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Getting Started Manual

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Voids

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List of modifications

Version	Date	Modifications	Pages	Writer	Checker
5.15	18/10/21	Correction to phase calibration		MFG	
5.14	08/03/21	SWATHplus & BSW-1 phase calibration		MFG	
5.13	27/08/20	Review and update		MFG	
5.12	13/03/20	New Graphic chart	105	FBY	
5.11	16/12/19	Notes on calculating SV		MFG	
5.10	16/09/19	Added note on SVS with Hypack		MFG	
5.09	13/05/19	Warning on making transducer connections in high temperatures, update on BSW-2-UW installation		MFG	
5.07	13/03/19	Clarifications and corrections in "Use with Real-Time Third-Party Applications"		MFG	
5.06	12/07/18	More information on cabling Bathyswath-2		MFG	
5.05	18/08/17	Advice on configuring COM ports, USB, Ethernet and Wi-Fi		MFG	
5.04	20/07/17	SU connector pinout		MFG	
5.03	02/02/17	Added instructions for Bathyswath-UW. Corrected typo in 117k BSW-1 transducer dims.		MFG	JSS
5.02	01/03/16	Review and additions for Bathyswath-STD and -UW		MFG	
5.01	15/01/16	Added transducer phase centre drawings		MFG	
5.00	13/05/15	ITER Systems format, check		MFG	
4.02	07/13	Previous format	102	MFG	N/A

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1 INTRODUCTION

1.1 REFERENCES

Ref 1 Bathyswath Technical Information.
Ref 2 Bathyswath Grid Processor Manual, “Bathyswath Grid Processor Manual.pdf”.
Ref 3 Installing Bathyswath, “Installing Bathyswath.pdf”.
Ref 4 Bathyswath Online Help; installed with the Bathyswath software
Ref 5 swathRT manual, “ETD_2020_Bathyswath_swathRT manual.pdf”
Ref 6 ITER Systems website, at http://iter-systems.com. In particular, see the support pages, at https://www.iter-systems.com/downloads-technical-documents/

1.2 GLOSSARY & ACRONYMS

ACRONYMS	DEFINITION
PPS	A system of electronic pulses for synchronising subsystem clocks
3D	Three-dimensional
AGDS	Acoustic Ground Discrimination System: a system that uses data from an echosounder to determine the type of the seabed
ASCII	A common computer format for human-readable text data
Attitude	The angular orientation of the system
AUV	Autonomous underwater vehicle
Bathymetry	Measuring depth
Bathyswath-H	High-frequency Bathyswath variant, working at 468kHz
Bathyswath-L	Low-frequency Bathyswath variant, working at 117kHz
Bathyswath-M	Medium-frequency Bathyswath variant, working at 234kHz
Bathyswath-UW	A Bathyswath system with the electronics, motion sensor and sound velocity sensor installed in an underwater bottle.
Beam-former	A sonar system that generates discrete beams of angular measurement to the seabed. Synonymous with ‘multibeam’.
CAD	Computer-aided design: computer software drawing packages
Chart datum	A nationally or internationally agreed baseline for height measurement
COTS	Commercial-off-the-shelf: i.e., bought from a shop, rather than specially built for a one-off job
DC	Direct current
DGPS	Differential GPS: improves the accuracy of basic GPS by comparing the position obtained by a GPS system with that obtained at a fixed GPS station at a known location
DTM	Digital Terrain Model: a digital ‘map’ of the seabed, where depth and sidescan data are stored with reference to their geographical position
DVD	Digital versatile disk
EMC	Electromagnetic compatibility: robustness to external electrical ‘noise’ signals, and limiting transmission of such unwanted signals
Ethernet	A commonly used method for connecting computers together in local networks
FPGA	Field Programmable Gate Array: a digital electronic logic chip that can be programmed to carry out a set of tasks

ACRONYMS	DEFINITION
GMT	Greenwich Mean Time; time zone; the Bathyswath software works in GMT
GNSS	Global navigation satellite system
GPS	Global Positioning System: a type of GNSS
Grazing angle	The angle that a sound ‘beam’ makes with the seabed
Grid file	The file used by the Grid Processor application to store its data. Uses an ‘.sxg’ file extension.
Horizontal range	The maximum reach of the sonar, measured horizontally along the seabed; compare with ‘Slant range’
Hydrography	Measurement of physical characteristics of waters; commonly used to refer to those measurements and descriptions of navigable waters necessary for safe navigation of vessels
Interferometer	A sonar system that measures depths by comparing the phase of the signal received on a set of vertically separated transducer staves. Also called ‘Phase Differencing Bathymetric System’ (PDBS)
Inverter	A unit that provides mains (120 or 240V AC) power supply from a DC supply, usually from a battery
ITS	ITER Systems
Line spacing	The distance between survey lines run across the seabed
LVC	Line Voltage Conditioner: a unit that ‘cleans’ a power supply, to reduce the effects of ‘noise’ or possibly damaging ‘spikes’ in the supply
Multibeam	See ‘Beam-former’
NMEA	National Marine Electronics Association: the NMEA 0183 format is commonly used to send data from marine electronics equipment such as compasses and positioning systems
Noise	Unwanted signal
NTP	Network Time Protocol: a method for synchronising computer clocks over a network
Online help	The electronic user manual that is accessed directly from Swath Processor
Patch test	A method used to calibrate the relative locations and angles of the components of a survey system, by comparing depth results from overlapping survey runs
PC	Personal Computer
PC Clock	Recording the time of a data sample using the time of the computer’s clock at the instant the sample is received in the software. Compare with ‘Sensor Clock’
PDBS	Phase Differencing Bathymetric System; see ‘Interferometer’
Ping	A complete transmit-receive cycle, measuring depth and sidescan information over a profile of the seabed. Also sometimes used to refer to just the transmitted acoustic signal.
Post-processing	Processing sonar data after it has been collected; compare with ‘real time’
PRF	Ping (or pulse) repetition frequency: the number of pings emitted per second

ACRONYMS	DEFINITION
Profile	A 2D set of depth measurements, usually taken sideways from a survey vessel
PSU	Power Supply Unit
QA	Quality assessment
Raw data file	The file used by the Swath Processor application to store raw data. Uses a '.sxr' file extension.
Real time	Data processing at the same time as data is collected; compare with 'Post-processing'
RF	Radio frequency
RIB	Rigid inflatable boat
ROV	Remotely operated vehicle: an unmanned underwater vehicle that is connected to a surface vessel by a cable and controlled by a human operator
RS232	A commonly used format for serial data connections
RTK	Real-time kinematic GPS: an accurate form of GPS measurement
Sensor Clock	Recording the time of a data sample using a clock maintained inside the sensor itself. Compare with 'PC Clock'
Session file	The file used by the Swath Processor application to store its settings. Uses a '.sxs' file extension.
Sidescan	Images of the seabed using the amplitude (strength) of the acoustic returns from the seabed. These are usually represented as grey pixels in a 'waterfall' display on the screen, with the brightness of pixels representing the strength of the signal.
Slant range	The maximum reach of the sonar, measured in a direct line from the sonar transducers to the seabed; compare with 'Horizontal range'
Spreading loss	Reduction of the amplitude of the sonar signal as it passes through the water
Squat	Change in height of a vessel in the water as the vessel moves
Survey line	An area of the seabed is usually surveyed by running a series of parallel straight lines across it
Swath	The Swath Processor application
swath	A 'ribbon' of seabed depth measurements, made up of a series of 'profile' measurements of depth as the sonar is moved forwards over the seabed
SWATHplus	Previous versions of the Bathyswath sonar were called "SWATHplus"
swathRT	A real-time data acquisition and control program for Bathyswath, which can be compiled to run on Linux, Windows, and other operating systems
Swath-sounding	Measuring the depth in a line extending outwards from the sonar transducer, then moving forwards to build up swaths
TCP/IP	A data format used to transfer data over Ethernet. UDP/IP (UDP) is another type. TCP/IP is a more reliable protocol, but is slightly slower.
TEM	Transducer Electronics Module: provides the input and output electronics for one sonar transducer
Third-party software	Software that is produced by organisations other than Bathyswath or its clients

ACRONYMS	DEFINITION
TIU	Transducer Interface Unit: the box containing the TEMs
Transducer	The component that is placed in the water and converts sound energy into electrical signals and vice versa
TVG	Time-varying gain: an adaptable gain correction applied to sidescan data to remove the gross changes in amplitude caused by range and transducer beam shape, leaving an image of the seabed itself
UDP	User Datagram Protocol; see 'TCP/IP'
UPS	Uninterruptible Power Supply: a power supply that maintains a mains power supply from battery if the mains supply (e.g. from a generator) fails
USB	Universal Serial Bus. A common computer peripheral interface.
USV	Unmanned surface vehicle
UTC	Coordinated Universal Time; a time zone, equivalent to GMT
UTM	Universal Transverse Mercator: a commonly used format for representing latitude and longitude positions in a plane representation as Easting and Northing
UUV	Unmanned underwater vehicle; usually synonymous with AUV
V-bracket	The V-shaped mechanical assembly that holds a pair of transducers
XTF	An industry-standard data format commonly used for sidescan data. These files use a '.xtf' file extension.
xyz	A position in three-dimensional space
xyza	Three-dimensional position plus amplitude
ZDA	An NMEA 0813 protocol message that is used with PPS signals to synchronise subsystem clocks

1.3 PREFACE

The Bathyswath documentation is divided into three main parts:

Technical Information – a summary of the technical parameters of the Bathyswath systems [Ref 1]

Getting Started – (this document) the normal text part of the documentation, which introduces Bathyswath and covers aspects such as software and hardware installation and deployment.

Online User Guide - covering all aspects of using the Bathyswath as a hydrographic surveying tool. The guide is accessed from the Swath Processor **Help menu.** It can also be accessed directly from the Swath Processor software by using the 'F1' key on the computer keyboard, to provide context-sensitive help. [Ref 4]

Grid Processor manual – this provides instruction for using the Bathyswath Grid Processor program. It can be accessed from the Help taskbar menu. [Ref 2]

In addition, there are:

Installation instructions – the software and other components are supplied with specific installation instructions, which build on the installation guides provided in this manual. [Ref 3]

Bathyswath Website [Ref 6] – this has a large amount of technical information about the product, including FAQs, which are updated as users ask questions.

Auxiliary equipment manuals – If Bathyswath is supplied with auxiliary equipment, such as attitude sensors, positioning systems and compasses. These will be supplied with their own manuals and/or online guides, and the operator should read these before using the system.

1.4 FOR NEW USERS

We suggest you start by reading "Bathyswath Technical Information" [Ref 1] as an introduction to Bathyswath. Then, read the rest of this manual for guidance on installing the hardware and software. Once the Bathyswath software is installed, you can access the Online User Guide from the Help menu of the software. The online information is provided in topics and has been structured to lead you through using Bathyswath as a hydrographic surveying tool. You can find information via the contents, index or full text search. From any topic, you can follow the hyperlinks (shown in coloured text and underlined) to see additional information on the same topic or related topics.

Section 3 provides a Quick Start guide for first-time users of Bathyswath.

All Bathyswath users should carefully read the safety instructions in section 2.

1.5 BATHYSWATH WEB PAGE

Latest information on Bathyswath and related products can be found on the ITER Systems web page: www.iter-systems.com. In particular, see the support pages, at https://www.iter-systems.com/downloads-technical-documents/

1.6 BATHYSWATH SUPPORT

Technical support is available from Bathyswath. Time-limited support may be provided with the sale, after which yearly support packages can be purchased. A convenient route to support is to email support@iter-systems.com

Clients who have purchased support, and new clients in the first year after purchase, can access the latest software and other useful tools from ITER Systems.

2 HEALTH & SAFETY

2.1 CAUTION

The information given in this manual is the best that is available at the time of issue but must be used with discretion. The text in this manual does not override statutory requirements concerning good work practices or safety precautions. All warning signs on equipment must be obeyed.

Where the ⚠ symbol appears in the margin, special attention should be given to health & safety considerations.

2.2 IMPORTANT NOTICES

All personnel are required to study these notices and familiarise themselves with all applicable safety precautions and bring them to the attention of others in the vicinity.

2.2.1 Lethal voltage warning

LETHAL VOLTAGE WARNING
VOLTAGES WITHIN THIS EQUIPMENT ARE SUFFICIENTLY HIGH TO ENDANGER LIFE.
COVERS MUST NOT BE REMOVED *EXCEPT BY PERSONS QUALIFIED AND AUTHORISED TO DO SO AND THESE PERSONS SHOULD ALWAYS TAKE E*___XTREME CARE___ *ONCE THE COVERS HAVE BEEN REMOVED.*

A current of 100 milliamps passing through the human body for one second can kill. This can occur at voltages as low as 35V ac or 50V dc. Some Bathyswath equipment uses electrical power that can be lethal. Whenever practicable, before carrying out installation, maintenance or repair; personnel involved must:

1. Isolate the equipment from the electrical supply.
2. Make tests to verify that the isolation is complete.
3. Ensure that no one can accidentally reconnect power.

If it is essential to work on the equipment with power connected, work must only be undertaken by qualified personnel who are fully aware of the danger involved and have taken adequate safety precautions to avoid contact with dangerous voltages.

2.2.2 Use environment

The Bathyswath-1 Transducer Interface Unit is intended for use on-board in a protected area and not directly exposed to the outside environment.

The Bathyswath-2-STD and Bathyswath-2-Omega Deck Units are designed for use on deck or in open boats, and are designed to be watertight to IP66. However, they should not be mounted in a location where it will be submerged for long periods of time.

2.2.3 Compass safe distance

It is recommended that the Bathyswath equipment be installed greater than 5m from a standard or steering magnetic compass. This equipment has not been tested or verified as meeting the compass safe distance specification in EN60945.

2.2.4 EMC requirement conformity

The Bathyswath-1 Transducer Interface Unit meets the EMC (electromagnetic compatibility) requirements of EN60945, and is therefore 'CE marked'. CE testing for Bathyswath-2 is pending, but no issues are anticipated.

2.2.5 Safety on deck

At all times when working on deck, observe all reasonable safety precautions. The following is a guide to safe working practice:

1. On deck, wear hard hats at all times.
2. On deck, wear life vests and safety lines at all times.
3. On deck, suitable deck boots or safety boots/shoes must be worn at all times.
4. On deck, wear suitable clothing at all times.
5. Do not work alone on the deck. A minimum of two operators is required, with the second operator observing.
6. When working during the hours of darkness, suitable flood lighting must be available to cover the area of operation.

It is the responsibility of all personnel to take all reasonable precautions to ensure their own safety and that of others working with them.

2.2.6 Safety aloft

If required to work aloft (i.e. installing GPS etc.), personnel must bring this to the attention of someone in authority at deck or at ground level. Place warning notices that work aloft is in progress. Ensure that the means of access aloft is secure and beware of wet or slippery ladder rungs and working areas. When working on or near a radar scanner and other moving or radio frequency radiating equipment, ensure that they are switched off and that the fuses have been removed and retained.

2.2.7 Personal protection

Whenever the possibility of an uncontrolled hazard exists, wear personal protection. For example, wear suitable gloves when handling deck-cables, etc. Other items of protection include hard hats, life vests, ear protection, work overalls and safety glasses.

2.2.8 Health hazard

The inhalation of dust and fumes or any contact with lubricants when cleaning the equipment may be temporarily harmful to health, depending on individual allergic reactions. Treat with caution components that are broken or overheated as they may release toxic fumes or dust. Do not inhale the fumes and ensure that the dust and debris do not enter open cuts or abrasions. It is prudent to regard all damaged components as being potentially toxic, requiring careful handling and appropriate disposal.

2.2.9 Radiation hazard: non-ionising

Most countries accept that radio frequency (RF) with mean power density levels up to 10mW/cm^2 present no significant hazard. RF power levels in excess of this may cause harmful effects, particularly to the eyes. No part of the Bathyswath equipment produces this level of radiation.

Users of cardiac 'pacemakers' should be aware that radio frequency transmissions might damage such devices or cause irregularities in their operation. Persons using a 'pacemaker' should ascertain whether their device is likely to be affected before exposing themselves to the risk of a malfunction.

2.2.10 Environmental impact: marine mammals

The Bathyswath sonar frequencies are above the frequencies and below the power levels that are known to cause harm and distress to marine mammals. Nevertheless, caution should be exercised in areas known to be used by whales, porpoises, and dolphins.

2.2.11 Firing the transducers in air

Bathyswath-2 transducers may be damaged if operated at high power in air. It is usually safe to do so with Bathyswath-1 and SWATHplus transducers.

2.3 SAFETY TRAINING

Most countries with an offshore industry have organisations that offer training in offshore safety. Many companies that carry out work offshore require that workers should possess an up-to-date certificate of such training. We strongly recommend that operators obtain the appropriate safety training.

3 QUICK START

This section is aimed at new users of Bathyswath, and gives a step-by-step guide on how to use Bathyswath for the first time.

We recommend that new users read “Bathyswath Technical Information” [Ref 1], before starting to use the system.

If you are using the system operationally, on the water, carefully read section 2, Health and Safety.

3.1 ONLINE HELP

The main reference for Bathyswath is the online help. This Getting Started manual is a quick start guide takes you as far as starting up the software, to the point where you can use the online help alongside the software.

3.2 INSTALLATION

See the Installation Guide [Ref 3] for instructions on installing the Bathyswath software, and then read section 8 for guidance on how to configure it for use with your sonar hardware.

3.2.1 Survey or Post-Processing

If you are using Bathyswath for surveying, you will first need to install the system hardware (read section 4).

If the software is being used for post-processing or training, it can be used without the Bathyswath hardware.

3.3 TURNING ON

If you are running the Bathyswath software without the survey hardware on your desktop or laptop computer, proceed to section 3.4.

Before turning anything on, perform a quick safety check; see section 11.1.1.

Make sure that the system power is active: this might be DC or mains. Turn on all the auxiliary systems: such as attitude system, position system, and compass.

If starting up in cold and/or damp conditions, particularly if the temperature is below freezing, use the cabin heater to bring up the conditions to a temperature above freezing, and so that there is no condensation on internal surfaces. Otherwise, as the computer and electronics warm up, they may experience internal condensation, which could cause damage.

Turn on the system computer.

Turn on the Bathyswath hardware.

3.4 STARTING THE SOFTWARE

The Bathyswath installer places shortcuts to the software in the Windows Start menu. Click on the start menu in the bottom-left corner of the screen, select ‘Programs’, ‘Bathyswath, then ‘Bathyswath’, and finally click on ‘Online Help’. This is the online help system.

Find the ‘Welcome’ page, and go from there.

The main Bathyswath programs, the ‘Swath Processor’ and ‘Grid Processor’ can also be started from the ‘Bathyswath’ start menu, as can a soft copy of this ‘Getting Started’ manual.

These programs can also be started by double-clicking on file icons for the Swath Processor 'session files' (*.sxs) and the Grid Processor grid files (*.sxg) in Windows Explorer.

See section 8 for more detailed instructions on starting the software.

4 HARDWARE INSTALLATION AND DEPLOYMENT

Bathyswath has been designed to be utilised on a variety of inshore survey craft. The systems are capable of being deployed permanently on dedicated survey vessels, or vessels of opportunity, such as fishing vessels and harbour master's launches. There are several methods of mounting the transducers and the attitude sensor:

- Hull mounted transducers, remote attitude sensor,
  (see sub section 4.14)
- Bow mounted pole mount, attitude sensor alongside transducers,
  (see sub-section 4.15)
- Over-the-side pole mount, attitude sensor alongside transducers,
  (see sub-section 4.16)
- Buoy mount.
  (see sub-section 4.17)

Bathyswath can also be installed on remote vehicles, such as remotely operated vehicles (ROVs), unmanned or autonomous underwater vehicles (UUVs or AUVs) and autonomous surface vehicles (ASVs). Installation on such vehicles usually requires interfacing and installation design specific to each vehicle. ITER Systems can provide detailed advice on request.

4.1 EQUIPMENT LIST

4.1.1 Bathyswath parts list, main assemblies

Part	*Qty*
Sonar transducer array, 468 kHz, *or* Sonar transducer array, 234 kHz, *or* Sonar transducer array, 117 kHz	2 or 3 2 or 3 2 or 3
Transducer Interface Unit (TIU) This could be a Deck Unit, (in Bathyswath-STD) Subsea Unit (in Bathyswath-UW), or, for older systems, a “Blue Box” or Pelicase unit (Bathyswath-1 and SWATHplus).	1
Software: Swath Processor, Grid Processor	1

4.1.2 Additional (and optional) equipment required for operational use

Part	*Qty*
Attitude and position information system	1
Computer (PC)	1
Pole-mount transducer V-bracket, 468 kHz, or	1
Pole-mount transducer V-bracket, 234 kHz, or	1
Pole-mount transducer V-bracket, 117 kHz, or	1
Variable-angle transducer V-bracket	1

Pole-mount pole assembly	1
Bow-mount assembly	1
Lightweight data and acquisition software for Linux or Windows: swathRT	1

4.1.3 Variable-angle transducer chassis

The standard transducer V-brackets are set up with a fixed transducer elevation angle of 30°. This has been found to be a good compromise for most survey work. However, for depths close to, or even exceeding, the stated depth capability of a particular sonar frequency, a transducer angle of 40° to 45° may give better results. A variable-angle transducer V-bracket can be supplied for this purpose.

4.2 SYSTEM DETAILS

See Technical Information [Ref 1] for the dimensions, power consumption and other parameters of Bathyswath system components.

4.2.1 Cabling required for a typical two-transducer installation

Cable name	*From*	*To*	*Type*	*Number of conductors*	*Diameter /mm*
Transducer Port	Port Transducer	DU or SU	Screened Twisted Pair ITS part 60263	7 screened pairs	12.0
Transducer Starboard	Starboard Transducer	DU or SU	Screened Twisted Pair ITS part 60263	7 screened pairs	12.0
Spider Cable	DU or SU	PC, PSU & PPS	ITS part 60204	Various	Various
-	Spider Cable	PC	Ethernet	2 screened pairs	4
-	Spider Cable	PSU	Screened Twisted Pair	2	4
-	Spider Cable	Position System (for PPS)	Coax	2	4
Umbilical Cable	DU or SU	Spider cable	ITS part 60211	21	16.5
Attitude Sensor Serial (PC)	Attitude Sensor	PC	Screened Twisted Pair	3 screened pairs	10
Compass Serial (PC)	Compass	PC	Screened Twisted Pair	3 screened pairs	10
Position Serial Input	Position System	PC	Screened Twisted Pair	3 screened pairs	10
Alternative attitude & position, Ethernet	Attitude & position system	PC	Ethernet	Screened pairs	5

Notes: All dimensions and weights are approximate.

A Spider Cable connects the Fisher waterproof connector on the Deck Unit, or the Wet-Mate connector on the Subsea Unit to standard connector types, e.g. RJ45 for Ethernet, BNC for PPS, barrel connector for power, etc. The Umbilical Cable connects the Subsea Unit to the Spider cable, in effect extending the spider cable. The Umbilical Cable is the only cable required to run from the Subsea Unit to the topside. See section 5.2.

Few modern PC computers are fitted with serial ports, so a serial interface unit is required. Ethernet-to-serial converters are convenient, and have the advantage of not connecting the sensor ground to the PC, thus reducing noise and ground loops, as Ethernet is a differential system. We have used Moxa NPort units successfully for this. If the Subsea Units is fitted with the optional Ekinox motion sensor, then this requires GPS data to be sent to it over an Ethernet UDP port; a serial-to-Ethernet unit can be used for this. USB to serial converters also work well.

4.3 POWER REQUIREMENTS

Bathyswath TIU Parameter	***Value***
Supply Voltage	110 -230V AC (50/60 Hz), or 9-36V DC
Supply Power	20 W or less, depending on transmit power
	Bathyswath 1 & SWATHplus: 25 W
Power Supply Fuse	3A 250 V slow-blow type (Bathyswath-1)

Bathyswath requires clean electrical power of 9-36V DC, approx. 10-20W, not including the power needed for the PC and for auxiliary systems, such as attitude and position. The system is supplied with a mains-to-DC converter, so that it can also be run from 110-240V AC mains.

Inverters can also be used to provide mains power from batteries. These sometimes give a very noisy output, so it is advisable to use high-quality units, or use the DC directly.

Small generators are available that provide 12V DC or 24 V as well as mains AC power, and are acoustically quiet. These units can be useful on small vessels.

Refer to section 4.10 for advice on grounding and earthing power supplies.

4.3.1 Supplying Power from Batteries

The Bathyswath Transducer Interface Unit (TIU) is suitable for receiving power from a 12V battery, or two such batteries in series. Equipment that requires mains can be supplied from an inverter. However, it is preferable, and safer, to use DC-powered equipment on small boats where possible. For example, when using a laptop computer, use a DC power supply in preference to the mains supply unit that came with the laptop. Such DC power units are sold for use in motor vehicles.

Some survey systems require both 12V and 24V. See Figure 4-1 for a recommended layout.

Warning

When supplying power from two batteries in series, in systems where both 24V and 12V are needed, **all units that require 12V must be powered from the "lower" of the two batteries** (the one that is not supplying the 24V output). Otherwise, the voltage of one of the batteries could be connected directly through the ground or negative power lines, causing serious **equipment failure** and a risk of over-heating and **fire**.

It is good practice to establish a single ground point for mains ground and DC power negative rails. See section 4.10.

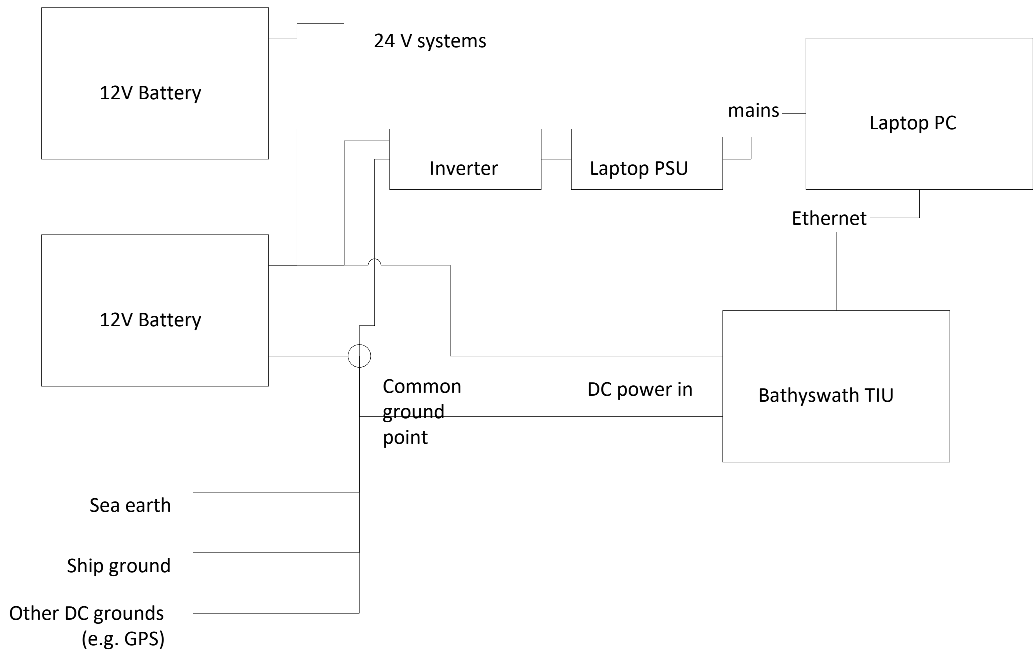


Figure 4-1 Recommended 12V-24V Power Connection

4.4 PC INSTALLATION

Bathyswath operates with a Windows compatible PC. The PC provides the operator interface and controls. See Section 8.1.1 for the recommended PC specification and information on installing the software. Laptop and tablet computers can be used.

The PC layout may vary, depending on the model used.

4.4.1 Data archiving

A large hard disk can contain many days' survey data. However, any disk fills eventually, and so the data needs to be stored for archive. External USB disks, sold for backing-up computer data, can be useful for this purpose.

4.4.2 Serial interface

This is a standard RS232 interface. It is used to communicate with auxiliary sub-systems such as the attitude sensor, compass and positioning system. Most modern PCs are no longer fitted with serial interfaces, so a way of connecting serial ports to the PC is needed. Ethernet-to-serial converters or USB-to-serial converters can be used for this. Some serial interface devices can cause large and un-defined time delays to the input data stream; these should be avoided. One useful tip is to disable any internal data buffering in the device.

Most RS232 cables use 9-pin D-type connectors. The pin use on these connectors is as follows. This same arrangement is used on most peripheral devices. Sometimes, a 'null modem' cable or converter is required to swap the transmit and receive lines. This connects pin 2 on one connector to 3 on the other, and vice-versa. Pin 5 is carried straight through.

Pin	*Use*
2	Receive (into the device)
3	Transmit (out of the device)
5	Ground

Some auxiliary systems, such as attitude sensors and positioning systems, only output data, and do not require an input. Therefore, only pins 2 and 5 are used. However, some such systems are configured by a program that is run on the PC, so the output line is also used.

The connectors on the PC and auxiliary devices are usually male, that is they have pins rather than sockets.

If more than one system requires data from an auxiliary system, the output can be spliced to both units, but **only on the transmit line from the auxiliary system**. Do not splice to inputs into the auxiliary device, otherwise the equipment could be damaged.

The use of opto-isolated inputs, either as a feature of the interface card, or as an in-line module, is recommended to minimise noise and damage from over-voltage conditions.

If a device supports both Ethernet and serial interfaces, the Ethernet alternative is usually the best choice.

See section 8.2.6 and onwards for advice on connecting serial ports to the computer via Ethernet, USB and Wi-Fi.

4.4.3 Attitude system Ethernet interface

Some attitude and position systems provide data over an Ethernet interface. See section 4.11.7 for details of configuring this interface.

4.5 SWATHPLUS ISA INTERFACE CARD

Versions of the "SWATHplus" TEMs supplied before autumn 2006 use an interface card that plugs into the computer's ISA bus. This was replaced by USB interfaces in the SWATHplus TEMs, and by Ethernet in the Bathyswath-2 TEMs.

See the installation instructions supplied with the software and hardware for the details of installing a SWATHplus ISA card.
New releases of the Bathyswath software are no longer tested with the ISA interface.

4.6 ETHERNET CONNECTIONS

Bathyswath-2 TEMs connect with the computer using Ethernet.

TEMs use the IP address “192.168.0.240” by default.

TEMs can also be configured to use a DHCP server to allocate IP addresses on connection to the network.

To set up a network to communicate with a TEM:

- Set the computer to a fixed IP address in the same domain as the TEM, i.e., “192.168.0.xxx”, where “xxx” is any number up to 254 other than 240. Any other devices connected to the system need to be set to the same sub-net.
- Use a sub-net mask of “255.255.255.0”.
- To change the computer’s IP address settings, open Control Panel, Network and Internet, Network and Sharing Center, Change Adaptor Settings, and select Ethernet. In Ethernet Properties, scroll down the list to find and select Internet Protocol Version 4 (TCP/IPv4), and click Properties. To use DHCP, select Obtain an IP address automatically. To select a specific IP address, select Use the following IP address, enter the IP address and Subnet mask, and click OK. The Default Gateway can be left blank.
  Some sub-systems on the network require a different IP sub-net, so it may be necessary to change everything to use that sub-net.

The Bathyswath-2 TEMs send out their status messages using UDP broadcast, but “ping” messages from Swath Processor to the TEM, and data returning from the TEM, are sent to specific IP addresses. That means that you may see the Found … message in the Status window, showing that a TEM is present on the network, even though the IP addresses of the TEM and computer are set up wrongly. If that case, you will get “Error … Ping Timed Out “messages in the Status window when you make the sonar active. So, if you get the *Found* message but *Ping Timed Out* errors, check the IP addresses and sub-mask of the computer and TEM.

The IP address used by the TEM can be changed using Swath Processor:

- Connect and turn on the TEM
- Start Swath Processor, and wait for the TEM to be detected (see the Status window)
- Open Sonar, then Configure
- In the Ethernet section, note the **IP Address Reported** field.
- If the TEM is reporting a different IP domain (the first three numbers of the address) to the computer, then temporarily change the IP address of the computer to that domain, but with a different final number in the IP address.
- Select **Set IP Addressing**, and enter the new IP address in **IP Address Change**.
- If the IP domain (first three numbers) was changed, then change the IP domain of the computer to that domain
- Use **Refresh** in the **Sonar** dialog to re-connect to the TEM
- Check the new IP address of the TEM in **IP Address Reported**.

4.6.1 Windows Firewall

The Windows Firewall will attempt to block Ethernet communications between the V2 TEM and Swath Processor, unless you tell it not to. The simplest solution, but most dangerous, is to turn off the Windows Firewall completely; this leaves your computer open to malware attacks. To do this, open the **Windows Control Panel**, go to **System and Security**, then **Windows Firewall**, and find **Turn Windows Firewall on or off** in the left-hand menu. Select **Turn Off Windows Firewall** in the Public network settings section. The best solution is to add Swath Processor to the firewall's list of allowed applications. Use Windows **Firewall & Network Protection**, then **Allow an app through the Firewall**.

A safer alternative is to add Bathyswath.exe to the list of applications that Windows allows to communicate through the firewall. The first time that Swath Processor runs, Windows should ask you if you want to exclude it from the Firewall; answer yes, and you should be OK.

If that doesn't work, use Windows **Firewall & Network Protection**, then **Allow an app through the Firewall**. Click **Allow another app**, click **Browse** to find Bathyswath.exe where it is installed in Program Files or Program Files (x86), and click **Add**. In **Network Types**, select both **Private** and **Public**. In the list of **Allowed apps and features**, make sure that both the **Private** and **Public** boxes are ticked next to Bathyswath.exe. This should allow all instances of Bathyswath.exe through the firewall, no matter where they are installed.

It is also possible that bathyswath.exe could get added to the list of applications that are specifically blocked by the firewall. Block instructions overrule Allow instructions, so if that happens, bathyswath.exe won't be allowed to communicate. To correct that, go to **Advanced Settings** in the **Windows Firewall** controls, select **Inbound Rules**, and click on the top of the Action column to find all the rules that are select to **Block**. If bathyswath.exe appears in this list, select the entry, and then **Delete** in the **Actions** column on the right.

4.6.2 Checking and Changing IP Address

A TEM reports the IP address that it is currently using over a UDP broadcast message. Therefore, you can see the address that it is set to, even though the computer might be on a different IP subnet and therefore not be able to send commands to the TEM.

The **Configure Sonar** dialog in the Swath Processor program is used to view and change these settings; refer to its Online Help page for more information (use the F1 key on the computer).

4.6.3 Suggested IP Address Scheme

The user is free to choose any IP addressing scheme that is convenient. However, the following is suggested for consistent operation.

Device	IP Address	Ports
Bathyswath TEM	192.168.0.240	From TEM: 52761 To TEM: 52762
PC	192.168.0.70	From NPort (GPS): 4001 From Ekinox: 4002 To Ekinox: 4003
Moxa NPort	192.168.0.254	To Ekinox: 4001 To PC: 4001
Ekinox	192.168.0.34	From PC: 4003 To PC: 4002
WIZnet	192.168.0.49	Chan. 1: 5000 (COM3) Chan. 2: 5001 (COM4) Chan. 3: 5002 (COM5) Chan. 4: 5003 (COM6)

4.6.4 Suggested IP Address Scheme with PicoMBES

Some versions of PicoMBES have a fixed IP address, so the following scheme is needed:

Device	IP Address	Ports
Bathyswath TEM	10.0.100.240	From TEM: 52761 To TEM: 52762
PC	10.0.100.70	From MBES: 13000 From NPort (GPS): 4001 From Ekinox: 4002 To Ekinox: 4003
Moxa NPort	10.0.100.254	To Ekinox: 4001 To PC: 4001
Ekinox	10.0.100.34	From PC: 4003 To PC: 4002
WIZnet	10.0.100.49	COM4: 5000 COM5: 5001 COM4: 5002
PicoMBES	10.0.100.120	From PC: 9000 To PC: 13000

4.7 BATHYSWATH-1 AND SWATHPLUS USB

Bathyswath-1 and SWATHplus systems use USB to connect from the TIU to the computer.

The Transducer Electronics Modules (TEMs) are supplied installed in a box called the Transducer Interface Unit (TIU). This has a separate DC or mains supply. The TEM USB connectors are brought out the rear of the unit using cables inside the housing.

4.7.1 USB Connection

If the USB connection is made direct from the TIU to the PC, the USB cable needs to be kept short to provide reliable communications. Note that the maximum cable length for USB-3 is shorter than that for USB-2, so you might need to fit a shorter USB cable when using USB-3.

If the TIU must be mounted at a distance from the PC, consider the use of a COTS USB extender system, such as a USB-to-Ethernet converter.

4.8 TRANSDUCER CONNECTIONS

The transducer connections are made with rugged, polyurethane, marine-grade cable. These are rather stiff, and care must be taken in planning the route that these cables take to reach the Deck Unit. Otherwise, the cables may tend to lie in a location that obstructs the operator's access to the PC or other systems. The connector is about 120 mm long. Allow a bend radius of about 50 mm.

Connect the transducer connectors to the connectors on the front of the Deck Unit or Subsea Unit. The selection of the TEMs in terms of port or starboard transducer is made in the Swath Processor **Sonar** dialog. Conventionally, the left-hand connector is connected to the port transducer. It is advisable to mark the transducer connectors with red and green tape to identify which one is which. The allocation of each channel to port or starboard can be made in Swath Processor.

The transducer cables use MacArtney MCOM 16-pin connectors. These connectors are made of neoprene, and have one pin missing from the circular pattern, so that it is normally impossible to connect them wrongly. However, with sufficient force it is possible to make the connection in the wrong orientation. If this happens, the **electronics of transducers can be damaged** by the energy of the sonar transmit pulse, so **check visually** before making the connection.

4.9 POWER CONNECTIONS

Connect the power to the power inlet connector on the Spider Cable, using the tail marked with a yellow sleeve. A second power tail, with a red sleeve, is reserved for high-power modules in the unit; this is a Peltier cooling module in the Deck Unit, and optional high-power modules such as Pan and Tilt heads in the Subsea Unit. The Bathyswath 2 Deck Unit takes DC power, 9 to 36V. The Bathyswath 1 TIU takes DC power, 9 to 32 V. This voltage range is suitable for use with either 12V or 24V batteries.

DC power can be provided from a ship's power system or from a separate battery.

If working with mains power, connect the mains-to-DC converter supplied with the system to the mains supply and the output lead to the Spider Cable or TIU.

When using the Subsea Unit, 24V is recommended, as the higher power requirement and longer cabling can result in sufficient voltage drop, which can take the power voltage at the electronics below the minimum accepted.

See section 5.2 for details of the Spider Cable connections.

4.10 GROUNDING AND EARTHING

Proper earthing and grounding of the system is very important for two essential reasons:

- Protecting personnel from the effects of mains faults.
- Limiting the effects of electrical noise on the sonar signal.

It also reduces the risk of accidentally connecting a power source across a ground connection: see section 4.3.1.

Bathyswath 2 is generally less sensitive to external electrical noise than Bathyswath 1, but you will still get best results if you reduce electromagnetic interference as described below.

4.10.1 Mains safety earth

For personnel safety, the mains power supply earth (if used: some systems are supplied with DC power) must be connected right through the system. Ensure that the earth connection to all the units that take mains power is effective. If in doubt, consult the person responsible for the vessel's electrical supply.

4.10.2 Noise reduction

Ships can be very electrically noisy. This noise can be picked up by the Bathyswath and degrade the depth measurements.

4.10.3 Measuring Noise

To evaluate the amount of noise pick-up, start the Bathyswath system running as in normal survey mode, but with the transmit signal turned off. Make sure that the transducers are plugged in to the TEMs, and are in the water, and that all auxiliary systems (attitude, position, etc.) are operating and plugged in to the Bathyswath system. Disable all the angle and phase filters. Look at the **Cross Profile** window. If noise is low, then this display will show a random 'cloud' of noise points. If there is significant noise pick-up, then the display will show a straight line issuing from each transducer. Depth measurement is severely compromised when these straight lines continue to exist when the transmit signal is enabled and the system is measuring a seabed.

Open an **Amplitude** window. The vertical scale is signal amplitude, and the horizontal scale is range. In Bathyswath-1 and SWATHplus, TEM output is logarithmic, so one division at the bottom of the window represents much less of a step in signal than one division at the top. The Bathyswath-2 signal is linear, but variable gains are applied in the TEM, under software control, usually automated.

In Bathyswath-1 and SWATHplus with the transmit signal disabled, the noise level should be below the second division of the screen, less than 10,000 for the arbitrary 16-bit numerical scale, and as low as possible. In Bathyswath-2, the noise level should be very close to the bottom of the screen, with no visible "spikes". If it is above this, effort should be taken to reduce it, and if it is approaching the middle of the scale (30,000), system performance will be very severely degraded. It is not advisable to proceed to survey with this level of noise still present. The target level can be established by replacing the transducer plug with one that shorts out the signal inputs. Note that the signal level rises considerably if nothing is connected to the TEM's transducer connector at all; this is normal, and so noise reduction investigations must be done with the transducers plugged in and in the water.

In Bathyswath-2 systems, almost any "ripple" or "pulses" in the Amplitude view with the transmit signal off are an indication of external interference and should be investigated and eliminated.

Examine the amplitude display for repeating "waves" or "spikes" of signal noise. These may be caused by electrical or acoustic interference from other systems, or they may come from the power supply used. These should be identified and eliminated. Try turning off or disconnecting other systems on the boat, to see if the noise signal changes.

If you are onboard the survey vessel with sufficient water below the boat, you can run the system with the transmit on, and use the **Amplitude** view to compare the levels of the echoes from the bottom with any visible noise band.

4.10.4 Earthing and Grounding

Correct earthing can significantly reduce signal noise. The earthing arrangement that gives the best results on any vessel can only be found by experiment. This is because each vessel has different noise characteristics and earthing arrangements.

This part of setting up a Bathyswath system is important, and should not be skipped or rushed. High external noise is a common cause of poor survey results.

On Bathyswath 1 and SWATHplus, the TEM Signal Ground is brought out to a connector on the back of each TEM. The ground is also bonded to the metalwork of the housings. One significant source of noise is the difference in potential between the sea and the electronics. This potential can be induced by electromagnetic noise. Connecting the Signal Ground to a good sea-earth can reduce this effect. This can be done by:

- On pole-mounted systems, run a wire between the TEM Signal Ground connector and the metalwork of the pole. Use a wire with a good cross-section, and ensure that the connection to the pole is robust. Keep seawater out of the copper cores of the wire, as corroded wires make very poor contact. Aluminium is covered with a clear layer of oxide that is surprisingly insulating, so simply wrapping bare wire around aluminium parts does not usually make sufficient electrical contact. Instead, use a self-tapping screw into a suitable hole in the aluminium and connect the wire to that screw. Inspect the cable at regular intervals when in use, and replace it if the cores become very dull in colour or show other signs of corrosion.
- On hull-mounted systems, connect the Signal Ground to the vessel's sea-earth.

Establish a star network (where all grounds connect to a single point) or a distributed star (a set of stars connected together), and avoid earth loops. This is not always simple, as there may be earth connections between the components of the system that are not obvious. This is illustrated in Figure 4-2 below.

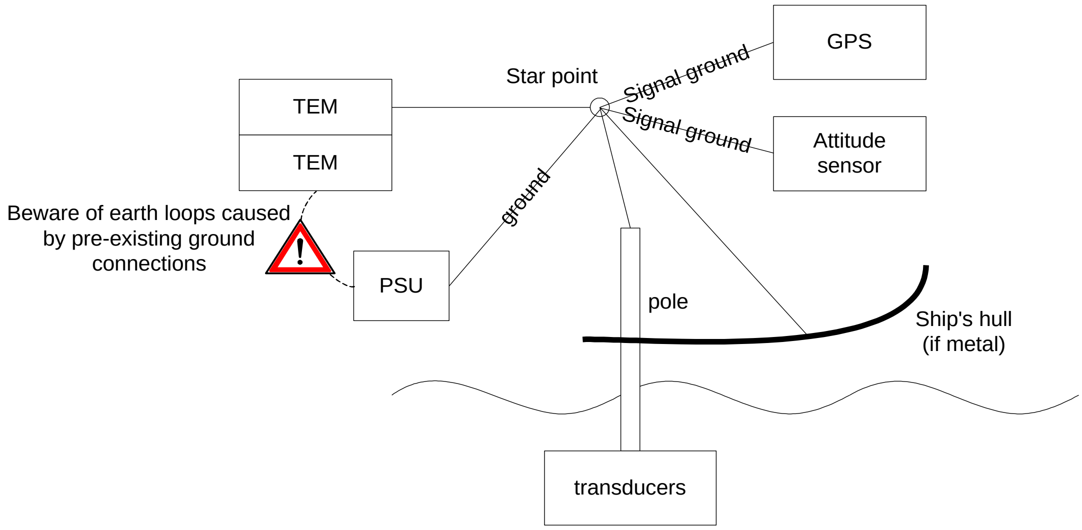


Figure 4-2 Schematic diagram of a typical earthing arrangement

Make a drawing of the cables and connections of the system as it is installed on the boat, including auxiliary systems and power supplies. Not only will this help in detecting problems, but also it will be useful for re-installing the system if it needs to be removed for storage or use on another vessel.

With Bathyswath-1 systems, it is not necessary to connect the earths of the two TEMs together if they are installed in the same housing, as their grounds are also connected together via the chassis.

It can also help to electrically isolate the body of external sensors from ground. For example, a system with an SMC 108 motion sensor in a stainless steel housing fitted to the top of the transducer-mounting pole was suffering from strong noise pulses, even after the serial data line was isolated using an Ethernet-to-serial converter. This was cured by fitting the SMC 108 body to the pole with nylon screws and a plastic sheet to isolate the SMC 108 body from the pole.

If the Bathyswath system and the auxiliary systems that are connected to it use different DC power supplies, connect the 0V of all the power supplies to the earthing star point.

If noise is still a problem, try connecting Signal Ground to mains earth. However, before attempting this, ensure that mains earth is effective and safe (see above).

The sea-earth connection can be made through are small capacitor if required. This prevents significant DC ground currents from running, whilst removing AC noise components. Around 50 nF would be a good start.

4.10.5 Electromagnetic Pickup

As well as noise coming through grounds, power lines and signal lines, noise can be picked up in cables from electromagnetic emissions from sources inside and outside the boat.

Do not coil up un-used parts of the earth wire: cut it to length. Coils can cause the earth wire to pick up external electrical interference. For the same reason, do not run the earth wire close to mains wires or the active signal wires from other electrical systems.

Sometimes, the sonar can pick up radar signals.

4.10.6 Sonar Interference

Bathyswath can sometimes pick up signals from other sonar systems. Most boats use a single-beam echosounder for navigation safety; the transmit pulse from these systems can be seen as a regular pattern of pulses in the Bathyswath sidescan images. The bathymetry results are not usually affected so strongly, or the bathymetry filters are effective at removing any interference. Bathyswath can also cause faulty depths in other echosounders and multibeam systems.

These interference effects can be removed by synchronising the transmit pulses of the sonar systems on the boat, provided that the other systems support transmit synchronisation.

4.10.7 If noise pick-up persists

- Try other combinations of earthing. Some earth connections will make things worse, by introducing ground loops where two items are already grounded together by another route.
- Ensure that the transducer cables do not run around or next to any other cables, especially mains, Ethernet, and auxiliary sub-systems (position, attitude, etc.).
- Look for external sources of interference. Radio and radar transmissions can be particularly troublesome, as they operate at similar frequencies to the Bathyswath sonar.
- Try changing the physical location of the components of the system.
- Disconnect the auxiliary inputs to the system to see if the noise level falls. It will be necessary to set the corresponding ‘attitude derivation’ or ‘position derivation’ to ‘Use Fixed Value’ in the dialogs under the Configuration menu in Swath Processor, in order to maintain a visible output in the Amplitude window. This is achieved in one step using the ‘Test Mode’ command under ‘Configuration’. (Tip: save a session file with the ‘Use Fixed Value’ settings; call it ‘TEM_test.sxs’ or similar). Once a particularly noisy auxiliary item has been identified, it can be targeted for careful earthing. One cause of noise is a sensor that is poorly earthed internally or in its own sub-system. If this cannot be rectified, consider the use of an opto-isolator in the serial line from the auxiliary system. These can be obtained from must suppliers of industrial computing equipment. If you can change to Ethernet for the interface, that will also help, as Ethernet does not generally use a ground connection.
- Ensure that connections to metalwork are electrically and mechanically robust. For example, aluminium forms a layer of oxide that is an excellent electrical insulator. It is usually necessary to use a self-tapping screw or similar to obtain a good earth. If the ship has a metal structure, then consider setting up an earth bolt, firmly electrically and mechanically bonded to the metal. This can form the ‘star point’ of the earthing system.
- If some instruments are powered from a separate 12V or 24V DC system, try running an earth to the negative rail.
- Try changing the power supply: for example, some mains inverters give out a very ‘spiky’ waveform, which can appear very strongly in the sonar signal. If the PSU cannot be changed, try using a line voltage conditioner unit.

4.10.8 Serial Communications

Serial communications lines, such as used from GPS and motion sensor systems, can be a strong source of electrical noise. Pay particular attention to the way that the ground connections of these lines are connected.

Serial-to-Ethernet converters are useful in this case, because Ethernet connections are transformer-coupled (there is no DC connection). However, noise can still get into the system via the ground line of the DC power to the converter and any Ethernet hubs used.

4.11 INSTALLING POSITION, HEADING AND ATTITUDE SUBSYSTEMS

4.11.1 Attitude sensor

When pole-mounting:

- If possible, use a version of the attitude sensor that is supplied in a pressure-tight bottle, and fix it next to the transducers. Otherwise, the attitude sensor will not be able to correct for the motion of the end of the pole relative to the sensor.
- Use the attitude sensor mounting bracket supplied by Bathyswath, appropriate to the unit being used.
- Using the Subsea Unit of Bathyswath-2-UW with the transducers fixed to it and the attitude sensor mounted inside ensures that the transducers and attitude sensor are perfectly mechanically coupled.

When mounting the transducers in the hull:

- Mount the attitude sensor as close to the transducers as possible.
- Mount the attitude sensor on the fore-and-aft centre line of the vessel.
- Align the attitude sensor's vertical axis with the vertical that applies when the vessel is afloat.
- Strive to make the above alignments as exact as is practical. It should, however, be noted that slight misalignments of 1 or 2 degrees can be compensated for in the patch-test calibration of the system.

Ensure that the attitude sensor's mount is completely rigid. The attitude sensor measures the angular location of the transducers to better than 0.05°. It must therefore not move relative to the transducers by more than this when the vessel rolls and pitches. Prepare a mounting bracket for the attitude sensor, that:

- is rigidly fixed to the structure of the vessel,
- cannot move relative to the transducers,
- does not need to be disturbed for any reason, and
- is not in a walkway.

Some attitude sensors are taller than they are wide. When mounting these units, consider using a frame that holds the top of the unit to prevent it swaying relative to the vessel.

In general:

- Refer to the attitude sensor's own handbook for installation instructions that are specific to the particular model used.
- Most attitude sensors are supplied with set-up software that runs on the PC computer. Run this software before using the sensor to survey.
- Most sensors need some kind of calibration process before they give an accurate output. This might typically consist of a settling period, followed by a series of turns or pre-defined manoeuvres. Consult the sensor's own manual for details.
- Ensure that the attitude sensor is mounted the correct way up, facing in the correct direction. Refer to the attitude sensor's manual for further details. Many models can be configured to work in different orientations. Make sure that the orientation is entered correctly into the motion sensor's set-up software.
- Accurately measure the location of the attitude sensor in three dimensions, relative to both the sonar transducers and the positioning system. It is necessary to account for the difference in position between the attitude system, position antenna and sonar transducers. This is called a 'lever arm' correction. In preference, use the attitude sensor's internal lever-arm correction facilities, rather than the lever arm corrections in Swath Processor. This is because the attitude system has more information at its disposal than Swath Processor, and hence should be able to make a better correction. Make sure that the lever arm correction is not made in both systems. That is, if the attitude system can perform the lever arm correction and output attitude and position valid for the location of the sonar transducers, set the position offsets in the Swath system to zero.
  Some attitude sensors are particularly sensitive to errors in the measurement of the relative position of GNSS antenna and attitude sensor, so make sure that this measurement is as accurate as you can make it.

See the Online User Guide topics on Calibration for further information on measuring and configuring the attitude sensor offsets.

4.11.2 Compass

A compass provides heading information.

The most common method of measuring heading is to use a dual-antenna GNSS system.

Most gyrocompasses can be interfaced to Bathyswath. For smaller installations, a magnetic fluxgate compass can be used, but this is less accurate and more prone to disturbance from external metallic objects, including the ship itself.

Some attitude systems provide heading directly, either from a built-in compass, or because their gyros are accurate enough to detect the rate and axis of the Earth turning, and therefore are gyrocompasses in their own right. In this case, a separate compass feed is not required.

Bathyswath obtains heading through various channels; only one is needed:

- From a dual-antenna GNSS system into the Position input
- A direct connection to the Compass input
- Via the attitude sensor. In some cases, the attitude sensor takes in heading from the compass, combines it with 'high-frequency' yaw from its own gyros, and transmits the combined heading value back to Bathyswath.

Bathyswath can read the compass information in a range of formats, including NMEA 0183.

Sometimes the compass provides heading information in a format that can be read by the attitude sensor, but not by Bathyswath. In this case, the heading channel that passes through the attitude sensor is used in processing, and the direct link to the Bathyswath is ignored.

If a fluxgate compass is used as a heading reference, it should be mounted away from magnetic fields on the vessel (engine, generators and large ferrous objects). The masthead is often the best location.

The compass must be installed and aligned in accordance with its own manual and good survey practice.

Heading information can also be obtained from course-made-good, which is the direction between successive positions from the GPS system. However, this is far less accurate than the heading from a compass, and should only be used as a last resort if heading from the compass or attitude system is not available.

See the Online User Guide topics on Calibration for further information on measuring heading and configuring heading offsets.

4.11.3 Position

The position of the vessel is obtained from a positioning sub-system. The position is usually derived from GNSS (including GPS), although several other types of system exist.

The position interface could be via UDP (usually UDP) or an RS232 serial port. A range of serial line parameters may be used. Bathyswath may be set-up to accept various settings of baud rate, number of bits, parity and stop bits. See the Online User Guide for how to set-up position inputs.

In order to maintain the accuracy of the survey, the positioning system should be accurate to 1 metre or better, with an update rate of 1 second or better. Surveys that require better depth accuracy may require better position accuracy than this.

Some positioning systems provide a measurement of height above datum. Bathyswath records this height information and it can use it instead of tide measurements. This will require the use of more accurate position data than for XY position only.

Be aware of the errors that can arise from differences in grid systems, geoids and datums. Bathyswath accepts position data as grid co-ordinated (easting and northing) or as latitude and longitude. In the latter case, the latitude and longitude are converted to grid positions when they are read into the system, using a range of conversion protocols, including Universal Transverse Mercator (UTM). A range of geoids and other conversion parameters are available in Swath Processor, in the **Position input Transformations** dialog. Post-processing is carried out using grid co-ordinates.

Some models of attitude sensor can accept information from the position system to help it correct for errors that arise from centripetal acceleration in turns. The position information required by the attitude sensor for this purpose must usually be of a specific NMEA format, but does not need to be as accurate in position as that used for locating the Bathyswath depth measurements. See the attitude sensor’s own manual for further details.

4.11.4 Height

The vertical height of the sensors can be obtained in several different ways:

- Heave from the attitude sensor, combined with tide information. These are essentially high frequency and low frequency components of vertical position. If tide is used, the depth of the transducers below the waterline must also be measured.
- GNSS height: the altitude component of the GNSS data. This is usually only accurate enough for surveying purposes if a high-accuracy GNSS system is used, for example Real Time Kinematic (RTK).
- Combining GNSS height and heave. As these are both capable of recording relatively high frequency information, the GNSS height needs to be filtered before combining. The length of the filter is selectable in the **Attitude Derivation** dialog. However, it is much better to allow the attitude system to perform this data merging if it has the capability to do so.
- From a pressure sensor in an underwater vehicle; this can be further combined with heave from the motion sensor if necessary.

Tide data is not needed if GNSS height can be used.

Tide information can be fed in as a real-time data stream into an Auxiliary serial port, if it is available.

4.11.5 System timing

The Bathyswath electronics maintains a real-time clock, which is used to time-stamp data packets that are sent to the software. This clock is kept accurate using timing messages from the software together with pulse-per-second (PPS) pulses from the GNSS position system. The software maintains an accurate millisecond clock, which is initialised from external time sources, including ZDA messages from the position system. See the context-sensitive help provided for the **Time Setting** dialog in Swath Processor for more details.

4.11.6 Combined attitude, heading and position systems

Some systems provide a combination of two or more of attitude, heading and position. In this case, it may be necessary to make more than one connection from the sensor to the Bathyswath computer.   Heading can be derived from the attitude string, but position needs to come in on a separate serial line. In any case, attitude and position are usually supplied in different formats, and need to be decoded differently.

The **Attitude Derivation** dialog under the **Configuration** section of Swath Processor provides a range of options for deriving roll, pitch, heading and height.

4.11.7 Attitude system Ethernet interface

Many attitude and position systems provide data as over an Ethernet interface. Ethernet interfaces are generally preferable to serial, because:

- Latency is less of a problem,
- Modern laptop computers tend to be fitted with Ethernet[1], but not serial ports,
- The attitude and position systems can provide more data over Ethernet, which helps with decoding. For example, such systems generally provide data packets with time-tags on Ethernet, but not serial.

[1] Although even that is becoming less common, and you may need a USB-to-Ethernet converter

Heavy traffic on the Ethernet line can slow down the reception of data from the attitude system. This can be eased by sending UDP data to the IP address of the computer rather than using Broadcast.

The Bathyswath software accepts UDP Ethernet inputs from any system that sends it.

1. Set up the attitude system to send data by Ethernet. This is done from the Attitude system's PC-based application. *Sometimes, the setup and monitoring program uses the same UDP port as it sends data out on in real time. A UDP port cannot be opened twice on one system, so you may need to close the sensor's setup program before connecting to Swath Processor.*
2. Run Swath Processor.
3. Click on **Attitude**, then **Network Settings**. Enter the port number that the sensor is broadcasting to (typically 3000 for F180 and 5602 for POS/MV).
4. Click **Connect,** and **OK** in the **Attitude Sensor Settings** dialog.
5. If position is being obtained from the same source, open the Position dialog, and select the appropriate input format, e.g. 'SBG', 'Coda MCOM', or 'POS/MV 102'.
6. Refer to section 7 for advice on selecting timing from 'Sensor Clock' or 'PC Clock'

4.11.8 Sound Velocity Sensors

Bathyswath can take inputs from sound velocity sensors in two ways:

1. Regular vertical profiles ('dips') taken by the operator using a separate, stand-alone instrument. The profiles (measurements of sound velocity against water depth) are entered as tables into Swath Processor.
2. Continuous updates from a sound velocity sensor mounted next to the transducer heads. This measurement is used to perform the calculation of the angle of the sound wave at the transducer head. This may be necessary if the survey takes place in an area where the sound velocity at the surface changes significantly, for example, in an estuarine area.

The vertical profiles are always necessary where the sound velocity changes with depth. The continuous updates are important where the surface sound speed changes across the area. Frequently, both are needed, but sometimes one or neither of them is adequate for an accurate survey.

See section 9.7.1 for more information on using sound velocity.

4.11.9 Echosounders

A single-beam echosounder can be mounted alongside the Bathyswath transducers. The echosounder does not have to be mounted close to the Bathyswath transducers, in order that the attitude system corrections apply, as a position offset can be entered into the Bathyswath software, and thus a 'lever-arm' correction made. It is likely that there would be acoustic crosstalk between the systems, and so the transmit pulse trigger output from the Bathyswath TEM should be connected to the echosounder's input trigger line, if available.

Bathyswath can read echosounder data on an RS232 serial line with formats including: Valeport, NMEA, AML, CSV, SVP16, WESTGEO and HYPACK.

4.12 WET-END DEPLOYMENT

The term 'wet-end' is used to collectively describe all those parts of the Bathyswath system that, when in use, are in contact with the water. Their method of deployment will differ slightly according to circumstances.

This manual covers three configurations. These are: hull mounting, bow-mounting, and side-mounting. Hull mounting or side-mounting are the best options when the transducers are to be permanently mounted to a vessel. Bow-mounting can be used when the system is to be installed for a limited time.

4.13 TRANSDUCER INSTALLATION – GENERAL

The following points apply to any installation. Also, refer to the instructions specific to the configurations below.

4.13.1 Transducer versions

Bathyswath currently may use three versions of transducer, operating at 117kHz, 234kHz, or 468kHz. The first two transducer types are usually fitted with a 20-metre cable, the 468kHz usually has a 15m cable. Bathyswath-2 transducers are fitted with pre-amplifiers in the transducers, and so can accept longer cables.

4.13.2 Transducer location

The faces of the transducers must not lie in aerated water. Aeration can occur when fine bubbles are drawn under the hull from the air-to-water interface around the hull, or from the action of propellers or other propulsion mechanisms. The sonar range of the system is severely curtailed when the transducers pass through the wash of a vessel. On no account should the transducers be mounted aft of the propellers. Avoid mounting the transducers aft of obstructions in the hull such as thruster tunnels.

The transducers should be mounted in a location where they remain in the water at all normal roll and pitch angles.

- Measure the location of the transducers in three dimensions relative to a fixed "common reference point" on the vessel.
- Also measure the position of the attitude sensor and position sensor antenna relative to this point.
- Measure the depth of the transducers relative to the water line.
- On the Bathyswath-2 transducers, measure to a point exactly in the centre of the face of the transducer, and about 5mm behind the face.

These measurements should be made with an accuracy of about 10 mm.

See the Online User Guide for more information on measuring sensor positions and orientation definitions.

Transducers should be mounted so that:

- The top face is horizontal, i.e., there is no pitch offset,
- The front face points downwards at 30 degrees to the horizontal. That is, the surface of the front face is at 30 degrees to vertical.
- One transducer points port and the other starboard, both at 90 degrees to the direction of motion of the vessel.

Other configurations are possible, and the software will correct for any transducer orientation. However, the angles described above are optimal for most survey conditions, and the transducers should be set up to within one or two degrees of this. Any slight offsets from these nominal angles can be measured using the post-processing patch test calibration procedure.

In some cases, it can be beneficial to adjust the vertical angle of the transducers. If operating in very deep water, close to the depth limit of the frequency option being used, then increasing the transducer angle to 40° or 45° can improve performance. Similarly, if the application is concentrating on scanning objects close to the water level, then pointing the transducers horizontally or even slightly upwards can give better results.

4.13.3 Transducer cabling

The signals from the transducers are at very low voltages and at radio-signal frequencies. They are therefore prone to external interference unless care is taken during installation. The cable length between transducer and electronics rack should be less than 20 metres, and less than 15m for 468kHz systems. The transducer cables supplied are shielded twisted pairs. Similar cables should be used if the installer supplies alternative cables to connect the transducers to the rack. Core sizes must be 16/0.2 (0.5 mm^2) or greater. Avoid cable routes near equipment or cables operating at radio frequencies, or carrying electrical power.

Bathyswath-2 transducers are fitted with preamplifiers, so this length restriction can be relaxed a little. However, it is always best to fit the Bathyswath TIU as close to the transducers as possible, and then to use Ethernet to connect from the TIU to the computer.

Transducers shipped after 2008 are usually fitted with a 1-metre 'tail', joined to an extension cable with an underwater cable. This allows different cable lengths to be fitted without needing to modify the transducer.

The transducers are activated by a transmission pulse at approximately 450 V rms. This can cause interference with other equipment, and could be a hazard to personnel if the cables or connectors are damaged.

4.14 HULL MOUNTED CONFIGURATION

Where the Bathyswath is to be permanently mounted on a dedicated survey vessel, the transducers and attitude sensor will be fixtures on the vessel.

4.14.1 Possible hull configurations

Broadly, there are two possibilities: flush-mounting or chock-mounting:

4.14.2 Flush-mounting

Mounting the transducers so that the active face of the transducer is flush with the surface of the hull will have the minimum effect on the operation of the vessel. However, this requires that the hull include a section at the correct angle (30° from the vertical), and in a suitable, aeration-free position. This option requires that a hole the size of the transducer must be cut in the hull. Typically, a watertight box section will be fixed into the hull, so that the integrity of the hull does not depend on the presence of the transducer. A watertight tube may be run from the back of the box up to the location of the instruments, which should be above the water level.

4.14.3 Chock-mounting

In this option, the transducer stands out from the hull. It is backed by a mounting frame and surrounded by a fairing to ease the flow. In this case, there is a little more resistance to flow, but this is not likely to affect vessel motion. The shape of the chock may cause the flow over the transducer face to be a little more turbulent, but on the other hand, the transducer face will be lifted away from surface effects on the vessel's hull. This option requires only a small hole to be drilled in the vessel's hull, to allow the transducer cable to pass through.

4.14.4 Transducers

These points are in addition to those listed in 'Transducer Installation -General', above.

- Mount the transducers with their faces as flush to the hull as possible, so that turbulence across them is kept to a minimum. If flush mounting is impossible then a fairing must be constructed to smooth water flow across the transducer face. This helps to reduce vibration and entrained air, and helps to protect against damage to the transducers caused by striking submerged objects.
- The horizontal axes must be horizontal with respect to gravity, when the vessel is at survey speed.
- The vertical axes of the transducers must be at as near to 30 degrees, looking down from the vertical, as is possible. In other words, the face of each transducer must make an angle of 30° with vertical.
- Design the location of the transducers to avoid multi-path reflections from the hull or other structures.

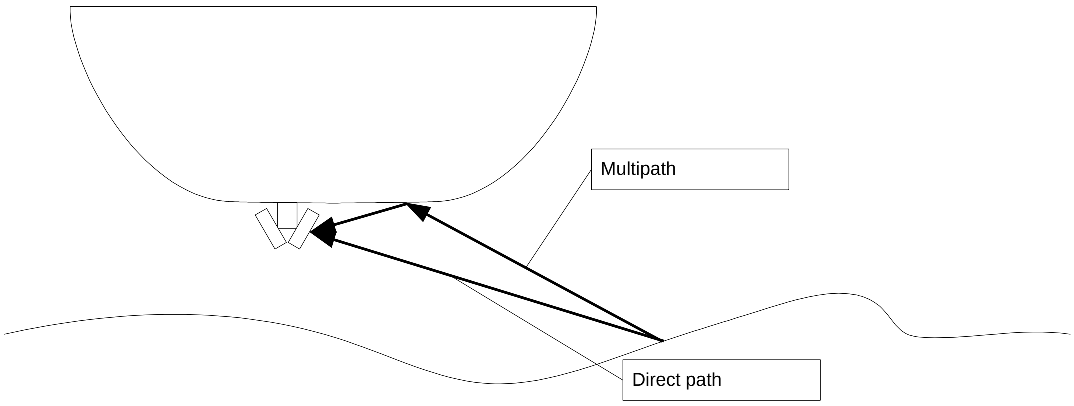


Figure 4-3 Multi-path reflections from hull

- The location of the transducers should be as close to the apex of the keel as is practical.
- The transducer pairs should be ideally laterally opposite each other. However, this is not essential, if the location of each transducer is accurately measured.
- Pass the transducer cables through watertight glands in the hull, or a sealed tube running to above the waterline, in order that they may be connected to the electronics.
- The location of each transducer must be accurately recorded, relative to some fixed point on the vessel.
- It is often convenient to use land-survey techniques to measure these locations.
- The locations must be measured in three dimensions, to an accuracy of about 10mm.
- Measure the angles that a normal to the transducers makes with vertical (elevation) and the fore-and-aft line (azimuth). An accuracy of about 1 degree is sufficient at this stage. The actual elevation angle of the sonar 'boresight' will be measured using the acquired depth data. See the Online User Guide topics on Calibration.
- When the vessel is afloat, record the location of the water line relative to the fixed point. The height of the vessel in the water may change as the vessel moves; this effect is called 'squat'. This effect is difficult to assess on a particular vessel, but could be significant if ultimate depth accuracy is required. Consider consulting the manufacturer of the vessel, or using a GNSS system that provides accurate height information instead.
- Make sure that the transducer installation will not adversely affect the operation of the vessel, or cause the transducers to be damaged. If the vessel is to lie on the bottom at low tide, ensure that the transducers are not placed in a position where they will be under mechanical stress or be abraded. Similarly, for small vessels that are routinely lifted by strops, or placed in transport or storage cradles, ensure that the transducers will be safe during such operations.
- Consider the effect of the transducers on vessel handling.
- The transducers are extremely robust, and contain few or no active electronic parts other than the piezo-electric ceramic elements themselves. However, a ship's hull is a very harsh environment, so consideration should be given to ease of repair in the case of damage.

4.14.5 Attitude sensor

Record the locations of the attitude sensor and the positioning aerial, relative to the same fixed point on the vessel.

See sub-section 4.11, 'Installing Position, Heading and Attitude Systems'.

4.14.6 Testing and trials

On some vessels, Bathyswath may not give optimum performance due to factors such as vessel noise and aeration. Although ITER Systems is happy to give advice on installing the transducers onto a vessel, it is not possible to give guarantees that no such problems will occur. The installation plan should therefore include time for sea-trials to find and cure any such problems.

4.15 BOW-MOUNT CONFIGURATION

The bow-mount is one of two deployment configurations available for vessels of opportunity.

For bow mounting, the pole is fitted with V-shaped brackets that fit around the bow of the vessel. The pole is then pulled back against the bow using ratchet straps. This method has the following advantages:

- It is very quick to fit, often requiring only a few minutes.
- It can be fitted to most vessels with no modification to the vessel at all.
- The transducers have a clear view of both sides of the vessel without needing to be below keel level.
- The sides of the vessel are left clear for docking.
- As the transducers are on the centreline of the vessel, the effect of vessel roll is minimised.

It has the following disadvantages:

- The straps must be kept tight; otherwise, the pole will fall off.
- The pole cannot be fitted to vessels whose bow angle is too shallow. In general, the bow must make an angle of less than 45° with the vertical.
- The water at the bow of the vessel can sometimes be aerated by the bow wave.
- The transducers may be lifted out of the water by vessel pitch.
- On large vessels, the bow can be more than the length of the transducer leads (20 metres) from a suitable location for the electronics.
- It is difficult to make the pole mount rigid relative to the vessel. This is a problem if the attitude sensor is mounted inboard.

4.15.1 Bow-mount components

The installation kit consists of pole, transducers, transducer frame, attitude sensor mount, adjustable angle bracket, bow-mount brackets and adjustable ratchet straps. See Figure 4-4 below.

The two bow-mount brackets are spaced on the pole so that they both make contact with the straight section of the rake of the bow. The brackets are fitted with padding on the surfaces that are in contact with the bow, to protect the ship. Make sure that this padding is intact before fitting the bow-mount.

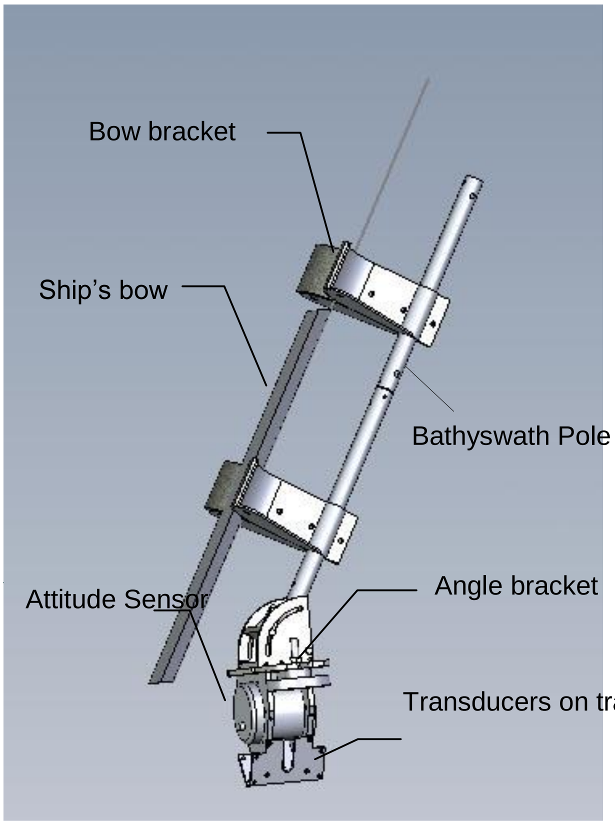


Figure 4-4 Bow-mount assembly: side view

4.15.2 Installation sequence

- Bolt the transducers to the cradle with the stamped 'TOP' labels uppermost.
- Attach the attitude sensor to the transducer frame. Each model of attitude sensor has a different mounting assembly to fix it to the Bathyswath frame. Some attitude sensors have locating holes that need to be correctly aligned. Ensure that the attitude sensor is located the correct way around.
- Attach the attitude sensor and the transducer assembly to the pole.
- The angle that the transducer frame makes with the pole should be adjusted at the adjustable bracket so that when the pole is secured to the bow the transducers are horizontal. Adjustment is accomplished by loosening the four bolts that run through the radiused slots.
- The bow angle may be estimated as follows. With the vessel at rest alongside a quay, hold an adjustable set square or mathematician's protractor at arm's length and use your eye to align the bottom of the square with the edge of the dock or surface of the water, and adjust the square so that the moving edge aligns with the rake of the bow. Fix the square at this angle and then transfer the angle to the bow mount (or 90° minus the measured angle, depending on the angle taken).
- It is necessary to know the depth of the transducers below the water line when the vessel is under-way. This depth can change with loading and speed. You may therefore find it helpful to fix markers to the pole at intervals. Electrician's tape wrapped around the pole is good for this. Carefully record the location of each mark relative to the centre of the transducers.

- Using cable wraps, tidy the cables from the transducers and the attitude sensor, securing them along the pole.
- Shackle the ends of the long sections of the ratchet straps to the holes provided on the V-brackets.
- Attach a safety line to the top of the pole and secure its free end to the vessel's bow.
- Pass the connectors (take care not to drop them in the water) to the vessel, along with the free ends of the straps.
- Attach four ratchet blocks to secure points. Two blocks are attached on the port side, and two on the starboard side. Fix two of them 2-3 metres aft of the bow, and the other two 5-8 metres aft of the bow.
- Two people are now required to lift the entire assembly over the quayside into the water.
- A third person, on the bow of the vessel should maintain tension on the safety line attached to the top of the assembly.
- Once the assembly is in the water its weight will decrease and the bow person should be able to support it whilst the two persons on the quay come aboard.
- These two should then take the free ends of the straps, attached to the top V-bracket, and pass them along the appropriate port and starboard sides.
- Attach the ends of the straps to the forward pair of ratchet blocks.
- Use the ratchets to tension the straps so that the top V-bracket is firmly in contact with the bow.
- At this point, it is useful to check the alignment of the pole with the bow, and to give correcting instructions to the people tightening the straps.
- Once the top mount is secure, take the bottom straps to the aft ratchet blocks.
- Again, during tensioning the quayside person is required to assist in alignment.
- On completion of strap tensioning, tie off the safety line to a bow strong point.
- Inspect the straps to ensure that they are not twisted, and that they do not cross any sharp edges in the hull. The straps can become abraded if they rub against such sharp edges, or if they are caught between the hull and the dockside when the vessel is moored. If this is the case, then re-route the straps, or protect the straps with robust covering.
- An alternative to using straps is to use steel rope between the pole and the ratchet blocks. Fix the steel rope to a length of strap a metre or two on front of the ratchet block. This allows the rope to be tightened with the ratchet. Where the rope touches the hull, it could damage the hull. Putting a protective tube over the wire rope can prevent this. Garden hose is ideal for this purpose.
- Route the cables through the vessel and connect them to the Bathyswath electronics, as specified above.
- Apply power to the Bathyswath system, and start Swath Processor. If the attitude system is fitted in an underwater bottle on the transducer frame, note the roll and pitch angles. Use the **Text** window in Swath Processor; make sure that the angles are displayed as numerical text. The sign convention of pitch is such that it is positive when the vessel is bow-up. Roll is positive port-side up.

- If the pitch angle is more than two degrees from zero, consider lifting the pole and adjusting the angle bracket to bring the transducer and attitude sensor assembly level.
- If the attitude system is not fitted to the transducer frame, examine the angle of the seabed by eye. However, remember that the seabed under the ship in dock may not be flat.
- Measure the depth of the centre of the transducers, relative to the water line. Note that this can change once the vessel is moving at survey speed. It will also change with loading and the location of personnel. Use the fixed marks on the pole if you fitted them. Record the pitch angle whilst this depth measurement is made. Also, measure the fore and aft distance from the transducers to the centre of pitch of the vessel. These measurements will allow you to estimate the change in water depth of the transducers, as the pitch of the vessel changes with speed.

4.16 SIDE-MOUNT CONFIGURATION

ITER Systems can supply a side-mount assembly, or a pole may be custom-built for a particular vessel.

The advantages of a side-mount are:

- It is usually more rigid than a bow-mount.
- It can be deployed at sea, provided that suitable fixings are designed.
- It is stable in pitch.

The disadvantages are:

- A small modification to the vessel is often needed.
- It is less stable in roll than a bow-mount.
- It needs to be lower than the bottom of the hull, and is thus liable to damage from striking the seabed. This also brings it closer to the seabed, thus reducing range in shallow water.

The pole may be fixed to the side of the vessel using a variety of techniques. Some vessels may have brackets fixed to their side that can be adapted for use with the Bathyswath pole. Others may need a small modification. The Bathyswath pole assembly includes a special bracket that enables the pole to be fixed to many vessels with a minimum of alterations. The simplest approach is to fix the bracket to the side of the vessel, using bolts, clamps, or similar fixings. The pole is fixed to the bracket using U-clamps. The end of the pole is pulled tight using guys running fore, aft, and sideways using a belly-strap running under the vessel to the rail on the other side. Steel rope is better for this application than rope, as it is less elastic. Screw-up tighteners (bottle screws) are useful to make the whole assembly rigid. The problem with this approach is that it can be difficult to recover and deploy at sea, so it may not be suitable if long transits to the survey site are needed. If the pole is mounted alongside an open deck area, recovery at sea can be possible. A drill for this must be thoroughly practised whilst alongside. Review this drill for safety.

An alternative approach is to weld U-shaped brackets to the side of the vessel, and fit the pole with mating studs. The pole can then be lowered into position when at sea. This procedure usually needs a hydraulic crane or winch, and can be hazardous in rough sea conditions. For this reason, another popular approach is to fit the pole with a swivelling mount at the top, so that it can be rotated up out of the water when not in use. The pole can be raised and lowered using a winch, and tightened fore and aft with ropes.

If a pole is fabricated specially, then it needs a horizontal square plate to be firmly welded to the end. This plate must have four 12 mm diameter holes, drilled in a square pattern on 120 mm centres.

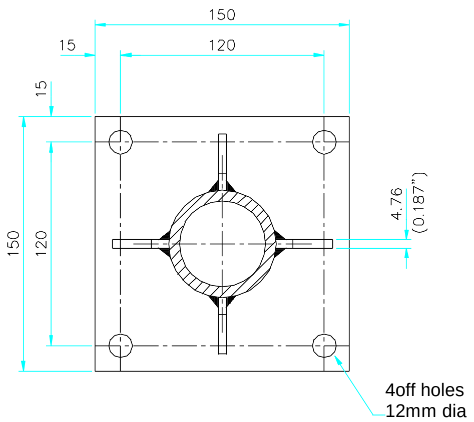


Figure 4-5 Pole-End Plate, to fit transducer frame

4.16.1 Side-mount components

The installation kit consists of pole, transducers, transducer frame, attitude sensor mount and pole bracket. Wire rope, shackles, bottle screws, and fixings allowing eyes to be made in the wire rope are also required. These latter components are available from most ship's chandlers, and need to be selected to suit the particular vessel used.

4.16.2 Installation sequence

The precise installation procedure will vary from installation to installation, depending on the various factors discussed above.

- Shackle three guy lines to the pad-eyes on the base of the pole. Three lines are required; one forward, one aft, and the third as a belly-strap.
- Locate hard points for the three lines, and fix shackles to them. Two of the hard points should be as far forward and aft as practical. The third should be on the other side of the vessel, directly across from the location of the pole.
- Assemble the attitude sensor and transducer frame assembly.
- Fix the assembly to the pole.

- Carefully measure and record the distance from the top of the pole to:
  - the bottom of the transducers, or the lowest point of the pole;
  - the centre of the transducers; and
  - the centre of the attitude sensor.
- It is also useful to mark the pole at intervals with tape, so that any changes in the depth of the transducers can be estimated when the vessel is underway.
- Estimate the depth of transducers that will be needed to clear the bottom of the hull.
- It is usually easiest to fix the side-bracket to the pole whilst the pole is out of the water. Estimate the correct location of the bracket that gives the required transducer depth.
- Fix the transducer and attitude sensor cables to the pole.
- Loosely fix the fore and aft guy lines to their hard points.
- Run the belly-strap under the vessel, and loosely fix it to its hard-point. A shackle or similar weight loosely passed over the line will help to sink it under the vessel. Be sure that the belly-strap does not foul the propellers or other hull fixtures.
- Lift the pole over the side and clamp it in place. Three or more people are required for this task.
- Secure the three guy lines, with adequate tension to steady the assembly when underway. Care should be taken not to bend the pole too much when doing this. However, a small amount of bend in the direction of the belly-strap is inevitable. The trick here is to fix the side-clamp so that the pole is angled outwards slightly, and then to pull it in with the belly-strap.
- Route the cables through the vessel and connect them to the Bathyswath electronics, as specified above.
- Apply power to the Bathyswath system, and start Swath Processor. If the attitude system is fitted in an underwater bottle on the transducer frame, note the roll and pitch angles. Use the 'Text' window in Swath Processor; make sure that the angles are displayed as numerical text. The sign convention of pitch is such that it is positive when the vessel is bow-up. Roll is positive port-side up.
- The pitch angle can usually be brought to zero by tightening and loosening the fore and aft guy lines as appropriate. The roll angle can be altered by tightening and loosening the belly-strap. If this does not provide sufficient control, place a chock on the appropriate side of the pole clamp.
- If the attitude system is not fitted to the transducer frame, examine the angle of the seabed by eye. However, remember that the seabed under the ship in dock may not be flat.

- Measure the depth of the centre of the transducers, relative to the water line. Note that this can change once the vessel is moving at survey speed. It will also change with loading and the location of personnel. Use the fixed marks on the pole, if you fitted them. Record the pitch angle whilst this depth measurement is made. Also, measure the fore and aft distance from the transducers to the centre of pitch of the vessel. These measurements will allow you to estimate the change in water depth of the transducers as the pitch of the vessel changes with speed.

4.16.3 Use on RIBs and other small boats

ITER Systems can supply a side-mount assembly for use on RIBs and other small boats. The principle of operation is the same as above, but the light weight of the assembly means that it can be safely deployed and recovered by one or two people.

4.17 BUOY MOUNT

Another deployment method that has been used is to construct a floating platform that can be strapped to the side or front of the boat for surveying. This works best with very small boats.

Such a platform can simply be constructed using the Bathyswath transducer bracket strapped to a pair of 'sausage buoys' or fenders. The attitude system and GNSS antenna can be fixed to the top of this assembly. The system cables are then run from the buoy to the computer system inside the boat.

Bathyswath users have used this method successfully to survey calm, inshore waters. However, ITER Systems can accept no responsibility for damage to equipment or risk to personnel from the use of such methods.

4.18 FINAL TESTS AND MEASUREMENTS

4.18.1 Safety

Once all the equipment is installed, review the arrangements for safety. Pay particular attention to the following:

- Ensure that all equipment and cables are firmly fixed down, so that they cannot come loose when the vessel moves.
- Ensure that cables do not obstruct walkways.
- Ensure that all connectors are thoroughly screwed home. Pay particular attention to underwater connectors, if used. Check O-rings.
- Ensure that all mains power cables and connectors are in thoroughly dry locations.

4.18.2 Tests

Make a final check of the attitude sensor orientation, using the Swath Processor Text view.

Refer to the Online User Guide for information on testing and diagnostics.

If necessary, run the attitude system calibration and set-up procedures (see section 4.11.1).

4.18.3 Measurements

In order that the Bathyswath data can be processed to produce a depth model, the following measurements are needed:

Measurement	*Accuracy Needed*	*Typical Value*	*Notes*
Attitude time offset	0.001s		Depends on the attitude sensor used

Measurement	***Accuracy Needed***	***Typical Value***	***Notes***
Magnetic variation	0.5°		Refer to local charts. Only needed if compass is magnetic
Grid convergence	0.5°		Needed if the compass provides magnetic or True heading; not necessary for dual-antenna GNSS systems.
Aerial position relative to attitude sensor	0.01m		Port-starboard and Forward-aft. Also height if using GNSS heights
Position time delay	0.1s	-1.0s	Only if using “PC clock” timing, see section 7. Can be obtained using processing calibration.
Location of transducers relative to attitude sensor	0.01m		All three directions. Measure to the acoustic centre; see section 11.7
Transducer mounting angles	0.1°	30°	Obtained from post-processing calibration
Depth of transducers under water surface	0.01m		Measure or calculate how this changes with vessel speed and loading. Only needed if using Tide for height measurement.
Sound velocity	0.5m/s	1400 – 1550m/s	See the Calibration section of the online user guide
Tide	0.01m		Unless GNSS height is used

4.18.4 Fault finding

Refer to the Fault-Finding topics of the Online User Guide.

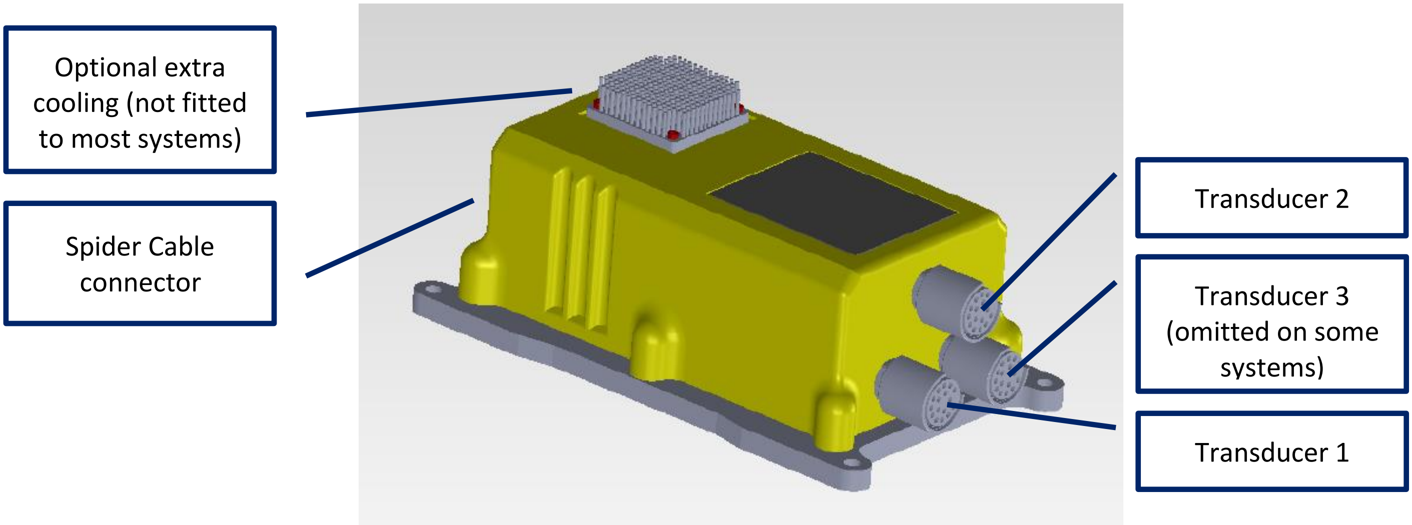
5 BATHYSWATH-2-STD SYSTEMS

Most Bathyswath-2 systems are the “standard” configuration, using the yellow Deck Unit.

The Deck Unit contains the Bathyswath electronics.

5.1 DECK UNIT CONNECTIONS

The Deck Unit has the transducer connections on one end and the Spider Cable connector on the other.



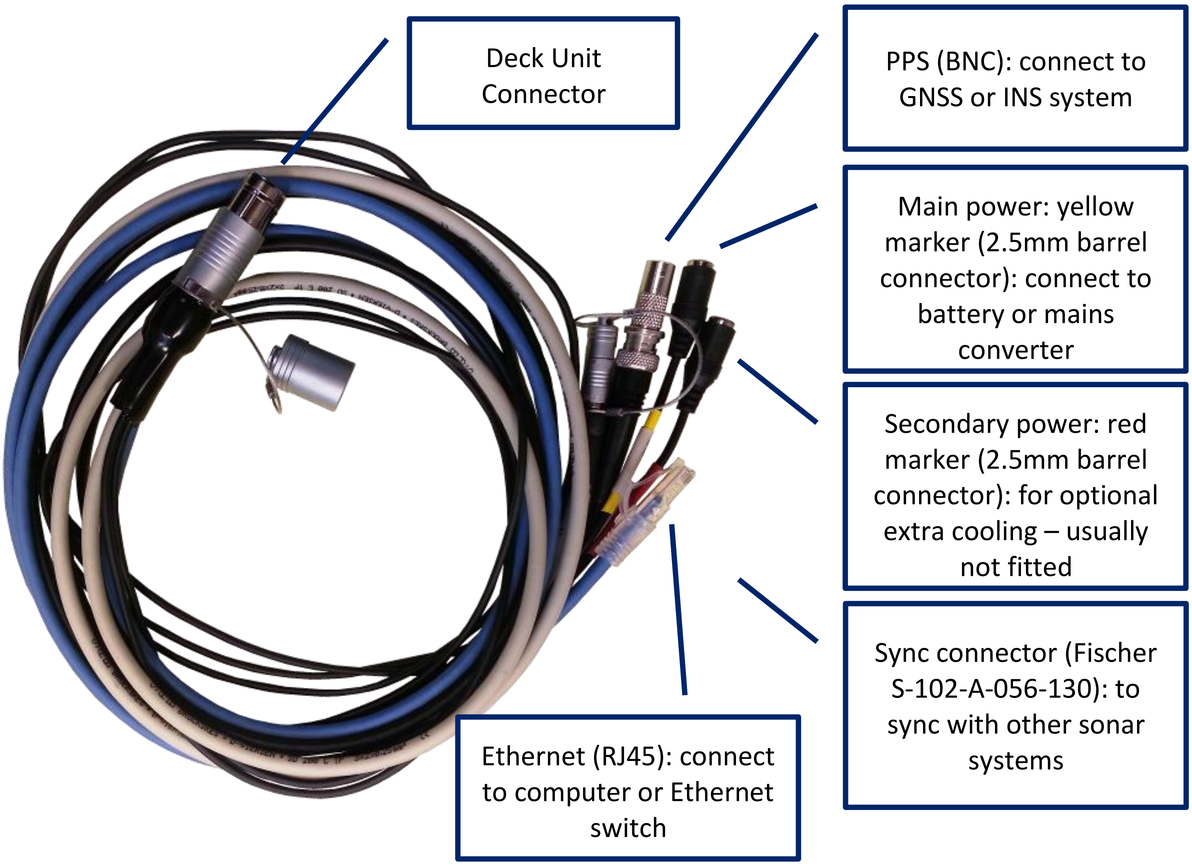
On the Deck Unit, the transducer connector channels are 1, 2 and 3 (if fitted) from left to right. Some systems do not have the transducer 3 connector; transducer 1 is on the left.

Transducer 1 is port and transducer 2 is starboard by default, although this can be changed in software if required. Transducer 3 is used for the forward-look transducer, if fitted.

Note the orientation of the connector, and match it with the pattern of pins in the connector. The bulkhead connectors used in the Deck Unit screw into the housing, so it is not possible to arrange for all the connectors to be orientated in the same way.

5.2 SPIDER CABLE

The Spider Cable connects to the 27-pin Fischer connector on the Deck Unit, and provides connections for all the inputs and outputs to the Bathyswath electronics on standard computer-type connectors.



A mains converter and screw-terminal adaptor are provided for powering the system from mains power or batteries. Use the connector with the **yellow** marker on its cable.

Bathyswath-2-UW systems use a similar Spider Cable at the top end of the Umbilical Cable.

5.2.1 Spider Cable connections

The spider cable connections are:

MCOM16F	Function	RJ45	S-102-A-056-130	2.5mm PWR, yellow	5-pin PWR, red	BNC, 50 Ω coax	4mm banana plug
3	Ethernet 2+ (org & white)	1					
1	Ethernet 2- (orange)	2					
4	Signal screen	Shell		Outer			
2	Ethernet 3+ (green & wht)	3					
5	Ethernet 3- (green)	6					
4	Signal screen	Shell		Outer			
13	PPS in 1+					Centre	
12	PPS in 1-					Outer	
8	sync in 2+		6				
7	sync in 2-		7				
10	sync out 2+		2				
9	sync out 2-		3				
6	System Power +			Centre			
16	System Power -			Outer			
4	Signal screen			Outer			
11	Overall Screen						
15	External Power +				3 5		
14	External Power -				1 2 4 Shell		
11	Sea ground						plug

Bathyswath-2-STD systems do not have the Sea Ground banana plug.

6 BATHYSWATH-2-UW SYSTEMS

Bathyswath-2-UW systems have the INS motion sensor and sound velocity sensor installed in the bottle. These are configured by ITER Systems before delivery, but you need to configure your laptop to match that configuration (see section 6.1), or adjust the configuration, as described in the rest of this section.

One advantage of Bathyswath-UW is that it is usually not necessary to spend time configuring the system. However, this section, from 6.2 onwards, gives detailed instructions for the configuration tasks, should they become necessary.

6.1 SET UP A NEW PC FOR USE WITH BATHYSWATH-SU

If a different PC computer is used with a Bathyswath-SU system, it needs to be set up as follows:

- Set the PC computer to the fixed IP address protocol 192.168.0.70. If you wish to use a different address, you need to set up the INS to send its outputs to that address.
- Connect the SU bottle to the PC computer and apply DC power (9 to 26V), using an Umbilical Cable and Spider Cable (see 5.2).
- Install the WIZ VSP virtual serial port tool, and use it to configure the virtual COM ports required.
    - See section 6.6.3

If the Bathyswath-UW system configuration in the system supplied works with the rest of your network, you don't need to do any more configuration work; you can continue to section 9, Using Bathyswath for Surveying.

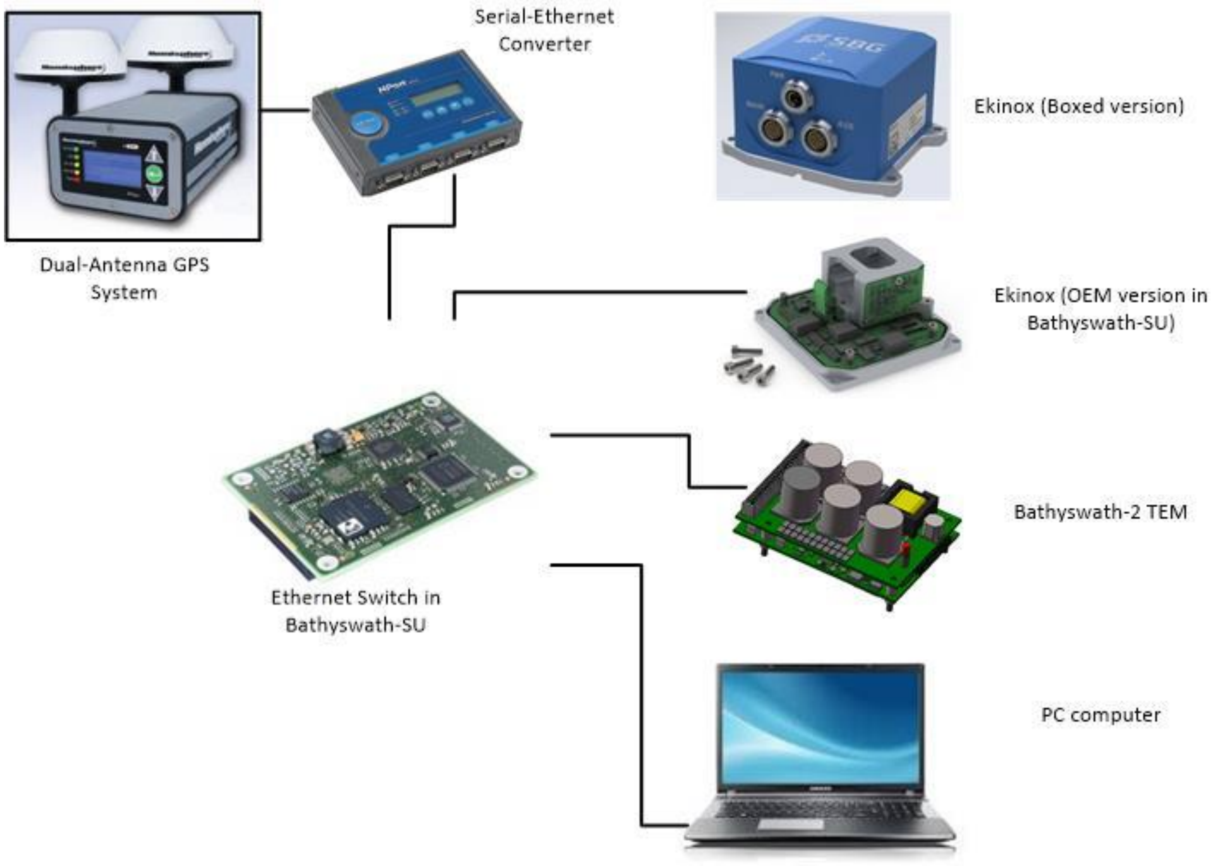
To change the configuration of the Bathyswath-UW system, read the rest of this section.

6.2 EQUIPMENT

Typical components used in a Bathyswath-UW system include:

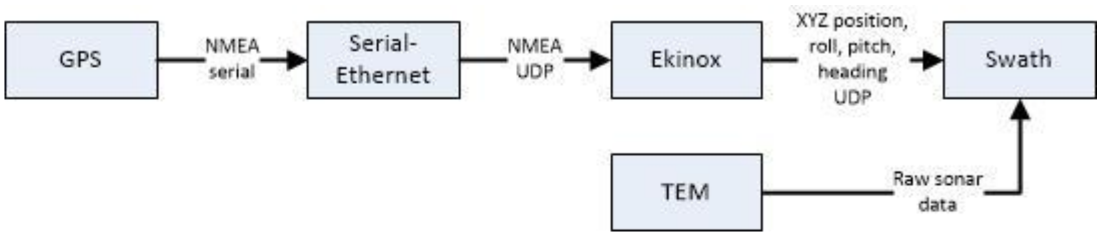
- Bathyswath-2 TEM (transducer electronics module) in the SU bottle,
- Ekinox INS (inertial navigation system) in the SU bottle,
- Ethernet switch in the SU bottle,
- Hemisphere dual-antenna GPS system, providing position and heading information,
- Serial-to-Ethernet converter in the SU bottle,
- External serial-to-Ethernet converter to connect the GPS to Ethernet,
- Laptop computer, running Swath Processor.

The serial-to-Ethernet converter connects the GPS to Ethernet, and everything else connects via the Ethernet switch in the SU bottle.



6.2.1 Data Flow

The flow of data through a Bathyswath-UW system runs like this:



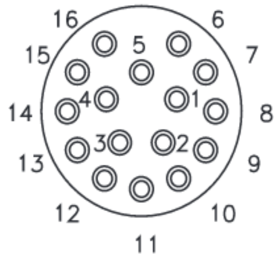
6.3 CONNECTIONS

The Bathyswath-UW bottle is fitted with a 16-way wet-mate connector. This connector can either be connected direct to the systems on a subsea vehicle, or to the Bathyswath-SU Umbilical cable. The Umbilical Cable can be connected to the Bathyswath-UW Spider Cable, which provides standard computer connectors: RJ45 for Ethernet, barrel connectors for power, BNC for PPS, etc. See section 5.2.

6.3.1 Connector Pin-Out

The connector used is MCOM16, male. Other connector manufactures provide compatible connectors.

The connector on the subsea unit bottle and the top end of the umbilical are identical. The connections are shown below.



Subconn MCOM16
series male face view

Wiring Schedule

Pin number	Function
6	System Power +
16	System Power -
15	External Power +
14	External Power -
11	Sea ground
3	Ethernet Pair 2+
1	Ethernet Pair 2-
2	Ethernet Pair 3+
5	Ethernet Pair 3-
4	Signal ground
13	PPS in 1+
12	PPS in 1-
4	Signal ground
10	sync out 2+
9	sync out 2-
4	Signal ground
8	sync in 2+
7	sync in 2-
4	Signal ground
4	Signal ground
4	Signal ground
4	Signal ground

6.3.2 Spider Cable

See section 5.2 for details of the Spider Cable connections.

6.4 SETUP

- Set up the INS system as described in section 6.7, Ekinox and GPS Setup, below.
- Run the WIZnet configuration software to set up the serial-to-Ethernet converter in the bottle, as described in section 6.6 below. This is only required for a new UW system, and does not need to be repeated when setting up a new computer with a UW bottle that has already been configured.

6.5 IP ADDRESSES

An IP addressing scheme is described in section 4.6.3.

6.6 WIZNET SERIAL-TO-ETHERNET CONVERTER SETUP

The WIZnet software is available from WIZnet, at http://www.wiznet.co.kr/product/serial-to-ethernet/, or from ITER Systems.

Two kinds of converter are fitted for different versions of Bathyswath-UW:

- WIZ100: 1 serial port,
- WIZ140: 4 serial ports.

Two configuration software tools are required in each case, one to set up the device (WIZ ***** Config Tool), which is different for the two device types, and one to assign COM port numbers to the device ports (WIZ VSP), which works with both types.

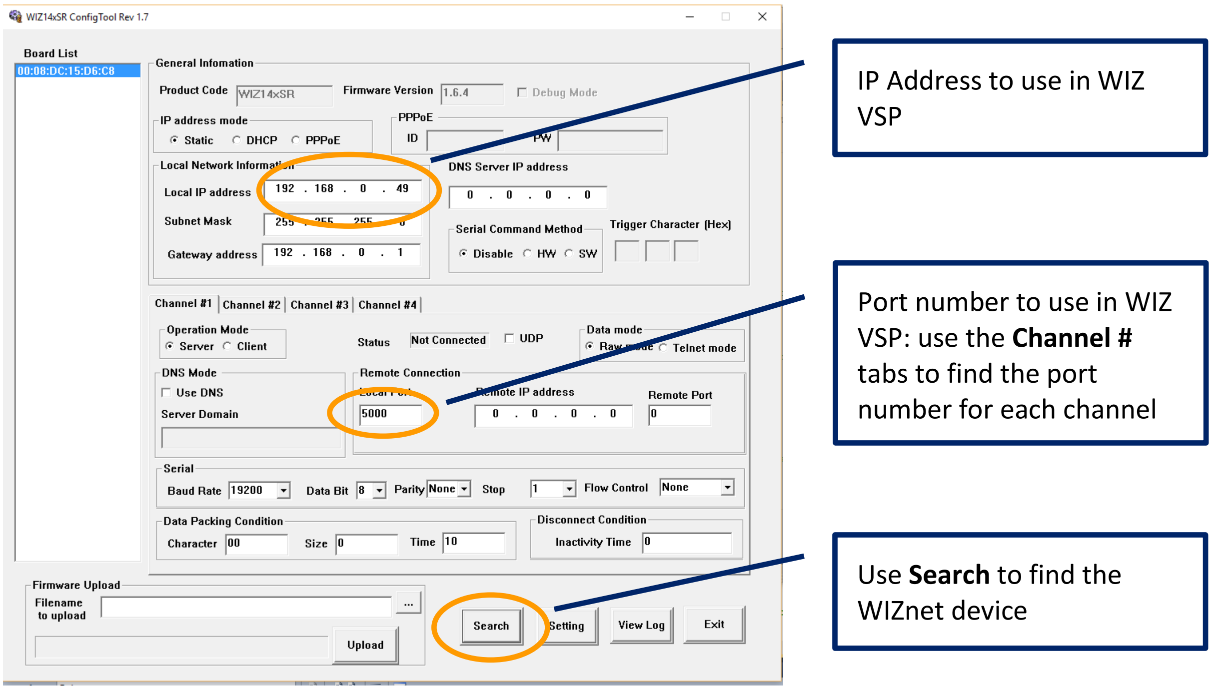
6.6.1 For the 1-port WIZ100

- Run **WIZ10xSR Config Tool** from the Windows Start menu.
- Click **Search** to find the WIZnet device. The window should be populated with the parameters of the device.
- Note, for use below:
  - The Local IP Address (e.g. 192.168.0.68). If this is not in the 192.168.0 domain, change the address in this window and click the **Setting** button.
  - The Local Port for the serial channel. The port number can also be changed by editing and clicking **Setting**.
- Set the correct baud rate in the **Serial** tab, **Speed** box. This is typically **19200** for the Valeport SV sensor.

6.6.2 For the 4-port WIZ140

- Run **WIZ14xSR Config Tool** from the Windows Start menu
- Click **Search** to find the WIZnet device. The window should be populated with the parameters of the device.

- Note:
  - The Local IP Address (e.g. 192.168.0.49). If this is not in the 192.168.0 domain, change the address in this window and click the **Setting** button.
  - The Local Port for each of the serial channels to be used. The SV sensor is usually connected to Channel #1. These port numbers can also be changed by editing them and clicking **Setting**.



6.6.3 Connecting Serial Ports to Swath Processor

You can either:

- Connect UDP ports in Swath Processor (connect to the port numbers above), or,
- Connect COM ports in Swath Processor (use the WIZ VSP tool to create virtual serial ports; see below).

6.6.4 WIZ VSP virtual serial port tool

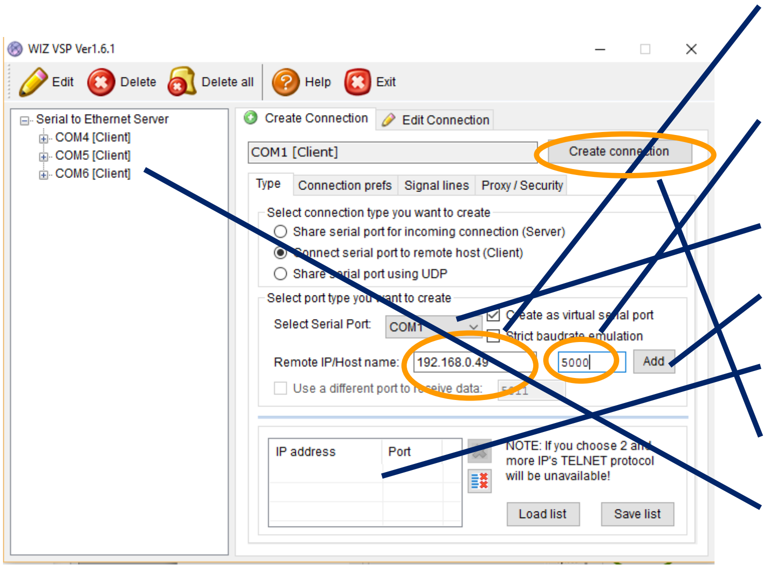
Install the Wiz VSP tool on the computer, using:

This assigns the port numbers for the serial channels found or set above to COM ports, which can be configured as inputs in Swath Processor.

- Install WIZVSP:
  - Run "**WizVSP_V1_61 > setup.msi**",
  - When prompted, enter the serial number "RUEW-NUVC-QTYW-NJVC-QZBD-NDIX".
- Run WIZVSP as administrator:
  - Right-click on **WIZnet > WIZVSP** in the Windows start menu,
  - Select **More**, and then **Run as administrator.**
- In **Select connection type you want to create**, select **Connect serial port to remote host (Client).**

- In **Select Serial Port**, select a COM port number that isn't already allocated on the computer, but ideally one that is in the range COM1 to COM6, otherwise you will need to assign new COM ports in the swathprocconfig.txt Initiation file.
  The standard port allocations are:
  Chan. 1: 5000 (COM3)
    - Chan. 2: 5001 (COM4)
    - Chan. 3: 5002 (COM5)
    - Chan. 4: 5003 (COM6)
- Select **Create as virtual serial port,**
- Enter the IP address and port number that were assigned in the WIZ14xSR Config Tool above,
- Click **Add**, and then **Create connection,**
- Wait until the process completes; this can take a minute or two to complete; WIZ VSP can show "Not Responding",
- It can help to close and open the **WIZVSP** program in between setting up the other ports; this program can easily get "stuck",
- You can check the COM port creation using **Device Manager > Virtual Serial Ports,**
- For the 4-port WIZnet device, repeat for the other three channels.

When complete, the SV input can be set up in the Aux Port in Swath Processor as normal, using the COM port created above.



1: Enter the IP address of the device here

2: Enter the port number of the channel here

3: Select the COM port

3: Click Add

4: Port details appear here

5: Click **Create Connection**

6: COM port appears here

6.7 EKINOX AND GPS SETUP

6.7.1 Equipment

Typical components used in an integrated Bathyswath system could be:

- Bathyswath-2 TEM (transducer electronics module) in the SU bottle,
- Ekinox INS (inertial navigation system) in the SU bottle,
- Ethernet switch in the SU bottle,
- Hemisphere dual-antenna GPS system, providing position and heading information,
- External Serial-to-Ethernet converter, for example Moxa NPort 5400, or a serial port, (which could be a USB-serial converter) plus a data-forwarding application such as Data Link.
- Laptop computer, running Swath Processor.

6.7.2 Setup

- Set up the PC computer as described in 6.1 above.
- Using the detailed instructions below, configure the GPS to send position, heading and timing data to the Ekinox through a UDP port from a serial-to-Ethernet converter. In the setup procedure below, we first use a virtual COM port to the computer to check that the GPS is sending the correct information, and then we convert the output to UDP.
- Connect the GPS to the computer using a serial port or a converter that provides a virtual COM port, e.g. through USB, or use the serial-Ethernet device in virtual COM port mode. If using a four-port Moxa NPort converter, you could use one port in UDP mode and another in COM mode. Run the GPS configuration tool on the PC Computer to set up the GPS system. For Hemisphere, a software tool called **PocketMax** is available.
  - Set up a baud rate that isn't so slow that the data can't all get through, and not so fast that data corruption can occur, e.g. 38400 or 57600. Disable flow control. Baud rates of 19200 or slower can cause clock problems in the Ekinox, even if there is no data corruption in the serial link from GPS to NPort.
  - Set up the following NMEA outputs:
    - **GGA** for position and altitude: 5 Hz,
    - **GST** for position quality: 5 Hz,
    - **RMC** for horizontal velocity and course: 5 Hz,
    - **HDT** for true heading: 5 Hz,
    - **ZDA** for UTC time data: 1 Hz (other rates cause an error); (note: this sometimes gets disabled by PocketMax when the baud rate is changed, so check it each time any changes are made),
    - **GSV** for space vehicle information: 1 Hz.
- Stop the GPS setup program, and use a terminal emulator on the PC to check that the required NMEA packets are being sent, and there is no corruption or data loss.
- In the following steps, a set of IP addresses and port numbers is suggested in section 4.6.3. If you use a different scheme, record it in your notes.

6.7.3 Serial-to-UDP Devices

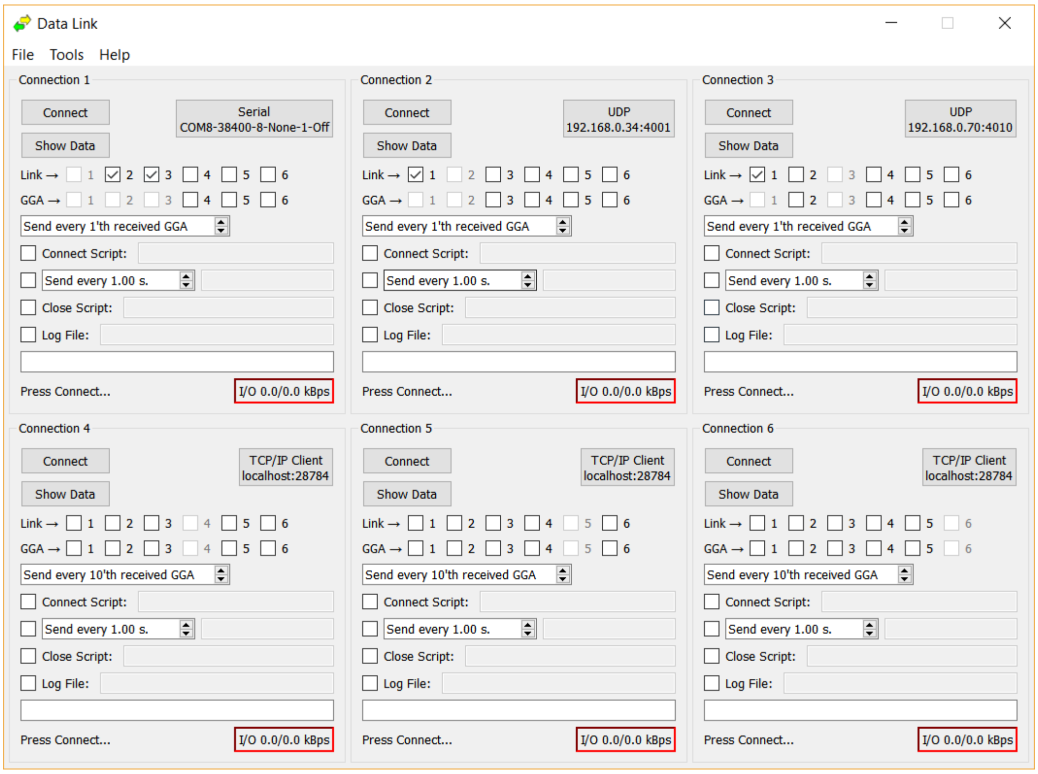
- Set up the serial-Ethernet converter to output UDP packets

- Connect the GPS serial line to the Serial-Ethernet converter (if not already connected).
- For Moxa NPort devices, use the NPort Administrator application:
  - Use Search to find the NPort device,
  - Select the device in the Configuration window, and click Configure,
  - Use the Serial tab,
  - Select Modify,
  - Select the serial port to be changed,
  - Click Settings,
  - Set the baud rate to that of the Hemisphere outputs,
  - Set FIFO Disable,
  - Click OK,
  - Click Operating Mode,
  - Select Modify, select the serial port and Settings again,
  - Change Operating Mode to UDP Mode,
  - Set up two outputs:
    - One with the IP address of the Ekinox; enter this into both the Begin and End fields; enter the port number that the Ekinox receives its GPS data on (e.g. 4001).
    - One with the IP address of the PC computer, so that the data can be checked on Wireshark; the same port number can be used.
    - In the Set up the termination character in the UDP mode to “0a”, the hex representation of line-feed. This ensures that start and end of UDP packets are aligned with the start and end of the NMEA messages received from the GPS system; this makes the packets easier to parse in software and to read in diagnostic tools such as Wireshark.
  - Click OK, and save and Exit NPort Administrator.

6.7.4 UDP forwarding applications

- Alternatively, connect the GPS to a serial port on the computer (which could be a serial-to-USB converter), and run the Septentrio DataLink application:
  - Install RxTools from https://www.septentrio.com/en/support/software
  - Run the “Data Link” tool,
  - Configure Connection 1 to receive from the serial port,
  - Configure Connection 2 to send to the UDP port, using the port number that the Ekinox has been set to receive on,
  - Configure Connection 3 to send to the same computer (e.g. 192.168.0.70), on, say, port 4010. This can be used by Swath Processor to read GPS data into an Aux Port.
  - Link 1 to 2 and 3, 2 to 1, and 3 to 1.

- Click Connect on both

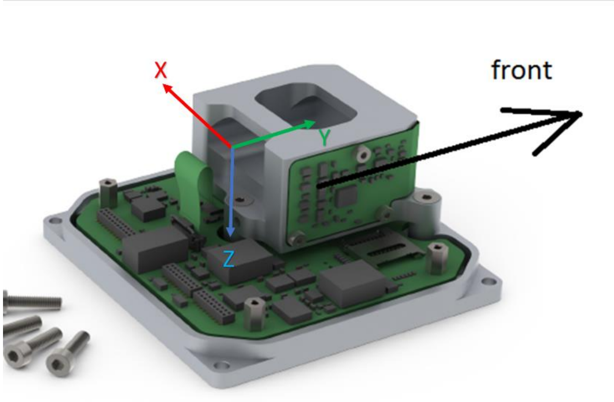


- You can set Data Link to connect automatically when it starts.
- Use Wireshark to check that the NMEA data is being sent as UDP packets.

6.7.5 Ekinox Set-up

- Run the Ekinox set-up and monitoring application to connect to the Ekinox INS. This can be done by one of several ways:
  - Run the SBG Systems **sbgCenter** application.
  - Enter the IP address of the Ekinox or an address of the form **http://ekinox_021000023.local./**, where 021000023 is the serial number of the device (different for every device, of course), into the browser's URL address window.
- If this does not communicate with the unit:
  - Revert the PC to DHCP addressing and try again: Ekinox defaults to DHCP.
  - If that doesn't work, try the SBG Systems **sbgCenter** application.
  - To find the IP address of the Ekinox use Wireshark or a similar network "sniffing" application: Ekinox will be sending packets out on UDP, so you should be able to see its IP address.
- Set up the Ekinox through its web interface:
  - Click **Configure** in the Ekinox Web Interface front window.
  - Click **Inputs/Outputs**, then **Ethernet**.
    - Set **Connection Mode** to **Static**, and enter an **IP Address** in the subnet chosen, e.g. "192.168.0.34".

- In **Eth0:**
  - Set to **UDP** and note its output port number. This is used as the input port number in Swath.
  - Disable **Broadcast.**
  - Enter the IP address of the PC (192.168.0.70 is suggested) into **Output IP.**
- In **Eth1:**
  - Set to **UDP,**
  - Set **input port number** to the one that the Serial-Ethernet converter was set up to send to (if using GPS information through a serial-to-Ethernet converter for providing aiding and INS position corrections).
- Click **Inputs/Outputs**, then **Logic I/O:**
  - Set **Sync in A** to **Rising Edge** or **Falling Edge**, according to how the GPS system outputs its PPS. Falling is more common.
- Click **Sensor**:
  - Select the **Motion Profile** tab:
    - Set **Motion Profile Selection** to **Marine Surface,**
  - Select the Alignment tab:
    - The OEM Ekinox is mounted on the CPB with its X axis pointing to port:



    - Therefore, the **Axis Misalignment** settings need to be set:
      - X Axis: Left
      - Y Axis: Forward
      - Z Axis: Down
    - Note that this is not the default configuration for Ekinox.
- Click **Aiding Assignment:**
  - Select **Eth1** against **GPS1,**
  - Set **Sync** to **Sync in A**: this is used for PPS.
- Click **Aiding Setting:**
  - Set **Receiver Model** to **NMEA**. This causes Ekinox to look for the NMEA messages listed above.
  - Set **GNSS Heading Mode** to **Dual Antenna (auto lever arm).**

        - Under **Main Antenna**, enter the vector from the INS to the main GPS antenna. Enter this as accurately as possible; small errors are enough to cause significant motion errors.
        - Set Aiding Use and Rejection **Position/Velocity** and **True Heading** to **Auto rejection**.
    - Click **Data Output:**
        - Select **Eth0,**
        - In **Log Configuration**, select:
            - **System Status**: 1Hz
            - **EKF Euler:** 50Hz
            - **EKF Nav:** 50Hz
            - **Heave:** 50Hz
            - **UTC:** 1Hz
            - **GPS1 Position**: New Data
            - **GPS1 True Heading**: New Data
            - other outputs may be enabled if required, e.g. the raw GPS data for monitoring, but take care not to overload the Ethernet connection.
    - Click **Save** to save these settings to the device; the device will re-start,
    - When the Web Interface restarts, check the main screen to check that the data status is all good. Global Status gives more detailed status information. Check that the Ekinox clock is valid (if not, there could be a problem with PPS or ZDA).
- Configure Swath for the Ekinox:
    - Click **Attitude:**
        - Select **Network**
        - Click **Network Settings**, and enter the number of the Ekinox Eth0 output port that was set up above (this defaults to 1234)
        - In **Data Format**, select **SBG ECom**
        - Select **Sensor Clock**
        - Click **Connect**
        - Check that the Status window shows "Socket connection created", and that there are no connection errors shown.
    - Click **Position:**
        - Select **Network**
        - In **Data Format**, select **SBG ECom**
        - Select **Sensor Clock**
    - Open a **Text view:**
        - Right-click, and select:
            - **Show Raw Port Text**
            - **Show Attitude**
            - **Show Position**
        - Confirm that Attitude and position data can be seen in the window.
    - **Start** the sonar.
    - Open another **Text view**, select only **Show Timing Data**, and check that the following are is less than 1 second and not changing significantly.

  - **Attitude time**
  - **Attitude; data time - PC clock time**
  - **Ping time - att time**
  - (Setting the GPS baud rate too low can cause the Ekinox clock updates to be in error, which causes the attitude data time to drift by several seconds a minute)
- Watch the Status view, and confirm that:
  - There are no ping timeout error messages shown: this can happen if the Ethernet is overloaded with messages
  - There are no other error messages, e.g. PPS errors.

7 SYSTEM CONFIGURATION AND TIMING

7.1 BACKGROUND

Results from a number of subsystems need to be brought together to create a set of valid depth measurements. These can include:

- Bathyswath sonar,
- Attitude system, providing roll, pitch & heave, possibly also heading,
- Compass, providing heading,
- GNSS system, providing position,
- Real-time sound velocity,
- Echosounder.

Some of these subsystems can be integrated into one unit.

To bring this data together correctly, the relative timing of all the data streams must be known. The most time-critical measurement is roll. For extremes of motion on a small vessel, a timing accuracy of better than 5ms may be needed. On a small vessel in a moderate sea, a timing error of 20ms in the attitude data is just detectable on the depth displays and data output.

Pitch, heading, and position are required with a timing accuracy of better than 0.5 seconds (500ms).

7.1.1 PC Clock or Sensor Clock

Some survey protocols require that all data is logged with time information that can be traced back to a common time source, usually UTC time derived from GNSS signals. This can be achieved using Bathyswath, but may not be supported by some auxiliary sensor systems used with it. A system where all the separate subsystems have their own clocks, synchronised together and ideally to GNSS time, usually gives the best result. This is called a “Sensor Clock” configuration. But if any one subsystem does not have its own clock and cannot send its data packets with accurate timestamps on them, then a “PC Clock” configuration must be used.

7.1.2 PC clock

The clocks in most PC computers are not particularly accurate. PC clocks are reputed to be accurate to 30 to 100ppm (parts per million, e.g. 100ppm is 0.36s in an hour). However, the Windows operating system adds its own timing errors and uncertainties. *Tip: the Windows Time Service can cause the PC time data to vary at rates of up to half a second per minute [8000ppm!]. Therefore, it can help to disable it, using ‘Settings > Control Panel > Administrative Tools > Services > Windows Time’.*

For these reasons, the Swath Processor software application maintains its own millisecond clock, which is initialised from a selection of time data sources; see the Online Help for “Time Settings”. This clock is called “PC Clock” to differentiate it from the Sensor and Sonar clocks. The clock time maintained by Windows is different to this “PC Clock”, although it is initialised from the Windows clock when the software starts, and so uses that time until a time update is received from an external source.

A method of synchronising the PC time to GNSS time should be considered. Some integrated attitude and position systems provide this as part of the supplied package. Alternatively, an NTP (Network Time Protocol) time server can be integrated into the system. However, for successful post-processing using PC Clock mode, it is only necessary for the time of the sonar, attitude and position data packets to be synchronised with each other, so it is not essential for the computer clock to be synchronised with GNSS time.

If a distributed computing system is being used, and one of the PCs is acquiring UTC-GPS time, e.g. via PPS, then an NTP time server can be set up on that PC, and NTP clients set up on the other PCs in the system. These NTP servers and clients are software applications, which can be obtained as shareware products for a few tens of dollars on the Internet. Bathyswath surveys have been successfully carried out using such configurations.

7.1.3 Serial port delays

Bathyswath records the time of a data string when the first character is received, so that the time it takes for the string to arrive is not a problem. However, there can be a large and indeterminate delay in that first character arriving. Older PCs have the serial port built into the PC card, and the timing is reliable. Newer PCs do not consider the serial port to be important, and so implement it on some kind of sub-bus, if at all: RS232 is regarded as a 'legacy port'. This is particularly true for laptops, which rarely have serial ports fitted, and so must use external port adaptors, using USB, PCMCIA or Ethernet. For a good USB implementation, the time delay could be as low as 10ms, but it can well be much more. Therefore, USB-serial adaptors are sometimes not the best option. Bathyswath has been tested with Ethernet USB adaptors, and shown good attitude stability.

Possible mitigations include:

- Get a serial port system that has a delay that is either very small or deterministic and known (the Bathyswath software includes a capability to correct for sensor time offsets).
- Use sensor systems that are synchronised with GPS time and add this time to the data string that they send out, and configure the Bathyswath software to use this time stamp.
- Use Ethernet outputs from the attitude sensors. Although there is a non-deterministic delay in the Ethernet transmission, it is small enough not to cause problems to Bathyswath processing (typically 50 microseconds or less).

7.1.4 Sonar data timing

Sonar data time can either be provided by the TEM's own clock, or using the PC clock time at the time of acquiring the data. The TEM's internal clock is accurate to about 50ppm, but it can be accurately synchronised with a time reference using a PPS input (see below). Each TEM records the time since its clock was reset, in seconds and milliseconds. The software records the PC time at which each TEM reset occurs, and generates a time stamp for each sonar 'ping' by adding this reset time to the TEM time clock.

In PPS mode, the PC reset time is rounded down to the nearest second, and the true GPS time in seconds is added. Thus, an accurate sonar time is available to the nearest millisecond, even though the PC time is up to half a second in error. For PC time errors of greater than half a second in either direction, an error in sonar time of a whole number of seconds will be seen.

If using Sonar Clock, the attitude and position sensors should be set to “Sensor clock”, so that all the clocks in the system are initialised from the same external clock source (usually GPS) and maintained by PPS. Do not use a mixture of PC Clock and Sensor clock on the sonar, attitude and position systems, otherwise differences between the clocks can cause attitude and position errors in the processed data. Other systems, such as sound velocity, are less critical on time. You can set everything to Sensor Clock or PC Clock using buttons in **Swath Processor > Configuration > Time Setting**.

7.1.5 PPS, Pulse per Second

Accurate clock systems often provide timing signals as electrical pulses sent out every second, on the second. These signals are called pulse-per-second, shortened to "PPS". GNSS systems such as GPS provide very accurate clock signals (a GNSS system is essentially a set of atomic clocks on satellites), so the most common source of PPS in a sonar "spread" is the GNSS system.

7.2 PPS INPUT TO TEMS

The TEMs can receive a PPS signal from an external timing system. This is often derived from a GNSS input, either from a GPS positioning system, or from a dedicated timing system that uses a GPS receiver.

When the TEM firmware detects a PPS pulse on its data input, it synchronises the TEM clock. See Figure 7-1.

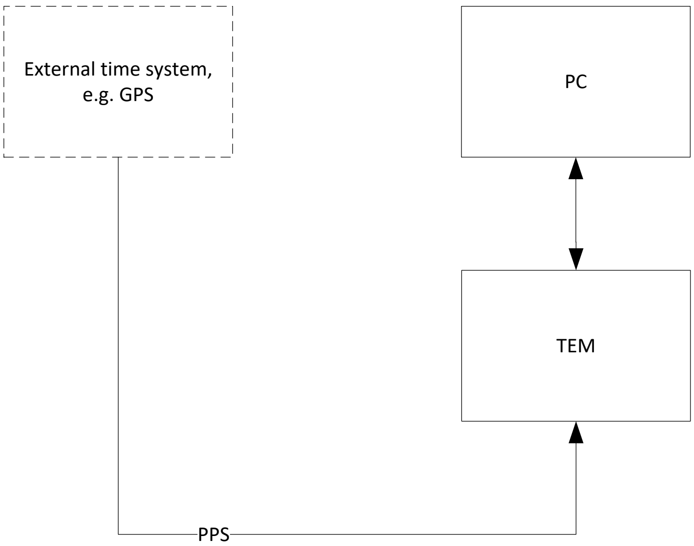


Figure 7-1 PPS Input to TEMs

7.2.1 Connecting the PPS signal

PPS is generally supplied as a BNC coax connection from the GPS system. A BNC connector is supplied on the Spider Cable for this purpose (see 5.2).

The Bathyswath PPS input is designed for high-impedance outputs. However, some systems provide PPS on a 50Ω output. In this case, it may be necessary to use a 50Ω BNC terminator and T-piece at the TIU PPS input.

7.2.2 Monitoring the PPS input

Swath Processor provides the ability to control the PPS input, and to monitor its status.

The Sonar control dialog in Swath Processor includes two controls:

- PPS Enable, and,
- Rising/Falling edge.

The first of these tells the TEMs to use the PPS signal to synchronise their clocks (or not). The second control determines whether the rising or the falling edge of the PPS square wave signal should be used for timing. *Note: CodaOctopus F180 and Applanix POS/MV systems provide a falling-edge PPS signal.*

A status indicator at the bottom of Swath Processor main dialog box (usually on the left of the screen) provides two status indicators:

- Ack, which acknowledges that the PPS signal is being received,
- Error, which checks that the period of the PPS signal is close to 1 second, as compared with the TEM's internal clock. The most common cause of an error of this type is if there is 'noise' on the PPS line, causing the TEM to trigger at times other than the correct signal edges. This might occur if the PPS impedance and termination are incorrect: see §7.2.1 above.

The main dialog box also contains a 'traffic light' status indicator, which summarises the state of the two status indications at a glance.

The Status window gives information about PPS status. Note that a PPS error state may briefly be detected when connecting or re-connecting the PPS signal, or changing the PPS state in software, as the TEM units synchronise to the regular PPS input.

7.3 SYSTEM CONFIGURATIONS

7.3.1 Alternatives

Bathyswath is designed to operate with a range of different equipment and system configurations. However, there are broadly two options for system timing:

- **Sensor clock** timing: all sensor information is recorded using the sensor's own clock time. This configuration provides data related to UTC-GPS time, with an accuracy of 10ms or so, but is more difficult to set up, and is only possible if the auxiliary sensor systems provide such timing information in their data interfaces.
- **PC clock** timing: all sensor information is logged using the time at which it appears at the PC for logging. This option provides a slightly less accurate solution, is prone to communications delays, and its relation to UTC-GPS time is only as good as the PC's clock synchronisation, which could be a second or more even with Windows time synchronisation tools. However, it is significantly more robust, easier to set up, and can be used with all attitude sensors.

7.4 SENSOR CLOCK TIMING CONFIGURATION

7.4.1 Description

In this mode, the sonar, and each sensor in the system, provides its data time-stamped with its own clock, and each of the clocks is tied to UTC-GPS time, using an external reference or time server.

7.4.2 Motivation

This configuration gives several advantages:

- Errors due to unknown or variable data communication times are eliminated,
- Attitude correction is better, as errors due to time offsets are eliminated,
- Post-processed attitude and position data can be used, as these files are also related to the sensor clocks,
- All data is traceable back to a global time source,
- Data can more easily be related to data from other systems being used at the same time,
- Some survey protocols specify such time referencing.

7.4.3 Potential problems

Disadvantages of sensor clock timing, compared to PC clock timing, include:

- It is harder to set up, requiring careful configuration of the overall system and each component,
- Time offsets between the various clocks can cause significant errors in data processing. The most common of these is ‘roll artefact’, where vessel roll is not properly applied to the sonar data, and the vessel’s roll appears as a sequence of ‘waves’ in the seabed data.
- It is only possible if each sensor sub-system:
  - Maintains its own clock,
  - Can be tied back to a central reference source,
  - Provides data in a format that includes time information. Most serial data interfaces from attitude sensors do not provide such timing data: formats missing this information include the ‘EM3000’ and ‘TSS1’ formats.

However, when the time data is recorded in Sensor Clock format, both the Sensor time and the PC time are recorded with each data item. Therefore, it is possible to revert to PC Clock timing in post-processing, if a Senor timing error is discovered after the survey is complete.

7.4.4 System diagram

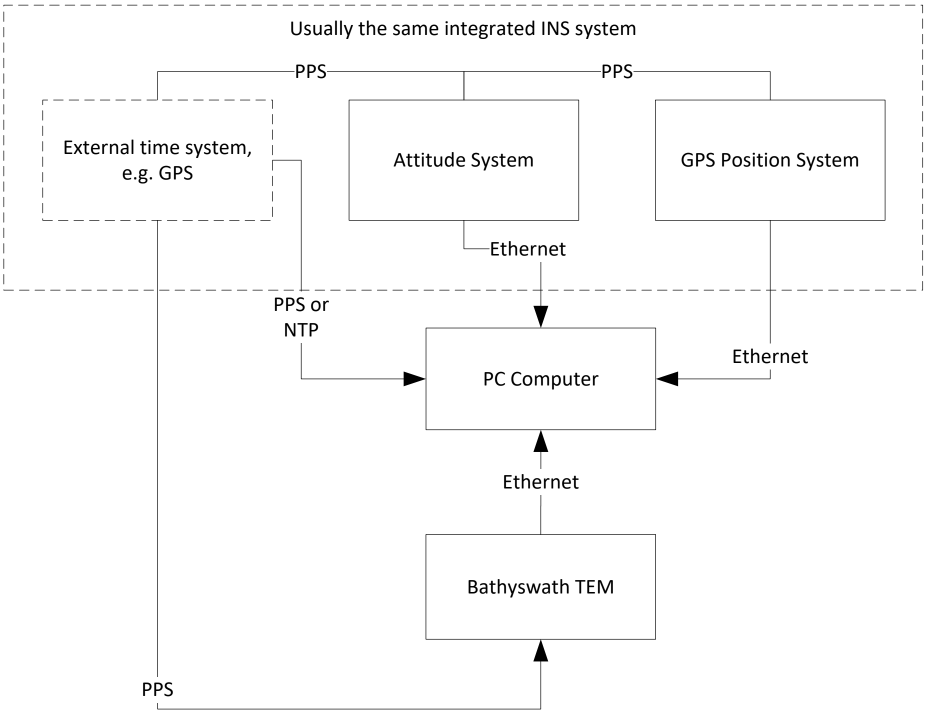


Figure 7-2 Sensor Clock Timing Configuration

7.4.5 Configuration settings

Connections:

- Use Ethernet output from the attitude and position sensor, using its 'native' sensor format, e.g. SBG ECom, CodaOctopus MCOM or POS/MV '102' format.
- Connect PPS from the attitude and position sensor to the TEM (see §7.2).
- Use NTP or PPS to synchronise the PC clock. However:
  - Good sonar-attitude time synchronisation is possible provided that the PC clock is accurate to the nearest half-second in either direction.
  - Swath Processor can be configured to synchronise the PC clock to the time coming from the position system; while this is only accurate to several tens of milliseconds, it is good enough for sonar-attitude synchronisation.
  - If a separate NTP server is used, make sure that it keeps well synchronised with the attitude system clock.

Swath Processor settings

- Configure the attitude and position Ethernet interfaces as explained in section §4.4.3.
- Select **Sensor Clock** using the button in **Swath Processor > Configuration > Time Setting**.
- Enable PPS in the Sonar dialog.

7.5 PC CLOCK TIMING CONFIGURATION

7.5.1 Description

In this mode, all data is time-stamped with the PC clock time at the moment of acquisition in Swath Processor.

7.5.2 Motivation

The advantages of this configuration are:

- Errors due to differences in system clocks are eliminated,
- Errors due to drift between clocks are eliminated,
- Errors due to Windows time sensing are eliminated,
- It is quicker to set up,
- It is the only possible configuration when using serial data interfaces from attitude sensors that do not include time data. These include the industry standard TSS1 and EM3000 formats.

7.5.3 Potential problems

Disadvantages of PC clock timing, compared to sensor clock timing, include:

- Times cannot be related back to universal UTC-GPS time to better than a second or so, and only then if the PC clock is synchronised in some way.
- Time synchronisation between sonar and attitude data is subject to communications delays from both systems, and therefore roll correction will not be quite as good in high roll rates.

7.5.4 System diagram

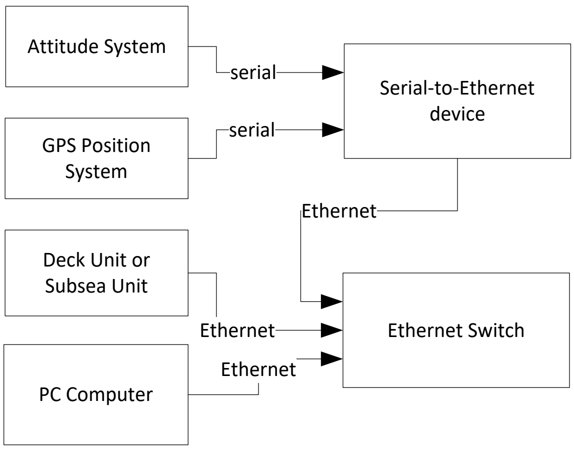


Figure 7-3 Bathyswath 2 PC Clock Timing Configuration

7.5.5 Configuration settings

Connections:

- Use serial output from the attitude and position sensor, using a suitable data format. Ethernet data interfaces still work in this mode, but if they are available, consider using Sensor Clock timing. On a laptop computer, it may be necessary to use an Ethernet-Serial data converter. USB data converters are not recommended, as they can insert delays of several tens of milliseconds.

- PPS to the TEMs is not necessary in this mode, as the TEM clock data is ignored.
- Use NTP or PPS to synchronise the PC clock if possible. However, this is not necessary to get good Bathyswath survey results.

In Swath Processor:

- Configure the attitude and position serial interfaces as explained in the Online Help.
- Select **PC Clock** using the button in **Swath Processor > Configuration > Time Setting**.
- Disable PPS in the Sonar dialog. (Although there is no harm for the PPS to be running: it is ignored in this mode).

Set a small delay to the attitude samples to account for serial data acquisition times: **Configuration > Sensor Parameters > Attitude Sensor Corrections > Time Offset**. An offset of –0.015 works well for an attitude sensor operating over a serial link.

7.6 MONITORING SYSTEM TIMING

7.6.1 Motivation

Especially if using Sensor clock timing, it is important that the relative timing of the components of the system is carefully monitored during surveys. To do this, open a **Text** window, and select **Show Timing Data**. This monitors the current PC time, and the time of the latest sonar, attitude, and position data samples, together with the differences between these. It also shows running averages for the ping-attitude and ping-position data samples.

7.6.2 Text View

Note that there is no reason why any of these differences should be exactly zero, as the data is acquired asynchronously, at different rates, for each data set. (An exception is the attitude and position data if these are coming from the same sensor; in that case a zero attitude-position time can be expected). As attitude data is acquired at a faster rate than sonar data, particularly when running at longer ranges, the latest attitude sample will almost always be later than the latest ping sample, and so the ping-attitude difference will be negative, and about half the ping period. It is not appropriate to attempt to compensate for this difference, for example using the Attitude Sensor corrections settings in Swath.

Use the **Show Timing** option in the Text View. See the context-sensitive help for details.

7.6.3 Sonar Views

Strong roll errors will show up as movement in the cross-profile displays. Note that the 'noise' data should roll with the vessel, but the seabed should stay level (apart from real changes in the seabed as the boat moves across it, of course).

Watch the colour-depth waterfall views for signs of roll errors; on a seabed with slight slopes on it, some quite small timing errors can be seen.

7.6.4 Correcting for Timing Errors

If the roll error is large, check that the transducers are connected the right way round and that the attitude sensor is correctly orientated and configured.

In Sensor Clock timing mode, watch the various timing offsets. Observe the 'now-att' time to look for differences in the PC clock and attitude clock (this only works in real time, not from recorded data). If there is a large error (more than 1 second), check how the PC clock is being synchronised, and correct it.

If there is a small residual roll error, try small time offsets in the **Attitude Sensor** corrections settings in Swath Processor. However, it is more convenient to use **Tools > Tweak Motion**. This allows you to adjust the offsets at the same time as watching the **Cross Profile** and **Waterfall** displays. You can also select and watch **Processed Ping Data** in a **Text view**. That computes and prints out a numerical value for the roll artefact (average deviation from horizontal), which is easier to assess than watching for roll artefacts in the Waterfall display.

8 SOFTWARE INSTALLATION

The Bathyswath real-time software package, Swath Processor and Grid Processor, is only supported on Microsoft Windows. The software is developed and tested on Windows 10. It will probably work on older versions of Windows, but no technical support is provided for them.

Swath Processor and Grid Processor require considerable processing power to store, process and display the large data volumes of data that the system acquires. See the Recommended PC Computer Specification below for full details.

A “lightweight” data acquisition alternative is provided for use on small remote vehicles, running either Linux or Windows. This is called **swathRT**. It has its own manual, Ref 5.

8.1 INSTALLATION

An installation program, ‘Bathyswath.msi’, is provided for Swath Processor and Grid Processor. This automatically installs the programs and all other software modules that it requires. See Ref 3 for more information.

8.1.1 Recommended PC Computer Specification

In general, the more computer power, memory, and disk space available the better. Most modern laptop computers are powerful enough to run the Bathyswath software. Systems using Intel Atom and similar low-end processors are usually not powerful enough to run Bathyswath-2 systems, although they may be adequate for real-time operation with Bathyswath-1. For use on small open boats, consider a laptop computer with plenty of battery life. Swath Processor is designed to be usable with touch-screen computers. This can be useful in small vessels or rolling ships.

Item	***Specification***	***Notes***
Operating System	Windows XP to Windows 10 inclusive	Bathyswath is compatible with Windows 64 bit or 32 bit; different installers are available for each
Processor	Processor 3GHz or better	We recommend at least this processor power. The system operates more slowly on lower-powered PCs. A more powerful processor always helps.
Graphics	3D accelerated graphics, at least 256Mb memory	Must support OpenGL functionality
Monitor	17” or larger	It is possible to open several display windows simultaneously, so a large screen is advisable. With laptops or panel computers, choose a model with a large screen. For post-processing, consider using a separate plug-in monitor.
Memory	8Gb or more	The more the better, particularly for post-processing

Item	*Specification*	*Notes*
Hard Drive	100Gb or more	The system uses about 0.5Gb per hour, so plenty of disk space is required for storage and processing. An external USB disk drive is a practical alternative to a large internal disk drive.
Network interface	Standard RJ45 Ethernet	For interfacing to Bathyswath-2 and some auxiliary sensors. USB-Ethernet converters work well for computers that don't have an Ethernet port.
Serial ports	RS232 ports for auxiliary sensors, if the ones used have serial ports. However, many such systems now use Ethernet or USB, so serial may not be needed.	For input of auxiliary data. Caution is required with plug-in units, e.g. USB; these can sometimes have an unacceptable delay between a message arriving and it being presented to software. For systems other than attitude and position, USB-to-serial is OK.
USB ports	4-off USB ports required; at least 6 are recommended for Bathyswath 1	2 for Bathyswath-1 TEMs, 2 free. More needed if the system uses them itself, e.g. for mouse or DVD drive. External USB disk drives and USB 'memory sticks' require more ports. 2 USB ports on the computer plus a USB hub is OK.
Mouse	Wheel mouse	A mouse with a wheel is essential for some of the swath controls, such as zooming and scrolling.
Keyboard	Windows compatible	
Touch-screen interface	Useful but not essential	Swath Processor is designed to support use with a touch screen, but works perfectly well without

8.2 PC CONFIGURATION

This section provides tips for configuring Windows PCs to get the best performance from Bathyswath. PC computers and operating system versions and configurations vary enormously, so not all of these tips will be appropriate for every situation.

Most PCs, including laptops, usually work well with the Bathyswath software with no modification.

8.2.1 Windows Versions

Bathyswath software is currently tested to run on Windows 10. It should work with Windows 8, 7, Vista and XP, but is not tested on those older systems.

8.2.2 Windows security settings

Microsoft Windows is ever more security conscious. This is important for preventing viruses and other 'malware' from infecting computer systems, but it can prevent Bathyswath from working well and interacting with other computer systems.

For networking, e.g. connecting to Ethernet attitude systems, check the Windows Firewall settings.

Even for stand-alone survey laptops, the use of a good-quality virus checker and firewall is highly recommended.

8.2.3 Screen savers and power-off modes

For survey use, disable screen savers and power-off modes.

8.2.4 Display resolution

A high screen resolution is recommended: at least 1280x1024.

8.2.5 USB, Bathyswath-1 and SWATHplus

Bathyswath-1 and SWATHplus systems connect to the computer through a USB port. Bathyswath-1 TIUs are fitted with an internal USB hub to connect the TEMs to the computer, so a single USB port is provided. Older SWATHplus TIUs have separate USB ports for each TEM; these can be connected to the PC using a USB hub. The performance can be assessed by opening Swath, setting the Ping Range to a short range (say 5m), and checking the ping rate in the bottom right-hand corner of the Swath window.

Bathyswath-1 and SWATHplus USB ports are type USB 1.1. They work with USB 2 and USB 3. The cable length supported by USB 3 is shorter than that supported by the previous USB versions, so when using with USB 3 you may need to use a shorter USB cable than that supplied or which you have previously used.
When using USB-C, use a USB-C to USB 2 or USB 3 hub.

8.2.6 Serial Ports

Some attitude, position and sound velocity sensors use serial ports to connect with the computer, although Ethernet, USB and Bluetooth are now more common. These serial ports usually use the RS232 standard. Most modern computers don't have serial ports fitted, and so serial port converter devices are used, typically Serial-to-USB or Serial-to-Ethernet. These are available from all computer and electronics equipment sellers. Serial-to-USB converters are usually easier to set up, but Serial-to-Ethernet converters have several advantages:

- The time delay in sending data to the computer is smaller than in USB; this is important for attitude and position data, but not so important for information that is not so time-sensitive, such as sound velocity.
- Ethernet is electrically isolated: the electrical ground is not passed through from input to output. This means that there is less risk of electrical noise from sensors and other devices affecting the sonar data quality.
- Most USB-to-Serial converters have one USB "dongle" for each serial port, plugged into one USB port.
    - This is simple, but has a few disadvantages:
        - On a system with several COM ports, you can run out of USB ports,
        - The USB dongles are bulky and get in the way, particularly when working on small boats,

        - The USB dongles can easily pull out of the USB connector.
    - In contrast, a Serial-to-Ethernet box can be mounted away from the computer, fixed down, with the serial connectors firmly screwed in. Ethernet RJ45 connectors have a locking lever, and so are less likely to come loose. The computer only has one cable connection to it (or none, if an Ethernet-to-WiFi converter is used).
- Most Serial-to-Ethernet devices can be configured to use either COM ports (see below) or UDP ports. Not all software applications can accept data from a UDP port, but they have advantages, including making it easier to send data from one serial port to several UDP ports.

8.2.7 Serial-to-Ethernet Converters

Most serial-to-Ethernet converters are configured through a Windows application that connects to the device.

Configurations should include:

- Windows port: this can use COM ports or UDP port connections:
    - Most devices support a mixture of COM and UDP,
    - The Swath Processor Attitude and Position ports use COM ports for serial devices; the Aux Ports can use COM or UDP.
- Disable FIFO buffers: it is usually better to "lose" a few data messages than to have messages arrive late.

See above for the relative benefits of USB and Ethernet serial converters.

Section 6.7.2 gives an example of setting up a serial-to-Ethernet converter for use with Bathyswath-UW systems.

8.2.8 Virtual COM Ports

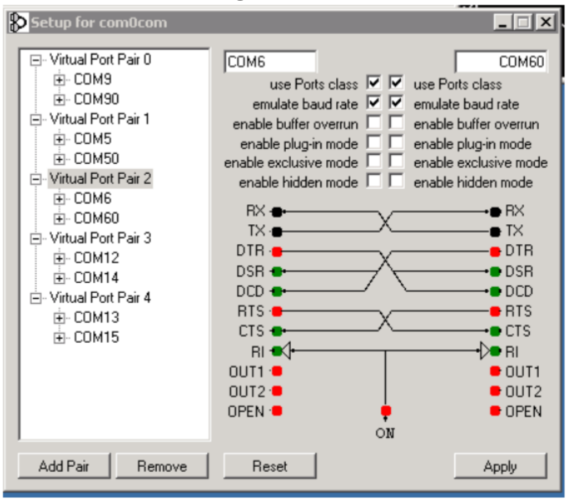
Sometimes it is useful to share the input from one serial port to COM port connections on two different applications. For example, if Bathyswath is used with a third-party bathymetric software package, it is useful to send attitude and position data to both Swath Processor and the third-party application.

In Windows, the serial port hardware (RS232, RS422, etc.) is made accessible to software applications through software devices called COM ports. These are called "COM1", COM2", etc. You can see which ones are set up on your computer using the Windows Device Manager, and looking at the Ports section. (If there are no COM ports, then there won't be a Ports section shown).

To do this:

- Install a virtual COM port application.
- The Septentrio DataLink application works well with Bathyswath installations. See section 6.7.4.
- We have also successfully used "com0com" (available from http://com0com.sourceforge.net/), but others are available.
- Set up a virtual COM port pair for each connection.

- The com0com configuration window looks like this:



Install an application that splits the output from one input COM port to two output COM ports. We have successfully used "hub4com" (available from the com0com link above), but others are available.

- Configure the COM splitter application to send the data from an input COM port to the virtual COM port pair created above.
- For example, using com0com and hub4com to duplicate COM10 so that it can be accessed through two new ports, COM6 and COM60:
  - Set up com0com to make a virtual port pair, COM6 and COM60 (see the screen shot above),
  - Start hub4com using the following command:
    - hub4com --route=0:1 \\.\COM10 \\.\COM60.
  - The com0com configurations continue to exist after rebooting Windows, but the hub4com instantiations do not. So, you need to:
    - Create a Windows command script (e.g. "serialSplitter.cmd"), using Notepad.
    - Put the hub4com commands as above into it.
    - Move this command script to the Windows startup folder:
      - In Windows 10:
        - Right-click the Windows button (bottom-left of the screen)
        - Select **Run**
        - Enter shell:startup
        - Windows Explorer opens at the location of the start-up folder: drag and drop your command script into it.

8.2.9 COM Port access in Swath Processor

When Swath Processor starts, it takes control of a set of COM ports for its serial port connections. This set needs to be selected carefully, so that

1. Swath Processor has access to the COM ports that it needs, and
2. Swath Processor does not prevent other applications from accessing the COM ports that they need.

This is done using the swathprocconfig.txt file, which is located in the same folder as the Bathyswath software executable files, by default “C:\Program Files\ITER Systems\Bathyswath”.

The default swathprocconfig file has:

```
NUM_COM_ports            numberPorts      6
COM_ports  port          1            COM1
COM_ports  port          2            COM2
COM_ports  port          3            COM3
COM_ports  port          4            COM4
COM_ports  port          5            COM5
COM_ports  port          6            COM6
```

To change this:

- Change “NUM_COM_ports numberPorts” to the number of COM ports needed,
- Delete or add “COM_ports port” lines to match that number,
- Ensure that “port 1” starts at 1 and increases by 1 for each line,
- Edit the “COM” entry at the end of the line to show the COM port number needed.

For example, if Swath Processor needs to use COM2, COM4 and COM12, enter:

```
NUM_COM_ports            numberPorts      3
COM_ports  port          1            COM2
COM_ports  port          2            COM4
COM_ports  port          3            COM12
```

Warning: swathprocconfig.txt is over-written when the Bathyswath software is updated, so make sure that you save it and copy over any changes that you have made after each re-installation.

8.2.10 Ethernet-to-WiFi converter

If the survey system is configured to use Ethernet throughout, for example using a serial-to-Ethernet converter for RS232 connections, and a laptop computer is used for the survey software, then the laptop can be freed from cable connections using an Ethernet-to-WiFi connector.

- Connect all the Ethernet devices to an Ethernet switch box (possibly including a serial-to-Ethernet box: see 8.2.7).
  - For SWATHplus and Bathyswath-1 systems, which use USB instead of Ethernet, you need to use a device that connects USB devices to Ethernet. Search for “Ethernet print server”); “USB-to-Ethernet converter” lists devices that allow an Ethernet wire to be connected to a computer through a USB port, which is the opposite of what we need here.

- Connect an Ethernet-to-WiFi converter to the Ethernet hub. We have successfully used the “TP-LINK TL-WR802N Portable Travel Router”, but several equivalent devices are available. They usually have plenty of data bandwidth, enough to transmit the Bathyswath sonar data and auxiliary data.
- Set up the WiFi port on the laptop computer to connect to the Ethernet-to-WiFi converter.
- You can now use the laptop computer to control and monitor the Bathyswath system and auxiliary devices from anywhere on the boat, without awkward trailing wires. This is particularly useful on small boats, where the laptop can be placed where the helmsman can see the coverage view and control the sonar.

8.3 TO INSTALL USB TEMS (BATHYSWATH 1 AND SWATHPLUS)

When plugged in for the first time, USB TEMs are auto-detected by the Windows software, which then asks for the information needed to install the necessary drivers. For further information see the accompanying document ‘Installing Bathyswath’.

Tip: the Bathyswath-1 and SWATHplus USB installation is not plug-and-play. You will need to follow the installation instructions exactly to install the drivers successfully.

8.4 SOFTWARE SETTINGS FILES

The Swath Processor program can be configured to work in many different configurations. The configuration details are stored in several different files, as appropriate to the configuration information stored. These are:

- The Bathyswath settings (or “session”) file, which has the file extension ‘.sxs’. This stores the details of a survey ‘session’, including:
  - The sonar settings (transmit power, ping length, etc.)
  - The auxiliary system settings (serial port number and baud rate, data format, use of auxiliary systems for creating attitude data),
  - Positions and angles for all the system components,
  - Correction offsets and multipliers for all data types,
  - Filter settings,
  - Location and settings of display windows.
- The Windows registry: this stores information such as the previous files and directories used, so that the user does not have to search the whole directory tree each time a new file is used.
- The swath processor initiation file. This stores information about the context of the computing system and other such start-up information. This file is not intended for the use of the general user, but rather is for installation and maintenance engineers. This file is always called ‘swathprocconfig.txt’. Details are supplied below.
- The Configuration file. This file stores the sub-set of data in the Swath settings file that concern the configuration of the sonar system, and is only used to transfer such information to and from external utility software.

8.4.1 Swath processor initiation file

This file stores 'fixed' information about the context of the computing system. This file is not intended for the use of the general user, but rather is for installation and maintenance engineers. Entering the wrong parameters into this file can cause the system to work incorrectly or not start up at all. If in doubt, do not edit this file. This file is always called 'swathprocconfig.txt', and is stored in the same location as the swath processor executable, 'bathyswath.exe'. By default, this is "C:\Program Files\ITER Systems\Bathyswath" for 64-bit installations, and "C:\Program Files (x86)\ITER Systems\Bathyswath" for 32-bit.

To edit this file, use a text editor such as Windows Notepad. Windows usually prevents direct editing of files in the Program Files directories. To get around this, find **Notepad** in the **Windows Start** menu, right-click on its icon, and choose **Run as Administrator**.

The swath processor initiation file is an ASCII text file. It consists of a set of entries, each entry being on one line of the file. A typical entry line consists of three words, separated by white space (spaces and tabs). The first word is the entry group, the next specifies the entry item, and the third gives its value.

The entries do not need to be in any particular location in the file, but if an entry type is repeated, then the information in the latest one in the file over-writes the information in any earlier ones.

A typical entry is:

```
sonar       hardwareFitted          1
```

The group is 'sonar'; there may be other entries that define the sonar settings.

The entry is 'hardwareFitted'; this particular item tells the software whether to expect Bathyswath TEMs to be accessible to it. The third item is set to '1', meaning in this case that the hardware is expected. If no hardware is expected, set this item to '0' (zero). This setting can be useful when the Swath Processor is installed on a system that is only used for post-processing, and it prevents the software from issuing a warning when it cannot find any Bathyswath hardware on start-up.

Other useful settings include:

- The 'COM_ports' group: defines the COM ports (serial ports) used by Swath Processor. See section 8.2.9.
- The 'buffer' group defines the size of data buffers used for storing system data. In rare cases, it can be necessary to increase a buffer size for an auxiliary sensor that is providing its data at an unusually high rate. Conversely, if it is necessary to reduce the memory load of the application to allow it to run on a computer with limited capacity (perhaps on a remote platform), then these buffers could be reduced in size (but make sure that the system is thoroughly tested after doing so).
- The 'geoid' group: this defines geoid parameters for use in converting position data
- The 'TM_data' group: this defines transverse Mercator parameters for use in converting position latitude and longitude data to transverse Mercator grid projection format.
- The 'LC_data' group: this defines Lambert Conic parameters for use in converting position latitude and longitude data to Lambert Conic grid projection format.
- The '7_param' group: this defines "7 parameter" geocentric transformation parameter sets for use in processing position data.

- The 'preset' group: this defines the pre-set filter settings used in the first window of the bathymetry filter dialogs. The meaning of each setting should be obvious in comparison with the bathymetry filter dialog items.

8.5 STARTING THE SOFTWARE

Windows provides several ways of starting software. Most users have their own favourites. The options include:

- The Windows 'Start' button. The installation program adds an 'ITER Systems' item to the start menu. Select **Swath Processor** for the real-time and processing program, and **Grid Processor** for the post-processing QA, calibration and gridding program.
- Click on the Swath Processor or Grid Processor icons on the desktop.
- Double clicking on the icon of a Swath Processor session file (.sxs) in the Explorer program. This option opens the selected session file within Swath Processor, and thus provides the settings that were stored in the session file.

8.5.1 Session File (.sxs) and project structure

Unless a specific session file was selected to open Swath Processor, it starts with a default set of settings, which are designed to work in many situations. Carefully check all the settings that this provides, and ensure that they are all appropriate to your installation. Once you have made these checks, and ensured that they all work, you may wish to save the settings as a template session file for use as a starting point in later work. For example, once you have set up the communications port parameters for the auxiliary equipment, and entered the sensors' positions in the Configuration dialogs, save the session file as, say 'setup.sxs'. Then, use **File** > **Save As** to save the file again, using a name that applies to the current project. This time, add the parameters that only apply to the current project, such as sound velocity and tide. Finally, use **Save** again, to ensure that this information is not lost in the event of a power failure, etc.

It is usually convenient to store all of the data associated with a survey project in one folder on the computer. Create a new folder, and store the .sxs session file in it. Open the session file in Swath Processor, and then use **Configuration > Project Structure**. This defines the directory structure used for the files in the project. For example, raw sonar data is stored in 'sonar/raw', processed data in 'sonar/proc', and so in.
Use the "As SXS file" button to set the "root" of the directory structure to the place where the session file is stored. This is important if you use a .sxs session file from another folder or computer.
When you click OK in the **Project Structure** dialog, the program automatically creates any necessary sub-folders.

You can use the **Project Structure** settings to set a different folder structure if you prefer.

See the context-sensitive help (F1 key) for more details.

8.6 USING THE SOFTWARE

The Bathyswath software is described in detail in Ref 1.

Full instructions for using the software are in the Online User Guide. You can access this by clicking on the **Help Topics** option on the Swath Processor **Help** menu, or pressing the F1 key on the keyboard.

The Grid Processor program has a separate manual [Ref 2]. This is accessible from the Bathyswath entry in the Windows Start menu or from the **Help** menu item in Grid Processor.

8.7 USE WITH REAL-TIME THIRD-PARTY APPLICATIONS

The Swath processor can be used with several third-party sonar processing and visualisation packages in real-time. These include QINSy (from QPS), PDS2000 (from Reson), Hypack (Hypack Inc.) and SonarWiz (Chesapeake Technology International).

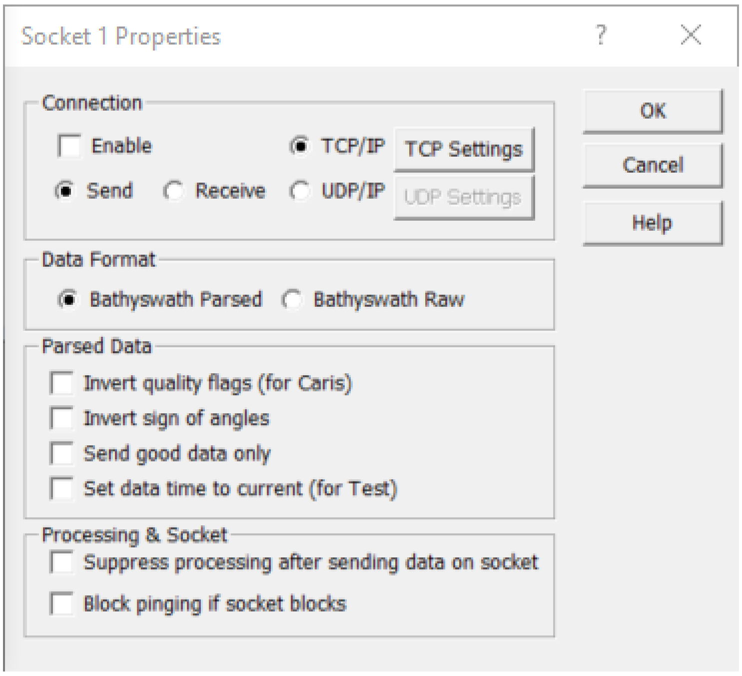
The Swath processor sends data to the third-party application using the 'Parsed Data' format, on a TCP/IP or UDP/IP link. This link can either be set up with both processes running on the same computer, or on different computers connected by Ethernet.

8.7.1 Configuring the software

Swath Processor can be configured either to run all its processes and displays, as per standalone operation, or the processing and displays can be suppressed to save on memory and processing power. The latter is usually preferable if both processes are running on the same computer.

To use Bathyswath with these applications:

1. Install the Bathyswath hardware and software for a standalone operation.
2. Start Swath Processor, and click on the **Socket 1** button in the Main Dialog Bar.



1. Select 'Enable'
2. Select 'Send'
3. For most applications, including Hypack, select **TCP/IP** or **UDP/IP**.
4. Click the **TCP/IP Settings** button to set the parameters of the TCP/IP link

a. Determine whether Swath is to act as the Server or Client in the TCP/IP connection, and select in the Socket Properties dialog. QINSy and Hypack are configured as clients, so select **Server** in this case.

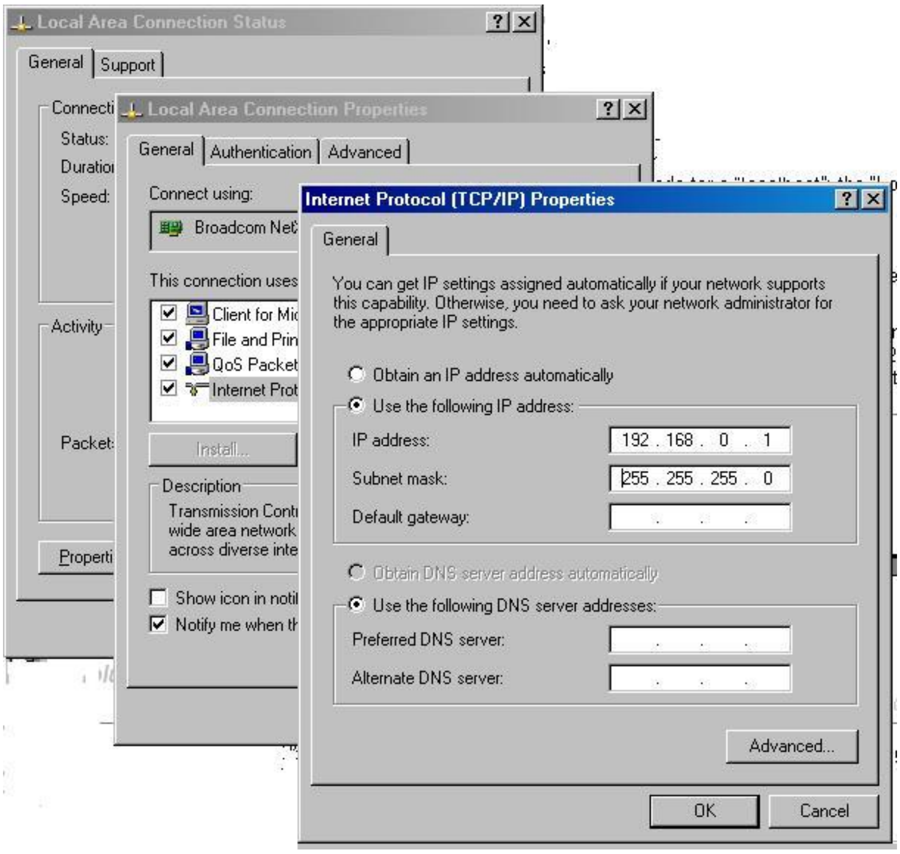
b. If using the Swath processor and Hypack on separate computers, set the IP address of the other computer in the '**IP Address**' box. Otherwise, enter '127.0.0.1'. This is the code for a 'localhost': the '**Local PC**' button enters this address for you.

5. … or the **UDP Settings** button to set the parameters of the UDP/IP link; port number and options for broadcast, multicast or unicast (send data to one IP address); the latter can be best if Ethernet bandwidth is limited.

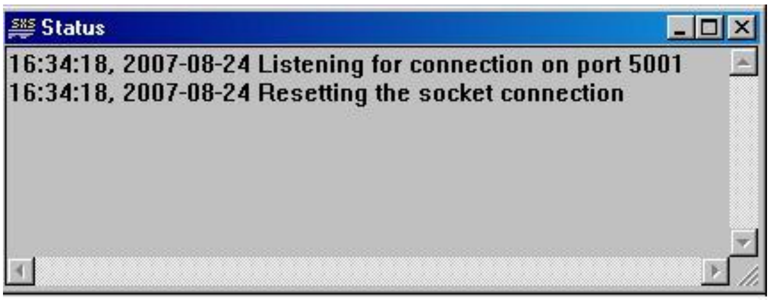
6. To configure a network between two computers:

   a. Connect the Ethernet ports of the two computers. This must be either through a network hub, or using a crossover cable.

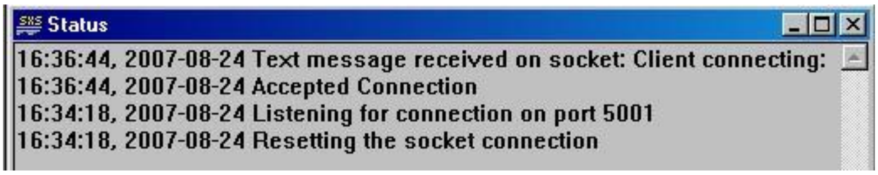
   b. Configure the IP address of the two computers so that they are on the same sub-net. For example, two computers might be set '192.168.0.1', and '192.168.0.2', and the sub-net mask of both of them set to '255.255.255.0'. The IP address of a Windows computer is set using **Start > Settings > Network Connections > Local Area Connection > Properties > Internet Protocol (TCP/IP) > Properties**



7. Select **Bathyswath Parsed**
8. To use the displays and processing in Swath Processor, alongside the third-party application, de-select **Suppress processing after sending data on socket**. Otherwise, select this option.
9. If the third-party application is the main processing, visualisation and data storage tool in the set-up, enable **Block pinging if socket blocks**. This causes Swath Processor to wait until the previous data packet has been sent over the socket link before sending the next one.
   If this option is left clear, Swath Processor continues to the next ping when the socket blocks, and the receiving process will miss pings.
10. Click **OK**
11. Watch the Status view for information about the state of the link. When the link is configured as a Server, to receive connections from the other process, the following message appears in the Status view:



12. When the other process makes a connection, the following status message appears:



13. The status of the socket can be checked at a glance using the ‘traffic light’ indicators in the Main Dialog Bar. However, a green light is no guarantee that the other process is successfully receiving and processing data, only that it is being sent without errors. The indicator goes amber if the socket ‘blocks’.
14. Save the session file to save these settings.
15. The connection can also be tested by using a second copy of the Swath processor as the receiving process. Configure the second Swath Processor with ‘Receive’, and ‘Client’. Both Swath Processors will need to be configured with session files specifying the correct attitude and position decode methods, etc.

If using Bathyswath and the other process on two separate computers, make sure that the two computers’ clocks are well synchronised. This can be achieved using an NTP server and client. For example, if the computer running the other process is synchronised to GPS time with PPS signals and ZDA messages, run an NTP server on the other computer and an NTP client on the Bathyswath computer. NTP server-client applications can be obtained cheaply as Internet shareware packages. See section 7.

8.7.2 Using third-party tools for both bathymetry and sidescan

Most third-party surveying software tools can process both bathymetry (depth) information and sidescan imaging data. However, the input requirements of these tools are often different for the two tasks. Bathymetry data is usually best filtered and downsampled in the Bathyswath Swath Processor software before sending to the third-party tool. This prevents that application from being ‘swamped’ with too much data. Sidescan data requires all the ‘raw’ data to provide good images. The filtered and down-sampled data does not provide high-resolution sidescan images.

Swath Processor provides a second TCP/IP port (**Socket 2**). This is useful for third-party applications that handle sidescan data on a separate port to the bathymetry data. Socket 2 sends out unfiltered data. (Socket 1 sends filtered data).

Some third-party programs, including Hypack/Hysweep, do not support the use of two separate input channels from Bathyswath. However, Hypack includes filtering software that keeps the full resolution of the sidescan data while intelligently reducing the data volume of the bathymetry data. For Hypack, use only Socket 2, and for QINSy, use Socket 1 for bathymetry data and Socket 2 for sidescan data.

8.7.3 Using sound velocity data with third-party software

Hypack/Hysweep, and some other software tools too, does not correct the angle of arrival of the signal from the bottom for sound velocity. That means that you cannot apply surface sound velocity in postprocessing, as you can with the Bathyswath software.

Therefore, if you are using Hypack/Hysweep, you will need to fit a continuous-reading sound velocity sensor (SVS) to the Bathyswath system, and interface it to the Bathyswath software in real time. If you don’t have access to an SV sensor, then you should obtain a suitable SV value for the day of the survey, and enter it into the **Default Value** section of the **Sound Velocity** dialog, and select **Default Value** for the **SV at Transducer** and **Range Calculation** selection boxes.

Swath Processor includes an option to use SV from an SV profile to compute SV at the sonar head for angle calculations. However, that doesn’t work for the data that is sent out of the TCP socket to Beamworx, so you must either use the SV sensor or enter a valid SV in the **Default Value** box.

9 USING BATHYSWATH FOR SURVEYING

Once the hardware and software are installed, as described in the previous sections, you are ready to use Bathyswath for hydrographic surveying.

The real-time software (Swath Processor) is used to set-up, control and run all aspects of the survey, including data collection, processing and recording. Detailed instructions for using Swath Processor are on the Online User Guide of the software. You can access this by clicking on the **Help Topics** option on the software's **Help** menu.

The Online User Guide also contains advice on the practical aspects of planning and preparation for carrying out a survey using Bathyswath, including calibration and quality control.

9.1 CHECKS BEFORE SURVEYING

This section summarises the checks that need to be made before each survey.

Several check sheets and crib sheets are referred to in this section. Copies of these are provided with the Bathyswath software.

9.1.1 Common checks

All sensors and interfacing need to be tested prior to survey. This will include the sensor message streams, as well as interfacing between acquisition computers. All sensors should be checked to ensure that the messages being output are correct for the survey, and that equipment is set up for use with the correct accuracies. For example, check that GNSS corrections are received and the resolution of the GNSS position is as specified for the job. Alarms should be activated in equipment to activate at the appropriate levels in both the sensor and any acquisition software. Position system confidence checks also need to be undertaken (section 9.3).

Survey data is cross-referenced by position and time. When collecting data, all sensors must be acquired on the same time base so that they can be correctly geo referenced. All acquisition computers need to be synchronised with each other and against GPS or UTC time. A number of the acquisition programs have synchronisation function to set the computer clock using the GPS time from the position input strings. The time set in this way can be variable and be subject to any latency in the interface as well as the 15ms time resolution accuracy that is generally available under Windows PC. This is not necessarily a problem, as a number of the sensors provide data that is time stamped at the sensor, but quite a few do not, and if these data sources are high frequency then latencies will be seen in the data. Acquisition programs often allow the user to correct for these latencies, but this can be variable in its success. Depending on computer loading and interface type, latencies can be seen to be variable through the interface, as well as be vulnerable to a 15ms jitter if time-stamped at the PC. It is recommended that if any sensor or computer can be set up to use a PPS source from a GPS then they should be set to do so. It is also highly recommended that an NTP time server and clients are used to keep the PCs used for acquisition in line, as NTP software will maintain the computers clocks to a higher accuracy than one of synchronisation functions. This is probably best achieved using an independent NTP server. In this case, all the acquisition computers will need to be networked and running NTP client software. Given this arrangement, all PCs will be synchronised. It may also be possible to achieve this by using a PPS controlled computer as the NTP server, but the problem with this solution is that some of the PPS solutions provided by survey software will maintain survey acquisition clocks, but may not maintain the PC clock. This is certainly the case for Hypack, and may be the case for QINSy and PDS2000.

See section 7 for advice on configuring the system timing.

Care also needs to be taken to check all equipment is installed correctly and that all cabling is safe and does not interfere with other systems.

9.1.2 Bathyswath hardware checks

Section 4 covers installation and deployment issues to note for Bathyswath and auxiliary sensor installation. Pay particular attention to sections 4.11, 'Installing Position, Heading and Attitude Subsystems', 4.13 'Transducer Installation – General', and 5.2, 'Spider Cable'.

For grounding and earthing, set the sonar to be active but not transmitting. Check the amplitude level seen without the transducers connected. The base level in the amplitude window should be as low as possible, 10k is ideal, but certainly lower than 20k to get good results. If spikes or sine wave seen then a sea earth may need to be run to the various sensors, but try a sea earth to the TIU first. Pay particular attention to any sensor powered by a battery or connected to the acquisition computers via RS232 serial connections. See section 4.10.

In addition to these general installation procedures, the Bathyswath system needs to be tested in line with the maintenance procedures listed in section 11, 'Maintenance', particularly section 11.1, 'Daily, and Before Leaving Port', and section 11.2, 'Weekly, and Before Each Survey'.

9.1.3 Calibration

Before surveying, all the equipment in the survey spread needs to be calibrated. This includes:

- The Bathyswath electronics in the Transducer Interface Unit (TIU), if using Bathyswath 1 and SWATHplus. This is not required for Bathyswath-2 systems.
- Sensors, such as the attitude sensor
- Position system
- Relative linear and angular offsets for all components

Also see section 11.2, 'Weekly, and Before Each Survey', and 'About Calibration' in the Bathyswath Online Help.

9.1.4 TIU hardware calibration (Bathyswath-1 and SWATHplus only)

At the beginning of every survey it is advisable to check that the **Bathyswath-1 and SWATHplus Transducer Electronics Modules** (TEMs) in the sonar electronics box, or TIU, have the same values as they did on delivery from the manufacturer. **Later systems (Bathyswath2 and on) use digital filters that do not drift, and so do not need this process**. The TIU electronics are tuned at the factory, so the phase measurement electronics give a zero value. The tests should be undertaken with the transducers attached. This procedure is detailed in section 11.2.1. If the values differ from factory calibration or from the previous survey calibration values, they must be noted in a phase offset table, and be entered in any session file used to acquire or process the survey data. The phase offsets should be entered and applied in the 'Phase Offset' dialogue under 'Configuration' in Swath. These offsets are used to correct any phase offset misalignments in the TIU so that the sounding angles determined are correct. The phase offsets must be correct when the patch test data is processed.

9.1.5 Sensor calibration

Before any swath sensor patch test can be conducted, the sensors being used for the survey must be calibrated following the procedures outlined by the sensor supplier. Such sensor calibrations include magnetic compass environment calibration and dual antenna GNSS heading system calibration.

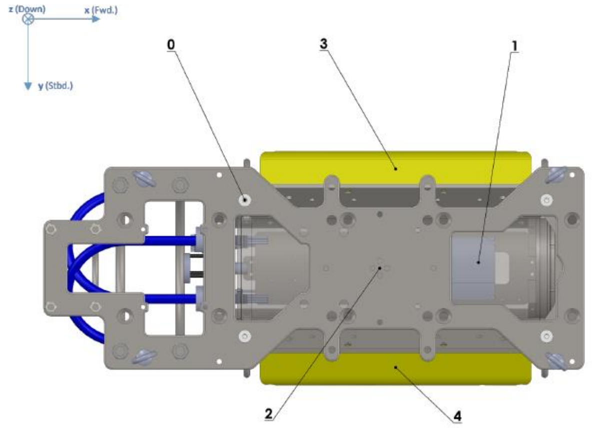
9.1.6 Sensor offset measurements

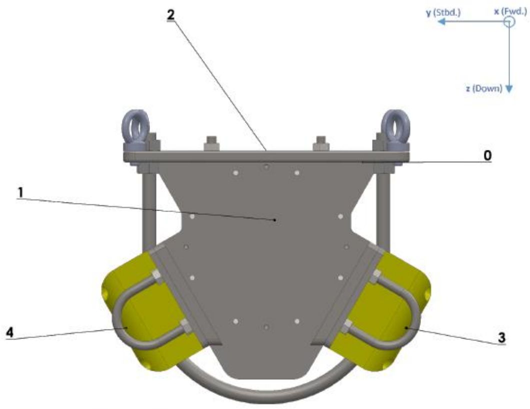
Offset measurements must be noted for each sensor. These include measurements required for the sensor set-up, and offsets between each sensor. A 'common reference point' (CRP) should be chosen for the survey. This is often the centre of the motion sensor, but it could be at any convenient location to which everything can be measured. The CRP is the position and height datum for the vessel, and offsets should be measured in reference to it. 'Lever arm' corrections need to be applied between the motion sensor and the sonar transducers, so that the motions applied are correct for the position of the sensors. This can be done in either the sensor, or the acquisition software, *but not both*. Applying lever arms within a motion sensor, especially if it is a combined motion, position and heading sensor or INS, will give more accurate results than those applied in software, but may be more difficult to correct for later if the lever arm is applied incorrectly in the instrument.

Vessel offset diagrams are provided with the Bathyswath software to codify sensor positions and offsets as well as define the survey reference point. Additionally, a 'Configuration Reference Sheet' has been provided to guide the operator on the correct place to input sensor offsets and corrections in Swath Processor.

Ideally, all offsets should be measured using a 'total station' land survey instrument or laser scanner, but steel tape, laser levels and plumb bobs can be effectively used if care is taken for the progression of measurements through bulkheads or outside to inside the vessel. If possible, all measurements should be taken to an accuracy of 1cm. Also determine static transducer draft, settlement and squat corrections, sound velocity corrections, and tide corrections. Apply these to the data prior to bias determination (patch test calibration), and system accuracy tests.

The diagram below shows the offsets for Bathyswath-2-UW systems.





Lever arms_Subsea Unit

	x	y	z
Pt 0 (hole point on the interface plate and on the lower side)	0,0 mm	0,0 mm	0,0 mm
Pt 1 (INS/IMU center point)	292,6 mm	77,8 mm	51,1 mm
Pt 2 (center point on the interface plate and on the upper side)	169,0 mm	85,0 mm	-10,0 mm
Pt 3 (PORT tdcr, 234 kHz)	189,0 mm	-38,8 mm	146,5 mm
Pt 4 (STBD tdcr, 234 kHz)	189,0 mm	208,8 mm	146,5 mm
Pt 3 (PORT tdcr, 468 kHz)	201,0 mm	-25,9 mm	139,0 mm
Pt 4 (STBD tdcr, 468 kHz)	201,0 mm	195,9 mm	139,0 mm

	x	y	z
Pt 0 (hole point on the interface plate and on the lower side)	-169,0 mm	-85,0 mm	10,0 mm
Pt 1 (INS/IMU center point)	123,6 mm	-7,2 mm	61,1 mm
Pt 2 (center point on the interface plate and on the upper side)	0,0 mm	0,0 mm	0,0 mm
Pt 3 (PORT tdcr, 234 kHz)	20,0 mm	-123,8 mm	156,5 mm
Pt 4 (STBD tdcr, 234 kHz)	20,0 mm	123,8 mm	156,5 mm
Pt 3 (PORT tdcr, 468 kHz)	32,0 mm	-110,9 mm	149,0 mm
Pt 4 (STBD tdcr, 468 kHz)	32,0 mm	110,9 mm	149,0 mm

	x	y	z
Pt 0 (hole point on the interface plate and on the lower side)	-292,6 mm	-77,8 mm	-51,1 mm
Pt 1 (INS/IMU center point)	0,0 mm	0,0 mm	0,0 mm
Pt 2 (center point on the interface plate and on the upper side)	-123,6 mm	7,2 mm	-61,1 mm
Pt 3 (PORT tdcr, 234 kHz)	-103,6 mm	-116,6 mm	95,4 mm
Pt 4 (STBD tdcr, 234 kHz)	-103,6 mm	131,0 mm	95,4 mm
Pt 3 (PORT tdcr, 468 kHz)	-91,6 mm	-103,7 mm	87,9 mm
Pt 4 (STBD tdcr, 468 kHz)	-91,6 mm	118,1 mm	87,9 mm

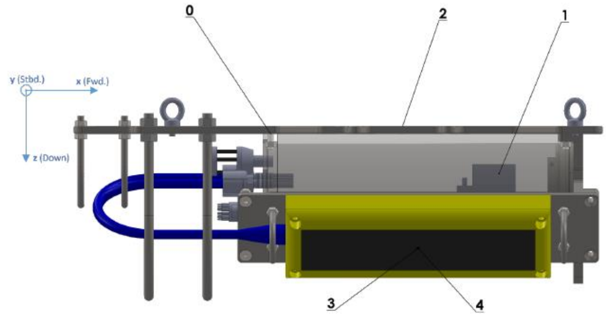


Figure 4 Offsets for Bathyswath-2-UW systems

9.2 SENSOR MISALIGNMENT (PATCH) TEST

Prior to commencing survey operations, the operator should conduct a patch test to quantify the accuracy, precision, and alignment of the swath system. The patch test is used to determine any residual biases (misalignments) in roll, pitch, heading, and navigation timing error. These values will be used to correct the initial alignment and calibrate the swath system. The sensor offsets are derived from post processing the patch test survey lines.

The patch test has a number of defined line patterns that need to be run or derived in a particular order. The survey line patterns required to be run to derive sensor misalignments on the survey vessel are shown in Figure 9-5. These diagrams show patterns used both for beam-forming multibeam systems and for Phase Differencing Bathymetry Sonars (PDBS) such as Bathyswath.

When collecting the patch test survey lines, line keeping and vessel speed are important, and harsh or sudden changes in direction or speed (except where specified) should be avoided.

The order in which the sensor misalignments and biases are determined may affect the accurate calibration of the swath system. The operator should determine the biases in the following order: pitch, navigation timing error, roll and heading. Variations from this order, or simultaneous determination of all values, may need to be undertaken in certain conditions, but any variation and reason for it should be noted by the operator.

Heave should be observed in no coarser than 0.05 metre increments. Roll and pitch shall be observed in no coarser than 0.1° increments.

Heading should be observed in no coarser than 0.5° increments.

Navigation timing error should be observed in no coarser than 0.01 second increments.

Pitch and navigation timing error biases should be determined from two or more pairs of reciprocal lines 500 to 1,000 m long, over a smooth distinct slope, perpendicular to the depth curves. The lines should be run at different speeds, varied by up to 5 knots, for the purpose of delineating the along track profiles when assessing time delay. Navigation timing error bias could also be determined from running lines over a distinct feature (i.e., shoal) on the bottom, as long as the feature is pinged by the vertical (nadir) beam. However, in very shallow water, less than 10 metres, small pitch offsets have little effect on survey results. So, it may be difficult to get good results from a patch test in shallow water, but small pitch errors may be safely ignored.

Roll bias calibration uses a series of lines that are run to provide a 100% overlap of port-to-port and starboard-to-starboard transducers. The preferred line pattern, as well as alternative patterns to be used in restricted conditions, is outlined in the patch test crib sheet.

Heading bias should be determined from two or more adjacent pairs of reciprocal survey lines, made on each side of a submerged object or feature (i.e., shoal), in relatively shallow water. Features with sharp edges should be avoided. Adjacent swaths should overlap by 10–20 percent while covering the shoal. Lines should be run at a speed that will ensure significant forward overlap.

The operator should note the exact procedures run, the order and results. This information is important to allow the post processing personnel to determine and check the system alignment of the sensor, the accuracy, and produce a calibration and system performance reports.

Once calibration data have been processed and final system biases determined, the new corrections can be used in a system accuracy test to ensure that the new system biases are adequate. The test should be conducted in an area similar in bottom profile and composition to the survey area, and during relatively calm seas and conditions to limit excessive motions and ensure suitable bottom detection. In addition, the system accuracy test should be conducted in depths equivalent to the deepest depths in the survey area. The system accuracy test is basically a set of at least three overlapping lines, with at least one cross line run orthogonal to the main survey lines.

The patch test and system accuracy tests should be repeated whenever changes (e.g., sensor failure, replacement, re-installations, re-configurations, or upgrade; software changes which could potentially affect data quality) are made to the system's baseline configuration, or whenever assessment of the data indicates that system accuracies do not meet the requirements specified for the project.

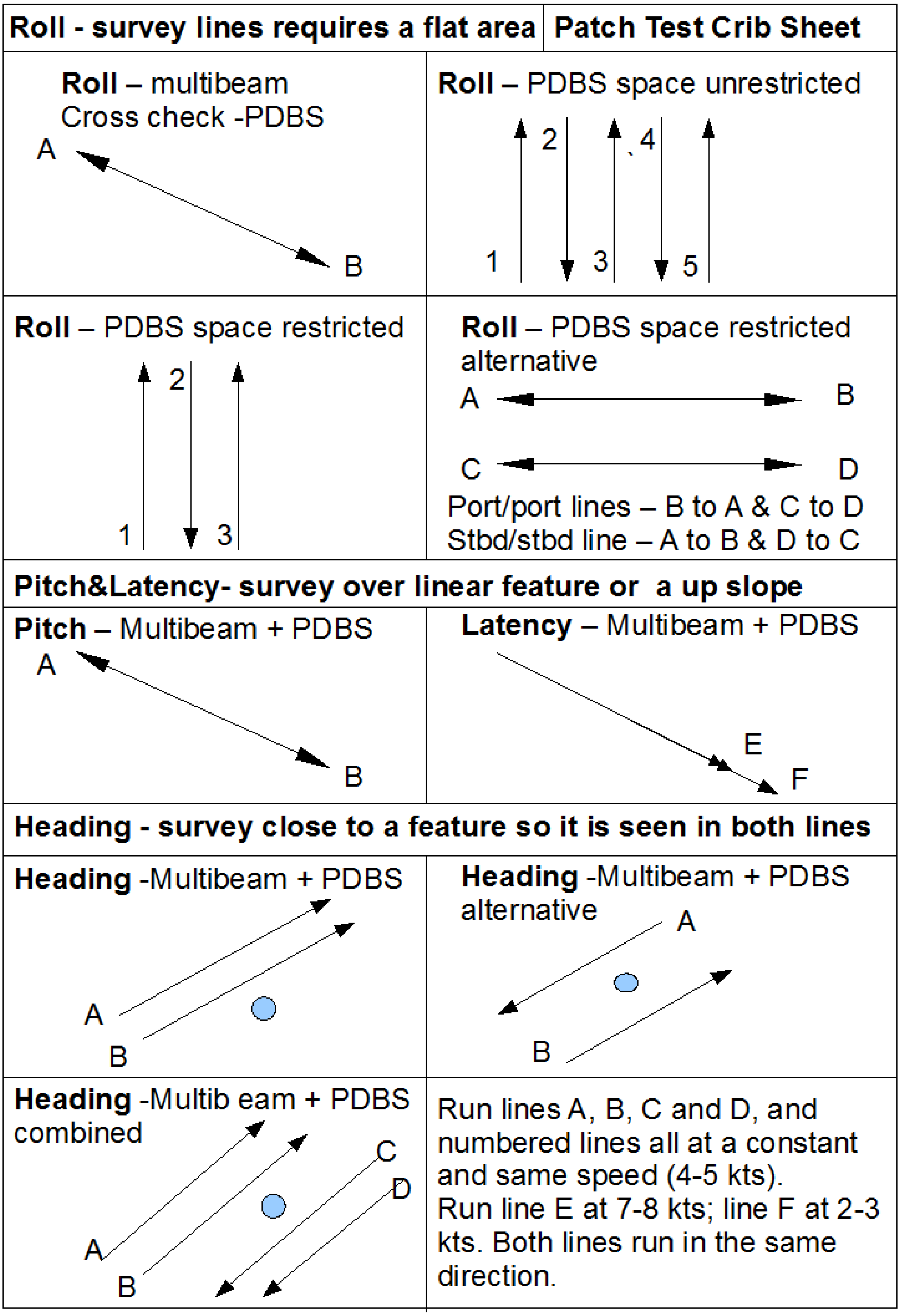


Figure 9-5 Patch Test Patterns

9.3 POSITIONING SYSTEM CONFIDENCE CHECKS

Confidence checks of the primary positioning system should be conducted and recorded in the survey records at least once every week. A successful confidence check should compare positions from the primary system to simultaneously observed check positions from a separate, independent system with a positional accuracy better than 10 metres. The inverse distance should not exceed 10 metres. The primary and secondary positioning systems should use different correction sources/systems. The confidence checks should be an integral part of the daily survey data record.

9.4 CROSSLINES

9.4.1 General

The regular system of survey lines should be supplemented by a series of crosslines for verifying and evaluating the accuracy and reliability of surveyed depths and plotted locations. Crosslines should be run orthogonally or diagonally across the planned survey.

The length of crosslines for swath surveys should be at least 5 percent of the length of all planned main survey lines. Comparisons should be made between main scheme lines and crosslines at 1% of all crossings (or 25 crossings, whichever is greater) distributed throughout the data both spatially and temporally. At these crossings the nadir or near-nadir depths of main scheme lines should be compared to each of the nearest unsmoothed soundings obtained from the crosslines. In addition, the nadir or near-nadir depths of the crosslines should be compared to the nearest unsmoothed main scheme soundings. The operator should perform a separate statistical analysis as a function of beam number/distance from nadir for each of the mains scheme - crossline intersections used for comparison.

9.5 ROUTINE SURVEY CHECKS

The following ongoing survey checks should be undertaken and logged:

- Positioning confidence checks,
- Bar checks,
- Draught checks,
- Crossline analysis,
- Sun-illuminated images,
- Single beam - swath comparisons,
- Primary / Secondary navigation system comparisons,
- Sound velocity measurement (and its correct application to echosounders and software),
- In addition to the above, the operator should perform spot-checks of the quoted error/uncertainty budget to ensure compliance.

9.6 UNCERTAINTY BUDGET ANALYSIS FOR DEPTHS

This was previously known as error budget analysis, but the term error implies something that can be absolutely measured, which is often not the case in hydrographic surveys. For this reason, the term uncertainty has now introduced instead of error. Literature regarding hydrographic survey and standards are currently in transition, so the terms uncertainty and error should be seen interchangeable, as sometimes both will appear within a single document.

The uncertainty associated with bathymetric measurements includes (a) uncertainty in the location of a measured bathymetric data point; (b) uncertainty in the depth associated with a bathymetric data point and (c) uncertainty in the backscatter strength associated with a bathymetric measurement.

Bathymetric uncertainty management involves both the design of a bathymetric system and the evaluation of results and products derived from bathymetric data. Measurements are always uncertain, to a greater or lesser degree. Uncertainties are of three fundamentally different types: accidental, systematic, and random. Each type must be dealt with differently. A common characteristic shared by all three, however, is that the reliability with which we can determine uncertainty is completely dependent upon the degree to which the bathymetric data is redundant (repeated measurements of the same seabed feature, or even footprint, which can be directly compared to ascertain consistency).

The operator should endeavour to minimise the uncertainties associated with the determination of depth (corrections to echo soundings). Uncertainty estimate ranges for six of the most common uncertainties (measurement uncertainty, transducer draft uncertainty, settlement and squat uncertainty, sound velocity uncertainty, heave uncertainty and tide/water level uncertainty) are presented below. These uncertainties are inherent to hydrographic surveying and all have practical minimums that are usually achievable only under ideal circumstances or with highly specialized equipment. In addition, some uncertainties may be dependent on depth (e.g. sound velocity). Maximum allowable uncertainties are specified to ensure that all error sources are properly managed. It should be noted that if the maximum value for each error source is used in an uncertainty budget (i.e. root-sum-squared), the result will exceed the prescribed accuracy standard. This is often known as the TPE (total propagated error) for a system, but again should be more correctly termed TPU (total propagated uncertainty). The minimum and maximum values discussed below are at the 95% confidence level (i.e. 2 sigma). These values are in line with the standards specified by a number of organisations, including IHO, NOAA and USACE (US Army Corps of Engineers).

9.6.1 Measurement error

This includes the instrument error for the sounding system, the effects of imperfectly measured roll and pitch, and errors in detection of the sea floor due to varying density of the bottom material. Swath systems are particularly susceptible to this error due to the off-nadir nature of outer beams. The minimum achievable value is expected to be 0.2 metres at 10 metres depth. The maximum allowable error is 0.3 metres plus 0.5% of the depth.

9.6.2 Transducer draft error

This error is controlled by variability in vessel loading, and the techniques used to measure and monitor transducer draft. This error is depth independent with an expected minimum of 0.05 metres and an allowable maximum 0.15 metres.

9.6.3 Settlement and squat error

Conventional methods of determining settlement and squat are limited by sea surface roughness and proximity of a suitable location to the survey area. Careful application of direct height measurement methods, such as Real Time Kinematic GPS, will minimise this error. This error is also depth independent, although the effect of settlement and squat is greater in shallow water. The practical expected minimum is 0.05 metres and the allowable maximum is 0.2 metres.

9.6.4 Sound velocity error

The factors associated with this error include (1) the ability to accurately measure sound velocity or calculate sound velocity from temperature, conductivity and pressure, (2) the spatial and temporal changes of sound velocity throughout the survey area and (3) how the sound velocity profile is used to convert measured time to depth. In addition, this error encompasses depth errors associated with refraction for swath systems. The expected minimum is 0.2 metres and the allowable maximum is 0.3 metres plus 0.5% of the depth.

9.6.5 Heave error

This error is directly dependent on the sea state and the sensitivity of the heave sensor but is not dependent on depth. The expected minimum is 0.05 metres and the allowable maximum is 0.2 metres.

9.6.6 Tide/water level error

The practical minimum is 0.2 metres and the allowable maximum is 0.45 metres.

9.7 ENVIRONMENTAL MEASUREMENTS

9.7.1 Sound Velocity (SV)

The sound velocity profile must be known accurately in swath sounding for two reasons. First, as in all echo-sounding, the depth is computed from the product of the velocity and the elapsed time between transmission of a sound pulse and reception of its echo. Second, since sound pulses travel at oblique angles through the water column, variations in the velocity profile will affect the path of sound through water. The sound path from the transducer to the bottom and back will affect not only the observed depth of water, but also the apparent position of the observed sounding. With very wide swath systems, correction for sound velocity is extremely important to reduce the effect of any sound path refraction.

In areas where the sound velocity at the surface is likely to change significantly across the area, a surface mounted continuous-reading SV sensor should be used on the sonar head. This surface sensor can be directly read by the Swath acquisition software. A surface probe will allow the operator to monitor changes in SV in real time and help aid decisions on when and where to take an SV profile.

If you are using third-party software for data logging and processing (e.g. Hypack/Hysweep) then you will need to fit a sound velocity sensor. See section 8.7.3.

An SV profiler is essential equipment for multibeam or swath data collection. If a choice needs to be made between a surface probe or a profiler, choose the profiler. A profiler works best if it is independent and self-recording, rather than tethered, as this will allow use over a greater range of depths. The profiler should be set to take a reading based on pressure at roughly every 0.5m to 1m intervals, depending on water depth. Use 0.5m triggering in water less than 10m deep. The profiler should be a direct reading SV meter, rather than a CTD (conductivity, temperature and depth), as this will give a more accurate reading for SV. SV probes and profilers need to be calibrated yearly to check and maintain the accuracy of the instrument.

An SV profile should be taken after arriving in the survey area. This will check that the equipment is working and the data can be downloaded; as well as allow the operator to survey using valid SOS data. An SV profile should be taken regularly. If a surface probe is used, then this can be used to monitor changes during the survey to allow the operator to make a decision on when to take a profile. It is advisable to take a profile at the start and end of the first line in the area to check whether the SV profile is uniform within the area. Profiles should also be taken at the start, middle and end of the day, but need to be taken at a frequency sufficient to be able to track changes within the survey area. When a profile is taken, the time and position of the profile should be noted and logged. In Swath Processor, in the SV dialogs, there are 'Here' and 'Now' buttons to help the operator capture this information.

SV can vary greatly depending on what environmental regime you are under. In a river you would expect the SV to be well mixed and fairly constant, but be aware where other river or streams enter the river, and also close to the coast. Estuarine areas can be particularly difficult, having river outflow making water brackish. There can be a salt wedge or freshwater surface layer. In these conditions, SV profiles should be frequent, and survey lines should be short and within discrete areas to try to mitigate any problems that the conditions may present. Coastal bays can present problems where the shallow water can experience warming, but may also have freshwater discharge from rivers. Offshore areas may show a significant change in the profile in deeper water.

9.7.1.1 Calculating Sound Velocity

If measuring sound velocity directly is too expensive or difficult, then an alternative can be to calculate it using information that is simpler to measure or to get from sources such as the Internet or port authorities. Some national and local authorities make sound velocity measurements available online.

9.7.1.2 Sound Velocity in Fresh Water

In fresh water, sound velocity mainly depends on temperature, so measuring the temperature with a thermometer can be adequate. Consider whether the water is well mixed or whether there is a warmer layer at the surface.

The sound velocity c can be computed from temperature T using Lubbers and Graaff's simplified equations:

$c = \quad 1405.03 + 4.624.T - 3.83 \times 10 -2.T^2$

See here for more information.

9.7.1.3 Sound Velocity in Seawater

In seawater, salinity also has a strong effect on sound velocity. If you have information about temperature T, salinity S and depth D, then you can calculate sound velocity using the Mackenzie equation:

$c(D,S,T) = 1448.96 + 4.591T - 5.304 \times 10^{-2}T^2 + 2.374 \times 10^{-4}T^3 + 1.340 (S-35) + 1.630 \times 10^{-2}D + 1.675 \times 10^{-7}D^2 - 1.025 \times 10^{-2}T(S - 35) - 7.139 \times 10^{-13}TD^3$

For operation from a surface vessel, the depth has minimal effect, and the equation becomes:

$c(S,T) = 1448.96 + 4.591T - 5.304 \times 10^{-2}T^2 + 2.374 \times 10^{-4}T^3 + 1.340 (S-35) - 1.025 \times 10^{-2}T(S - 35)$

9.7.1.4 Making Corrections by Eye

If you have neither direct measurement of sound velocity nor measurements of temperature and salinity, then you can still attempt some estimation of sound velocity using the sonar profile images. Select data from an area that you know to be flat, for example looking at data from adjacent survey lines. Use your local knowledge to guess the sound velocity conditions, for example a sun-warmed surface layer 1 metre thick, or a saltwater wedge 5 metres below the surface. Estimate water temperatures and salinity, and calculate sound velocity for two or three depths, and construct a sound velocity table. Enter that data into Swath Processor, and look at the bottom depth profiles to see if they have become flatter. If not, repeat and refine the process. Note that a single sound velocity value does not affect the angle of the profile; it only moves the entire profile up or down.

9.7.2 Tide and Height Datum

Depths measured by a sonar system need to be referred back to a common height datum. Even if this is not a requirement for charting purposes, it is necessary in order to be able to merge survey lines taken at different times within the same area.

Height datum control can be provided in a number of different ways, but the most common are to use GPS height or to use tide tables.

9.7.2.1 GPS height

Kinematic GPS, real time or post processed, will provide the actual height of the vessel and sensor, and so track directly any height changes at the vessel, relative to a geoid height. Most GPS sensors provide heights relative to the WGS84 datum. Swath Processor includes the facility to perform geoid conversions on input positions.

GPS height should only be used if the height accuracy from the GPS is 10cm or better. This is usually not the case for standalone GPS or differential GPS (DGPS).

If GPS height is used, Swath Processor provides the option of merging in heave data from the attitude sensor.

9.7.2.2 Tide

If GPS height is not available at sufficient accuracy, heights are first processed relative to the water surface, and then the height of the water surface is added. This water height is what we call tide, and it changes with time. Therefore, a set of tide tables is needed, logging tide height with time.

Predicted tide data is usually not sufficiently accurate for good surveying. Therefore, a tide gauge should be installed within the survey area; or a number of gauges if the area is extensive. It is always good to have some redundancy for height control measurement. This can be provided by tidal observations from local ports and harbours, or from ground staff observing any changes over time at particular points on the shore or riverbank within the survey area. Observations need to be taken frequently enough to track any significant changes in height, and at a maximum interval of 30 minutes. The position of any height control point needs to be noted, as well as the height relative to the datum being used, e.g., chart datum, local level, or mean sea level.

9.7.2.3 Lakes, rivers and canals

Height changes within lakes and river or canal sections should be monitored, even if RTK GPS height is being measured. In rivers and canals a height station should be set up, and measurements should be taken at the start and end of every section surveyed.

9.7.3 Positioning

The position of the sonar system has to be recorded at all times in a survey, and the quality of that position data must be carefully monitored throughout the survey.

See section 4.11.3 for information on installing position sensors.

Position accuracy can be prone to environmental problems in particular areas. Areas to be aware of include rivers or canals with significant trees lining the bank, urban corridors, bridges and overhead obstacles. In these conditions, radio or GSM modem corrections for DGPS or RTK may have problems, with some areas experiencing dropouts. Radio modems tend to require line of sight, so will be affected in urban or tree-lined corridors. GSM modems will suffer from any cell phone coverage issues. GSM modems use GPRS data streams whose bandwidth may be reduced at peak times, increasing latency or even causing a failure in the communication of corrections. Overhead obstacles, urban or tree-lined corridors may also cause multi path issues for the corrections as well as for the GPS position. As a backup it is best to record the corrections and the vessel position independently so that post processed position and heights can be derived if necessary. It is also advisable that at an inertial positioning and motion system (INS) be used. An inertial system should provide some provide good positioning in areas of sporadic problems, as well as allowing survey under overhead obstacles such as power lines or bridges.

9.8 RUNNING SURVEY LINES

A Bathyswath survey usually consists of a number of separate ‘survey lines’. To cover a rectangular area, a set of overlapping parallel lines is run over it. See Ref 1 for advice on planning the spacing between these lines. A tool is provided in Swath Processor to generate line plans and to help the helmsman to follow survey lines.

Create a separate raw data file for each survey line.

Record all line names, settings, etc in the survey log.

Attitude sensors work best in straight lines and are less accurate in turns. Therefore, try to ensure that lines are straight, or have very gentle curves. Use gentle line-keeping to keep the vessel on track. It is better to accept a few metres off-track error than to have a line with many short, sharp turns in it.

Allow about 30 seconds straight run before the start of lines and after the end. This is about 60 metres at 4 knots. This practice allows the attitude sensor to settle down after the turns, and improves filtering and interpolation of position data at the start and end of the lines. It also allows the helmsman to get settled in to running a straight line after turning in to the start point.

On long surveys, such as pipeline or cable routes, try to break the survey up into manageable lengths; say 5 to 10 km. Record separate data files for each section. This greatly aids post-processing. Best results are also achieved with straight, rather than curved or dog- legged lines.

Run the survey lines so that adjacent lines run in opposite directions. This ensures that port overlaps with port, and starboard with starboard. This pattern can be achieved by running the lines alternately, or by skipping two lines each time. The latter pattern is useful as it reduces turning time. For example, if the lines are numbered 1,2,3,4,5,6,7 ..., they may be run in the order 1,4,7,2,5 etc.

Create a convention for naming lines, and stick to it. Do not re-use line names. If it is necessary to re-run a line, use a different name. For example, if 'Line12' needs to be re-run, call the new line 'Line12A'. You may find it helpful to use a naming convention that tells you something about the line. Examples of this are distance from the centreline, and the direction that the line is run. So 'line30E' is a line 30 metres from the centre line, run in an easterly direction. Use the same line naming convention across the survey spread. For example, if lines have been planned in a navigation program and given names, use those in Swath Processor.

One or more crosslines running at right angles to the other lines helps with quality control, and can be very useful where, for example, lines disagree where they overlap due to tide errors. See section 9.2.

9.8.1 End of Survey Areas

Before leaving each survey area, use the **Coverage View** to ensure that sufficient coverage has been achieved. The sonar range can be trimmed on this display to reflect the range for which data quality is deemed acceptable. Re-run any lines that are considered to be sub-standard, and fill any gaps seen on the coverage plot. Use data replay facility to check that all the data necessary has been gathered, and run a representative sample of the data through the post-processing system before leaving the survey area. Use estimated tide data if necessary.

Repeat the pre-survey calibration measurements if these are likely to have changed; see section 9.1.

10 POST PROCESSING SOFTWARE

Post-processing converts the data acquired in real-time by Bathyswath into digital depth models. These depth models are used to produce displays and plots of the surveyed area. Users may select to use Bathyswath post-processing software, or a third-party program, to suit their application. The post-processing program is called Grid Processor. Grid Processor has its own manual. General survey practice and use of Swath Processor is covered in the online help package, provided with the Bathyswath software, and accessible using the Help menu or the keyboard F1 key.

The stages involved in processing Bathyswath data include:

- Enter all the auxiliary data required for processing. Some or all of this may have been entered during the survey:
  - Position offsets for all the components of the system on the vessel: transducers, motion sensor, position sensor, etc.
  - Tide tables (if used),
  - Sound velocity profiles (if used),
  - Surface sound velocity,
  - Time offsets (where necessary),
  - Re-processed position and attitude data files (if used, and if the attitude and position systems used provide this feature).
- Re-process the raw data (sxr) files collected during the survey to produces processed time-series data files (sxp):
  - First, replay a few files and assess the data quality. Use the bathymetry filters to maximise the bathymetry data quality at the spatial resolution required.
  - When you are satisfied with the offsets and filter settings, store the session file with a suitable name, so that it can be re-used for subsequent processing.
- Use the Grid Processor to create gridded digital terrain model (DTM), or ‘grid’ files, (sxg) from the sxp files, and look at a sample of the data.
- Process the patch-test calibration lines, using the patch-test calibration procedures to compute the patch-test offsets.
- Assess the results of the patch-test calibration, and re-run the patch test process to refine the patch-test offsets if necessary.
- When you are satisfied with the results of the patch-test area, process the main survey area.
- You can use third party tools to provide some end use data products: for example, charting packages to create charts, engineering packages volumetric packages, etc.

11 MAINTENANCE

Bathyswath is very simple and robust, and needs very little regular maintenance. However, the following instructions should help to keep a Bathyswath system accurate and operational.

11.1 DAILY, AND BEFORE LEAVING PORT

11.1.1 Safety check

Inspect all components of the system for safety, including:

Personal safety:

- Ensure that all electrical supplies are intact and undamaged,
- Ensure that the insulation of all cables is intact,
- Ensure that all cables are properly fixed down and do not present a trip hazard,
- Ensure that there is a safety plan for the vessel being used and that all personnel understand it: this is outside the scope of this manual, but nonetheless literally vitally important.
- Refer to the safety advice in section 2 of this manual.

Equipment safety:

- Ensure that all equipment is firmly fixed down. It may not be at risk of tipping over when in dock, but consider the effect of a rolling ship on every item.

11.1.2 Functional check

- Before leaving port, start up the system and check that profiles can be seen of the dock floor, however short. Ensure that the range and slope of the profiles that you can see are consistent with the arrangement of the boat with respect to the dock.
- Check the space remaining on the computer disk for sonar data. Allow for up to 0.5 Gbytes per hour.
- If the transducers are out of the water, do a 'rub test'. Rub the face of each transducer in turn with your hand, and look at the signal level in the Amplitude display. Check that the level rises on the transducer you expect it to (port or starboard). A common source of confusion is to plug the transducers into the wrong TEM. *Tip*: use red and green electrician's tape on the port and starboard (respectively) transducer connectors and TEMs.
- Check that the attitude, position, and compass system outputs are consistent with what you expect for the current orientation of the boat.
- If there is to be a long transit out to the survey area, run up the sonar system as soon as the boat leaves the dock, and make sure that the seabed profiles are consistent with the local area. For example, when operating alongside, check that the dockside appears on the side that you expect. Make sure that the profiles do not move up and down as the boat rolls. This could be caused by:
  - The transducers being plugged into the wrong side,
  - The attitude sensor being mounted the wrong way around, or configured so that it 'thinks' it is pointing the wrong way.
  - System timing errors (see §7**Error! Reference source not found.**).
- As soon as possible, record and process a small amount of raw data, to make sure that the post-processing process is valid.

11.2 WEEKLY, AND BEFORE EACH SURVEY

11.2.1 Calibrate the TEMs

The transducer electronics modules (TEMs) measure the phase differences of the incoming sonar signals, comparing each one against an accurate clock signal.

The Bathyswath-1 and SWATHplus TEM use analogue components in the sonar signal filters, which can drift with time, and so require calibration. Bathyswath-2 uses digital filters, which do not require such calibration. Therefore, **the following can be ignored for Bathyswath-2 systems and later**.

The electronics is set up in the factory so that two identical signals measured in difference TEM channels gives zero phase. However, all electronics can drift over time, and this drift needs to be accounted for in a calibration process.

Rather than having to return the TEMs to a workshop to be set up, a simple procedure, run from the main Bathyswath software, can measure and account for any phase offsets in the TEM electronics.

The calibration procedure is as follows:

1. Power up the system, including the TEMs, and allow at least 15 minutes for operating temperature to stabilise.
2. Make sure that the Bathyswath transducers are plugged in. If these are not available, use the Bathyswath TEM Calibration Box or a TEM transducer-shorting plug: contact Bathyswath if required. *Calibrating a TEM with its input open-circuit will result in calibration values that are incorrect for survey use.*
3. Start the Bathyswath software.
4. TEMs produced before October 2006 need a special Calibration Box, supplied with the Bathyswath system. Newer TEMs provide their own calibration signal when in 'Calibrate' mode, and so do not need the Calibration Box. For the older TEMs:
    a. Insert the Calibration Box's connector into the top TEM connector (known as channel 1 or port channel) in lieu of the transducer cable.
    b. On the calibration box, select the correct frequency for the TEM to be calibrated.
    c. Switch on the calibration box.
5. You will probably need to use **Configuration > Attitude Derivation > Test Mode**, so that you can see sonar data in the Swath Processor windows if the position and attitude data is not present.
6. In the **Sonar** dialog, click **Configure**, then **Test & Calibration**. In **Inject Calibration Signal**, select **TEM**. Use **OK** to close the dialogs.
7. Click **Start** in the Sonar Control dialog.
8. From the **Calibration** menu, choose **Phase Offsets**
9. From the drop-down list select **Transducer 1**
10. In a **Cross Profile** view, you should see two straight lines radiating out from the top-centre of the display. This means that the TEM is in calibrate mode. If you can still

see a cloud of noise points in the Cross Profile view, then the TEM is not in calibrate mode: re-check the steps above.

11. Allow the displayed offset values to stabilize, could be 30 seconds or more) and check the **Apply Offsets** box.
12. Click the **Apply** button.
13. For your records, make a note of the phase calibration offsets derived, with the date of the calibration.
14. Save the 'session file' (.sxs). This file could be used as the basis of all future 'session files' as it contains the phase offset calibration values. Otherwise, you can copy the calibration values into other session files that you create.
15. If you are using a calibration box, transfer it to the lower TEM connector.
16. Repeat steps 7 through 15, substituting Transducer 2 for Transducer 1
17. Make sure that the calibration values recorded are used in every session file that uses these TEMs, even for post-processing.
18. Turn off calibrate mode using **Sonar > Configure** > **Test & Calibration** > **Inject Calibration Signal > Off**.

11.2.2 Connector checks

Check the state of all cables and connectors. Loose or damaged cables and connectors are probably the most common source of system problems.

Check the state of sea-earth cables. These are often implemented with bare wire at the sea end, and can therefore corrode quickly. This corrosion can occur for a significant length of the wire, so it is often necessary to replace the whole wire. Try to find a way of keeping seawater out of the wire.

11.2.3 System checks

A set of system checks is suggested under 'Testing' in the on-line help.

11.2.4 Computing system checks

As with any computing system, a regular check of the system helps to keep the computer running efficiently and effectively. This includes: cleaning out old data, performing backups of essential software and data,

11.2.5 Patch-test calibration

Run a calibration patch-test survey at the start of every survey, whenever the sonar transducers or attitude sensor are moved, and at regular intervals throughout long survey campaigns. See section 9.2.

11.3 MONTHLY, (OR LESS OFTEN, DEPENDING ON CONDITIONS)

11.3.1 Inspect transducers for marine growth

Marine growth on the surface of transducers will severely reduce their effectiveness. All such marine growth should be removed as gently as possible: do not use sharp tools or mechanical grinders; otherwise, the transducer face can be damaged.

11.3.2 Corrosion check

Check all items for corrosion. Fit sacrificial anodes, inspect them at regular intervals, and replace them if necessary. Such anodes can be obtained from any chandlers.

11.3.3 Cleaning

Clean the computing and electronics systems:

Use a damp cloth, no solvents. Do not use tissue paper to clean the display screens.

Display screens: use a soft cloth lightly moistened with a mild detergent solvent, then wipe clean with a soft dry cloth.

Casing: wipe over with a soft cloth lightly moistened with a mild detergent solvent.

Connectors: clean connectors with IPA alcohol spray or switch cleaner. See section 11.6.2 for instructions on cleaning and greasing the underwater connectors.

11.4 YEARLY

11.4.1 Transducer capacitance check

These checks apply to Bathyswath-1 only; Bathyswath-2 transducers have internal pre-amplifiers, so the capacitance of the transducer staves cannot be measured.

A check of the transducer capacitance, using a simple hand-held multimeter, can give an indication of problems with transducers or their cables and connectors, before such problems are noticeable in the sonar results.

Measure the capacitance between each pair (A+, A- etc) and between the members of the pairs and their screens (A+ - A screen, etc), and note them down in a system logbook. The receive staves (A, B, C and D) should have similar capacitances, and the two transmit staves (Tx) should have similar capacitance. When these measurements are repeated at the next check period, look for any significant changes.

See section 11.6 for the transducer connector layout.

11.5 TRANSDUCER CHECKS

After two years, and then every five years, it is advisable to check the aging of the active ceramic components in the transducers. This is done by returning the transducers to Bathyswath, who will arrange for a subset of the transducer calibration tests to be performed. The results from these tests are compared with those performed after manufacture. This will indicate whether there is any degradation in the transducer performance.

11.6 TRANSDUCER CONNECTOR DIAGRAMS

Details of the connector at the TIU and the connector on the transducer's one-metre tail are shown below.

11.6.1 Bathyswath-2 Transducer connector

On Bathyswath-2 systems, the transducers are fitted with Subconn MCOM16 wet-mate connectors. The same connector type is used for the transducer extension cable at both ends, and on the TIU electronics housing.

The Bathyswath-1 and Bathyswath-2 connections are compatible with each other, so that Bathyswath-2 transducer extension cables can be used to connect to Bathyswath-1 transducers.

Function	MCOM16F (Subconn)
Rx Stave A+	15
Rx Stave A-	14
Rx Stave B+	13
Rx Stave B-	12
Rx Stave C+	10
Rx Stave C-	9
Rx Stave D+	8
Rx Stave D-	7
TX +	6
TX -	16
TXDR TEST +	2
TXDR TEST 0V	5
Pre-Amp PWR +	3
Pre-Amp PWR 0V	1
Rx Screen	4
Overall screen	11

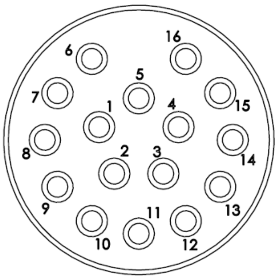


Figure 11 MCOM16F female connector (mating face)

Figure 12 MCOM16M male connector (mating face)

11.6.2 Greasing and cleaning the connectors

The Subconn connectors should be greased with
“Molykote® 44 Grease, Medium”, a Dow Corning product.

General cleaning and removal of any accumulated sand or mud on a connector should be performed using spray-based contact cleaner (isopropyl alcohol). New grease must be applied again prior to mating.

See the MacArtney support site for more information: http://macartney.com/support .

11.6.3 Bathyswath-1 TIU Transducer connector

The wiring of the Bathyswath transducer connectors in the standard TIU is shown in Figure 11-3.

TIU: Pin letter on 26-way Connector	Function	Description
B	+	Stave A
A	-	Stave A
R	SCREEN	Stave A
P	+	Stave B
N	-	Stave B
M	SCREEN	Stave B
L	+	Stave C
K	-	Stave C
J	SCREEN	Stave C
H	+	Stave D
G	-	Stave D
F	SCREEN	Stave D
E	+	TX
D	-	TX
C	SCREEN	TX

The different transducer frequency versions are encoded in pins W, X, Y, c and b. These codes are implemented in the transducer connectors as follows:

Transducer	Implementation
117	Pins W Y and b linked together
234	Pins X c and b linked together
468	Pins c and b linked together

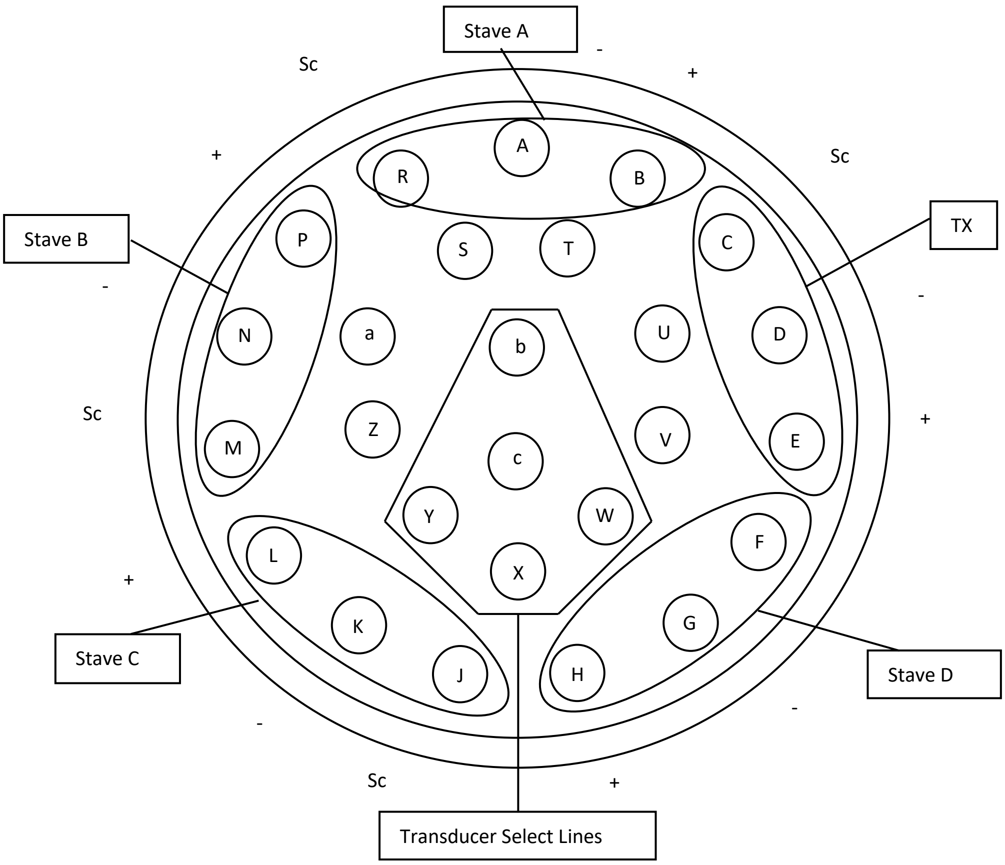
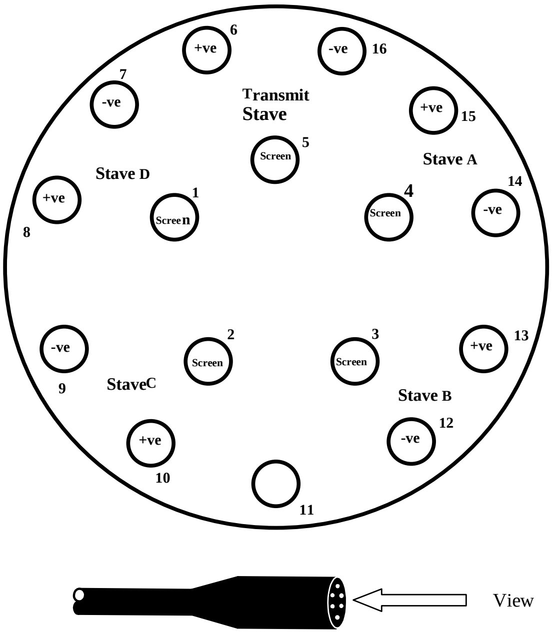


Figure 11-3 Bathyswath-1 TIU Transducer Connector Layout

11.6.4 Bathyswath-1 Transducer Connector

On the Bathyswath-1 transducer 1-metre tail, the connections are as follows:

Pin number on 16-way con	Function	Description	Colour
15	**+**	**Stave A**	**White**
14	**-**	**Stave A**	**Blue**
4	SCREEN	Stave A	N/A
13	**+**	**Stave B**	**White**
12	**-**	**Stave B**	**Orange**
3	SCREEN	Stave B	N/A
10	**+**	**Stave C**	**White**
9	**-**	**Stave C**	**Yellow**
2	SCREEN	Stave C	N/A
8	**+**	**Stave D**	**White**
7	**-**	**Stave D**	**Green**
1	SCREEN	Stave D	N/A
6	**+**	**TX**	**White**
16	**-**	**TX**	**Red**
5	SCREEN	TX	N/A
11	Overall Screen	Overall Screen	N/A

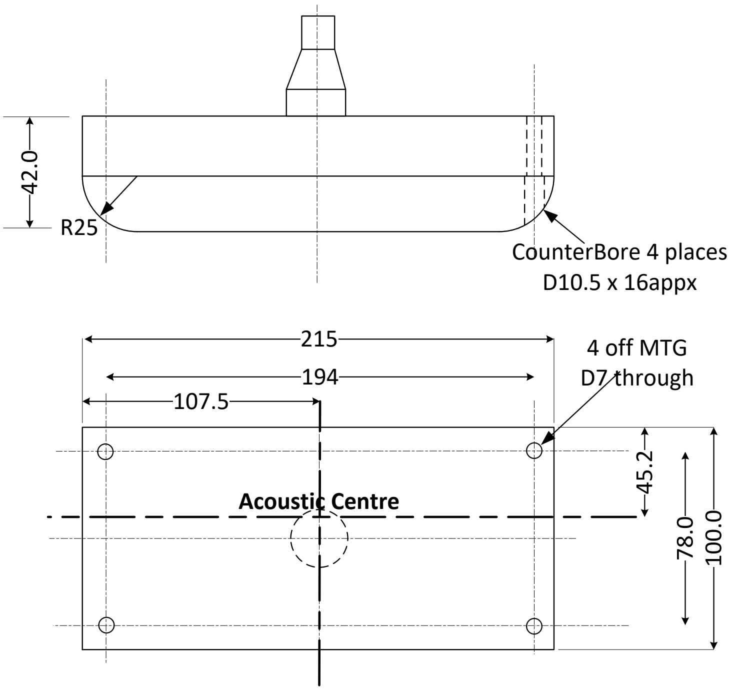


11.7 TRANSDUCER DRAWINGS

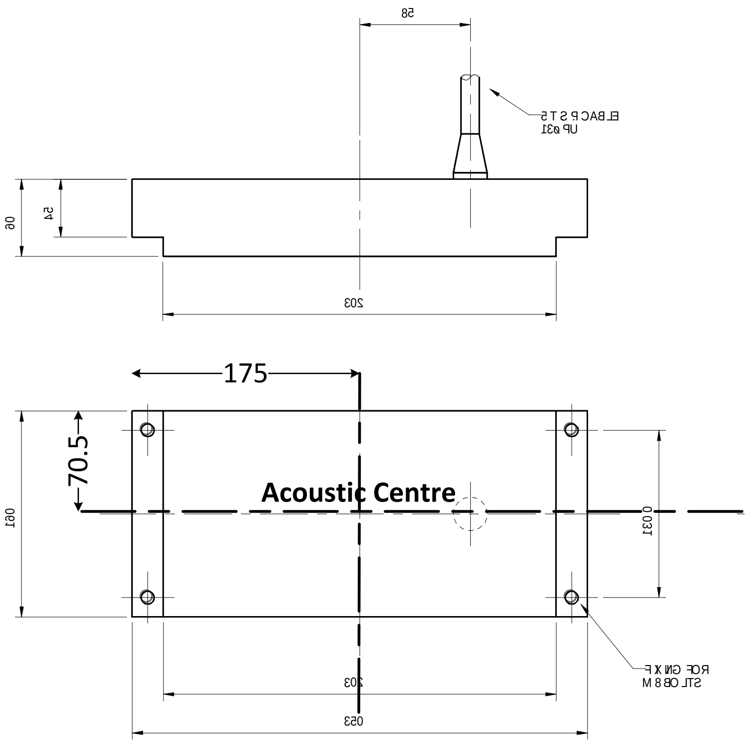
The vertical acoustic centre is shown with a dotted line. The horizontal acoustic centre is the physical centre, and about 1cm behind the front face.

On Bathyswath-2 transducers, the acoustic centre is exactly in the centre of the transducer face, and about 5mm behind the face.

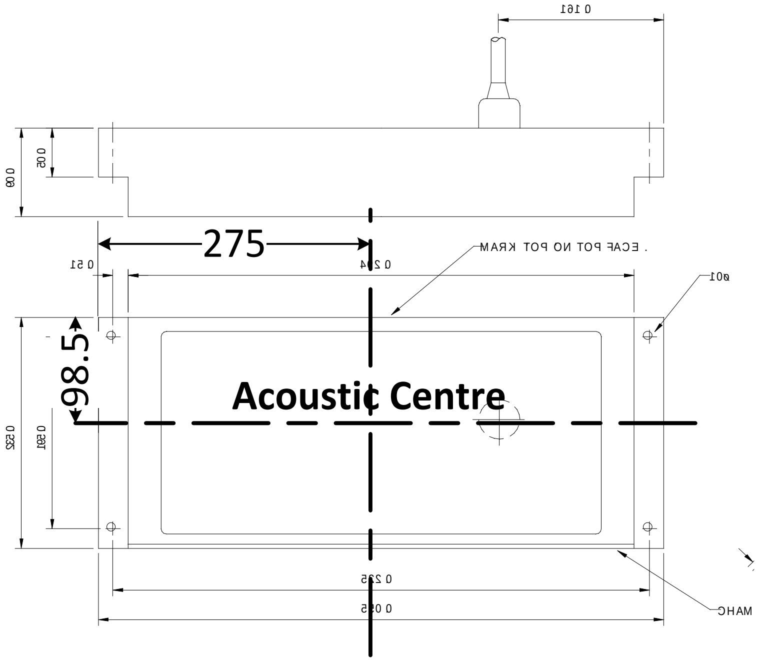
11.7.1 468kHz Bathyswath-1



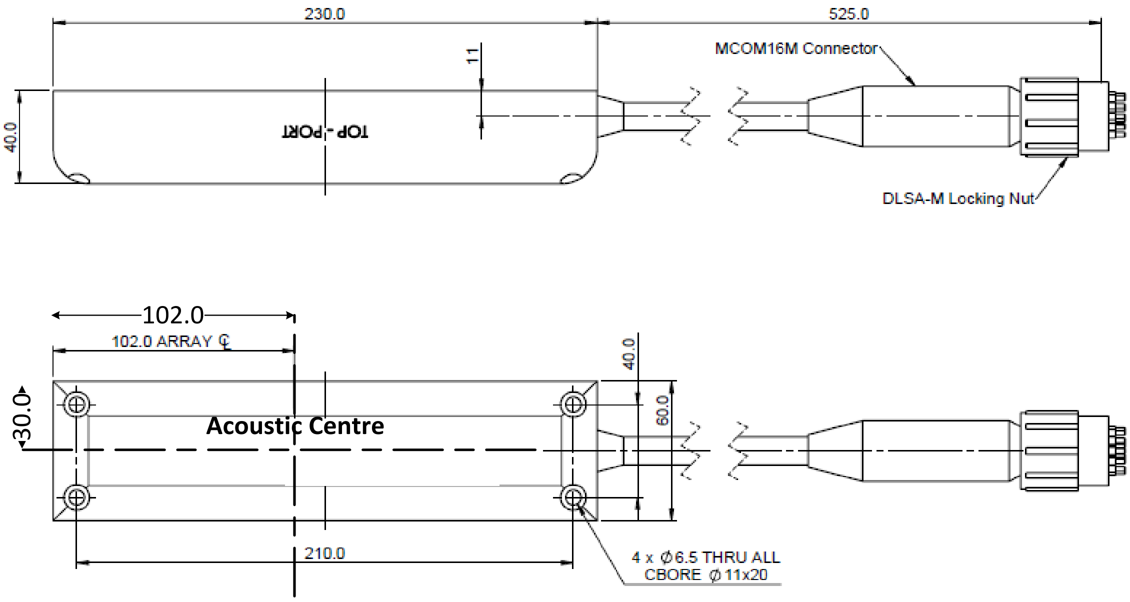
11.7.2 234kHz Bathyswath-1



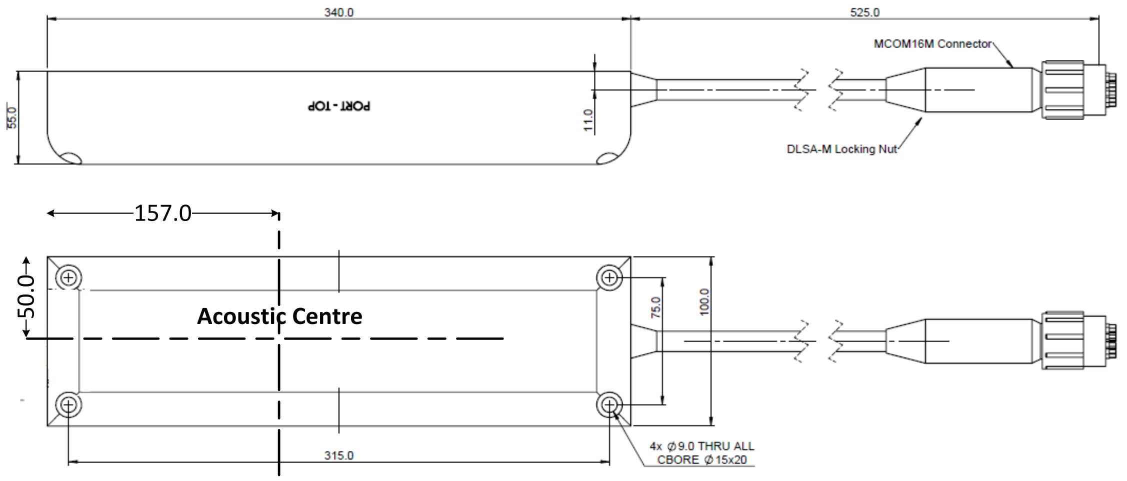
11.7.3 117kHz Bathyswath-1



11.7.4 468kHz Bathyswath-2



11.7.5 234kHz Bathyswath-2



11.7.6 117kHz Bathyswath-2