' back on forth across the line, trying to maintain zero offline.

Surveying into a beach may only allow very limited run-in, if the lines are also to be surveyed out from the beach. In this case it may be better to design the lines so that they run parallel to the beach. Of course, if it shallows greatly towards the beach, the lines should be run parallel to this slope anyway as detailed above.

9.2 Record Keeping

It is essential that detailed records be kept of all aspects of the multibeam survey. The logging of all details of the survey will greatly assist those in charge of processing the data. Maintaining a vessel log, that reflects offsets, draft measurements, sound velocity profiles and etc; will give the surveyor a reference that can be easily accessed. The more information that is logged, the easier it will be during processing and it will also provide the surveyor with a means to assess survey technique with a view to improving the efficiency of the survey.

9.2.1 Vessel Record

A hardbound ledger book should be kept for the vessel record. The vessel record should include, but is not limited to:

- Diagram of the vessel with measurements
- All offsets
- Daily draft measurements
- Diary of sound velocity profiles
- Surveyors / Operators
- Equipment list
- Equipment interface information
- Diary reflecting dates of individual surveys

The vessel record is meant to be a quick reference for general information that is required for multibeam surveying. Some of the information does not change from survey to survey and should go either in the front of the book or the back of the book. A section of pages can then be devoted to the information that does change from survey to survey or day to day.

As an example:

- Page 1 – Plan of the vessel with all vessel measurements
- Page 2/5 – Plan of the vessel with all offsets
- Page 6/9 – Equipment list and interfacing information
- Pages 10/20 – Dates of individual surveys with listing of surveyors responsible for those surveys
- Pages 21/40 – Diary of draft measurements
- Pages 41/60 –Diary of sound velocity measurements

As can be seen, this is a general reference which can provide dates and general details.

When naming surveys and sound velocities, a certain degree of logic in their naming will greatly assist deciphering an individual event out of many events. In the case of sound velocity profiles, it is common to name the profiles for the date that they were taken. A sound velocity profile taken on 04 July 2009 would be referred to as 20090704. If more than one profile is taken during the day, then a letter suffix can be added: 20090704a, to separate the profiles, or a time of cast can be added to the file name. Keep in mind that personnel, who were not on board during the data collection, may need to reference the information; keeping it logical and chronological will help.

Ensure that many blank pages are kept for the various categories. When a book is filled, plainly mark on the cover the inclusive dates that the vessel log covers. If possible, also mark this information along the spine of the vessel log. These logs should be kept in a safe and dry place on the vessel.

9.2.2 Daily Survey Log

The Daily Survey Log is where all the details of the survey are recorded: start/stop time of the lines, line names, and line direction, speed of survey, and comments pertaining to that survey line. A copy of the appropriate survey log should accompany all multibeam data along its path during processing.

Daily Survey Logs are of two types: rough and smooth. The smooth log is a sheet that is arranged in rows and columns, where the appropriate survey information is entered, much like a spread sheet. It can be a single sheet that is printed out on board, or it can be professionally produced pad of sheets. The rough log is similar to the vessel log; it is normally a ledger book; the start/stop times, line name, line direction and comments are entered line by line, usually on the right hand page as they occur. The left hand page then is left for details of draft, sound velocity profile data, tides or any other information that is pertinent to the lines that are detailed on the right hand page.

A copy of the survey log is sent along with the multibeam data to processing and a copy is kept on board the vessel.

An example of the information on a smooth log:

- Sensor offsets
- Calibration offsets
- Date
- Survey name, area and surveyors
- Name of sound velocity file
- Name of tide file
- Vessel name
- Start/Stop time of survey line
- Line name
- Direction
- Comments

Due to the nature of a single sheet type log, the information should be entered on each individual sheet, even though many items do not change from one day to the next.

With the log book style of daily log the items that do not change can be listed on one page, so that everything following that page will be under those parameters (offsets, vessel name etc.). The right hand page will include the start/stop times, line name, direction and comments. The left hand page, as noted above, is for additional information. A further advantage to using a log book is the space available to sketch diagrams of the survey or other visual aids that might make the survey easier to understand.

The surveyor uses a log book to record the data as it occurs. A daily survey log sheet can be created in any word processor or spreadsheet program. At a convenient time the surveyor can call a sheet up, within the appropriate program, enter the data and print it out. This has many advantages, the most obvious is that the daily log sheet is typed in and printed out making it very legible to read; it can be stored down to memory, making a permanent record.

Although maintaining a good detailed log of daily survey events may be difficult to get use to, after a short time the advantages will become obvious.

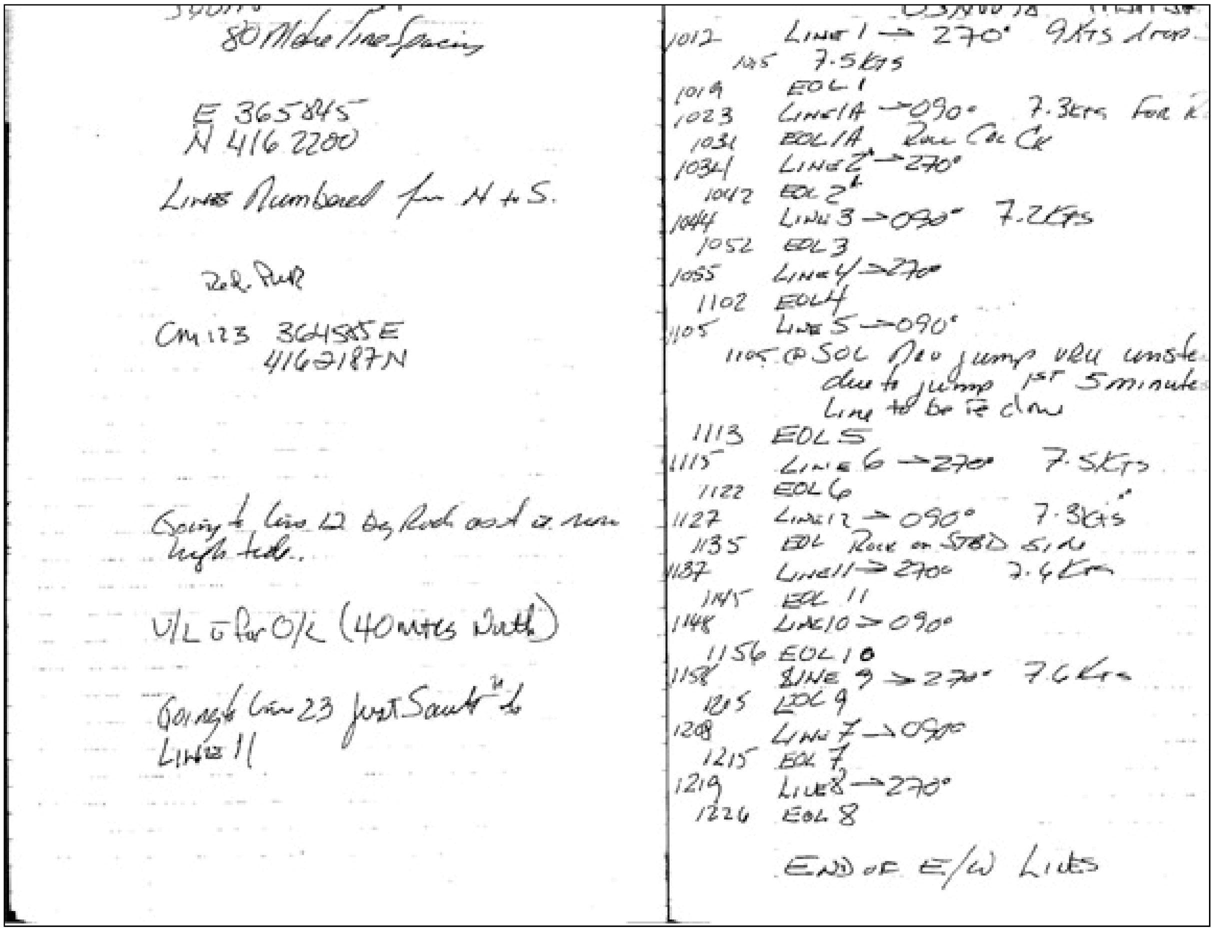

Figure 77: Rough log, kept during survey operations...does not need to be neat, but must contain all pertinent information

2002 Sydney Harbour Survey

DATE:	**13 May 2002 (UTC)**	**SURVEY NAME: Area B/ Area A**	**PAGE/PAGES**	**1/1**
Vessel:	**440**	**All Times in UTC (UTC = LOCAL - 10)**		

OFFSET INFORMATION (metres)

NB Draft change

	X	Y	Z	Pitch	Roll	Yaw	Latency
Multibeam	0.0	4.21	-1.00	0.673°	0.692°	3.43°	
Motion Sens	0.0	0.0	0.295				
DGPS	-1.40	-3.40	3.38				0 (Used PPS)

SV Profiles	20020512_2300UTC
	20020513_2240UTC
Tide File	200205_11-15UTC.tid.txt

GEODESY	**Datum:**	**WGS 84**	**Projection:**	**UTM Zone 56S (CM 153° E)**

Start	Stop	Line Name	Direction	Speed	Comments
0021	0033	0042 Area B (200)	038°	5.1 kts	
0038	0052	0043 Area B (190)	218°	4.4 kts	
0058	0107	0044 Area B (180)	038°	5.4 kts	
0111	0118	0045 Area B (170)	218°	4.2 kts	Stop line, computer not responding well.
0126	0137	0046 Area B (170)	218°	4.0 kts	Completion of above line after circle.
0140	0150	0047 Area B (160)	038°	5.2 kts	
0157	0211	0048 Area B (150)	218°	4.0 kts	
0225	0225	0049 Area B (Infill)			Infill Lines various headings and speeds
0228	0229	0050 Area B (Infill)			
0232	0232	0051 Area B (Infill)			
0234	0235	0052 Area B (Infill)			
0235	0237	0053 Area B (Infill)			
0237	0238	0054 Area B (Infill)			
0242	0243	0055 Area B (Infill)			
0246	0246	0056 Area B (Infill)			
0248	0249	0057 Area B (Infill)			
		STOP AREA B SURVEY			
		START AREA A SURVEY			
2240		SV Profile 20020513_2240UTC			33° 50'.9S, 151° 12'.0E; 333470E, 6253200N
2315	2325	0001 Western Centreline	297°	5.2 kts	@2321 noise on starboard side due to other vessel
2334	2347	0002 Western Centreline (25)	117°	4.4 kts	@2340 Mouse button stuck, range ran too shallow
2351	2358	0003 Western Centreline (-25)	297°	4.4 kts	Stop line – Lost differentials
		LAST ENTRY			

Surveyor: Charles W. Brennan Signed: Charles W Brennan

Figure 78: Smooth log; information copied from real-time survey log

APPENDIX III: Offset Measurements

10 Lever Arm Measurement – Offsets

Each component or sensor that produces information, unique to its position, will have a point that is considered the reference point of that sensor. The Sonic 2024/2022, the motion sensor, and the GPS antenna will have a documented point from which to measure. The gyrocompass' data is not dependent on its position on the vessel so, therefore, does not require an offset measurement.

10.1 Vessel Reference System

When all equipment (Sonic 2024/2022 sonar head, motion sensor, gyrocompass and GPS) have been permanently mounted, the physical offsets to a central reference point (CRP) must be measured. The central reference point (CRP) or vessel reference point (VRP) is that point that the surveyor chooses to be the origin for the X and Y grid that will define the horizontal relationship between all of the sensors. The vertical or Z reference can be the water line or other logical vertical reference. Generally, the CRP corresponds to the centre of gravity or rotation of the vessel. All of the sensors must have their physical relationship to each other measured and entered into the data collection software or the processing software.

All offsets, between sensors, are defined by an X, Y and Z offset from a reference (CRP or VRP) point. The X axis runs athwartship, i.e. from the port side to the starboard side. The Y axis runs alongship from the bow to the stern. The Z axis runs perpendicular through the reference. The origin can be any point; the origin will remain the same for all sensors. Some surveyors take the GPS antenna as the origin for all measurements, others take the sonar head itself, while others might take the motion sensor (especially if it on the centre of rotation for the vessel). The sign convention is standard for a Cartesian plane, translated to a vessel: starboard of the reference point is positive, forward of the reference point is positive. The sign for Z may differ, depending on the data collection or processing software.

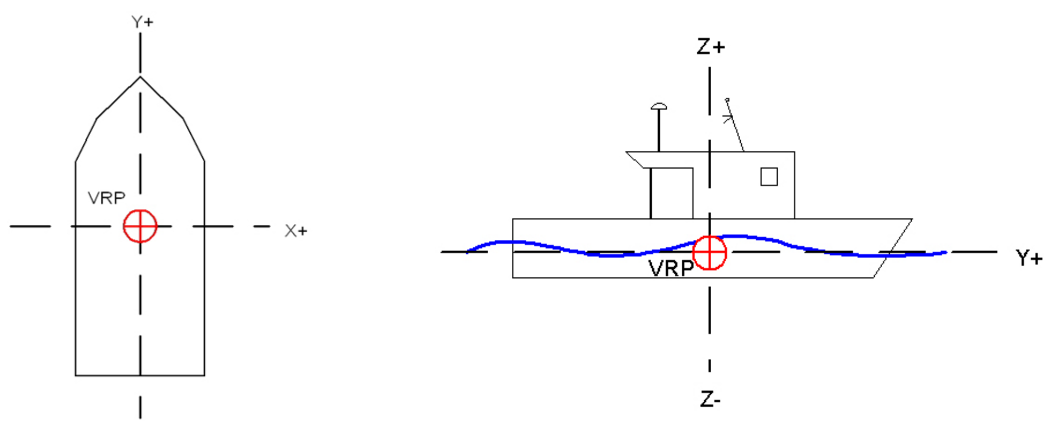

Figure 79: Vessel Horizontal and Vertical reference system

10.2 Measuring Offsets

The accurate measurement of offsets is vital to the accuracy of the survey data. If possible, the vessel will be put on a hard stand so that it can be very accurately measured using standard land survey equipment, such as a total station. However, this may not be possible and the offsets will have to be measured using a tape and plumb-bob, which is detailed below.

10.2.1 Sonic 2024 Acoustic Centre

Please refer to the drawings on Page 104 to 106 to obtain measurements, with reference to the system offsets, when mounting on the Sonic mounting frame.

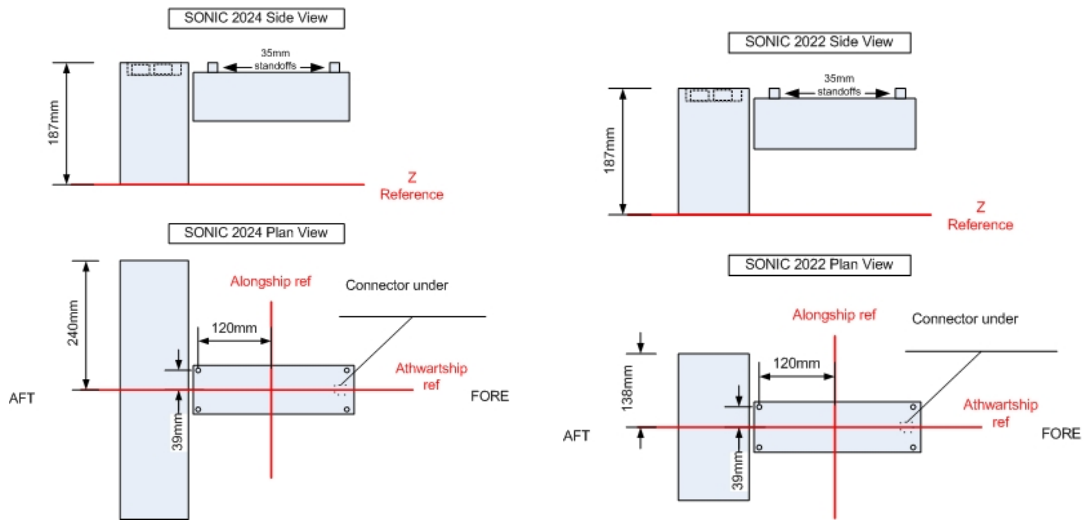

Figure 80: Sonic 2024/2022 Acoustic Centre

10.2.2 Horizontal Measurement

All measurements should be made with a metal tape measure. A cloth tape can stretch, it can also be knotted or kinked, unknown to the persons making the measurements. At a minimum, two people should be assigned to take the measurements; three people will work better with the third person writing down the measurements. One person will be the holder and the other will be the reader. Starting at either the reference point or the sensor, the distance will be measured. When either the reference point or the sensor is reached, the two people will reverse roles: the holder is now the reader and the reader is the holder, the transverse is made back to the point of beginning, but not using the same path. If reference marks were made on the first leg, they should not be used on the second leg back. If the measurement from the sensor to the reference point, in one direction, agrees with the measurement in the opposite direction, made by a different reader and holder, then the offset is good. If there is a small disagreement in measurements, the two measurements can be averaged. If there is a large disagreement then the process should be repeated. What is a small disagreement? A few centimetres can be expected.

10.2.3 Vertical Measurement

To measure elevations or the Z offset, the use of a plumb bob is required. This can be something as simple as a spanner tied to a length of line and lowered from one deck to the next. The plumb bob will also allow for accurate measurements in the X and Y direction when transposing them from one deck to the other.

The plumb bob works, of course, by gravity so generally points to the centre of the earth. This being the case, if the vessel is not in good trim, i.e. has a list, the resting position of the plumb bob may not be at the true vertical point under the place from which it is being held. This is very critical when transposing X and Y measurements from one deck to another.

The draft of a vessel will not be constant. Prior to going out on a survey, the fuel and water may be filled up, causing the vessel to settle lower in the water. Possibly less people are on board causing the vessel to rise higher in the water. The main concept here is that the draft of the sonar head changes. All X and Y offsets remain the same as long as the sensors are not moved, but the Z offset changes constantly depending on the draft of the vessel.

If possible, the pole should be marked to show the depth of the head. Measuring up from the sonar head's acoustical reference, rings can be painted on the pole in 10 cm (or other) increments, with 2 cm hatching between rings. The surveyor may have to observe the pole over the course of a few minutes to determine where the water line is and would then estimate the depth by interpolating between the 10 cm depth rings.

Another method would be for the surveyor to initially measure from the sonar head's acoustical reference to the top of the hydrophone pole. This is the total pole measurement. At the start of a survey day, the surveyor will go to the pole and measure from the top of the pole to the water line (using the tape measure and plumb bob or similar weight), this is called the dry measurement. Taking the dry measurement from the total pole measurement yields the wet measurement, which is the draft of the sonar head. Due to wave motion, the surveyor may have to take a series of measurements to ensure an accurate reading.

When the draft or Z of the sonar head is determined the Z for the GPS antenna and the motion sensor can be adjusted accordingly, if the Z reference is the water line. In most data collection software a Z shift, in relation to the water surface, can be entered in for the CRP, which will do the vertical adjustment for all offsets

It is very important that when measuring the draft on small vessels that the person taking the measurement does not unduly cause the vessel to list towards that side. Having someone counter balance the weight of the person taking the measurement is a good idea. This is also true of any temporary list the vessel is experiencing. On small survey vessels, a person leaning over the side, to take the draft measurement, can induce upwards, or exceeding a 10cm error in depth readings during survey operation.

On some vessels it is advisable to take draft readings during the survey or immediately after completion of the survey, as the draft will change that much.

All offset information should be recorded in the daily survey log and the vessel's permanent survey record.

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APPENDIX IV: The Patch Test

11 Introduction

The alignment of the Sonic 2024/2022 sonar head to the motion sensor and gyro is critical to the accuracy of the determined depths. It is not possible to install the sonar head in exact alignment with the motion sensor and gyro to the accuracy required (x.xx°). If GPS time synchronization is not used, the latency of the position, as reported by the GPS, must also be measured during the calibration. This being the case a multibeam calibration must be performed to measure the angular misalignment between the Sonic 2024/2022 and the motion sensor and gyro and, if necessary, the position latency; this is called the Patch Test.

The patch test is performed with each new installation or whenever a sensor is moved. In the case of an over-the-side mount, a large number of calibration computations need to be performed to determine how well the pole goes back into the same position each time it is deployed. With more permanent mounting arrangements, a minimum of 5 separate patch tests should be conducted in order to derive a standard deviation that would indicate the accuracy of the derived values.

The patch test involves collecting data over certain types of bottom terrain and processing the data through a set of patch test tools. There are two primary methods of processing the data that are currently used: an interactive graphical approach and an automatic, iterative surface match. Each of these techniques has strengths and weaknesses and the preferred approach is dependent on the types of terrain features available to the surveyor. All modern multibeam data collection software packages contain a patch test routine. Please read the software manual for explicit information regarding the requirements for that software's patch test. The below criteria is, in general, the norm for a patch test.

11.1 Orientation of the Sonic 2024/2022 Sonar Head

The orientation of the sonar 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.

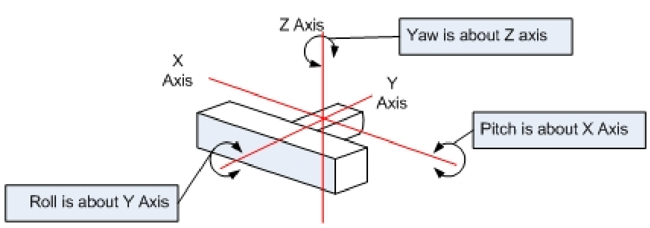


Figure 81: Sonic 2024/2022 axes of rotation

Any error in the measured roll of the Sonic 2024/2022 sonar 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 Sonic 2024/2022 head will primarily have a detrimental effect on the accuracy of the positions that are determined for each slant range/depth.

A pitch error of 1° will cause an along-track error in the position of 0.4 meter when the sonar head is 25 meters above the seabed.

11.2 Patch Test Criteria

The patch test requires collecting sounding data over two distinct types of sea floor topography; a flat bottom is used for the roll computation whereas a steep slope or feature is used for the latency, pitch, and yaw data collection.

Care must be taken that the sonar head covers the same area on both data collection runs, this may not be the same as vessel position, especially with an over-the-side mount or if the sonar head rotated. Only the latency data collection requires a different speed from normal survey speed.

The data collection for Latency, Pitch and Yaw should be done in as deep water as possible. This is particularly true for the pitch computation due to the fact that in shallow water the angle of pitch may not be easily determined due to a lack of resolution.

11.2.1 Latency Test

The vast majority of installations will incorporate GPS time synchronisation and, as such, no latency is expected in the GPS position. However, it is necessary to complete at least one or two latency tests to prove that the latency, for all practical purposes, is zero. Most patch test programs will not yield zero latency, but the derived value would be so small so as to constitute a practical zero.

For the latency test, data is collected on a pre-defined line up a steep slope or over a well defined object (such as a rock or small wreck). The line is surveyed at survey speed up the slope, and then surveyed again, in the same direction, but at a speed that should be half of the survey speed. If the vessel cannot make way at half survey speed then the fast run will need to be taken at a higher speed than normal survey speed and this can influence the latency test due to squat or settlement. The main consideration is that one line should be twice the speed of the other.

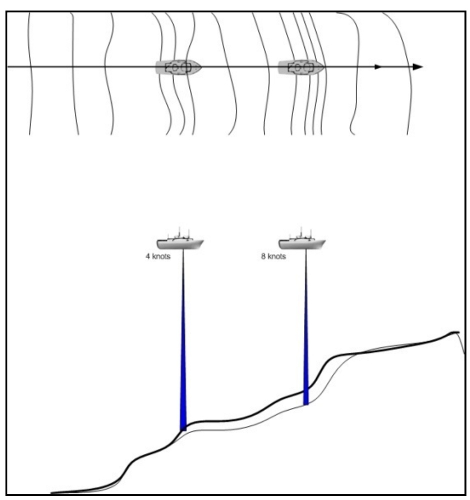


Figure 82: Latency Data collection

11.2.2 Roll Test

The data collection for roll has to be over a flat sea floor. One line is surveyed twice, in reciprocal directions and at survey speed.

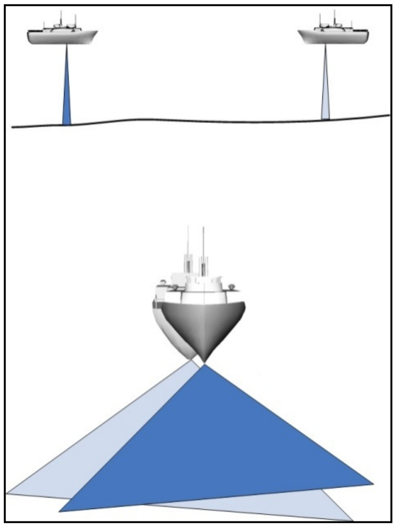


Figure 83: Roll data collection

When the data, from the two data collections, are looked at in profile, there will be two seafloors sloped in opposite directions. Most patch test programs will go through a series of iterations to determine when the difference between the two surfaces is the smallest, and this is the roll offset.

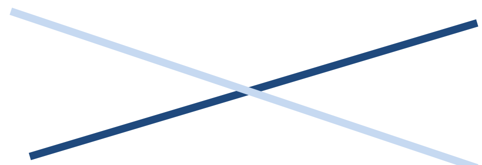
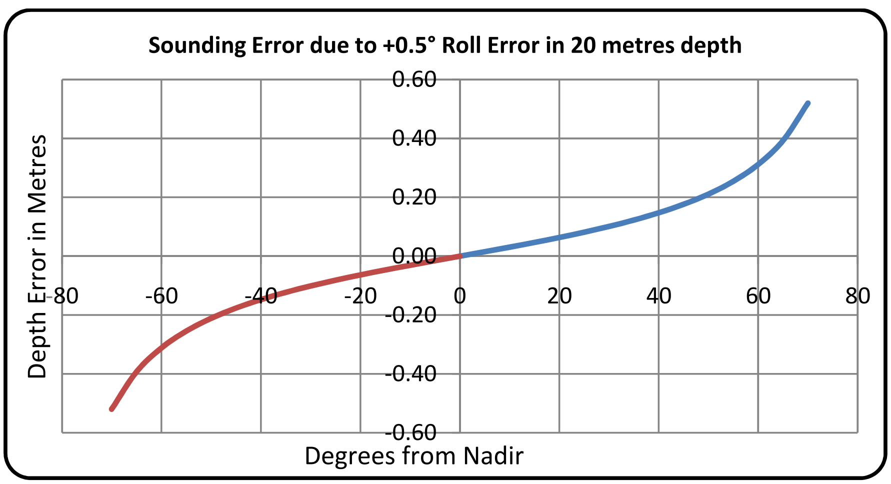


Figure 84: Roll data collections

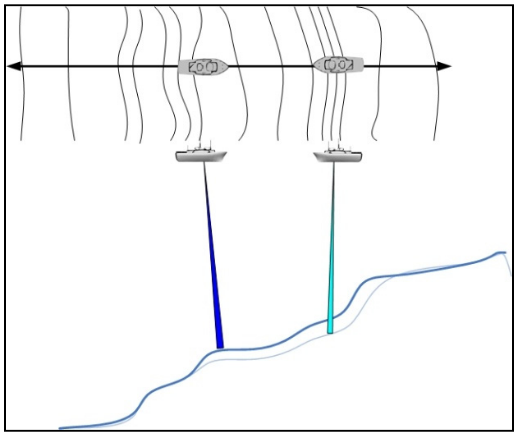
Roll is perhaps the most critical value in the patch test routine as an error in roll will result in an error in sounding depths. However, the computation to determine the roll misalignment is usually the easiest and most consistent.



Graph 1: Depth errors due to incorrect roll alignment

11.2.3 Pitch Test

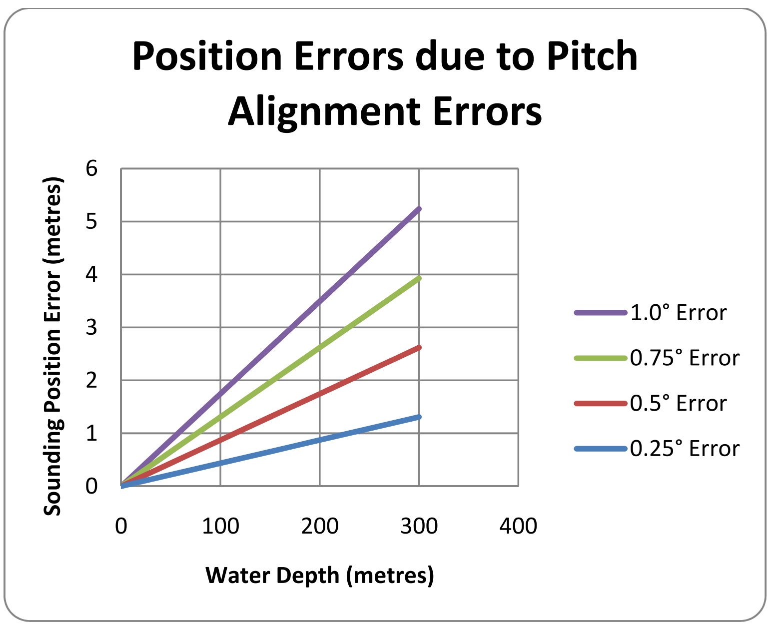
The pitch data collection is over the same type of sea floor as the latency data collection, i.e. steep slope or feature on the sea floor. One line is surveyed, twice, in reciprocal directions at survey speed. It is very critical that the sonar head passes over the same exact part of the slope on each run.



A profile of the data will show two different slopes, which represent the reciprocal data collections. The patch test software goes through a series of iterations of pitch angle corrections until the difference between the two surfaces reaches a null. Whatever the angle of correction, which results in the minima or null, that angle will be reported as the pitch misalignment.

Figure 85: Pitch data collections

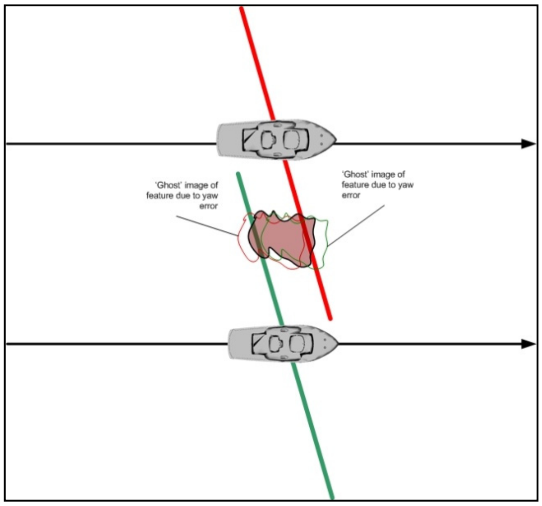
A pitch error will result in a an along –track position error, which increases greatly with depth



Graph 2: Position errors as a result of pitch misalignment; error can be either negative or positive

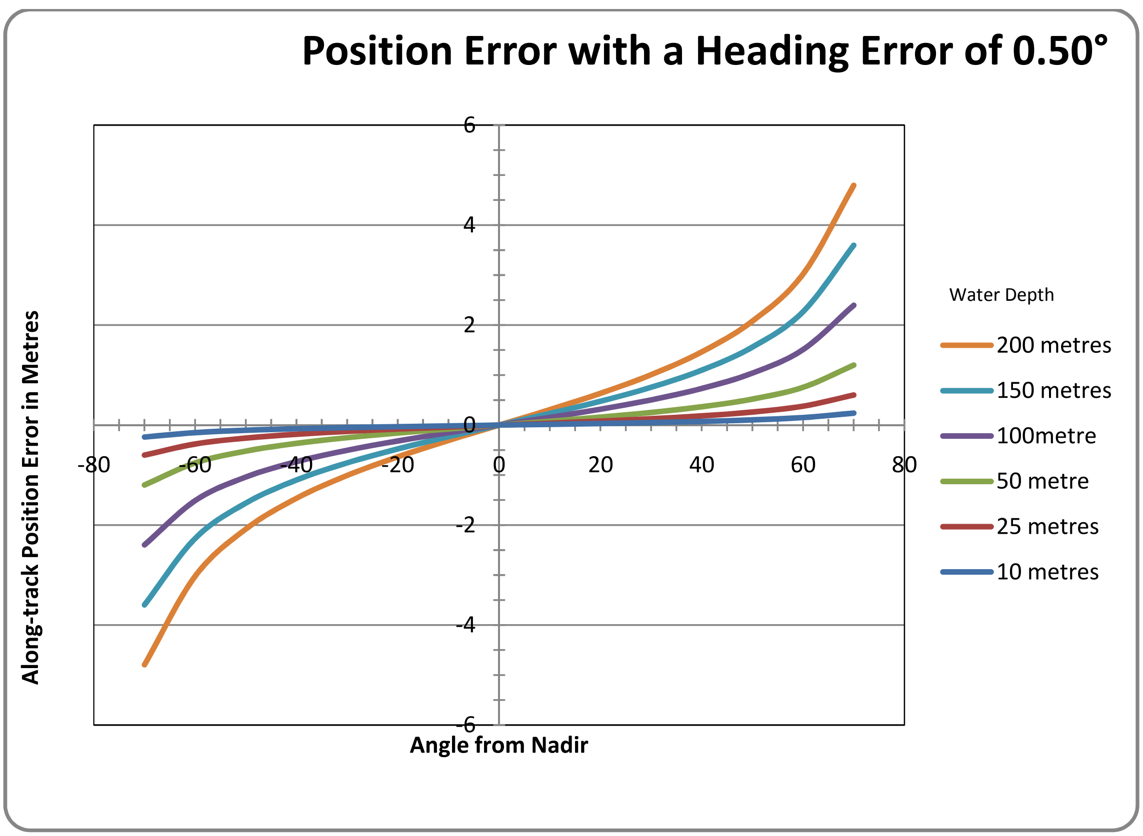
11.2.4 Yaw Test

The yaw data collection and subsequent solving for the yaw offset is usually the most difficult of the 4 tests that comprise a patch test. This is especially true if a slope is used for the yaw computation; a feature generally works much better. The reason for this is that the area that is used for the computation is not directly under the vessel, but in the outer beams and the slope may not be perfectly perpendicular in relation to the course of the vessel.

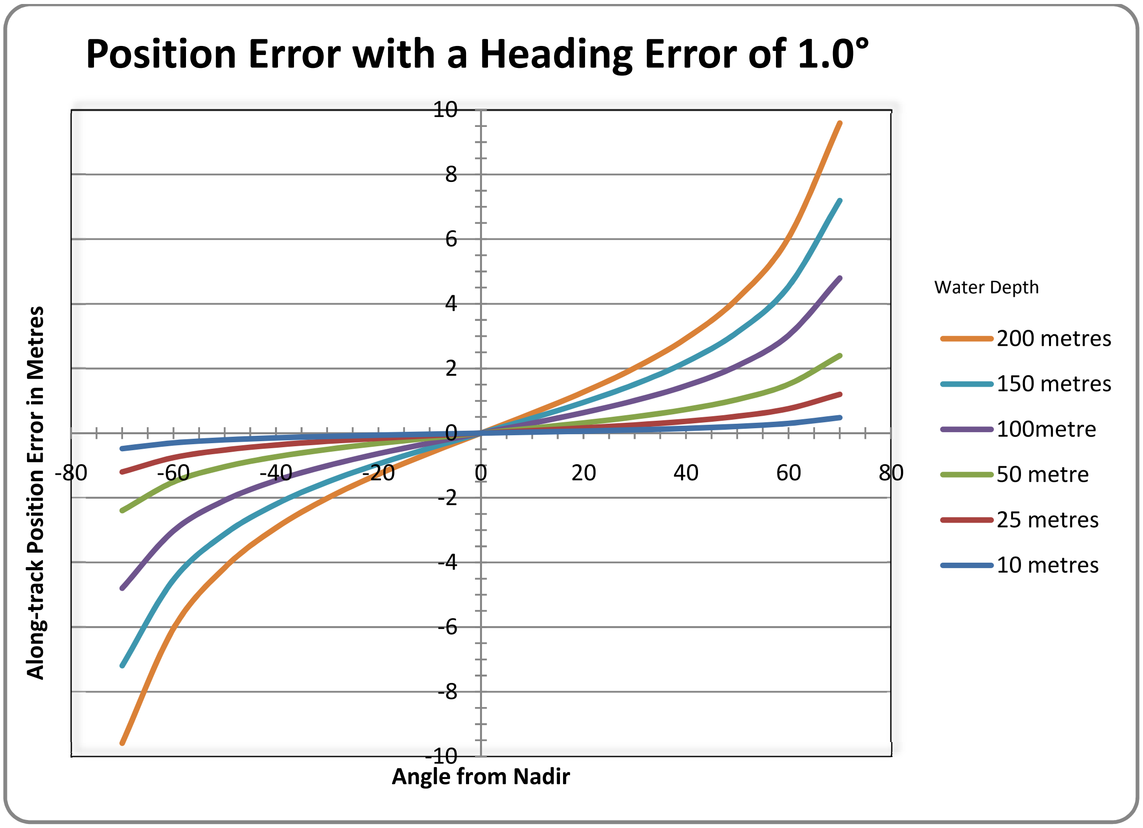


For the Yaw data collection two parallel lines are used, with the vessel surveying in the same direction on those lines. The lines are to be on either side of a sea floor feature or over a slope. The lines should be approximately 2 – 3 times water depth in separation. A yaw error will result in a depth position error, which increase with the distance away from nadir.

Figure 86: Yaw data collection



Graph 3: Along track position error caused by 0.5° error in yaw patch test



Graph 4: Along-track position error caused by 1.0° error in yaw patch test error

11.3 Solving for the Patch Test

Depending on the data collection software that is employed and how it solves for the patch test, there will be a distinct order that the tests will be solved for, but this does not influence the data collection for the patch test. In general, latency will be solved before pitch; roll will be solved for before yaw. It is not uncommon that a larger than expected error in one of the tests will make it necessary to go back and resolve for all previous values. This can be the case with a large yaw offset, as this will influence to a greater degree the accuracy of the latency and pitch computations if done using a slope.

The resultant patch test values are corrections that are entered in the data collection software and not in the Sonic 2024/2022 software, as the values are used for process data.

APPENDIX V: Basic Acoustic Theory

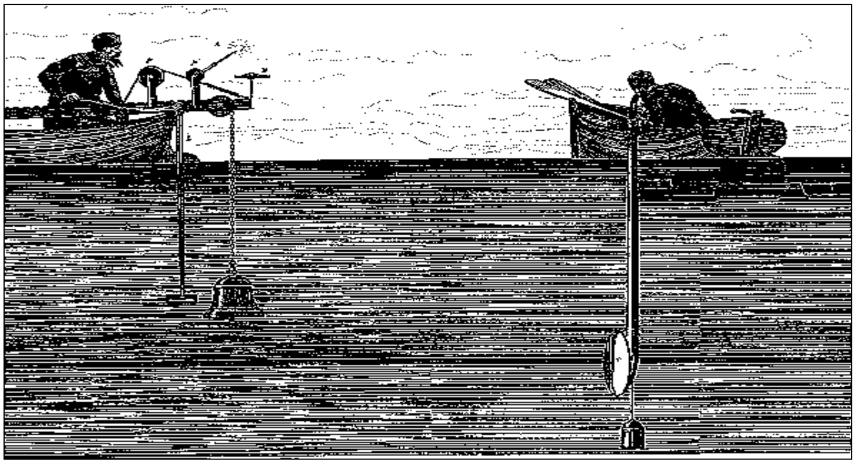


Figure 87: In 1822 Daniel Colloden used an underwater bell to calculate the speed of sound under water in Lake Geneva, Switzerland at 1435 m/Sec, which is very close to recent measurements.

12 Introduction

With multibeam, as with any echosounder, a main concern is: sound in water. Once the projector transmits the acoustic energy into the water, many factors influence that energy's velocity and coherence. The major influence is the velocity of sound in water.

12.1 Sound Velocity

The major influence on the propagation of acoustic energy is the sound velocity of the water column. As the acoustic pulse passes through the water column, the velocity and direction (refraction) of the wave front will vary based on the water column sound velocity. If the sound velocity, through the water column, is not accounted for in the data collection software the depths and the depth location will be in error. For this reason, sound velocity casts are an oft repeated routine during multibeam survey.

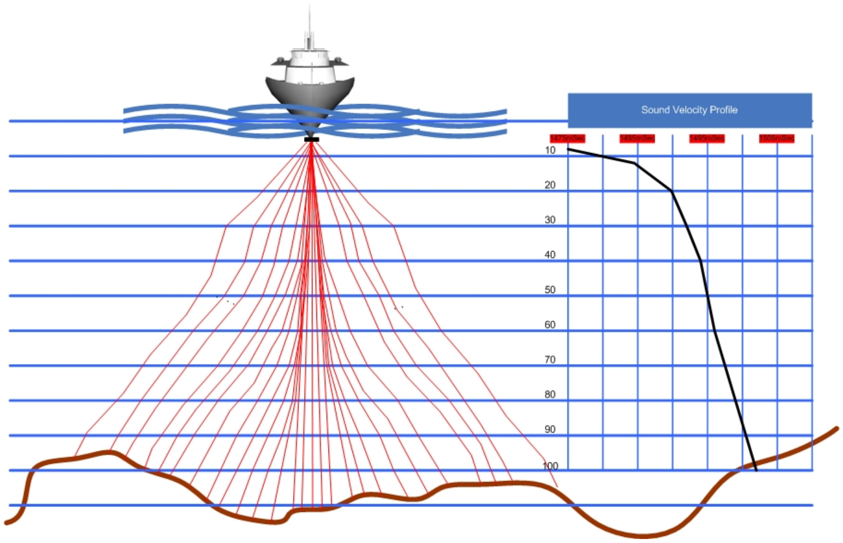


Figure 88: Concept of refraction due to different sound velocities in the water column

The velocity of sound in water varies both horizontally and vertically. It cannot be assumed that the velocity of sound in the water column remains constant over large areas or throughout the day in a more local area. The main influences on sound velocity are: Conductivity (salinity), Temperature and Depth (pressure).

1 ° C change in Temperature	=	4.0 m/sec change in velocity
1 ppt change in Salinity	=	1.4 m/sec change in velocity
100 m change in Depth (10 atm's pressure)	=	1.7 m/sec change in velocity

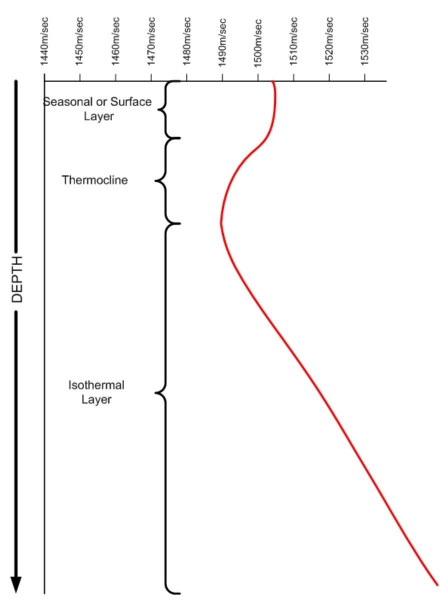


Figure 89: Sound velocity profile

12.1.1 Salinity

Generally, salinity ranges from 32 – 38 parts per thousand (ppt) in ocean water. A change in salinity will create density changes, which affect the velocity of sound. As a general rule, a change in salinity of only 1 ppt can cause a sound velocity change of 1.4m/sec. There are many influences on the salinity concentration in sea water.

1. Evaporation
2. Precipitation
3. Fresh water influx from rivers
4. Tidal effects (salt wedges)

12.1.2 Temperature

Temperature is the major influence on sound velocity in water. A 1°C change is equal to approximately a 4m/sec change in velocity. Once the upper layer is passed, the temperature normally decreases until pressure becomes the more dominating influence on the velocity of sound, which is approximately at 1000 metres. The normal influences on the temperature component of sound velocity include:

1. Solar heating
2. Night time cooling
3. Rain / run off
4. Upwelling

12.1.3 Refraction Errors

Refraction errors occur due to the wrong sound velocity profile being applied to the data. The error increases away from nadir and, as such, is more apparent in the outer beams. The visual effect is that the swath will curl up (smile) or curl down (frown). The actual representation is that the soundings are either too shallow or too deep.

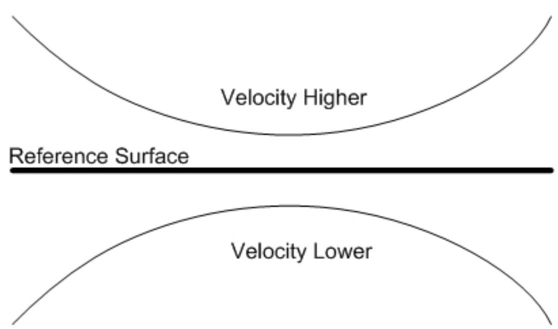


Figure 90: Refraction Error indication

At an angle of 45° in 10 meters of water, a ±10 meters per second velocity error will result in a depth error on the order of ± 4.6 cm. .

- Convex (smiley face) = Sound velocity profile used higher than real profile
- Concave (frown face) = Sound velocity profile used lower than real profile

12.2 Transmission Losses

The transmission of an acoustic pulse is generally called a 'ping'. When the projector sends out the acoustic pulse many factors operate on that pulse as it moves through the water column to the bottom and also on its return upward. The major influence of the water column sound velocity characteristics was detailed above; this affects the speed of transmission (and return). There are other influences that will affect acoustic energy in water and these are transmission losses.

12.2.1 Spreading Loss

Spreading loss does not represent a loss of energy, but refers to fact that the propagation of the acoustic pulse is such that the energy is simply spread over a progressively larger surface area, thus reducing its density. Spreading loss is not frequency dependent.

12.2.1.1 Spherical Spreading

Spherical spreading loss is the decrease in the source level if there are no boundaries (such as the water surface or sea floor) to influence the acoustic energy; all of the acoustic energy spreads out evenly, in all directions, from the source. The loss in intensity is proportional to the surface area of the sphere. The intensity decreases as the inverse square of the range for spherical spreading. With Spherical spreading, the transmission loss is given as: **TL = 20log(R)**, where R is range

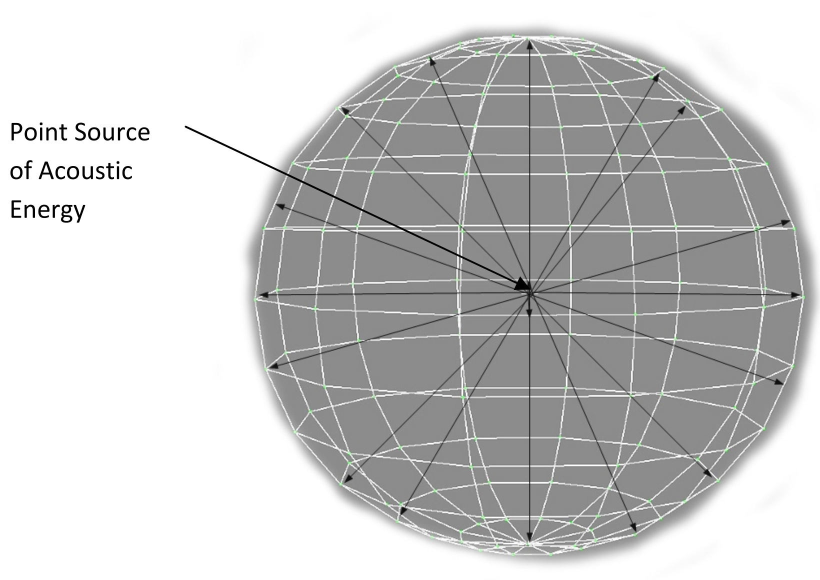


Figure 91: Concept of Spherical Spreading

12.2.1.2 Cylindrical Spreading

In reality the acoustic energy cannot propagate in all directions due to boundaries such as the sea floor and the water surface; this give rise to Cylindrical Spreading. Cylindrical spreading is when the acoustic energy encounters upper and lower boundaries and is 'trapped' within these boundaries; the sound energy begins to radiate more horizontally away from the source. With Cylindrical spreading the acoustic energy level decreases more slowly than with Spherical spreading. With Cylindrical spreading, the transmission loss is given as: **TL = 10log(R)**, where R is range.

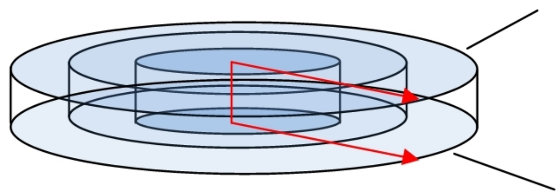


Figure 92: Concept of Cylindrical Spreading

12.2.2 Absorption

Absorption is frequency dependent and refers to the conversion of acoustic energy to heat when it strikes chemically distinct molecules in the water column. Magnesium Sulphate $MgSO_4$ predominates, with Boric Acid $B(OH)_3$ playing a major part at lower frequencies. Temperature is also an influence on absorption. Absorption is one of the key factors in the attenuation of the acoustic energy based on frequency; the higher the frequency, the greater the absorption. The higher the sonar operating frequency, the more rapid the vibration (or excitement) of the particles in the water and this leads to the greater transference of acoustic energy; thus, the attenuation of the acoustic wave. This is the reason why lower frequencies are used to obtain deeper data. At 400 kHz, the normal seawater absorption is approximately 100 dB/km, whereas at 200kHz the absorption is approximately 50 dB/km. These are values for normal sea water (with a salinity of 35 ppt). Fresh water has little, if any salinity (<0.5ppt), so absorption is considerably less.

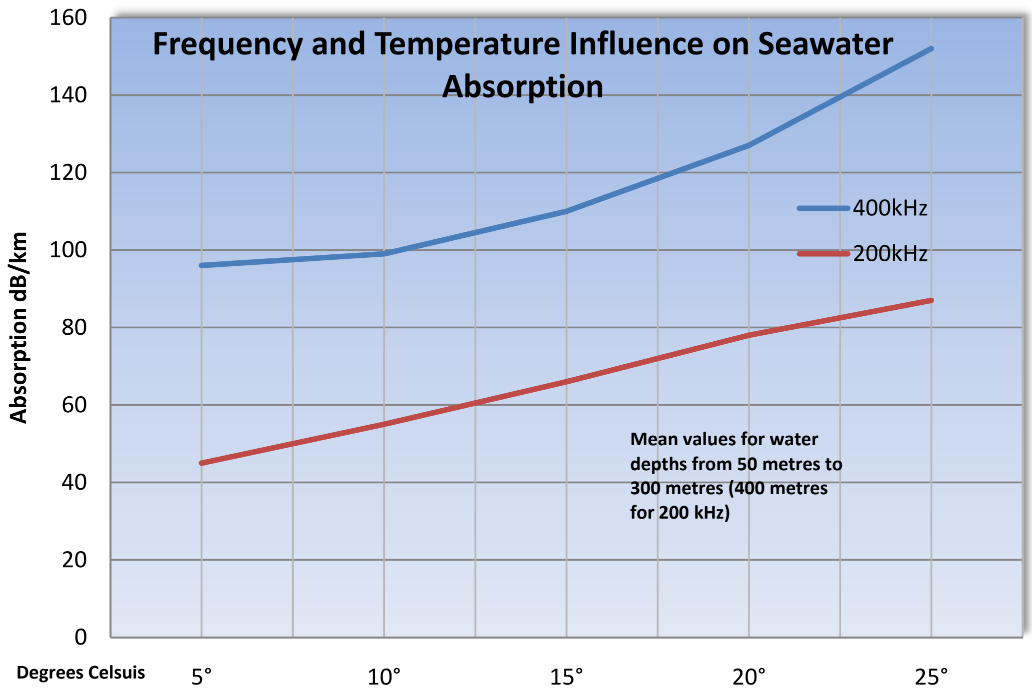
The below table and charts illustrate how frequency, water temperature, and salinity affect absorption

Seawater Absorption Values: Salinity = 35ppt, pH=8[2] dB/km											
			400kHz						200kHz		
Temp (C)	**5°**	**10°**	**15°**	**20°**	**25°**		**5°**	**10°**	**15°**	**20°**	**25°**
Depth (m)											
50	97	100	111	130	154		46	56	68	80	89
100	96	100	110	128	153		46	55	67	79	88
150	96	99	110	128	152		46	55	66	78	88
200	95	99	109	127	151		45	55	66	78	87
250	95	98	109	126	150		45	54	66	77	86
300	95	98	108	125	149		45	54	65	77	86
						400m	44	53	64	76	84
Mean Value	**96**	**99**	**110**	**127**	**152**		**45**	**55**	**66**	**78**	**87**

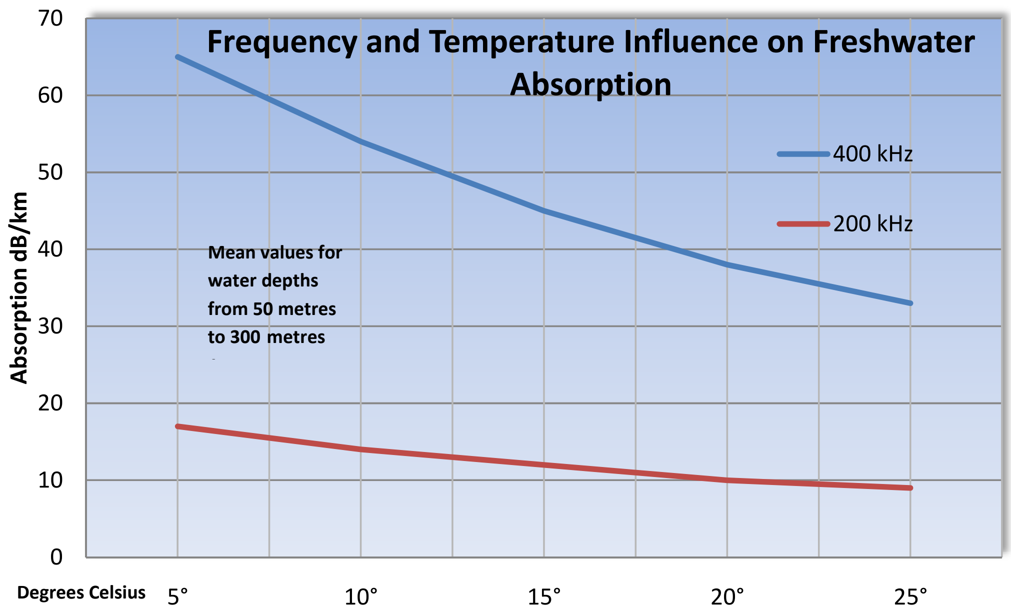
Freshwater Absorption Values: Salinity = 0.5ppt, pH=7 dB/km											
			400kHz						200kHz		
Temp (C)	**5°**	**10°**	**15°**	**20°**	**25°**		**5°**	**10°**	**15°**	**20°**	**25°**
Depth (m)											
50	65	55	46	39	33		17	14	12	10	9
100	65	54	46	38	33		17	14	12	10	9
150	65	54	45	38	33		17	14	12	10	9
200	65	54	45	38	32		17	14	12	10	9
250	65	54	45	38	32		16	14	12	10	9
300	64	54	45	38	32		16	14	12	10	9
Mean Value	**65**	**54**	**45**	**38**	**33**		**17**	**14**	**12**	**10**	**9**

Table 10: Absorption Values for Seawater and Freshwater at 400 kHz and 200 kHz

[2] Equation used for computation is from: Ainslie M.A., McColm J.G., "A simplified formula for viscous and chemical absorption in sea water", Journal of the Acoustic Society of America, 103(3), 1671-1672 as employed on the NPL website, op cit.



Graph 5: Seawater Absorption (Salinity 35ppt)



Graph 6: Freshwater Absorption

Seawater Absorption db/km				
Freq.	**10°C**	**15°C**	**20°C**	**25°C**
200	55	67	80	89
210	57	69	82	94
220	59	71	85	97
230	61	74	88	101
240	63	76	91	105
250	65	78	94	109
260	67	80	96	113
270	69	82	99	116
280	71	84	101	120
290	73	86	104	123
300	75	88	106	126
310	78	91	108	129
320	80	93	111	132
330	82	95	113	135
340	85	97	115	138
350	87	99	118	141
360	90	102	120	143
370	92	104	122	146
380	95	106	125	149
390	98	109	127	152
400	100	111	129	154

Table 11: Operating Frequency - water temperature - absorption

12.2.3 Reverberation and Scattering

The sea is not homogenous in nature. Everything from suspended dust particles to fish, from the sea surface to the sea floor will scatter, that is reradiate, the acoustic energy. All of the effects of individual scattering can be termed reverberation. The effect of reverberation is to lessen the acoustic energy and this leads to transmission losses.

Reverberation is divided into three main areas: sea surface reverberation, bottom reverberation, and volume reverberation (the body of water that the energy is passing through).

Both the sea surface and the sea bottom will reflect and scatter sound, thus affecting the propagation of sound. Sea surface scattering is influenced by how rough the sea is (which is related to wind velocity) and also the trapped air bubbles in the near surface region. The sea surface is also a good reflector of acoustic energy; this can lead to second and even tertiary bottom returns as the bottom return acoustic energy is reflected by the sea surface and is then reflected once more by the sea bottom.

In the case of the sea floor, the strength of the scattering depends on the type of bottom (composition and roughness), the grazing angle of the acoustic pulse and the operating frequency of the sonar.

There is also bottom absorption based on the sea floor terrain and composition. Bottom absorption is also dependent on the operating frequency of the sonar and the angle of incidence. Bottom absorption will be greater for a higher frequency and large angle of incidence. It is more or less intuitive that a mud bottom will absorb more of the acoustic energy than a rocky bottom. When the acoustic energy is absorbed it means there is less that will be reflected back to the Sonic 2024/2022's receivers. The surveyor must be aware of the bottom composition as adjustments can be made to the Sonic 2024/2022 operating parameters to help compensate for the bottom absorption.

In waters with a large sediment load, the suspended particles will scatter the sound wave, thus leading to transmission loss. In the scattering process, there is also a degree of energy that it is reflected (backscatter); this can be a cause for 'noise' in the sonar data. Again, the surveyor should be aware of this condition and, if need be, change the operating parameters of the Sonic 2024/2022. When discussing the changing of the operating parameters, it is generally a matter of increasing transmit power or pulse length to get more total power into the water. In some circumstances, increasing the Absorption value will allow the system to rapidly increase gain to capture the reflected energy that has been dissipated by seafloor absorption or scattering in the water column.

As noted above many of the effects of absorption, scattering, and bottom absorption are frequency dependent. With the Sonic 2024/2022, the operator can adjust the sonar frequency to optimise the system for the survey conditions. This will take some trial and error; however, lower frequencies tend to do best in areas of absorbent bottom and high sediment load (scatter).

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Appendix VI Sonic Control Commands

13 R2Sonic Control Commands

13.1 Introduction

The Sonic 2024/2022 is configured and control using a set list of commands. Sonic Control works by sending these commands to system. The control commands, provided here, can be used to control the Sonic 2024/2022. This describes the commands sent from the user interface to the sonar head and SIM.

Head firmware version 12-Apr-2010 and SIM firmware version 08-Apr-2010 utilize the commands in this document. Future versions of firmware will adhere to this format and may include additional commands.

Older versions of head and SIM firmware are **not** compatible with this format.

13.2 General Notes

1. These formats are designed for easy 4-byte alignment. Be sure your compiler/linker doesn't insert any extra padding between values. If necessary, use your compiler's "packed" directive.
2. All values have big-endian byte order. Your compiler may provide conversion functions such as htonl, htons, ntohl, ntohs, however those assume integers so you'll need to be very careful with floats.
3. u32 means unsigned integer, 32 bits.
   f32 means IEEE-754 32-bit floating point.
4. All packets are UDP/IP datagrams.
5. It's recommended that all commands be sent periodically, at a 1 to 0.5 Hz rate. This ensures that the sonar head and SIM always have the proper settings should a power interruption occur.

13.2.1 Port Number

Port = Baseport +2 where the baseport is the sonar head or SIM baseport

13.2.2 Type Definitions

typedef unsigned int u32;
typedef float f32;

13.2.3 Command Packet Format

Pseudo C format for commands

```
// *** BEGIN PACKET: COMMAND FORMAT Ø ***
u32   PacketName;             // 'CMDØ'

// Command (for network efficiency, the packet can contain multiple commands,
// but ensure the IP datagram reaches the sonar unfragmented).

u32   CommandName;            // example 'RNGØ' to set range
x32   CommandValue;           // a 4-byte value such as u32 or f32

// *** END PACKET: COMMAND FORMAT Ø ***
```

13.3 R2Sonic Head Commands – Binary Format

Cmd	Format	Units	Values	Description
ABS0	f32	dB/km	0 to 200	absorption
BIE0	u32		0 = off 1 = on	bathy intensity enable
BMAX	f32	metres	0 to 999	max range filter head default = 999
BMIN	f32	metres	0 to 500	min range filter head default = 0
BOS0	u32		0 = Equiangle 1 = Equidistant	bottom sampling
BPHS	f32	radians	0.523599 = normal 999 = shallow 999 = vert. features	bottom type
DGA0	f32	metres	0 to 500	depth gate min
DGB0	f32	metres	0 to 500	depth gate max
DGO0	u32		0 = off 1 = on	depth gate enable use FILT or DGO0, not both
DHM0	u32		0 = single head 1 = master simultaneous 2 = master alternating 3 = slave simultaneous 4 = slave alternating	head sync mode (single and dual head modes)
FILT	u32		0 = off 1 = range 2 = depth 3 = range & depth	depth, range filter enables use FILT or DGO0, not both
FRQ0	f32	Hz	200000 to 400000	frequency
GAN0	f32	dB	1 to 45	gain ($\Delta 1$ = 2dB)
PRL0	f32	Hz	0.1 to 60	ping rate limit user-value
PRO0	u32		0 = projector forward 1 = projector aft	projector orientation
PROJ	u32		0 = none 1 = narrow (1°) 2 = wide (20°)	projector type selector
PRU0	u32		0 = off 1 = on	ping rate limit user-enable
PRZ0	f32	metres	-0.20 to +0.20	projector mounting Z offset default = 0.119
RET0	f32	radians	-45° to +45°	receiver tilt
RNG0	f32	metres	2 to 500	range
ROS0	u32		0 = off 1 = on	roll stabilization enable
SER0	f32	radians	-70° to +70°	sector rotate wedge edges must not go beyond ±80°
SEW0	f32	radians	10° to 160°	sector width
SNIP	u32		0 = off 1 = on	snippets enable
SPR0	f32		0 to 60 typically 30	spreading loss
SVL0	f32	m/s	1250 to 1600	sound velocity user-value

Cmd	Format	Units	Values	Description
SVUØ	u32		0 = use SVP 1 = user value	sound velocity user-enable
TXLØ	f32	seconds	0 to 500µs	pulse length
TXPØ	f32	dB//1µPa	0, 191 to 221	power
TWIX	u32		0 = flat bottom 1 = vertical features	bottom type

13.4 R2Sonic SIM Commands – Binary Format

Cmd	Format	Units	Values	Description
BDGØ	u32	bps	standard baud rates 300 to 115200	GPS baud
BDMØ	u32	bps	standard baud rates 300 to 115200	motion baud
BDSØ	u32	bps	standard baud rates 300 to 115200	SVP baud
DBGØ	u32		7 or 8	GPS data bits
DBMØ	u32		7 or 8	motion data bits
DBSØ	u32		7 or 8	SVP data bits
DRGØ	u32		0 = auto	GPS driver
DRMØ	u32		0 = auto	motion driver
DRSØ	u32		0 = auto	SVP driver
ENGØ	u32		0 = off 1 = on	GPS serial port enable
ENMØ	u32		0 = off 1 = on	motion serial port enable
ENSØ	u32		0 = off 1 = on	SVP serial port enable
PAGØ	u32		0 = none 1 = odd 2 = even	GPS parity
PAMØ	u32		0 = none 1 = odd 2 = even	motion parity
PASØ	u32		0 = none 1 = odd 2 = even	SVP parity
POGØ	u32		0 = rising 1 = falling	PPS edge
SPOØ	u32		0 = head power off 1 = head power on	sonar head power

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Appendix VII: R2Sonic Data Format

14 R2Sonic Uplink Data Formats

14.1 . Introduction

This describes the data formats sent from the sonar head to the data collection software. The formats are given in pseudo C.

Head firmware version 12-Apr-2010 utilise the data formats in this document. Head firmware version 25-Mar-2010-11-14-27 uses the bathymetry packet format described in this document. Future versions of firmware will adhere to this format and may include additional information.

The data format in older versions of sonar head firmware are different than the format described in this document.

14.2 . General Notes

1. Each bathy or snippet section includes a name/size mini-header to allow the parser to easily skip unneeded or unrecognized sections. These formats are designed for easy 4-byte alignment. Be sure your compiler/linker doesn't insert any extra padding between values. If necessary, use your compiler's "packed" directive.
2. All values have big-endian byte order. Your compiler may provide conversion functions such as htonl, htons, ntohl, ntohs, however those assume integers so you'll need to be very careful with floats.
3. u8, u16, u32 means unsigned integers of 8, 16, 32 bits.
   s8, s16, s32 means signed integers of 8, 16, 32 bits.
   f32 means IEEE-754 32-bit floating point.
4. All packets are UDP/IP datagrams.

14.3 . Port Numbers

Bathymetry data port = Baseport + 0
Snippets data port = Baseport + 6
Device status port = Baseport + 2
Where the baseport is the data collection software baseport.

14.4 . Type Definitions

typedef unsigned char u8;
typedef unsigned short u16;
typedef unsigned int   u32;
typedef signed char   s8;
typedef signed short   s16;
typedef signed int   s32;
typedef float   f32;

14.5 . Bathymetry Packet Format

```
// *** BEGIN PACKET: BATHY FORMAT Ø ***

  u32  PacketName;                 // 'BTHØ'
  u32  PacketSize;                 // [bytes] size of this entire packet
  u32  DataStreamID;               // reserved for future use
  // section HØ: header
  u16  HØ_SectionName;             // 'HØ'
  u16  HØ_SectionSize;             // [bytes] size of this entire section
  u8   HØ_ModelNumber[12];         // example "2Ø24", unused chars are nulls
  u8   HØ_SerialNumber[12];        // example "1ØØØ17", unused chars are nulls
  u32  HØ_TimeSeconds;             // [seconds] ping time relative to ØØØØ hours 1-Jan-197Ø, integer part
  u32  HØ_TimeNanoseconds;         // [nanoseconds] ping time relative to ØØØØ hours 1-Jan-197Ø, fraction part
  u32  HØ_PingNumber;              // pings since power-up or reboot
  f32  HØ_PingPeriod;              // [seconds] time between most recent two pings
  f32  HØ_SoundSpeed;              // [meters per second]
  f32  HØ_Frequency;               // [hertz] sonar center frequency
  f32  HØ_TxPower;                 // [dB re 1 uPa at 1 meter]
  f32  HØ_TxPulseWidth;            // [seconds]
  f32  HØ_TxBeamwidthVert;         // [radians]
  f32  HØ_TxBeamwidthHoriz;        // [radians]
  f32  HØ_TxSteeringVert;          // [radians]
  f32  HØ_TxSteeringHoriz;         // [radians]
  u32  HØ_TxMiscInfo;              // to be determined
  f32  HØ_RxBandwidth;             // [hertz]
  f32  HØ_RxSampleRate;            // [hertz] sample rate of data acquisition and signal processing
  f32  HØ_RxRange;                 // [seconds two-way]
```

```
 f32  HØ_RxGain;                  // [∆HØ_RxGain = 1; 2dB gain change]
 f32  HØ_RxSpreading;             // [dB (times log range in meters)]
 f32  HØ_RxAbsorption;            // [dB per kilometer]
 f32  HØ_RxMountTilt;             // [radians]
 u32  HØ_RxMiscInfo;              // to be determined
 u16  HØ_reserved;                // reserved for future use
 u16  HØ_Points;                  // number of bathy points

 // section RØ: 16-bit bathy point ranges

u16  RØ_SectionName;             // 'RØ'
 u16  RØ_SectionSize;             // [bytes] size of this entire section
 f32  RØ_ScalingFactor;
 u16  RØ_Range[HØ_Points];        // [seconds two-way] = RØ_Range * RØ_ScalingFactor
 u16  RØ_unused[HØ_Points & 1];   // ensure 32-bit section size

 // section AØ: bathy point angles, equally-spaced (present only during "equi-angle" spacing mode)

 u16  AØ_SectionName;             // 'AØ'
 u16  AØ_SectionSize;             // [bytes] size of this entire section
 f32  AØ_AngleFirst;              // [radians] angle of first (port side) bathy point, relative to array centerline, AngleFirst < AngleLast
 f32  AØ_AngleLast;               // [radians] angle of last (starboard side) bathy point
 f32  AØ_MoreInfo[6];             // several to-be-determined values such as attitude info to assist the GUI display

 // section A2: 16-bit bathy point angles, arbitrarily-spaced (present only during "equi-distant" spacing mode)

 u16  A2_SectionName;             // 'A2'
 u16  A2_SectionSize;             // [bytes] size of this entire section
 f32  A2_AngleFirst;              // [radians] angle of first (port side) bathy point, relative to array centerline, AngleFirst < AngleLast
 f32  A2_ScalingFactor;
 f32  A2_MoreInfo[6];             // several to-be-determined values such as attitude info to assist the GUI display
 u16  A2_AngleStep[HØ_Points];    // [radians] angle[n] = (32-bit sum of A2_AngleStep[Ø] through A2_AngleStep[n]) * A2_ScalingFactor
 u16  A2_unused[HØ_Points & 1];   // ensure 32-bit section size

 // section I1: 16-bit bathy intensity (present only if enabled)

 u16  I1_SectionName;             // 'I1'
 u16  I1_SectionSize;             // [bytes] size of this entire section
 f32  I1_ScalingFactor;
 u16  I1_Intensity[HØ_Points];    // [micropascals] intensity[n] = I1_Intensity[n]) * I1_ScalingFactor
 u16  I1_unused[HØ_Points & 1];   // ensure 32-bit section size
```

```
  // section GØ: simple straight-line depth gates

  u16  GØ_SectionName;              // 'GØ'
  u16  GØ_SectionSize;              // [bytes] size of this entire section
  f32  GØ_DepthGateMin;             // [seconds two-way]
  f32  GØ_DepthGateMax;             // [seconds two-way]
  f32  GØ_DepthGateSlope;           // [radians]


  // section G1: 8-bit gate positions, arbitrary paths (present only during "verbose" gate description mode)

  u16  G1_SectionName;              // 'G1'
  u16  G1_SectionSize;              // [bytes] size of this entire section
  f32  G1_ScalingFactor;
  struct
  {
    u8   RangeMin;                  // [seconds two-way] = RangeMin * G1_ScalingFactor
    u8   RangeMax;                  // [seconds two-way] = RangeMax * G1_ScalingFactor
  }    G1_Gate[HØ_Points];
  u16  G1_unused[HØ_Points & 1];    // ensure 32-bit section size

  // section QØ: 4-bit quality flags

  u16  QØ_SectionName;              // 'QØ' quality, 4-bit
  u16  QØ_SectionSize;              // [bytes] size of this entire section
  u32  QØ_Quality[(HØ_Points+7)/8]; // 8 groups of 4 flags bits (phase detect, magnitude detect, colinearity, brightness), packed left-to-right

// *** END PACKET: BATHY FORMAT Ø ***
```

14.6 . Snippet Format

```
// *** BEGIN PACKET: SNIPPET FORMAT 0 ***

  u32  PacketName;                   // 'SNI0'
  u32  PacketSize;                   // may be zero in UDP, otherwise: [bytes] size of this entire packet
  u32  DataStreamID;                 // reserved for future use

  // section H0: header (present only in first snippet packet of each ping)

  u16  H0_SectionName;               // 'H0'
  u16  H0_SectionSize;               // [bytes] size of this entire section
  u8   H0_ModelNumber[12];           // example "2024", unused chars are nulls
  u8   H0_SerialNumber[12];          // example "100017", unused chars are nulls
  u32  H0_TimeSeconds;               // [seconds] ping time relative to 0000 hours 1-Jan-1970, integer part
  u32  H0_TimeNanoseconds;           // [nanoseconds] ping time relative to 0000 hours 1-Jan-1970, fraction part
  u32  H0_PingNumber;                // pings since power-up or reboot
  f32  H0_PingPeriod;                // [seconds] time between most recent two pings
  f32  H0_SoundSpeed;                // [meters per second]
  f32  H0_Frequency;                 // [hertz] sonar center frequency
  f32  H0_TxPower;                   // [dB re 1 uPa at 1 meter]
  f32  H0_TxPulseWidth;              // [seconds]
  f32  H0_TxBeamwidthVert;           // [radians]
  f32  H0_TxBeamwidthHoriz;          // [radians]
  f32  H0_TxSteeringVert;            // [radians]
  f32  H0_TxSteeringHoriz;           // [radians]
  u32  H0_TxMiscInfo;                // to be determined
  f32  H0_RxBandwidth;               // [hertz]
  f32  H0_RxSampleRate;              // [hertz] sample rate of data acquisition and signal processing
  f32  H0_RxRange;                   // [seconds two-way]
  f32  H0_RxGain;                    // [∆H0_RxGain = 1; 2dB gain change]
  f32  H0_RxSpreading;               // [dB (times log range in meters)]
  f32  H0_RxAbsorption;              // [dB per kilometer]
  f32  H0_RxMountTilt;               // [radians]
  u32  H0_RxMiscInfo;                // to be determined
  u16  H0_reserved;                  // reserved for future use
  u16  H0_Snippets;                  // number of snippets
  f32  H0_MoreInfo[6];               // several to-be-determined values such as attitude info to assist the GUI display
```

```
  // section S1: 16-bit snippet data (for network efficiency packet may contain several of these sections)
  // (supports snippets up to 32K samples by fragmenting at the IP level rather than by the application like 81xx)

  u16  S1_SectionName;             // 'S1'
  u16  S1_SectionSize;             // [bytes] size of this entire section
  u32  S1_PingNumber;              // pings since power-up or reboot
  u16  S1_SnippetNumber;           // snippet number, Ø to HØ_Snippets-1
  u16  S1_Samples;                 // number of samples in this snippet, sample rate is HØ_RxSampleRate
  u32  S1_FirstSample;             // first sample of this snippet relative to zero range, sample rate is HØ_RxSampleRate
  f32  S1_Angle;                   // [radians] angle of this snippet, relative to array centerline
  f32  S1_ScalingFactorFirst;      // scaling factor at start of snippet, Ø=ignore, use linear interpolation to get other values
  f32  S1_ScalingFactorLast;       // scaling factor at end of snippet, Ø=ignore
  u32  S1_reserved;                // reserved for future use
  u16  S1_Magnitude[S1_Samples];   // [Magnitude] = S1_Magnitude[n] * (linear interpolate between S1_ScalingFactorFirst and
S1_ScalingFactorLast)
  u16  S1_unused[S1_Samples & 1];  // ensure 32-bit section size

// *** END PACKET: SNIPPET FORMAT Ø ***
```

Appendix VII – Drawings

Drawing Index

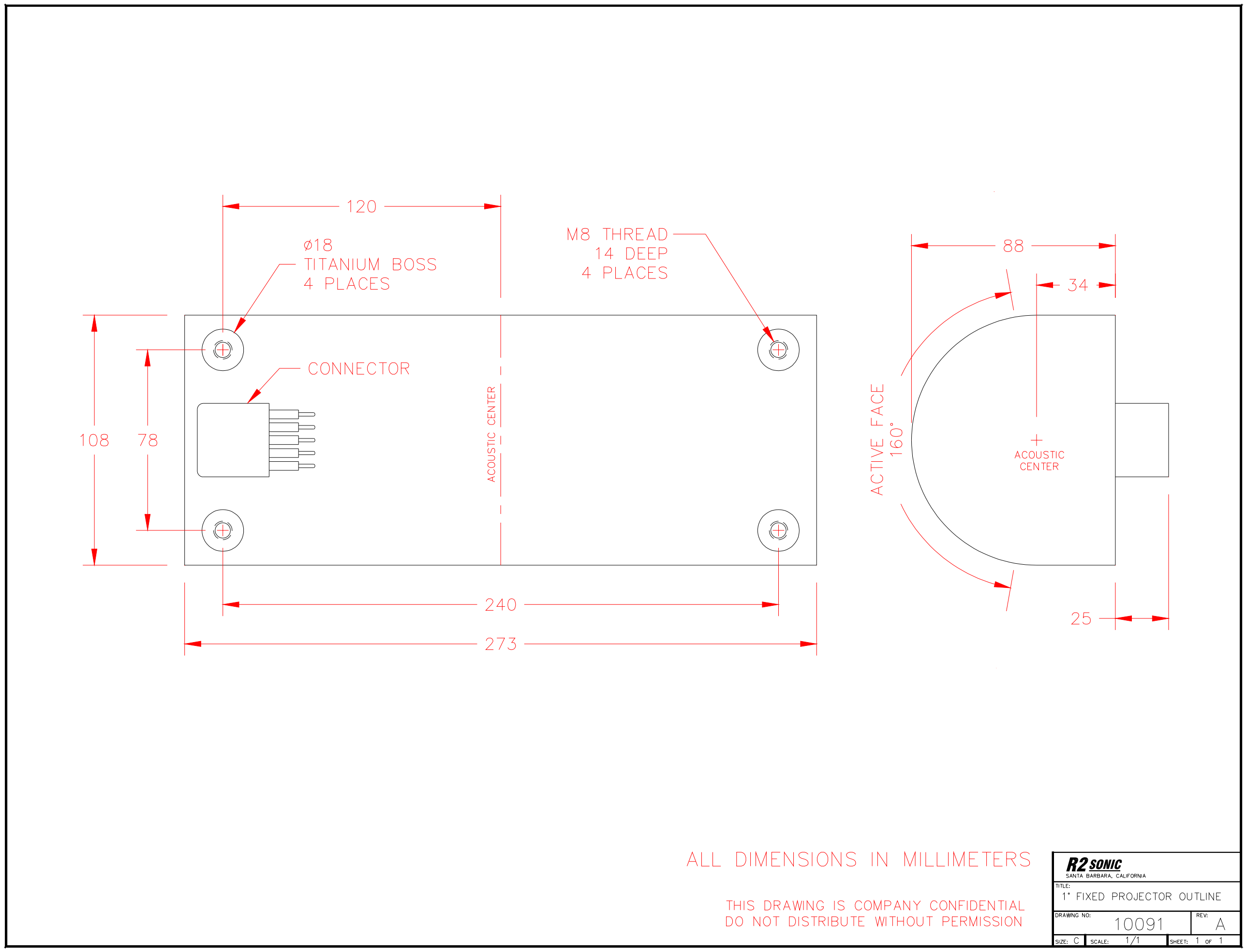

Figure 93: Sonic 2024/2022 Projector

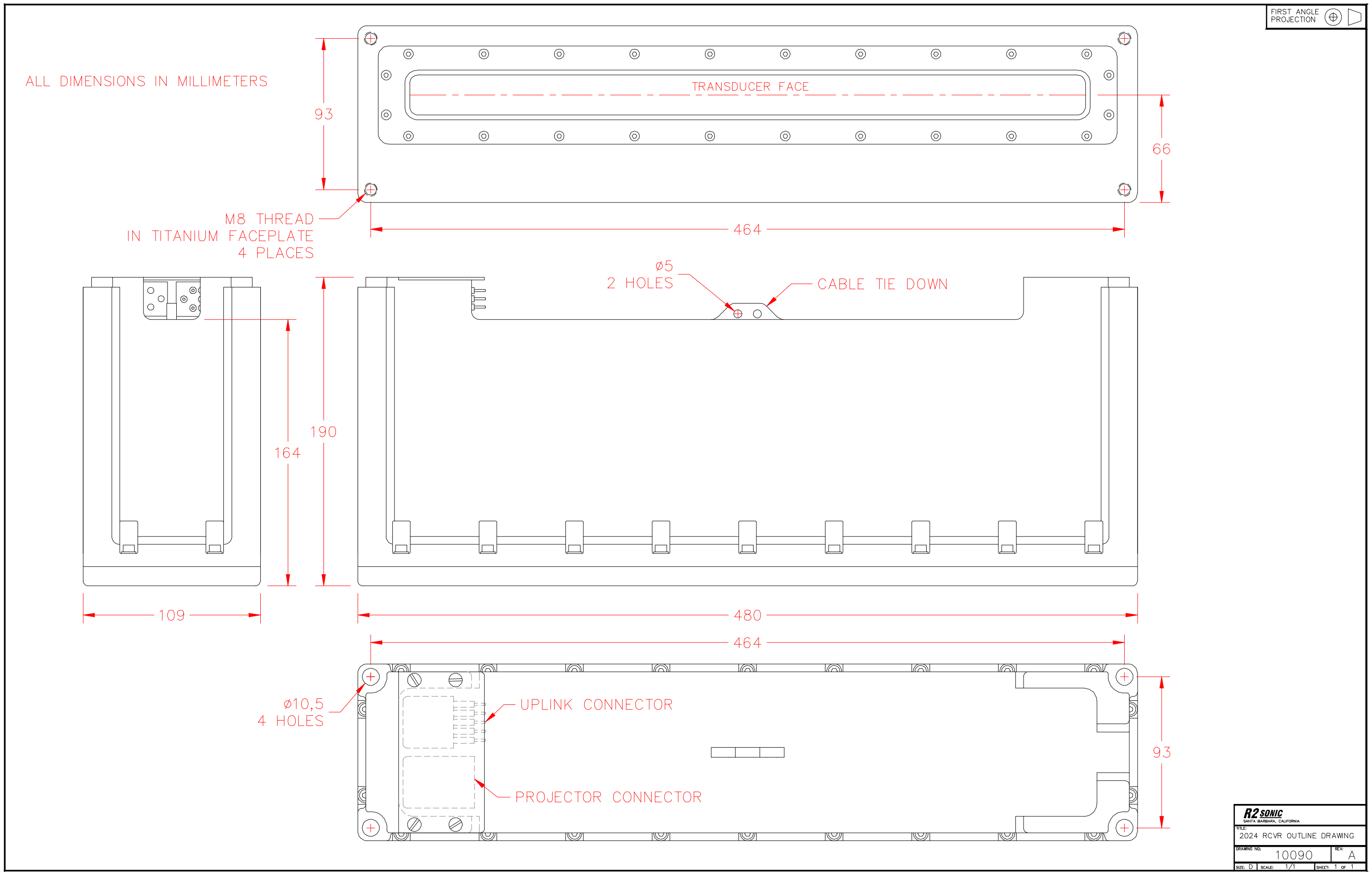

Figure 94: Sonic 2024 Receive Module

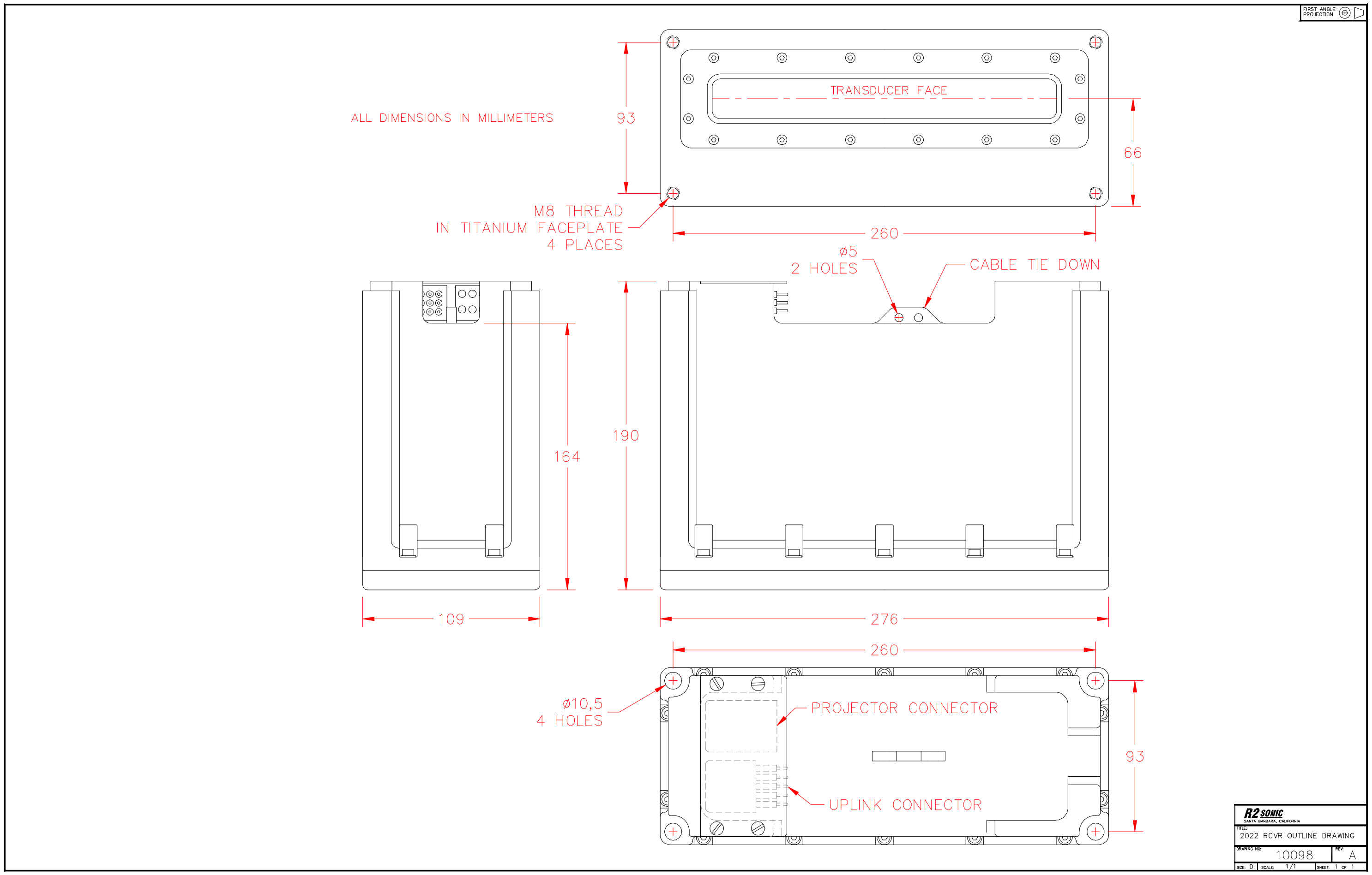

Figure 95: Sonic 2022 Receive Module

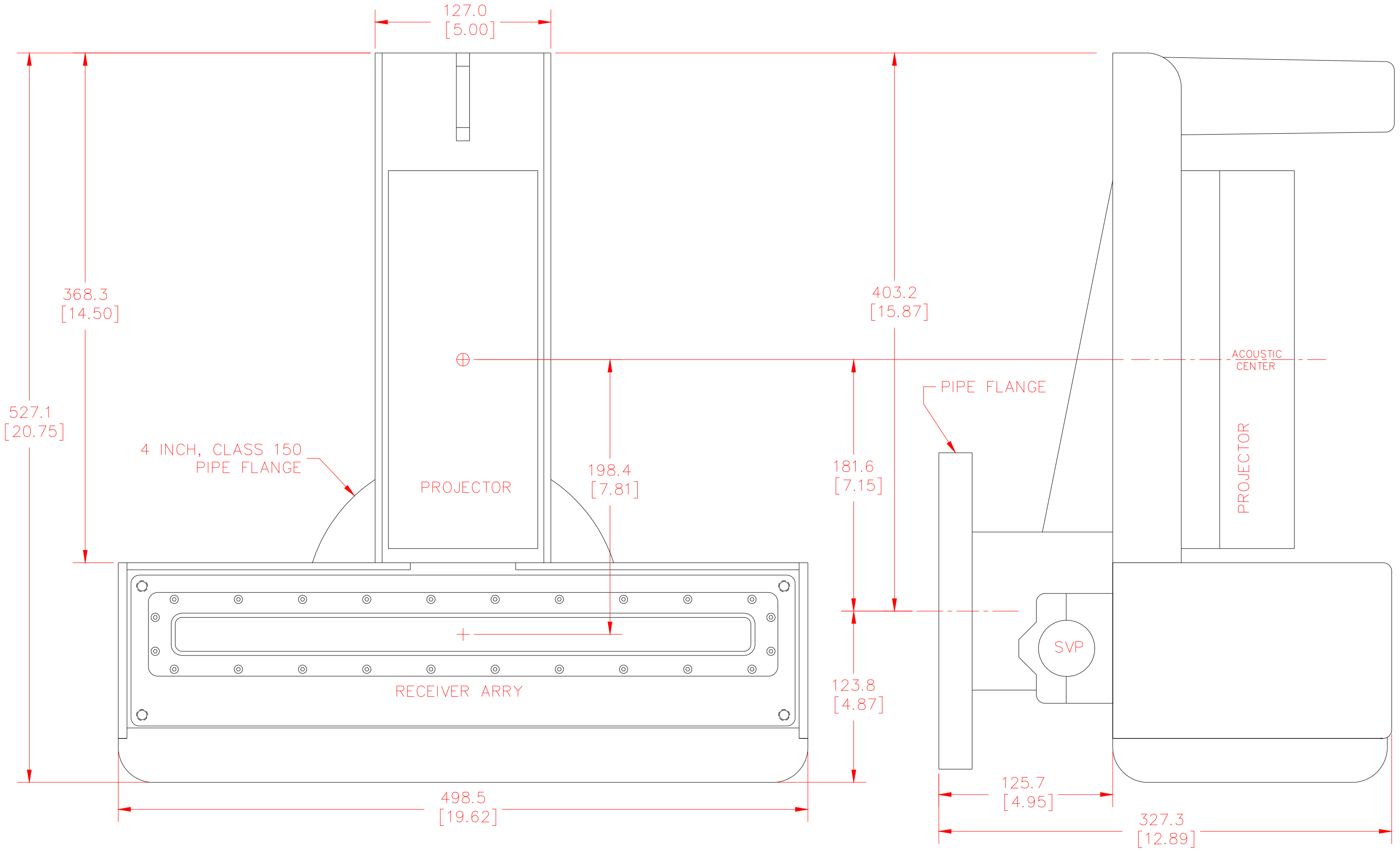

Figure 96: Sonic 2024 Mounting Bracket Drawing 1

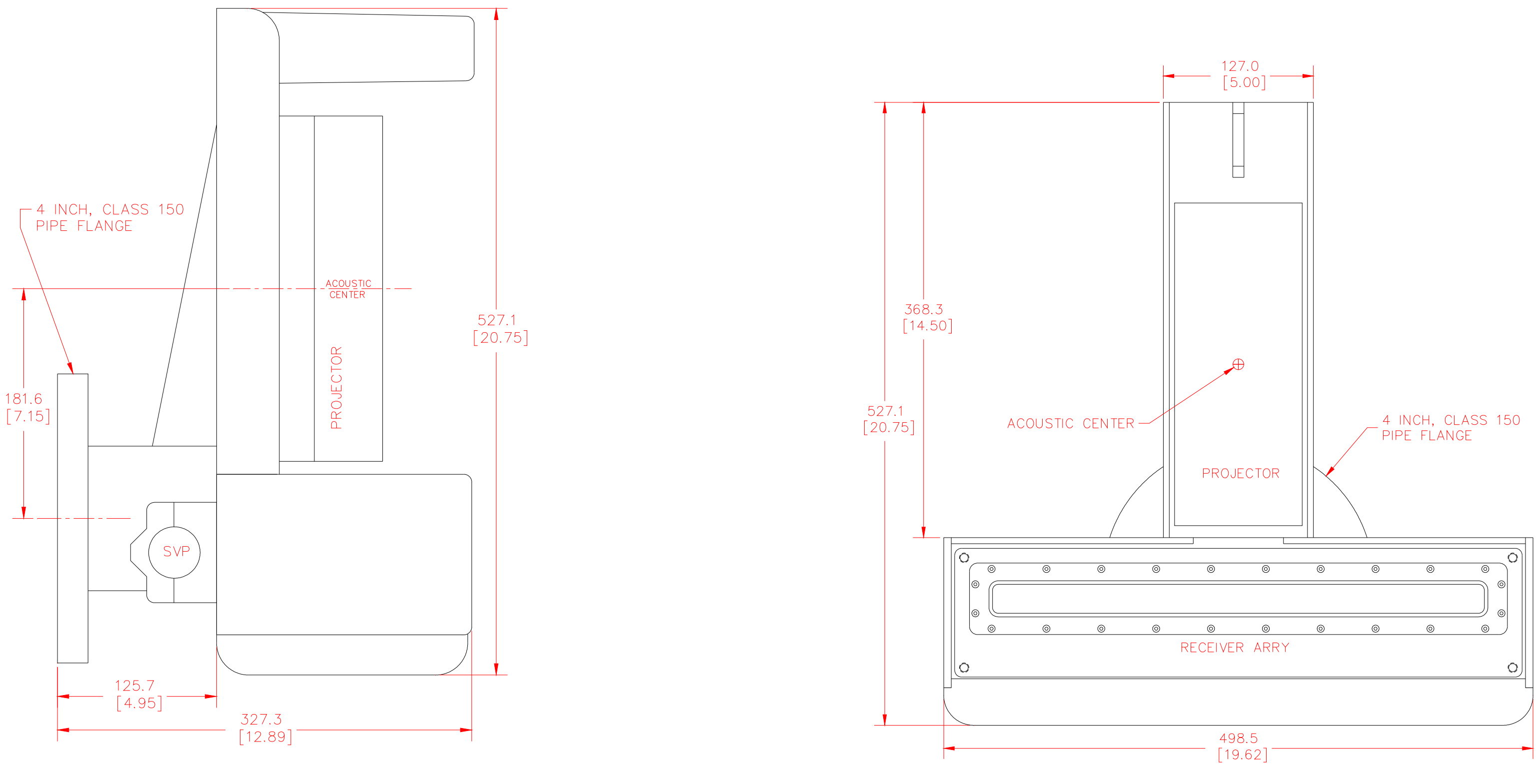

Figure 97: Sonic 2024 Mounting Bracket Drawing 2

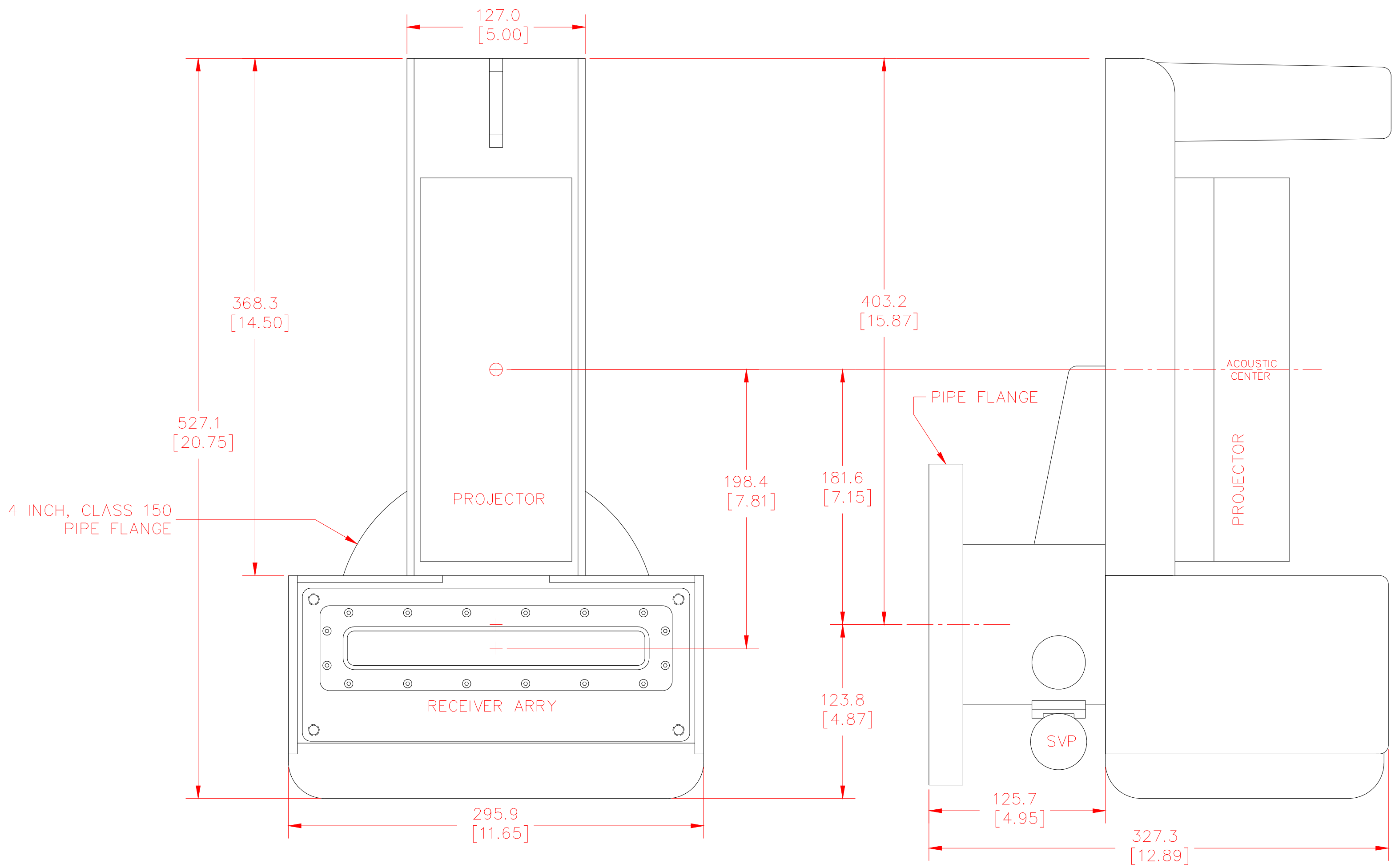

Figure 98: Sonic 2022 Mounting Bracket Drawing 1

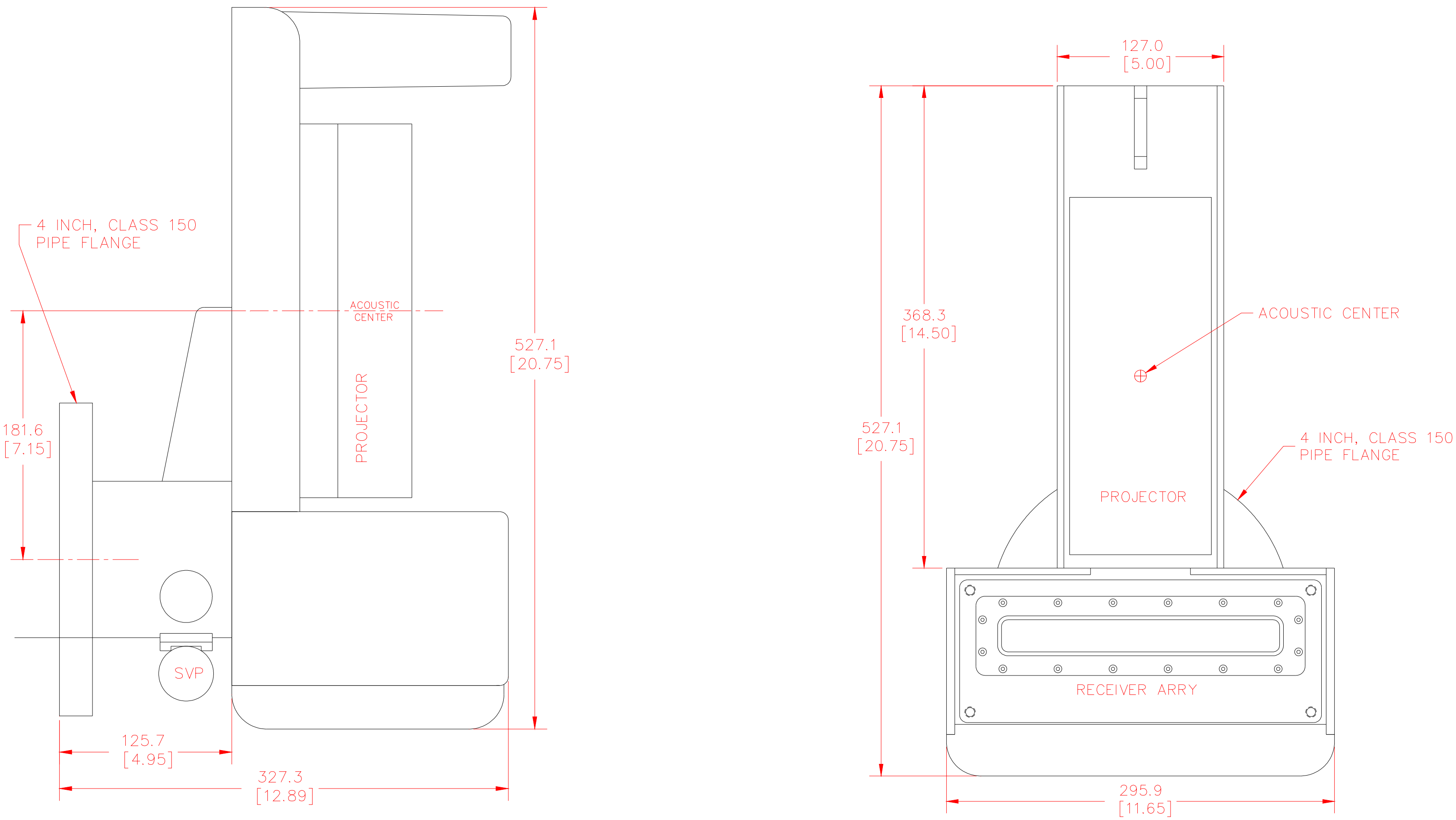

Figure 99: Sonic 2022 Mounting Bracket Drawing 2

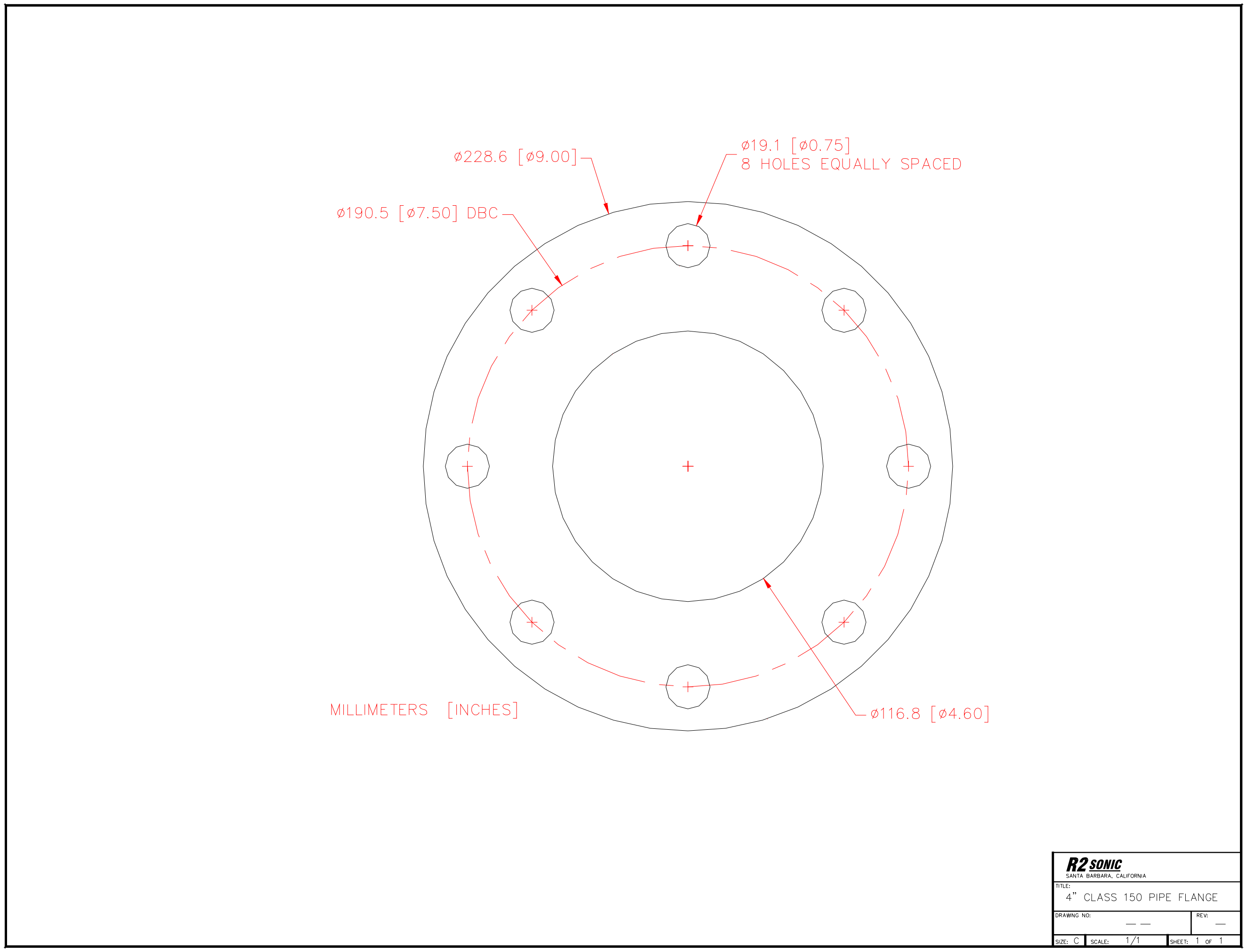

Figure 100: Sonic 2024/2022 Mounting Bracket Flange

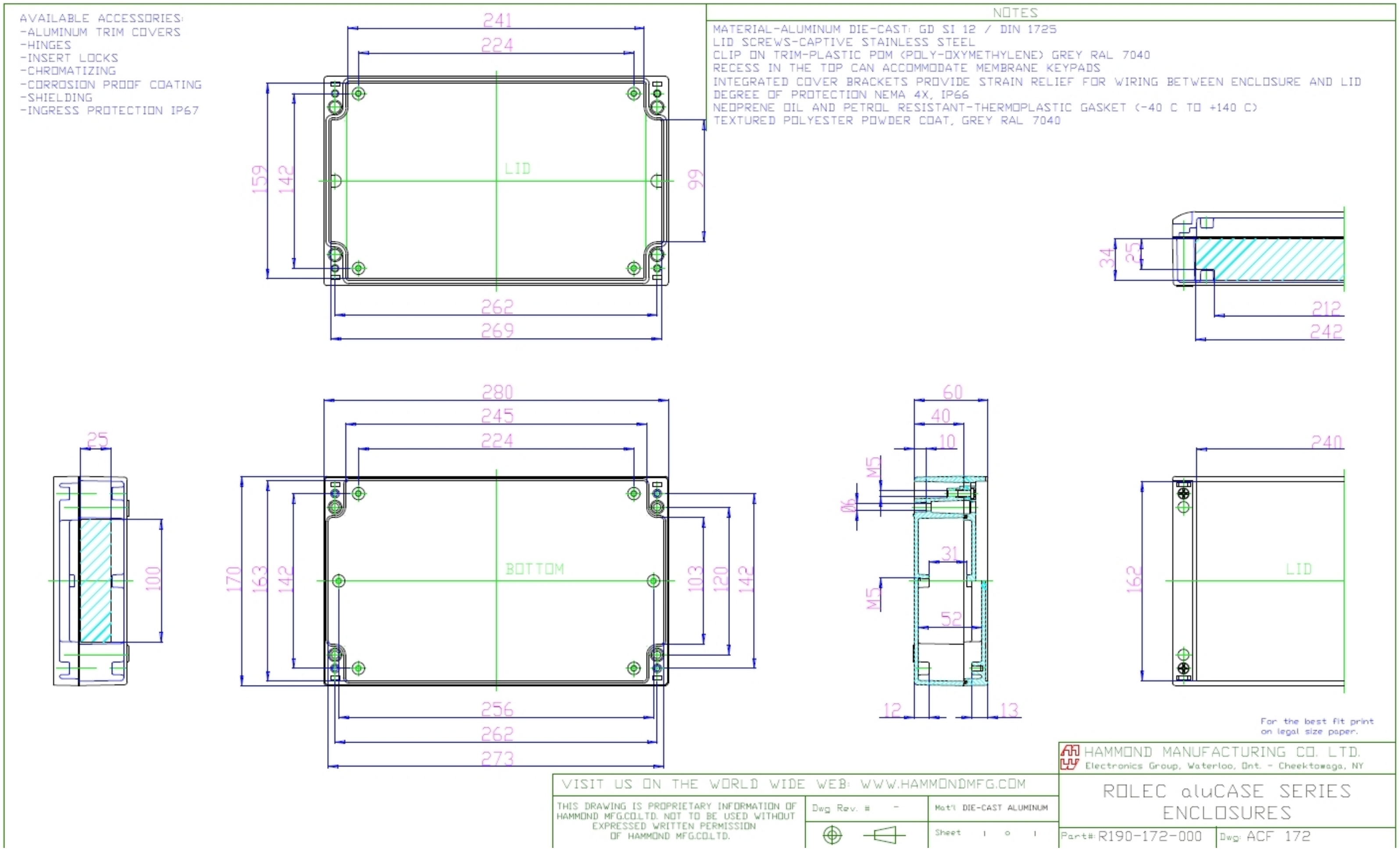

Figure 101: SIM Box Drawing

Version	3.0	Rev	r000
Date	25-08-2010		

Part No. 96000001

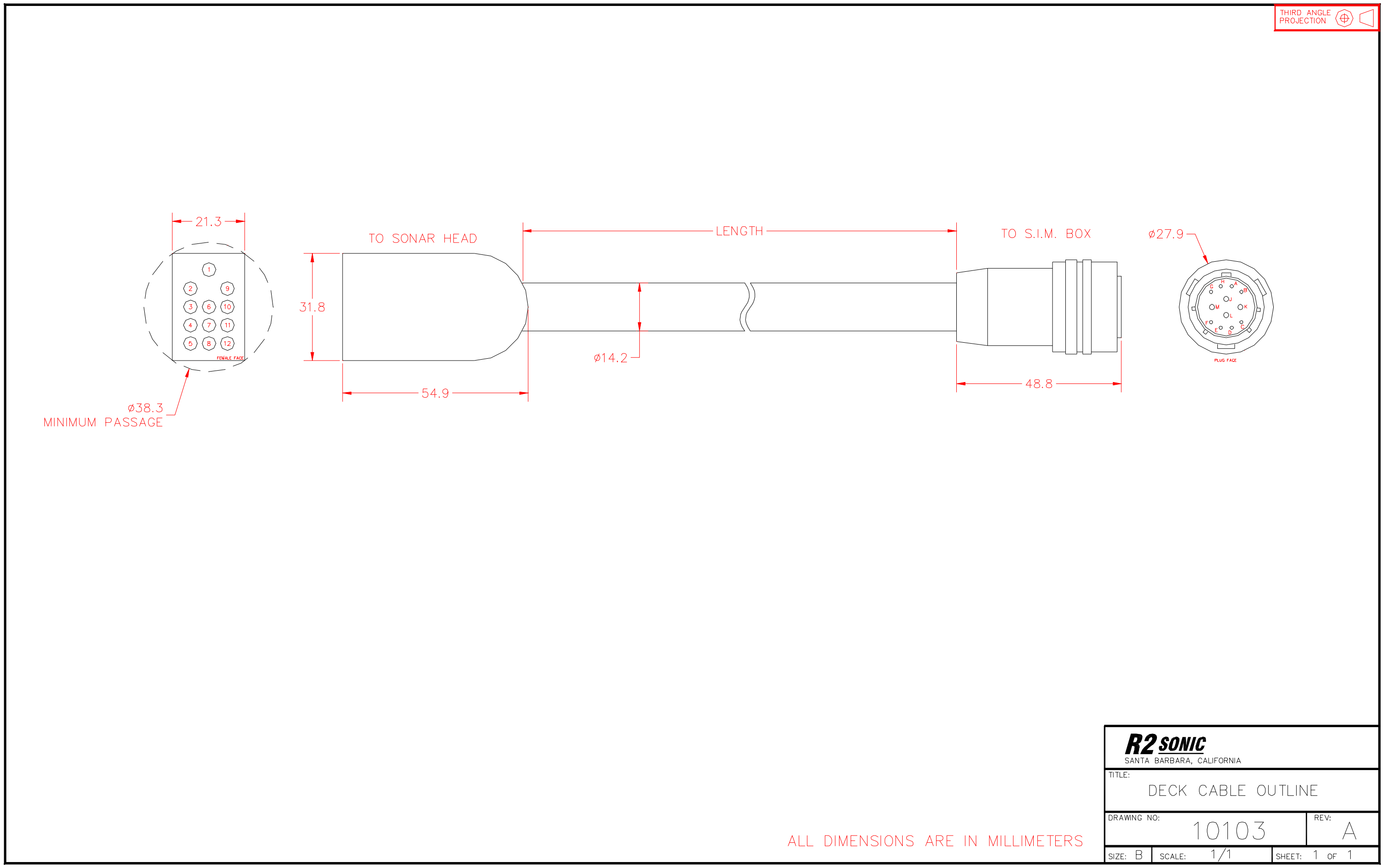

Figure 102: R2Sonic Deck lead minimum connector passage dimensions